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# Efficiency Vermont

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# Technical Reference User Manual (TRM) Measure Savings Algorithms and Cost Assumptions

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# Introduction 1.1 Purpose of Technical Reference Manual

This Technical Reference Manual (TRM) provides descriptions of energy efficiency measures implemented by Efficiency Vermont's programs together with all the necessary algorithms and default assumptions for estimating the energy (both electric and fossil fuel) and peak electric capacity impacts. In addition, all parameters required for the application of cost-effectiveness tests (such as loadshapes, costs and lifetimes) are provided.

The manual is made up of *characterizations* which document all assumptions for a particular efficient technology. Within each characterization, there may be one or many specific sets of assumptions that characterize a specific application (e.g. multiple efficiency levels, fuels, capacity ranges, etc.) or technology type (e.g. various LED fixture types) all of which share the same algorithm, but where one or more inputs may be variant.

# 1.2 Use and Application of the TRM

## 1.2.1 Claiming Savings and Cost-Effectiveness Calculations

The TRM is the system of record for claiming savings and performing cost effectiveness tests for the efficiency measures and applications characterized and installed within a particular program year.

The primary cost-effectiveness test used by Efficiency Vermont to evaluate the performance of efficiency measures is the *Societal Cost Test* (SCT), as described in the California Standard Practice Manual<sup>[1]</sup>. A positive cost-effective test result (or screening) is required for overall portfolio, total program, and customer project level screening, with some exceptions for low-income programs, pilots, and new technologies that require heightened program support. Components or measures within a project may be non-cost-effective, particularly if required for health and safety, so long as the project, program or portfolio screens as a whole.

All components needed to perform a cost-effectiveness test are found within the TRM and the calculations are performed through application of a Screening API (Application Programming Interface) accessed through Efficiency Vermont's analysis and tracking system *Tracker*.

# 1.2.2 Annual Savings Verification

At the end of each program year, a version of the TRM containing all measures that were active at any time during that program year is saved and used as the basis for corroborating Efficiency Vermont savings claims during the annual evaluation of the ratepayer-funded programs in Vermont, referred to as the Savings Verification process.

# 1.2.3 Portfolio Planning and Evaluation (Demand Resource Plan)

The TRM also provides the basis for first year assumptions within the implementation of portfolio modelling exercises including the Demand Resource Plan, filed every three years. The TRM characterizations generally do not provide documentation of future year adjustments to first year assumptions, though in instances where such adjustments are known (e.g. forthcoming Federal Standard changes) they may be documented and planned for. Therefore where modeling is required for multiple years in to the future, additional assumptions concerning future year changes need to be documented outside of the TRM and within the specific application used for forecasting and portfolio screening.

# 1.2.4 Forward Capacity Market

Efficiency Vermont is an active bidder into the ISO-New England (ISO-NE) *Forward Capacity Market (FCM)*. The FCM is an annual Auction where bidders commit to the supply of future capacity in exchange for a market-priced payment, with a goal to ensuring that the New England power grid will have sufficient resources to meet future demand. Demand-side efficiency programs that can guarantee the generation of electricity savings during the ISO-NE defined peak period can be included in the market.

The TRM is a major component of the Measurement and Verification (M&V) plan that is required in order to qualify to participate in the FCM auction. Efficiency Vermont submits a new version of the plan with a copy of the active TRM to ISO-NE for review every year.

# **1.3 Prescriptive v Custom Measures**

### Introduction

The primary objective of the TRM is to document the savings assumptions for *prescriptive* measures – i.e. those measures with a high volume and with relatively low per unit savings, where individual custom calculations would be cost-prohibitive, or where the likely variation of savings is low and/or the availability of input data is prohibitive to a custom application of the measure.

However there is a spectrum of "prescriptiveness" across characterizations, ranging from those with a single deemed savings value, to those semi-custom characterizations where multiple inputs are required for each application. The TRM may also be used to document *custom* protocols and/or provide one or more of the key cost-effective test inputs that cannot be collected on site (such as lifetime) for those measures that are evaluated outside of the TRM (e.g. through modeling software, metering etc).

When evaluating which form a particular measure will take, the balance of the cost of implementation against the corresponding potential accuracy of the savings estimate is considered.

# **1.4 Development and Review Process**

The manual is maintained by members of Efficiency Vermont's Evaluation, Measurement, and Verification (EM&V) department. There are four main scenarios when changes are made to the TRM:

- 1. New characterizations are created whenever a new technology is ready for implementation and where savings will be claimed through a prescriptive process.
- 2. Existing measures are updated with new information, e.g. for a Federal Standard or efficient specification update, following publication of new evaluation results that provide an improved basis for existing assumptions, or where new measure implementation methods require additional variable assumptions.
- 3. Existing measures are updated to fix errors or provide improved clarifications.
- 4. Reliability updates Any characterization that has not received any update for three years is automatically included in a review process to check for continued validity, consistency with other measures, accuracy of assumptions and whether any new evaluation results should be considered. Changes arising from the reliability review are activated in the subsequent program year.

## 1.4.1 Review Processs

Once a characterization draft is complete an initial screening of the measure is completed to assess whether the assumptions lead to a cost-effective application. The measure is then reviewed internally by VEIC EM&V staff, before being sent to the Vermont Public Service Department for review. When all comments are received and resolved, the measure is made *Active* in the TRM on its Effective Date and all prescriptive measures installed from that date will utilize the new assumptions.

# 1.4.2 Application of Updates

Whenever possible, characterizations are made active after the Internal and External review process described above is complete, such that the new assumptions are applied only for measures installed prospectively. However, when considered appropriate (e.g. to align with the effective date of a specification change, or when fixing a significant error), the characterization change may be made *retroactively* and any prior installation in the present program year will be adjusted accordingly.

[1] 'California Standard Proactive Manual, Economic Analysis of Demand-Side Programs and Projects', October 2001.

# **Characterization Structure**

The TRM contents are organized by Program and then End Use. However where the same technology is supported in multiple programs, and where the characterization methodology and algorithm(s) are similar, some characterizations have been consolidated into one, providing alternative assumptions for each program type where appropriate.

Each characterization is made up of the following components:

# 1.1 Update Summary

The update summary describes the current characterization's updates from its previous version (if applicable). This will outline specific changes to the characterization, if that is a cost update or efficient condition update.

# **1.2 Referenced Documents**

All referenced documents are listed with a hyperlink to open the document. These may include analysis spreadsheets used to calculate the savings, evaluations, and memos.

# **1.3 Descriptions**

# 1.3.1 Program Type

The Program Type section will provide the calculation type that is used in the characterization and the program delivery/implementation type. This helps the reviewer understand how the measure is being delivered to customers and how savings will be calculated.

# 1.3.2 Measure Description

The Measure Description section includes a general description of the measure, how it saves energy, and the specific *reporting category*(s) and delivery mechanism(s) being characterized. It will be clearly stated whether the measure is intended to represent a Market Opportunity (i.e. time of replacement or new construction), Early Replacement, Retrofit or Early Retirement application, and the method of implementation (e.g. Up-, Mid- or Down-stream, Direct Install, or Building Performance Programs). See definitions in section 3.2 and 3.3.

# 1.3.3 Baseline Efficiencies

The baseline assumptions will be clearly defined. For a Market Opportunity measure the baseline is generally based on one of two approaches: either a minimum code or standard efficiency level, or a market based estimate representing what is most common in the marketplace, often determined through a baseline study.

For Early Replacement, Retrofit and Early Retirement applications the baseline is generally the existing equipment as it is currently operated, or as it would be expected to be operated in the absence of the energy efficiency measure/equipment.

# 1.3.4 Efficient Equipment

The Efficient Equipment section includes a clear definition of the criteria by which it will be determined whether equipment qualifies as efficient. This may include specific technologies, minimum efficiencies, energy efficiency standards (such as ENERGY STAR or CEE Tiers), or other criteria.

# **1.4 Algorithms**

# 1.4.1 Algorithm Outputs

The Algorithm section provides mathematical formulas for the impact of the measure on each of the following as appropriate:

- Electric Demand Savings: calculation of the first year connected load reduction (or penalty). This is used to estimate the Summer and Winter *coincident peak kW* reduction, by multiplying with the coincidence factors from the measure's loadshape. This usually represents the maximum kW reduction associated with the measure, but some loadshapes deliberately assume that it represents the average kW reduction.
- 2. Electric Energy Savings: calculation of the first year total kWh saved (or penalty) per unit.

- 3. Fossil Fuel(s) Savings: calculation of first year MMBtu savings (or penalty) or any applicable fossil fuel (natural gas, liquefied petroleum gas (propane), distillate, kerosene, wood (logs, pellets or chips)).
- 4. Water Savings: calculation of first year water savings (or penalty)

## 1.4.2 Algorithm Variables

Each variable within an algorithm will be listed and defined. Variables can take the form of Constants, Deemed Values or Inputs:

- 1. Constants values that are universal, such as conversion factors that will have the same values in all contexts.
- 2. Deemed Values variables for which an average, typical, or representative value has been determined for the measure or application in question. In many cases there may be multiple deemed values provided for different applications, efficiency levels, installation locations etc. Each unique combination of Deemed Values will be screened separately and use a different *Item Code* to track installation; see section 2.8.2 for more information. Each deemed value will have a source reference specifying the basis of the assumption(s). If the values were calculated, the details of the calculation will be provided either in a footnote or in an attached referenced document.
- 3. Inputs custom values that are input into the algorithm directly based on information collected onsite or provided on a prescriptive form or invoice. A default value may be provided for instances where the input data is missing or incomplete.

Depending on the construction of the algorithm and its variables, each measure output may be a single deemed value, multiple deemed values depending on one or more variable, or be a custom output requiring calculation dependent on one or more Inputs.

## 1.4.3 In Service and Leakage Rates (where applicable)

Many Market Opportunity characterizations include variables to address the likelihood that a purchased measure will end up being installed within the Vermont service territory:

- In Service Rate (ISR): Representing the assumed proportion of all sales that end up getting installed. This is particularly important for measures that are provided free or at low cost to the customer.
- Leakage Rates: Representing the assumed proportion of sales through the program that are installed outside of the Vermont service territory and so are ineligible to be counted towards efficiency goals.

# 1.4.4 Mid Life Baseline Adjustment (where applicable)

In some characterizations, it is appropriate to apply a mid-life adjustment to the kWh and/or MMBtu savings at some point within the life of a measure. This affects the lifetime savings of the measure as well as the Net Present Value. Possible scenarios requiring this adjustment are:

- 1. Early replacement measures where the first X years' savings are from the existing equipment to the new efficient equipment while the following Y years' savings are from a hypothetical new baseline unit to the efficient equipment.
- 2. Situations where the baseline alters one or more times during the life of the efficient measure, resulting in a change to the assumed baseline efficiency, for example, incorporation of the impact of EISA lighting standards on baseline replacement lamp efficacies within the lifetime of an LED installation.

When such an adjustment is required, the characterization will specify the adjustment percentage (i.e. 'new savings after adjustment' / 'first year savings') plus the timing of the adjustment (either number of years from installation or to occur in a specific future year).

# 1.5 Loadshapes

Every measure with electric savings has a loadshape provided. Each loadshape is made up of six percentage values; four energy periods (totaling 100%) that are multiplied by the first year electric energy savings and applied to a unique set of *avoided costs* (for Winter Peak, Winter Off-Peak, Summer Peak and Summer Off-Peak), and two *coincidence* 

*factors* (Winter and Summer) corresponding to the percent of kW savings that is concurrent with ISO-NE's defined coincident peak periods. Loadshapes also include an assumed hours of use which is used in determining the loadshape, but may be different to the hours used in a measure's savings calculation.

Active Efficiency Vermont loadshapes can be found here.

## **1.5.1 Efficiency Vermont Avoided Cost Period Definitions**

As of January 1, 2016, Efficiency Vermont is using the following avoided costs energy periods based on the Avoided Energy Supply Costs in New England: 2015 Report prepared for the Avoided-Energy-Supply-Component (AESC) Study. The coincident peak periods are based on ISO New England performance hours for the forward capacity market.

Winter Peak Energy:	7AM - 11PM, weekdays, October to May;
Winter Off-Peak Energy:	11PM - 7AM, weekdays, all weekend hours, October to May;
Summer Peak Energy:	7AM - 11PM, weekdays, June to September;
Summer Off-Peak Energy:	11PM - 7AM weekdays, all weekend hours, June to September.
Summer Gen. Capacity:	1PM-5PM, weekday, non-holiday, June-August
Winter Gen. Capacity:	5PM-7PM, weekday, non-holiday, December-January

# **1.6 Net Savings Factors**

The characterization provides the *Gross Savings* estimate, i.e. the estimated savings experienced at the customer's meter as a result of the energy efficiency measure. To complete the cost effectiveness tests, it is necessary to convert the Gross Savings into *Net Savings*, i.e. the estimated savings at generation and attributable to the program. Net Savings is calculated as follows:

NetkWh	$= \sum (\text{netkWh}_i)$
netkWh <sub>i</sub>	= ΔkWh * (1+LLF <sub>i</sub> ) * (FR + SPL - 1) * RPF <sub>i</sub>
NetkW <sub>j</sub>	= ΔkW * (1+LLF <sub>j</sub> ) * (FR + SPL - 1) * CF <sub>j</sub>

Where:

netkWh<sub>i</sub> = kWh energy savings at generation-level, net of free riders and persistence, and including spillover, for period i (Winter On-Peak, Winter Off Peak, Summer On-Peak and Summer Off-Peak)

*i* = subscript used to denote variable energy rating periods (Winter Peak, Winter Off-Peak, Summer Peak, Summer Off-Peak).

 $\Delta kWh$  = gross customer annual kWh savings for the measure

 $LLF_i$  = line loss factor for period *i*. The Line Loss factor represents the marginal electricity losses from the generator to the customer – expressed as a percent of meter-level savings.

FR = *Freeridership factor*, as presented in the measure characterizations. The Freeridership factor is equal to 1 minus the percent freeridership. For example, if it is assumed that 10% of measure installations are freeriders, FR will be equal to 0.9.

SPL = *Spillover factor*, as presented in the measure characterizations. The Spillover factor is equal to 1 plus the percent spillover. For example, if it is assumed that a measure has 5% spillover, SPL will be equal to 1.05.

RPF <sub>i</sub>	= rating period factor for period <i>i</i> [as provided by the loadshape]
netkW <sub>j</sub>	= kW demand savings, net of free riders and persistence, and including spillover, for season j
j	= subscript used to denote variable seasonal peaks (Summer or Winter).
ΔkW	= gross customer connected load kW savings for the measure
LLF <sub>j</sub>	= line loss factor for seasonal peak <i>j</i>
CFj	= the percent of kW savings that is concurrent with Vermont's seasonal peak, for season j [as

provided by the loadshape]

## 1.6.1 Line Loss Factors

All of the parameters above except *Line Loss factors (LLF)* are provided in each measure characterization. The LLFs do not vary by measure, but by costing period, and are provided in the following table[1]. Note the "Including PTF" values are used in the Net Savings calculation above:

Distribution Line Loss Values - Efficiency Vermont

Marginal Losses by Costing Period	not including PTF*	Including PTF
Winter Peak	11.8%	14.8%
Winter Off-Peak	9.8%	12.3%
Summer Peak	11.9%	15.0%
Summer Off-Peak	9.5%	11.9%

Average Losses at Peak Hour	not including PTF	Including PTF
Winter	9.0%	11.3%
Summer	8.9%	11.2%

\*PTF means pooled transmission facility

Values "including PTF" are to be used in Net Savings calculations to reflect the impact on power generation.

## 1.6.2 Measure Codes and Item Codes

Each characterization will have one or more associated *Measure Codes*, used to identify the general technology. A single measure code may represent many different (but related) specific technologies, and they all will share the same Net to Gross Factors (Freerider and Spillover rates) within each program *Track*.

Measure codes are eight-character alpha-numeric codes, consisting of the following:

- The first three digits represent the end use being impacted by the measure.
- The remaining five digits represent the measure, application and/or efficiency level as appropriate.

For example: CKLC3WRP

CKL: Cooking and Laundry end use

C3: CEE Tier 3

WRP: Clothes Washer

For example: LFHEXLED

LFH: Lighting Hardwired Fixture end use

EX: Exterior

LED: LED Fixture Type

Each unique output from a characterization's algorithm, using a combination of all the deemed prescriptive assumptions, will also have a unique Item Code prescribed. Item Codes are alpha-numeric codes that identify a specific prescriptive measure, market, implementation method and/or specification. For example 'BES-XTR-F' is an 'LED Exterior Fixtures, 2,001-5,000 lumens' and 'EPT3FCW' is a 'Residential Efficient Products Front Loading Clothes Washer (CEE Tier 3)'. Many characterizations do not currently display Item codes.

# 1.7 Lifetimes

The measure life quantifies the number of years (or hours) that the new high efficiency equipment is expected to function and provide the savings characterized. It is often based on the rated engineering life of the equipment, but is sometimes adjusted based on the expected *Persistence* of the savings. Persistence represents the fraction of gross measure savings obtained over the measure life. For measures where equipment tends to be removed, made inoperative, overridden or poorly maintained before the end of its rated life (e.g., controls or economizers), applying a persistence factor to adjust the measure life may be necessary. Persistence factors are applied directly to the engineering life to determine an adjusted measure life within the TRM characterization.

For early replacement/retrofit measures where a mid-life adjustment is prescribed, the expected remaining life of the existing unit will also be provided.

# 1.8 Measure Cost

The measure cost represents the difference in cost between the baseline condition and the efficient measure.

For a Market Opportunity baseline, the measure cost will represent an incremental cost, or the difference between the purchase and installation of the baseline equipment and the purchase and installation of the efficient equipment. Installation costs only need to be included where there is a difference between baseline and efficient installation costs.

For an Early Replacement or Retrofit measure, the measure cost is the full cost of purchase and installation, including any cost of removing and disposing of the existing equipment. The TRM will also provide the estimated purchase and installation cost of the hypothetical deferred baseline (i.e. the replacement of existing equipment that would have occurred had the efficient measure not already replaced it) and the timing of that deferred replacement cost consistent with the timing of the mid-life adjustment.

For an Early Retirement measure, the measure cost is the full cost of collection and disposal of the existing equipment.

# **1.9 Operation and Maintenance Cost Adjustments**

For any measure where there is forecast to be a difference in the operation and maintenance (O&M) costs (including replacement of component parts such as lamps) between the baseline and the efficient case, these costs are described within the characterization. The costs and lives for up to two components each for the baseline and efficient case can be provided.

For a select number of measures, a regular O&M cost may change significantly over the life of a measure (e.g. the cost of replacement baseline bulbs before and after the impact of EISA legislation). In these cases, an equivalent annualized payment may be calculated that results in the same net present value as the actual stream of costs over the measure life.

# 1.10 Reference Tables

Many measures include one or more reference tables. These tables often document multiple inputs for characterizations with a large number of specific technology types (e.g. LED light fixtures) and/or the savings outputs for each unique set of deemed variables with the specified measure or item code.

# 1.11 Footnotes & Citations

The final section of the characterization contains footnotes which provide additional context or explanation and/or referenced citations for the assumptions provided, all of which are attached in the Reference Documents Section.

[1] From document titled Vermont Public Service Board Order: EEU AVOIDED COSTS FOR 2016-2017 TIME PERIOD (EEU-2015-04 Order Attachment.pdf)

# General Concepts and Assumptions 1.1 Reporting Category and Track Definitions

The current Efficiency Vermont Reporting Categories are presented below. These are specified with a four digit MAS90Job number:

MAS90Job	Description
6012	Business Retrofit
6013	C & I Equipment Replacement
6014	C & I New Construction
6015	Customer Credit
6017	Low Income Multi Family Retrofit
6018	Low Income Multi Family New Construction
6019	Market Rate Multi Family New Construction
6020	Market Rate Multi Family Retrofit
6032	Energy Efficient Products
6034	Low Income Single Family Homes
6036	Existing Homes
6038	Residential New Construction Single Family Homes
6041	Low Income Single Family New Construction

Within each reporting category are subcategories or Tracks which provide additional context of the project type. A list of Tracks used within the TRM can be found here.

# **1.2 Measure Calculation Types**

There are five distinct measure calculation types described below, each with key differences in the determination of baseline.

Program	Definition
Market Opportunity: Time of Sale	Definition: A program in which the customer is incentivized to purchase or install higher efficiency equipment than they would have done if the program had not existed.
	Baseline Case = New base level equipment, often corresponding to a federal standard or at a level representing standard industry practice.
	Efficient Case = New, high efficiency equipment meeting a program specified level.

Program	Definition					
Market Opportunity:	Definition: A program that intervenes during building design to support the use of more-efficient equipment and construction practices.					
New Construction	Baseline = New base level equipment at the efficiency level defined in the applicable Building Energy code, federal standard level or standard practice as derived by baseline studies.					
	Efficient Case = The program's prescribed level of building specification.					
Early Replacement	Definition: A program that replaces existing equipment before the end of its expected life. To qualify as early replacement, there needs to have been prior contact with the customer replacing functioning equipment – e.g. during on site audit or through prior phone/email contacts, and evidence must be provided that the unit is being replaced to achieve energy savings.					
	Baseline = Dual; for the expected remaining useful life of the existing equipment the baseline is the efficiency of the existing equipment and then shifts to represent new baseline equipment.					
	Efficient Case = New, high efficiency equipment meeting a program specified level.					
Retrofit	Definition: A program that upgrades or enhances existing equipment.					
	Baseline = Existing equipment or the existing condition of the building or equipment. A single baseline applies over the measure's life.					
	Efficient Case = Either new, high efficiency equipment or modifications of existing equipment to make it operate more efficiently.					
Early Retirement	Definition: A program that retires duplicative equipment before its expected life is over.					
	Baseline = The existing equipment, which is retired and not replaced.					
	Efficient Case = Since the unit is retired, the efficient case consumption will be zero.					

# 1.3 Program Delivery / Implementation Type Definitions

Presented below are descriptions of common methodologies that are used by programs to implement measures, delivering the energy saving technology(s) or practice(s) to their customers:

- Upstream: Providing incentives to manufacturers to lower the cost to the consumer of an efficient option or to invest in R&D or production of more efficient options at the start of a supply channel or to pass along the discount to distributors or retailers to decrease their costs and increase adoption and stocking.
- Midstream: Providing incentives to distributors or retailers to encourage the stocking and marketing of the efficient options and/or lower the cost to the consumer.

- · Downstream: Providing incentives directly to the end user or consumer through coupons or rebates.
- Direct Install: A program where measures are installed during a site visit by a staff member or contractor.
- Free product: Product is provided to customers free of charge. This could be during a promotional event, left with customers after a site visit or through the mail.
- Efficiency Kits: A selection of low cost energy saving products are provided to customers for free or a low charge. Often kits are required to be requested to increase likelihood of installation.
- Home Energy Reports: Electricity bill inserts that provide information on a residences relative consumption compared to similar homes in the local area to encourage behavioral change and/or efficient measure purchases.

# 1.4 Interactive effects

In some characterizations, the savings algorithm(s) include factors to estimate the impacts of interactions of the measures with other end uses, for example, cooling and heating effects from interior lighting waste heat. The TRM does not, however, provide a methodology for accounting for interactions between measures installed concurrently.

In custom projects, Efficiency Vermont Energy Consultants perform site-specific customized calculations to account for interactions between measures (e.g., individual savings from installation of window film and replacement of a chiller are not additive because the first measure reduces the cooling load met by the second measure). If a project includes both prescriptive and custom measures, the prescriptive measures will be calculated in the normal manner and assumed to be installed prior to determining the impacts of the custom measures. To determine interacting custom measure savings, Energy Consultants calculate measure impacts in descending order of measure life (i.e., starting with the longest lived measure), assuming each prior measure is installed before calculation of the savings from the next.

# 1.5 Heating and Cooling Degree-Day Data

Where a characterization's variable assumptions are sensitive to outdoor temperatures, heating and cooling degree days (HCDDs) are often used to calculate site or region specific assumptions. HCDDs are calculated using TMY3 data from the Department of Energy National Oceanic and Atmospheric Administration (NOAA).

# **1.6 Inflation and Discount Rates**

The Vermont screening tool calculates the *Net Present Value (NPV)* of an efficiency measure by comparing the initial measure cost and any future cost impacts with the present value of the energy savings over the lifetime of the measure. The following financial assumptions are used in the calculation of present value:

## 1.6.1 Real Discount Rate

The value of all future costs or savings are discounted to the *Program Year* using the Real Discount Rate (RDR) of 3.0%. This rate is currently affirmed in a 2015 Public Service Board ruling EEU-2015-04 "Order RE: EEU Avoided Costs for 2016-2017 Time Period".

## 1.6.2 Future Inflation Rate

The projected future inflation rate, used for adjusting measure costs, Operation and Maintenance costs, and deferred baseline replacement costs from the Program Year to the *Base Year* (defined as the first year of the current three year performance period). Current value is 2.0% based upon rates used in AESC 2015 Update: "10 year treasury note - Composite of CBO for 2017 thru 2026 and AEO 2016 for 2017 thru 2031".

## 1.6.3 Inflation Rate to Base Year

This is only used to adjust future avoided costs to the Base Year. It is based on the escalation rates used to determine the Avoided costs from the 2015 Association of Energy Service Companies (AESC) report and is currently 1.51%.

# **1.7 Stipulated Database Adjustments**

# 1.7.1 RES / C&I Split for EP Retail Lighting

For upstream lighting programs delivered through Efficient Products, a specified percentage of purchases are assumed to be Residential and the remainder are assumed to be Commercial, with the relevant characterization assumptions applied to each portion. The current split is set at 89.5% Residential and 10.5% Commercial, as determined through a TAG agreement.

## 1.7.2 Upstream/Midstream Reconciliation

To avoid double counting of savings where measures are supported both Upstream (incentive provided to suppliers of equipment) and by a Midstream (retailers) or downstream (end-user) incentives, reconciliation procedures are in place to deduct any duplication of savings. These procedures are documented in the Efficiency Vermont Business Process Manual section of the Vine here.

# **Glossary of Terms**

Active Date: The date from which a particular measure characterization is active and the assumptions documented are applied to new installations.

**Avoided Costs:** The forecasted marginal cost of generation of electric or fossil energy that an energy efficiency measure will save over its lifetime.

**Base Year:** The first year of the current three year Efficiency Vermont performance period. The value of all costs and savings are discounted to represent this base year's dollars.

**Characterizations:** Documentation of all the necessary cost-effectiveness screening assumptions for a particular measure or group of similar measures.

**Coincidence Factors:** Coincidence factors represent the fraction of connected load expected to be coincident with a particular system peak period, on a diversified basis. Coincidence factors are provided for summer and winter peak periods.

**Custom:** A project or measure that requires multiple site specific inputs to complex modeling analyses, or requires pre and post metering to quantify the savings associated with it.

**Environmental Externalities:** The prescribing of an economic value to the environmental impact of the production (or saving) of energy.

**Expected Remaining Life:** The assumed remaining life of existing equipment that is being replaced for efficiency reasons prior to the end of its natural life.

**Forward Capacity Market (FCM):** A market based auction where bidders commit to the supply of (or savings of) future capacity in exchange for a market-priced payment.

Freeridership Factor: The fraction of gross program savings that would have occurred without the programs involvement.

**Gross Savings:** The estimated impact of an efficiency measure at the customer's meter(s). When multiplied by the customer's energy rates the impact on their energy bills is determined.

**Item Code:** An alpha-numeric codes, up to 16 characters in length, which identifies a specific prescriptive measure, market, implementation method and/or specification.

Line Loss Factors (LLF): The marginal electricity losses from the generator to the customer – expressed as a percent of meter-level savings. The Energy Line Loss Factors vary by period. The Peak Line Loss Factors reflect losses at the time of system peak, and are shown for the two seasons of the year (Summer and Winter). Line loss factors are the same for all measures.

**Low Income Adder:** Adjustment to account for the greater benefits resulting from energy savings in low-income sectors because the energy bill-to-income ratio is higher relative to other sectors and because non-energy benefits for comfort, health, and safety appear to be greater in that sector as well.

**Measure Code:** An eight-character alpha-numeric code used to identify a general measure technology and sharing the same Net to Gross Factors (Freerider and Spillover rates) within each program Track.

**Net Present Value (NPV):** The delta between the value of all costs and savings over the lifetime of an efficiency measure in the base year dollars.

**Net Savings:** The estimated impact of an efficiency measure at generation that can be attributed to the efficiency program. Calculated by incorporating the line loss factors and freeridership and spillover rates.

**Non-Energy Benefit/Impacts (NEB/NEI):** Additional outcomes of energy efficiency activities relating to participant, utility or societal impacts such as comfort, health, durability, productivity, property values etc. Note that Operation and Maintenance and water impacts are calculated separately and not included in any NEB adder.

**Persistence:** Adjustments used when appropriate to reduce lifetime savings in recognition that the measure may not provide the calculated annual savings for the entire rated engineering life of the unit.

**Prescriptive:** An efficiency measure that is considered appropriate to assume consistent prescribed savings for each specified application, rather than perform a custom calculation for each installation.

**Program Year:** The year in which an efficiency measure was reported. Efficiency Vermont program years run on a calendar year basis.

**Reliability Review:** An annual review process for characterizations that have not had a recent update to ensure ongoing validity, consistency and to update with new evaluation results.

### Glossary of Terms

**Retroactive:** Application of a change to an existing characterization to measures already installed and claimed in a program year.

**Societal Cost Test (SCT):** The principal cost effectiveness test utilized by Efficiency Vermont to evaluate the value of an efficiency measure. The net benefit to society of the activities is based upon lifetime benefits (i.e. the societal avoided costs of energy savings, including externalities (environmental benefits) and other non-energy benefits over the life of a measure) minus lifetime costs (including measure cost, O&M costs (or benefits), risk discount (to account for risks associated with investments in supply-side resources that are avoided by investing in demand side management), and avoided replacement costs).

Spillover Factor: Savings attributable to the program, but generated by customers not directly participating.

**Total Resource Benefits:** The total present value of the electric energy savings (or increase), electric coincident peak demand reduction (or increase), fuel savings (or increase), and water use savings (or increase) over the lifetime of the measure. Note that TRB is *not* affected by any of the following: environmental externalities, non-energy benefits and low income adders, operations and maintenance costs, measure costs, or increase.

Track: Classification and division of Reporting Categories into subgroups of similar implementation methods.

Measure Number Portfolio:	: IV-G-2 b 89							
Status:	Active							
Effective Date:	2016/1/1							
End Date: Program:	2021/12/31 Efficient Produ							
End Use:	Electronics	JCIS PIOGIAI						
Update Sum Update to ENERGY		5 specificatio	ons.					
Referenced	Document							
ENERGY STAR     ECOVA_Display				Analysis 8-14-14				
Michigan Electr	ric and Natural	Gas Energy	Efficiency	Potential Study, 2	013			
Description With rapid advance	ments in LCD (	Liquid Cryst	al Display)	technology, ICD	monitors are o	wickly replacing of	Ider CRT technologies	s in both residential and
commercial applica	tions. This pro %, 15%, 20%, 3	gram will p 30%, or 409	rovide an % in place	incentive with the of one of a monit	purchase of a or meeting an	LCD monitor that d not exceeding E	meets or exceeds the	e Energy Star Version 6.0 0. The monitors will be
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Residential (ΔkW)	Efficiency Level					
	ESv6 + 10%	ESv6 + 15%	ESv6 + 20%			
17≤d<23	0.004	0.004	0.004			
23≤d<25	0.004	0.006	0.006			
25≤d<61	0.005	0.006	0.008			

	Commercia	I	ESv6 +	10%	ESv6		ES\ 209	r6 + %	ESv6 + 30%	
								l		
d<61		0.00	5	0.006		0.008				
d<25		0.00	4	0.006		0.006				

(ΔkWh)	ESV0 + 10%	15%	20%	30%
17≤d<23	7.4	10.6	10.4	15.7
23≤d<25	14.3	14.5	14.8	21.7
25≤d<61	21.4	21.4	21.4	45.6

Residential (ΔkWh)	ESv6 + 10%	ESv6 + 15%	ESv6 + 20%
17≤d<23	7.3	7.6	6.9
23≤d<25	7.2	9.7	9.9
25≤d<61	8.4	10.9	13.7

Baseline Efficie Baseline is a monitor me									
	ncies eeting the minimum and not exc	eeding th	e Energy S	itar 6.0 crit	eria.				
High Efficiency High efficiency is an LCD	Monitor exceeding the Energy S	5tar 6.0 r	equiremen	ıts by 10%,	15%, 20%	, or 30%.[*	0		
Operating Hour	'S cording to usage patterns for bo	th reside	ntial and o	ommercial	LCD monito	ors.			
.,,,,,,									
Load Shapes									
	om 80 Plus computer program <								
	n <i>Work Paper: High Efficiency L</i> oly, Commercial Desktop	.CD Comp	uter Monit	tor Progran	1 For the M	ass Market	Channel	р. З	
75a Internal Power Supp									
Number	Name	Status	Winter On kWh	Winter Off kWh	Summer On kWh	Summer Off kWh	Winter kW	Summer kW	,
74 Internal Pow	er Supply, Commercial Desktop	Active	39.2%	27.5%	19.6%	13.7%	50.0%	80.0%	
75 Internal Pow	er Supply, Residential Desktop	Active	33.8%	32.9%	16.9%	16.4%	52.2%	40.5%	
Net Savings Fa	ctors								
let to Gross values belo									
Measures									
EQPMONTR Efficient C	omputer Monitor								
racks [Base Track]									
6032EPEP [is base track	k] Efficient Products - Resident	ial							
Track Name	Track Nr. Measure Coo	ie Free F	tider Spill	Over					
fficient Products - Resi	dential 6032EPEP EQPMONTR	0.70	1.00						
Persistence									
The persistence factor is	assumed to be one.								
ifetimes									
leasure life is based on	an estimated monitor life of 4	/ears. [6]							
Measure Cost The incremental cost for	the Ultra Efficient LCD Monitor	is \$2.60	1						
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	stments								
¢0									
\$0									
50 Fossil Fuel Desc	ription								
Fossil Fuel Desc Reference Tabl	ription	Table, P	νοι_max						
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50 Fossil Fuel Desc Reference Tabl Energy Star 6.0 Displa Screen Size	cription es ay Maximum On Mode Power Displays with Dp ≤20	),000 pix	els/in²	pixels/in		20,000			
Computer Monitors	cription es y Maximum On Mode Power Displays with Dp 520 y, Signage Displays, and Digit	),000 pix	els/in²	pixels/in	2		0		
io Fossil Fuel Desc Reference Tabl inergy Star 6.0 Displa Screen Size	cription es ay Maximum On Mode Power Displays with Dp ≤20	),000 pix	els/in²	pixels/in (6.0xr1)+		(0.05xA)+3			
60 Fossil Fuel Desc Reference Tabl Anergy Star 6.0 Disple Screen Size Computer Monitors d<12.0	cription es y Maximum On Mode Power Displays with Dp 526 (5.007)+(0.0504)+3.0 (6.007)+(0.0504)+3.0 (5.07	),000 pix	els/in²	pixels/in (6.0xr1)+ (6.0xr1)+	2 (3.0xr2 )+(	(0.05xA)+3 (0.01xA)+5	.5		
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O           Fossil Fuel Desc           Reference Table           mergy Star 6.0 Disple           Screen Size           Computer Monitors           d<12.0	Displays with Dp 520           (6.0xr)+(0.05xb)+3.0           (6.0xr)+(0.05xb)+3.3           (6.0xr)+(0.05xb)+3.5           (6.0xr)+(0.05xb)+3.5           (6.0xr)+(0.05xb)+3.4           (6.0xr)+(0.05xb)+3.4           (6.0xr)+(0.05xb)+3.4	),000 pix	els/in²	pixels/in (6.0xr1)+ (6.0xr1)+ (6.0xr1)+ (6.0xr1)+	2 -(3.0xr2 )+( -(3.0xr2 )+( -(3.0xr2 )+(	(0.05xA)+3 (0.01xA)+5 (0.025xA)+ (0.06xA)-4.	.5 3.7 0		
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Screen Size           Computer Monitors           d<12.0	Estimation           est           bisplays with Dp 520           bisplays with Dp 520           (6.0xr)+(0.05xk)+3.0           (6.0xr)+(0.05xk)+3.0           (6.0xr)+(0.05xk)+3.7           (6.0xr)+(0.025xk)+3.7           (6.0xr)+(0.025xk)+3.7           (6.0xr)+(0.025xk)+3.7           (6.0xr)+(0.025xk)+3.7           (6.0xr)+(0.025xk)+3.7           (6.0xr)+(0.025xk)+3.7           (6.0xr)+(0.1xk)+3.5           (6.0xr)+(0.1xk)+3.7           (0.0xr)+(0.1xk)+3.7           (0.0xr)+(0.1xk)+3.5           (0.0xr)+(0.1xk)+3.5           (0.0xr)+(0.1xk)+3.5           (0.0xr)+(0.1xk)+3.5	0,000 pix	els/in²	pixels/in (6.0x1)+ (6.0x1)+ (6.0x1)+ (6.0x1)+ (6.0x1)+ (0.27xA)+	2 -(3.0xr2)+( -(3.0xr2)+( -(3.0xr2)+( -(3.0xr2)+( -(3.0xr2)+(	(0.05xA)+3 (0.01xA)+5 (0.025xA)+ (0.06xA)-4. (0.1xA)-14.	.5 3.7 0		

Category	Energy Star 6.0
Standby (Off Mode)	≤ .5 W
Sleep Mode	≤ .5 W
Active State	
< 27 inches	0.30*P <sub>ON_MAX</sub>
≥ 27 inches	0.75*Pon_max

### Incentive Level

Footnotes

- [1] Ecova, Displays Program Potential Energy Savings Analysis, 2014. ECOVA\_Displays Program Potential Energy Savings Analysis 8-14-14.docx
- [2] Page 137, Table 5-20. Navigant Consulting, Inc. (2009). Energy Savings Potential and RDBD Opportunities for Commercial Building Appliances. Prepared for U.S. Department of Energy, Energy Efficiency and Renewable Energy Building Technologies Program.
- [3] Page 55, Table 3-34. Urban, Bryan, Verena Tiefenbeck, and Kurt Roth (2014). Energy Consumption of Consumer Electronics in U.S. Homes in 2013. Prepared for the Consumer Electronics Association by Fraunhofer Center for Sustainable Energy Systems.
- [4] ENERGY STAR Program Requirements for Displays (Version 6.0)
- [5] Work Paper: High Efficiency LCD Computer Monitor Program For the Mass Market Channel, p. 3
- [6] Michigan Electric and Natural Gas Energy Efficiency Potential Study, 2013, Page 298: http://www.dleg.state.mi.us/mpsc/electric/workgroups/mi\_ee\_potential\_studyw\_appendices.pdf
- [7] Page 52, Electronic Displays, Codes and Standards Enhancement (CASE) Initiative for PY 2013: Title 20 Standards Development. March 8, 2013.

### **Controlled Power Strip**

Measure Numbe	TIV-G-4 c
Portfolio:	EVT TRM Portfolio 2018-03
Status:	Active
Effective Date:	2018/1/1
End Date:	[ None ]
Program:	Efficient Products Program
End Use:	Electronics

Update Summary Update to add assumptions for market opportunity and for free giveaways to customers who request power strips.

## Referenced Documents

- Nette lance: Loadshape\_smart\_rev8 Loadshape\_smart\_rev8 States and the state of the states of the

Description This measure describes savings associated with Tier I Advanced Power Strips. These multi-plug power strips have the ability to automatically disconnece specific connected loads depending upon the power draw of a control load, also plugged into the strip. Power is disconnected from the switched (controlled) outlets when the control load power draw is reduced below a certain adjustable threshold, thus turning off the appliances plugged into the switched outlets. By disconnecting, the shardhy load of the controlled devices, the overall load of a centralized group of equipment (i.e. entertainment centers and home office) can be reduced.

This measure applies to the following implementation methods:

- Oriect installation of power strips in residential buildings or in college dorms
   Retail sales
   Free giveways to customers who request power strips

# Algorithms Electric Demand Savings

ectric Demand Savings		
∆kW <sub>DI_Entertainment</sub> Center	$= \Delta kWh_{D1\_Entertainment\ Center}\ /\ Hours_{Residential}$	
ΔkW <sub>DI_Office</sub>	$= \Delta kWh_{DI\_Office} / Hours_{Residential}$	
∆kW <sub>DI_College</sub>	= $\Delta kWh_{DI\_College}$ / HOUrS <sub>College</sub>	
ΔkW <sub>MOP</sub>	= $\Delta kWh_{MOP}$ / Hours <sub>Residential</sub>	
ΔkW <sub>Free Giveaway</sub>	$= \Delta kWh_{Free Givenway} \ / \ Hours_{Residential}$	
ymbol Table		
ectric Energy Savings		
∆kWh <sub>DI_Entertainment</sub> Center	= SaveElecEntertainment Center X ISR	
ΔkWh <sub>DI_Office</sub>	= SaveElec <sub>Office</sub> x ISR	
ΔkWh <sub>DI_College</sub>	= SaveElec <sub>College</sub> x ISR	
∆kWh <sub>MOP</sub>	= ((SaveElecEntertainment Center x %Entertainment Center) + (SaveElecOffice	x %Office)) x ISF

Wh

here	:		
	%Entertainment Center	-	Relative penetration of use with home entertainment systems $= 5996^{[3]} \label{eq:system}$
	%Office	1	Relative penetration of use in home offices $= 4196^{[3]} \label{eq:second}$
	$\Delta kW_{D1\_College}$	-	Gross customer connected load kW savings for direct installation of power strips in college dorms (kW) See Reference Tables section for deemed savings values
	$\label{eq:linear} \begin{array}{l} \Delta kW_{D1\_Entertainment} \\ \text{Center} \end{array}$	1	Gross customer connected load KW savings for direct installation of power strips in entertainment centers in residential buildings (KW) See Reference Tables section for deemed savings values
	$\Delta kW_{D1_Office}$	-	Gross customer connected load kW savings for direct installation of power strips in home offices (kW) See Reference Tables section for deemed savings values
	∆kWFree Giveaway	1	Gross customer connected load kW savings for free giveaways (kW) See Reference Tables section for deemed savings values
	ΔkW <sub>MOP</sub>	-	Gross customer connected load KW savings for market opportunity (KW) See Reference Tables section for deemed savings values
	$\Delta kWh_{D1\_College}$	-	Gross customer annual kWh savings for direct installation of power strips in college dorms (kWh) See Reference Tables section for deemed savings values
	$\Delta kWh_{D1\_Entertainment}$ Center	-	Gross customer annual KWh savings for direct installation of power strips in entertainment centers in residential buildings (KWh) See Reference Tables section for deemed savings values
	$\Delta kWh_{D1\_Office}$	-	Gross customer annual kWh savings for direct installation of power strips in entertainment centers in home offices (kWh) See Reference Tables section for deemed savings values
	$\Delta kWh_{Free \; Giveaway}$	-	Gross customer annual kWh savings for free giveaways (kWh) See Reference Tables section for deemed savings values
	ΔkWh <sub>MOP</sub>	-	Gross customer annual kWh savings for market opportunity (kWh)

	See Re	eference Tables	ection for d	eemed sav	ings values				
HoursCollege	= Averag = 4,95	ge hours of use p 3 <sup>[1]</sup>	er year in a	college in e	efficient (co	ontrolled of	f) mode		
HOUrSResidential	= Averag = 8,04	ge hours of use p (2)	er year in a	residential	application	i in efficien	t (controll	ed off) mode	2
ISR	ISR = In service rate, or the percentage of units rebated that are actually installed = 100% for direct install and market opportunity and 63% for free giveaways <sup>(4)</sup>								
SaveElec <sub>College</sub>	= Annua	l electric energy :							
SaveElecEntertainment	= 54.8 = Annua		avings (kW	h) for enter	tainment c	enter use			
Center SaveElec <sub>Office</sub>	= 75.1 = Annua	(6) I electric energy :	avings (kW	h)for office	use				
	= 31.0	(6)							
Baseline Efficienci The assumed baseline is a st		w shin link daas	nak control	omu of the s	connected I	an da			
The assumed baseline is a si	anuaru powe	er surp unac does		any or the t	.onnected i	udus.			
High Efficiency The efficient case is the use	of an advanc	ed power strip.							
Load Shapes									
See Loadshape_smart_revB. 96a Standby Losses - Enterta 97a Standby Losses - Home	ainment Cent	2r							
	kame	Statu	Winter S On kWh	Winter Off kWh	Summer On kWh	Summer Off kWh	Winter kW	Summer kW	
96 Standby Losses - 97 Standby Losses -		nt Center Active	32.0% 29.0%	35.0%	16.0%	17.0%	72.5%		
57 541407 25525	nome onice	Active	23.070	50.070	11070	19.070	20.070	70.570	
Net Savings Facto	rs								
Measures									
EQPPWRHO Residential Off									
EQPPWREC Residential En									
EQPPWCEC College Entert	ainment Cont	rolled Power Stri	p						
Tracks [Base Track]									
6032EPEP [is base track]	Efficient Produ	ucts - Residential							
6034LISF [is base track] [ 6036RETR [is base track] F									
Track Name Efficient Products - Resident		Measure Code	Free Rider 1.00	Spill Over 1.00					
Efficient Products - Resident			1.00	1.00					
LISF Retrofit			1.00	1.00					
LISF Retrofit Res Retrofit			1.00 1.00	1.00 1.00					
Res Retrofit				1.00					
Efficient Products - Resident	ial 6032EPEP	EQPPWCEC	1.00	1.00					
LISF Retrofit	6034LISF	EQPPWCEC		1.00					
Res Retrofit	OUSORETR	EQPPWCEC	1.00	1.00					
Persistence The persistence factor is ass	umod to bo 1								
The persistence factor is ass	umed to be j								
Lifetimes The expected lifetime of the	measure is 5	years <sup>[7]</sup> .							
Measure Cost									
The installation cost of the m									
Measure costs are presented	i below, depe	ending on program	n type.						
Program Type Mea	sure Cost								
Direct Install \$23.2	75[9]								
MOP \$21.4	48[8]	1							
Free Giveaway \$13.3	75[10]								
O&M Cost Adjustm	ients								
There are no operation and		cost adjustments	for this me	asure.					
Fossil Fuel Descrip		a dhualac e a sa							
There are no fossil-fuel algo	norms or def	auit values for thi	s measure.						
Reference Tables									
Savings are presented below	, depending	on program type	[5]						

Program Type	ΔkW	ΔkWh
Direct Install: Entertainment Center	0.00933	75.1
Direct Install: Office	0.00385	31.0
Direct Install: College Dorm	0.01106	54.8
MOP	0.00708	57.0
Free Giveaway	0.00446	35.9

#### Footnotes

- Refer to APS in Dorms tab of analysis document: EVT\_Controlled Power Strip\_Analysis\_Feb 2018.xisx. Annual hours for college applications are calculated assuming a 32 week school year and results in 4,953 hours a year.
- [2] Derived from CalPlug Tier 2 APS Evaluation Study Retrieved from: http://embertec.com/assets/pdf/CalPlug\_Tier2\_APS\_Evaluation.pdf. Advanced Power Strips are assumed to be plugged in at all times. Annual hours when the equipment is turned off are 7,340. The equipment is estimated to be in standay mode 1.9 Hours/day or 708 hours/year. Savings are achieved during periods when equipment is off or in standay mode. Thus, the hours of operation used to determine demand savings are 7,340 + 708 = 8,048. No savings are achieved during the remaining 712 hours per year when equipment is in use.
- [3] Relative weightings of home office and entertainment systems is based on Cadmus Group & Navigant, "EmPower Maryland Final Evaluation Report Evaluation Year 4; Residential Retrofit Programs," June 23, 2014, p. 91.
- [4] Advanced power strip ISR is average of ISRs from Cadmus, "Process Evaluation Report, PPL Electric EE&C Plan, Program Year Five," November 13, 2014, p. 147.
- [5] Analysis of energy savings from VEIC study at the University of Vermont. APS in Dorms: A New Application for Savings?, Vermont Energy Investment Corporation, 2014. Refer to analysis on APS in Dorms tab on EVT\_Controlled Power Strip, Analysis\_Feb 2018.xtsx.
- Advanced Power Strips Deemed Savings Methodology, Northeast Energy Efficiency Partnerships (NEEP), January 2012. Refer to Report, NEEP-APS-Deemed Savings-Report-4-30-12.pdf.
- [7] 10-year estimate: Lockheed Martin, Inc., Energy Solutions, Advanced Power Strip Research Report Final Report, Prepared for the New York State Energy Research and Development Authority (INSERDA), 2011. As persistence has not been studied for this measure, 5 years is being used as a conservative estimate.
- [8] Average of 5-plug and 7-plug incremental cost differences between a power strip and an advanced power strip, NYSERDA Advanced Power Strips Report, Page 4.
- [9] Full installation cost for direct install based on actual program cost of \$13.75 for an advanced power strip and labor estimated at 1/2 hour at \$20/hour.

[10] Cost of an advanced power strip for free giveaways from actual program data.

### **ENERGY STAR Computers**

Measure Number:	IV-G-5 b
Portfolio:	EVT TRM Portfolio 2019-07
Status:	Active
Effective Date:	2019/1/1
End Date:	[ None ]
Program:	Efficient Products Program
End Use:	Electronics

Update Summary Updated disktips computer to incorporate ENERGY STAR v7.0 specifications. Added notebook and thin clients as device options in addition to the existing disktips computer offerings.

Changed the name of the measure from Desktop Computers to ENERGY STAR Computers. Created a new measure code and included new net savings factors.

- Referenced Documents Research Into Action, NEEA 80 PLUS Market Progress Evaluation, Nov 2013 C ADUS, Computers CoSE Institute PY2013, Aug 2013 California IDUS, Supplemental CASE Technical Report Computers\_lan 2014 80 PLUS Deaktop Savings, 2SAug2014, Revised Elsv7 ENERGY\_STAR, Certified, Computers, V7, Dee 2018 DERROY, STAR, Office Equipment Calculator ENERGY, STAR Office Equipment Calculator EVT\_Computers, Analysis, Nay 2019

#### Description

Uescription This measure is for ENERGY STAR rated desktop computers and select portable computers such as notebooks and thin clients. Energy savings for these devices are characterized for both commercial and residential applications. The applicable ENERGY STAR specification is version 7.0, which was made effective on November 16, 2018.

In addition to notebook and thin clients, this measure includes desktop computers with Energy Star Version 7.0 rating, ES 7.0 +20%, ES 7.0 with 80 PLUS Platinum PSUs, and ES 7.0 with 80 PLUS Titanium PSUs.

#### Program Type

Market Opportu

## Program Delivery / Implementation Type

## **Baseline Efficiencies**

Baseline Ethiciencies The baseline measure is a desktop, notebook, or thin client with no Energy Star rating. The baseline wattage draw for each device at the four primary modes of operation are detailed in the table below. The total energy consumption is based on the algorithm and primary mode of operation loadshape which is shown in more detail further on in the characterization.

### Baseline Operating Parameters<sup>[1]</sup>

Measure Watt Draw in Mode (Watts)	Off	Sleep	Long Idle	Short Idle	Total Energy Consumption	
Desktop Baseline	0.88	2.10	26.50	27.90	83.28	124.75
Notebook Baseline	0.53	1.20	5.75	11.03	11.14	38.88
Thin Client Baseline	1.12	8.71	8.71	10.55	25.20	52.00

## Efficient Equipment

The efficient requipments The efficient request is a dealkoy, notebook, or thin client with an ENERGY STAR v7.0 rating. Additional derivations of dealkop computers are included, depending on their increased efficiencies over ENERGY STAR v7.0 rating (ES 7.0 +20%) or a pairing with a high efficiency 80 PLUS PSU (ES 7.0 with 80 PLUS Elations PSU (ES 5.0 with 80 PLUS Thanium PSU).

#### Efficient Operating Parameters

Measure Watt Draw in Mode (Watts)	Off			Short Idle
ES 7.0 Desktops <sup>[2]</sup>	0.69	1.49	16.70	18.15
ES 7.0 +20% Desktops <sup>[3]</sup>	0.70	1.46	16.30	17.77
ES 7.0 Desktops w/ 80 PLUS Platinum PSUs <sup>[4]</sup>	0.50	1.50	15.53	16.88
ES 7.0 Desktops w/ 80 PLUS Titanium PSUs <sup>[5]</sup>	0.50	1.50	15.18	16.50
ES 7.0 Notebook <sup>[6]</sup>	0.31	0.70	3.33	6.39
ES 7.0 Thin Client <sup>(6)</sup>	0.71	5.53	5.53	6.70

Algorithms Electric Demand Savings  $\Delta kW$  = (Watts<sub>Base,Long</sub> - Watts<sub>Eff,Long</sub>)/1000

Symbol Table

## Water Savings

Electric Energy Savings

∆kWh

= 8760/1000 × (((Watts<sub>Base,OH</sub> × %Time <sub>OH</sub>) + (Watts<sub>Base,Skep</sub> × %Time <sub>Skep</sub>) + (Watts<sub>Base,Long</sub> × %Time <sub>Long</sub>) + (Watts<sub>Base,Skep</sub> × %Time <sub>Skep</sub>) + (Watts<sub>Base,Long</sub> × %Time <sub>Long</sub>) + (Watts<sub>EH,Long</sub> × %Time <sub>Skep</sub>) + (Watts<sub>EH,Long</sub> ×

#### Symbol Table

Fossil Fuel Savings

nere:	
%Time Long	= typical percent time in long idle mode
%Time <sub>Off</sub>	= typical percent of time a desktop, integrated desktop or notebook is in off mode during the year
%Time Short	= typical percent time in short idle mode
%Time Sleep	= typical percent time in sleep mode
ΔkW	= gross customer connected load kW savings for the measure (kW)
ΔkWh	= gross customer annual kWh savings for the measure (kWh) <sup>[7]</sup>
Watts Eff,Off	= power in off mode
Watts Base, Long	= power in long idle mode

Watts Base, Sleep	-	power in sleep mode	
Watts Eff,Long	-	power in long idle mode	
Watts Eff,Short	-	power in short idle mode	
Watts Eff,Sleep	-	power in sleep mode	
Watts <sub>Base,Long</sub>	-	power in long idle mode	
Watts <sub>Base,Off</sub>	-	power in off mode	
Watts <sub>Base,Short</sub>	-	power in short idle mode	
Watts <sub>Eff,Long</sub>	-	power in long idle mode	

#### Deemed Energy and Demand Savings

Measure	Item Code		Energy Savi	ings (kWh)	Demand Savings (kW)		
ricasure	Residential	Commercial	Residential	Commercial	Residential	Commercial	
ES 7.0 Desktops	EPRESPCA	EPCOMPCA	29.4	43.8	0.0098	0.0098	
ES 7.0 +20% Desktops	EPRESPCB	EPCOMPCB	30.6	45.5	0.0102	0.0102	
ES 7.0 Desktops w/ 80 PLUS Platinum PSUs	EPRESPCC	EPCOMPCC	33.5	50.0	0.0110	0.0110	
ES 7.0 Desktops w/ 80 PLUS Titanium PSUs	EPRESPCD	EPCOMPCD	34.5	51.6	0.0113	0.0113	
ES 7.0 Notebook	EPRESNOTE	EPCOMNOTE	4.7	16.4	0.0024	0.0024	
ES 7.0 Thin Client	EPRESTHIN	EPCOMTHIN	9.2	19.0	0.0032	0.0032	

### Operating Hours

Measure Annual Mode Time (%)	Off	Sleep	Long Idle	Short Idle
Duty Cycle - Commercial Desktop and Thin Client <sup>[8]</sup>	45%	5%	15%	35%
Duty Cycle - Commercial Notebook <sup>[8]</sup>	25%	35%	10%	30%
Duty Cycle - Residential Desktop <sup>(9)</sup>	44%	24%	22%	10%
Duty Cycle - Residential Notebook and Thin Client <sup>[10]</sup>	78%	15%	2%	5%

### Mid-Life Savings Adjustment

#### Load Shapes

/4a internal Power Supply, Commercial Desktop 75a Internal Power Supply, Residential Desktop								
Number	Name	Status			Summer On kWh			Summer kW
74	Internal Power Supply, Commercial Desktop	Active	39.2%	27.5%	19.6%	13.7%	50.0%	80.0%
75	Internal Power Supply, Residential Desktop	Active	33.8%	32.9%	16.9%	16.4%	52.2%	40.5%

### **Net Savings Factors**

Measures EQPESCOM Energy Star Computers

Tracks [Base Track] 6032EPEP [is base track] Efficient Products - Residential

 Track Name
 Track Nr. Measure Code
 Free Rider Spill Over

 Efficient Products - Residential 6032EPEP EQPESCOM
 0.60
 1.00

# Lifetimes The expected lifetime of the measure is 4 years.<sup>[11]</sup>

#### Measure Cost The incremental cost for a Thin Client is \$1.

The incremental cost for a Notebook and 80 Plus Desktop PSU is \$5. The incremental cost for a Energy Star desktop PSU is \$20.[12]

### O&M Cost Adjustments

### Reference Tables

#### Footnotes

- FOOTDOTES
  [1] The disktop computer baseline power levels at the varying primary modes of operation (off, sleep, short idle, and long idle) are sourced from,
  "Computers: Technical Report Supplemental Analysis and Test Results, Supplemental to CASE Report submitted on August 6, 2013," California
  Energy Commission, January 2014 (page 30, table 14). The notebook and thin clinter baseline wattage draws are sourced as a straight average of
  non-qualifying products for Tier 11 and Tier 2, as detailed in the "Computers: Codes and Standards Enhancement (CASE) Initiative for PADDI3: Title 20
  Standards Development, Analysis of Standards Proposal for Computers", California Energy Commission, August 2013 (page 6). As the source
  material detailed the total baseline energy comsimption for notebook and thin clinte, in or dure to determine the power levels at the different modes
  of operation, the devices annual mode time was leveraged and the power levels backed out.
- [2] Analysis of current DT I2 category desktops in the ENERGY STAR version 7.0 Qualified Products List (QPL) as accessed on 12/03/2018 (see, "ENERGY\_STAR\_Certified\_Computers\_v7.0\_17Dec2018.xlsx")
- [3] Analysis of current DT I2 category desktops in ENERGY STAR version 7.0 QPL, passing with > 20% margin, as accessed on 12/03/2018 (s "ENERGY\_STAR\_Certified\_Computers\_v7.0\_17Dec2018.v/sv")
- [4] 80 PLUS program savings calculator, additional 7% reduction in idle power levels over ENERGY STAR version 7.0 computers with 80 PLUS Silver PSU levels. The program calculator was used to establish relative and comparable savings, and as a result, absolute idle power values do not match. For more details on the derivation of the 7% savings factor, please see, "80 PLUS Desktop Savings\_ZSAug2014\_Revised ESv7.xisc", 'Analysis Summary tab
- [5] 80 PLUS program savings calculator, additional 9.1% reduction in idle power levels over ENERGY STAR version 7.0 computers with 80 PLUS Silver PSU levels. The program calculator was used to establish relative and comparable savings, and as a result, absolute idle power values do not match. For more details on the derivation of the 9.1% savings factor, please see, "80 PLUS Desktop Savings, 25Aug2014\_Revised ESVZ-vis/", Analysis Summary tab
- [6] Analysis of all applicable categories for notebooks and thin clients in the ENERGY STAR version 7.0 QPL, as accessed on 02/05/2019 (see "EVT\_Computers, Analysis, May 2019.xlsx")
- [7] Algorithm is originally sourced from the "Energy Star Program Requirements, Product Specification for Computers, Eligibility Criteria Version 7.0", effective November 16, 2018 (page 15, Equation 4: Calculation for Workstations) and further corroborated by the EVERGY STAR Office Equipment Calculator, which is included as a reference to this measure characterization.

- [8] The commercial duty cycle for devices is sourced from the ENERGY STAR Program Requirements, Product Specification for Computers, Eligibility Criteria Version 7.0, effective November 16, 2018 (page 12; tables 4-5: mode weightings)
- [9] "Energy Consumption of Consumer Electronics in U.S Homes in 2013", Fraunhofer, June 2014, (page 30, table 3-13)
- [10] The residential duty cycle for notebook and thin clients are sourced from the ENERGY STAR Office Equipment Calculator, Labtops. The assumptions were made that ENERGY STAR labtop operation mirrors that of notebooks and thin clients as they all fall under the portable labtop device category. Additionally, as idle time was not included, assumed a similar distribution from ENERGY STAR specifications for commercial products.
- [11] "Computers: Codes and Standards Enhancement (CASE) Initative for P/2013: Title 20 Standards Development, Analysis of Standards Proposal for Computers", California Energy Commission, August 2013 (page 6)
- [12] The 80 PLLS Desktop PSU and BRERGY STAR Desktop PSU incremental costs are sourced from "NEEA 80 PLLS Market Progress Evaluation Report #5", Research Into Action, November 26, 2013 (page 24). The incremental costs for the notebook and thin client are sourced from "Computers: Code and Standards Enhancement (CASE) Inative for P2013: Tible 20 Standards Development, Analysis of Standards Proposal for Computers", California Energy Commission, August 2013 (page 41)

### **80 PLUS Servers**

Measure Number	IV-G-6 b
Portfolio:	EVT TRM Portfolio 2018-11
Status:	Active
Effective Date:	2019/1/1
End Date:	[ None ]
Program:	Efficient Products Program
End Use:	Electronics

### Update Summary

Updated the measure to reflect the new ENERGY STAR specification for servers, version 3.0. The measure characterization for servers leverages 80 PLUS specifications. It had Silver as the baseline and deemed savings for Gold, Platinum, and Titanium. The new ENERGY STAR specification essentially has 80 PLUS Platinum as the new minimum qualifying ortenia. As a result, removed the deemed savings for Gold, seeing as it no longer meets the minimum qualifying criteria for ENERGY STAR. Trad add reference, Contradet 80 PLUS and adset id, with these new ENERGY FAR specifications, are they planning on making any changes to their rating system, and they responded that there were no current planned revisions.

#### Referenced Documents

- Internal Power Supply Load Profile
   informal Power Supply Load Profile
   informal Power Supply Cad Profile
   2015-6- Computer Effectory- New Supply TAs FINAL
   INERKO, STAR, Certified, Enterprise, Senere, 20150803
   Sener Power Supples Data Points, PMO
   IRRE, LMP Chapter 20
   ENERGY STAR Computer Sever Program Requirements, Version 3

### Description

Description Commercial customer incentives for installing servers with power supplies rated at or higher than 80 PLUS Platinum <sup>[1]</sup>. At the moment, 80 PLUS Silver efficiency power supplies are most commonplace in the market and will serve as the baseline. 80 PLUS Platinum and 80 PLUS Titanium power supplies are eligible for incentive.

#### **Baseline Efficiencies**

The baseline efficiency for this measure is an 80 PLUS Silver server.

Efficient Equipment
The high efficiency for this measure is a server that is rated as an 80 PLUS Platinum or 80 PLUS Tilanium.

# Algorithms Electric Demand Savings

ΔkW

 $= ((PSU Watt_{Baseline} / (1000 \times Server Efficiency_{Baseline})) - (PSU Watt_{Efficient} / (1000 \times Server Efficiency_{Efficient}))) + Cooling Interaction KW$ 

#### Symbol Table

Electric Energy Savings 
 AkWh
 = ((PSU Watt<sub>Baseline</sub> / (1000×Server Efficiency<sub>Baseline</sub>)) - (PSU Watt<sub>Efficient</sub> / (1000×Server Efficiency<sub>Efficient</sub>))) + Cooling Interact ion kWh

ΔkW	-	gross customer connected load kW savings for the measure
Cooling Interaction kW	-	Cooling load reduction based on tonnage <sup>[3]</sup>
Cooling Interaction kWh	-	Cooling load reduction based on cooling FLH <sup>(6)</sup>
HOURS	-	Hours of operation for the measure = 8760
PSU Watt <sub>Baseline</sub>	-	Wattage of baseline power supply unit <sup>[4]</sup>
PSU Watt <sub>Efficient</sub>	-	Wattage of efficient power supply unit <sup>[5]</sup>
Server Efficiency <sub>Baseline</sub>	-	Refer to Table 1: Power Supply Efficiency
Server Efficiency <sub>Efficient</sub>	-	Refer to Table 1: Power Supply Efficiency

### Deemed Energy and Demand Savings<sup>[2]</sup>

Measure Description	Item Code	Energy Savings (kWh)	Demand Savings (kW)
Computer Server; with <400W Units with Platinum Rated Power Supply	EP80PLAT1	83	0.01
Computer Server; with 400-600W Units with Platinum Rated Power Supply	EP80PLAT2	138	0.02
Computer Server; with 600-1000W Units with Platinum Rated Power Supply	EP80PLAT3	207	0.03
Computer Server; with >1000W Units with Platinum Rated Power Supply	EP80PLAT4	386	0.05
Computer Server; with <400W Units with Titanium Rated Power Supply	EP80TITAN1	116	0.01
Computer Server; with 400-600W Units with Titanium Rated Power Supply	EP80TITAN2	193	0.02
Computer Server; with 600-1000W Units with Titanium Rated Power Supply	EP80TITAN3	290	0.04
Computer Server; with >1000W Units with Titanium Rated Power Supply	EP80TITAN4	541	0.07

## Load Shapes Desktop and Datacenter Server.[7]

25a Flat (8760 hours)

 Number
 Name
 Statu
 Winter
 Winter
 Summer
 Summer
 Winter
 Summer
 Summer
 Winter
 Summer
 Summer
 Winter
 Summer
 Summer</th

### Net Savings Factors

Measures EQPCMPTR Efficient Computers/Servers

### Tracks [Base Track]

6032EPEP [is base track] Efficient Products - Residential

Lifetimes Measure life<sup>(8)</sup> is based on an estimated server life of 5 years.

Measure Cost The incremental cost for the 80 PLUS Servers are as follows:<sup>(9)</sup>

Platinum: \$40
Titanium: \$75

## Reference Tables

Loading	Silver (Baseline)	Platinum	Titanium
5%	75.1%	85.6%	90.6%
10%	79.0%	87.9%	92.1%
15%	82.9%	90.2%	93.5%
20%	86.8%	92.5%	94.9%
30%	88.0%	93.1%	95.3%
40%	89.2%	93.7%	95.8%
50%	90.4%	94.3%	96.2%
60%	90.1%	94.0%	95.9%
70%	89.8%	93.7%	95.6%
80%	89.5%	93.4%	95.3%
90%	89.2%	93.2%	95.1%
100%	88.9%	92.9%	94.8%

#### Footnotes

[1] 80 PLUS servers website: http://www.plugloadsolutions.com/80pluspo ersupplies.aspx

- [2] Refer to Electric Forecast Summary tab in the document: 2015-6 Computer Efficiency Power Supply TAS FINAL.xlsx
- [3] Refer to the analysis file for calculation of Cooling Interaction kW: 2015-6 Computer Efficiency Power Supply TAS FINALXLSX
- [4] This is calculated by multiplying baseline input wattage x number of power supplies x load factor. This analysis can be found in 2015-6 Computer Efficiency Power Supply TAs FINALXLSX
- [5] his is calculated by multiplying efficient input watage x number of power supplies x load factor. This analysis can be found in 2015-6 Computer Efficiency Power Supply TAs FINALXLSX
- [6] Refer to the analysis file for calculation of Cooling Interaction kWh: 2015-6 Computer Efficiency Power Supply TAS FINALXLSX
- [7] See < Internal Power Supply Load Profile.xls>
- [8] NRE, The Uniform Methods Project: Methods for Determining Energy Efficiency Savings for Specific Measures, Chapter 20 Data Center IT Efficiency Measures, January 2015 (Page 17.)
- [9] Refer to the economic assumption and incremental costs in the analysis file: 2015-6 Computer Efficiency Power Supply TAs FINAL.xls
- [10] 2015-6 Computer Efficiency Power Supply TAs FINALXLSX supplied by Ecova on 4/14/2016

## High Efficiency Pre-Rinse Spray Valve

Measure Number	CI-HWE-PRSV a
Portfolio:	
Status:	Active
Effective Date:	2020/1/1
End Date:	[ None ]
December	Commonsial 9. Industry

Program: Commercial & Industrial End Use: Hot Water

## Update Summary

## Referenced Documents

- U.S. DOE, Building America Standard DHW Schedules, May 2014
   US DOE, Enroy Standard, CSY, New 2015
   ER Water Sense, Commercial PRSV Notice Sunset, Oct 2018
   Cadmus, WI Focus on Energy Potential Study, June 2017
   DERRN STAR CRE Calculation, Oct 2016
   EVT\_Pre-Rinse Spray Valve, Analysis

Description Pre-rinse spray valves use a spray of water to remove food waste from dishes prior to cleaning in a dishwasher. More efficient spray valves use less water thereby reducing water consumption and hot water heating consumption. Pre-rinse spray valves include a nozzle, squeeze lever, and dish guard bumper. Pre-rinse spray valves are manually operated, and the frequency of use depends on the volume of dirty dishes washed at a facility. The primar impacts of this measure are water savings. Reduced hot water consumption saves either natural gas or electricity, depending on the type of energy the hot water heater uses.

The measure replaces existing higher-flow pre-rinse sprayers used in commercial kitchens with low-flow prerinse sprayers. Installing these devices is an inexpensive and lasting approach to water conservation. These products save energy by reducing the amount of energy needed to process, move, and heat water. The samual energy assings come from replacing a standard pre-runse sprayer had with a lowflow pre-rinse sprayer.

Program Type Calculation Type: Time of Sale (Market Opportunity) and Retrofit Program Delivery / Implementation Type: Midstream

Baseline Efficiencies The baseline equipment is a less-efficient pre-rinse spray valve, with a flow rate depending on the replacement scen

For Time of Sale (TOS) replacement scenarios, the baseline equipment is a new pre-rinse spray valve with a flow rate meeting federal appliance standards of 1.23 gpm.<sup>[1]</sup> For retrofit replacement scenarios, the baseline equipment is an existing pre-rinse spray valve of an assumed 1.60 gpm.<sup>[2]</sup>

Efficient Equipment The efficienct equipment is a pre-rinse spray valve with a flow rate of 0.984 gpm or less.<sup>[3]</sup>

Algorithms Water Savings = ((GPM<sub>Base</sub> - GPM<sub>EE</sub>) x 60 x Hours) / 748 ΔCCF Symbol Table

## Electric Demand Savings There are no electric demand savings for this measure.

Electric Energy Savings

∆kWh = (GPM<sub>Base</sub> - GPM<sub>EE</sub>) x 60 x Hours x 8.33 x (T<sub>out</sub> - T<sub>in</sub>) x (1 / η) / 3412 x Elec<sub>Water</sub>

#### Symbol Table

Fossil Fuel Savings  $= (\text{GPM}_{\text{Base}} - \text{GPM}_{\text{EE}}) \times 60 \times \text{Hours} \times 8.33 \times (\text{T}_{out} - \text{T}_{in}) \times (1 / \eta) / 1000000 \times (1 - \text{Elec}_{Water})$ ΔMMBtu

ΔCCF	<ul> <li>Gross customer annual water savings for the measure</li> </ul>
ΔkWh	<ul> <li>Gross customer annual kWh energy savings</li> </ul>
ΔMMBtu	<ul> <li>Gross customer annual MMBtu energy savings</li> </ul>
η	<ul> <li>Efficiency of the existing hot water heater<sup>[5]</sup></li> </ul>
	= 98% for electric water heaters
	= 70% for natural gas- and propane-fired water heaters
	= 67.5% for oil-fired water heaters
1000000	<ul> <li>Conversion from Btu to MMBtu</li> </ul>
3412	<ul> <li>Conversion from Btu to kWh</li> </ul>
60	= Minutes per hour
748	<ul> <li>Constant to convert from gallons to CCF</li> </ul>
8.33	= Density of water
Elec <sub>Water</sub>	<ul> <li>Adjustment factor used to direct the hot water heating savings depending on fuel typ</li> </ul>
	= 1 for electric hot water heaters
	= 0 for fuel-fired hot water heaters
GPM <sub>Base</sub>	<ul> <li>Flow rate of the baseline pre-rinse spray valve in gallons per minute</li> </ul>
	= 1.23 gpm for time of sale
	= 1.60 gpm for retrofit
GPMEE	<ul> <li>Flow rate of the installed pre-rinse spray valve in gallons per minute</li> </ul>
	= 0.984 gpm
Hours	<ul> <li>Annual hours of operation of the pre-rinse spray valve</li> </ul>
	= 333 hours <sup>(4)</sup>
Tin	<ul> <li>Water temperature entering the hot water heater</li> </ul>
	= 51.9°F <sup>(6)</sup>

	= 121.9°F <sup>[7]</sup>							
Deemed Energy Savings								
Measure Replacement Scenario					Time of Sale			
	Annual Energy S				Annual Ener	gy Savings		
	2,146		HWECPS		857		HWECPSVETOS	
Natural Gas (MMBtu)	10.252		HWECPS		4.094		HWECPSVNGTOS	
Propane (MMBtu)	10.252		HWECPS	/PRET	4.094		HWECPSVPTOS	
Oil (MMBtu)	10.632		HWECPS	/ORET	4.246		HWECPSVOTOS	
Load Shapes 90b Restaurant Indoor Lighting								
Number Name	Status Or	'inter h kWh	Winter Off kWh	Summe On kWi	r Summer n Off kWh	Winter s	Summer kW	
90 Restaurant Indoor Ligh	ting Active 40	.7%	25.7%	20.2%	13.4%	63.0%	77.0%	
Measures HWESPRAY Low flow Pre-Rinse : Tracks (Base Track) 6013UPST [is base track] Upstre Track Name Track Name Upstream - Commercial (6013UPS	am - Commercia Measure Code		Rider Spill					
Measure Cost For a time of sale replacement sce	nario, the incren	nental c	ost is \$0. I	For retro	ît replaceme	ents, the inc	remental cost is \$76. <sup>[8]</sup>	
Reference Tables Deemed Water Savings Measure Replacement Scenario Time of Sale Retrofit	ΔCCF 6.571 16.454							
ootnotes								
conservation criteria for comm	ercial prerinse sp 3.6.1: U.S. DOE,	oray val "Techr	ves, effect iical Suppo	ive Janua ort Docun	ry 28, 2019 ient: Energy	(10 CFR 43	the Federal Appliance Standards for ene 1.266), weighted by estimated 2018 shipt rogram for Consumer Products and Com	ments for
Assuming, in retrofit scenarios	, the existing pre ext on the federa	-rinse s I energy	pray valve conserva	met the	federal appli	ance stand	e (10 CFR 431.266), effective January 1, ards from 2006, qualifying existing units a sense, "WaterSense Notice of Sunset of t	as 14 years
	improvement ove	er feder	al criteria.	Recomm	ending a cor	nparable 21	pray valves in 2019, EPA WaterSense del 0% improvement over current federal api rray Valve", October 2018)	
<ol> <li>Energy Star Certified Commendation days per year is based on rest</li> </ol>						nutes of op	eration per day, 312 days per year. The r	number of
water heaters are based on th	e 2019 Wisconsir Wisconsin Publi	n Focus c Servic	on Energy e Commis	TRM wh	ich sourced,	Cadmus, "	e efficiency of the natural gas- and propa 2016 Potential Study for Focus on Energy sites. For oil-fired water heaters, conser	", data

[6] Average value for Burlington, Montpelier, Rutland, and Springfield, VT from U.S. DOE Standard Building America DHW Schedules, May 2014.

[7] Assuming a 70 degree temperature rise from the inlet temperature per Food Service Technology Center calculator assumptions to account for variations in mixing and water heater efficiencies. Corroborated by the Energy Star Certified Commercial Kitchen Equipment Calculator, 2016.

[8] Measure life and incremental costs are based on the life-cycle cost analysis as sourced from U.S. Department of Energy, "Energy Conservation Standards for Commercial Pre-Rinse Spray Valves", November 2015 (10 CFR Part 429 and 431; Docket Number EERE-2014/87-STD-0027)

### Flexible Load Management: Residential Electric Water **Heater Controls**

Measure Number: FLM-RES-WHC a Portfolio: Status: Active Status: Active Effective Date: 2021/1/1 End Date: [ None ] Program: Residential & Multifamily End Use: Hot Water

Update Summary This is version 1.0 of the characterization.

#### Referenced Documents

prehensive-Report-2018-07-27 RES-1-FINA \_MA\_Loadshape\_RES-1-FINAL-Cor
 WaterHeating\_FlexLoadPotential

#### Description

Loss inpution Loss flexibility is enabled through controls and supporting hardware that safely increase the temperature of the hot water inside the insulated water I before the flexible resource is needed. The thermal storage of the water tank supplies hot water when needed by the customer but does not byically need to draw additional power during on pack times. The resource must be capable of being connected to an active distribution utility grid-managem program such that it can be dispatched during peak times.

This measure is applicable to both electric resistance water heaters (ERWH) as well as heat pump water heaters (HPWH).

Program eligibility requires that the system needs to have a tempering valve that is in good condition and properly set. This is also required by Vermont code.

Installation of controls is considered a retrofit activity.

#### **Baseline Efficiencies**

Baseline is an ERWH or HPWH without control equipment and therefore no grid interactivity.

#### Efficient Equipment

ETICHENT Equipment The efficient condition is defined as an ERVM or HPWH that has either had controls enabled or been retrolited with controls and necessars hardware that would enable a distribution utility to control its electric load draw. It has the ability to be grid interactive, meaning it's capab of providing grid balancing services as determined by the distribution utility.

### Algorithms

Electric Demand Savings No electric demand savings are claimed. Data will be collected and shared over 2021-2023 to understand if and how distribution utili ties are able to utilize this resource. EVT is committed to collecting the necessary data to understand any demand savings and their seasonal coincidence factors.

Flexible Load kW As defined by PIP #125 Flexible Load Management (FLM), <u>Bexible Load kW</u> is the maximum amount of demand reduction avai at least one hour between 4pm and 10pm on any day in any season, measured and reported in units of kW.

At best, controls could allow complete shutoff of water heaters for any given hour and therefore Flexible Load kW is estimated by power draw of an ERWH and HPWH during the hours between 4pm and 10pm. The RES 1 BASELINE LOAD SHAPE STUDY, Prepared for The Electric and Gas Program Administrators of Ma setts. Na ant 2018 (s

files) provides an hourly summary of demand, by month, for ERWHs and HPWH and is used as the basis to deem the following impacts:							
Electric Water Heater Type	ItemCode	Flexible Load kW Credit (kW) <sup>[1]</sup>					
Charles Developments	CLAR DECEMBER ED	0.40034					

Eleculic Resistance	PLIPI-RESDRIV-ER	0.40951
Heat Pump	FLM+RESDHW+HP	0.17472

Electric Energy Savings No energy savings are claimed, or necessarily expected. EVT recognizes there is a possibility that controlled HPWHs in particular may see an increase electricity consumption, especially for those that have secondary resistance heating coils. EVT is committed to tradying and reporting WM impacts for participants and will make appropriate revisions to claimed energy impact when more is understood. Fossil Fuel Savings

Load Shapes

This is a placeholder loadshape until data collection can inform a more appropriate choice. 8a Residential DHW conserve

Number		<b>C</b> 1-1-1-1	Winter	Winter	Summer	Summer	Winter	Summer
number	Name	Status	On kWh	Off kWh	On kWh	Off kWh	kW	kW

Residential DHW conserve Active 48.7% 29.1% 14.3% 7.9% 40.1% 20.3% 8

### **Net Savings Factors**

Measures
FLMHWEHW Flexible Load Management - Domestic Hot Water

Tracks [Base Track] 6032EPEP [is base track] Efficient Products - Residential

Track Name Track Nr. Measure Code Free Rider Spill Over th Products - Residential 6032EPEP FLMHWEHW 1.00 1.00

#### Lifetimes

- A measure life of 3 years is assumed, which considers several factors:
- Water heater controls are a new and evolving technology
   Some level of attrition is possible given the behavioral component that influences impact
   Controls will be installed on existing water heaters

Measure Co Measure costs inc	<b>ost</b> clude the material co	st of controls and	the electrician I	abor cost to instal	ll them.
Electric Water Heater Type	ItemCode	Controller Cost <sup>[2]</sup>	Labor Cost <sup>[3]</sup>	Total Cost	
Electric					1

### Footnotes

See referenced document WaterHeating\_HexLoadPotential for derivation of deemed savings. Loadshape data from the MA Loadshape Study is used as the basis and average demand is calculated over the entire year for the time period between 4pm and 10pm.

[2] Assumes Mello controller for electric resistance water heater, which retails for \$125-\$150 (average of \$137.5) and \$150 for a Skycentrics CTA-2045 control module for heat pump water heater.

[3] Assumes a one-hour labor charge for installation of controls by an electrician.

Heat R	ecovery	Units for Dai	ry Farms	
Measure Numbe Portfolio: Status: Effective Date: End Date: Program: End Use:	r: T-K-2 b EVT TRM Portfolio 21 Active 2018/1/1 [ None ] Commercial & Indust Hot Water			
<ul> <li>characterization</li> <li>incorporate cut</li> <li>Due to a limite</li> <li>The only revise</li> </ul>	atively low volume of n on for this measure ago istom projects from 20 ed effect on the savings ion made was to the ir	gregated savings and costs over a 113 through 2017 to supplement this s estimates, these values were not incremental cost estimates. The upp		03 to 2012, it was decided to
• Dairy-HRU-An	Documents alysis_v3			
	lairy applications that used water heating system		sor of a refrigerated milk cooling system to	pre-heat water for either an
Estimated M	leasure Impac	ts		
		Average Annual Savings per unit	Average number of measures per year <sup>[1]</sup>	Average Annual Savings per year
Heat Recovery U	nit (Electric Savings)	6.378 MWH	11	70.16 MWH
Heat Recovery U Savings)	nit (Fossil Fuel	52.46 MMBTU	14	734.4 MMBTU
Algorithms Electric Demand AkW Symbol Table Electric Energy	= 4.475 kW			
ΔkWh Symbol Table	= 6,378 kWh			
Fossil Fuel Savi	ngs			
ΔΜΜΒΤυ	= 52.46 MMBTU			
Where:				
ΔkW		customer connected load kW savir		
ΔkWh AMMBTU		customer average annual kWh sav customer average annual MMBTU		
			s from 2003 through 2012, see Dairy HRU.	Analysis_v3.xls
Baseline Eff The baseline refle		om the refrigerator compressor. <sup>[2]</sup>		
High Efficie				
The high efficiency	r case is installation an	d use of a heat recovery unit on th	e refrigerator compressor.	
Operating H	lours			
Load Shape	S iooler / Heat Recovery	Unit		
Number	Name		nter Summer Summer Winter Sur kWh On kWh Off kWh kW k	nmer
111 Farm F	fate Cooler / Heat Reo		4% 31.6% 23.1% 27.0% 16.1	
Net Saving	s Factors			
Measures HWEHRCMP Hea	t recovery, compresso	r		
Tracks [Base Tr				
	e track] Pres Equip R e track] 6014PRES	pl		
Persistence The persistence fa	ctor is assumed to be	one. <sup>[3]</sup>		
Lifetimes				

10 years.

Measure Cost Heat Recovery Unit (Electric or Fossil Fuel Savings): \$4,353 <sup>[4]</sup>

O&M Cost Adjustments There are no standard operation and maintenance cost adjustments used for this measure.

Fossil Fuel Description There are no fossil-fuel algorithms or default savings when electric savings is claimed for this measure. As the energy savings are ass water heater, fossil fuel savings occur if the water heater uses fossil fuel rather than electricity. ed with the

### Footnotes

Lissues that there will be ~50% more Rx measures per year than the average number of custom measures per year from 2003 through 2011, see AG RRU Analysis.ds

[2] While a heat recovery unit would be baseline for a new construction project, farmers typically re-use old equipment when extensively renovating old facilities. New construction, due to construction of new facilities, is rare and EVT staff has only heard of one case (between 2006 and 2012) where a new construction project resulted in purchase of new equipment.

[3] This equipment has no moving parts or controls and therefore rarely experiences downtime prior to failure due to corrosion at the end of service life.

[4] Value derived from Efficiency Vermont custom data 2010-2017, see Dairy HRU Analysis\_v3.xls

### Thermostatically Initiated Shower Restriction Valve

Measure Number:	IV-I-2 c
Portfolio:	EVT TRM Portfolio 2018-03
Status:	Active
Effective Date:	2018/1/1
End Date:	2021/12/31
Program:	Efficient Products Program
End Use:	Hot Water

Update Summary Update to revise the implementation method for this measure to free giveaways of products that are requested by customers.

- Referenced Documents Catinus, America Missouri EP Impact & Process Evaluation, Nay 2016 Gatinus, Showerhead and Faucet Aerater Water Skudy, Jane 2013 Narigant, energy/SMART Energy Savings Kits, Apr 2016 U.S., Censs Bareu, ACS Tade DPO4 Vermont, 2015 U.S., DCB, Building America Standard DW4 Schedules, Nay 2014 Stemam, Disagregating Residential Shower Varm-1/W Nate, Aug 2014 EVT\_Shower Restriction Valve\_Analysis, Feb 2018, v2

Description This measure relates to the installation of a thermostatically initiated shower restriction value in a home. The value prevents hot water waste during shower warm-up by closing off flow once hot water has reached the fixture. The value is reopened manually by pulling down on a connected cord. Once flow has been cut off after the shower, the value resets itself. This measure applies to free glueaways to customers who request products.

Baseline Efficiencies The baseline is no restriction valve in place.

Efficient Equipment The efficient condition is a thermostatically initiated shower restriction valve used in conjunction with a standard showerhead.

### Algorithms

Algorithms Electric Demand S	avings	
ΔkW	= ΔkWh/HOURS	
Symbol Table		
Electric Energy Sa	vinas	
ΔkWh	= ((GPM × Wast	teTime × # people × # showers × usedays/year / SH/home × 8.3 × 1.0 × (TEMP <sub>th</sub> - TEMP <sub>th</sub> )) / $\eta$ Electric_DH R × %Electric_DHW
Symbol Table		
Fossil Fuel Saving	s	
ΔMMBtu	= ((GPM × Wast 1,000,000) × ISR	teTime $\times$ # people $\times$ # showers $\times$ usedays/year / SH/home $\times$ 8.3 $\times$ 1.0 $\times$ (TEMP <sub>m</sub> - TEMP <sub>m</sub> )) / nFuel_DHW / X $\times$ SFuel_DHW
Symbol Table		
Water Savings		
ΔCCF	= GPM × Waste	Time x # people x # showers x usedays/year/ SH/home / 748 x ISR
Where:		
# people	= Averag = 2.33	ge number of people per household [2]
# showers	= Showe = 0.6 <sup>[3</sup>	ers per person per day 3)
%Electric_DH	W = Propor = 25%	tion of water heating supplied by electricity
%Fuel_DHW	= Propor Fuel O 20%	tion of water heating supplied by fuel oil, natural gas, or propanel <sup>4</sup> Natural Bropane         Bropane           Gas         25%         27%
ΔCCF		customer annual water savings for the measure eference Tables section for deemed savings values.
ΔkW		customer connected load kW savings for the measure eference Tables section for deemed savings values.
ΔkWh		customer annual WVh savings for the measure eference Tables section for deemed savings values.
ΔMMBtu		customer annual MMBu savings for the measure eference Tables section for deemed savings values.
ηElectric_DH	W = Recove = 0.98	ery efficiency of electric water heater §5]
ηFuel_DHW	= Recove = 0.78	ery efficiency of fuel water heater (12)
1,000,000	= Conver	rsion factor from Btu to MMBtu
1.0	= Specifi	ic heat of water (Btu/lb-°F) (constant)
3,412	= Conver	rsion factor from Btu to kWh
748	= Consta	ant to convert from gallons to CCF
8.3	= Consta	ant to convert gallons to lbs
GPM	= Flow ra	ate (gpm) of showerhead

HOURS	<ul> <li>Annual full load hours</li> <li>= 3,427.1 hours<sup>[1]</sup></li> </ul>
ISR	<ul> <li>In service rate, or the percentage of units rebated that are actually installed</li> <li>= 45%<sup>(7)</sup></li> </ul>
SH/home	= Average number of showerheads per household $= 1.3^{(6)}$
TEMPin	= Assumed temperature of water entering house = 51.9 $F^{(9)}$
TEMP <sub>sh</sub>	= Assumed temperature of water coming from showerhead $= 101 \ F^{(10)}$
usedays/year	<ul> <li>Days showerhead is used per year</li> <li>= 365</li> </ul>
WasteTime	= Average hot water waste time (minutes) avoided per shower due to restriction value $= 0.88^{[11]} \label{eq:eq:expansion}$

#### Load Shapes

For DHW systems not on Utility Controlled DHW program (Default): Loadshape #8, Residential DHW Conservation, For DHW systems on Utility Controlled DHW program: Loadshape #54, Controlled DHW Conservation; Loadshapes #8 and #54 are based on Itron 8760 hourly load data. 8a Residential DHW conserve 54a Controlled DHW Conservation 
 Number
 Name
 State
 Winter
 Number
 Summer
 Minite
 Nummer

 8
 Residential DHW conserve
 Active
 48.7%
 19.1%
 14.3%
 7.9%
 40.1%
 20.3%

 54
 Controlled DHW Conservation
 Active
 48.7%
 29.1%
 14.3%
 7.9%
 20.5%
 21.5%

### Net Savings Factors

Measures
HWESHTRV Thermostatically Initiated Shower Restriction Valve

Tracks [Base Track] 6034LISF [is base track] LISF Retrofit 6036RETR [is base track] Res Retrofit

 Track Name
 Track Nr.
 Measure Code
 Free Rider Spill Over

 Res Retrofit
 6036RETR HWESHTRV
 0.90
 1.00

 LISF Retrofit
 6034LISF
 HWESHTRV
 1.00
 1.00

## Lifetimes

asure life is assumed to be 10 years.<sup>[13]</sup>

Measure Cost The measure cost for free giveaways is the actual program cost of a new shower valve: \$16.75.

### Reference Tables

ΔkW	∆kWh	ΔMMBtu (fuel oil)	∆MMBtu (natural gas)	ΔMMBtu (propane)	ΔCCF
0.00345	11.8	0.041	0.053	0.055	0.52

### Footnotes

- [1] Full load hours from Loadshape #8a (Residential DHW Conserve) and #54a (Controlled DHW Conserve)
- [2] Weighted average household size of owner-occupied versus renter-occupied housing units ((71% \* 2.42) + (29% \* 2.12)) based on 2011-2015 American Community Survey 5-Year Estimates for Vermont. See reference file U.S. Census Bureau, ACS Table DP04 VT\_2015,pdf.
- [3] Cadmus and Opinion Dynamics, for the Michigan Evaluation Working Group, "Showerhead and Faucet Aerator Meter Study Memorandum," June 2013, page 11, Table 8.
- [4] DHW fuel percentages for free products based on data received by Efficiency Vermont on 08/21/2017 from the upcoming NMR Vermont Residential
- [5] Review of AHRI database shows that electric water heaters have a recovery efficiency of 98%. . Note that during November 2017 TAG, EVT and DPS agreed that assumptions for HPWH will be added during the next TRM reliability update cycle in 2020.
- [6] The Energy Policy Act of 1992 (EPAct) established the maximum flow rate for showerheads at 2.5 gallons per minute (gpm).
- [7] In the absence of evaluation studies supporting an ISR for free shower restriction valves, EVT began with the ISR assumption for low-flow showerhead (56%) from the Home Energy Kits measure: "Average of showerhead in service rate for kits including one showerhead (65%) from Navigant, "energy/SMRAT Energy Savings Kits, GPT 4 Evaluation Report (FINAL), "Anni 12, 2016, p. 20, and kits showerhead in service rate for sins family home (47%) from Cadman, "Amerin Missouri Efficient Podults Impact and Process Shouladors, P2 0215, Pa 13, 2016, p. 23." EVT reduced the ISR to 45% for shower restriction valves since customers are likely to be less familiar with these products.
- [8] Average of values for single family and multifamily households from Cadmus and Opinion Dynamics, for the Michigan Evaluation Working Group, "Showerhead and Faucet Aerator Meter Study Memorandum," June 2013, page 12, Table 9.
- [9] Average value for Burlington, Montpelier. Rutland, and Springfield, VT from U.S. DOE Standard Building America DHW Schedules, May 2014.
- [10] Cadmus and Opinion Dynamics, for the Michigan Evaluation Working Group, "Showerhead and Faucet Aerator Meter Study Memorandum," June 2013, page 11, Table 7.
- [11] Average of values from Troy Sherman, "Disaggregating Residential Shower Warm-Up Waste: An Understanding and Quantification of Behavioral Waste Based on Data from Laverace Berkeley National Labs," August 11, 2014, p. 11 and Cadmus and PPL Electric, "Flick Study for a Thermostatic Shower Residention Valve," 2015, p. 6, Table 4.
- [12] Based on a review of fuel DHW systems available in AHRI database.
- [13] California DEER Ex Ante Database
- [14] See file EVT\_Shower Restriction Valve\_Analysis\_Feb 2018\_v2.xlsx for calculation details.
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Measure Number: R Portfolio: Status: Act Effective Date: 20: End Date: [ N Program: Exi	ive
Additional options I     Electric HPWH     Unknown Elect     Unknown DHW     Updated ISR for free	s have been made: and associated SR assumption for each program: pric DHW 7
<ul> <li>Cadmus_ShoverhJ</li> <li>Navigant_energyJ</li> <li>Navigant_energyJ</li> <li>Schultdt_Energy R</li> <li>EVT_Low Flow Fac</li> <li>NMR_VT SF Existin</li> <li>10 CFR § 430,32</li> <li>AHRI_SearchResul</li> <li>ODE_EERE_Std_DH</li> <li>EVT Data CUBE 200</li> <li>US Census_2019_J</li> </ul>	le-update, 2014-02-05.slos: aad aard Faucet Aerator Meter Study, June 2013 4MRT Energy Swings MS, Apr 2016 aard Assumptions for Demand Side Management Planning, Apr 2009 alded Water Friker, Measurements, 2008 cott Aerators, Analysis, June 2017_v6 g homes Onsite Revort = TRNU. C70218 Energy and water conservation standards is, Residential Water Heaters, 19WTank, 2021 B, Residential Water Heaters, 2014 W, events, 2014, 05, 20, VT 21
consumption of hot wal The measure applies to • Retrofit direct insta • Free giveaways thi • The Dropship prog	
Algorithms Electric Demand Sa ΔkW Symbol Table Electric Energy Sav ΔkWh	= ΔW/h / HOURS
Symbol Table Fossil Fuel Savings ΔMMBtu	= (((GPM <sub>wate</sub> x Throttle <sub>bum</sub> ) - (GPM <sub>wate</sub> x Throttle <sub>bum</sub> )) × Tperson/day x # people x usedays/year x DR x 8.3 x 1.0 x (TEMP faxer = TEMP <sub>m</sub> ) / 1,000,000 / r/sue_DHW / XER x %Fue_DHW
Symbol Table Water Savings ΔCCF	$= ((GPM_{cold} \times Throttle_{cold}) - (GPM_{cold} \times Throttle_{cold})) \times Tperson/day \times # people \times usedays/year \times DR / 748 \times ISR$
Where: # people	<ul> <li>Average number of people per household</li> <li>= 2.30<sup>(2)</sup></li> </ul>
%Electric_DHW	
%Fuel_DHW	Proportion of water heating supplied by fuel oil, natural gas, or propane     10% if fuel DHW system,     When DHW fuel type is unknown, or for free products at Vermont Foodbanks, assume: <sup>[1]</sup> Fuel Oil Gas Propane     Z7% 13% 33%
ΔCCF	= Gross customer annual water savings for the measure, in hundreds of cubic feet
ΔkW	See Reference Tables section for deemed savings values. = Gross customer connected load kW savings for the measure
ΔkWh	See Reference Tables section for deemed savings values.  Gross customer annual Wth savings for the measure
ΔMMBtu	See Reference Tables section for deemed savings values.  Gross customer annual MMBu savings for the measure  Constructions Tables sections for deemed savings to later.
ηElectric_DHW	See Reference Tables section for deemed savings values. Recovery efficiency of electric water heater. The Unknown Electric GHW value is a Weighted average of Electric Water Heaters in VT. Quantity of HPMH was derived from EVT Program data and NMR Report on Single Family homes in VTI <sup>4</sup> .
	System Type Recovery Efficiency

	Electric Resistance         0.98 <sup>15</sup> Electric HPWH         3.49 <sup>16</sup> Unknown Electric DHW         1.71
ηFuel_DHW	= Recovery efficiency of fuel water heater = 0.83 <sup>(15)</sup>
1,000,000	= Conversion factor from Btu to MMBtu
1.0	<ul> <li>Specific heat of water (Btu/lb-°F) (constant)</li> </ul>
3,412	= Conversion factor from Btu to kWh
748	<ul> <li>Constant to convert from gallons to CCF</li> </ul>
8.3	<ul> <li>Constant to convert gallons to lbs</li> </ul>
DR	= Percentage of water flowing down drain $= 63\%^{7/1}$
GPM <sub>exist</sub>	<ul> <li>Flow rate (gpm) of existing faucet</li> <li>= 2.2<sup>[1]</sup></li> </ul>
GPM <sub>low</sub>	<ul> <li>Flow rate (gom) of low flow faucet</li> <li>1.0 or 1.5 gpm for Direct Install</li> <li>1.5 gpm for free products</li> </ul>
HOURS	= Annual full load hours = 3,427.1 hours <sup>(1)</sup>
ISR	<ul> <li>In service rate, or the percentage of units rebated that are actually installed</li> <li>100% for Direct Install</li> <li>6296<sup>10</sup> for free products</li> <li>90%<sup>100</sup> for Dropship</li> </ul>
TEMP <sub>faucet</sub>	= Assumed temperature of water used by faucet = 88 F( <sup>11</sup> )
TEMPin	<ul> <li>Assumed temperature of water entering house</li> <li>= 51.8 F<sup>(12)</sup></li> </ul>
Throttlebase	= Ratio of user setting to full-throttle flow rate for baseline faucet $= 0.83^{(12)} \label{eq:rate}$
Throttle <sub>low</sub>	= Ratio of user setting to full-throttle flow rate for low flow faucet $= 0.95^{(13)} \label{eq:generalized}$
Tperson/day	= Average daily length of use per person, per faucet (min/person/faucet) $= 1.6^{(14)} \label{eq:faucet}$
usedays/year	<ul> <li>Days faucet used per year</li> <li>= 365 days</li> </ul>

Baseline Efficiencies The baseline is assumed to be a standard faucet aerator with a flow rate of 2.2 gpm. Savings assumptions include a 0.83 throttling factor for baseline faucets<sup>[12]</sup> to account for the fact that faucets are not always operated at full flow, reducing the flow rate to 1.83 gpm.

High Efficiency The efficient condition is a faucet aerator with a flow rate of either 1.0 gpm or 1.5 gpm for direct install programs and 1.5 gpm for free giveaways. Savings assumptions include a 0.95 throttling factor for new faucets<sup>[3]</sup> to account for the fact that faucets are not always operated at full flow, redu the flow rate to 0.95 gpm for 1.0 gpm aerators and 1.4 gpm for 1.5 gpm aerators.

	hapes systems not on U #8, Residential			ogram (De	fault):				
For DHW systems on Utility Controlled DHW program: Loadshape #54, Controlled DHW Conservation									
Loadshape	is #8 and #54 ar	re based on Itr	on 8760 l	nourly load	data.				
	ntial DHW conser olled DHW Conse								
Number	Nan	ne	Status				Summer Off kWh		Summer kW
8	Residential DHV	V conserve	Active	48.7%	29.1%	14.3%	7.9%	40.1%	20.3%
54	Controlled DHW	Conservation	Active	48.7%	29.1%	14.3%	7.9%	20.5%	12.1%
Net Sa	vings Fact	ors							
Measure	s								
HWEFAUG	T Faucet aerat	or/flow restrict	tor						
Tracks [i	Base Track]								
	[is base track]	Efficient Prod	ucts - Re	sidential					
6034LISF	[is base track]	LISF Retrofit							
6036RET	R [is base track]	Res Retrofit							
6038VESH	I [is base track]	RNC VESH							
6032LIEP	[6032EPEP]	Efficient Prod	ucts - Lov	v Income					
Persist The persis	tence factor is a	ssumed to be o	one.						
Lifetim The measu	<b>IES</b> ure life is assume	ed to be 10 yea	ars. <sup>(16)</sup>						
Analysis p	eriod is the same	e as the lifetime	e.						
Мозси	re Cost								
rieasu	ie cost								

The measure cost for direct install is the actual cost (material and labor) of installing the new aerator<sup>[17]</sup> = \$13, if actual is unk

The measure cost for free giveaways and the dropship program is the actual program  $cost^{120}$  of a new aerator = \$2, if actual is unknown.

The measure cost for the Tailored Communities Energy Savings Kit componments are the actual program cost:

How Rate	Location	Model	manuracturer	cost per unit
1.0	Bathroom	N3210B-PC	AMC	\$1

.5 Kitchen N3115P AMC \$2	

**O&M Cost Adjustments** 

There are no operation and maintenance cost adjustments for this measure

# Reference Tables

Program Type	DHW Fuel and Flow Rate	ΔkW	ΔkWh	∆MMBtu (fuel oil)	∆MMBtu (natural gas)	ΔMMBtu (propane)	ΔCCF	ITEM CODES
Direct Install	Electric Resistance, 1.0 GPM	0.01944	66.6				0.99	DHWFAERATOR2 DHWFAERATMF2 LIDHWFAERATOR2
	Electric HPWH, 1.0 GPM	0.00546	18.7				0.99	DHWFAERATORHP2 DHWFAERATMFHP2 LIDHWFAERATORHP2
	Unknown Electric, 1.0 GPM	0.01107	38.0				0.99	DHWFAERATORUE2 DHWFAERATMFUE2 LIDHWFAERATORUE2
	Oil, 1.0 GPM			0.268			0.99	DHWFAERATOROL2 DHWFAERATMFOL2 LIDHWFAERATOROL2
	Natural Gas, 1.0 GPM				0.268		0.99	DHWFAERATORNG2 DHWFAERATMFNG2 LIDHWFAERATORNG2
	Propane, 1.0 GPM					0.268	0.99	DHWFAERATORPR2 DHWFAERATMFPR2 LIDHWFAERATORPR2
	Unknown, 1.0 GPM	0.00299	10.2	0.072	0.035	0.089	0.99	DHWFAERATORUK2 DHWFAERATMFUK2 LI-AERAT-UNK1
	Electric Resistance, 1.5 GPM	0.00890	30.5				0.45	DHWFAERATOR DHWFAERATMF
	Electric HPWH, 1.5 GPM	0.00250	8.6				0.45	DHWFAERATORHP DHWFAERATMFHP
	Unknown Electric, 1.5 GPM	0.00507	17.4				0.45	DHWFAERATORUE DHWFAERATMFUE
	Oil, 1.5 GPM			0.123			0.45	DHWFAERATOROL DHWFAERATMFOL
	Natural Gas, 1.5 GPM				0.123		0.45	DHWFAERATORNG DHWFAERATMFNG
	Propane, 1.5 GPM					0.123	0.45	DHWFAERATORPR DHWFAERATMFPR
	Unknown, 1.5 GPM	0.00137	4.7	0.033	0.016	0.041	0.45	DHWFAERATORUK DHWFAERATMFUK LI-AERAT-UNK2
	Electric Resistance, 1.0 GPM	0.01749	59.9				0.89	DHWFAERATOR2DS DHWFAERATLI2DS
Dropship	Electric HPWH, 1.0 GPM	0.00491	16.8				0.89	DHWFAERATORHP2DS DHWFAERATLIHP2DS
	Unknown Electric, 1.0 GPM	0.00997	34.2				0.89	DHWFAERATORUE2DS DHWFAERATLIUE2DS
	Oil, 1.0 GPM			0.242			0.89	DHWFAERATOROL2DS DHWFAERATLIOL2DS
	Natural Gas, 1.0 GPM				0.242		0.89	DHWFAERATORNG2DS DHWFAERATLING2DS
	Propane, 1.0 GPM					0.242	0.89	DHWFAERATORPR2DS DHWFAERATLIPR2DS
	Unknown, 1.0 GPM	0.00269	9.2	0.065	0.031	0.080	0.89	DHWFAERATORUK2DS DHWFAERATLIUK2DS
	Electric Resistance, 1.5 GPM	0.00801	27.4				0.41	DHWFAERATORDS DHWFAERATLIDS
	Electric HPWH, 1.5 GPM Unknown Electric, 1.5	0.00225	7.7				0.41	DHWFAERATORHPDS DHWFAERATLIHPDS DHWFAERATORUEDS
	Unknown Electric, 1.5 GPM	0.00456	15.6				0.41	DHWFAERATLIUEDS
	Oil, 1.5 GPM			0.119			0.41	DHWFAERATOROLDS DHWFAERATLIOLDS DHWFAERATORNGDS
	Natural Gas, 1.5 GPM				0.119		0.41	DHWFAERATUNGDS DHWFAERATUNGDS DHWFAERATORPRDS
	Propane, 1.5 GPM					0.119	0.41	DHWFAERATLIPRDS DHWFAERATORUKDS
Free Products	Unknown, 1.5 GPM	0.00123	4.2	0.030	0.014	0.036	0.41	DHWFAERATUKDS DHWFAERATUKDS LIFDBNK-HAERATE

### Footnotes

[1] Full load hours from Loadshape #8a (Residential DHW Conserve) and #54a (Controlled DHW Conservation).

[2] Weighted average household size of owner-occupied versus renter-occupied housing units ((70.8% \* 2.41) + (29.2% \* 2.04)) based on 2015-2019 American Community Survey 5-Year Estimates for Vermont. See reference file US Census\_2019\_ACS\_SYR\_DP04\_VT.csv.

[3] DHW fuel percentages for free products based on data received by Efficiency Vermont from the 2018 NMR Group "Vermont Single-Family Existing Homes On-Site Report", Table 59.

[4] Please see EVT Data CUBE 2021.xisx for EVT Program data on HPWH quantities in VT. Please see Table 6 of the NMR Group "Vermont Single-Family Existing Homes On-Site Report", which supports a value of 171,322 own-occupied single-family homes in VT. Applying the 27% of homes with Electric Water Heating, a found in table 59 of the report, results in 33,134 VT Homes with Electric Resistance Water Heaters and 13,590 VT homes with Electric Heat Pump Water Heaters.

[5] Review of AHRI database shows that electric water heaters have a recovery efficiency of 98%. Note that during November 2017 TAG, EVT and DPS agreed that assumptions for HPWH will be added during the next TRM reliability update cycle in 2020.

2020.

[6] Review of AHRI database shows that Electric Heat Pump Water Heaters have a recovery efficiency of 348.56%. For the raw data, please see AHRI\_SearchResults\_Residential Water Heaters\_HPwTank\_2021.xlsx.

[7] Because faucet usages are at times dictated by volume (for example, filling a sink to wash dishes), only usage that would allow water to go straight down the drain will provide savings. DR values are from Navigant Consulting, Inc. for the Orbario Every Board, "Neasures and Assumptions for Demand Sides Wanagement Planning, Appendic C: Substantiation Sheets," April 16, 2000, pages C-57 and C-61. DR values weighted by typical number of kitchen faucets (1 faucet) and bath faucets (2 faucets) in a household: (1/3 \* 0.50) + (2/3\* 0.70) = 0.63.

[8] Federal standard for faucets, 10 CFR § 430.32 - Energy and water conservation standards (o) faucets

[9] Average of Bathroom & Kitchen Aerator in service rates (63% & 60%, respectively) from Navigant, "energySMART Energy Savings Kits, GPY 4 Evaluation Report (FINAL)," April 29, 2016, p. 20. This was based off of a Telephone Survey from PY4, weighted by strata.

[10] Dropship is estimated higher than free giveaway product as the building owner or contractor is required to actively order the required product online,

confirm that it will be installed and EVT may inspect the installation at a later date. However since the installation is not performed by EVT staff or contractor (as in direct install), a 10% discount is applied.

[11] Cadmus and Opinion Dynamics, for the Michigan Evaluation Working Group, "Showerhead and Faucet Aerator Meter Study Memorandum," June 2013, Table 7, page 11. TEMPRacet values weighted by typical number of kitchen faucets (1 faucet) and bath faucets (2 faucets) in a household: (1/3 \* 39) + (2/3\* 66) = 88.

[12] Average value for Burlington, Montpelier, Rutland, and Springfield, VT from U.S. DOE Standard Building America DHW Schedules, May 2014. Values found on Weather Inputs sheet on spreadsheet. http://energy.gov/eere/buildings/downloads/building-america-standard-dhw-schedules Please see DOE\_EERE\_Std\_DHW\_events\_2014.05.20, VT.xksm

- [13] Schultdt, Marc, and Debra Tachibana, "Energy Related Water Foture Measurements: Securing the Baseline for Northwest Single Family Homes. 2008 ACEEE Summer Study on Energy Efficiency in Buildings," 2008, page 1-265.
- [14] Cadmus and Opinion Dynamics, for the Michigan Evaluation Working Group, "Showerhead and Faucet Aerator Meter Study Memorandum," June 2013, Table 6, page 10.
- [15] Review of AHRI database shows that Gas Residential Water Heaters (with Active AHRI certifications, Natural Gas, Fuel OII & Propane Gas included) have an average recovery efficiency of 83%. Accessed February 2021.
- [16] Measure lifetime from California DEER. See file DEER2014-EUL-table-update\_2014-02-05.xlsx.
- [17] A full install cost of \$13 is based on market research average of \$6 for faucet aerator and assess and install cost of \$7, based on 20 minutes of labor at \$20/hour.
- [18] Data from EVT program manager was \$1.75. Rounded to \$2 to account for labor & shipping costs.

[19] See file EVT Analysis file for calculation details.

# Low Flow Showerhead Measure Number: RS-DHW-LFSH a Portfolio: Status: Active Effective Date: 2021/1/1 End Date: [None] Program: Existing Homes End Use: Hot Water Update Summary The following additiongs have been made: Cropship program added, and associated ISR assumption Additional options for each program: Electric HPWH Unknown Becktric DHW Unknown DHW Referenced Documents Referenced Documents DEERD14-RL-Index-path. 2014-02-05-size Cadmus, Ameren Missouri EP Impact & Process Evaluation, May 2016 Cadmus, Showerhead and Faucet Areafor Meter Study, June 2013 Invigrat, rempros/MART Energy Shomps Mb, Apr 2016 VTR Bis Baseline SHX: Chronis report - DRAFT 051217 MRY, UTS Fasting froms: Online Report - FINAU 02018 In DCRS 430, 32 - Energy and water conservation standards ARRL, Sacrificesults, Residential Water Heaters, PMOrtal, 2021 ERRL, WaterSame Labeled Poolucits, Feb 2021 EVT Data CLEB 2021 ENT Data CLEB 2025 TR US Census\_2019\_ACS\_5YR\_DP04\_VT Analysis\_RES Low Flow Showerhead\_ ad 2020 - EVT Final Description Description This measure drankterizes the installation of a low-flow showerhead in a single family home or a multifamily building. The qualifying efficient flow rate for the direct install, dropping and free giveway programs is 1.5 gallons per minute (gm). For the RNC program, the qualifying flow rate is a VatarEsrense-labeled showerhead. As of Perbany 2021, the warroug VaterEsrense labeled efficient Showerhead flow rate is 1.8 gpm. The measure applies to RNC, retrofit direct install implementation, dropping program, or free giveaways to customers who request products. Algorithms Electric Demand Savings $\Delta kW = \Delta kWh / HOURS$ Symbol Table Electric Energy Savings $= ((GPM_{base} - GPM_{brw}) \times Tshower \times \# people \times \# showers \times usedays/year / SH/home \times 8.3 \times 1.0 \times (TEMP_{dh} - TEMP_{m}) / \eta \\ Electric_DHW / 3,412) \times ISR \times \% Electric_DHW$ ∆kWh Symbol Table Fossil Fuel Savings = ((GPM<sub>base</sub> - GPM<sub>bin</sub>) × Tshower × # people × # showers × usedays/year / SH/home × 8.3 × 1.0 × (TEMP<sub>sh</sub> - TEMP<sub>in</sub>) / ηF uel\_DHW / 1,000,000) × ISR × %6Fuel\_DHW Symbol Table Water Savings ΔCCF = ((GPM<sub>base</sub> - GPM<sub>base</sub> ) × Tshower × # people × # showers × usedays/year / SH/home / 748) × ISR Where: # people = Average number of people per household = 2.30<sup>(2)</sup> # showers = Showers per person per day = 0.6[3] %Electric\_DHW = For direct install, Dropship or RNC, 100% if electric DHW system, 0% if non-electric DHW sy = $27\%^{[4]}$ for free giveaways, or unknown fuel DHW systems %Fuel DHW Proportion of water heating supplied by fuel oil, natural gas, or propane = For Direct Install, Dropship or RNC, 100% if fuel DHW system, 0% if non-fuel DHW system = For free products, or unknown fuel DHW systems, assume:[4] Construction of the product of the system Construction of the system Constructio ΔCCF See Reference Tables section for deemed savings values. ΔkW Gross customer connected load kW savings for the measure See Reference Tables section for deemed savings values. = Gross customer annual kWh savings for the measure ∆kWh See Reference Tables section for deemed savings values. ΔMMBtu = Gross customer annual MMBtu savings for the measure See Reference Tables section for deemed savings values. Recovery efficiency of electric water heater. The Unknown Electric GHW value is a Weighted average of Electric Water Heaters in VT. Quantity of HPWH was derived from EVT Program data and NMR Report on Single Family homes in VT<sup>[3]</sup>. ηElectric\_DHW System Type Recovery Efficiency Electric 0.98<sup>(6)</sup>

			Resistance
			Electric HPWH 3.49 <sup>(7)</sup>
			Unknown Electric 1.71
			DHW
	ηFuel_DHW	-	Recovery efficiency of fuel water heater
			= 0.83 <sup>[19]</sup> for direct install, dropship or free giveaways
			= 0.89 <sup>(20)</sup> for RNC
	1,000,000	-	Conversion factor from Btu to MMBtu
	1.0	-	Specific heat of water (Btu/Ib-°F) (constant)
	3,412	-	Conversion factor from Btu to kWh
	748	-	Constant to convert from gallons to CCF
	8.3	-	Constant to convert gallons to lbs
	GPM <sub>base</sub>	-	Flow rate (gpm) of baseline showerhead
			= 2.5 gpm for direct install, dropship or free giveaways <sup>[8]</sup>
			= 2.4 gpm for RNC <sup>(9)</sup>
	GPM <sub>low</sub>	-	Flow rate (gpm) of low showerhead
			= 1.5 gpm for direct install, dropship or free giveaways <sup>[10]</sup>
			= 1.8 gpm for RNC <sup>[11]</sup>
	HOURS	-	Annual full load hours
			= 3,427.1 hours <sup>[1]</sup>
	ISR	-	In service rate, or the percentage of units rebated that are actually installed
			= 100% for direct install or RNC
			= 56% <sup>(12)</sup> for free products
			= 90% <sup>(13)</sup> for Dropship
	SH/home	-	Average number of showerheads per household
			= 1.3 for existing homes or multifamily buildings <sup>[14]</sup>
			= 2.1 for RNC <sup>[15]</sup>
	TEMPin	-	Assumed temperature of water entering house
			= 51.8 F <sup>(16)</sup>
	TEMPsh	-	Assumed temperature of water coming from showerhead
			= 101 F <sup>[17]</sup>
	Tshower	-	Average shower length in minutes
			= 7.8 <sup>[18]</sup>
	usedays/year	-	Days showerhead is used per year
			= 365
	line Efficienci		
gpm. <sup>(9</sup>		OF II	ee giveaways is a standard showerhead using 2.5 gpm. The baseline for RNC is a showerhead with a flow rate of 2.4
High	Efficiency		
The ef	ficient condition for dir	ect ir	stall or free giveaways is a showerhead with a flow rate of 1.5 gpm. The efficient condition for RNC is a showerhead
with a	flow rate of 1.8 gpm.	4]	
	I Shapes	v Ce	ntrolled DHW program (Default):
	ape #8, Residential D		
	W systems on Utility C ape #54, Controlled D		
			d on Itron 8760 hourly load data.

Loadshapes #8 and #54 are based on Itron 8760 hourly load data. 8a Residential DHW conserve 54a Controlled DHW Conservation

Number	Name	Status				Summer		Summer
Number	Hame	Status	On kWh	Off kWh	On kWh	Off kWh	kW	kW
8	Residential DHW conserve	Active	48.7%	29.1%	14.3%	7.9%	40.1%	20.3%
54	Controlled DHW Conservation	Active	48.7%	29.1%	14.3%	7.9%	20.5%	12.1%

# Net Savings Factors

Measures
HWESHOWR Low flow showerhead

Tracks [Base Track] 6018LINC (is base track) LIMF NC 6019MFNC (is base track) MF Mkt NC 6034LISF (is base track) LISF Retrofit 6036RETR [is base track] Res Retrofit 6038VESH [is base track] RNC VESH 
 6017PRES [is base track]
 6017PRES

 6017CUST [is base track]
 6017CUST

 6020PRES [is base track]
 6020PRES

Persistence The persistence factor is assumed to be one.

Lifetimes The measure life is assumed to be 10 years.<sup>[21]</sup> Analysis period is the same as the lifetime.

### Measure Cost

The measure cost for direct install is the actual cost (material and labor) of installing the new showerhead<sup>221</sup> = \$22, or \$27 for handheld options The measure cost for free giveaways and the dropship program is the actual program cost<sup>[21]</sup> of a new showerhead: \$4 The measure cost for the Tailored Communities program is the actual program cost<sup>[24]</sup> of a showerhead: \$24 The incremental measure cost for RNC is \$6<sup>(23)</sup>.

### O&M Cost Adjustments

There are no operation and maintenance cost adjustments for this measure

Reference Ta	ables
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Program Typ	eDHW Fuel	∆kW	∆kWh	∆MMBtu (fuel oil)	∆MMBtu (natural gas)	ΔMMBtu (propane)	ACCF	ITEM CODES
	Electric Resistance	0.10770	369.1				4.04	DHWSHOWERHD DHWSHOWERMF LIDHWSHOWERHD
	Electric HPWH	0.03024	103.6				4.04	DHWSHOWERHDHP DHWSHOWERMFHP LIDHWSHOWERHDHP
	Unknown Electric	0.06136	210.3				4.04	DHWSHOWERHDUE DHWSHOWERMFUE LIDHWSHOWERHDUE
Direct Install	Oil			1.487			4.04	DHWSHOWERHDOL DHWSHOWERMFOL LIDHWSHOWERHDOL
	Natural Gas				1.487		4.04	DHWSHOWERHDNG DHWSHOWERMFNG LIDHWSHOWERHDNG
	Propane					1.487	4.04	DHWSHOWERHDPR DHWSHOWERMFPR LIDHWSHOWERHDPR
	Unknown	0.01657	56.8	0.401	0.193	0.491	4.04	DHWSHOWERHDUK DHWSHOWERMFUK LIDHWSHOWERHDUK
	Electric Resistance	0.04098	140.4				1.54	DHWSHWERRNC
	Electric HPWH	0.01151	39.4				1.54	DHWSHWERHPRNC
	Unknown Electric	0.02335	80.0				1.54	DHWSHWERUERNC
RNC	Oil			0.528			1.54	DHWSHWEROLRNC
	Natural Gas				0.528		1.54	DHWSHWERNGRNC
	Propane					0.528	1.54	DHWSHWERPRRNC
	Unknown	0.00630	21.6	0.142	0.069	0.174	1.54	DHWSHWERUKRNC
	Electric Resistance	0.09693	332.2				3.64	DHWSHOWERDS LIDHWSHOWERDS
	Electric HPWH	0.02722	93.3				3.64	DHWSHOWERDSHP LIDHWSHOWERDSHP
	Unknown Electric	0.05523	189.3				3.64	DHWSHOWERDSUE LIDHWSHOWERDSUE
Dropship	Oil			1.338			3.64	DHWSHOWERDSOL LIDHWSHOWERDSOL
	Natural Gas				1.338		3.64	DHWSHOWERDSNG LIDHWSHOWERDSNG
	Propane					1.338	3.64	DHWSHOWERDSPR LIDHWSHOWERDSPR DHWSHOWERDSUK
	Unknown		51.1	0.361	0.174	0.442	3.64	LIDHWSHOWERDSUK
Free Products	Unknown	0.00928	31.8	0.225	0.108	0.275	2.26	LIFDBNKSHWERHD

### Footnotes

- [1] Full load hours from Loadshape #8a (Residential DHW Conserve) and #54a (Controlled DHW Conservation)
- [2] Weighted average household size of owner-occupied versus renter-occupied housing units ((70.8% \* 2.41) + (29.2% \* 2.04)) based on 2015-2019 American Community Survey 5-Year Estimates for Vermont. See reference file US Census\_2019\_ACS\_SYR\_DP04\_VT.csv.
- [3] Cadmus and Opinion Dynamics, for the Michigan Evaluation Working Group, "Showerhead and Faucet Aerator Meter Study Memorandum," June 2013, page 11, Table 8.
- [4] DHW fuel percentages based on data received by Efficiency Vermont from the 2018 NMR Group "Vermont Single-Family Existing Homes On-Site Report", Table 59.
- [5] Since the vast majority of Electric HPWH in VT have come through EVTs programs, a fair estimate of the number of HPWH in VT would equate the number of units captured in this program data. Since the introduction of this measure in 2011, there have been 13,605 units throughout various projects as of March 39, 221. Peases ee DF Data (UEE 2021.txsfc TeV Program data).

In order to determine the quantity of Bectric Resistance DHW Systems in Residences of VT, we used this program data, along with the NMR Group "Vermont Single-Family Edsting Homes On-Site Report". Using the percentage of homes in VT with electric water heating (27% per Table 59), along with the quantity of ourer-coupled single-family homes in VT (17), 322 per Table 6), then subracting the Electric HPWH units in VT, we calculated 33,119 Single-family homes in Vermont with Electric Resistance water heaters.

Using the Recovery Efficiencies for these systems, along with the calculated quantities of units in VT, we then calculated a weighted average Recovery Efficiency to use in situations where the type of Electric Water Heater is unknown.

- [6] Review of AHRI database shows that electric water heaters have a recovery efficiency of 98%.
- [7] Review of AHRI database shows that Electric Heat Pump Water Heaters have a recovery efficiency of 348.56%. For the raw data, please see AHRI\_SearchResults\_Residential Water Heaters\_HPwTank\_2021.xlsx.
- [8] The Energy Policy Act of 1992 (EPAct) established the maximum flow rate for showerheads at 2.5 gallons per minute (gpm), which is the minimum qualifying flow rate for Efficiency Vermont direct install programs. Baseline flow rate is verified on site by reviewing the equipment label and measuring the flow rate. In our programs, baseline flow rate is a rent recorded.
- [9] Average showerhead flow rate in new single-family homes from NMR Group, "Vermont Residential New Construction Baseline Study Analysis of On-Site Audits (Draft Report)," May 12, 2017, page 11, Table 6.
- [10] Flow rate of showerhead provided by p
- [11] Efficient showerhead flow rate for RNC is the average flow rate of products on the WaterSense Labeled Products list as of February 12, 2021. See file EPA\_WaterSense Labeled Products\_Feb 2021.xlsx.
- [12] Average of showerhead in service rate for kills including one showerhead (65%) from Navigant, "energy-SMART Energy Savings Kils, GPV 4 Evaluation Report (FINAU,)" April 29, 2016, p. 20, and kills showerhead in service rate for single family homes (47%) from Cadmus, "Ameren Missouri Efficient Products Imped and Process Evaluation: PP 2015; World 39, 13, 2016, p. 21.
- [13] Dropship is estimated higher than free giveaway product as the building owner or contractor is required to actively order the required product online, confirm that it will be installed and EVT may inspect the installation at a later date. However since the installation is not performed by EVT staff or contractor (us index install). Joint discount is applied.
- [14] Average of values for single family and multifamily households from Cadmus and Opinion Dynamics, for the Michigan Evaluation Working Group, "Showerhead and Faucet Aerator Meter Study Memorandum," June 2013, page 12, Table 9.
- [15] Average number of low-flow showerheads from NMR Group, "Vermont Residential New Construction Baseline Study Analysis of On-Site Audits (Draft Report)," May 12, 2017, page 12. Low flow is defined in the RNC report as 2.5 GPM, which is the maximum flow rate established by the Energy Policy Act of 1992 (EPAK). Since the saturation rate of low-flow showerheads is 98% for new homes in PVT Enricory (Table 8, page 13), EVT assumes 2.1 showerheads/home is a reasonable assumption for RNC. Please see NMR\_VT RNC Baseline SF Onsite Report Draft, 051217.docr
- [16] Average value for Burington, Montpelier, Rutland, and Springfield, VT from U.S. DOE Standard Bailding America THW Schedules, Nay 2014. Values found on Weather Inputs sheet on spreadsheet. http://energy.gov/energbaildings/downloads/bailding-america-standard-dhw-schedules Please see OE DEERE Still DHW events. 2014 05 20 VT.xkm

[17] Cadmus and Opinion Dynamics, for the Michigan Evaluation Working Group, "Showerhead and Faucet Aerator Meter Study Memorandum," June 2013, page 11, Table 7.

- [18] Cadmus and Opinion Dynamics, for the Michigan Evaluation Working Group, "Showerhead and Faucet Aerator Meter Study Memorandum," June 2013, page 10, Table 6.
- [19] Review of AHRI database shows that Gas Residential Water Heaters (with Active AHRI certifications, Natural Gas, Fuel OII & Propane Gas included) have an average recovery efficiency of 83%. Accessed February 2021.

[20] The fuel DHW system recovery efficiency for RNC is a weighted average based on the distribution of DHW system types in new homes from NMR Group, "Vermork Residential New Construction Baseline Study Analysis of On-Site Audits (Draft Report)," May 12, 2017. Energy factors from the Vermort RRF (report vere converted to recovery efficiencies using information from the AHRI database, accessed January 2018. See EVT Analysis file for details.

- [21] Measure lifetime from California DEER. See file DEER2014-EUL-table-update\_2014-02-05.xlsx.
- [22] Actual program cost + assumed labor of approximately \$7 (\$20/hr, for 20 mins). Actual program cost is either \$15 or, for the hand-held version, \$20. [23] Data from EVT program manager was \$3.65.

[24] Cost estimate provided by program, for a 1.5 GPM Showerhead with Thermostatically Restricted Valve, Model #EV3011-CP150-SB, manufactered by Exolve.

[25] Incremental Cost, Based on a comparison of WaterSense & non-WaterSense qualified products available on HomeDepot.com during March 2021. See EVT Analysis file for details.

[26] See file EVT Analysis file for calculation details.

Pipe W				
Measure Number Portfolio:	RS-DHW-	-PWRP a		
Status:	Active			
	2021/1/1			
	[ None ] Existing Hor	mes		
	Hot Water			
pdate Sum				
ne following chan				
<ul> <li>Dropship progr</li> <li>Additional optic</li> </ul>		ind associated ISR assur program:	nption	
<ul> <li>Electric HP</li> </ul>	WH			
<ul> <li>Unknown E</li> <li>Product specifi</li> </ul>				
<ul> <li>Measure C</li> <li>R-value</li> </ul>	lost			
<ul> <li>Length of p</li> </ul>				
<ul> <li>Diameter of</li> <li>Thickness</li> </ul>		material		
Referenced				
<ul> <li>Measures and</li> <li>DEER2014-EUI</li> </ul>	Assumptions -table-undate	for DSM Planning Appe e_2014-02-05.xlsx	ndix C Substantiation S	Sheets
<ul> <li>NMR_VT SF Ex</li> </ul>	isting Homes	s Onsite Report - FINAL		
		ential Water Heaters_HF ential Water Heaters_20		
EVT Data CUBE	2021			
<ul> <li>EVT Program I</li> <li>EVT - Analysis,</li> </ul>		2021_Pipe Pre-Slit Insula /rap_2021 - Final	tion 1 foot _ ICF Contr	ractor Store
escription				
				ater tank to the first elbow. This is the most cost effective section to insulate elbow which acts as a heat trap. Insulating this length therefore helps
				entation at a residential location.
lgorithms				
lectric Demand				
ΔkW	= ∆kW	/h / 8,760		
Symbol Table				
lectric Energy S	Savings			
AkWh		A Rest = Carry / Rest	) X I X AT X 8 760 X	× ISR) / nElectric_DHW / 3,412
LIKIVII	= ((Ce	sost / Nexist - Cnew / Nnew	J ~ E ~ EI ~ 0,700 7	× 15K) / I[Lieutic_01W / 5,412
Symbol Table				
ossil Fuel Descr	iption			
∆MMBtu	= ((C <sub>e</sub>	<sub>exist</sub> / R <sub>exist</sub> - C <sub>new</sub> / R <sub>new</sub>	) × L × ΔT × 8,760 ×	< ISR) / nFuel_DHW / 1,000,000
/here:				
ΔkW		Gross customer con	nected load kW saving	is for the measure
ΔkWh		Gross customer ann		
ΔMMBtu		Gross customer anni		
ΔΤ			e difference between s	supplied water and outside air temperature (°F).
		55°F[1]		
ηElectric_D	HW =	Water Heaters in VT		er. The Unknown Electric DHW value is a Weighted average of Electric as derived from EVT Program data and NMR Report on Single Family
		homes in VT <sup>[2]</sup> .		
		System Type	Recovery	
		Electric Devices	Efficiency	_
		Electric Resistance	0.98 <sup>[3]</sup>	_
		Electric HPWH Unknown Electric	1.71	
ηFuel_DHW		<ul> <li>Recovery efficiency of = 0.83<sup>[11]</sup></li> </ul>	n iuei water heater	
1,000,000		Conversion factor fro	om Btu to MMRhu	
3,412		Conversion factor fro		
			ou la NIVII	
8,760		Hours per year		
Cexist		Circumference (ft) o	f uninsulated pipe <sup>[5]</sup>	
		Diameter pipe (in)		
			0.131	
			0.196	
Cnew		Circumference (ft) o		
			thickness of foam (in)	
		0.5"	3/8" 1/2"	0.327 0.458
ISR				0.458 rebated that are actually installed
ЪК		<ul> <li>In service rate, or th</li> <li>= 100% for Direct Ir</li> </ul>		reverse one dre detadny installeu
		= 90% <sup>(7)</sup> for Dropsh		
L		Length of pipe from	water heating source	covered by pipe wrap (ft)
		= 7 ft <sup>[8]</sup>		
Rexist		<ul> <li>Pipe heat loss coefficient</li> </ul>	tient of uninsulated nir	pe [(hr-°F-ft <sup>2</sup> )/Btu]
		= 1.0 <sup>(9)</sup>		
Rnew		<ul> <li>Pipe heat loss coefficient</li> </ul>	cient of newly insulated	d pipe [(hr-°F-ft)/Btu]
NIEW		= 1.0 + R value of in		
		= 4.2		

**Baseline Efficiencies** The baseline condition is an uninsulated, domestic hot or cold water pipe.

High Efficiency The high efficiency condition is a domestic hot or cold water pipe with R-3.2 pipe wrap installed on the hot or cold water pipes up to the first elbow

Load Shapes 7a Residential DHW insulation 53a Controlled DHW Insulation

 
 Number
 Name
 Status
 Winter
 Winter
 Summer
 Summer
 Summer</t 
 7
 Residential DHW insulation
 Active
 31.7%
 34.9%
 15.9%
 17.5%
 100.0%

 53
 Controlled DHW Insulation
 Active
 31.7%
 34.9%
 15.9%
 17.5%
 51.0%
 59.4%

### Net Savings Factors

Measures HWEPIPES Insulate hot water pipes

Tracks [Base Track] 6034LISF [is base track] LISF Retrofit 6036RETR [is base track] Res Retrofit

Persistence The persistence factor is assumed to be one.

### Lifetimes 12 ve

Analysis period is the same as the lifetime

### Measure Cost

e cost is the actual program cost of installing the pipe wrap: \$2<sup>[13]</sup>

O&M Cost Adjustments There are no operation and maintenance cost adjustments for this measure.

# Reference Table

Program Type	DHW Fuel	ΔkW	ΔkWh	∆MMBtu (fuel oil)	∆MMBtu (natural gas)	ΔMMBtu (propane)	ITEM CODES
	Electric Resistence	0.00612	53.6				DHWPIPEINSU LIDHWPIPEINSU
	Electric HPWH	0.00172	15.1				DHWPIPEINSUHP
	Unknown Electric	0.00349	30.5				DHWPIPEINSUUE
Direct Install	Oil			0.216			DHWPIPEINSUOL
	Natural Gas				0.216		DHWPIPEINSUNG
	Propane					0.216	DHWPIPEINSUPR
	Unknown	0.00094	8.2	0.059	0.028	0.070	DHWPIPEINSUUK
	Electric Resistence	0.00551	48.2				DHWPIPEINDS LIDHWPIPEINDS
	Electric HPWH	0.00155	13.6				DHWPIPEINDSHP LIDHWPIPEINDSHP
	Unknown Electric	0.00314	27.5				DHWPIPEINDSUE
Dropship	Oil			0.194			DHWPIPEINDSOL LIDHWPIPEINDSOL
	Natural Gas				0.194		DHWPIPEINDSNG LIDHWPIPEINDSNG
	Propane					0.194	DHWPIPEINDSPR LIDHWPIPEINDSPR
	Unknown	0.00085	7.4	0.053	0.025	0.063	DHWPIPEINDSUK LIDHWPIPEINDSUK

### Footnotes

[1] Assumes 120°F water leaving the hot water tank and average temperature of basement of 65°F.

[2] Since the vast majority of Electric HPWH in VT have come through EVTs programs, a fair estimate of the number of HPWH in VT would equate the number of units captured in this program data. Since the introduction of this measure in 2011, there have been 13,605 units throughout various projects as of March 9, 2021. Please see EVT Data CUBE 2021.Msx for EVT Program data.

In order to determine the quantity of Electric Resistance DHW Systems in Residences of VT, we used this program data, along with the **NMR Group** "Vermont Single-Family Diskting Homes On-Site Report". Using the percentage of homes in VT with electric water heating (27% per Table 59), along with the quantity of owner-coccupied single-family homes in VT (171,22 per Table 6), then subtracting the Electric HPWH units in VT, we calculated 33,119 Single-family homes in Vermont with Electric Resistance water heaters.

Using the Recovery Efficiencies for these systems, along with the calculated quantities of units in VT, we then calculated a weighted average Recovery Efficiency to use in situations where the type of Electric Water Heater is unknown.

[3] Review of AHRI database shows that electric water heaters have a recovery efficiency of 98%

[4] Review of AHRI database shows that Electric Heat Pump Water Heaters have a recovery efficiency of 348.56%. For the raw data, please see AHRI\_SearchResults\_Residential Water Heaters\_HPwTank\_2021.xisx.

[5] C = Diameter (in) \* n/12. For a 0.5" pipe,  $C_{exist} = 0.131 ft;$  for a 0.75" pipe,  $C_{exist} = 0.196 ft$ 

[6] C = Diameter (in) \* n/12.

For 0.75" pipe and 1/2" foam ((0.75 + 0.5 + 0.5) \* n/12)

[7] Dropship is estimated higher than a free giveaway product as the building owner or contractor is required to actively order the required product online, confirm that it will be installed and EVT may inspect the installation at a later date. However since the installation is not performed by EVT staff or contractor (as in direct instal), a 10<sup>45</sup> discount is applied.

[8] Assuming 3.5 feet each of both the hot and cold pipes.

- [9] Navigant, "Measures and Assumptions for Demand Side Management (DSM) Planning; Appendix C Substantiation Sheets", April 2009, page 77.
- [10] Assuming R-3.2 (1/2" foam) pipe wrap insulation is added, as provided by the program. Please see attached specifications pdf or https://id.amcgmarketplace.com/product/pipe-insulation/
- [11] Review of AHRI database shows that Gas Residential Water Heaters (with Active AHRI certifications, Natural Gas, Fuel Oil & Propane Gas included) have an average recovery efficiency of 83%. Accessed February 2021.
- [12] Measure lifetime from California DEER. Average of values for electric DHW (13 years) and gas DHW (11 years). See file DEER2014-EUL-tableupdate. 2014-02-05.xtsx.
- [13] Program data provided list cost from vendor at \$1.65 for a 7 ft section of pipe wrap. Rounded to \$2 to account for labor & shipping costs.

[14] See file EVT Analysis file for calculation details.

## **Heat Pump Water Heater**

Measure Number: RS-HWE-HPWH d Portfolio: Status: Active Effective Date: 2021/1/1 End Date: [None] [ None ] Efficient Products Program Hot Water Program: End Use:

Update Summary
Update High Efficiency equipment standards to the latest NEEA "A Specification for Residential Water Heaters, Advanced Water Heating
Specifications" Version 7.0, diffective June 30, 2020. There has also been a shift in the Federal Baseline from measuring the Efficiency Rating as EF to UEF
(Uniform Energy Factor). Values are comparable, with only a change to the rating's name. NEEA also renamed their Northern Climate Uniform Energy
Factor (UEFnc) to Cool Climate Efficiency (CCE).

Also there was a program request to combine Tiers 1 & 2, whereas Tiers 3 & 4 remain seperate. As of December 2020, there are no Tier 2 Qualified products in the list tabulated by NEEA.

### Referenced Documents

- NEEA HPWH Advanced-Water-Heating-Specification\_7\_0\_FINAL
   NMR\_VT SF Existing Homes Onsite Report FINAL 072018
   ACSOPPY2018\_DPM\_2020-12-08
   Electronic Code of Federal Regulations eCFR\_Title 10 Energy Chapter II D 430\_32

- Electronic Code of Federal Regulations oFCR\_Title 10 Energy Chapter II D 430\_32
   NEEA\_AVISE NEWH-qualified-producti-lineLipotated 11\_3\_2020
   1271697\_44\_41\_73\_14\_tmp2019
   EPA, vocadotexes, 2020
   NEEP, Inproved-PW daterHeaters\_Incremental Costs, 2016
   NEEP Incremental Cost Study F1NUL 06/016
   NIEEL, National Residential Efficiency Measures Database Retroft Measures for Water Heater\_J4PWH 50
   TRM\_Analysis\_RES HPWH\_NEEA\_Spec\_2020 EFN4L

### Description

This measure charaterization provides documentation of prescriptive savings estimates for the installation of Heat Pump Water Heater (HPWH) in place of a baseline water heater in a residential application.

Savings are presented dependent on the existing water heater fuel type, Federal Standards, and HPWH storage volume. HPWH efficiency has been reduced to account for differences in field performance versus rated efficiency due to ambient conditions, hot water demand, and other factors, and a heating penalty is assessed to account for the impact of the PMWH of the homes heating justaly.

In program year 2017 Efficiency Vermont HPWH program adopted the NEEA Northern Climate Specification, which provides added energy efficiency guidance to manufacturers developing HPWHs. The updated equipment specification is known as the Advanced Water Heater Specification. Homes with existing natural gas water heaters are not eligible for savings under this measure.

# Program Type Calculation Type: Time of Sale (Market Opportunity)

Program Delivery / Implementation Type: Upstream, Downstream; Direct Install

### **Baseline Efficiencies**

The baseline condition for a market opportunity HPWH is assumed to be a new water heater that uses the same fuel as the home's existing water h and follows the current Federal Standard for residential water heaters<sup>1</sup>]

### High Efficiency

re the installed equipment must be NEEA Tier 1, 2, 3 or 4 certified HPWH [2] .

### Algorithms

Electric Demand Savings The reduction (or increase) in electric demand due to the installation of a HPWH is derived below ba sed on prescriptive energy s

### = \Delta kWh / Hours ∆kW

Symbol Table

Electric Energy Savings For cases where this measure is installed in a home with an existing electric resistance water heater, or in a new construction project, electric savings account for the improvement in performance of a HPWH over a baseline electric resistance water heater. For homes with existing fossil fuel water heaters, the installation of a HPWH results in an electric penalty equal to the annual electricity use of the wa

heater to represent the added electric load.

In both scenarios, a penalty is taken into account for the heating load placed on a home's heating system by the HPWH, apportio percentage of homes in Vermont with electric heat.

For prescriptive purposes, savings and penalties will be assigned using Deemed Values, outlined in Table 3.

ΔkWh	= $\Delta UEF_{Elec} \times Q_{DHW} \times (1 - PF\_ElecHeat)$
ΔUEF <sub>Elec</sub>	= (1/UEF_{ExcBASE} - 1/UEF_{HPWh}) for homes with existing electric water heaters and new homes
ΔUEF <sub>Elec</sub>	= – 1/UEF_HPWh for homes with existing fossil fuel fired water heaters
PF_ElecHeat	= WHHF x ExistDHWElec x %HeatSourceElectric / COP

# Symbol Table

Forsil Fuel Savings For homes with existing fossil fuel water heaters, fuel switching results in fuel savings equal to the annual fuel use that would have resulted if a baseline For upstream measures where fossil fuel type may be unknown, savings are apportioned based on the breakdown of water heating fuels in Verr homes, excluding natural gas. A fossil fuel penalty is taken to account for the heating load placed on a home's heating system by the HPWH. mont

For prescriptive purposes, this increased heating usage is allocated by fuel type based on the breakdown of primary heating fuel types in Vermont h excluding natural gas.

Savings and penalties will be assigned using deemed values, outlined in Table 3.

	hteatwoon) x %HeatSourcewoon))
	ŋHeatwood) x %HeatSourcewood))
	HF x ExistDHWElec x ΔUEF <sub>Elec</sub> x Q <sub>DHW</sub> x (((1/ηHeato <sub>1L</sub> ) x %HeatSource <sub>O1L</sub> )+((1/ηHeat <sub>PROPANE</sub> ) x %HeatSource <sub>PROPANE</sub> )
SF_FF_DHW = Q <sub>D</sub>	$\label{eq:hardenergy} \texttt{X} \texttt{ExistDHWFF} \texttt{X} (((1/\texttt{UEF}_{PROPANE}) \texttt{X} \texttt{%DHW}_{PROPANE}) \texttt{+} ((1/\texttt{UEF}_{O1L}) \texttt{X} \texttt{\%DHW}_{O1L}))$
ΔMMBtu = (SF	_FF_DHW - PF_FF_Heating)

%DHW <sub>OIL</sub>						
						known fuel types, a prescreening is conducted to exclude
		homes with existing	natural gas	water heater	s.	
		Water Heater Fu	el Source	%		
		Oil-fired		1.0		
		Unknown Fossil Fue	a[11]	0.46		
		Propane-fired		0.0		
		L				
2/DIN/		-				
%DHWPROPANE		homes with existing				known fuel types, a prescreening is conducted to exclude
				%		
		Water Heater Fu	ei source			
		Oil-fired		0.0		
		Unknown Fossil Fue	2(11)	0.54		
		Propane-fired		1.0		
%HeatSource	-	Portion of homes in	Vermont wit	h various he	at sources.	Please see table below for values:
		Heating Fuel Type	Percenta	age of hom	es (VT) <sup>[3]</sup>	
		Electric	6.2%			
		Fuel Oil	53.4%			
		Propane	20.3%			
		Wood/Other	20.1%			
AkW	-	Gross customer conr	nacted load k	All cavinas fi	or the mean	200
		Cross castoriner com	incence indea i	ar sarings i	or the med.	Sui C
ΔkWh	-	Gross customer anni	ual KWh savi	ngs for the n	neasure	
ΔMMBtu	-	Gross customer ann	ual MMBtu sa	avings for the	e measure	
ΔUEF <sub>Elec</sub>		Change in efficiency	or water hea	aung system		
ηHeat	-	Weighted Average E	fficiency, ple	ase see belo	w for Fuel	Types.
		Fuel Oil <sup>[12]</sup> Prop	ane <sup>[12]</sup> W	ood <sup>[13]</sup>		
		82.8% 87.79		1.0%		
COR					wating a	
COP		Coefficient of Perform	mance of ele	concispace h	reaung syst	200
		=2.52[4]				
ExistDHWElec	-	1 if the home has an	n existing ele	ctric water h	eater <sup>[5]</sup>	
		= -1 if the home has	s an existing	fossil fuel fir	ed water h	eater
ExistDHWFF		1 if the home has	avietina 6 -	cil fuol fire d	water he-t	0.5
CAISCONVER		1 if the home has an = 0 if the home has				
		- u ii une nome has	an existing e	acunc water	neater	
Hours	-	Full load hours of wa	ater heater			
		= 2533				
DE Electiont		Manting papally factor		oreion of olo	etaio kont is	a home to uniter heat
PF_ElecHeat						home to water heat.
PF_FF_Heating	-	Heating penalty factor	or from conv	ersion of nor	n-eletric he	at in home to water heat.
Q <sub>DHW</sub>	-	Heat delivered to wa	ter in HPWH	l tank annual	ly [6].	
		= 2,649 kWh <sup>[7]</sup>			,	
		= 9.04 MMBtu				
		- 5.04 140.000				
SF_FF_DHW	-	Savings from fuel sv	vitching, acco	ounts for rep	lacement o	f baseline fossil fuel fired water heater by HPWH.
UEFHPWh	-	Uniform Energy Fact	or of heat pu	ump water h	eater – pre	scriptive value based on NEEA Northern Climate Energy
		Factor, broken down	n by Tier & V	olume capac	ity <sup>(8)</sup>	
						nding on NEEA certificiation date. This is only a difference in
					-	ently no Tier 2 certified products on the NEEA QPL.
		1		> 55 gallor	15	
		Tier 1 / Tier 2 2.3	3	2.41		
		Tier 3 2.9	5	3.10		
			-	3.10 3.20		
UEFElecBASE		Tier 3 2.9	5	3.20	iter heater	ı)
UEFElecBASE	-	Tier 3 2.9 Tier 4 3.1 Uniform Energy Fact	5 or of baselin	3.20		ŋ
UEFElecBASE		Tier 3         2.9           Tier 4         3.1           Uniform Energy Fact           Fuel         Tanl	5 cor of baselin k Volume	3.20 e electric wa	F	ı)
UEFElecBASE		Tier 3         2.9           Tier 4         3.1           Uniform Energy Fact           Fuel         Tanl           Electric         ≥ 20	5 cor of baselin k Volume ) gal and ≤ 5	3.20 e electric wa 5 gal 0.	<b>EF</b> 92	ŋ
	-	Tier 3         2.9           Tier 4         3.1           Uniform Energy Fact           Fuel         Tanl           Electric         ≥ 20           UEF calculations ass	5 xor of baselin k Volume ) gal and ≤ 5 <i>sume Medium</i>	3.20 e electric wa 5 gal 0. n Draw patte	e <b>F</b> 92 rn <sup>(9)</sup> .	
UEFEISCBASE	-	Tier 3         2.9           Tier 4         3.1           Uniform Energy Fact           Fuel         Tanl           Electric         ≥ 20           UEF calculations ass           Uniform Energy Fact	5 k Volume ) gal and ≤ 5 sume Medium cor (efficiency	3.20 e electric wa 5 gal 0. n Draw patte	e <b>F</b> 92 rn <sup>(9)</sup> .	
	•	Tier 3         2.9           Tier 4         3.1           Uniform Energy Fact           Fuel         Tanl           Electric         ≥ 20           UEF calculations ass	5 k Volume ) gal and ≤ 5 sume Medium cor (efficiency	3.20 e electric wa 5 gal 0. n Draw patte	e <b>F</b> 92 rn <sup>(9)</sup> .	
	-	Tier 3         2.9           Tier 4         3.1           Uniform Energy Fact         Fuel           Fuel         Tanl           Electric         ≥ 20           UEF calculations ass         Uniform Energy Fact           Uniform Energy Fact         Fuel           Oil         All (C)	5 x Volume a) gal and ≤ 5 <i>sume Medium</i> xor (efficiency k Volume 14)	3.20 e electric wa 5 gal 0. n Draw patte y) of Baseline UEF 0.53	eF 92 rn <sup>(9)</sup> .	
	-	Tier 3         2.9           Tier 4         3.1           Uniform Energy Fact         Tanil           Electric         ≥ 20           UEF calculations ass         Uniform Energy Fact           Uniform Energy Fact         Fuel Tanil	5 x Volume a) gal and ≤ 5 <i>sume Medium</i> xor (efficiency k Volume 14)	3.20 e electric wa 5 gal 0. <i>n Draw patte</i> y) of Baseline <b>UEF</b> 0.53	eF 92 rn <sup>(9)</sup> .	
UEF01L		Tier 3         2.9           Tier 4         3.1           Uniform Energy Fact         Tanl           Electric         ≥ 20           UEF calculations ass         Uniform Energy Fact           Fuel         Tan           Oil         All           UEF calculations ass         Uniform Energy Fact	5 5 k Volume ) gal and ≤ 5 <i>urme Medium</i> tor (efficiency k Volume 14) urme Medium	3.20 e electric wa 5 gal 0. n Draw patte 0.53 n Draw patte	EF 92 92 • Fuel Oil w <i>rn</i> <sup>(9)</sup> .	ater heater <sup>(1)</sup> .
		Tier 3         2.9           Tier 4         3.1           Uniform Energy Fact         Tanl           Electric         ≥ 20           UEF calculations ass         Uniform Energy Fact           Fuel         Tan           Oil         All'           UEF calculations ass         Uniform Energy Fact           Uniform Energy Fact         Uniform Energy Fact	5 5 5 0 gal and ≤ 5 <i>urme Medium</i> or (efficiency k Volume 14) <i>urme Medium</i> <i>urme Medium</i>	3.20 e electric wa 5 gal 0. 10 Draw patte 0.53 10 Draw patte 0.53 10 Draw patte	EF 92 92 • Fuel Oil w <i>rn</i> <sup>(9)</sup> .	ater heater <sup>(1)</sup> .
UEF01L		Tier 3         2.9           Tier 4         3.1           Uniform Energy Fact         Tanh           Electric         ≥ 20 <i>LEF calculations</i> ass         Uniform Energy Fact           Goi         All' <i>Oci</i> All'           Uniform Energy Fact         Electric           Goi         All' <i>Uniform</i> Energy Fact         Face <b>Fuel Type</b> Tanh	5 5 5 wor of baselin k Volume b) gal and ≤ 5 www.edium or (efficiency www.edium tiq) www.edium tiq) www.edium tiq) wor (efficiency tiq) vor (efficiency tiq) vor (efficiency tiq)	3.20 e electric wa 5 gal 0. 10 Draw patter () of Baselinu UEF () 0.53 10 Draw patter () 0f Baselinu () 0f Baselinu	EF 92 92 • Fuel Oil w <i>rn</i> <sup>(9)</sup> .	ater heater <sup>(1)</sup> .
UEF01L		Tier 3         2.9           Tier 4         3.1           Uniform Energy Fact         Tani           Electric         ≥ 20           Utiform Energy Fact         Tani           Fuel Type         Tani           Oil         Aur           Utiform Energy Fact         Energy Fact           Evel Type         Tani           Oil         Aur           Uniform Energy Fact         Fuel Type           Tani         Aur           Oil         Aur           Propane         ≥ 20	5 5 5 0 gal and ≤ 5 <i>urme Medium</i> or (efficiency k Volume 14) <i>urme Medium</i> <i>urme Medium</i>	3.20 e electric wa 5 gal 0. 10 Draw patte 0.53 10 Draw patte 0.53 10 Draw patte	EF 92 92 • Fuel Oil w <i>rn</i> <sup>(9)</sup> .	ater heater <sup>(1)</sup> .
UEF01L		Tier 3         2.9           Tier 4         3.1           Uniform Energy Fact         Tanl           Electric         ≥ 20           Uber Calculations ass         Uniform Energy Fact           Fuel Type         Tan           Oil         All'I           UEF calculations ass         Uniform Energy Fact           Fuel Type         Tank           Propane         ≥ 20           gal         gal	5 5 5 5 5 5 5 5 5 5 5 5 5 5	3.20 e electric wa 5 gal 0. 1 Draw patter () of Baseline 1 Draw patter () of Baseline () of Baseline () OF Baseline () DEF 0.56	EF 92 92 • Fuel Oil w <i>rn</i> <sup>(9)</sup> .	ater heater <sup>(1)</sup> .
UEF01L		Tier 3         2.9           Tier 4         3.1           Uniform Energy Fact         Tanl           Electric         ≥ 20           Uber Calculations ass         Uniform Energy Fact           Fuel Type         Tan           Oil         All'I           UEF calculations ass         Uniform Energy Fact           Fuel Type         Tank           Propane         ≥ 20           gal         gal	5 5 5 wor of baselin k Volume b) gal and ≤ 5 www.edium or (efficiency www.edium tiq) www.edium tiq) www.edium tiq) wor (efficiency tiq) vor (efficiency tiq) vor (efficiency tiq)	3.20 e electric wa 5 gal 0. 1 Draw patter () of Baseline 1 Draw patter () of Baseline () of Baseline () OF Baseline () DEF 0.56	EF 92 92 • Fuel Oil w <i>rn</i> <sup>(9)</sup> .	ater heater <sup>(1)</sup> .
UEF01L		Tier 3         2.9           Tier 4         3.1           Uniform Energy Fact         Tanh           Electric ≥ 20         200           UEF calculations ass         201           Uniform Energy Fact         Tanh           Noil All (         All (           ULEF calculations ass         Uniform Energy Fact           Fuel Type Tanh         Tanh           Propane ≥ 20         201           Propane ≥ 55 gal         921	5 5 5 5 0 gal and ≤ 5 <i>uume Medium</i> or (efficiency <b>k Volume</b> Hel uume Medium or (efficiency <b>volume</b> gal & ≤ 55 gal & ≤ 100	3.20 e electric wa j g al 0. <i>a Draw patte</i> <i>y</i> ) of Baseline UEF 0.53 <i>D Draw patte</i> <i>y</i> ) of Baseline <i>D</i> (0.56 0.56	eF 92 e Fuel Oil w rn <sup>(9)</sup> .	ater heater <sup>(1)</sup> .
UEF01L		Tier 3         2.9           Tier 4         3.1           Uniform Energy Fact         Tani           Electric         ≥ 20           LUF calculations ass         Uniform Energy Fact           Fuel         Tani           Oil         All (:           LUF calculations ass         Uniform Energy Fact           Fuel Type         Tani           Oil         All (:           Uniform Energy Fact         Energy Fact           Propane         ≥ 20           gal         Propane         ≥ 30           Propane         ≥ 55 c	5 5 5 5 0 gal and ≤ 5 <i>uume Medium</i> or (efficiency <b>k Volume</b> Hel uume Medium or (efficiency <b>volume</b> gal & ≤ 55 gal & ≤ 100	3.20 e electric wa j g al 0. <i>a Draw patte</i> <i>y</i> ) of Baseline UEF 0.53 <i>D Draw patte</i> <i>y</i> ) of Baseline <i>D</i> (0.56 0.56	eF 92 e Fuel Oil w rn <sup>(9)</sup> .	ater heater <sup>(1)</sup> .
UEF01L	-	Tier 3         2.9           Tier 4         3.1           Uniform Energy Fact         Tanh           Electric ≥ 20         200           UEF calculations ass         201           Uniform Energy Fact         Tanh           Noil All (         All (           ULEF calculations ass         Uniform Energy Fact           Fuel Type Tanh         Tanh           Propane ≥ 20         201           Propane ≥ 55 gal         921	5 5 5 5 5 0 gal and ≤ 5 0 gal and ≤ 5 141 141 141 142 142 142 143 144 143 144 144 144 144 144	3.20 e electric wa f gal 0. f Draw patte e) of Baseline UEF 0.55 f Draw patte e) of Baseline UEF 0.56 0.56 0.76	eF         92           92         92           a Fuel Oil w         97	ater heater <sup>(1)</sup> . vater heater <sup>(1)</sup> .
UEF01L UEFpropane	-	Tier 3         2.9           Tier 4         3.1           Uniform Energy Fact         Tanl           Electric         ≥ 20           UEF calculations ass         Uniform Energy Fact           Fuel Type         Tan           Oil         All (C           Utiform Energy Fact         Fuel Type           Fuel Type         Tank           Propane         ≥ 52 (gal           UEF calculations ass         Uniform Energy Fact           Fuel Type         Tank           Propane         ≥ 55 (gal           Quet         Soft (Calculations ass)	5 5 5 5 5 0 gal and ≤ 5 0 gal and ≤ 5 141 141 141 142 142 142 143 144 143 144 144 144 144 144	3.20 e electric wa f gal 0. f Draw patte e) of Baseline UEF 0.55 f Draw patte e) of Baseline UEF 0.56 0.56 0.76	eF         92           92         92           a Fuel Oil w         97	ater heater <sup>(1)</sup> . vater heater <sup>(1)</sup> .
UEF01L UEFpropane	-	Tier 3         2.9           Tier 4         3.1           Uniform Energy Fact         Tan           Electric         ≥ 20           LEF calculations ass         Uniform Energy Fact           Fuel         Tan           Oil         All           UteF calculations ass         Uniform Energy Fact           Fuel Type         Tan           Oil         All           Uniform Energy Fact         Uniform Energy Fact           Fuel Type         Tank           Propane         ≥ 20           gal         Propane           > 25         Sal           UEF calculations ass         Peropane           > Sal         Sal           Department         Sal           UEF calculations ass         Peropane	5 5 5 5 5 0 gal and ≤ 5 0 gal and ≤ 5 141 141 141 142 142 142 143 144 143 144 144 144 144 144	3.20 e electric wa f gal 0. f Draw patte e) of Baseline UEF 0.55 f Draw patte e) of Baseline UEF 0.56 0.56 0.76	eF         92           92         92           a Fuel Oil w         97	ater heater <sup>(1)</sup> . vater heater <sup>(1)</sup> .
UEF01L UEFpropane	-	Tier 3         2.9           Tier 4         3.1           Uniform Energy Fact         Tan           Electric         ≥ 20           LEF calculations ass         Uniform Energy Fact           Fuel         Tan           Oil         All           UteF calculations ass         Uniform Energy Fact           Fuel Type         Tan           Oil         All           Uniform Energy Fact         Uniform Energy Fact           Fuel Type         Tank           Propane         ≥ 20           gal         Propane           > 25         Sal           UEF calculations ass         Peropane           > Sal         Sal           Department         Sal           UEF calculations ass         Peropane	5 5 5 5 5 0 gal and ≤ 5 0 gal and ≤ 5 141 141 141 142 142 142 143 144 143 144 144 144 144 144	3.20 e electric wa f gal 0. f Draw patte e) of Baseline UEF 0.55 f Draw patte e) of Baseline UEF 0.56 0.56 0.76	eF         92           92         92           a Fuel Oil w         97	ater heater <sup>(1)</sup> . vater heater <sup>(1)</sup> .
UEFoil UEFpropanie WHHF		Tier 3         2.9           Tier 4         3.1           Uniform Energy Fact         Tani           Electric         2.20           Utiform Energy Fact         Tani           Electric         2.20           Utiform Energy Fact         Tani           Fuel Type         Tani           Oil         Attributors ass           Uniform Energy Fact         Fuel Type           Fuel Type         Tanik           Propane         2.0           gal         Propane           VEF calculations ass         Portion of reduced w           =0.56 (c)         Gal	5 5 5 5 5 0 gal and ≤ 5 0 gal and ≤ 5 141 141 141 142 142 142 143 144 143 144 144 144 144 144	3.20 e electric wa f gal 0. f Draw patte e) of Baseline UEF 0.55 f Draw patte e) of Baseline UEF 0.56 0.56 0.76	eF         92           92         92           a Fuel Oil w         97	ater heater <sup>(1)</sup> . vater heater <sup>(1)</sup> .
UEF01L UEFpropane		Tier 3         2.9           Tier 4         3.1           Uniform Energy Fact         Tani           Electric         2.20           Utiform Energy Fact         Tani           Electric         2.20           Utiform Energy Fact         Tani           Fuel Type         Tani           Oil         Attributors ass           Uniform Energy Fact         Fuel Type           Fuel Type         Tanik           Propane         2.0           gal         Propane           VEF calculations ass         Portion of reduced w           =0.56 (c)         Gal	5 5 5 5 5 0 gal and ≤ 5 0 gal and ≤ 5 141 141 141 142 142 142 143 144 143 144 144 144 144 144	3.20 e electric wa f gal 0. f Draw patte e) of Baseline UEF 0.55 f Draw patte e) of Baseline UEF 0.56 0.56 0.76	eF         92           92         92           a Fuel Oil w         97	ater heater <sup>(1)</sup> . vater heater <sup>(1)</sup> .
UEFoil UEFpropanie WHHF		Tier 3         2.9           Tier 4         3.1           Uniform Energy Fact         Tani           Electric         2.20           Utiform Energy Fact         Tani           Electric         2.20           Utiform Energy Fact         Tani           Fuel Type         Tani           Oil         Attributors ass           Uniform Energy Fact         Fuel Type           Fuel Type         Tanik           Propane         2.0           gal         Propane           VEF calculations ass         Portion of reduced w           =0.56 (c)         Gal	5 5 5 5 5 0 gal and ≤ 5 0 gal and ≤ 5 141 141 141 142 142 142 143 144 143 144 144 144 144 144	3.20 e electric wa f gal 0. f Draw patte e) of Baseline UEF 0.55 f Draw patte e) of Baseline UEF 0.56 0.56 0.76	eF         92           92         92           a Fuel Oil w         97	ater heater <sup>(1)</sup> . vater heater <sup>(1)</sup> .
UEFoil UEFpropanie WHHF		Tier 3         2.9           Tier 4         3.1           Uniform Energy Fact         Tani           Electric         2.20           Utiform Energy Fact         Tani           Electric         2.20           Utiform Energy Fact         Tani           Fuel Type         Tani           Oil         Attributors ass           Uniform Energy Fact         Fuel Type           Fuel Type         Tanik           Propane         2.0           gal         Propane           VEF calculations ass         Portion of reduced w           =0.56 (c)         Gal	5 5 5 5 5 0 gal and ≤ 5 0 gal and ≤ 5 141 141 141 142 142 142 143 144 143 144 144 144 144 144	3.20 e electric wa f gal 0. f Draw patte e) of Baseline UEF 0.55 f Draw patte e) of Baseline UEF 0.56 0.56 0.76	eF         92           92         92           a Fuel Oil w         97	ater heater <sup>(1)</sup> . vater heater <sup>(1)</sup> .
UEFoil UEFPROPANE WHHF		Tier 3         2.9           Tier 4         3.1           Uniform Energy Fact         Tani           Electric         2.20           Utiform Energy Fact         Tani           Electric         2.20           Utiform Energy Fact         Tani           Fuel Type         Tani           Oil         Attributors ass           Uniform Energy Fact         Fuel Type           Fuel Type         Tanik           Propane         2.0           gal         Propane           VEF calculations ass         Portion of reduced w           =0.56 (c)         Gal	5 5 5 5 5 0 gal and ≤ 5 0 gal and ≤ 5 141 141 141 142 142 142 143 144 143 144 144 144 144 144	3.20 e electric wa f gal 0. f Draw patte e) of Baseline UEF 0.55 f Draw patte e) of Baseline UEF 0.56 0.56 0.76	eF         92           92         92           a Fuel Oil w         97	ater heater <sup>(1)</sup> . vater heater <sup>(1)</sup> .
UEFoil UEFpropanie WHHF	= =	Tier 3         2.9           Tier 4         3.1           Uniform Energy Fact         Tani           Electric         2.20           Utiform Energy Fact         Tani           Electric         2.20           Utiform Energy Fact         Tani           Fuel Type         Tani           Oil         Attributors ass           Uniform Energy Fact         Fuel Type           Fuel Type         Tanik           Propane         2.0           gal         Propane           VEF calculations ass         Portion of reduced w           =0.56 (c)         Gal	5 5 5 5 5 0 gal and ≤ 5 0 gal and ≤ 5 141 141 141 142 142 142 143 144 143 144 144 144 144 144	3.20 e electric wa f gal 0. f Draw patte e) of Baseline UEF 0.55 f Draw patte e) of Baseline UEF 0.56 0.56 0.76	eF         92           92         92           a Fuel Oil w         97	ater heater <sup>(1)</sup> . vater heater <sup>(1)</sup> .
UEFoil UEFpagrane WHHF -Life Savings A	= = Adjus	Tier 3         2.9           Tier 4         3.1           Uniform Energy Fact         Tan           Electric         2.20           Utiform Energy Fact         Tan           Electric         2.20           Utiform Energy Fact         Tan           Fuel Type         Tan           Oil         AUT           UEF calculations ass         Uniform Energy Fact           Fuel Type         Tank           Propane         2.20           gal         Propane           >SST         Potion of reduced w           =0.542189         Stment	or of baselin and states and sta	3.20	ep         92           92         1           92         1           92         1           92         1           92         1           92         1           92         1           92         1           92         1           92         1           93         1           94         1           95         1           97         1   97<	ater heater <sup>[1]</sup> .
UEFpropante WHHF -Life Savings J	= = Adjus	Tier 3         2.9           Tier 4         3.1           Uniform Energy Fact         Tan           Electric         2.20           Utiform Energy Fact         Tan           Electric         2.20           Utiform Energy Fact         Tan           Fuel Type         Tan           Oil         AUT           UEF calculations ass         Uniform Energy Fact           Fuel Type         Tank           Propane         2.20           gal         Propane           >SST         Potion of reduced w           =0.542189         Stment	or of baselin and states and sta	3.20	ep         92           92         1           92         1           92         1           92         1           92         1           92         1           92         1           92         1           92         1           92         1           93         1           94         1           95         1           97         1   97<	ater heater <sup>(1)</sup> . vater heater <sup>(1)</sup> .
UEFPROPANE UEFPROPANE WHHF -Life Savings / d Shapes sidential DHW fuel sw ber Name	= = Adju: vitch	Tier 3         2.9           Tier 4         3.1           Uniform Energy Fact         Tan           Electric         2.20           Utiform Energy Fact         Tan           Electric         2.20           Utiform Energy Fact         Tan           Fuel Type         Tan           Oil         AUT           UEF calculations ass         Uniform Energy Fact           Fuel Type         Tank           Propane         2.20           gal         Propane           >SST         Potion of reduced w           =0.542189         Stment	s or of baselin k Volume gal and s 5 s (or (efficiency) k Volume (efficiency) gal & s 55 gal & s 100 ume Medium maste head th heads head the field with of KW	3.20  4.20 4	שר איז	ater heater <sup>(1)</sup> . vater heater <sup>(1)</sup> . vater heater <sup>(1)</sup> . vater heater <sup>(1)</sup> . Winter Summer
UEFPROPANE UEFPROPANE WHHF -Life Savings / d Shapes sidential DHW fuel sw ber Name	= = Adju: vitch	Tier 3         2.9           Tier 4         3.1           Uniform Energy Fact         Tani           Bactric         2.9           Uniform Energy Fact         Tani           Bactric         2.9           Uniform Energy Fact         Tani           Bactric         2.9           Uniform Energy Fact         Tani           Dia         AUT           UEF calculations ass         Uniform Energy Fact           Buel Type         Tani           Propane         2.0           gal         Propane           2.9         Gal           UEF calculations ass         Portion of reduced w           =0.54210         Status         Wint	s or of baselin k Volume gal and s 5 s (or (efficiency) k Volume (efficiency) gal & s 55 gal & s 100 ume Medium maste head th heads head the field with of KW	3.20  4.20 4	שר איז	ater heater <sup>(1)</sup> . vater heater <sup>(1)</sup> . vater heater <sup>(1)</sup> . vater heater <sup>(1)</sup> . Winter Summer
UEFPROPANE UEFPROPANE WHHF -Life Savings / d Shapes sidential DHW fuel sw ber Name	= = Adju: vitch	Tier 3         2.9           Tier 4         3.1           Uniform Energy Fact         Tani           Bactric         2.9           Uniform Energy Fact         Tani           Bactric         2.9           Uniform Energy Fact         Tani           Bactric         2.9           Uniform Energy Fact         Tani           Dia         AUT           UEF calculations ass         Uniform Energy Fact           Buel Type         Tani           Propane         2.0           gal         Propane           2.9         Gal           UEF calculations ass         Portion of reduced w           =0.54210         Status         Wint	s or of baselin k Volume gal and s 5 s (or (efficiency) k Volume (efficiency) gal & s 55 gal & s 100 ume Medium maste head th heads head the field with of KW	3.20  4.20 4	שר איז	ater heater <sup>(1)</sup> . vater heater <sup>(1)</sup> . vater heater <sup>(1)</sup> . vater heater <sup>(1)</sup> . Winter Summer
UEFort. UEFPROPANE WHHF -Life Savings J d Shapes sidential DHW fuel sw ber Name Residential DHW	= = Addjus: vitch we V fuel so	Tier 3         2.9           Tier 4         3.1           Uniform Energy Fact         Tani           Bactric         2.9           Uniform Energy Fact         Tani           Bactric         2.9           Uniform Energy Fact         Tani           Bactric         2.9           Uniform Energy Fact         Tani           Dia         AUT           UEF calculations ass         Uniform Energy Fact           Buel Type         Tani           Propane         2.0           gal         Propane           2.9         Gal           UEF calculations ass         Portion of reduced w           =0.54210         Status         Wint	s or of baselin k Volume gal and s 5 s (or (efficiency) k Volume (efficiency) gal & s 55 gal & s 100 ume Medium maste head th heads head the field with of KW	3.20  4.20 4	שר איז	ater heater <sup>(1)</sup> . vater heater <sup>(1)</sup> . vater heater <sup>(1)</sup> . vater heater <sup>(1)</sup> . Winter Summer
UEFPROPANE UEFPROPANE WHHF -Life Savings / d Shapes sidential DHW fuel sw ber Name	= = Addjus: vitch we V fuel so	Tier 3         2.9           Tier 4         3.1           Uniform Energy Fact         Tani           Bactric         2.9           Uniform Energy Fact         Tani           Bactric         2.9           Uniform Energy Fact         Tani           Bactric         2.9           Uniform Energy Fact         Tani           Dia         AUT           UEF calculations ass         Uniform Energy Fact           Buel Type         Tani           Propane         2.0           gal         Propane           2.9         Gal           UEF calculations ass         Portion of reduced w           =0.54210         Status         Wint	s or of baselin k Volume gal and s 5 s (or (efficiency) k Volume (efficiency) gal & s 55 gal & s 100 ume Medium maste head th heads head the field with of KW	3.20  4.20 4	שר איז	ater heater <sup>(1)</sup> . vater heater <sup>(1)</sup> . vater heater <sup>(1)</sup> . vater heater <sup>(1)</sup> . Winter Summer
UEFoit. UEF <sub>PROPANE</sub> WHHF -Life Savings J d Shapes idential DHW fuel sw ber Name Residential DHW	= = Adjus vitch N fuel sv X fuel sv	Tier 3         2.9           Tier 4         3.1           Uniform Energy Fact         Tani           Electric         2.20           Uniform Energy Fact         Tani           Electric         2.20           Uniform Energy Fact         Tani           Electric         2.01           Uniform Energy Fact         Tani           Fuel Type         Tani           Propane         2.01           Propane         2.02           pal         Propane           2.95         2.01	s or of baselin k Volume gal and s 5 s (or (efficiency) k Volume (efficiency) gal & s 55 gal & s 100 ume Medium maste head th heads head the field with of KW	3.20  4.20 4	שר איז	ater heater <sup>(1)</sup> . vater heater <sup>(1)</sup> . vater heater <sup>(1)</sup> . vater heater <sup>(1)</sup> . Winter Summer

Tracks [Base Track] 6013UPST [is base track] Upstream - Commercial 6032EPEP [is base track] Efficient Products - Residential 6032UPST [6032EPEP] Upstream - Residential 6013EPEP [6032EPEP] Efficient Products - Comm

 Track Name
 Track N. Measure Code
 Free Rider Spill Over

 Upstream - Commercial
 6013UPST HWEHWHTP
 1.00
 1.00

 Efficient Products - Residential 6032EPEP HWEHWHTP
 1.00
 1.10

### Lifetimes

LITECIMES The expected measure life is assumed to be 12 years<sup>[15]</sup>. For retrofit measures, it is assumed that the existing water heating equipment has four years of remaining life and would be replaced with baseline equipment with the associated installed cost at end of life. Analysis period is the same as the lifetime.

### Measure Cost

For measures installed in a market opportunity situation, the measure cost is the incremental cost for the installation of a HPWH versus baseline equipment based on the existing water heater fuel type<sup>[16]</sup>. For retrofit measures, the measure cost is the full cost for the installation of a HPWH. Table 1 – Measure Costs - Market Opportunity

HPWH Volume	Existing DHW Energy Source	Incre	mental Cost	
	Electric			
< 55	Oil fired	s	818	
< 33	Propane fired	>		
	Unknown Fossil Fuel			
	Electric			
> 55	Oil fired	\$	934[17]	
2 33	Propane fired	2	934(**)	
	Unknown Fossil Fuel			

HPWH Volume	Full Cost of Installation [18]
< 55	\$ 2,087.41
> 55	\$ 2,820.23[19]

### O&M Cost Adjustments

, nance cost adjustments for this measure n and mi

### Prescriptive Savings

Fr cscl spute Savings For prescriptive purposes this measure has been binned based on Storage Volume range, existing water heater fuel type and proposed HPWH NEEA Tier as follows:

### Table 3 – Prescriptive Savings Values<sup>[20]</sup>

Storage Volume	Existing DHW Fuel Source	NEEA Tier	∆kWh	ΔkW	ΔMMBtu_Propane	∆MMBtu_Oil	ΔMMBtu_Wood
	Electric	Tier 1 / Tier 2	1,714.58	0.68	-0.74	-2.07	-0.88
		Tier 3	1,953.06	0.77	-0.85	-2.36	-1.01
		Tier 4	2,009.00	0.79	-0.87	-2.43	-1.04
		Tier 1 / Tier 2	-1,154.74	-0.46	-0.49	15.77	-0.58
	Fuel Oil	Tier 3	-909.76	-0.36	-0.38	16.06	-0.46
< 55		Tier 4	-852.31	-0.34	-0.36	16.12	-0.43
		Tier 1 / Tier 2	-1,154.74	-0.46	15.56	-1.36	-0.58
	Propane	Tier 3	-909.76	-0.36	15.66	-1.07	-0.46
		Tier 4	-852.31	-0.34	15.69	-1.00	-0.43
	Unknown Fossil Fuel	Tier 1 / Tier 2	-1,154.74	-0.46	8.51	6.18	-0.58
		Tier 3	-909.76	-0.36	8.62	6.47	-0.46
		Tier 4	-852.31	-0.34	8.64	6.53	-0.43
	Electric	Tier 1 / Tier 2	1,756.15	0.69	-0.76	-2.12	-0.91
		Tier 3	1,996.31	0.79	-0.87	-2.41	-1.03
		Tier 4	2,021.96	0.80	-0.88	-2.44	-1.04
		Tier 1 / Tier 2	-1,112.03	-0.44	-0.47	15.82	-0.56
	Fuel Oil	Tier 3	-865.34	-0.34	-0.37	16.11	-0.43
> 55		Tier 4	-838.99	-0.33	-0.35	16.14	-0.42
/ 33		Tier 1 / Tier 2	-1,112.03	-0.44	11.35	-1.31	-0.56
	Propane	Tier 3	-865.34	-0.34	11.46	-1.02	-0.43
		Tier 4	-838.99	-0.33	11.47	-0.99	-0.42
		Tier 1 / Tier 2	-1,112.03	-0.44	7.28	5.18	-0.56
	Unknown Fossil Fuel	Tier 3	-865.34	-0.34	7.39	5.47	-0.43
	Fossil Fuel	Tier 4	-838.99	-0.33	7.40	5.50	-0.42

### Footnotes

- [1] CFR, Tile 10: Energy, Chapter II D §430.32(d) Energy and water conservation standards and their compliance dates. (Water Heaters). Vr is the Rated Storage Volume (in galions), as determined pursuant to 10 CFR 429.17. See sheet "Federal Std" in the Analysis File. Current link: http://www.edr.gov/cgi-bin/text-tdn?SID=80dfr785ea350ebeee184bb0ae03e708mc=true8node=se10.3.430\_132&rgn=dix8
- [2] NEEA Advanced Water Heater Specification v7.0 effective June 30, 2020. See file "NEEA HPWH Advanced-Water-Heating-Specification, Z. Q. FINAL.pdf". Current link. https://neea.org/our-work/advanced-water-heating-specification
- [3] American Community Survey, 2014-2018 ACS SYr Data Profile, VT, Housing Characteristics Tables, excerpt from Table DP04. See sheet "ACS Syr VT\_2018" in Analysis file for a data summary or see file "ACSDPS1/2018.DP04\_2020-12-08.csv" for the raw source data. (ACS 2018).
- [4] The COP used is an assumption based upon baseline single head CCHP efficiencies, derived from an analysis of installed heat pumps in Vermont from Vermont heat pump distributors. Calculated from an HSFF of 8.6. Please review "EVT-CCHP-Efficiency Levels" sheet, copied data from Variable Speed Mini-Split Heat Pumps (Market Opportunity) measure analysis file.
- [5] This factor ensures proper accounting of the heating penalty dependent on the fuel type of the home's existing water heater
- [6] UEF of Baseline water heater<sup>[7639]</sup> used in the calculations is 0.92 <sup>[8923]</sup>.
- [7] Average annual DHW heat input for Vermont homes, derived from metered data for homes on CVPS Rate 3: Olf-Peak Water Heating rate. See sheet "Qoven" in Analysis File.
- [3] NEEA Advanced Water Heater (Specification v7.0), Qualified Products List, accessed November 3, 2020. See sheet "NEEA QPL 2020" in Analysis file for a data summary or see file "NEEA\_AVINE NPWH-qualified-products-list, Updated 11.3.2020 updf" for the raw source data. Current link https://neea.org/our-work/datamets/water-beating-specification
- (9) Volume used (Vr) based on average volume from NEEP Phase 3 Incremental Cost Study Data. See sheet "NEEP Raw Cost Data" in Analysis file for a data summary or see file "NEEP\_Improved#PWaterHeaters\_Incremental Costs\_2016.vts." In the Installed Costs Table, for the raw source data. (NEEP 2016).
- [10] Based on bin analysis of annual Heating Hours for Burlington, VT using the 2019 set of TMY3 data: 4747 / 8760 = 54.2%. Coordinates of data =

44.41 N, 73.14 W. Location comparable to Burlington Airport. See sheet "TMY3\_Heating Hours" in Analysis file for a data summary or see file "1271697\_44.41\_73.14\_tmy-2019.csv" for the raw source data.

- Percentage Fossil Fuel split of "Homes heated in Vermont" was sourced from VT SF Existing Homes Onsite Report, Table 59, removing Natural Gas. (NMR Group, Inc. 2018)
- [12] Weighted efficiencies based on VT SF Existing Homes Onsite Report Tables 46 & 47. (NMR Group, Inc. 2018)
- [13] Weighted Average Efficiency was based off of EPA Compliant Models from Wood Stove Database, Room Heaters. See sheet "EPA WoodStoves" in Analysis file for a data summary or see file "EPA, woodstoves, 2020.xis/" for the raw source data. Current link https://www.epa.gov/compliance/epa-certified-wood-heater-database (EPA Database accessed December 2020).
- [14] Federal standard only provided for tank volume ≤ 50 gal. This calculated UEF was used for all sizes of fuel oil-fired tanks, as > 50 gallons is very rare.
- [15] NREL, National Residential Efficiency Measure Database Lifetime of Heat Pump measures. Please see files in Referenced Documents. Current link: https://remdb.nrel.gov/measures.php?gid=68ctId=270
- [16] NEEP Emerging Technologies Incremental Cost Study Final Report, Table 3-34, pg 81. (2016). See sheet "NEEP Cost Summary" in the Analysis File. For Original Report see file "NEEP Incremental Cost Study FINAL\_051016.pdf". Current linic: http://www.neep.org/incremental-cost-emerging-
- [17] Average of Baseline Storage Water Heater for 60 & 80 (Gallons) categories in Market 1 Northern New England Incremental Cost (\$/Unit).
- [18] Full cost is based on average Installed cost from NEEP Phase 3 Incremental Cost Study Data. See sheet "NEEP Raw Cost Data" & realted pivot table in "Nisc Calcs" of Analysis file for a data summary. For the raw data source, please see file "NEEP\_Improved+PWaterHeaters\_Incremental Costs, 2016.xksr," Installed Costs Table (NEEP 2016).
- [19] Average Full Cost Heat Pump Water Heater for 60, 66 & 80 gallon capacity categories (NEEP 2016).
- [20] See Analysis files for derivation of savings and input values. Prescriptive EF for each bin based on average EF of NEEA certified water heaters for each EF range.

# Ducted Air Source Heat Pump (Market Opportunity)

Ducte	a Air Sou	irce Heat Pump (Market Opportui	nity)
	er: CR-HVC-CDHPM a	•	
Portfolio: Status:	Active		
Effective Date:			
End Date: Program:	[ None ] Existing Homes		
End Use:	HVAC		
Update Su The updates to t	nmary nis measure include:		
	e number of bins for this		
		ost recent version of the NEEP Qualified Products List. ne updates to the ductless mini-split ASHP measure.	
		in changes to the deemed savings.	
	d Documents a Homes Onsite Report	- DAET 122117	
New York S	andard Approach for Est	timating Energy Savigns from Energy Efficiency Programs 2016	
	enct Standards (CFR-20 es_Measure Life Report	012-title10-vol3-sec430-32) t_Jun 2007	
	IOP and Retrofit_2018_ rgy Code Handbook_V4.	1	
<ul> <li>EVT_Centra</li> </ul>	y Ducted ASHP_Analysis	s_Aug 2020_v2	
NEEP Air So     Mid-Atlantic	rce Heat Pump QPL_Au TRM_V9	g 2020	
Descriptio			
		allation of centrally ducted air source heat pumps. Heating and cooling savings are clair al savings of an efficient heat pump versus the installation of a less efficient baseline he	
		ar efficiency standards and have a capacity of <= 72,000 Btu/hr. The characterization a cation, or application - residential or commercial. The characterization of this measure	
program deliver			
Program T	<b>/pe</b> Market Opportunity (Ti	me of Sale)	
	/Implementation Methor		
Baseline E	ficiencies		
The baseline co efficiencies:	dition is assumed to be	a new heat pump that is capable of providing heat using the heat pump cycle and mee	ts the following minimum
	ential Baseline Efficier	ncy <sup>[1]</sup>	
Equipment	HSPF SEER		
Air-Source Heat	Pump 8.2 14		
Table 2 - Comr	ercial Baseline Efficie	ncv <sup>[2]</sup>	
Equipment	HSPFSEER		
Air-Source Heat	Pump 8.1 14		
Efficient E	uipment	e. Ihe installed environment must be a centrally ducted air source heat numm listed on N	FP's Qualified Products
Efficient E To qualify for sa List, COP at 5°F	uipment ings under this measure ≥ 1.75 (at maximum cap	e, the installed equipment must be a centrally ducted air source heat pump listed on Ne activ operation), and be capable of providing heat using the heat pump cycle down to	-5°F. It must also meet or
Efficient E To qualify for sa List, COP at 5°F exceed the follo	uipment ings under this measure ≥ 1.75 (at maximum cap ing efficiency criteria, p	pacity operation), and be capable of providing heat using the heat pump cycle down to er AHRI Standard 210-240-2008 for Unitary Air-Conditioning and Air-Source Heat Pump	-5°F. It must also meet or
Efficient E To qualify for sa List, COP at 5°F exceed the follo Table 3 - Resid	uipment ings under this measure ± 1.75 (at maximum cap ing efficiency criteria, p ential and Commercia	pacity operation), and be capable of providing heat using the heat pump cycle down to er AHRI Standard 210-240-2008 for Unitary Air-Conditioning and Air-Source Heat Pump	-5°F. It must also meet or
Efficient E To qualify for sa List, COP at 5°F exceed the follo	uipment ings under this measure 1.75 (at maximum cag ing efficiency criteria, p ential and Commercia HSPF SEER	pacity operation), and be capable of providing heat using the heat pump cycle down to er AHRI Standard 210-240-2008 for Unitary Air-Conditioning and Air-Source Heat Pump	-5°F. It must also meet or
Efficient E To qualify for sa List, COP at 5°F exceed the follor Table 3 - Resid Equipment	uipment ings under this measure 1.75 (at maximum cag ing efficiency criteria, p ential and Commercia HSPF SEER	pacity operation), and be capable of providing heat using the heat pump cycle down to er AHRI Standard 210-240-2008 for Unitary Air-Conditioning and Air-Source Heat Pump	-5°F. It must also meet or
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Efficient E To qualify for sa List, COP at 5°F exceed the follor Table 3 - Resid Equipment	Uipment ings under this measure 1.75 (at maximum cap ing efficiency criteria, pe netial and Commercia HSPF SEER Pump 10 15.6	pacity operation), and be capable of providing heat using the heat pump cycle down to er AHRI Standard 210-240-2008 for Unitary Air-Conditioning and Air-Source Heat Pump	-5°F. It must also meet or
Efficient E To qualify for sa List, COP at 5°F exceed the follo Table 3 - Resid Equipment Air-Source Heat	luipment ings under this measure ing efficiency oriteria, p ential and Commercia hSPF.EER Pump10 15.6	pacity operation), and be capable of providing heat using the heat pump cycle down to er AHRI Standard 210-240-2008 for Unitary Air-Conditioning and Air-Source Heat Pump	-5°F. It must also meet or
Efficient E To qualify for sa List, COP at SPF exceed the follo Table 3 - Resit Equipment Air-Source Heat Algorithms Electric Dema	luipment ings under this measure ing efficiency oriteria, p ential and Commercia hSPF.EER Pump10 15.6	acidy operation), and be capable of providing heat using the heat pump cycle down to er AFRI Standard 210-240-2008 for Unitary Air-Conditioning and Air-Source Heat Pum I High Efficiency <sup>(3)</sup>	-5°F. It must also meet or
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# see table 6 for more details

Average Cooling Capacity Bin	Capacity Range	Item Code	∆kWh	∆kW
9,000	<=10,500	RESASHPMOP09	228	0.13
12,000	>10,500 and <= 13,500	RESASHPMOP12	334	0.20
15,000	>13,500 and <= 16,500	RESASHPMOP15	378	0.23
18,000	>16,500 and <= 21,000	RESASHPMOP18	589	0.37
24,000	>21,000 and <= 27,000	RESASHPMOP24	629	0.37
30,000	>27,000 and <= 33,000	RESASHPMOP30	948	0.59
36,000	>33,000 and <= 39,000	RESASHPMOP36	1,263	0.80
42,000	>39,000 and <= 45,000	RESASHPMOP42	1,708	1.11
48,000	>45,000 and <= 51,000	RESASHPMOP48	2,288	1.52
54,000	>51,000 and <= 57,000	RESASHPMOP54	2,401	1.59
60,000	>57,000 and <= 63,000	RESASHPMOP60	2,901	1.91
66,000	>63,000 and <= 69,000	RESASHPMOP66	3,471	2.37
72,000	>69,000 and <= 72,000	RESASHPMOP72	3,946	2.71

### Table 5 - Commercial Savings Summary<sup>[4]</sup>

Average Cooling Capacity Bin	Capacity Range	Item Code	∆kWh	∆kW
9,000	<=10,500	COMASHPMOP09	280	0.14
12,000	>10,500 and <= 13,500	COMASHPMOP12	376	0.21
15,000	>13,500 and <= 16,500	COMASHPMOP15	420	0.25
18,000	>16,500 and <= 21,000	COMASHPMOP18	601	0.40
24,000	>21,000 and <= 27,000	COMASHPMOP24	711	0.40
30,000	>27,000 and <= 33,000	COMASHPMOP30	988	0.64
36,000	>33,000 and <= 39,000	COMASHPMOP36	1,285	0.85
42,000	>39,000 and <= 45,000	COMASHPMOP42	1,680	1.17
48,000	>45,000 and <= 51,000	COMASHPMOP48	2,142	1.58
54,000	>51,000 and <= 57,000	COMASHPMOP54	2,271	1.66
60,000	>57,000 and <= 63,000	COMASHPMOP60	2,754	1.98
66,000	>63,000 and <= 69,000	COMASHPMOP66	3,100	2.46
72,000	>69,000 and <= 72,000	COMASHPMOP72	3,473	2.81

### Table 6 - Deemed Values

Average Cooling Capacity Bin	Heating Capacity (kBtuh)	Average Cooling Capacity (tons)	HSPFEfficient	SEER <sub>Efficient</sub>
9,000	8.50	0.75	9.33	21.49
12,000	10.72	1.00	9.66	19.78
15,000	14.55	1.25	9.41	18.54
18,000	15.64	1.50	10.19	18.36
24,000	20.48	2.00	9.63	19.44
30,000	29.49	2.50	9.82	18.53
36,000	30.71	3.00	10.43	18.76
42,000	42.24	3.50	10.44	18.58
48,000	39.88	4.00	11.92	18.19
54,000	49.25	4.50	11.15	18.01
60,000	48.03	5.00	12.16	18.86
66,000	59.91	5.50	12.13	17.01
72,000	65.31	6.00	12.43	16.71

Load Shapes 116b Prescriptive Cold Climate Variable Speed Heat Pump (Market Opportunity)

Number	Name	Status	Winter On kWh	Winter Off kWh	Summer On kWh	Summer Off kWh	Winter kW	Summer kW
116	Prescriptive Cold Climate Variable Speed Heat Pump (Market Opportunity)	Active	40.8%	47.7%	6.2%	5.4%	36.9%	3.8%

## Net Savings Factors

Measures				
SHRDASHP Centrally D	Oucted Air S	Source Heat Pump	p - Heat Pur	np Baseline
Tracks [Base Track]				
6013UPST [is base trac	k] Upstrea	am - Commercial		
6032UPST [6032EPEP]	Upstrea	am - Residential		
Track Name	Track Nr.	Measure Code	Free Rider	Spill Over
Upstream - Commercial	6013UPST	SHRDASHP	1.00	1.00

Lifetimes The expected measure life is assumed to be 18 years.<sup>[10]</sup>

Measure Cost Table 7 - Residential and Commercial Measure Cost<sup>[11]</sup> Measure cost represents the market opportunity incremental install ist of an effic

Average Cooling Capacity Bin	Incremental Cost
9,000	\$1,106
12,000	\$1,140
15,000	\$1,117
18,000	\$1,288
24,000	\$2,143
30,000	\$2,230
36,000	\$2,816
42,000	\$3,160
48,000	\$3,305
54,000	\$3,551
60,000	\$4,790
66,000	\$3,259
72.000	\$3.201

### Footnotes

[1] The residential baseline efficiencies are sourced from the Federal Efficiency Standards as of 1/1/2015 for single and packaged central air

conditioners and heat pumps. Please find the ruling attached (Federal Efficient Standards (CFR-2012-title10-vol3-sec430-32)).

- [2] The commercial baseline efficiency values are sourced from the VT CBES 2015 for the minimum efficiency requirements for electrically operated unitary and applied heat pumps.
- [3] Cold climate air source heat pump, per NEEP's Qualified Products List, last updated on August 11, 2020. Rease either find it attached ("NEEP Air Source Heat Pump QPL, Aug 2020.stsc") or as the "NEEP Product List" tab in the excel analysis file: "EVT\_Centrally Ducted ASHP\_Analysis\_Aug 2020\_v2.v5.c".
- (4) Replacement scenario is defined as a MOP, so the baseline equipment is a less efficient heat pump meeting the minimum federal efficient standards. Savings are being claimed on both the heating and cooling system. The peak demand savings for winter is being used as the primary demand savings. Please note that the NEEP Qualified Products List did not have centrally ducted air source heat pumps in the 66,000+ capacity bins, so instead of using actual equipment values for the 66,000 and 72,000 capacity bins, a trend analysis was performed based on the other bins in order to calculate prescriptive savings.
- [5] Residential EFUH Cooling is calculated in an analysis of heat pump metered data. The partial load of each heat pump is summed up through the heating asson, and taken as an average across all units metered. This analysis can be found on the EFUH Calculator tab in the EVT\_CCPM PMO and Rectific (2018, when.)
- [6] The commercial EFLH heating and cooling hours are sourced from the New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs, version 4, January 2017 (New York TRM). Hours are based on an average between the city of Massena and Albany, with it being an average between old and new building types and weighted by small commercial buildings.
- [7] Residential EPLH Heating is estimated from an 8,760 equivalent full load hours analysis. The analysis assumes the heating systems provide heating below 50°F, except in summer months May to August, and estimates savings based on incremental efficiency down to the lower heating limit of the baseline system at -5°F. The analysis assumes the heat pump provides heating based on its rated capacity (up to the estimated based) for each weather bin. EFLH is calculated in an analysis of heat pump metered data. The partial load of each heat pump is summed up through the heating season, and taken as an average across all units metered. This analysis can be found on the EFLH calculator tab in the EVT\_CCHP MOP and Retroft\_2018\_viso.
- [8] The heating capacity and efficient heating HSPF is sourced from NEEP's Qualified Products List for centrally ducted heat pumps rated at varying temperatures (47%; 17%; and 5% outdoor wet bulb temperature) and represent a weighted average BB approach based on Burlington, VT weathe data and capacities.
- [9] The efficient cooling SEER and average cooling capacity is sourced from the NEEP Qualified Products List and represent a weighted average across all capacities
- [10] "Measure Life Report, Residential and Commercial/Industrial Lighting and HVAC Measures", GDS Associates, June 2007.
- [11] Mid-Atlantic Technical Reference Manual, version 9.0, October 2019 (Air Source Heat Pump, pg. 96). For more detail on the incremental cost estimates for the different measure birs, please see the "Incremental Cost" tab in "EVT\_Centrally Ducted ASHP\_Analysis\_Aug 2020\_v2.xts".

### **Ducted Air Source Heat Pump (Retrofit)**

Measure Numbe	CR-HVC-CDHPR a
Portfolio:	
Status:	Active
Effective Date:	2020/1/1
End Date:	[ None ]
Program:	Existing Homes
End Use:	HVAC

# Update Summary The updates to this measure include:

- Expanded the number of bins for this measure.
   Updated the analysis file with the most recent version of the NEEP Qualified Products List.
   Updated the EFUH to coincide with the updates to the ductless mini-spit ASHP measure.
   Please note, these updates resulted in changes to the deemed savings.

### Referenced Documents

- from Energy Efficiency Programs 2016
- Referenced Documents VT SF Existing Homes Onsite Report DRAFT 122117 New York Standard Approach for Estimating Energy Sa GDS Associates, Measure Life Report, Jon 2007 EVT\_CCPF MOP and Retroft 2018, EVT\_Centrally Ducted ASHP, Analysis, Aug 2020, v2

- NEEP Air Source Heat Pump QPL\_Aug 2020
   Mid-Atlantic\_TRM\_V9

### Description

Description This measure claims savings for the installation of centrally ducted air source heat pumps. Heating savings are claimed as a retroft of the home's existing fossil fuel heating system, and accounts for the fossil fuel system providing supplemental heat at low audoor air temperatures, a only 2% of Vermont homes utilize central air conditioning<sup>11</sup>, for this retroft replacement scenario, the added electrical load associated with the heat pump is counted as a penalty for both heating and coding. The installed air source heat pump must meet Every Star efficiency standards and have a capacity of <a T\_2000 Buy/r. The characterization assumes a standard mode of operation regardless of installation, location, or application - residential or commercial. The installed air source heat pumps is intended to supplement the existing fossil fuel heating system and not completely replace it, and the characterization of this measure assumes a midstream program delivery method.

This measure is in connection with the Market Opportunity characterization for centrally ducted air source heat pumps. As both characterizations, retrofit and market opportunity, will be implemented in tandem through an upstream delivery mechanism, the actual replacement scenario will be unknown and savings will be claimed for both measures to make sure they are additive and do not overlap.

# Program Type Calculation Type: Retrofit

Program Delivery/Implementation Method: Midstream

Baseline Efficiencies The baseline condition is assumed to be the existing fossil fuel furnace. Sites with natural gas fossil fuel systems are excluded from participation in this measure and as a result, are not included in the characterization.

### Table 1 - Residential Baseline Efficiency<sup>(2)</sup>

Existing Fuel Type	Average Furnace Efficiency
Fuel Oil	81.3%
Propane	87.4%
Table 2 - Commercial Baselin	
Table 2 - Commercial Baselir Existing Fuel Type Fuel Oil	e Efficiency <sup>(3)</sup> Average Furnace Efficiency 82.0%

# Table 3 - Central Air Conditioning Baseline Efficiency

······,						
Sector	SEER					
Residential <sup>[1]</sup>	11.4					
Commercial <sup>(4)</sup>	11.7					

# Efficient Equipment The installed heat pump is assumed to meet the efficiencies outlined in table 4. Table 4 - Residential and Commercial High Efficiency

Table 4 - Residential and Commerc	ial High Efficie	ency
Equipment	HSPF	SEER
Residential Air-Source Heat Pump	8.2	14
Commercial Air-Source Heat Pump	8.1	14

Δlc	10	ritt	nms	

Electric Demand Savings

 $\Delta kW_{Penalty} = kBtuh \ x \ (-1/HSPF_{Efficient})$ 

## Symbol Table

Electric Energy Savings 
$$\label{eq:linear} \begin{split} \Delta kWh_{Penalty} &= kBuh \times (-1) HSPF_{Efficient}) \times EFLH_{Heating} + \{(tons \ x \ (12/SEER_{Baseline} \ \cdot \ 12/SEER_{Efficient}) \times \%CAC) \ \cdot \ (tons \ x \ (12/SEER_{Efficient}) \times (12/SEER_{Efficient})$$

### Symbol Table

Fossil Fuel Savings = (kBtuh x EFLH<sub>Heating</sub> /  $\eta_{Efficiency}$ ) / 1000 ∆MMBtu

nere:	
%CAC	= Percent of existing homes in Vermont with central air conditioning $= 29 \beta^{(7)}$
ΔkWPenalty	= Total average summer coincident peak kW penalty (deemed assumption for prescriptive)
$\Delta kWh_{Penalty}$	= Gross customer electric energy penalty (deemed assumption for prescriptive)
ΔMMBtu	<ul> <li>MMBtu savings for each fuel type (deemed assumption for prescriptive)</li> </ul>
ηEfficiency	<ul> <li>Efficiency of the fossil fuel heating system see tables 1 and 2 for more details</li> </ul>
EFLH <sub>Cooling</sub>	Equivalent full load cooling hours 240 hours (residential) <sup>[1]</sup> 591 hours (commercial) <sup>[9]</sup>

EFLH <sub>Heating</sub>	<ul> <li>Equivalent full load heating hours</li> </ul>
	1,383 hours (residential) <sup>[10]</sup>
	1,062 hours (commercial) <sup>[9]</sup>
HSPFEfficient	= Heating Seasonal Performance Factor for Efficient equipment, Btu/Wh
	see table 4 for more details
kBtuh	<ul> <li>Average rated heating capacity<sup>(11)</sup></li> </ul>
	see table 8 for more details
SEERBaseline	= Seasonal Energy Efficiency Ratio for Baseline equipment, Btu/Wh
	see table 3 for more details
SEER <sub>Efficient</sub>	= Seasonal Energy Efficiency Ratio for Efficient equipment, Btu/Wh
	see table 4 for more details
tons	<ul> <li>Average cooling capacity<sup>(12)</sup></li> </ul>
	see table 8 for more details

Table 5 - Furnace Type Distribution<sup>[5]</sup>

 Fuel Type
 Residential
 Commercial

 Fuel Oil
 65.5%
 37.8%

 Propane
 34.5%
 62.2%

### Table 6 - Residential Savings Summary<sup>[6]</sup>

Average Cooling Capacity Bin	Capacity Range	Item Code	∆kWh	∆kW	∆MMBtu Oil	∆MMBtu Propane
9,000	<=10,500	RESASHPRET09	-1,584	-1.037	9.5	4.6
12,000	>10,500 and <= 13,500	RESASHPRET12	-2,009	-1.308	12.0	5.9
15,000	>13,500 and <= 16,500	RESASHPRET15	-2,706	-1.775	16.2	7.9
18,000	>16,500 and <= 21,000	RESASHPRET18	-2,938	-1.907	17.4	8.5
24,000	>21,000 and <= 27,000	RESASHPRET24	-3,856	-2.498	22.8	11.2
30,000	>27,000 and <= 33,000	RESASHPRET30	-5,475	-3.596	32.9	16.1
36,000	>33,000 and <= 39,000	RESASHPRET36	-5,781	-3.745	34.2	16.8
42,000	>39,000 and <= 45,000	RESASHPRET42	-7,826	-5.151	47.1	23.0
48,000	>45,000 and <= 51,000	RESASHPRET48	-7,528	-4.863	44.4	21.8
54,000	>51,000 and <= 57,000	RESASHPRET54	-9,209	-6.006	54.9	26.9
60,000	>57,000 and <= 63,000	RESASHPRET60	-9,105	-5.858	53.5	26.2
66,000	>63,000 and <= 69,000	RESASHPRET66	-11,209	-7.307	66.8	32.7
72,000	>69,000 and <= 72,000	RESASHPRET72	-12,220	-7.965	72.8	35.6

## Table 7 - Commercial Savings Summary<sup>[6]</sup>

Average Cooling Capacity Bin	Capacity Range	Item Code	∆kWh	ΔkW	ΔMMBtu Oil	ΔMMBtu Propane
9,000	<=10,500	COMASHPRET09	-1,485	-1.050	4.2	6.5
12,000	>10,500 and <= 13,500	COMASHPRET12	-1,900	-1.324	5.3	8.2
15,000	>13,500 and <= 16,500	COMASHPRET15	-2,526	-1.797	7.1	11.2
18,000	>16,500 and <= 21,000	COMASHPRET18	-2,791	-1.930	7.7	12.0
24,000	>21,000 and <= 27,000	COMASHPRET24	-3,674	-2.529	10.0	15.7
30,000	>27,000 and <= 33,000	COMASHPRET30	-5,101	-3.640	14.4	22.6
36,000	>33,000 and <= 39,000	COMASHPRET36	-5,509	-3.791	15.0	23.6
42,000	>39,000 and <= 45,000	COMASHPRET42	-7,267	-5.214	20.7	32.4
48,000	>45,000 and <= 51,000	COMASHPRET48	-7,205	-4.923	19.5	30.6
54,000	>51,000 and <= 57,000	COMASHPRET54	-8,680	-6.080	24.1	37.8
60,000	>57,000 and <= 63,000	COMASHPRET60	-8,768	-5.930	23.5	36.9
66,000	>63,000 and <= 69,000	COMASHPRET66	-10,573	-7.397	29.4	46.0
72,000	>69,000 and <= 72,000	COMASHPRET72	-11,528	-8.063	32.0	50.1

### Table 8 - Deemed Values

Average Cooling Capacity Bin	Heating Capacity (kBtuh)	Average Cooling Capacity (tons)
9,000	8.50	0.75
12,000	10.72	1.00
15,000	14.55	1.25
18,000	15.64	1.50
24,000	20.48	2.00
30,000	29.49	2.50
36,000	30.71	3.00
42,000	42.24	3.50
48,000	39.88	4.00
54,000	49.25	4.50
60,000	48.03	5.00
66,000	59.91	5.50
72,000	65.31	6.00

# Load Shapes 123a Prescriptive Cold Climate Variable Speed Heat Pump (Retrofit)

Number	Name	Status	Winter On kWh	Winter Off kWh	Summer On kWh	Summer Off kWh	Winter kW	Summer kW
123	Prescriptive Cold Climate Variable Speed Heat Pump (Retrofit)	Active	41.6%	48.6%	5.2%	4.6%	36.9%	5.5%

### Net Savings Factors

Measures SHFDASHP Centrally Ducted Air Source Heat Pump - Fuel-fired Baseline

 Tracks [Base Track]

 6013UPST [is base track]
 Upstream - Commercial

 6032UPST [6032EPEP]
 Upstream - Residential

# Track Name Track Ne. Measure Code Free Rider Spill Over Upstream - Commercial 6013UPST SHFDASHP 1.00 1.00

Lifetimes The expected measure life is assumed to be 18 years.<sup>[13]</sup>

Measure Cost Table 8 - Residential and Commercial Measure Cost<sup>[14]</sup> The incremental retrofit cost is the full equipment cost of the air source heat pump.

Average Cooling Capacity Bin Incremental Cost

9,000	\$411
12,000	\$548
15,000	\$685
18,000	\$823
24,000	\$1,097
30,000	\$1,371
36,000	\$1,645
42,000	\$1,919
48,000	\$2,193
54,000	\$2,468
60,000	\$2,742
66,000	\$3,016
72,000	\$3,290

### Footnotes

- [1] "Vermont Single-Family Existing Homes Onsite Report", NMR Group, December 2017 (page 49)
- [2] Average residential furnace efficiency of existing homes in Vermont, as sourced from homes surveyed in NMR Group's 2017 on site surveying; "Vermont Single-Family Existing Homes Onsite Report", NMR Groupt, December 2017 (page 45)
- [3] Mean observed efficiency for warm air fossil fuel furnaces for existing commercial buildings, as sourced from "Vermont Market Assessment Report", Cadmus (page 65). The efficiency of propane furnaces was not included in the report. In order to incorporate the propane fuel type into the analysis, opted to use the combined efficiency values for propane boilers and furnaces, as sourced from the data for the same report.
- [4] The baseline cooling efficiency for commercial central air conditioning systems is based on an aggregation of all cooling systems under 5.5 tons in commercial buildings, as sourced from the "Vermont Market Assessment Report", Cadmus, April 2017
- [5] As the program delivery method for this measure is midstream, the intention is the fuel type of the furnace being off-set will be unknown, and this necissitates a fuel type distribution of furnaces being impacted by this measure. The MMBu energy savings are thus split across the different fuel types based on their saturation in the state of Vermont and is dependant on the building stock and sector. Sites utilizing natural gas fuel are exclude from participation in the instate and are removed from consideration in this characterization. The definition. The definition for the fuel type distribution and the accompanying sources can be viewed in detail in the "EVT\_Centrally Ducted ASHP\_Analysis\_Aug 2020\_v2.vs."
- [6] Replacement scenario is defined as a RET, so the baseline equipment is the existing fossil fuel heating system (electric resistance heating was not considered a vable baseline for this measure). Fossil fuel sannys are being daimed for the heating system with an electric resistance heating was not considered a vable baseline for this measure). Fossil fuel sannys are being daimed for the heating system with an electric resistance heating was not being the heating and cooling system with an electric resistance heating was not being statismed as wings. Please note that the NEEP Qualified Products List dd not have centrally ducted air source heat pumps in the 66,000 + opacity bins, so instead of using actual equipment values for the 66,000 and 72,000 capacity bins, a trend analysis was performed based on the other bins in order to calculate pre-criptive sanings.
- [7] 2% of Vermont single-family houses have central air conditionings, as sourced from the "VT SF Existing Homes Onsite Report", December 2017, NMR Group, page 49
- [3] Residential EFUH Cooling is calculated in an analysis of heat pump metered data. The partial load of each heat pump is summed up through the heating asson, and taken as an average across all units metered. This analysis can be found on the EFUH Calculator tab in the EVT\_CCHP More and Restrict\_2018, exist.
- [9] The commercial ERH heating and cooling hours are sourced from the New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs, version 4, January 2017 (New York TRM). Hours are based on an average between the city of Massena and Albany; with it being an average between old and new building types and weighted by small commercial buildings.
- [10] Residential EFUH Heating is estimated from an 8,760 equivalent full load hours analysis. The analysis assumes the heating systems provide heating below 50°F, except in summer months Nay to August, and estimates savings based on incremental efficiency down to the lower heating limit of the baseline system at -5°F. The analysis assumes the heat pump provides heating based on is rated capacity (up to the estimated load) for each weather bin. EFLH is calculated in an analysis of heat pump metered data. The partial load of each heat pump is summed by the heating season, and taken as an average across all units metered. This analysis can be found on the EFLH calculator tab in the EVT\_CCHP MOP and Retroft\_2018\_wlssc.
- [11] The heating capacity is sourced from NEEP's Qualified Products List for centrally ducted heat pumps rated at varying temperatures (47%, 17%, and 5% outdoor wet buib temperature) and represent a weighted average BIN approach based on Burlington, VT weather data and capacities.
- [12] The average cooling capacity is sourced from the NEEP Qualified Products List and represent a weighted average across all capacities
- [13] "Measure Life Report, Residential and Commercial/Industrial Lighting and HVAC Measures", GDS Associates, June 2007.
- [14] Mid-Atlantic Technical Reference Manual, version 9.0, October 2019 (Air Source Heat Pump, pg. 96). For more detail on the incremental cost estimates for the different measure bins, please see the 'Incremental Cost' tab in 'EVT\_Centrally Ducted ASHP\_Analysis\_Aug 2020, v2.xlsx\*.

### **Ductless Air Source Heat Pump (Market Opportunity)**

Measure Numbe	r: CR-HVC-DMHP c
Portfolio:	
Status:	Active
Effective Date:	2021/1/1
End Date:	[ None ]
Program:	Existing Homes
End Use:	HVAC

Update Summary Included the 40,000 Btu/h (32,001 - 46,000) and 56,500 Btu/h (46,001 - 65,000) capacity bins into the single zone measure per P&I staff request. Please note, this TRM update was intended for only the expansion of capacity bins. This was done to align measure characterization with program implementation. While out-dated items were noted in the review of the measure, this will be taken into account when a comprehensive reliability review is performed on this measure later in the year. Those changes will be enacted for program year 2022, while these changes are intended to impact the measure for this year's program, 2021.

### Referenced Documents

- Every construction
   Constru

### Description

This measure claims savings for the installation of single and multi-head variable speed mini-split heat pumps. Heating and cooling savings are claimed as a market opportunity to account for the incremental savings of an efficient heat pump versus the installation of a baseline heat pump. Now the use of heat pumps as a supplemental heating source, the characterization assumes a standard mode of operation regardless of installation location.

Program Type Calculation Type: Market Opportunity (Time of Sale) Program Delivery/Implementation Method: Midstream

Baseline Efficiencies The baseline condition is assumed to be a new heat pump that is capable of providing heat using the heat pump cycle down to 5% and meets the The baseline condition is assume following minimum efficiencies:

Table 1 - Single Head Baseline Efficiency<sup>[1]</sup> 
 Table 1 - Single Head Baseline Efficie
 Equipment
 HSPF\_EER
 SEER

 Air-Source Heat Pump8.6
 9.8
 15.6
 7.8
 15.6

 Table 2 - Multi Head Baseline Efficier
 Equipment
 HSPF\_EER\_SEER
 SEER
 Air-Source Heat Pump8.2
 12
 14.5

### Efficient Equipment

EIT-LETER Exponential To qualify for swaps under this measure, the installed equipment must be a new mini-split heat pump that has a variable speed inverter-driven compressor, CDP at  $S^{+}$  E. 17.5 (at maximum capacity operation), and be capable of providing heat using the heat pump cycle down to  $S^{+}$ . It must also meet or exceed the following efficiency ortems, per APR Estradard 20.2440 SUB for tuihary Ar-Conditioning and Ar-course Heat Pump equipment.

# Table 3 - Single-Head High Efficiency<sup>[3]</sup>

Equipment	HSPF	EER	SEER
Air-Source Heat Pump	10	12	20
Table 4 - Multi-Head	High	Effi	ciency
	-		ciency SEER

Algorithms Electric Demand Savings Given the primary impact is on heating, demand impact is characterized for heating.

ΔkW = ( $\Delta$ kWh / EFLH) × New Construction Factor

### Symbol Table

∆kWh	= ( $\Delta kWh_{Cooling} + \Delta kWh_{Heating>=SE} \cdot \Delta kWh_{Heating) × New Construction Factor$
∆kWh <sub>Cooling</sub>	$= Q_{Cooling} \times EFU+_{Cooling} \times (1/SEER_{Baseline}\cdot 1/SEER_{Efficient}) \times 1kWh/1000 \ Wh$
∆kWh <sub>Heating&gt;SF</sub>	$= (Max  Capacity_{SF}) \times EFLH \times (1/HSPF_Busine \times 90\% \cdot 1/HSPF_Efficient \times 90\%) \times 1  kWh/1000  Wh$
$\Delta kWh_{Heating < SF}$	= $\Delta$ MMBtu × (1/COP <sub>cSF</sub> -%ElecHeat)× 1 kWh/ 3412 Btu
%ElecHeat	= portion of homes with electric space heat
ALIECHEBU	<ul> <li>= potot of nones war electric space near</li> <li>= 2%<sup>[5]</sup> (deemed assumption for prescriptive savings)</li> </ul>
%HeatSource	<ul> <li>Percent of existing heating systems using fuel type <i>f</i><sup>(9239)</sup></li> <li>51% for fuel oil</li> <li>26% for procease</li> </ul>
	= 20% to populare = 4% for Wood = 11% for Netural Gas
	= 8% for Electric
ΔkW	<ul> <li>Total average winter coincident peak kW reduction (deemed assumption for prescriptive)</li> </ul>

$\Delta kWh_{Heating >= SF}$	-	= Heating Energy Savings above 5°F
$\Delta kWh_{Heating < SF}$	-	= Heating Penalty below above 5°F
ΔkWh	-	= Gross customer electric energy savings
ΔMMBtu	-	MMBtu savings for each fuel type <i>j</i> (deemed assumption for prescriptive)
η <sub>Heatj</sub>	-	= Heating system efficiency for fuel type $j$ (deemed assumption for prescriptive) <sup>[9240]</sup>
		= 83% for fuel oil
		= 86% for propane
		= 66% for Wood/Other
		= 87% for Natural Gas
		=100% for Electric
90%	-	<ul> <li>Climatic adjustment to HSPF<sup>(6)</sup> (deemed assumption for prescriptive savings)</li> </ul>
COP <sub><sf< sub=""></sf<></sub>	-	= Assumed Coefficient of Performance below 5 degrees Fahrenheit
		=2.0[7]
EFLHCooling		= Equivalent Full Load Hours for heating
'y		= 239.81 <sup>(8)</sup>
EFLH	-	Equivalent Full Load Hours for heating
		= 1,383 <sup>(8)</sup>
HSPFBaseline	-	= Heating Seasonal Performance Factor for Baseline equipment, Btu/Wh
		= 8.6 <sup>(9)</sup> (Single-head deemed assumption for prescriptive savings)
		$= 8.2^{[10]}$ (Multi-head deemed assumption for prescriptive savings)
HSPFEfficient	-	= Heating Seasonal Performance Factor for Efficient equipment, Btu/Wh
Max Capacity <sub>SF</sub>	-	Average Maximum Capacity (Btu/hr) of the CCHP at 5 degrees Fahreneheit <sup>[11]</sup>
New Construction	-	Factor to account for better thermal envelope of new construction homes
Factor		= 99.25%[4]
_		
QCooling	-	= nominal cooling capacity, Btu/hr
Q <sub>Heating <sf,i< sub=""></sf,i<></sub>	-	= Maximum of rated heating capacity and estimated load in weather bin <code>/below 5°F</code> , <code>MMBtu</code>
SEER <sub>Baseline</sub>	-	= Seasonal Energy Efficiency Ratio for Baseline equipment, Btu/Wh
		= 15.6 <sup>[10]</sup> (Single-head deemed assumption for prescriptive savings)
		= $14.5^{(10)}$ (Multi-head deemed assumption for prescriptive savings)
SEER <sub>Efficient</sub>	-	= Seasonal Energy Efficiency Ratio for Efficient equipment, Btu/Wh

	hapes criptive Cold Climate Variable Speed Heat Pump (Market Opportunity)							
Number	Name	Status	Winter On kWh	Winter Off kWh		Summer Off kWh	Winter kW	Summer kW
116	Prescriptive Cold Climate Variable Speed Heat Pump (Market Opportunity)	Active	40.8%	47.7%	6.2%	5.4%	36.9%	3.8%

## Net Savings Factors

Measures SHRHPCVH Ductless single-head variable speed heat pump SHRHPMHC Ductless multi head variable speed heat pump

 Tracks [Base Track]

 6032UPST [6032EPEP]
 Upstream - Residential

 6013EPEP [6032EPEP]
 Efficient Products - Commercial

Lifetimes The expected measure life is assumed to be 15 years.<sup>[12]</sup>

Measure Cost Single Head Measure Costs<sup>[13]</sup> The incremental installed measure cost of an efficient versus a baseline CCHP:

Nominal Equipment Capa	city (Btu/hr) Incremental Costs
6,000	\$483
9,000	\$493
12,000	\$591
15,000	\$588
18,000	\$611
24,000	\$693
40,000	\$881
56,500	\$1,074

### Multi-Head Measure Cost<sup>[13]</sup>

Measure cost represents the market opportunity incremental installed cost of an efficient versus a baseline multi head CCHP.

Nominal Equipment Capacity (Btu/hr)	Incremental Cos
18,000	\$411
24,000	\$265
30,000	\$1,343
36,000	\$603
42,000	\$787
48,000	\$736

# Savings Summary

Туре	Capacity	Capacity Ranges	Item Code	∆kWh Total	ΔkW
Single Zone	6,000	5,000 - 8,000 BTU/h	CCHPSHEEC6K	612.3	0.41
Single Zone	9,000	8,001 - 11,000 BTU/h	CCHPSHEEC9K	619.1	0.41
Single Zone	12,000	11,001 - 14,000 BTU/h	CCHPSHEEC12K	607.9	0.40
Single Zone	15,000	14,001 - 17,000 BTU/h	CCHPSHEEC15K	872.5	0.58
Single Zone	18,000	17,001 - 22,000 BTU/h	CCHPSHEEC18K	680.3	0.44

Single Zone	24,000	22,001 - 32,000 BTU/h	CCHPSHEEC24K	792.6	0.51
Single Zone	40,000	32,001 - 48,000 BTU/h	CCHPSHEEC40K	1,102.0	0.70
Single Zone	56,500	48,001 - 65,000 BTU/h	CCHPSHEEC56K	1,482.1	0.93
Multi Zone	18,000	16,000 - 20,000 BTU/h	CCHPMHEEC18K	680.7	0.44
Multi Zone	24,000	20,001 - 24,000 BTU/h	CCHPMHEEC24K	1,160.6	0.77
Multi Zone	30,000	24,001 - 32,000 BTU/h	CCHPMHEEC30K	1,324.0	0.89
Multi Zone	36,000	32,001 - 38,000 BTU/h	CCHPMHEEC36K	1,759.3	1.17
Multi Zone	42,000	38,001 - 44,000 BTU/h	CCHIPMHEEC42K	2,268.7	1.54
Multi Zone	48,000	44,001 - 65,000 BTU/h	CCHPMHEEC48K	1,791.0	1.16

### Footnotes

 Baseline single head CCHP efficiencies is derived from an analysis of installed heat pumps in Vermont from Vermont heat pump distributors. Review Efficiency Levels tab in EVT\_CCHP\_MOP and Retrofit\_2021.xlsx.

[2] Based on November 2014 TAG Agreement. Review of multi-head CCHP shows HSPF average is below single-head units.

[3] High efficiencies for single and multi zone cold climate heat pumps are derived from various sources. HSFF rating based on NEEP criteria, refer to Cold Climate Air-source Heat Pump Specification-Version 2.0Bas/2017 (1).pdf. ERI Anting based on BHRAFS STAR specifications for air source heat pumps, refer to thirts://www.emergistra.op/inoducli/heating.colimate.pumps\_air\_source/key\_product\_referia.

[4] See EVT\_CCHP\_MOP and Retrofit\_2021.xlsx, New Construction tab for detailed analysis

[5] Percentage of heating fuel types in existing Vermont homes from NMR Group, "Survey Analysis of Owners of Existing Homes in Vermont (Draft)" December 5, 2016; page 29, Table 38 (Statewide Data). Kerosene, coal, and solar were excluded. The report states that "all nine respondents who use electricity as their primary heating fuel reported that they have electric resistance baseboard rather than an electric heat pump."

- [6] Energy & Resource Solutions. (2014). Emerging Technology Program Primary Research Ductless Heat Pumps. Lexington, MA: NEEP Regional EM&V Forum. Table 1-2. Page 5.
- [7] Conservative average of low temperature COP according to manufacturer's engineering documents.

[8] EFLH is calculated in an analysis of heat pump metered data. The partial load of each heat pump is summed up through the heating season, and taken as an average across all units metered. This analysis can be found on the EFLH Calculator tab in the EVT\_CCHP\_MOP and Retroft\_2021.xlsx.

[9] Per TAG Agreement

[10] See Baseline Efficiency section

[11] This value is derived as an average of capacities that the CCHP can provide at 5 degrees Fahrenheit. These are from the engineering spec sheets of the CCHPs that are on the EVT QPL. For the 40,000 Btu/h and 56,500 Btu/h capacity bins, the values were interpolated from the previous bins.

[12] California DEER Effective Useful Life values, updated October 10, 2008. Various sources range from 12 to 20 years, DEER represented a reasonable mid-range.

[13] Navigant Consulting Inc. (2013). Incremental Cost Study Phase Two Final Report. Burlington, MA: NEEP Evaluation, Measurement, and Verification Forum. Review Costs tab of EVT\_CCHP\_MOP and Retrofit 2021.xlsx.

## Variable Frequency Drives (VFD)

Measure Number	: I-A-2 e
Portfolio:	EVT TRM Portfolio 2019-04
Status:	Active
Effective Date:	2020/1/1
End Date:	[ None ]
Program:	Commercial & Industrial
End Use:	HVAC

Update Summary
This update is the outcome of reliability review. The update reflected in this version is accomodation of new cost information. All other assumpti
found to have maintained reasonable validity and therefore were not revised.

- Nevgart Consulting, (2013, January 16), Incremental Cost Study Phase Two Final Report.
   Efficiency Vennor 2015 VPD Loadshapes and Costs
   odmus, (2014), Variable Speed Drive Loadshape Project, Lexington: NEEP Regional Evalue
   Incremental\_Cost\_Recommendations\_Non\_Lighting\_050917
   VFD Costs

### Description

Uescription This measure derarderization presents standardized savings algorithms and assumptions for VFDs applied to motors of 100 HP or less for the following HAC applications: supply fans, return fans, cooling water pumps, circulation pumps for water source heat pump systems, and heating hot water pumps ("Standardized Approach"). Standardized savings algorithms and assumptions of up to 10 HP for boiler draft fans and cooling tower fans are also applicable. All other VFDs are treated as custom measures.

The calculations for most of the applications rely heavily on a study conducted on behalf of the Northeast Energy Efficiency Partnerships (NEEP) Evaluation, Measurement, and Verification Forum (PRV Forum), which conducts research studies to support energy-efficiency programs and policy in the Northeast and Mid-Atlantic. States. In 2012, the EMBV Forum and its Sponsors commissioned this Variable Speed Drive (VSD) Loadshape study to determine the hourtheast and Mid-Atlantic.

Between 2013 and 2014, Cadmus and DMI (the evaluation team) worked with the EM&V Forum's Technical Committee to complete this study. The referenced report (Cadmus 2014) describes the study objective, methods, and results. The attached spreadsheet (NEEP 2016 provides more details on the data and the calculations.

### **Baseline Efficiencies**

Baseline Efficiencies The baseline operation for supply fans, return fans, hot water pumps, cooling water pumps, and WSIPF circulation pumps are described extensively in (Cadma, 2014). Sections 31, 32, and 33 of that document summarize how the baseline motors were being operated, while the methods of developing the baseline for modeling are described in detail in Section 2.4.4. The baseline includes a wide variety of operating confidence motors with confinuous operation and were/low (or or on) operating hours, and then one-second and associal systems. "Cooling water pumps" include both childer water pumps and condenser water pumps. "Heating hot water pumps" refers to pumps that save space heating bads, which may also save DHW bads, as well as pumps that operate as hot water pumps for the heating season and cooling water pumps for the cooling season; it does not include DMV-only pumps.

For boiler draft fans, the baseline is assumed to be a draft fan with no VFD, while for cooling towers, the baseline reflects a tower fan with discharge damper controls.<sup>[2]</sup>

### Efficient Equipment

tallation and use of a VFD.

# Algorithms

Electric Deman	d Savings
ΔkW	= DSVG × HP × OTF
Symbol Table	
lectric Energy	Savings
∆kWh	= ESVG × HP × OTF
Symbol Table	
ossil Fuel Savi	ngs
/here:	
ΔkW	<ul> <li>gross kW connected load reductions for the measure, representing the average kW savings at either the summer o winter coincidence period (whichever is greater); see also Tables 4-6 below for prescriptive kW reduction values for each combination of horsepower and application</li> </ul>
ΔkWh	<ul> <li>gross customer annual KWh savings for the measure; see also Table 3 below for prescriptive KWh savings values for each combination of horsepower and application</li> </ul>
DSVG	<ul> <li>demand savings factor, calculated as the maximum of the summer and winter demand savings factors; see Table J below (kW/HP)</li> </ul>
ESVG	<ul> <li>energy savings factor; see Table 1 below (kWh/HP)</li> </ul>
HP	<ul> <li>horsepower of the motor to which the VFD is applied</li> </ul>
kWh	<ul> <li>gross customer annual KWh savings for the measure; see also Table 3 below for prescriptive KWh savings values for each combination of horsepower and application</li> </ul>
OTF	<ul> <li>operational testing factor for standard approach applications. OTF = 1.00 when the project undergoes operational testing or commissioning services, OTF = 0.9 otherwise. For prescriptive rebate form applications the OTF will be assumed to be 0.9.</li> </ul>

Load S	hapes									
102a VFD	- Boiler draft fans <10 HP									
103a VFD	- Cooling Tower Fans <10 HP									
117a VFD WSHP Circulation Pumps - Prescriptive <=100 HP										
55c VFD Supply Fans - Prescriptive <=100 HP										
56c VFD Return Fans - Prescriptive <=100 HP										
	Cooling Water Pumps - Prescriptive <=100 HP									
76c VFD H	leating Hot Water Pumps - Prescriptive <=100 HP									
			Winter	Winter	Summer	Summer	Winter	Summer		
Number	Name	Status	On kWh	Off kWh	On kWh	Off kWh	kW	kW		
102	VFD - Boiler draft fans <10 HP	Active	45.8%	53.1%	0.7%	0.4%	40.0%	0.0%		
103	VFD - Cooling Tower Fans <10 HP	Active	10.1%	5.0%	58.6%	26.3%	0.0%	61.6%		
117	VFD WSHP Circulation Pumps - Prescriptive <=100 HP	Active	45.5%	23.1%	20.3%	11.1%	100.0%	77.1%		
55	VFD Supply Fans - Prescriptive <=100 HP	Active	48.3%	18.5%	24.0%	9.2%	92.0%	100.0%		
56	VFD Return Fans - Prescriptive <=100 HP	Active	53.6%	13.5%	26.2%	6.7%	90.7%	100.0%		
59	VFD Cooling Water Pumps - Prescriptive <=100 HP	Active	45.5%	21.5%	22.2%	10.8%	100.0%	94.3%		
76	VFD Heating Hot Water Pumps - Prescriptive <=100 HP	Active	35.8%	17.7%	8.0%	38.5%	100.0%	43.4%		

### Net Savings Factors

### Measures

MTCSTVFD	Variable frequency drive, standardized
MTCVFDSF	VFD, standardized HVAC - Supply Fans
MTCVFDRF	VFD, standardized HVAC - Return Fans
MTCVFDCP	VFD, standardized HVAC - Cooling Water Pumps
MTCVFDHP	VFD, standardized HVAC - Heating Hot Water Pumps
MTCVFDBF	VFD, standardized HVAC - Boiler Draft Fans
MTCVFDWP	VFD, standardized HVAC - WSHP Circulation Pumps
MTCVFDCF	VFD, standardized HVAC - Cooling Tower Fans

 Tracks [Base Track]

 6012CNIR [is base track]
 C&I Retro

 6013PRES [is base track]
 Pres Equip Rpl

Lifetimes The measure life is assumed to be 15 years for HVAC applications.

Measure Cost Because this is a retrofit measure, the cost is assumed to be the full installed cost of a VFD, and varies by controlled motor horsepower. See Table 2 "VFD Measure Costs" below.

### Reference Tables

	ESVG	DSVG <sup>[4]</sup>	DSVGwinter	DSVG <sub>summer</sub>
	kWh/hp	kW/hp	kW/hp	kW/hp
Supply Fans	2,033	0.288	0.265	0.288
Return Fans	1,788	0.302	0.274	0.302
Cooling Water Pumps	1,633	0.194	0.194	0.183
Heating Hot Water Pumps	1,548	0.221	0.221	0.096
WSHP Circulation Pumps	2,562	0.297	0.297	0.229
Boiler Draft Fans	500	0.270	0.108	0.0
Cooling Tower Fans	239	0.280	0.0	0.17248

# Table 2. Variable Frequency Drive (VFD) Costs<sup>[5]</sup>

Horsepower	Labor	Equip/Materials	<b>Total Installation Cost</b>
2	\$456.08	\$1,558.20	\$2,014.27
3	\$472.03	\$1,619.02	\$2,091.05
5	\$503.94	\$1,740.67	\$2,244.61
7.5	\$543.83	\$1,842.31	\$2,386.14
10	\$583.71	\$1,943.95	\$2,527.66
15	\$830.89	\$2,898.95	\$3,729.84
20	\$912.50	\$3,189.44	\$4,101.94
25	\$994.12	\$3,479.93	\$4,474.05
30	\$1,075.73	\$3,770.42	\$4,846.15
40	\$1,238.96	\$4,351.39	\$5,590.36
50	\$1,402.19	\$4,932.37	\$6,334.56
60	\$1,895.35	\$5,513.35	\$7,408.70
75	\$1,959.51	\$6,384.81	\$8,344.32
100	\$2,066.43	\$7,837.26	\$9,903.68

### Table 3. Prescriptive Energy Savings (kWh)

Horsepower	Supply Fans	Return Fans	Cooling Water Pumps	Heating Hot Water Pumps	WSHP Circulation Pumps	Boiler Draft Fans	Cooling Tower Fans
2	3,659.4	3,218.4	2,939.4	2,786.4	4,611.6	900.0	430.2
3	5,489.1	4,827.6	4,409.1	4,179.6	6,917.4	1,350.0	645.3
5	9,148.5	8,046.0	7,348.5	6,966.0	11,529.0	2,250.0	1,075.5
7.5	13,722.8	12,069.0	11,022.8	10,449.0	17,293.5	3,375.0	1,613.3
10	18,297.0	16,092.0	14,697.0	13,932.0	23,058.0	4,500.0	2,151.0
15	27,445.5	24,138.0	22,045.5	20,898.0	34,587.0	NA	NA
20	36,594.0	32,184.0	29,394.0	27,864.0	46,116.0	NA	NA
25	45,742.5	40,230.0	36,742.5	34,830.0	57,645.0	NA	NA
30	54,891.0	48,276.0	44,091.0	41,796.0	69,174.0	NA	NA
40	73,188.0	64,368.0	58,788.0	55,728.0	92,232.0	NA	NA
50	91,485.0	80,460.0	73,485.0	69,660.0	115,290.0	NA	NA
60	109,782.0	96,552.0	88,182.0	83,592.0	138,348.0	NA	NA
75	137,227.5	120,690.0	110,227.5	104,490.0	172,935.0	NA	NA
100	182,970.0	160,920.0	146,970.0	139,320.0	230,580.0	NA	NA

### Table 4. Prescriptive Connected Load Reduction (kW)

Horsepower	Supply Fans	Return Fans	Cooling Water Pumps	Heating Hot Water Pumps	WSHP Circulation Pumps	Boiler Draft Fans	Cooling Tower Fans
2	0.51840	0.54360	0.34920	0.39780	0.53460	0.48600	0.50400
3	0.77760	0.81540	0.52380	0.59670	0.80190	0.72900	0.75600
5	1.29600	1.35900	0.87300	0.99450	1.33650	1.21500	1.26000
7.5	1.94400	2.03850	1.30950	1.49175	2.00475	1.82250	1.89000
10	2.59200	2.71800	1.74600	1.98900	2.67300	2.43000	2.52000
15	3.88800	4.07700	2.61900	2.98350	4.00950	NA	NA
20	5.18400	5.43600	3.49200	3.97800	5.34600	NA	NA
25	6.48000	6.79500	4.36500	4.97250	6.68250	NA	NA
30	7.77600	8.15400	5.23800	5.96700	8.01900	NA	NA
40	10.36800	10.87200	6.98400	7.95600	10.69200	NA	NA
50	12.96000	13.59000	8.73000	9.94500	13.36500	NA	NA

60	15.55200	16.30800	10.47600	11.93400	16.03800	NA	NA
75	19.44000	20.38500	13.09500	14.91750	20.04750	NA	NA
100	25.92000	27.18000	17.46000	19.89000	26.73000	NA	NA

Table 5. Prescriptive Winter Coincident Demand Reduction (kW)

			Cooling Water	Heating Hot	WSHP	Boiler Draft	Cooling Tower
Horsepower	Supply Fans	Return Fans	Pumps	Water Pumps	Pumps	Fans	Fans
2	0.47700	0.49320	0.34920	0.39780	0.53460	0.19440	0.00
3	0.71550	0.73980	0.52380	0.59670	0.80190	0.29160	0.00
5	1.19250	1.23300	0.87300	0.99450	1.33650	0.48600	0.00
7.5	1.78875	1.84950	1.30950	1.49175	2.00475	0.72900	0.00
10	2.38500	2.46600	1.74600	1.98900	2.67300	0.97200	0.00
15	3.57750	3.69900	2.61900	2.98350	4.00950	NA	NA
20	4.77000	4.93200	3.49200	3.97800	5.34600	NA	NA
25	5.96250	6.16500	4.36500	4.97250	6.68250	NA	NA
30	7.15500	7.39800	5.23800	5.96700	8.01900	NA	NA
40	9.54000	9.86400	6.98400	7.95600	10.69200	NA	NA
50	11.92500	12.33000	8.73000	9.94500	13.36500	NA	NA
60	14.31000	14.79600	10.47600	11.93400	16.03800	NA	NA
75	17.88750	18.49500	13.09500	14.91750	20.04750	NA	NA
100	23.85000	24.66000	17.46000	19.89000	26.73000	NA	NA

Table 6. Prescriptive Summer Coincident Demand Reduction (kW)

					WSHP		
			Cooling Water	Heating Hot	Circulation	Boiler Draft	Cooling Tower
Horsepower	Supply Fans	Return Fans	Pumps	Water Pumps	Pumps	Fans	Fans
2	0.51840	0.54360	0.32940	0.17280	0.41220	0.00	0.31046
3	0.77760	0.81540	0.49410	0.25920	0.61830	0.00	0.46570
5	1.29600	1.35900	0.82350	0.43200	1.03050	0.00	0.77616
7.5	1.94400	2.03850	1.23525	0.64800	1.54575	0.00	1.16424
10	2.59200	2.71800	1.64700	0.86400	2.06100	0.00	1.55232
15	3.88800	4.07700	2.47050	1.29600	3.09150	NA	NA
20	5.18400	5.43600	3.29400	1.72800	4.12200	NA	NA
25	6.48000	6.79500	4.11750	2.16000	5.15250	NA	NA
30	7.77600	8.15400	4.94100	2.59200	6.18300	NA	NA
40	10.36800	10.87200	6.58800	3.45600	8.24400	NA	NA
50	12.96000	13.59000	8.23500	4.32000	10.30500	NA	NA
60	15.55200	16.30800	9.88200	5.18400	12.36600	NA	NA
75	19.44000	20.38500	12.35250	6.48000	15.45750	NA	NA
100	25.92000	27.18000	16.47000	8.64000	20.61000	NA	NA

Table 7. ItemCode Mapping

Note: "NA" entries indicate product combination is not offered in the EVT presriptive program.

Horsepower	Supply Fans	Return Fans	Cooling Water Pumps	Heating Hot Water Pumps	WSHP Circulation Pumps	Boiler Draft Fans	Cooling Tower Fans
2	VT-VFDSUPFAN2	VT-VFDRETFAN2	NA	NA	NA	VT-VFDBDRFAN2	VT-VFDCTRFAN2
3	VT-VFDSUPFAN3	VT-VFDRETFAN3	VT-VFDCHWPMP3	VT-VFDBDPMP3	VT-VFDWSHPPMP3	VT-VFDBDRFAN3	VT-VFDCTRFAN3
5	VT-VFDSUPFAN5	VT-VFDRETFAN5	VT-VFDCHWPMP5	VT-VFDBDPMP5	VT-VFDWSHPPMP5	VT-VFDBDRFAN5	VT-VFDCTRFAN5
8	VT-VFDSUPFAN7.5	VT-VFDRETFAN7.5	VT-VFDCHWPMP7.5	VT-VFDBDPMP7.5	VT-VFDWSHPPMP7.5	VT-VFDBDRFAN7.5	VT- VFDCTRFAN7.5
10	VT-VFDSUPFAN10	VT-VFDRETFAN10	VT-VFDCHWPMP10	VT-VFDBDPMP10	VT-VFDWSHPPMP10	VT-VFDBDRFAN10	VT-VFDCTRFAN10
15	VT-VFDSUPFAN15	VT-VFDRETFAN15	VT-VFDCHWPMP15	VT-VFDBDPMP15	VT-VFDWSHPPMP15	NA	NA
20	VT-VFDSUPFAN20	VT-VFDRETFAN20	VT-VFDCHWPMP20	VT-VFDBDPMP20	VT-VFDWSHPPMP20	NA	NA
25	VT-VFDSUPFAN25	VT-VFDRETFAN25	VT-VFDCHWPMP25	VT-VFDBDPMP25	VT-VFDWSHPPMP25	NA	NA
30	VT-VFDSUPFAN30	VT-VFDRETFAN30	VT-VFDCHWPMP30	VT-VFDBDPMP30	VT-VFDWSHPPMP30	NA	NA
40	VT-VFDSUPFAN40	VT-VFDRETFAN40	VT-VFDCHWPMP40	VT-VFDBDPMP40	VT-VFDWSHPPMP40	NA	NA
50	VT-VFDSUPFAN50	VT-VFDRETFAN50	VT-VFDCHWPMP50	VT-VFDBDPMP50	VT-VFDWSHPPMP50	NA	NA
60	VT-VFDSUPFAN60	VT-VFDRETFAN60	VT-VFDCHWPMP60	VT-VFDBDPMP60	VT-VFDWSHPPMP60	NA	NA
75	VT-VFDSUPFAN75	VT-VFDRETFAN75	VT-VFDCHWPMP75	VT-VFDBDPMP75	VT-VFDWSHPPMP75	NA	NA
100	VT- VFDSUPFAN100	VT- VFDRETFAN100	VT-VFDCHWPMP100	VT-VFDBDPMP100	VT-VFDWSHPPMP100	NA	NA

Footnotes

[1] (Cadmus, 2014), Sections 2.4.4 Hourly Baseline Operating Power (pp. 38-43); 3.1 Final Study Sample (p.51); 3.2 Observations on VSD Operation (pp. 51-55); 3.3 Pre-Retrofit Operation (pp. 55-57).

[2] (Efficiency Vermont, 2011), Overview; Summary.

- [3] Savings factors for Supply Fans, Return Fans, Cooling Water Pumps, Heating Hot Water Pumps, and WSHP Circulation Pumps from (Cadruus, 2014), Table 6 Annual Energy Savings per Unit Horsepower (p. xiv) and Table 7 ISO-NE Summer and Winter On-Peak Demand Savings per Unit Horsepower (p. xiv). Savings factors for Explice Draft Fans and Cooling Tower Fans from (Efficiency Vermont, 2011), Summary worksheet. The Efficiency Vermont savings analysis is based on Equest modeling performed by Efficiency Vermont. For Doller draft fans the factors are based on an analysis of office applications, while for cooling tower fans the factors are based on an average of the results of analyses for office and school applications.
- [4] The DSVG represents the maximum of the summer and winter demand savings factors identified in the source analyses. The summer and winter DSVG may be derived by multiplying the DSVG by the respective coincidence factors from the designated loadshapes for each application.

(5) Equipment and labor costs from the Mid-Atlantic Tenchincal Reference Manual Version 8, adjusted to the Northern New England region per the methodology set forth in the Nwigant Consulting, 2013 Incremental Cost Study Phase Two Final Report (see Referenced Documents). Cost derivation is shown in Referenced Document titled "VFD Costs.Jss." Original data source for the Mid-Atlantic TRM Version 8 costs is the Referenced Document titled "Incremental\_Cost, Recommendations. Jon. Lighting, 050117."

# Commercial Pruchlass Permanent Ma

Measure Number:	I-A-6 c
	94
	Active
Effective Date:	
	[None]
	Commercial & Industrial HVAC
210 0501	
Jpdate Sumr	nary
	ure include the following:
	ere determined to be out-of-date and have been updated with more recent studies, resources, and savings spreadsheets.
<ul> <li>Energy/Demand efficient fans.</li> </ul>	Algorithms have been updated to include a bonus factor to account for additional kWh savings for cooling due to less heat loss of
	and savings calculations have been updated to reflect updated references.
	nace Fan Motor Savings
	y Savings Potential and Opportunities for High-Efficiency Electric Motors in Residential and Commercial Equipment", 2013. able-update. 2014-02-05.xlsx
	able-update_2014-02-05.xlsx M Fan Motor Savings.xlsx
NREL, "Evaluation	n of Retrofit Variable-Speed Furnace Fan Motors", 2014.
	I Shape Report_Final_August2
<ul> <li>New York Stand</li> </ul>	ard Approach for Estimating Energy Savigns from Energy Efficiency Programs 2016
ffer and savings es fficiency of the heal notor for businesses	imation relate only to the efficiency gains associated with an upgrade to a BLPM fam motor, rather than for improvements in the ing and cooling equipment. That is, increases in AFLIE or EER/SEER are NOT covered by this measure. The installation of a BLPM is an apply to: just the heating system (heating only), just the central A/C system (cooling only), or for an in indef servings both
ffer and savings esi fficiency of the heal notor for businesses eating and cooling :	imation relates only to the efficiency gains associated with an upgrade to a RPM fan motor, rather than for improvements in the ing and cooling equipment. That is, increases in APLE or ERN/SEER are NOT covered by this measure. The installation of a BLPM can apply to: just the heating system (heating only), just the central A/C system (cooling only), or for an air handler servings bot systems (heating and cooling).
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		1238 hours <sup>[5]</sup> ; Heating hours are 0 for Cooling Only applications.
Watts <sub>Base</sub>	-	Power consumption of baseline fan motor. 571 Watts. <sup>[2]</sup>
WattsEE	-	Power consumption of energy efficient fan motor. 392 Watts. <sup>[3]</sup>

# Average Savings for BLPM Commercial HVAC Fan Motors Application kWh savings kW savings

Heating Only	222	0.179
Cooling Only	181	0.240
Heating and Cooling	403	0.240

Baseline Efficiencies A low-efficiency permanent split capacitor (PSC) fan motor on a hot air furnace, split sy both heating and cooling. ed air h

High Efficiency A brushless permanent magnet motor (BLPM, also called ECM, ICM, and other handling system serving both heating and cooling.

Operating Hours Heating: 1238 hours/year.<sup>[5]</sup> Cooling: 755 hours/year.<sup>[4]</sup>

Load S See deriva	hapes tion of the savings profiles in "Commercial Furna	ice Fan M	otor Savin	gs.xls".				
	78c BLPM Fan Motor Commercial Heating 79c BLPM Fan Motor Commercial Coolino							
	· · · · · · · · · · · · · · · · · · ·							
80c BLPM I	Fan Motor Commercial Heating & Cooling							
80c BLPM I	Fan Motor Commercial Heating & Cooling Name	Status	Winter On kWh		Summer On kWh	Summer Off kWh	Winter kW	Summer kW
		<b>Status</b> Active					kW	

80 BLI	M Fan Moto	or Commercial H	eating & Cooli	ng Active	30.9%	42.2%	19.1%	7.8%	50.2%	52.4%
Net Savi	ngs Fac	tors								
Measures										
SHEFNMTR I	urnace fan	motor								
Tracks [Bas	e Track]									
6012CNIR [is	base track]	C&I Retro								
6013CUST [is	base track	Cust Equip Rpl								
6013PRES [is	base track]	Pres Equip Rpl								
6018LINC [is	base track]	LIMF NC								
6019MFNC [is	base track	1 MF Mkt NC								
Track Name	Track Nr.	Measure Code	Free Rider S	pill Over						
C&I Retro	6012CNIR	SHEFNMTR	1.00 1	.00						
Cust Equip Rp	6013CUST	SHEFNMTR	1.00 1	.00						
Pres Equip Rp	6013PRES	SHEFNMTR	1.00 1	.00						
LIMF NC	6018LINC	SHEFNMTR	1.00 1	.00						
MF Mkt NC	6010MENC	SHEFNMTR	1.00 1	.00						

Persistence The persistence factor is assumed to be one.

Lifetimes 15 years.

Measure Cost \$180 for Market Opportunity<sup>[7]</sup>

# O&M Cost Adjustments

cost adjustments for this measure

Fossil Fuel Description There is an increase in fossil fuel use associated with this measure, due to the decrease in waste heat produced by the BLPM motor during the heating

 $\Delta \text{MMBtu}~=0.5^{(8)}$  for Heating Only, as well as Heating and Cooling  $\Delta$ MMBtu = 0.0 for Cooling Only

### Incentive Level

Footnotes

- [1] Borus Factors derived from the difference in total swings of the efficient motor and the calculated savings based on motor demands and operating hours. NREL, "Technical Report: Evaluation of Retrofit Variable-Speed Furnace Fan Motors", 2014, Page 18, Table 8. For bonus factor calculation see reference file "Commercial BLPM Fan Motor Savings.x6".
- [2] Average baseline motor demand derived from results of NREL, "Technical Report: Evaluation of Retrofit Variable-Speed Furnace Fan Motors", 2014. Page 12, Tables 3 and 4. For calculation see reference file "Commercial BLPM Fan Motor Savings.xlsx".
- [3] Average efficient motor demand derived from results of NREL, "Technical Report: Evaluation of Retrofit Variable-Speed Furnace Fan Motors", 2014. Page 12, Tables 3 and 4. For calculation see reference file "Commercial BLPM Fan Motor Savings.vlsv".
- [4] EFLH for commercial air conditioning are derived directly from the following KEMA, report. KEMA, "CRI Unitary HVAC Load Shape Project Final Report", Northeast Energy Efficiency Partnerships, Regional Evaluation, Measurement, and Verification Forum, August 2, 2011. Pg. 57, Table 3-1.
- [5] Equivalent full load heating hours were derived from New York reported EFLH for small commercial heating applications. Hours were adjusted using TMY3 data for Vermont and New York. See reference file "Commercial BZPH Fan Notor Savings.xlsx", "EFLH, Heating" Tab. New York EFLH hours are referenced from New York State Jult Nitilies, "New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs", Version 4, April 2016. Pg. 444, Appendix G Small Commercial Heating EFLH.
- [6] Effective Useful Life as determined in the 2014 update of the DEER Database. See reference file "DEER 2014 EUL Table Update.xlsx"
- [7] Costs are based on the market opportunity of a BLPM motor on a new furnace. Navgant Consulting, "Energy Savings Potential and Opportunities for High-Efficiency Electric Motors in Residential and Commercial Equipment", 2013. Page 28, Table 3.6.
- [8] See calculation in "Commercial BLPM Fan Motor Savings.xbs," based on waste heat reduction of fan motor resulting in an increase in heating load. Results from NREL study were adjusted based on Vermont operating hours. NREL, "Technical Report: Evaluation of Retroft Variable-Speed Furnace Fam Motors", 2014. Appas 16-17, Tables 6-7.

### Brushless Permanent Magnet (BLPM) Circulator Pump

Measure Number: I-A-7 b					
Portfolio:	96				
Status:	Active				
Effective Date:	2017/1/1				
End Date:	[ None ]				
Program:	Commercial & Industrial				
End Use:	HVAC				

Update Summary
The measure has been updated to replace a list of manufacturer pump data with more recent circulator pump studies and pump motor efficiency data

- Referenced Documents

   Navgard, "Energy Savings Noterital and Opportunities for Hgh-Efficiency Electric Motors in Residential and Commercial E

   Commercial EUMP Anny Motor Analysis.dss

   ERRL, "Assessment of New Technologies and their Applications", 2013.
   ERRL, "Assessment of New Technologies and their Applications", 2013. ial Equ nt", 2013.

Description Description This measure is for installing circulator pumps with brushless permanent magnet pump (BLPM) motors, less than or equal to three horsepower. Typical applications include baseboard and radiant floor heating systems that utilize a primary/secondary loop system in multifamily residences and small commercial buildings. This measure is restricted to systems that use IBMs are more efficient because they lack trushes that add firtidion to the motor, as well as the ability to modulate their speed to match the IBMS are motor stature. As the system flow demand changes (zones open or close), the drive rearess the torque efference as the impleiv via the class in them orbits stature. As the system flow demand changes (zones open or close), the drive senses the torque efference as the impleiv via the change in the magnetic field difference and adjusts its speed by altering the frequency to the motor. BLPMs are especially efficient in no-load/low-load applications.

Baseline Efficiencies The baseline equipment is a circulator pump using a low-efficiency induction motor. It is assumed that this pump is installed on the primary loop of a multi-loop system, and is running constantly when outside temperatures are 55% or lower during the winter heating season (October – April).

Efficient Equipment
The efficient equipment is a circulator pump with brushless permanent magnet motor.

Algorithms Electric Demand Savings

# ΔkW = (Watts<sub>Base</sub> - Watts<sub>Eff</sub>) / 1000

Demand Savings for Commercial BLPM Pump Motors<sup>[1]</sup>

Where $W_{MAX} = Maximum rat$	ed wattage of efficient	circulator pump (namep	late information)	
Maximum Rated Watts (BLPM Motor)	Average Rated Watts for BLPM Pump Motor <sup>[2]</sup>	Average Watts for Baseline Pump Motor <sup>[3]</sup>	Average Demand Savings ΔkW	
$W_{MAX} \le 144$	74	141	0.0675	
$144 < W_{MAX} \le 575$	276	371	0.0953	
$575 < W_{MAX} \le 2500$	1082	1209	0.1270	

Electric Energy Savings

ΔkWh = (Watts<sub>Base</sub> - Watts<sub>Eff</sub> × (1 - Control)) / 1000 × Hours

### Energy Savings for Commercial BLPM Pump Motors[1]

	Where $W_{MAX} = Maximum$ rated wattage of efficient circulator pump (nameplate information)									
	Maximum Rated Watts (BLPM Motor)	Average Annual Energy Savings ΔkWh								
	$W_{MAX} \le 144$	401.3								
ľ	$144 < W_{MAX} \le 575$	780.1								

$144 < W_{MAX} \le 575$	780.1
$575 < W_{MAX} \le 2500$	1924.3
Symbol Table	

Fossil Fuel Savings

Where	:		
	ΔkW	-	Gross customer connected load kW savings for the measure (kW). Savings calculated by different bins of efficient wattages
	ΔkWh	-	Gross customer annual kWh savings for the measure (kWh)
	1000	-	Conversion from watts to kilowatts
	Control	-	Control factor accounts for additional savings due to reduced power operation and control functions utilized with BLPM pump motor; 0.27. <sup>[4]</sup>
	Hours	-	Annual operating hours during heating season; 4592 hours. <sup>[5]</sup>
	Watts <sub>Base</sub>	-	Watt rating of baseline induction motor. Baseline rating is estimated based on rating of efficient motor replacement
	Watts <sub>Eff</sub>	-	Maximum Watt rating of efficient BLPM motor. Refer to Demand Savings table below for motor size bins

# Operating Hours

rating hours are assumed to be 4592<sup>[5]</sup>

Load Sha 17b Commerce	<b>pes</b> ial Space Heat							
Number	Name	Status				Summer Off kWh	Winter kW	Summer kW
17 Co	mmercial Space Heat	Active	43.2%	52.3%	1.6%	3.0%	17.9%	0.6%

Net Savings Factors

Measures SHECPMTR Brushless Permanent Magnet (BLPM) Circulator Pump

Tracks [Base Track] 6013UPST [is base track] Upstream - Commercial

 Track Name
 Track Nr.
 Measure Code
 Free Rider
 Spill Over

 Upstream - Commercial 6013UPST
 SHECPMTR
 0.95
 1.00

Persistence The persistence factor is assumed to be 1.

Lifetimes 20 years – bylical circulator pumps using low-efficiency induction motors are expected to last around 15 years; circulator pump motors with BLPMs bylically operate at lower RPMs, thus producing less heat and extending the life of the motor.

Measure Cost The estimated full cost for this measure varies based on the size of the motor. See the table below for further details.

### Cost for Commercial BLPM Pump Motors<sup>[6]</sup>

Where  $W_{MAX} = Maximum$  rated wattage of efficient circulator pump (nameplate information)

Maximum Rated Watts (BLPM Motor)	Average Cost (incl. Labor)
$W_{MAX} \le 144$	\$547
$144 < W_{MAX} \leq 575$	\$1,643
$575 < W_{MAX} \le 2500$	\$3,316

### O&M Cost Adjustments

None

Water Descriptions

### Footnotes

[1] For pump savings analysis see reference file "Commercial BLPM Pump Motor Analysis.xlsx"

- [2] Average wattages determined from list of EVT qualified pump models as of December 2016. For details see reference file "Commercial BLPM Pump Motor Analysis.xtsx".
- [3] Average baseline wattages are calculated using motor efficiency curves and the average wattages of efficient BLPM motors. For calculations see reference file "Commercial BLPM Pump Notor Analysis.Xex". Efficiencies developed from the following sources. U.S. DOE, "Premium Efficiency Motor Selection and Application Caide", 2014; Neivagn, "Every Saving Potential and Opportunities for High-Efficiency Electric Motors in Residential and Commercial Equipment" provided to the U.S. DOE, 2013.
- [4] The control factor is derived using motor efficiency curves and the results of the following EPRI studies to account for additional savings from operating control modes of efficient BZM motors; EPRI, "Assessment of New Motor Technologies and their Applications", 2013. EPRI, "Assessment of New Energy Efficient Circulator Pump Technology", 2010. For details see reference file "Commercial BLPM Pump Motor Analysis.xlsx".
- (5) Operating hours are calculated as the total hours between the months of October 1<sup>st</sup> and April 30<sup>th</sup> where the outside air drv-bulb te ure is below 55°. Hours are an average number of heating season hours from 2012 through 2015. See reference file "Commercial BLPM Pump Motor Analysis.xisr."

[6] For costs analysis see reference file "Commercial BLPM Pump Motor Analysis.xlsx"

## **Commercial Ventilation Fan**

Measure Number	: I-B-5 b
Portfolio:	EVT TRM Portfolio 2017-07
Status:	Active
Effective Date:	2018/1/1
End Date:	[ None ]
Program:	Commercial & Industrial
End Use:	HVAC

Update Summary This is a reliability update that includes a change of high efficiency levels (CFM/watt) based on custom projects that have been perform years. This analysis follows the previous methodology, which reveiwed custom projects from 2009-2012. ned over the past 4

### Referenced Documents

 measure\_life\_GDS[1]
 evt-commercial-ventile sis-july-2017-xls

Description An ENERGY STAR qualified efficient fan configured to meet ASHRAE 62.1 requirements for bathroom ventilation. This market opportunity is defined by the need for continuous mechanical ventilation in bathrooms and mechanical closets of small commercial and industrial buildings during operating hours. This measure assumes an efficient fan will be run during business hours to provide 10-500 CFM under static pressure conditions ranging from 0.1 to 0.25 inches of water.

Algorithms Electric Demand Sav	ings					
ΔkW	= CFM ×	(1 / Fan <sub>Effic</sub>	ency, Baseline - 1 / Fan <sub>e</sub>	fficiency, Efficient) /	1000	
Symbol Table						
lectric Energy Savir	nas					
ΔkWh	= Hours	×∆kW				
Where:						
ΔkW	-	connected I Demand Sa	oad kW savings per q vings	ualified ventilatio	on fan ar	nd controls
		CFM code	Nominal CFM Range	Assumed CFM	ΔkW	
		CFM1	10-89	70	0.029	
		CFM2	90-150	110	0.046	
		CFM3	151-250	175	0.073	
		CFM4	251-500	350	0.145	
ΔkWh	-	Energy Sav	ings			
		CFM code	Nominal CFM Range	Assumed CFM	∆kWh	
		CFM1	10-89	70	85	
		CFM2	90-150	110	133	
		CFM3	151-250	175	212	
		CFM4	251-500	350	424	
CFM	-		pacity of the exhaust I CFM" column	fan. Savings calo	culatation	n use a common rating within the range, as shown in th
Fan <sub>Efficiency</sub> , Basel	ine =	Efficacy for 1.7 CFM/W	baseline fan <sup>[1]</sup> att			
Fanefficiency, Efficiency	ent =	Efficacy for 6.1 CFM/W	efficient fan <sup>(2)</sup> att			
Hours	-	assumed an 2920 <sup>[3]</sup>	nnual run hours			
Baseline Efficie New standard efficiency commercial bathrooms of	exhaust-o		n fan operating in acc	ordance with re	commer	ded ventilation rate indicated by ASHRAE 62.1 for
High Efficiency New efficient exhaust-or bathrooms during busine		ion fan, oper	ating in accordance w	vith recommende	ed ventil	ation rate indicated by ASHRAE 62.1 for commercial

# Operating Hours 2870<sup>[3]</sup>

# Load Shapes 113a Commercial Small Exhaust-only Vent Fan

		Number	Name	Status				Summer Off kWh		Summer kW
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# Net Savings Factors

Measures VNTXCEIL Exhaust fan, ceiling VNTXVFAN Exhaust fan, variable speed

Tracks [Base Track] 6012CNIR [is base track] C&I Retro 6013CUST [is base track] Cust Equip Rpl 6013PRES [is base track] Pres Equip Rpl 6014PRES [is base track] 6014PRES 6014CUST [is base track] 6014CUST

Persistence The persistence factor is assumed to be one.

# Lifetimes 15 years<sup>(4)</sup>. Analysis period is the same as the lifetime.

Measure Cost Incremental cost per installed fan is \$110 for quiet, efficient fans<sup>[5]</sup>.

O&M Cost Adjustments There are no O&M Cost Adjustments for this measure.

# Fossil Fuel Description There are no fossil fuel savings for this measure.

## Footnotes

[1] Weighted average of 20 best-selling ceiling exhaust fans at Grainger on 6/26/2017 using assumed sales distribution, 2017 Base-Efficacy sheet of EVT\_Commercial Ventilation Fan\_Analysis\_June 2017.xtsx

- [2] Average of fans installed through EVT custom projects 2012-2016, 2017 EE-Efficacy sheet of EVT\_Commercial Ventilation Fan\_Analysis\_June 2017.vdsx
- [3] Median of run hours of fans installed through EVT custom projects 2008-2011, Cell C67 on 2017 EE-Efficacy tab of EVT\_Commercial Ventilation Fan\_Analysis\_June 2017.vdsx.
- [4] Estimate based upon GDS Associates Measure Life Report "Residential and C&I Lighting and H/AC measures" 25 years for residential whole-house fans, 19 for residential thermostatically-controlled attic fans, and 15 years for several commercial measures.
- [5] Based on historical incremental costs from EVT custom project data (2012-2016). Refer to Cell H59 on 2017 EE-Efficacy tab of EVT\_Commercial Ventilation Fan, Analysis, June 2017.visx.

### Package Terminal Heat Pump (Hotel Room)

Measure Number:	I-B-6 b
Portfolio:	EVT TRM Portfolio 2019-0
Status:	Active
Effective Date:	2020/1/1
End Date:	[ None ]
Program:	Commercial & Industrial
End Use:	HVAC

Update Summary Updated the baseline and efficient metrics to meet federal efficiency standards. Interestingly enough, the code of federal regulations efficiency standards for PTAC and PTHP enceed those stipulated in VT 2015 CBCs. Updated the baseline and efficient metrics to meet 10 CFR 431.37(c)). Baseline is defined as a code-compliant PTAC with electric resistance heating and the efficient scanario is a code-compliant PTAF. As bottleric resistance heating and the efficient scanario is a code-compliant PTAF. As bottleric resistance heating and the efficient scanario is a code-compliant PTAF. As bottleric resistance heating and the efficient scanario is a code-compliant PTAF. As bottleric resistance heating and the efficient scanario is a code-compliant PTAF. As bottleric resistance heating and the efficient scanario is a code-compliant PTAF. As bottleric resistance heating and the efficient scanario is a code-compliant PTAF. As the deriver scanario as a code-compliant PTAF. As bottleric resistance heating and the efficient scanario is a code-compliant PTAF. As the deriver scanario as code-compliant PTAF. As the deriver scanario as a code-compliant PTAF with enderviser scanario as a code-compliant PTAF. As the deriver scanario as a code-compliant PTAF with enderviser scan

- Additionally, there were some revisions made to the 8760 analysis that calculates the deemed savings for this measure. In the analysis file, the follo revisions were made:
- revesors were made:
   Updated the monthly hotel occupancy rates. The original rates were sourced from some VT benchmarking summary that I could no longer access.
  Overall, some of the rates looked small to borderline unreasonable. For instance, we were claiming hotel occupancy rates for rooms in May was 22.7%, 46.5% in the summer months, and the list goes on. Revised the monthly hotel occupancy rates to national averages, as sourced from Statista, that seem much more reasonable.
  Revised the cut-off temperature for the heat pump from 24PF to 35PF. This lower bound temperature was when the heat pump sourced from resistance heating. Through reasonable. Throug research and communication with Charlie Carpenter, EVT, the 35PF value was developed.
  As a result of these revisions, along with some errors corrected in how the loadshape was being calculated, a new loadshape for this measure was drafted.

- Revised the incremental cost. Additionally, made minor edits to the measure description and source notes to be more transparent and clear on the characterization

### Referenced Documents

- NYSERDA PTHP Market Development\_Oct 2018
   PTHP Analysis\_Revised\_v3

### Description

Description This measure characterizes the installation of a package terminal heat pump (PTHP) replacing a package terminal air conditioner (PTAC) with electric resistance heat. PTHP's are predominantly used in hotel and motel accomodations, and are designed to supply each guest room with individual heating and air conditioning. However, the efficacy of PTHP's in cold-climates are diminished as they don't have a good means of dealing with first build up on the coils. As a result, the heat pump compressor tends to shut off in colder temperatures<sup>[1]</sup> and the system reverts to electric resistance heating. An average system capacity of 9,000 Bu/h<sup>2]</sup> was assumed.

This program will be targeted exclusively to hotels and motels likely to have existing PTAC units with electric resistance heat. While there may be applications for PTH-9 explorers in the context of new construction, the baseline is difficult to generalize. Therefore new construction applications handled through a custom process.

# Program Type Calculation Type: Time of Sale (Market Opportunity)

Program Delivery / Implementation Type: Downstream

### Program Delivery / Implementation Type

Baseline Efficiencies The baseline reflects a code compliant PTAC with electric resistance heat.<sup>[3]</sup>

High Efficiency The efficient equipment is a code compliant PTHP. <sup>[4]</sup>

### Algorithms

Electric Demand Savings Electric energy and demand savings are deemed and based on an hourly, 8760 analysis of TMY3 data, on an installed PTHP with a capacity of 9,000 Eluctric energy and demand savings are deemed and based on an hourly, 8760 analysis of TMY3 data, on an installed PTHP with a capacity of 9,000 Eluctric mergy and demand savings are deemed and based on an hourly, 8760 analysis of TMY3 data, on an installed PTHP with a capacity of 9,000 Eluctric mergy and demand savings are deemed and based on an hourly, 8760 analysis of TMY3 data, on an installed PTHP with a capacity of 9,000 Eluctric mergy and demand savings are deemed and based on an hourly, 8760 analysis of TMY3 data, on an installed PTHP with a capacity of 9,000 Eluctric mergy and demand savings are deemed and based on an hourly, 8760 analysis of TMY3 data, on an installed PTHP with a capacity of 9,000 Eluctric mergy and demand savings are deemed and based on an hourly, 8760 analysis of TMY3 data, on an installed PTHP with a capacity of 9,000 Eluctric mergy and demand savings are deemed and based on an hourly, 8760 analysis of 306 for the heat pump (with an additional 1,038 full load heating hours for the electric resistance backup, not included in the analysis).<sup>[8]</sup>

ΔkW		= 0.258	15 kW						
Symbol	Table								
Fossil Fu N/A Water S N/A	iel Savings avings								
'	Energy Savi	ngs							
∆kWh		= 558 k	Wh						
Where:									
Δ	kW	-	Gross cu	istomer co	nnected loa	ad kW savir	ngs for the	e measure	
۵	kWh	-	Gross cu	istomer av	erage annı	ual kWh sav	ings for t	he measure	2
Mid-Li	fe Saving	ıs Adjı	istmen	t					
Load S	P, Hotel								
Number	Name	Status			Summer On kWh	Summer Off kWh	Winter kW	Summer kW	
114	PTHP, Hotel	Active	41.1%	51.5%	1.0%	6.4%	3.2%	0.0%	
Measure	<b>avings Fa</b> es "L Package te		at hump						
	Base Track] R [is base trac		letro						

Lifetimes 15 years

Measure Cost

\$100[6]

O&M Cost Adjustments nance cost adjustments used for this measure. re are no standard operation and

Persistence The persistence factor is assumed to be one.

Reference Tables Item Code: BES-PTHP-H

### Footnotes

- [1] For the purposes of the analysis, the lower bound outdoor air temperature threshold at which heat pump feature operates was determined to be 39°F. Below this temperature the unit shifts to resistance heat mode as per; "High Performance Packaged Terminal Heat Pump Market and Development Research Report," MYSEBDA, October 2018. The 35°F threshold was estimated from the page ES-2 in the report when it stated; "Most PTHPs operate as heat pumps only down to the 30s."
- [2] The 9,000 Bu/h average capacity of a PTHP is sourced from the "High Performance Packaged Terminal Heat Pump Market and Development Research, M/SER0A, October 2018, page 4. The study indicates that 50% of the U.S. PTAC and PTHP market is comprised of 9,000 Bu/h units, with other common sizes being 7,000 Bu/h and 12,000 Bu/h.
- [3] Federal efficiency standards exceed 2015 Vermont Commercial Building Energy Standards (Table C403.2.3(3)). As a result, baseline PTAC cooling efficiency is sourced from the Code of Federal Regulations (10 CFR 43.37(C)) for standard equipment size, with a capacity => 7,000 Bu/h and <= 15,000 Bu/h, and manufacture on or after 3marsy 1, 2017.
- [4] Federal efficiency standards exceed 2015 Vermont Commercial Building Energy Standards (Table C403.2.3(3)). As a result, efficient PTHP heating and cooling efficiencies are sourced from the Code of Federal Regulations (10 CFR 431.97(c)) for standard equipment size, with a capacity => 7,000 Btu/h and <= 15,000 Btu/h, and manufactured on or after October 8, 2012.</p>
- [5] Full load heating and cooling hours are based on an hourly, 8760 analysis of TMY3 data, and assumes a balance point of 55%; an unoccupied setback of 5%; the heat pump providing heating down to 35% before switching to electric resistance; an estimate on sites employing setback controls (59%); monthly occupancy rates for accomodations; and an assumption that the equipment is oversized by 25% on average. For more detail on the analysis, please see "TPH Panalysis, Revised, V3.skr."
- [6] "High Performance Packaged Terminal Heat Pump Market and Development Research Report", NYSERDA, October 2018, page ES-2

# Advanced Thermostats

 Measure Number:
 ED-1 b

 Portfolio:
 EVT TRM Portfolio 2019-01

 Status:
 Active

 Effective Data:
 2019/1/1

 End Date:
 [None]

 Program:
 Commercial & Industrial

 End Use:
 HVAC

Update Summary Updated to bring the Fe (auxiliary electric heat from fans/pumps) in line with the new assumption for Residential. Updating savings accordingly

- Referenced Documents

   VT CL Disting Buildings Market Assessment and Characterization, 2012-10-6, FIVAL.
   VT CL New Construction Market Assessment and Characterization, FIVAL, 2012-12-21
   L. SAG Smart Thermostate Freiminary Gas Inpact Findings 2015-12-08 to L. SAG
   Subulse informing the TWH Swings Characterization for Advanced Thermostats
   VGS Luage Regression Vice A, (1912017
   2015 Vermont Business Sector Market Characterization and Assessment Study
   Programmable Thermostate Finance Fan Arabysis
   SMB-Advanced Thermostat, 01102019

### Description

Description This measure characterises the energy savings from the installation of a new thermostal(s) in a small to medium business location, to reduce heating and cooling consumption through a configurable schedule of temperature set-points (like a programmable thermostal) and automatic variations to that schedule to better match HAAC system runtimes to meet occupant comfort needs. These schedules may be defaults, established through user interaction and be charged meanily at the device or remotely through a web or mobile app. Automatic variations to that schedule could be driven by local sensors and software algorithms, and/or through connectivity to an intervet software service. Data triggers to automatic schedule charges may include, nervices, weather data and forecasts.<sup>11</sup> This class of products and services are relatively new, diverse, and rapidly changing. Generally, the savings expected for this measure arrity testablished at the level individual flattures, but atther at the system level and how it performs oreall. Note that it is a very active area of ongoing study to better map features to savings value, and establish standards of performance measurement based on field data so that a scharder of difficiency can be developed. That work is not yet complete but does inform the treatment of some aspects of this characterization and recommendations.

absence of sma on this small The measure assumes that the advanced thermostat is controlling a portion of the buildings heating/cooling load and, in the al specific assumptions, is assumed to control a similar load as Residential applications. This will be revised as data is collected or application. Efficiency Vermont will track and provide incentives for up to six advanced thermostats per commercial building. all bu The thermostat must be installed and connected with the manufacturer in order to be eligible for a rebate.

### **Baseline Efficiencies**

The baseline mix of progra buildings<sup>(2)</sup>. . ble v manual thermostats for small to medium business customers is 89% manual and 11% programmable for existing

For New Construction, the baseline is a programmable thermostat due to code requirements.

### Efficient Equipment

Efficient Equipment The criteria for this measure are established by replacement of a manual-only or programmable thermostat, with one that has the default enabled capability—or the capability to automatically—establish a schedule of temperature setpoints according to driving device inputs above and beyond basic time and temperature data of conventional programmable thermostats. As summarized in the description, this category of products and services is for and rapidly advancing in regarks to their capability, usably, and sophistication, but at a minimum must be capable of two-way communication<sup>11</sup> and exceed the typical performance of manual and conventional programmable thermostats through the automatic or default capabilities described above.

Algorithms Electric Demand Sa	vings				
ΔkW	= Max( $\Delta kWh_{heating}$ / EFLH <sub>heat</sub> , $\Delta kW$	h <sub>cooling</sub> / EFLH <sub>cool</sub> )			
Symbol Table					
Electric Energy Sav	ings				
ΔkWh	$= \Delta kWh_{heating} + \Delta kWh_{cooling}$				
ΔkWh <sub>heating</sub>	= %ElectricHeat × Elec_Heating_Co	nsumption × %Controlled × Heat	ing_Reduction + (	ΔMMBtu × F <sub>e</sub> × 293)	
ΔkWh <sub>cooling</sub>	= %AC × ((EFLH <sub>cool</sub> × Capacity × 1	/SEER)/1000) × Cooling_Reduction	n		
Symbol Table					
Fossil Fuel Savings					
ΔMMBtu	= Σ (%FossilHeat × Heating_Consur	nption $\times$ %Controlled) $\times$ Heating	_Reduction		
Where:					
%AC	= Fraction of custome	rs with central air-conditioning			
		Central air conditionin	ig? %AC		
		Yes		100%	
		No		0%	
		Unknown		56%[6]	
%Controlled	<ul> <li>Assumed percentage</li> </ul>	e of total heating load being contr	olled by thermost	at	
	= 69% for Existing E	Buildings and 53% for NC <sup>[7]</sup>			
%ElectricHeat	<ul> <li>Percentage of heatir</li> </ul>	ng savings assumed to be electric			
		Heating fuel	%ElectricHeat		
			Existing Buildings <sup>(8)</sup>	New Construction	
		Electric	100	196	
		Fossil Fuel	0%		
		Unknown	25%	61%	
%FossilHeat		ng savings assumed to be fossil fu known that it is not natural gas)	uel (note for the 'u	inknown' category nat	ural gas is not
		Heating fuel	%FossilHeat	_	1
			Existing	New	
			Duilding	Construction	



				Electr					0%			
				Unkni		Oi		27%		0%		
							opane	48%		39%		
												l
	ΔkW	-	Annual demand rea	duction								
	\kWh <sub>cooling</sub>	-	Electric savings fro	m cooli	ing energ	gy usage	reductions					
	\kWh <sub>heating</sub>	-	Electric savings fro						nts for b	oth electri	c heat (h	neat pumps) and
			fan/pump savings i	n the c	ase of a	fossil he	ating system	1.				
4	\$kWh	-	Electrical savings a	re a fu	nction of	both he	ating and co	oling energ	y usage i	reductions		
4	\MMBtu	-	Fuel savings if foss	il fuel l	neating s	ystem						
3	293	-	kWh per MMBtu									
(	Capacity	-	Capacity of AC unit	. (Note	: One re	frigerati	on ton is equ	al to 12,00	0 Btu/hr.	)		
			= 41,400 Btuh/hr[1	0]								
-	Cooling_Reduction	_	Assumed percenta	aa radi	uction in l	total cov	ling operat	concumptio	n dua ta	installatio	a of adua	ancod thormoctat
,	Looinig_Reduction		Assumed percenta	ye reu		LOLAI COL	ning energy	consumptio	n uue to	IIIStallauo		inceu ulermostat
			= 8.0%[11]									
	:FLH <sub>cool</sub>	-	Estimate of annual	full loa	d cooling	hours	or air condit	ioning equi	oment.			
			= 755 <sup>[4]</sup>					5				
1	FLH <sub>heat</sub>		Assumed Equivaler	nt Full L	.oad Hou	rs for he	ating					
			= 1062 <sup>[5]</sup>									
I	Elec_Heating_Consumption	•	Estimate of annual	heatin	g consum	nption fo	r heat pump	heated bui	ldings:			
					_							
							g_Consump					
					Existi 8,273	ing Buil	dings	New C	onstruct	tion		
					0,273			0,410		_		
1	īe -	•	Furnace fan / boile	r pump	energy	consum	ption as a pe	rcentage of	fannual	fuel consu	mption	
			= 1.91% <sup>[14]</sup>									
	Heating_Consumption		Estimate of annual	heatin	a consum	nation						
	consumption		Estimate of annual	Treater P		puon	_	Gas_Hea	ting_Co	onsumpti	on (MME	Btu)
						_		Existing				onstruction <sup>(18)</sup>
					Gas			81			67	
					Oil			84			70	
					Unkno	own		82			67	
	leating_Reduction		Assumed percenta	no rodi	uction in t	total he	ntina enerav	consumptic	n due to	advanced	thermos	stat
	edding_reddedorr		resumed percenta	gereu			ung energy	consumptio	100000	duranceu	u la	
			Progra	am			Existing The	ermostat	н	eating_R	eductio	n(15)
							Туре					
			Existing	g Buildi onstruc	-		Jnknown (Bi Programmat			.0%		
									-			
-						_			-			
5	SEER	-	The cooling equipn	nent's S	Seasonal	Energy	Efficiency Ra	itio rating (I	kBtu/kWh	1)		
					SEER							
					Existi	ing Buil	dings	New C	onstruct	tion		
					11.7	16]		20.2[16]				
					L						_	
	Shapes											
125b SM	B Advanced Thermostat - F IB Advanced Thermostat - I	lectr	ic Heat & Cooling									
	B Advanced Thermostat - I Imercial Space Heat	unkno	own Heat & Cooling									
Numbe		Nam	P		Status	Winte	r Winter h Off kWh	Summer	Summe	er Winte	r Sumn	mer
124	SMB Advanced Thermos											
	SMB Advanced Thermos SMB Advanced Thermos						14.5% 38.8%					
126	SMB Advanced Thermos			ooling	Active	31.2%	32.2%	22.6%	13.9%	14.2%	34.7%	6
17	Commercial Space Heat				Active	43.2%	52.3%	1.6%	3.0%	17.9%	0.6%	
Note	Savings Factors											
Measur												
	ART Advanced Thermosta											
Tracks	[Base Track]											
6013PR	ES [is base track] Pres Eq		pl									
6014PR	ES [is base track] 6014PR	ES										
Lifeti The exp	<b>mes</b> ected measure life for adva	ncer	thermostate is area	imed to	be simi	lar to th	at of a proce	ammable #	ermosta	t 10 vears	[19] haco	d upon equinment
life only.							e. e progr			yours	5000	per equipment

### Measure Cost

FOR GAIN OF COSE For DI and other programs for which installation services are provided, the actual material, labor, and other costs should be used, with a default of \$265 (\$225 for the thermostat and \$40 for labor). For other program types the average incremental cost for the new installation measure is assumed to be \$175<sup>201</sup>.

For new construction, the incremental cost between a programmable and advanced thermostat is assumed to be \$150(21).

### Prescriptive Savings Tables

Savings		Existing Buildings											
Туре	Fuel	Natural Gas Heat, Cooling	Natural Gas Heat, No Cooling	Oil Heat, Cooling	Oil Heat, No Cooling	LP Heat, Cooling	LP Heat, No Cooling	HP Heat, Cooling	Unknown Heat (not NG), Unknown Cooling				
Iter	n Code	ADVSTATSMBE1	ADVSTATSMBE2	ADVSTATSMBE3	ADVSTATSMBE4	ADVSTATSMBE5	ADVSTATSMBE6	ADVSTATSMBE7	ADVSTATSMBE8				
Heating	Natural Gas (MMBTU)	4.5	4.5	0.0	0.0	0.0	0.0	0.0	0.0				
Heating	Oil (MMBTU)	0.0	0.0	4.6	4.6	0.0	0.0	0.0	1.3				
Heating	LP (MMBTU)	0.0	0.0	0.0	0.0	4.5	4.5	0.0	2.1				
Heating	Electric (kWh)	25	25	26	26	25	25	457	133				
Cooling	Electric (kWh)	214	0.0	214	0.0	214	0.0	214	120				
	Total MMBTU	4.5	4.5	4.6	4.6	4.5	4.5	0.0	3.4				
	Total kWh	239	25	240	26	239	25	670	253				
	kW	0.2831	0.0238	0.2831	0.0247	0.2831	0.0238	0.4300	0.1585				
	Loadshape Used	oadshape Thermostat = 17 - Commercial Thermostat =		17 - Commercia Space heat	124 - SMB Advanced Thermostat - Fossil Heat & Cooling	17 - Commercial Space heat	Thermostat -	126 - SMBAdvanced Thermostat - Unknown Heat & Cooling					

					New Bu	uildings			
Savings Type	Fuel		Heat, No Cooling	Oil Heat, Cooling	Cooling	LP Heat, Cooling	Cooling	HP Heat, Cooling	Cooling
Iten	n Code	ADVSTATSMBN1	ADVSTATSMBN2	ADVSTATSMBN3	ADVSTATSMBN4	ADVSTATSMBN5	ADVSTATSMBN6	ADVSTATSMBN7	ADVSTATSMBN8
Heating	Natural Gas (MMBTU)	2.0	2.0	0.0	0.0	0.0	0.0	0.0	0.0
Heating	Oil (MMBTU)	0.0	0.0	2.1	2.1	0.0	0.0	0.0	0.0
Heating	LP (MMBTU)	0.0	0.0	0.0	0.0	2.0	2.0	0.0	0.8
Heating	Electric (kWh)	12	12	12	12	12	12	190	121
Cooling	Electric (kWh)	124	0.0	124	0.0	124	0.0	124	69
	Total MMBTU	2.0	2.0	2.1	2.1	2.0	2.0	0.0	0.8
	Total kWh	136	12	136	12	136	12	314	190
	kW	0.1640	0.0111	0.1640	0.0115	0.1640	0.0111	0.1793	0.1135
	Loadshape Used	124 - SMB Advanced Thermostat - Fossil Heat & Cooling	17 - Commercial Space heat	124 - SMB Advanced Thermostat - Fossil Heat & Cooling	17 - Commercial Space heat	124 - SMB Advanced Thermostat - Fossil Heat & Cooling	17 - Commercial Space heat	Thermostat -	126 - SMB Advanced Thermostat - Unknown Heat & Cooling

### Footnotes

- For example, the capabilities of products and added services that use ultrasound, infrared, or geofencing sensor systems, automatically develop individual models of home's thermal properties through user interaction, and optimize system operation based on equipment type and performance traits based on vester forecasts demonstrate the type of automatic schedule change functionality that apply to this nease of navelet forecasts demonstrate the type of automatic schedule change functionality that apply to this nease of navelet forecasts demonstrate the type of automatic schedule change functionality that apply to this nease of navelet forecasts demonstrate the type of the navelet forecast demonstrate the navelet forecast demonstrate the navelet forecast demonstrate the navelet [1]
- [2] Based on findings for Office building type from 'Figure 63: Saturation of HVAC System Control Types by Facility Type' from the 2016 VT Business Sector Market Characterization and Assessment Study, April 30 201. Note EMS (Energy Management Systems) were found in 25% of the Offices. It is assumed that these would not be installing Advanced Thermostats and so are not included in the baseline mix.
- [3] This measure recognizes that field data may be available, through this 2-way of pability, to better inform characterization of efficiency criteria and savings calculations. Efficiency Vermont will be exploring ways to better utilize this data once the program is underway and once the ENERGY STAR specification and program process is finalized.
- [4] EFLH for commercial air conditioning are derived directly from the following KEMA report. KEMA, "C&I Unitary HVAC Load Shape Project Final Report", Northeast Energy Efficiency Partnerships, Regional Evaluation, Measurement, and Verification Forum, August 2, 2011. Pg. 57, Table 3-1.
- [5] Commercial FLH is a weighted average of commercial FLH values from New York Joint Utilities, "New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs (Version 4)," April 29, 2016 and Vermont building data provided by Cadmus. See File EVT\_Commercial EFLH\_Analysis\_JAV2017 for calculation details.
- [6] Value is for Office Building Type as representative of small and medium business customer likely to participate, from Business Sector Market Assessment and Baseline Study: Existing Commercial Buildings, Vol. 1, Final Report, prepared by KEMA for the Department of Public Service, July 10, 2009, Table 5-9
- Consistent with Residential assumptions; Based on review of # of thermostats per home data from Vermont Single-Family Existing Homes Onsite Report, 2/15/2013 and Vermont Residential New Construction Baseline Study Analysis of On-Site Audits, 2/13/2013. See 'Advanced Thermostat Analysis, 04182017\_FINAL.xis' [7] Cor
- [8] Unknown values are based upon data for Efficiency Vermont from 'Figure 46 Heating System Fuel Type by EEU from 2016 VT Business Sector Market Characterization and Assessment Study, April 30 2017. Percentage for electricity is reduced to only include heat pump systems as resistance heat will not be controlled by an Advanced Thermostal (heat pump percentage to based on values for non-VT gas from Figure 47 Distribution of Heating System Types by Facility Size and VT Gas Territory' from the same study). Note that the unknown values do not include natural gas as this will be known.
- (9) Unknown values are based upon data for Efficiency Vermont from 'Figure 128 Heating System Fuel Type by EEU from 2016 VT Business Sector Market Characterization and Assessment Study, April 30 2017, Percentage for electricity is reduced to only include heat pump systems as resistic heat will not be controlled by an Advanced Thermotal (heat pump percentage is based on values for non-'Tgu as from 'Figure 120 Eichtrukton Heating System Types by Facility Size and VT Gas Territory' from the same study). Note that the unknown values do not include natural gas as t and the same study of the same study. ral gas as this Heating Syster will be known.

[10] Consistent with Residential assumptions: TAG Agreement 2017.

- [11] Consistent with Residential assumptions; This assumption is based upon the review of many evaluations from other regions in the US (see "Studii informing the TRM Swings Characterization for Advanced Thermostats.doc/"). These sources, are from different regions products, and program delivery designs, but otlectively form as sound basis, and directional guidance for the existence and magnitude of cooling savings. Because coolin savings are more volatile than those for heating due to variables in control behaviors, population, and product factors, conservative estimate based upon the array of results from these studies. Further evaluation and regular review of this key assumption is encouraged.
- [12] Consistent with Residential assumptions; Estimate is based upon calculation of average heating load from Ven ont Single-Family Existing Hor Onsite Report, 2/15/2013. This is converted to KWh using relative efficiencies, and an assumption that 90% of heat pump load is delivered in heat pump mode v resistance. See "Advanced Thermostat Analysis\_04182017\_FINAL.xixx", for details.

[13] Consistent with Residential assumptions; Estimate is based upon calculation of average heating load from Vermont Residential New Construction Baseline Study Analysis of On-Site Audits, 2/13/2013. This is converted to kWh using relative efficiencies, and an assumption that 90% of heat pump

load is delivered in heat pump mode v resistance. See "Advanced Thermostat Analysis\_04182017\_FINAL.xisx", for details.

[14] Fe is not one of the AHRI certified ratings provided for residential furnaces, but can be reasonably estimated from a calculation based on the certified values for fuel energy (EI in NMBTU)yr) and Eae (WN/yr). An average of a 300 record sample (non-random) out of 1495 was 3.14%. This is, appropriately, ~50% greater than the Energy Star version 3 criteria for 2% Fe. See "Programmable Thermostats Furnace Fan Analysis.visx" for reference.

For boilers, fuel and electric use values were taken from Table 10.1, page 30 of James Lutz et al., Lawrence Berkeley Laboratory "Modeling energy consumption of residential furnaces and boilers in US homes". This was then weighted by furnace v boiler distribution to estimate an average value of 1.91%.

- For Small Business this is assumed to be consistent with Residential.
- [15] Savings of 8.8% for manual, and 5.6% for programmable thermostats are taken from Navgant's PowerPoint on Impact Analysis from Preliminary Gas savings Indings (side 26 of 11: SAG Smart Thermostat Preliminary Gas Impact Findings 2015-12-08 to 11: SAG,Gyd). These values are used as the basis for the weighted average savings value for existing buildings. The weighting of manual be programmable thermostats for values on basis and use velotited average savings value for existing buildings. The weighting of manual be programmable thermostats for values on basis of the weighted average savings value for existing buildings. The weighting of manual be programmable thermostats for values on based upon Office building byte from Figure G3 Saturation of HAIC System Control Types by Facility Type' of 2016 VT Business Sector Market Characterization and Assessment Study, April 30 2017. Note EMS (Sienergy Management Systems) were found in 25% of the Offices. It is assumed that these would not be insaling Advanced Thermostats and so are not included in the baseline mix.
- [16] SEER assumption for existing buildings is based on 'Table 16 Cooling Efficiency of Single-Zone Unitary HAC systems <5.5 tons' and for new construction 'Table 56 Cooling Efficiency of Single-Zone Unitary HAC systems' from 2016 VT Business Sector Market Characterization and Assessment's Study, April 30 2017.
- [17] Consistent with Residential assumptions; Estimate is based upon calculation of average heating load; (FLH \* Capacity/1,000,000)/AFUE. FLH and Capacity are based upon natural gas billing data analysis provided by Vermont Cas Systems (VGS) (see VCS Lbage Regression Work, 04182012.rds). AFUE assumptions are from Vermont Single-Family bisitient phones Onter Rept 2, 12/32013. Note the FLH calculation attempts to isolate heating only consumption (removing DHW and other loads). For calculation of savings see "Advanced Thermostat Analysis, 04182017\_FINAL.xds", for details.
- [18] Consistent with Residential assumptions; Estimate is based upon calculation of average heating load; (FLH \* Capacity/1,000,000)/AFUE. FLH and Capacity are based upon natural gas billing data anaylsis provided by Vermont Gas Systems (VGS) (see VGS Usage Regression Work, 04182017.xts'). AFUE assumptions are from Vermont Residential New Construction Baseline Study Analysis of On-Site Audits, 2/13/2013. Note the FLH calculation attempts to isolate heating only consumption (removing DHW and other loads). For calculation of savings see "Advanced Thermostat Analysis, 04182017, FINAL.visx", for details.
- [19] Table 1, HVAC Controls, Measure Life Report, Residential and Commercial/Industrial Lighting and HVAC Measures, GDS Associates, 2007
- [20] Market prices vary considerably in this category, generally increasing with thermostat capability and sophistication. The core suite of functions required by this measure's eligibility criteria are available on units readily available in the market roughly in the range of \$200 and \$250, excluding the availability of any wholesale or volume discounts. The assumed incremental cost is based on the middle of this range (\$225) minus a cost of \$50 for the based on the middle of this range (\$225) minus a cost of \$50 for the baseline equipment blend of manual and programmable thermosts. Note that any add-on energy service costs, which may include one-time setup and/or annual per device costs are not included in this assumption.

[21] Assumed to be \$225 minus \$75 for programmable thermostat.

[22] See 'SMB Advanced Thermostat.xls' for calculations.

### **Residential Fan—Quiet, Exhaust-Only Continuous** Ventilation

Measure Number: TIT-E-1 d Portfolio: EVT TRM Portfolio 2017-06 Portfolio: EVI TRM Portfo Status: Active Effective Date: 2017/1/1 End Date: [None ] Program: Existing Homes End Use: HVAC

Update Summary This is part of EVT TRM reliability, as well as adding a two tier set up to account for efficiency differences between ENERGY STAR and ENERGY STAR Most Efficient residential vertiliation bath fans.

### Referenced Documents ASHRAE 62.2 Section 4.1 Whole House Ventilation

- ADYMEC 62.2 Sector 11 MINE Made Vernamon
   measure\_life\_GDS[1]
   Novgart Consulting.(2013, January 16). Incremental Cost Study Phase Two Final Report.
   EVT\_ENERGY STAR Ventilition Fan\_Analysis\_May 2017

### Description

Description This market opportunity is defined by the need for continuous mechanical ventilation due to reduced air-infiltration from a tighter building shell. In retrofit projects, existing fans may be too loud, or insufficient in other ways, to be operated as required for proper ventilation. This measure assumes a fan capacity of 50 CFH rated at less than 2.0 sones at 0.1 inches of water column static pressure. This measure may be applied to larger applied to 130 CFH, efficient fans with bi-level controls because the savings and incremental costs are very similar. All eligible installations shall be sized to provide the mechanical ventilation rate indicated by ASH4RE.62.2. This measure applies to the Low Income Single Family, Multifamily, Residential New Construction, and Existing Homes programs.

stimated Measu	timated Measure Impacts							
l <b>gorithms</b> lectric Demand Saving	gs							
ΔkW =	$CFM \times (1/Fan_{Efficiency}, Baseline \sim 1/Fan_{Efficiency}, Efficient)/1000$							
ΔkW =	$FM \times (1/Fan_{Efficiency}, Baseline * 1/Fan Efficiency, Most Efficient)/1000$							
Symbol Table								
/here:	<ul> <li>Gross customer connected load KW savings per qualified ventilation fan and controls.</li> </ul>							
ΔkWh	<ul> <li>Gross customer annual kWh savings per qualified ventilation fan and controls.</li> </ul>							
CFM	<ul> <li>Nominal Capacity of the exhaust fan, 50 CFM<sup>[1]</sup></li> </ul>							
Fan Efficiency, Efficient	<ul> <li>Average efficacy for ENERGY STAR fan, 4.84 CFM/Watt<sup>[S884]</sup></li> </ul>							
Fan Efficiency, Most	<ul> <li>Average efficacy for ENERGY STAR fan, 12.48 CFM/Watt<sup>[2]</sup></li> </ul>							
Efficient								
Efficient Fan <sub>Efficiency</sub> , Baseline	= Average efficacy for baseline fan, 2.8 CFM/Watt(3)							

### **Baseline Efficiencies**

d to be Vermont Residential Building Energy Code, which is 2.8 CFM/Watt ficiency is as

High Efficiency New efficient criteria is assumed to be 4.84 CFM/Watt for ENERGY STAR Vent Fans, and 12.48 CFM/Watt for ENERGY STAR Most Efficient Vent Fans

### **Operating Hours** ious, 87 Co

### Load Shapes

25a Flat (8760 hours) 
 Number
 Name
 Status
 Winter On kWh
 Winter Of kWh
 Summer
 Summer
 Winter
 Winter

 25
 Flat (8766 hours)
 Active
 31.9%
 34.9%
 15.9%
 15.9%
 100.0%
 100.0%

### Net Savings Factors

Measures VNTXCEIL Exhaust fan, ceiling

Tracks [Base Track] 6018LINC [is base track] LIMF NC 6019MFNC [is base track] MF Mkt NC 6032EPEP [is base track] Efficient Products - Residential 6034LISF [is base track] LISF Retrofit 6036RETR [is base track] Res Retrofit 6038VESH [is base track] RNC VESH 5102OLS [5100EPEP] Retail Efficient Products On-line Store

### Persistence

The persistence factor is assumed to be one.

Lifetimes
19 years<sup>(4)</sup>
Analysis period is the same as the lifetime.

Measure Cost
Incremental cost per installed fan is \$60.65 for quiet, efficient fans.<sup>(9)</sup>
O&M Cost Adjustments

Savings Summary

EVERCY STAR Vent Fan

2.008(C.0.)

Person'STAR Vent Fan

2.008(C.0.)

Foossil Fuel Description

Footnotes

1. SUCPM is the closest available fan size to ASHRAE 62.2 Section 4.1 Whole House Ventilation rates based upon typical square footage and bedroom
2. Average CFWywatt for ENERGY STAR certified fans from current Qualified Products List

[3] 2015 Vermont Resiential Business Energy Standard, Table R403.6.1 Mechanical Ventilation System Fan Efficacy

[4] Conservative estimate based upon GDS Associates Measure Life Report "Residential and C&I Lighting and HAC measures" 25 years for whole-house fans, and 19 for thermostatically-controlled attic fans.

(5) NEEP Incremental Cost Study Phase Two, Page 34, Table 55. Costs are weighted averages based on ENERGY STAR QPL CFM model counts.

[6] Refer to analyis document: EVT\_ENERGY STAR Ventilation Fan\_Analysis\_May 2017.xlsx.

Measure Numbe Portfolio:	
	74
Status:	Active
Effective Date:	
End Date: Program:	[ None ] Multifamily
	Multifamily HVAC
	Documents
	eat-timer.com/ery/EducationDetail.aspx?Id=3 xiler Reset Factsheet
OutdoorReset	
igher, during fall ligh efficiency gas vhen an efficient b Comprehensive Th wailable (i.e. the l	set control regulates the boiler water temperature used for space heating, reducing the temperature when the outside temperature is and spring, improving boiler efficiency and reducing heat loss of the circulating loso. Outdoor reset controls are byically standard on boiler models, but are an add on for oil boiler units. This measure characterization documents additional savings that will be claimed doil is installed in place of a baseline model without the controls. The AFLE rating used to claim savings for this upgrade (in the ermal Measure) does not capture savings associated with the Outdoor Reset Control. Not that if specifics from the installation are empth and insulation level of the circulating loop, the boiler set and run timely, then a custom loot will be used to actime set specific.
avings.	
Estimated M	leasure Impacts
Algorithms cossil Fuel Savir f specifics from th rill be used to cap AMMBtu	ngs in estallation are available (i.e. the length and insulation level of the circulating loop, the boiler size and run time), then a custom tool ture site specific savings.  SF x Annual Heat Load
Vhere:	
ΔMMBtu	
Annual Hea	
	= Custom (based on heating load result from modeling)
SF	= Savings Factor for Bollers with Outdoor Reset control $= Srg(1)$
tandard boiler wi	thout outdoor reset control.
itandard boiler wi	thout outdoor reset control.  ncy reset control.
Baseline Eff itandard boiler wi High Efficien Soiler with outdoor Operating H	thout outdoor reset control.  ncy reset control.
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tandard boller wi tigh Efficient Deperating H coad Shape /a. No electric sa Net Saving: Met Saving: SHECONTR Impr irack [Base Tr 6019MFNC [is base frack Name] Train MF NC 6015	thout outdoor reset control.
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itandard boller wi itandard boller wi itandard boller with outdoor Deperating H coad Shape ya. No electric sa Net Savings Weasures SHECONTR Impr Fracks[Base Tr GOIBUNC[is bass GOI9MFNC[is bass GOI9MFNC[is bass GOI9MFNC[is bass frack Name] Tran Wef Mit NC [GOIS Persistence fa	thout outdoor reset control.
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High Efficiencies of the sense	thout outdoor reset control.
High Efficiencies of the second secon	thout outdoor reset control.
High Efficiencies of the second secon	thout outdoor reset control.
High Efficiencies     High Efficiencies     Deperating H     Load Shape     //a. No electric sa     Net Savings     Heasures	thou couldoor reset control.
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tandard boller wi tigh Efficien coad Shape (a. No electric sa Net Saving: Measures Heasure	hou outdoor reset control.

"5%", http://www.dteenergy.com/pdfs/boilerResetFactSheet.pdf
 "15% or more"; http://www.heat-timer.com/en/EducationDetail.aspx?Id=3
 "5 to 30%"; http://www.arcmech.com/images/fm/pdir17/OutdoorResetARCreduced.pdf

[2] Based on EVT conversations with local HVAC contractors.

## Advanced Thermostat Optimization Services

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	EVT TRM Portfol Active	lio 2019	9-02								
Effective Date:	2019/1/1										
End Date: Program:	2021/12/31 Efficient Product	ls Progr	ram								
End Use:	HVAC	is riogi	am								
Jpdate Sum											
lpdated values to	make consistent w	vith rec	ent Advanced Th	ermostat (	update (PF	2018-11)	and to incl	ude MF ass	umptions		
VGS Usage Re     Nest_seasonal	Documents	4182013 aper									
<ul> <li>dcseu-seasona</li> </ul>	al-savings-proposa mostatOptimized v	al-upda	ted-pdf								
n add-on optimiza Itering algorithms articipants enrolli	ides the character tion services whici is to generate addit ng together with a ncy Vermont for fu	th are d tional h an end	lesigned to enhan eating and coolin of year report del	ce the sav g savings tailing tho:	vings from than would	their exist d be realiz	ing advanc ed from jus	ed thermos t the advar	tat. Softw iced therr	are add or nostat alor	ns deploy set point ne. Details of the
Baseline Eff	<b>iciencies</b> sustomer with an a	advance	ed thermostat tha	t has not	enrolled or	n an additi	onal optimi	zation prog	ram.		
Efficient Equ The efficient case i	uipment is a participant tha	at has e	enrolled on an op	timization	program.						
Algorithms											
lectric Demand		ut.									
ΔkW	= Max(ΔkW	Vh <sub>Coolin</sub>	gOptimized / EFLH <sub>C</sub>	ool₂∆kWh	katingOptim	ized / EFLH	Heat)				
Symbol Table											
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121 11	Residential	hermostat - Electri N/C	ic reat & coulin	g Active 36.5 Active 6.69		9.0% 6.7% 51.1% 38.69		5.0%	
leasure SHESMAF racks [I	RT Advanced Base Track	Thermostat	ıcts - Residentia	l					
. <b>ifetin</b> he expec		life for savings as	sociated with th	e Nest Seasonal S	avings program	is 1 year.			
	re Cost o enroll is \$6.	00 per participant	for a single yea	r(4)					
eemed s	avings are pr	vings Tables		provide default sa	avings for when i	mplementation d	oes not allow the	e building or heating	g type to
e known. ummer S	easonal Prog	ram:							
			Saving	з Туре	Fuel	Weighted Average			
			Cooling		Electric (kWh) kW	24.9 0.0664			
/inter Se	asonal Progra	m:	Loadsh	ape	11a Residential AC				
			Savings Type	Fuel	Natural	ted Average Non Itural	c		
			Heating N	latural Gas (MMBT	Gas TU) 1.8	Gas Heat			
			Heating Heating Heating	Oil (MMBTU) LP (MMBTU) Electric (kWh)	0.0	1.0         0.0           0.7         0.0           7.9         181.9	-		
				Total MMBTU Total kWh kW Loadshape	1.8 10.0 0.0114 0.	1.7         0.0           .7.9         181.9           0204         0.2071           ntial Space heat	_		
		Single Family Ex							Unknow
Savings Type	Fuel Natural	Natural Gas Heat, Cooling	Natural Gas Heat, No Cooling	Oil Heat, Cooling	Oil Heat, No Cooling	LP Heat, Cooling	LP Heat, No Cooling	HP Heat, Cooling	(not NG) Unknown Cooling
Heating	Gas (MMBTU)	1.8	1.8	0.0	0.0	0.0	0.0	0.0	0.0
leating	(MMBTU)	0.0	0.0	1.9	1.9	0.0	0.0	0.0	1.1
Heating	(MMBTU) Electric	0.0	0.0	0.0	0.0	1.8	1.8	0.0	0.3
Heating	(kWh) Electric	10.1	10.1	10.4	10.4	10.1	10.1	184.0	7.7
Cooling	(kWh) Total	25.0	0.0	25.0	0.0	25.0	0.0	25.0	1.6
	MMBTU Total kWh	1.8 35.1	1.8	1.9 35.4	1.9	1.8	1.8	0.0 209.0	1.4 9.3
	kW	0.0667	0.0115	0.0667	0.0119	0.0667	0.0115	0.2096	0.0087
	Loadshape Used	120b Advanced Thermostat - Fossil Heat & Cooling	5a Residential Space heat	120b Advanced Thermostat - Fossil Heat & Cooling	5a Residential Space heat	120b Advanced Thermostat - Fossil Heat & Cooling	5a Residentia Space heat	121b Advanced Thermostat - Electric Heat & Cooling	122b Ad Thermos Unknown & Coolin
		Residential New	Construction						
5avings Type	Fuel	Natural Gas Heat, Cooling	Natural Gas Heat, No Cooling	Oil Heat, Cooling	Oil Heat, No Cooling	LP Heat, Cooling	LP Heat, No Cooling	HP Heat, Cooling	Unknown (not NG) Unknown Cooling
leating	Natural Gas (MMBTU)	1.2	1.2	0.0	0.0	0.0	0.0	0.0	0.0
leating	Oil (MMBTU)	0.0	0.0	1.2	1.2	0.0	0.0	0.0	0.2
leating	LP (MMBTU)	0.0	0.0	0.0	0.0	1.2	1.2	0.0	1.0
leating	Electric (kWh)	6.5	6.5	6.8	6.8	6.5	6.5	112.4	6.6
Cooling	Electric (kWh)	16.3	0.0	16.3	0.0	16.3	0.0	16.3	0.6
	Total MMBTU	1.2	1.2	1.2	1.2	1.2	1.2	0.0	1.2
	Total kWh	22.8	6.5	23.1	6.8	22.8	6.5	128.7	7.2
	kW Loadshape Used	0.0434 120b Advanced Thermostat - Fossil Heat & Cooling	0.0076 5a Residential Space heat	0.0434 120b Advanced Thermostat - Fossil Heat & Cooling	0.0080 5a Residential Space heat	0.0434 120b Advances Thermostat - Fossil Heat & Cooling	0.0076 5a Residentia Space heat	0.1315 121b Advanced Thermostat - Electric Heat & Cooling	0.0077 122b Ad Thermos Unknows & Coolin
		Multi Family Exis	ting Homes						
									Unknowr

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Heating	Natural Gas (MMBTU)	0.9	0.9	0.0	0.0	0.0	0.0	0.0	0.0
Heating	Oil (MMBTU)	0.0	0.0	1.0	1.0	0.0	0.0	0.0	0.7
Heating	LP (MMBTU)	0.0	0.0	0.0	0.0	0.9	0.9	0.0	0.2
Heating	Electric (kWh)	5.3	5.3	5.5	5.5	5.3	5.3	96.5	5.3
Cooling	Electric (kWh)	17.7	0.0	17.7	0.0	17.7	0.0	17.7	0.7
	Total MMBTU	0.9	0.9	1.0	1.0	0.9	0.9	0.0	1.0
	Total kWh	23.0	5.3	23.2	5.5	23.0	5.3	114.2	6.0
	kW	0.0472	0.0060	0.0472	0.0062	0.0472	0.0060	0.1099	0.0061
		120b Advanced Thermostat -		120b Advanced Thermostat -		120b Advanced Thermostat -		121b Advanced Thermostat -	122b Advanced Thermostat -
	Loadshape Used	Fossil Heat & Cooling	5a Residential Space heat	Fossil Heat & Cooling	5a Residential Space heat	Fossil Heat & Cooling	5a Residential Space heat	Electric Heat & Cooling	Unknown Heat & Cooling

		Multi Family New	Family New Construction										
Savings Type	Fuel	Natural Gas Heat, Cooling	Natural Gas Heat, No Cooling	Oil Heat, Cooling	Oil Heat, No Cooling	LP Heat, Cooling	LP Heat, No Cooling	HP Heat, Cooling	Unknown Heat (not NG), Unknown Cooling				
Harker	Natural Gas												
Heating	(MMBTU)	0.8	0.8	0.0	0.0	0.0	0.0	0.0	0.0				
Heating	Oil (MMBTU)	0.0	0.0	0.8	0.8	0.0	0.0	0.0	0.1				
Heating	LP (MMBTU)	0.0	0.0	0.0	0.0	0.9	0.9	0.0	0.7				
Heating	Electric (kWh)	4.5	4.5	4.7	4.7	4.5	4.5	76.9	4.5				
Cooling	Electric (kWh)	15.6	0.0	15.6	0.0	15.6	0.0	15.6	0.3				
	Total MMBTU	0.8	0.8	0.8	0.8	0.8	0.8	0.0	0.8				
	Total kWh	20.0	4.5	20.2	4.7	20.0	4.5	92.5	4.8				
	kW	0.0415	0.0052	0.0415	0.0055	0.0415	0.0052	0.0899	0.0053				
		120b Advanced		120b Advanced		120b Advanced		121b Advanced	122b Advanced				
		Thermostat -		Thermostat -		Thermostat -		Thermostat -	Thermostat -				
	Loadshape	Fossil Heat &	5a Residential	Fossil Heat &	5a Residential	Fossil Heat &	5a Residential	Electric Heat &	Unknown Heat				
	Used	Cooling	Space heat	Cooling	Space heat	Cooling	Space heat	Cooling	& Cooling				

## Footnotes

- [1] EVT applied 25% adjustment factor to U.S. Climate Cooling Region 2 Full Load Hours of 500 hours for 375 hours.
- [2] Estimated by following a methodology outlined in the Uniform Methods Project using natural gas billing data provided by Vermont Gas Systems (VGS) for homes that participated in Efficiency Vermont's Residential New Construction (RNC) program. Since capacity has not been collected through the Home Performance with ERROY STAR program. It was not possible to perform the analysis with a more appropriate data set for this program. For Estisting Homes, the NKC data was limited to any these homes with annual age consumption grater than 258Lu/sq ft in an attempt to remove the high performance/ low load homes in RNC. See VGS Usage Regression Work\_04182017.xls' for analysis.
- [3] Based on findings from Nest "Seasonal Savings Impacts in Vermort", December 2016 through April 2017 (464 participating thermostats) and a deployment with over 20,000 units in Nassachusetts (see attachment 1, page 12 of "DCSEU Seasonal Savings Proposal Updated"). The savings determined through these evaluations represent the average savings from all participants, including those that pull out or override the program. Threes studies only looked at the impact on heating loads through significant cooling impacts have also been found (see 'Nest seasonal\_savings\_white\_paper.pdf). This measure assumes the same impact on cooling loads.

Note that through participation Efficiency Vermont will be gathering evaluation data to allow calculation of a EVT specific assumptions in the future.

[4] See attachment 1 of 'DCSEU Seasonal Savings Proposal\_Updated'.

[5] See with 'EVT\_AdvThermostalOptimized V3.vis' for the calculation. Note weighted average assumptions (for gas heated homes and non-gas heated homes) based on fuel mix from programmable thermostat sales October 2017 through March 2018.

## **Advanced Thermostats**

Measure Number	RS-HVC-ADVT a
Portfolio:	No life Abria
Status:	Active
Effective Date:	2021/1/1
End Date:	[ None ]
Program:	Efficient Products Program
End Use:	HVAC

### Update Summary

Update to include additional swings from Thermostat Optimization (e.g. Next Seasonal Savings and ecobee+) for a percentage of customers purchasing a new Advanced Thermostat measure. Seasonal savings is now available to all and will not be a separate utility sponsored program, so this will be the only Seasonal Savings that is daimed.

Update to assumptions based on Vermont Single-Family Existing Homes Onsite Report, 7/2018 and Vermont Residential New Construction Hor Survey Report, 5/2018.

## Referenced Documents

- Referenced Documents VT-R5-New-Construction-On-Site-Final-Report-2-13-13 Studies Informa (bet TMR Saving: Characterization for Advanced Thermostats VT-SF Edsting Homes-Oneitic Report\_Timal 021513 VGS Usage Regression Vicio-Quite Studies USA USA Uthermost the Terminary Case Inpact Endings2015-12-08 to 1L-SAG Efficiency Vermont Summer 2018 Seasonal Savings Seasonal Savings Impacts Writer 2012, 20\_C Efficiency Vermont EVT Advanced Thermostat and Optimization\_2020

### Description

Description
This measure characterizes the household energy savings from the installation of a new thermostat(s) for reduced heating and cooling consumption
through a configurable schedule of temperature set-points (like a programmable thermostat) and automatic variations to that schedule to better match
HVAC system rutimes to meet occupant comfort needs. These schedules may be defaults, established through user interaction, and be changed
manually at the device or remetly through a work or moliate particulation. These schedules may be defaults, established through user interaction, and be changed
annually at the device or remetly through a work or moliate particulation. This chass of products and services are relatively traviations to that schedule could be drived by local sensors and software
algorithms, and/or through connectivity to an intermet software service. Data briggers to automatic schedule changes might include, for example:
cocupany/schivity detection, annual & departure of conditioned spaces, optimization based on historical or population-specific trends, weather data and
forecasts.<sup>11</sup> This class of products and services are relatively through evelopied. Instactively new diverse, and practively new, diverse, and practively classifies greaceds of the tribung are are dronging
usdu/ to better may estualish is handrards of performance measurement based on field datas to that a schedard of efficiency
can be developed. That work is not yet complete but does inform the treatment of some aspects of this characterization and recommendations.

Savings estimates are provided for Existing Homes, Residential New Construction and Multifamily Existing and New. Note all savings will be claimed through Efficient Products, however the baseline for New Construction is a programmable thermostat (due to code requirements) while the baseline for Existing Homes and Multifamily Existing is assumed to be an ix of manual and programmable thermostats.

The measure assumes that the advanced thermostat is controlling a portion of the whole home's heating/cooling load. Efficiency Vermont will track and provide incentives for up to two advanced thermostals per residence.

The thermostat must be installed and connected with the manufacturer in order to be eligible for a re

## **Baseline Efficiencies**

For existing buildings the baseline is assumed to be a mix of programmable and manual thermostats. For New Construction, the baseline is a programmable thermostat.

## Efficient Equipment

Efficient Equipment The oriteria for this measure are stabilished by replacement of a manual-only or programmable thermostat, with one that has the default enabled capability—or the capability to automatically—establish a schedule of temperature setpoints according to driving device inputs above and beyond basic time and temperature data of conventional programmable thermostats. As summarized in the description, this category of products are services is broad and rapidly advancing in regarks to their capability, usability, and sophistication, but at a minimum ture be capable of the v-way communication<sup>12</sup> and exceed the bylical performance of manual and conventional programmable thermostats through the automatic or default capabilities described above.

## Algorithms Electric Demand Savings

ΔkW	= Max(ΔkWh <sub>heating</sub> / EFLH <sub>heat</sub> , ΔkWh <sub>cooling</sub> / EFLH <sub>cool</sub> )
Symbol Table	
Electric Energy	Savings
ΔkWh	= AkWheating + AkWheating
	= (%ElectricHeat × (ThersmotatSavings + OptimizationSavings)) + FanSavings
	$\label{eq:linearity} \begin{split} \Delta kWh_{testing} &= (\% ElectricHeat \times ((Elec_Heating_Consumption \times \% Controlled \times AdvThermostat_HeatReduction) + (Elec_Heating_Consumption \times \% Controlled \times (1 - AdvThermostat_HeatReduction) \times \% OptSavingsHeat()) + (\Delta MNBiu \times F_{e} \times 233) + (\Delta MNBiu \times F_{$
$\Delta kWh_{cooling}$	= %AC × (ThermostalSavings + OptimizationSavings)
	DAWh <sub>cooling</sub> = %AC × (((EFLH <sub>cool</sub> × Capacity × 1/SEER)/1000) × AdvThermostat_CoolReduction) + (EFLH <sub>cool</sub> × Capacity × 1/ SEER)/1000) × (1 - AdvThermostat_CoolReduction) × %OptSavingsCool))
Symbol Table	
Fossil Fuel Savir	igs
ΔMMBtu	= $\Sigma$ (%FossilHeat × (ThermostatSavings + OptimizationSavings))
	$\label{eq:MMBL} \Delta MMBL = \Sigma (%Fossilikat \times ((Heating_Consumption \times %Controlled) \times AdvThermostat_HeatReduction) + (Heating_Consumption \times %Controlled) \times (1 - AdvThermostat_HeatReduction) \times %Controlled) \times (1 - AdvThermostat_HeatReduction) \times %Controlled) = 0$
Where:	
%AC	<ul> <li>Fraction of customers with central air-conditioning</li> </ul>
	%AC

	%AC			
Central air conditioning?	Existing	Residential New Construction	Multifamily Existing	Multifamily New Construction
Yes		100%		
No		0%		
Unknown	6.9% <sup>[5]</sup>	10.0%[5]	4.1%[6]	6.0%(7)
<u> </u>				

		Percentage of heating savi					
			Heating	fuel		%ElectricHeat	
			Electric Fossil Fue	1		100%	
			Unknown			0%[10]	
			L				
%FossilHeat	-	Percentage of heating savi included as it will be know single family values below.	n that it is n		. Multifamily is as		
		Heatin			%FossilHeat Existing Buildings(22)	New Construction	:0]
		Electric Fossil F			0	96	
		Unknow		Oil	78%	18%	
			-	Propane	22%	82%	
%OptSavingsCool	-	Estimated additional coolin = 0.65% [11]	g savings fro	om users with	Thermostat Optin	nization services.	
%OptSavingsHeat	-	Estimated additional he = 0.79% <sup>[11]</sup>	at savings fr	om users with	Thermostat Opti	mization services.	
ΔkW		Annual demand reduction.					
ΔkWh <sub>cooling</sub>		Electric savings from coolin				to have a second	
∆kWh <sub>heating</sub>		Electric savings from heati fan/pump savings in the ca Electrical savings are a fur	ase of a foss	I heating syste	ım.		it (heat pumps) ai
ΔkWh ΔMMBtu		Electrical savings are a fur Fuel savings if fossil fuel h			ing energy US	aye reaucuons.	
ΔMMBtu 293		kWh per MMBtu	eauny syster				
AdvThermostat_CoolReduction		Assumed percentage m advanced thermostat =8.0% <sup>[12]</sup>	eduction in t	otal household	cooling energy co	onsumption due to i	installation of
AdvThermostat_HeatReduction	-	Assumed percentage r thermostat	eduction in t	otal household	heating energy c	onsumption due to	advanced
		Program Existing Hom Multifamily E New Constru	disting	Existing 1 Type Unknown Unknown Programm	(Blended)	Heating_Redu           7.5%           8.1%           5.6%	uction <sup>(1)</sup>
Capacity	-	Capacity of AC unit. (Note: = 37,200 Btuh <sup>[14]</sup> for single					
EFLHcool	-	Estimate of annual househ					
		= 375 <sup>[3]</sup>					
EFLH <sub>heat</sub>		Assumed Equivalent Full Le family values below.		r heating. Mult	ifamily is assume	d to be the same a	s the equivalent s
			EFLH <sup>(1)</sup> Existing I 878	lomes	New Const 855	ruction	
Elec_Heating_Consumption	-	Estimate of annual househ		consumption fo		ted homes:	
			Elec_Hea	Residenti			
			Homes	New Construct	MultiFan	nily Existing	Multifamily New Construction
			8,271[16]	6,416 <sup>[17]</sup>		180 <sup>[18]</sup>	2,467 <sup>[18]</sup>
Fe	-	Furnace fan / boiler pump = 1.91% <sup>[19]</sup>	energy cons	umption as a p	percentage of ann	nual fuel consumption	nc
FanSavings	-	Electric savings from reduc	ced furnace	an usage with	fuel heat.		
Heating_Consumption	-	Estimate of annual househ	old heating of	consumption			
					g_Consumption		
				Existing Homes <sup>(24)</sup>	Residential Ne Construction	W Multifamily Existing	Multifamily Ne Construction
			Gas	80	67	31	26
			Oil	85	70	33	27
			Unknown	82	67	32	26
OptimizationSavings	-	Additional savings for The	mostat Opti	nization deplo	yment		
SEER	-	The cooling equipment's S same as the equivalent sin			Ratio rating (kBtu/	'kWh). Multifamily i	s assumed to be t

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			Existing 11.4 <sup>(20)</sup>	g Homes		New Con: 15.0 <sup>[21]</sup>	struction		
T	ThermostatSavings = Standard saving	s from Ad	vanced Th	ermostat					
5b Resid 120d Ad 122d Ad	Shapes ential Space heat vanced Thermostat - Fossil Heat & Cooling vanced Thermostat - Unknown Heat & Cooling vanced Thermostat - Electric Heat & Cooling								
Numbe	r Name	Status				Summer Off kWh		Summer kW	
5	Residential Space heat	Active	42.9%	57.1%	0.0%	0.0%	25.0%	0.0%	
120	Advanced Thermostat - Fossil Heat & Cooling	Active	14.1%	14.9%	40.5%	30.5%	2.8%	16.0%	
122	Advanced Thermostat - Unknown Heat & Cooling	Active	35.6%	46.5%	10.2%	7.7%	25.0%	9.3%	
121	Advanced Thermostat - Electric Heat & Cooling	Active	36.5%	47.8%	9.0%	6.7%	25.0%	8.0%	
Measur SHESM/ Tracks	Savings Factors tes NRT Advanced Thermostat (Base Track) EP [is base track] Efficient Products - Residential								
Lifetii The expe life only.	ected measure life for advanced thermostats is assu	umed to b	e similar to	o that of a p	programma	ible thermo	ostat 10 yı	ears <sup>(26)</sup> bas	ed upon equipmer
	ure Cost	e provider	the actu	al material	labor and	other cost	s should l	no used wi	th a default of \$76

For DI and other programs for which installation services are provided, the actual material, labor, and other costs should be used, with a default of \$255 (\$225 for the thermostat and \$40 for labor). For retail, lining 'tour Om Thermostat (BYOT) programs<sup>[27]</sup>, or other program types the average incremental cost for the new installation measure is assumed to be \$175<sup>201</sup>.

For new construction, the incremental cost between a programmable and advanced thermostat is assumed to be \$150<sup>(29)</sup>.

Prescriptive Savings Tables
Deemed savings are provided below. See "EVT Advanced Thermostat and Optim ation 2020.xls" for more details of the calculati

					Existing	Homes			
Savings Type	Fuel	Natural Gas Heat, Cooling	Natural Gas Heat, No Cooling	Oil Heat, Cooling	Oil Heat, No Cooling	LP Heat, Cooling	LP Heat, No Cooling	HP Heat, Cooling	Unknown Heat (not NG), Unknown Cooling
Item	Codes:	ADV1THERMOEH1	ADV1THERMOEH2	ADV1THERMOEH3	ADV1THERMOEH4	ADV1THERMOEH5	ADV1THERMOEH6	ADV1THERMOEH7	ADV1THERMOEH8
Heating	Natural Gas (MMBTU)	5.0	5.0	0.0	0.0	0.0	0.0	0.0	0.0
Heating	Oil (MMBTU)	0.0	0.0	5.0	5.0	0.0	0.0	0.0	4.2
Heating	LP (MMBTU)	0.0	0.0	0.0	0.0	5.0	5.0	0.0	1.1
Heating	Electric (kWh)	27.8	27.8	29.4	29.4	27.8	27.8	515.5	29.1
Cooling	Electric (kWh)	105.2	0.0	105.2	0.0	105.2	0.0	105.2	7.3
	Total MMBtu	5.0	5.0	5.3	5.3	5.0	5.0	0.0	5.2
	Total kWh	133.0	27.8	134.6	29.4	133.0	27.8	620.7	36.3
	kW	0.2805	0.0317	0.2805	0.0335	0.2805	0.0317	0.5871	0.0331
		1							
<b>_</b> .					Residential Ne	w Construction			
Savings Type	Fuel	Natural Gas Heat, Cooling	Natural Gas Heat, No Cooling	Oil Heat, Cooling	Oil Heat, No Cooling	LP Heat, Cooling	LP Heat, No Cooling	HP Heat, Cooling	Unknown Heat (not NG), Unknown Coolin
Item	Codes:	ADV1THERMONC1	ADV1THERMONC2	ADV1THERMONC3	ADV1THERMONC4	ADV1THERMONC5	ADV1THERMONC6	ADV1THERMONC7	ADV1THERMONC
Heating	Natural Gas (MMBTU)	2.2	2.2	0.0	0.0	0.0	0.0	0.0	0.0
Heating	Oil (MMBTU)	0.0	0.0	2.3	2.3	0.0	0.0	0.0	0.4
Heating	LP (MMBTU)	0.0	0.0	0.0	0.0	2.2	2.2	0.0	1.9
Heating	Electric (kWh)	12.4	12.4	13.0	13.0	12.4	12.4	216.0	12.9
Cooling	Electric (kWh)	88.7	0.0	88.7	0.0	88.7	0.0	88.7	8.9
	Total MMBtu	2.2	2.2	2.3	2.3	2.2	2.2	0.0	2.3
	Total kWh	101.2	12.4	101.7	13.0	101.2	12.4	304.7	21.8
	kW	0.2367	0.0146	0.2367	0.0152	0.2367	0.0146	0.2526	0.0237
					Multifam	ily Existing			
					multidiii	ny coloung			
Savings Type	Fuel	Natural Gas Heat, Cooling	Natural Gas Heat, No Cooling	Oil Heat, Cooling	Oil Heat, No Cooling	LP Heat, Cooling	LP Heat, No Cooling	HP Heat, Cooling	(not NG),
Туре	Fuel Codes:			Oil Heat, Cooling		LP Heat, Cooling			Unknown Coolir

Heating	Oil (MMBTU)	0.0	0.0	2.7	2.7	0.0	0.0	0.0	2.2
Heating	LP (MMBTU)	0.0	0.0	0.0	0.0	2.6	2.6	0.0	0.6
Heating	Electric (kWh)	14.4	14.4	15.2	15.2	14.4	14.4	266.3	15.0
Cooling	Electric (kWh)	45.2	0.0	45.2	0.0	45.2	0.0	45.2	1.9
	Total MMBtu	2.6	2.6	2.7	2.7	2.6	2.6	0.0	2.7
	Total kWh	59.6	14.4	60.4	15.2	59.6	14.4	311.5	16.9
	kW	0.1206	0.0164	0.1206	0.0173	0.1206	0.0164	0.3033	0.0171

					Multifamily Ner	w Construction			
Savings Type	Fuel	Natural Gas Heat, Cooling	Natural Gas Heat, No Cooling	Oil Heat, Cooling	Oil Heat, No Cooling	LP Heat, Cooling	LP Heat, No Cooling	HP Heat, Cooli	Unknown Heat ng (not NG), Unknown Cooling
Item	Codes:	ADV1THERMFNC1	ADV1THERMFNC2	ADV1THERMFNC3	ADV1THERMFNC4	ADV1THERMFNC5	ADV1THERMFNC6	ADV1THERMEN	C7 ADV1THERMFNC8
Heating	Natural Gas (MMBTU)	1.5	1.5	0.0	0.0	0.0	0.0	0.0	0.0
Heating	Oil (MMBTU)	0.0	0.0	1.6	1.6	0.0	0.0	0.0	0.3
Heating	LP (MMBTU)	0.0	0.0	0.0	0.0	1.5	1.5	0.0	1.3
Heating	Electric (kWh)	8.5	8.5	8.9	8.9	8.5	8.5	147.8	8.6
Cooling	Electric (kWh)	44.2	0.0	44.2	0.0	44.2	0.0	44.2	2.6
	Total MMBtu	1.5	1.5	1.6	1.6	1.5	1.5	0.0	1.5
	Total kWh	52.8	8.5	53.1	8.9	52.8	8.5	192.0	11.2
	KW	0.1180	0.0100	0.1180	0.0104	0.1180	0.0100	0.1728	0.0100

### Footnotes

- [1] For example, the capabilities of products and added services that use ultrasound, infrared, or geofercing sensor systems, automatically develop individual models of home's thermal properties through user interaction, and optimize system operation based on explainent type and performance traits based on wather forecasts demonstrate the type of automatic shrulde chargine functionally that apply to this measure characterization.
- [2] This measure recognizes that field data may be available, through this 2-way communication capability, to better inform characterization of efficienc criteria and savings calculations. Efficiency Vermont will be exploring ways to better utilize this data once the program is underway and once the DRERGY STAR Specification and program process is finalized.
- [3] EVT applied 25% adjustment factor to U.S. Climate Cooling Region 2 Full Load Hours of 500 hours for 375 hours.
- (4) Estimated by following a methodology outlined in the Uniform Methods Project using natural gas billing data provided by Vermont Cas Systems (VGS) for homes that participated in Efficiency Vermont's Residential New Construction (RNC) program. Since capacity has not been collected through the Home Performance with DERGN STAR program it was not possible to perform the analysis with a more appropriate data set for this program. For Existing Homes, the NC data was limited to only those homes with annual gas consumption grater than 2580u/sq ft in an attempt to remove the high performance/ low load homes in RNC. See VGS Ukage Regression Work\_04182017.xk<sup>2</sup> for analysis.
- [5] Based on 2018-2020 Adv Thermostat Program participants. See "CUBE" tab in "EVT Advanced Thermostat and Optimization 2020 Update.xls".
- [6] Estimate based on scaling national cooling prevalence in MF V SF (based on Table HC7.1 from RECS 2015) to the single family existing home cooling prevalence in 2018-2020 Advanced Thermostat Program participants. See tab 'HC7.1 2015' in "EVT Advanced Thermostat and Optimization 2020 Update.xts".
- [7] Estimate based on scaling national cooling prevalence in MF V SF (based on Table HC7.1 from RECS 2015) to the single family new construction cooling prevalence in 2018-2020 Advanced Thermostat Program participants. See tab 'HC7.1 2015' in 'EVT Advanced Thermostat and Optimization 2020 Update xls'.
- [8] Based on review of # of thermostats per home data from Vermont Single-Family Existing Homes Onsite Report, 7/2018 and Vermont Residential New Construction Baseline Study Analysis of On-Ste Audits, 2/13/2013. See "EVT Advanced Thermostat and Optimization 2020 Update.xls".
- [9] Based on data from Table HC6.1 from 2009 EIA RECS showing number of thermostats in multi family buildings (note this information was not included in the 2015 RECS survey). See tab 'HC6.1 2009' in "EVT Advanced Thermostat and Optimization 2020 Update.xts".
- [10] Unknown value is based on TAG agreement 2017.
- [11] This assumption accounts for market share of the two suppliers of Optimization (Next and Ecobee), % of season that optimization is applied (where appropriate), % of clastomers assumed to opt in to the service and the %eavings expected to be achieved. These assumptions will be reviewed regularly to ensure they continue to be a reasonable estimation. See "Optimization Assumptions" tab of "EVT Advanced Thermostat and Optimization 2020 Update.xks" for more details.
- [12] This assumption is based upon the review of many evaluations from other regions in the US (see "Studies informing the TRM Savings Characterization for Advanced Thermostats.docd"). These sources, are from different regions, products, and program delivery designs, but collectively form a sourd basis, and directional guidance for the existence and magnitude of cooling savings. Because cooling savings are more volatile than those for heating due to variables in control behaviors, population, and product factors, conservations is warranted and SPs is considered a conservative estimate based upon the array of results from these studies. Further evaluation and regular review of this key assumption is encouraged.
- [13] Savings of 8.8% for manual, and 5.6% for programmable thermostats as presented in Navigant's PowerPoint on Impact Analysis from Preliminary Gas savings findings (side 28 of '11. SAG: Smart Thermostat Preliminary Gas Impact Findings 2015-12-08 to 12. SAG.pdf). These values are used as the basis for the weighted average savings value for existing buildings. The weighting of manual to programmable thermostats for when unknown is based upon Vermont Single-Family Existing Homes Onsite Report, 7/2018, 'Table 51 Type of Thermostat' for existing homes and data from Table HC6.1 from 2015 RECS.
- [14] Used to estimate total cooling load of average house. Based on CAC capacity from Vermont Single-Family Existing Homes Onsite Report, 7/2018, Table 55 'Characteristics of Air Conditioning Systems, Statewide'.
- [15] Estimate of multifamily cooling capacity is based on %adjustment of SF V MF relative cooling consumption data for the Northeast from Table CE3.2 of 2015 RECS multiplied by the single family capacity assumption. See tab 'CE.2 2015' in "EVT Advanced Thermostat and Optimization 2020 Update.xts".
- [16] Estimate is based upon calculation of average heating load from Vermont Single-Family Existing Homes Onsite Report, 7/2018. This is converted to Wh using relative efficiencies, and an assumption that 90% of heat pump load is delivered in heat pump mode v resistance. See "EVT Advanced Thremostat and Optimization 2020 Update.45".
- [17] Estimate is based upon calculation of average heating lead from Vermont Residential New Construction Baseline Study Analysis of On-Site Audis, 2/13/2013. This is connected to With using relative efficiences, and an assumption that 50% of heat pump load is delivered in heat pump mode v resistance. See "VTr Advanced Thermostat and Optimization. 2020 Update." for details.
- [18] Multifamily per unit consumption is estimated using relative (single v multi family) space heating consumption data for the Northeast from Table CE3.2 of 2015 RECS multiplied by the Existing Homes consumption assumption. See tab 'CE.2.2015' in 'EVT Advanced Thermostat and Optimization 2020 Udottex.45<sup>4</sup>.
- [19] F<sub>e</sub> is not one of the AHRI certified ratings provided for residential furnaces, but can be reasonably estimated from a calculation based on the certified values for fuel energy (EF in MMBTU/yr) and Eae (WM)/yr). An average of a 300 record sample (non-random) out of 1495 was 3.14%. This is, appropriately, ~59% greater than the Energy Star version 3 criteria for 2% F<sub>e</sub>. See "Programmable Thermostats Furnace Fan Analysis.visc" for reference.
  - For boilers, fuel and electric use values were taken from Table 10.1, page 30 of James Lutz et al., Lawrence Berkeley Laborator, "Modeling energy consumption of residential furnaces and boilers in US homes". This was then weighted by furnace v boiler distribution to estimate an average value of 1.01%.
- [20] Used to estimate total cooling load of average house. Based on CAC values from Vermont Single-Family Existing Homes Onsite Report, 7/2018, Table

55 'Characteristics of Air Conditioning Systems, Statewide'.

- [21] Used to estimate total cooling load of average new construction house. Based on Vermont Residential New Construction Baseline Study Analysis of On-Site Audits, 2/13/2013.
- [22] Vermont Single-Family Existing Homes Onsite Report, 7/2018, Table 40 using ACS data, percent of homes that are not natural gas, wood or other.
- [23] Vermont Residential New Construction Homeowner Survey Report, 5/2018, Table 26. Percent of homes that are not natural gas, wood or other.
- [24] Estimate is based upon calculation of average heating load; (FLH \* Capachy/1,000,000)/AFUE. FLH and Capachy are based upon natural gas billing data anaytiss provided by Vermont Gas Systems (VGS) (see VGS Usage Regression Work, 04182012, Xsf). AFUE assumptions are from Vermont Single-Family Estimp (Hense Christife Report, 7/2018). Note the FLH calculation attempts to solate heating only consumption (removing DHW and other loads). For calculation of savings see "EVT Advanced Thermostat and Optimization 2020 Update.x8s\* for details.
- [25] Estimate is based upon calculation of average heating load; (FLH \* Capacity/1,000,000)/AFUE: FLH and Capacity are based upon natural gas billing data anaylesis provided by Vermot Gas Systems (VGS) (see VGS Usage Regression Work,04182017.sk), AFUE assumptions are from Vermot Residential New Construction Baselines Bushy Analysis of On-Site Audits, 2112/2013. Note the PLI calculation attachtes to isolate heating only consumption (removing DHW and other loads). For calculation of savings see "EVT Advanced Thermostat and Optimization 2020 Update.sks" for details.
- [26] Table 1, HVAC Controls, Measure Life Report, Residential and Commercial/Industrial Lighting and HVAC Measures, GDS Associates, 2007
- [27] In contrast to program designs that utilize program affiliated contractors or other trade ally partners that support customer participation through thermostat distribution, installation and other services, BYOT programs enroll customers after the time of purchase through online rebate and program integration sign-ups.
- [28] Market prices vary considerably in this category, generally increasing with thermostat capability and sophistication. The core suite of functions required by this measure's eligibility criteria are available on units readily available in the market roughly in the range of \$200 and \$250, excluding the availability of any wholesale or volume discounts. The assumed incremental cost is based on the middle of this range (\$225) minus a cost of \$50 for the baseline equipment blend of manual and programmable thermostis. Note that any add-on energy service costs, which may include one-time setup and/or annual per device costs are not included in this assumption.

[29] Assumed to be \$225 minus \$75 for programmable thermostat.

## **ENERGY STAR Dehumidifiers**

Measure Number:	RS-HVC-DEHUM5 a
Portfolio:	EVT TRM Portfolio 2019-12
Status:	Active
Effective Date:	2020/1/1
End Date:	[ None ]
Program:	Efficient Products Program
End Use:	HVAC

Update Summary The existing dehumidifier measure for Time of Sale and Early Replacement ENERGY STAR qualified units is being revised to incorporate the latest standards, including new categories, as well as redefining existing ones.

- Referenced Documents rds from the code of federal regulations for dehumidifiers 10 CFR 430.32.v 1 &2 • Fe
- Testen apparatic Entenny standards in the Loce of recent regulated
   ENERGY STATe Dubmindifiers V Program Specifications
   Dehamidifiers V Program Specifications
   Dehamidifiers State Conservation Standards for Dehamidifiers July 2012
   ENERGY STAK Applance, calculation, Dehamidifiers\_Last Updated 2016
   EVT Dehamidifier Analysis Nov 2019\_Final

Description A dotunidifier meeting the new minimum qualifying efficiency standard established by ENERGY STAR Program (Version 5.0), effective October 31, 2019, and ENERGY STAR Most Efficient 2020 Criteria, effective, 01/01/2020, is purchased and installed in a residential setting in place of a baseline unit. This measure applies to Time of Sale (Market Opportunity) and Early Replacement programs.

Program Type <u>Calculation Type</u>: Time of Sale (Market Opportunity) and Early Replacement

Program Delivery / Implementation Type: Downstream and Free Product (Low Income Single-Family Voucher Program)

## **Baseline Efficiencies**

line efficiency is a dehumidifier that meets the Code of Federal Regulations appliance efficiency standards as defined below <sup>[1]</sup> :

	Product Capacity	Early Replacement Baseline Efficiency [2]	Time of Sale Baseline Efficiency <sup>[3]</sup>
	(Pints/Day)	(L/kWh)	(L/kWh)
Portable	≤25	≥1.35	≥1.30
	25.01 ≤ 50	≥1.43	≥1.60
	50.01 <155	≥1.93	≥2.80
	Product Case Volume	Early Replacement Baseline Efficiency <sup>[2]</sup>	Time of Sale Baseline Efficiency[3]
Whole-Home	(ft <sup>3</sup> )	(L/kWh)	(L/kWh)
whole-nome	≤8	NA	≥1.77
	>8	NA	≥2.41

## Efficient Equipment

Efficient Equipment High efficiency is defined as any model meeting or exceeding DERGY STAR qualifying efficiency standard established by the current ENERGY STAR (Version 5.0). The Most Efficient Tier was included by ENERGY STAR and made effective on 01/01/2020. As defined by ENERGY STAR, a portable dehumidifier is designed to operate within the space without the attachment. A value of additional ducting, although means may be provided for optional duct attachment. A whole-home dehumiding is a unit designed to be incorporated into the home's HAAC system, or installed with its own duct system; and provide dehumidification for all conditioned spaces within the building enclosure.

Performance Criteria for ENERGY STAR Qualified Dehumidifiers:

	Product Capacity	ENERGY STAR Integrated Energy Factor	Most Efficient ENERGY STAR Integrated Energy Factor
Portable	(Pints/Day)	(L/kWh)	(L/kWh)
	≤25	≥1.57	≥1.70
	25.01 ≤ 50	≥1.80	≥1.90
	50.01 <155	≥3.30	≥3.40
	Product Case Volume	ENERGY STAR Integrated Energy Factor	Most Efficient ENERGY STAR Integrated Energy Factor
Whole-Home	(ft <sup>3</sup> )	(L/kWh)	(L/kWh)
	≤8	≥2.09	≥2.22
	>8	≥3.30	≥3.40

## Algorithms

	Savings	
ΔkW	= ΔkWh(Hours	
Symbol Table		
Electric Energy S	avings	
ΔkWh	$= (((Avg Capacity \times 0.473) / 24) \times Hours) \times (1 / (L/kWh_Base) - 1 / (L/kWh_Eff))$	
Symbol Table		
Fossil Fuel Saving	js	
Where:		
Where:	= Gross customer connected load KW savings	
	= Gross customer connected load KW savings     = gross customer annual KWh savings for the measure	
ΔkW	-	
ΔkW ΔkWh	= gross customer annual kWh savings for the measure	
ΔkW ΔkWh 0.473	gross customer annual KWh savings for the measure     Gonstant to convert Pints to Liters     Gonstant to convert Liters/day to Liters/hour	
ΔkW ΔkWh 0.473 24	gross customer annual KWh savings for the measure     Gonstant to convert Pints to Liters     Gonstant to convert Liters/day to Liters/hour	
ΔkW ΔkWh 0.473 24	e = gross customer annual kWh savings for the measure     = Constant to convert Pints to Liters     = Constant to convert Liters/day to Liters/hour     y = = Average capacity of the unit (pints/day)	
ΔkW ΔkWh 0.473 24 Avg Capacity	= = gross customer annual KWh savings for the measure = Constant to convert Pints to Liters = Constant to convert Liters/day to Liters/hour y = Average capacity of the unit (pints/day) = 38.4 <sup>[5]</sup>	
ΔkW ΔkWh 0.473 24 Avg Capacity	=       = gross customer annual KWh savings for the measure         =       = Constant to convert Pints to Liters         =       = Constant to convert Jiters/day to Liters/hour         y       =         =       = Average capacity of the unit (pints/day)         =       38.4 <sup>[15]</sup> =       = Run hours per year         =       163.2 <sup>[4]</sup>	

Time of Sale, Whole-Home = 1.77 [6] Early Replacement, Portable = 1.41 [2] ENERGY STAR, Portable = 1.76 [7] ENERGY STAR Most Efficient: Portable = 1.86 [7] ENERGY STAR, Whole-Home = 2.09 (8) ENERGY STAR Most Efficient: Whole-Home = 2.22 [8]

### Deemed Energy and Demand Savings Time of Sale

Measure	Item Code	Deemed Demand Savings ( $\Delta kW$ )	Deemed Energy Savings (AkWh)
ENERGY STAR: Portable	EPDEHUM	0.061	99
ENERGY STAR: Whole-Home	EPDEHUMW	0.094	153
ENERGY STAR Most Efficient: Portable	EPDEHUME2	0.085	139
ENERGY STAR Most Efficient: Whole-Home	EPDEHUME1	0.124	203

### Early Replacement

		Remaining Life of Existing Unit		Remaining Measure L	Mid 126 Contract	
Measure	Item Code	Deemed Demand Savings (ΔkW)	Deemed Energy Savings (ΔkWh)	Deemed Demand Savings (ΔkW)	Deemed Energy Savings (ΔkWh)	Mid-Life Savings Adjustment
ENERGY STAR: Portable	EPDEHUMER	0.106	172	0.061	99	58%
ENERGY STAR Most Efficient: Portable	EPDEHUMERME2	0.130	212	0.085	139	66%

## Mid-Life Savings Adjustment

ent for the early replacement measure, please see the deemed energy and demand savings above For the mid-life saving

### Load Shapes 73a Residential - Dehumidifier

## **Net Savings Factors**

Measures ACEDEHUM Energy Star Dehumidifier ACEDHUME ENERGY STAR Residential Dehumidifier Most Efficient tie

## Tracks [Base Track]

6032EPEP [is base track] Efficient Products - Residential 6034LISF [is base track] LISF Retrofit

6013EPEP [6032EPEP] Efficient Products - Commercial

Track Name	Track Nr.	Measure Code	Free Rider	Spill Over
Efficient Products - Residential	6032EPEP	ACEDEHUM	0.77	1.00
LISF Retrofit	6034LISF	ACEDEHUM	1.00	1.00
Efficient Products - Residential	6032EPEP	ACEDHUME	0.95	1.05
LISF Retrofit	6034LISF	ACEDHUME	1.00	1.00

Persistence The persistence factor is assumed to be one.

### Lifetimes

d measure life for a dehumidifier is 12 years, according to the ENERGY STAR Dehumidifier Calculator For early replacement, the remaining useful life of the existing unit is assumed to be 1/3 of the measure life, or 4 years Analysis period is the same as the lifetime.

### Measure Cost

The incremental cost for the time of sale measure is the difference in cost between a baseline and an ENERGY STAR qualified unit. For early replace measures the full cost of an ENERGY STAR unit is used. Please see the below table for cost assumptions.

TOS				Early Replace	ement		
Portable		Whole-Home	2	Portable		Whole-Home	
ENERGY STAR	ENERGY STAR Most Efficient	ENERGY STAR	ENERGY STAR Most Efficient	ENERGY STAR	ENERGY STAR Most Efficient	ENERGY STAR	ENERGY STAR Most Efficient
\$10 [9]	\$75 <sup>[10]</sup>	\$32 [11]	\$75 <sup>(10)</sup>	\$523[12]	\$588 <sup>[12]</sup>	\$1911[12]	\$1976 <sup>[12]</sup>

### O&M Cost Adjustments

nance cost adjustments for this measure n and main

Fossil Fuel Description There are no fossil-fuel algorithms or default values for this measure.

## Footnotes

- [1] The Federal Standard for Dehumidifiers changed as of June 2019; https://www.ecfr.gov/cgi-bin/text-idx?rgn=div8&node=10:3.0.1.4.18.3.9.2
- [2] Minimum 2012 Federal Standard Energy Factor. Federal efficiency standards for dehumidifiers manufactured between September 30, 2012 and June 13, 2019: 10 CFR 430.32.v.1. Weighted by capacity and equiment type based on available products on the ENERGY STAR Qualified Products List. difiers manufacti
- [3] Minimum 2019 Integrated Energy Factor. Federal appliance efficiency standards from the code of federal regulations for dehum on or after June 13, 2019. 10 CFR 430.32 v.2
- [4] Based on 68 days of 24 hour operation: ENERGY STAR Dehumidifier Calculato
- [5] Average Water Removal Capacity (pints/day) from all units Energy Star QPL. Refer to Savings Calc tab of the analysis document: "EVT\_Dehumidifier\_Analysis\_Nov 2019\_Final.xisx".
- [6] Baseline Efficiency for smaller size Case Volume =< 8.0 ft<sup>3</sup>. Refer to Savings Calc tab of analysis document: "EVT\_Dehumidifier\_Analysis\_Nov 2019\_Final\_xlsx<sup>4</sup>.
- [7] Weighted average from Energy Star QPL. Refer to Savings Calc tab of analysis document: "EVT\_Dehumidifier\_Analysis\_Nov 2019\_Final.xlsx".
- [8] ENERGY STAR Efficiency (L/kW) for smaller size Case Volume =< 8.0 ft<sup>3</sup>, Refer to Savings Calc tab of analysis document: "EVT\_Dehumidifier\_Analysis\_Nov 2019\_Final.xdsx".
- [9] Based on incremental costs from 2016 ENERGY STAR Appliance Calculator. Refer to weighted average calculation on Savings Calc tab of "EVT\_Dehumidifier, Analysis, Nov 2019\_Final.xlsx".

- [10] DDE, Office of EERE, Appliance and Equipment Standards, Energy Conservation Standards for Residential Dehunidifiers, 10 CFR Part 430, July 23, 2012, page 73. The sourced table is an analysis on the incremental manufacture production costs on dehunidifiers with anying incretive levels. Assuming the markup costs between the baseline unues and the most efficient units are ended infection. The final incremental cost production does in a straight average of all the dehunidifiers, both stand alone and whole house, with an efficiency level meeting or exceeding DEBRY STAR's Most. Efficient criteria. Opted to combine the incremental cost into one value because the stand alone and whole house incremental costs were near idential.
- [11] Based on incremental costs from 2016 ENERGY STAR Appliance Calculator. Refer to calculation of average on Savings Calc tab of "EVT\_Dehumidifier\_Analysis\_Nov 2019\_Final.vds.".

[12] In order to derive the ENERGY STAR and ENERGY STAR Most Efficient capital equipment costs for the early replacement incremental costs, the time of sale incremental cost was added to the capital equipment cost of the baseline units. The baseline equipment costs are sourced from DDE Energy Consensation Standards for Residential Dehumiding Explanment Standard 10 CFR Part 430, July 23, 2012 (pg. 143-146) and weighted according to the available capacity units on the ENERGY STAR Qualified Products List.

## **Dehumidifier Recycling**

Measure Number:	RS-HVC-DEHUMREC a
Portfolio:	EVT TRM Portfolio 2020-06
Status:	Active
Effective Date:	2020/1/1
End Date:	[ None ]
Program:	Efficient Products Program
End Use:	HVAC

### Update Summary easure

Note: Created new measure codes and net savings factors for this measure. Copied the NSF from "ENERGY STAR Dehumidifiers".

## Referenced Documents

- Referenced Documents = UFRKY STAFA Appliance, calculator, Dehumidifers, Last Updated 2016 = EVT Dehumidifer Analysis Nov 2019, Final = Dehumidifer CRF\_ERE-2012-8FT-STD-0027-0045 = For Consumers, Responsible Appliance Dappaal (RAD)\_USE EPA = NRM, CEE Fial\_CT Appliance Retriement, Dec 2005 = UIS Code: TIRE 42, 2007 Energy Conservation Standards = EVT\_Dehumidifer Recycling, Analysis, Apr 2020\_v2

Description
This measure involves the removal of an existing, inefficient, functioning dehumidifier from service prior to the end of its natural life (Early Retirement).
Entrory savings are based on the energy consumption of the retired dehumidifier during its estimated remaining life. However, the measure
characterization also assumes a percentage of necycled dehumidifier will ultimately be neplaced. The energy consumption of this new unit, in place of
the recycled unit, is laken info account in the savings estimate. If primary data includate the unit is neplaced forthright rather than retired/recycled, energy
savings should be based on the Time of Sale 'B/ERGY'STAR Dehumidifier' measure.

# Program Type Calculation Type: Early Retirement

Program Delivery / Implementation Type: Downstream

Baseline Efficiencies The baseline scenario is an existing, inefficient, functioning dehumidifier. The equipment efficiency is based on the unit meeting federal appliance efficiency standards at the date of manufacture, as detailed in the table below:

Product Capacity (pints/day)	Minimum 2007 Federal Standard Energy Factor (L/kWh) <sup>[1]</sup>	Minimum 2012 Federal Standard Energy Factor (L/kWh) <sup>[2]</sup>
≤ 25	1.00	1.35
> 25 and ≤ 35	1.20	1.35
> 35 and ≤ 45	1.30	1.50
> 45 and ≤ 54	1.30	1.60
> 54 and ≤ 75	1.50	1.70
> 75 and ≤ 185	2.25	2.50
Average <sup>[3]</sup>	1.38	1.60

### Efficient Equipment

Efficient Equipment The efficient Scenario is the removal of an existing dehumidifier from service. However, it is assumed that a percentage of units will be replaced, with the energy assing reduced in order to account for the consumption of these replacement units. These replacement units are assumed to meet the current federal appliance efficiency standards for dehumidifiers manufactured on or after June 13, 2019.<sup>[4]</sup>

# Algorithms Electric Demand Savings

ΔkW = (Capacity x 0.473 / 24) x ((1 / L per kWh<sub>Base</sub>) - (% Replaced x (1 / L per kWh<sub>New</sub>)))

Symbol Table		
Electric Ener	au Caulman	

$\Delta kWh = (Capacity x 0.473 x Hours / 24) x ((1 / L per kWh_{Base}) - (% Replaced x (1 / L per kWh_{New})))$	Symbol Table	
	ΔkWh	= (Capacity x 0.473 x Hours / 24) x ((1 / L per kWh_{Base}) - (% Replaced x (1 / L per kWh_{New})))

Fossil Fuel Savings

nere:	
% Replaced	<ul> <li>Percent of units recycled that are replaced</li> <li>= 76%<sup>[5]</sup></li> </ul>
ΔkW	<ul> <li>Gross customer connected load kW savings for a recycled dehumidifier.</li> </ul>
ΔkWh	= Gross customer annual KWh savings for a recycled dehumidifier.
0.473	<ul> <li>Constant to convert pints to liters.</li> </ul>
24	<ul> <li>Constant to convert liters per hour to liters per day</li> </ul>
Capacity	= Average water removel capacity of the recycled dehumidifier in pints per day $= 55.7 \ pints/day^{[1]}$
Hours	= Average annual equipment run hours = 1,632 hours <sup>(6)</sup>
L per kWh <sub>Base</sub>	Efficiency of the recycled dehumidifier in liters of water per KWh consumed, as provided in 'Baseline Efficiencies' table above. Values reflect a manufacture date range that coincides with timing of federal efficiency standards. = 1.38 U/KWh if unit manufactured before October 2012 = 1.60 U/KWh if unit manufactured between October 2012 and June 2019
L per kWh <sub>New</sub>	= Efficiency of replacement dehumidifier in liters of water per KWh consumed. = 2.18 $U/kWh^{(4)}$

### Deemed Energy and Demand Savings

Measure	Item Code	Deemed Demand Savings (ΔkW)	Deemed Energy Savings (ΔkWh)
Dehumidifer Recycling - Manufactured before October 2012	ACEDEHREC1	0.4128	674
Dehumidifer Recycling - Manufactured between October 2012 and June 2019	ACEDEHREC2	0.3034	495

## Load Shapes

73a Residential - Dehumi

								Summer			
Nur	nber	Name		Status				Off kWh		kW	
73	R	esidential - Dehu	midifier	Active	15.9%	17.5%	31.7%	34.9%	0.0%	35.3%	
Ne	et Sav	ings Factor	s								
	sures										
ACE	DEHER	Dehumidifier Re	cycling								
Trac	ake FR a	se Track]									
		is base track] Ef	ficient P	roducts -	Residentia						
		-									
-		<b>ck Name</b> ducts - Residentia				Free Rid	er Spill Ov 1.00	er			
EIIIC	Jent Pro	uucus - Residenta	11 00326	PEP ACEL	CHER	0.77	1.00				
Life	etime	s									
The	measure	e life is 5 years, v	vhich is	the remai	ning meas	ure life of	the existing	g, recycled,	dehumid	ifier.[7]	
M		Cont									
		e Cost ntal cost for this	measur	e is \$73.5	7.						
The	increme	ntal measure cos	t accou	nts for the	cost to pi	k-up and	recycle the	existing de	humidifie	r plus a rep	placement cost to the customer for a new
dehu	midifier	. The incrementa	l cost al	so assum	es the cust	omers rep					ture replacement cost they would have
		ourn out of the ed									
											alculated by multiplying the percentage of ated lifecycle NPV of the future deferred
		cost is calculated									
oot	note	s									
		07 minimum fede (U.S. Code: Title								ds for dehu	midifiers manufactured on or after October
		L2 minimum fede 0 CFR 430.32(v))		iance ene	rgy factor i	s sourced	from code	of federal	regulatior	is for dehur	nidifiers manufactured on or after October 1
[3]	The ave	erage equipment	efficien	cies are so	oured from	a weighte	d average	of Efficience	y Vermor	nt rebated E	NERGY STAR dehumidifiers, and the
	correlat	ing baseline effic	iency, b	ased on t	ne rebated	unit's cap	acity. The a	average eq	uipment o	apacity of S	55.7 pints per day is based on this source as
		e EVT program o ehumidifier Recy					January 2	016 throug	h mid-Oct	ober 2019.	For more detail, please see;
							dahuma' P		ashward -	n office 1	12 2010 (10 CED 420 22 (-)(2)) The
											13, 2019 (10 CFR 430.32.(v)(2)). The nont rebated ENERGY STAR dehumidifiers
		in the rebated un									
[5]	Based o	n Nexus Market F	Researc	h Inc, RLV	V Analytics	Decembe	er 2005; "Ir	npact, Proc	ess, and	Market Stu	dy of the Connecticut Appliance Retirement
											AR units and 13% with non-ENERGY STAR,
											n air conditioners, assumed identical n-ENERGY STAR since the increment of
	savings	between baselin									STAR Dehumidifiers EVT measure when the
		it is purchased.									
[6]	Run hoi	urs per year is so	urced fr	om the El	NERGY STA	R Dehumi	difier Calcu	lator, whic	h assume	s 68 days c	f 24 hour operation.
											e life for a dehumidifier of 12 years minus
		rage age of retire al Reference Mar				uals a rem	aining life (	of 5 years.	This is fu	rther corrol	porated by the Mass Save, Massachusetts
[8]	The est	imated recycling	cost is s	ourced fr	om a quote	from Rec	leim, which	n operates	appliance	recyclina p	rograms in other jurisdictions across the
	country						,			-,	
[9]	The est	imated cost of a	standar	d efficienc	y dehumid	fier is sou	rced from	the baselin	e capitol o	cost for the	EVT ENERGY STAR Dehumidifier measure
											luded in the reference document section rental cost for this measure because it is
											they will be processed through EVT's
	program	n offerings, matc	hing the	incremer	ntal savings	and incre	mental cos	ts to the cl	aimed me	etrics for the	at ENERGY STAR Dehumidifier measure.

[10] For more detail on the derivation of the incremental cost, please see: 'EVT\_Dehumidifier Recycling\_Analysis\_Apr 2020\_v2.xlsx

# **ENERGY STAR Residential Ventilation Fans, Non-**Continuous Measure Number: BS-HVC-ESRVF Portfolio: EVT TRM Portfolio 2020-01 Status: Active Effective Date: 2020//1 End Date: [None] Program: Existing Homes End Use: HVAC Referenced Documents ASHRAE 62.2 Section 4.1 Whole House Ventilation 2015 ICC VT Residential Building Energy Standards 2019 ENERGY STAR Certified Ventilating Fans for Ba 2015 VT Energy Code Handbook, V4.1 2012 JECC, DOE, Residential Fan Efficiency 2007 GDF Associates Measure Life Report ENERKY STAR Ventilating Fans Most Efficient 2020 Criteria V4.1 EVT Bath Fan Analysis\_Final Bath Fan\_SST19 Results\_Final Description Description This market opportunity is defined by the need for non-continuous mechanical ventilation for Existing Home retroft projects. This measure assumes a fan capacity of 50 CFM rated at less than 2.0 sones at 0.1 inches of water column static pressure. All eligible installations shall be sized to provide the mechanical ventilation rate indicated by ASHRAE 62.2. An efficient bathroom ventilation fan must meet the qualifying efficiency standard established by EREKGY STAR Morgann (Version 4.1) and ENERGY STAR Most Efficient 2020 Criteria. This measure applies to the Low Income Single Family, Multifamily, and Existing Homes programs. Program Type Calculation Type: Market Opportunity: Time of Sale Delivery Type: Direct Install Algorithms Electric Demand Savings ΔkW = CFM × $(1/\eta_{Baseline} - 1/\eta_{Efficient})/1000$ ΔkW = CFM × (1/ $\eta$ <sub>Baseline</sub> - 1/ $\eta$ <sub>Most Efficient</sub>)/1000 Symbol Table Electric Energy Savings $\Delta kWh$ = Hours x $\Delta kW$ Where: ΔkW = Gross customer connected load kW savings per qualified ventilation fan and controls AWV = Gross customer connected load XW savings per qualitied vertilation its and co AWVh = Gross customer annual KWh savings per qualified vertilation fan and controls. n\_Eficient = Minimum Efficacy for ENERGY STAR fan, 2.8 CPM(Watt)<sup>[1]</sup> Minimum Efficacy for Baseline fan, 1.4 CFM/Watt <sup>[2](3)</sup> η <sub>Baseline</sub> η <sub>Most Efficient</sub> = Minimum Efficacy for Most Efficient ENERGY STAR fan, 10.0 CFM/Watt Nominal Capacity of the exhaust fan, 50 CFM <sup>[4][5]</sup> CFM Hours = Assumed Annual Run Hours, 850 for non-continuous ventilation [6] Baseline Efficiencies Baseline efficiency is assumed to be the Minimum Vermont Residential Building Energy Code, which is 1.4 CFM/Watt.<sup>[2][3]</sup> New efficient Equipment New efficient criteria is assumed to be 2.8 CFM/Watt for ENERGY STAR Ventilating Bathroom Fans<sup>(1)</sup>, and 10.0 CFM/Watt for ENERGY STAR Most Efficient Ventilating Bathroom Fans. Efficient Equipment Load Shapes 10a Residential Ventilation Number Name Status Winter Winter Summer Summer Summer Winter Summer Summer</t Residential Ventilation Active 31.7% 34.9% 15.9% 17.5% 32.2% 32.2% 10 Net Savings Factors Measures VNTXCEIL Exhaust fan, ceiling Tracks [Base Track] 5032EPEP [is base track] Efficient Products - Residential 6034LISF [is base track] LISF Retrofit 6036RETR [is base track] Res Retrofit Track Name Track Nr. Measure Code Pree Rider Spill Ove Efficient Products - Residential 6032EFPD VITXCEIL 1.00 1.00 LSF Retrofit 6036RETR/VITXCEIL 1.00 1.00 Res Retrofit 6036RETR/VITXCEIL 0.90 1.00 Lifetimes 19 years [7] Analysis period is the same as the lifetime

io cinentar cost per installeu farm	c \$65 33	for quiet a	fficient fans. [8] ENERGY STAR Most Efficient average cost per fan is approxiamtely \$74.13 <sup>[9]</sup>
	5 300.00	ior quiet, e	moenchans, or Energy Strike Hose Enicience average cose per rains approximitely \$74,150
Update Summary			
		W ∆kWł	
ENERGY STAR, Efficient Vent Fan		018 15.19	
ENERGY STAR, Most Efficient Vent	t Fan 0.0	031 26.12	
Deemed Energy and D	eman	d Savir	igs
	ΔkW	ΔkWh	
ENERGY STAR, Efficient Fan	0.018	15.19	
ENERGY STAR, Most Efficient Fan	0.031	26.12	
10]			
ootnotes			
	tified Dec	-idontial V/	ntilating Fans — Minimum Efficacy
			ting_cooling/fans_ventilating/key_product_criteria
2] 2015 ICC VT Residential Build	ing Energ	y Standard	s, Chapter 4, Table R403.6.1 "Mechanical Ventilation System Fan Efficacy", page 30
			s, Chapter 4, Table R403.6.1 "Mechanical Ventilation System Fan Efficacy", page 30 R403.5.1: Mechanical Ventilation System Fan Efficacy, page 7
3] 2012_IECC_DOE_Residential F	an Efficie	ency, Table	R403.5.1: Mechanical Ventilation System Fan Efficacy, page 7
3] 2012_IECC_DOE_Residential F	an Efficie	ency, Table Systems, c	R403.5.1: Mechanical Ventilation System Fan Efficacy, page 7
<ol> <li>2012_IECC_DOE_Residential F</li> <li>2019 Berkley Lab, Residential</li> <li>2015 VT Energy Code Handbo</li> </ol>	an Efficie Building S	systems, c Systems, c Sec 3.1b	R403.5.1: Mechanical Ventilation System Fan Efficacy, page 7 ting ASHRAE Standard 62.2 https://homes.lbl.gov/ventilate-right/step-2-kitchen-and-bath-ventilation
2012_IECC_DOE_Residential F     2019 Berkley Lab, Residential     2019 Berkley Lab, Residential     2015 VT Energy Code Handbo     EVT Bath Fan Analysis File, Se	an Efficie Building S ok, V4.1,	ency, Table Systems, c Sec 3.1b #1, "1_Cal	R403.5.1: Mechanical Ventilation System Fan Efficacy, page 7
2012_IECC_DOE_Residential F     2019 Berkley Lab, Residential     2019 VT Energy Code Handbo     DVT Bath Fan Analysis File, Se     https://www.hvi.org/resource	an Efficie Building ! ok, V4.1, ee sheet s/publica	Systems, c Systems, c Sec 3.1b #1, "1_Cal tions/home	R403.5.1: Mechanical Ventilation System Fan Efficacy, page 7 ting ASHRAE Standard 62.2 https://homes.lbi.gov/ventilate-right/step-2-kitchen-and-bath-ventilation st/, using the Home Ventilating Institute's recommendation of minimum 20 minutes after each use. -ventilation-guide-articles/how-much-ventilation-do-i-need/
2012_IECC_DOE_Residential F     2019 Berkley Lab, Residential     2019 VT Energy Code Handbo     DVT Bath Fan Analysis File, Se     https://www.hvi.org/resource	an Efficie Building S Iok, V4.1, Se sheet S/publica	Systems, c Systems, c Sec 3.1b #1, "1_Cal tions/home	R403.5.1: Mechanical Vertilation System Fan Efficacy, page 7 ting ASHRAE Standard 62.2 https://homes.lkl.gov/vertilate-right/step-2-kitchen-and-bath-vertilation ss*, using the Home Vertilating Institute's recommendation of minimum 20 minutes after each use. -vertilation-guide-articles/how-much-vertilation-do-i-need/ stessure Life Report "Residential and C&IL Lighting and HA/C measures" 25 years for whole-house
2012_IECC_DOE_Residential F     2019 Berkley Lab, Residential F     2019 Berkley Lab, Residential     2019 VT Energy Code Handbo     EVT Bath Fan Analysis File, Sc     https://www.hvi.org/resource     Conservative estimate based i	an Efficie Building ! lok, V4.1, ee sheet s/publica upon GDS	Systems, c Systems, c Sec 3.1b #1, "1_Cal tions/home Sassociate billed attic f	R403.5.1: Mechanical Vertilation System Fan Efficacy, page 7 ting ASHRAE Standard 62.2 https://homes.lkl.gov/vertilate-right/step-2-kitchen-and-bath-vertilation ss*, using the Home Vertilating Institute's recommendation of minimum 20 minutes after each use. -vertilation-guide-articles/how-much-vertilation-do-i-need/ st Measure Life Report "Residential and C&I Lighting and HVAC measures" 25 years for whole-house ans.
2012_JECC_DOE_Residential F     2019 Berkley Lab, Residential     2019 Berkley Lab, Residential     2019 VT Energy Code Handboo     EVT Bath Fan Analysis File, Se     https://www.hik.org/resource     Conservative estimate based     fans, and 19 for thermostatica	an Efficie Building ! wk, V4.1, ee sheet s/publica upon GDS ally-contro	Systems, c Systems, c Sec 3.1b #1, "1_Cal tions/home s Associate blled attic f #2, "2_EVT	R403.5.1: Mechanical Vertilation System Fan Efficacy, page 7 ting ASHRAE Standard 62.2 https://homes.lbl.gov/vertilate-right/step-2-kitchen-and-bath-vertilation ss*, using the Home Vertilating Institute's recommendation of minimum 20 minutes after each use. -vertilation-guide-articles/how-much-vertilation-do-i-need/ steasure Life Report "Residential and C&I Lighting and HVAC measures" 25 years for whole-house ans. Data"

[9] EVT Bath Fan Analysis File, See sheet #3, "3\_ESTAR\_!"
 [10] EVT Bath Fan Analysis File, See "1\_Calcs"

## ENERGY STAR Room A/C

Measure Number: (RS-HVC-MEAC b) Portfolio: Status: Active Effective Date: 2020/1/1 End Date: [None ] Program: Efficient Products Program End Use: HVAC

Update Summary Addition of standard ENERGY STAR level to downstream measure, consistent with ESRPP

- Referenced Documents cpa-rpp-product-analysis-evt-2017 CBA Associates, Measure Life Report\_Jun 2007 Conicidence Fador Study Room AC PUC MH Incremental\_Cost\_Recommendations\_Non\_Lighting\_050917 Room Air Conditioner FDRRW STAR Most Efficient 2020 Final Criteria evt-energy-ata-room-ac-analysis-2020-six doe-eerer-2007-bit-sid=0010-0050

Description This measure involves the purchase and installation of a room air conditioning unit that meets the ENERGY STAR or ENERGY STAR Most Efficient requirements in place of a baseline unit. The baseline is based on the Federal Standard effective June 1st, 2014. The measure do residential assumptions, but will also be available for commercial applications, but claim the same savings.

# Program Type Calculation Type: Time of Sale

Program Delivery/Implementation Type: Downstream

## **Baseline Efficiencies**

The baseline assumption is a new room air conditioning unit that meets the Federal Standard (effective June 1st, 2014) efficiency standards as pre above. Table 1: Baseline Efficiencies<sup>[1]</sup>

/pe and Class (Btu/hr)	Federal Standard with louvered sides (CEER)	Federal Standard without louvered sides (CEER)				
< 8,000	11	10				
8,000 to 10,999	10.9	9.6				
11,000 to 13,999	10.9	9.5				
14,000 to 19,999	10.7	9.3				
20,000 to 27,999	9.4	9.4				
>=28,000	9	9.4				
<14,000	9.8	9.3				
14,000 to 19,999	9.8	8.7				
>=20,000	9.3	8.7				
	< 8,000 8,000 to 10,999 11,000 to 13,999 14,000 to 19,999 20,000 to 27,999 >=28,000 <14,000 14,000 to 19,999	< 8,000 11 8,000 to 10,999 10.9 11,000 to 13,999 10.9 14,000 to 13,999 10.7 20,000 to 27,999 10.7 20,000 to 27,999 0.4 ~~28,000 9 				

## Efficient Equipment

To qualify for this measure the new room air conditioning unit must either meet ENERGY STAR v4.1 specifications or ENERGY STAR Most Efficient (defined as outperforming the U.S. Department of Energy Federal Minimum Combined Energy Efficiency Ratio by at least 35% for models with a cap >=14,000 Bu/hr and at least 25% for models with a capacity <14,000 Bu/hr).

### Table 2: Efficient Equipment<sup>[2]</sup>

		ENERGY STAR	ENERGY STAR	ENERGY STAR Most Efficient	ENERGY STAR Most Efficient
roduct Type and Class (Btu/hr)		With louvered sides (CEER)	Without louvered sides (CEER)		Without louvered sides (CEER)
< 8,000		12.1	11.0	13.75	12.50
8,000 to 10,999	8,000 to 10,999	12.0	10.6	13.63	12.00
Without Reverse Cycle	11,000 to 13,999	12.0	10.5	13.63	11.88
without Reverse Cycle	14,000 to 19,999	11.8	10.2	14.45	12.56
	20,000 to 27,999	10.3	10.3	12.69	12.69
	>=28,000	9.9	10.3	12.15	12.69
	<14,000	10.8	10.2	12.25	11.63
With Reverse Cycle	14,000 to 19,999	10.8	9.6	13.23	11.75
	>=20.000	10.2	9.6	12.56	11.75

## Algorithms

Electr	ic Demand Sav	ings				
∆kW		= ∆k	Wh / EFLH			
Symb	ol Table					
Electri	ic Energy Savin	ngs				
ΔkW	h		Wh <sub>Weighted Av</sub>	rerage H × Btu/hr × (1/CEER <sub>base</sub> - 1	/CEER <sub>ee</sub> ))/1000	
Where:						
	ΔkW		= gross cu	stomer connected load kW s	savings for the m	easure.
			= 0.0759	9kW for ENERGY STAR		
			= 0.3702	2kW for ENERGY STAR Most	Efficient	
	ΔkWhClass		= gross cu	stomer annual kWh savings	for each capacity	/ class
	∆kWh <sub>Weighted Ave</sub>	erage	= gross cu	stomer weighted average a	nnual kWh saving	s for the measure
			= 10.7 k	Wh for ENERGY STAR <sup>[4]</sup>		
			= 52.2 k	Wh for ENERGY STAR Most	Efficient <sup>(5)</sup>	
	Btu/hr		<ul> <li>Capacity</li> </ul>	of rebated unit (Btu/hr)[6]		
	CEERbase		= Combine	ed Energy Efficiency Ratio of	baseline unit	
			Refer to	Table 1 for Baseline Efficier	ncies	
	CEERee		= Combine	ed Energy Efficiency Ratio of	ENERGY STAR M	lost Efficient unit
			Refer to	Table 2 for Efficient Condition	on Criteria	

 EFH
 = Full Laad Hours of room air conditioning unt<sup>13</sup>

 141
 141

 System
 Summer Vinter Sum Vinter Vinter Vinter Sum Vinter Vinter Sum Vinter Vint

### Footnotes

[1] Federal Standard effective June 1, 2014. Section 430.32 Title 10: Energy Subpart C—Energy and Water Conservation Standards. https://www.edr.gov/cgi-bin/text-tick?rgn=div88node=10:3.0.1.4.18.3.9.2

[2] See Room Air Conditioner ENERGY STAR Most Efficient 2020 Final Criteria

[3] Equivalent full load hours for Burlington, VT from RLW Report: Final Report Coincidence Factor Study Residential Room Air Conditioners, June 23, 2008. See 'Coincidence Factory Study Room AC PUC'.

[4] See 'epa-rpp-produc-analysis-evt-2017.xls' for weighting calculation.

[5] See 'evt-energy-star-room-ac-analysis-2020.xlsx' for both capacity specific calculations and weighted average.

[6] Representative capacities are provided in the corresponding spreadsheet files.

[7] Department of Energy, Office of Energy Efficency and Renewable Energy, "Energy Conservation Program, Energy Conservation Standards for Residential Clothes Dryers and Room Air Conditioners", 10 CFR Part 430 (Docket: EERE-2007-6T-STD-0010, pg. 22514)

[8] ENERGY STAR is the estimate provided by ESRPP. ENERGY STAR Most Efficient is based on the weighted average of capacity/product bins from 2019 program data, see 'evt-energy-star-room-ac-analysis-2020.dsx'.

## **Room Air Conditioner Recycling**

Measure Number:	RS-HVC-RACREC a
Portfolio:	EVT TRM Portfolio 2020-08
Status:	Active
Effective Date:	2020/1/1
End Date:	[ None ]
Program:	Efficient Products Program
End Use:	HVAC

### Update Summary neasure

Note: Created new measure codes and net savings factors for this measure. Copied the NSF from "ENERGY STAR Most Efficient Room A/C".

- Referenced Documents

  Concidence Factor Study Room AC PUC NM
  ENERCY STAR Version 4.1 Specifications
  ENERCY STAR Room AIC conditioner Calculator
  DOEEERE, 2007-BT-STD 0010-0050
  EVF. Toom A.C. Analysis, Mar 2020
  For Consumers \_\_Responsible Appliance Dappeal (RAD) \_US EPA
  INR\_CEE Eail\_CT Appliance Retirement\_Doc.2005
  Room AC CFF, ESRE-2014-BT-50 0059-0001
  EVT\_Room AC Recycling\_Analysis\_Apr 2020\_v2

Description
This measure involves the removal of an existing, inefficient, functioning room air conditioner from service prior to the end of its natural life (Early
Retirement). Energy savings are based on the energy consumption of the retired room air conditioner during its estimated remaining life. However, the
measure characterization also assumes a percentage of recycled air conditioner sill ultimately be replaced. The energy consumption of this new unit, in
place of the recycled unit, is taken into account in the savings estimate. If primary data indicate the existing, recycled room air conditioner is replaced
with a new IRENGY TSIA qualifying unit, the savings remement between baseline and IRENGY TSIA should be captured. The measure characterization
assumes the program will target and retire room air conditioners manufactured and put into service prior to June 1, 2014.<sup>[1]</sup>

### Program Type Calculation Type: Early Retirement

Program Delivery / Implementation Type: Downstream

## Baseline Efficiencies

The baseline scenario is an existing, inefficient, functioning room air conditioner. The equipment efficiency is based on the unit meeting federal appli-efficiency standards for a room air conditioner manufactured between October 1, 2000 and May 31, 2014<sup>[21]</sup>, as detailed in the table below:

	Product Class (Btu/h)	Federal Standard with louvered sides (EER <sub>Base</sub> )	Federal Standard without louvered sides (EER <sub>Base</sub> )	
--	-----------------------	---	--	--

	< 8,000	9.7	9.0
	8,000 to 10,999		8.5
	11,000 to 13,999	9.8	8.5
Without Reverse Cycle	Cycle 14,000 to 19,999	9.7	8.5
	20,000 to 24,999	8.5	
	25,000-27,999	8.5	8.5
	>=28,000	0.5	
With Reverse Cycle	< 14,000	N/A	8.5
	>= 14,000	N/A	8.0
	< 20,000	9.0	N/A
	>= 20,000	8.5	N/A

Casement-only 8.7 Casement-slider 9.5

### Efficient Equipment

The efficient scattering is the removal of an existing room air conditioner from service. However, it is assumed that a percentage of units will be replace with the energy savings reduced in order to account for these replacement units. These replacement units are assumed to meet the federal appliance efficiency standards for room air conditioners manufactured or or aft *r*-law 2, 1204.11

# Algorithms Electric Demand Savings

ΔkW	= (Capacity x (1 / (EER <sub>Exist</sub> x 1.01)) / 1000) - (% Replaced x (Capacity x (1 / CEER <sub>New</sub> )) / 1000)					
Symbol Table						
Electric Energy Saving	<u>g</u> s					
ΔkWh	= (Hours x Capacity x (1 / (EER <sub>Exist</sub> x 1.01)) / 1000) - (% Replaced x (Hours x Capacity x (1 / CEER <sub>New</sub> )) / 1000)					
Symbol Table						
Fossil Fuel Savings						
Vhere:						
% Replaced	= Percent of units recycled that are replaced = 76%[3]					
ΔkW	= Gross customer connected load kW savings					
ΔkWh	<ul> <li>Gross customer annual kWh energy savings</li> </ul>					
1.01	<ul> <li>Factor to convert EER to CEER (CEER includes standy and off-power consumption)<sup>[4]</sup></li> </ul>					
Capacity	= Capacity in Btu/h of room air conditioner = 12,263 Btu/h <sup>(1)</sup>					
CEER <sub>New</sub>	= Efficiency of replacement air conditioner = 10.3 <sup>(c)</sup>					
EER <sub>Exist</sub>	= Efficiency of existing, recycled air conditioner = 9.2 <sup>(7)</sup>					
Hours	= Average annual equipment run hours = 141 hours <sup>(8)</sup>					

Deem	ed Energy a	and Demand Savings	

 
 Item Code
 Deemed Demand Savings (ΔkW)
 Deemed Energy Savings (ΔkWh)
 Room A/C Recycling ACEESRACREC 0.4149 59

### Load Shapes 99b Room Air Conditio

 
 Number
 Name
 Status
 Winter
 Winter
 Summer
 Summer</t Room Air Conditioning Active 0.7% 2.8% 53.3% 43.2% 0.0% 11.9% 99

## **Net Savings Factors**

ACEACREC Room Air Conditioner Recycling

### Tracks [Base Track] 6032EPEP [is base track] Efficient Products - Residential

Track Name Track Nr. Measure Code Free Rider Spill Over tt Products - Residential 6032EPEP ACEACREC 0.67 1.33 Efficient I

Lifetimes The measure life is estimated to be 3.5 years.<sup>(9)</sup>

### Measure Cost

he incremental cost for this measure is \$30.96 The incremental measure cost accounts for the cost to pick-up and recycle the existing ro new room air conditioner. The incremental cost also assumes the customers replacing the e existing room air conditioner plus a replacement cost to the customer for a replacing their room air conditioners are deferring a future replacement cost

they would have incurred on burn out of the equipment at the end of its useful life. The estimated cost for recycling is \$20.<sup>(10)</sup> The estimated cost for a replacement unit is \$129.20, (which was calculated by multiplying the per

units assumed to be replaced, 76%, by the assumed cost of a standard efficiency unit, \$170<sup>[11]</sup>). And the estimated lifecycle NPV of the future deferred replacement cost is calculated out to be \$118.24<sup>[12]</sup>.

### Footnotes

- Effective June 1, 2014 the Code of Federal Regulations released new appliance efficiency standards for room air conditioners manuface after this date (10 CFR 430.32(b)). tured on or
- [2] Federal appliance efficiency standards from the Code of Federal Regulations for room air conditioners manufactured between October 1, 2000 and May 31, 2014 (10 CFR 430.32(b)).
- [3] Based on Nexus Market Research Inc, RLW Analytics, December 2005; "Impact, Process, and Market Study of the Connecticut Applance Retirement Program: Overall Report: Report status: that G3% of room air conditioners are replaced with INER/O'STAR units and 13% within room-DERGYSTAR, for a total of 75% of units are registed. However, in order to be conservative, this formula assumes all are non-DERGYSTAR.
- Since the existing unit will be rated in EER, this factor is used to appropriately compare with the new CEER rating. Version 4.1 of the BNEROY STAR specification provided equivalent EER and CEER ratings and for the most popular size band the EER rating is approximately 1% higher than the CEER See "DERROY STAR Version 4.1 Boom At Conditiones Program Requirements". [4] Since the ex
- [5] Average capacity of all units listed on the CEC Appliance Database, as accessed on 3/26/2018. For more detail, please see: "EVT\_Room AC Recycling\_Analysis\_Apr 2020\_v2.xlsx"
- [6] Federal efficiency standards for room air conditioner manufactured after June 1, 2014: 10 CFR 430.32(b) Weighted by capacity and equipment type based on available products on the CEC Appliance Database, as accessed on 3/26/2018.
- [7] Federal efficiency standards for room air conditioner manufactured between October 1, 2000 and May 31, 2014: 10 CFR 430.32(b) Weighted by capacity and equipment type based on available products on the CEC Appliance Database that are non-ENERGY STAR units, as accessed on 3/26/2018.
- [8] Equivalent full load hours for Burlington, VT from RLW Report: Final Report Coincidence Factor Study Residential Room Air Conditioners, June 23, 2008. See 'Coincidence Factory Study Room AC PUC'.
- [9] The measure life is assumed to be 1/3 of the full measure life of a room air conditioner, which is 10.5 years, as sourced from; Department of Energy, Office of Energy Efficency and Renevable Energy; Tenergy Conservation Program, Energy Conservation Standards for Residential Codes Dryes and Noom Air Conditioners; 1) Cert Ren't and (Docket: EBE-Code: TesT000.10, pp. 22514).
- [10] The estimated recycling cost is sourced from a quote from Redeim, which operates appliance recycling programs in other jurisdictions across the
- [11] The estimated cost of a standard efficiency room air conditioner is sourced from the baseline capitol cost for the EVT ENERGY STAR Room A/C measure for a standard, non-ENERGY STAR unit. For contextual reference, the analysis file for that measure is included in the reference document section ("EVT\_Room A/C, Analysis, Mar 2020.x/sx"). It was deemed an appropriate source for the incremental cost for this measure because it is assumed that if a customer opts for their replacement room air conditioner to be an ENERGY STAR Are DERGY STAR Most Efficient certified unit, they will be processed through EVT's program offerings, matching the incremental savings and incremental costs to the claimed metrics for those existing measure.

[12] For more detail on the derivation of the incremental cost, please see: 'EVT\_Room AC Recycling\_Analysis\_Apr 2020\_v2.xlsx'

## **ENERGY STAR Room A/C**

Measure Number:	RS-HVC-ROOMAC b
Portfolio:	EVT TRM Portfolio 2020-0
Status:	Active
Effective Date:	2020/1/1
End Date:	[ None ]
Program:	Low Income Single Family
End Use:	HVAC

Update Summary New Measure. Br/T has an existing room air conditioner measure that is specifically for ENERGY STAR's Emerging Tech qualified units. That measure details savings across multiple bins, based on product class and capacity. This measure is designed specifically for the emerging low income appliance voculer program that covers the entire cost of a room air conditioner. The program is designed to be implemented in the fashion that very little information will be collected and reported to BVT; so as a result, the energy savings for this measure is split into two bins, depending on the replacement scenario, and veryinde across all product classes and capacities for any available ENERGY STAR unit. The measure details savings for early replacement and time of sale replacement scenarios.

03/2020 Update: Incorporated ENERGY STAR Most Efficient Criteria into the characterization

### Referenced Documents

- Referenced Documents GGS Associates, Measure Life Roport, Jan 2007 Incremental, Cost, Recommendations, Non, Lighting, 050917 EHERGY STAR Version 4.1. Specifications Code of Federal Regulations, Noon Air Conditioner EHERKY STAR Room Air Conditioner Calculator NEFP\_CF Study Res Room A.R.(2014) Analytics, 2008 Room Air Conditioner EHERKY STAR Most Efficient 2020 Final Cri DOE-EERE, 2007 AFF.STD-000-0050 EVT\_Room AC\_Analysis, Mar 2020

### Description

Description
This measure inclues the purchase and installation of a room air conditioning unit that meets DIERGY STAR version 4.1 or EDERGY STAR Most Efficient
requirements. The measure is characterized specifically for the low income single-family voucher program, in which eligible customers will receiver a
voucher that will cover the full cost of a new room air conditioner. The deemed savings for this program was aggregated and weighted due to the
implementation of the program where collecting air conditioners type, capacity, and efficiency not possible. The savings are detailed for two replacement
scenarios, early replacement and time of sale or market opportunity. The early replacement option will be used for customers option in to the retailers
offering of recycling the existing air conditioner. And the time of sale replacement option will be used if the customers option and an existing unit was
not recycled by the purchasing retailer.

Program Type <u>Calculation Type</u>: Time of Sale (Market Opportunity) and Early Replacement Program Delivery / Implementation Type: Downstream and Free Product (Low Income Single-Family Voucher Program)

## **Baseline Efficiencies**

Ime of Sale (Market Opportunity). The baseline assumption is a new room air conditioning unit that meets federal efficiency standards for units manufactured on or after June 1, 2014 (10 CFR 430.32(b)). For more detail on the specifications based on product class and capacity, see Reference Tables.

Early. Replacement: The baseline assumption for the remaining measure life is an existing, inefficient, functioning room air conditioning unit. The equipment efficiency is based on the unit meeting foderal appliance efficiency stadards between October 1, 2000 and May 31, 2014.<sup>[1]</sup> After the remaining measure life, the baseline shifts to the Time of Sale (Market Opportunity) baseline; a new room air conditioning unit meeting current federal efficiency standards.

### Efficient Equipment

The efficient equipments a room air conditioner that meets the ENERGY STAR program requirements, version 4.1, effective October 26, 2015 or the 2020 ENERGY STAR Most Efficient criteria. For more detail on the specifications based on product class and capacity, see Reference Tables.

# Algorithms

Electr	ric Demand Sa	avings	
∆kV	v	$= \Delta kWh$	/ EFLH
Symt	ool Table		
Electr	ric Energy Sav	/ings	
∆kW	Vh	= EFLH x	Capacity x (1 / CEER <sub>Base</sub> - 1 / CEER <sub>EE</sub> ) / 1000
Symt	ool Table		
Fossil N/A	l Fuel Savings		
Where	2:		
	ΔkW	-	Gross customer connected load kW savings
	∆kWh	-	Gross customer annual kWh energy savings
	Capacity	-	Capacity in Btu/h of room air conditioner
			= 12,263 Btu/h <sup>[3]</sup>
	CEER <sub>Base</sub>	-	Combined Energy Efficiency Ratio of baseline unit
			Time of Sale = 10.3 <sup>[4]</sup>
			Early Replacement = 9.2 <sup>[5]</sup>
	CEEREE	-	Combined Energy Efficiency Ratio of efficient unit
			ENERGY STAR = 11.4 <sup>[6]</sup>
			ENERGY STAR Most Efficient = 13.3 <sup>[7]</sup>
	EFLH	-	Full Load Hours of room air conditioning unit
			= 141 hours <sup>[2]</sup>
	Life Savin		
	-	-	r the early replacement scenario is:
	1.6% for ENERGY 5.5% for ENERGY		
1024	d Shapes		
	oom Air Conditio	ning	

 Number
 Name
 Status
 Winter
 Winter
 Summer
 Summer
 Summer</t

	ings Fa	ctors						
Measures								
ACEESARP	Energy Sta	r room AC						
ACEESAER	Energy Sta	r room AC, early	replacemer	nt				
Tracks [Ba	se Track]							
6034LISF [is	base track	() LISF Retrofit						
Track Name	Track Nr	Measure Code	Fron Ridor	Spill Over				
				1.00				
LISF Retrofit								

99 Room Air Conditioning Active 0.7% 2.8% 53.3% 43.2% 0.0% 11.9%

Lifetimes The assumed measure life for a room air conditioner is 10.5 years.<sup>[1]</sup> For early replacement, the remaining useful life of the existing unit is assumed to be 1/3 of the measure life, or 3.5 years.

Measure Cost The incremental cost for the time of sale measure is assumed to be \$50 for EVERGY STAR units and \$133 for EVERGY STAR Most Efficient units. Incremental costs for time of sale measures represent the difference in costs between a baseline and an efficient unit. For early replacement measures the full cost of an efficient unit is used, which is \$220<sup>(9)</sup> for ENERGY STAR units and \$303<sup>(20)</sup> for ENERGY STAR Most Efficient units.

## O&M Cost Adjustments

# Reference Tables Deemed Energy and Demand Savings

Measure - Time of Sale	Item Code	Deemed Demand Savings (ΔkW)	Deemed Energy Savings (ΔkWh)
ENERGY STAR Room A/C Time of Sale	ACEESRACVOU	0.1149	16.2
ENERGY STAR Most Efficient Room A/C Time of Sale	ACEESRACVOU2	0.2688	37.9

		Remaining Life of Existing Unit		Remaining Measure Life		
Measure - Early Replacement	Item Code	Deemed Demand Savings (ΔkW)	Deemed Energy Savings (ΔkWh)	Deemed Demand Savings (ΔkW)	Deemed Energy Savings (ΔkWh)	
ENERGY STAR Room A/C Early Replacement	ACEESRACVOUER	0.2574	36.3	0.1149	16.2	
ENERGY STAR Most Efficient Room A/C Early Replacement	ACEESRACVOUER2	0.4106	57.9	0.2688	37.9	

## Code of Federal Regulations for Room Air Conditioners Manufactured After June 1, 2014 (Baseline, Time of Sale)

Product Class (Btu/h)		Federal Standard with louvered sides (CEER <sub>Base</sub> )	Federal Standard without louvered sides (CEER <sub>Base</sub> )
	< 8,000	11	10
	8,000 to 10,999		9.6
	11,000 to 13,999	10.9	9.5
Without Reverse Cycle	14,000 to 19,999	10.7	9.3
	20,000 to 24,999	9.4	
	25,000-27,999	9	9.4
	>=28,000		
	< 14,000	N/A	9.3
With Reverse Cycle	>= 14,000	N/A	8.7
with Reverse Cycle	< 20,000	9.8	N/A
	>= 20,000	9.3	N/A

 Casement
 Federal Standard (CEER<sub>Bese</sub>)

 Casement-only
 9.5

 Casement-slider
 10.4

## Code of Federal Regulations for Room Air Conditioners Manufactured Between October 1, 2000 and May 31, 2014 (Baseline, Early Replacement)

Product Class (Btu/h)		Federal Standard with louvered sides (EER <sub>Base</sub> )	Federal Standard without louvered sides (EER <sub>Base</sub> )
	< 8,000	9.7	9.0
	8,000 to 10,999	9.8	8.5
	11,000 to 13,999	9.0	8.5
Without Reverse Cycle	14,000 to 19,999	9.7	8.5
	20,000 to 24,999	8.5	
	25,000-27,999		8.5
	>=28,000	8.5	
	< 14,000	N/A	8.5
	>= 14,000	N/A	8.0
With Reverse Cycle	< 20,000	9.0	N/A
	>= 20,000	8.5	N/A

Casement Federal Standard (EER<sub>Bore</sub>) Casement-only 8.7 Casement-slider 9.5

## ENERGY STAR Qualifications for Room Air Conditioners (Efficient)

Product Class (Btu/h)		ENERGY STAR with louvered sides (CEER <sub>EE</sub> )	ENERGY STAR without louvered sides (CEER <sub>EE</sub> )
	< 8,000	12.1	11
	8,000 to 10,999	12	10.6
	11,000 to 13,999	12	10.5
Without Reverse Cycle	14,000 to 19,999	11.8	10.2
	20,000 to 24,999	10.3	10.3
	25,000-27,999	10.5	
	>=28,000	9.9	
	< 14,000	N/A	10.2
with December Code	>= 14,000	N/A	9.6
With Reverse Cycle	< 20,000	10.8	N/A
	>= 20,000	10.2	N/A

Casement	ENERGY STAR (CEEREE)
Casement-only	10.5

Casement-slider 11.4

## ENERGY STAR Most Efficient 2020 Qualifications for Room Air Conditioners (Efficient)

To qualify for this measure, the new room air conditioning unit must outper efficiency ratio by: erform the U.S. Department of Energy federal mi

# At least 35% for models with a capacity of >= 14,000 Btu/h At least 25% for models with a capacity of < 14,000 Btu/h</li>

Product Class (Btu/h)		ENERGY STAR Most Efficient with louvered sides (CEER	ENERGY STAR Most Efficient without louvered sides (CEER	
	< 8,000	13.75	12.50	
	8,000 to 10,999	13.63	12.00	
	11,000 to 13,999	13.63	11.88	
Without Reverse Cycle	14,000 to 19,999	14.45	12.56	
	20,000 to 24,999	12.69		
	25,000-27,999	12.09	12.69	
	>=28,000	12.15		
	< 14,000	12.25	11.63	
With Reverse Cycle	14,000 to 19,999	13.23	11.75	
	>= 20,000	12.56	11.75	

### Footnotes

- Federal appliance efficiency standards from the code of federal regulations for room air conditioners manufactured between October 1, 2000 and May 31, 2014 (10 CFR 430.32(b)).
- [2] Equivalent full load hours for Burlington, VT from RLW Report: Final Report Coincidence Factor Study Residential Room Air Conditioners, June 23, 2008 (http://www.puc.nh.gov/Electric/Monitoring%20and%20Evaluation%20Reports/National%20Erid(117\_RLW\_CF%20Res%20RAC.pdf)
- [3] Average capacity of all units listed on the CEC Appliance Database, as accessed on 3/26/2018. For more detail, please see: "EVT\_Room AC\_Analysis\_Mar 2020.xlsx"
- [4] Federal efficiency standards for Room A/C manufactured after June 1, 2014: 10 CFR 430.32(b) Weighted by capacity and equipment type based on available products on the CEC Appliance Database, as accessed on 3/26/2018
- [5] Federal efficiency standards for Room A/C manufactured between October 1, 2000 and May 31, 2014: 10 CFR 430.32(b) Weighted by capacity and equiment type based on available products on the CEC Appliance Database, as accessed on 3/26/2018
- [6] ENERGY STAR Program Requirements for Room A/C, version 4.1, effective October 26, 2015 Weighted by capacity and equipment type based on available products on the CEC Appliance Database, as accessed on 3/26/2018
- [7] ENERGY STAR Most Efficient 2020 Recognition Criteria for Room A/C Weighted by capacity and equipment type based on available products on the CEC Appliance Database, as accessed on 3/26/2018
- [8] Department of Energy, Office of Energy Efficency and Renewable Energy, "Energy Conservation Program, Energy Conserv Residential Clothes Dryers and Room Air Conditioners", 10 CFR Part 430 (Docket: EERE-2007-8T-STD-0010, pg. 22514) ervation Standards for
- [9] Energy Star Room Air Conditioner Savings Calculator
- [10] Incremental costs are sourced from the NEEP Mid-Atlantic TRM (version 9.0, October 2019) which uses hedroiic models and data pulled from "2010-2012 WO017 Ex Ante Neasure Cost Study", Itorn, conducted on behalf of the California Public Utility Commission in 2014. For more information, please see UT TRM document". Theremental Cost Study Throm, conducted on behalf of the California Public Utility Commission in 2014. For more information, please see UT TRM document Tromemental Costs. The California Public Utility Commission in 2014. For more information, please see UT TRM exametric Transmentations. Public Utility Commission in 2014. For more information, please see UT TRM measure "ENERGY STAR Most Efficient Room A(C" and the 'Costs' tab in "ext-energy-star-room-ac analysis-star". The derived incrmental costs were then weighted by capacity and equipment type based on available products on the CEC Appliance Database, as accessed on 3/26/2018. The Early Replacement cost (Ind legitionment cost) on accidiated by basing the cost of a baseline unit as sourced from the ENERGY STAR Room Air Conditioner Savings Calculator and adding the incremental cost of an ENERGY STAR Most Efficient unit.

## **Central Wood Pellet Boilers and Furnaces**

Measure Number:	VII-C-10 c
Portfolio:	EVT TRM Portfolio 2018-02
Status:	Active
Effective Date:	2018/1/1
End Date:	[ None ]
Program:	Existing Homes
End Use:	HVAC

Update Summary Several assumptions have been updated in response to 2017 TAG discussions, revisions made to other measures during FY 2017, and updated cost

- Welce and ViFuel for both residential and commercial buildings, to reflect updated Vermont market assessment reports
   Nesse values for commercial buildings, to reflect the updated Vermont market assessment report for existing buildings and to match the updated Efficient Space Networks the Network State S

### Referenced Documents

- Referenced Documents
  UB 506, "rectinical Support Document for Commercial Packaged Boilers", 2016.
  NEEP\_BNU\_Family Enging TechReasearch, Report, Final
  recr-advanced-wood-pelied-system-eligible-eagpment-inventory-vt/2016
  VT SF basing homes Dnate Report, Final 02153
  VGS Usage Regression Work\_04182017
  2016 Vermott Basines Sector Market Characterization and Assessment Study
  NMR\_Survey Analysis of Owners in Esisting Homes in Vermont, Dec 2016
  EVT\_Commercial EFUL, Analysis, 2017
  EVE, Loptated Buildings Sector Appliance and Equipment Costs and Efficiencies\_Nev 2016
  VT Res Basines SNC Owner prov. OR&FT 05217
  EVT\_Central Wood Pellet Bollers and Furnaces, Analysis, Jan 2018

### Description

re applies to the installation by an approved contractor of a new central wood pellet boiler or furnace rated less than or equal to 340.000 Buy/h (< 100 kW) in new or existing, residential or commercial buildings. For installations in existing buildings or homes, it is assume that the existing space heating system will remain in place and that the new pellet system will satisfy  $90\%^{1/2}$  of the buildings heating load.

Pellet systems must be installed according to manufacturer's recommendations and meet the following minimum efficiency and emissions requir nts 85% peak efficiency based on higher heating value (H±N) at full-load conditions
 <0.08 lb/MMBtu of particulate matter less than 2.5 microns (PM<sub>2.5</sub>)

Baseline Efficiencies The baseline is a blend of UP, oil, wood, and electric heating systems, based on the percentage of each system installed as a primary heating source in existing Vermont buildings for retrofits or in new Vermont buildings for new construction (NC).

### Efficient Equipment

The new equipment must be a new central wood pellet boiler or furnace installed according to manufacturer's recommendations and meeting efficiency and emissions requirements. For existing buildings, the new pellet system is assumed to satisfy 90% of the building's heating load. etina minimum In 2018 and forward, in TEPF-funded programs, EVT will not court the increased wood fuel use associated with biomass fuel switches from fossil fuels. Therefore, beginning in 2018 this measure does not apply a pellet heating penalty, except when the baseline is wood.

## Algorithms

lectric Demand S	avings
$\Delta kW_{Res}$	$= \Delta kWh_{Res}/FLH$
ΔkW <sub>Comm</sub>	$= \Delta kWh_{Comm}/FLH$
Symbol Table	

The electric energy savings from the installation of a new pellet heating system in place of an electric heating system are described below See table below<sup>(5)</sup> for deemed electric energy and demand savings based on customer, building type, and equipment capacity

Customer	Building Type	Equipment Capacity (Btu/hr)	ΔkWh	ΔkW
		25,000 - 80,000	139.8	0.17910
	Existing	>80,000 - 150,000	256.7	0.32889
Residential		>150,000 - 340,000	526.1	0.67406
Residential		25,000 - 80,000	477.7	0.72924
	NC	>80,000 - 150,000	877.1	1.33915
		>150,000 - 340,000	1797.7	2.74460
	Existing	25,000 - 80,000	311.2	0.29307
		>80,000 - 150,000	571.6	0.53818
Commercial		>150,000 - 340,000	1171.4	1.10301
commercial		25,000 - 80,000	2751.0	2.59035
	NC	>80,000 - 150,000	5051.7	4.75682
		>150,000 - 340,000	10353.6	9.74914
$\Delta kWh_{Res}$	= FLH × (Capa	city / 1,000,000) / ŋ <sub>Base, Electric</sub> >	< 293.071 × %Pel	let × %Elec
∆kWh <sub>Comm</sub>	= FLH × (Capa	city / 1,000,000) / ŋ <sub>Base, Electric</sub> /	OF × 293.071 ×	%Pellet × %Elec

Symbol Table

Fossil Fuel Savings The fuel savings from the installation of a new pellet heating system in place of an LP, oil, or wood heating system, the fuel penalities from the installation of a new pellet heating system in place of a wood heating system, and net savings are described below. The fuel savings for each fuel type are summed to create a blended fuel savings value.

See table below<sup>[12]</sup> for deemed fuel savings, penalties, and net savings based on customer, building type, and equipment capacity.

			ΔMMBtu <sub>Save</sub> (total savings before	ΔMMBtu <sub>Net</sub> (total savings after applying
Customer		ΔMMBtu <sub>Save</sub> (by fuel type)	applying pellet penalty)	pellet

			LP	7.665						
		25,000 - 80,000	Oil	28.878		47.550	8.285	5	39.265	
			Wood	11.007						
			LP	14.076	5					
Residential	Existing	>80,000 - 150,000	Oil	53.030		87.318	15.21	14	72.105	
			Wood	20.212	2					
			LP	28.848	3					
		>150,000 - 340,000	Oil	108.68	36	178.960	31.18	31	147.779	
			Wood	41.425	5					
			LP	20.807	7					
		25,000 - 80,000	Oil	2.319		34.467	9.850	D	24.617	
			Wood	11.341	L					
			LP	38.209	9					
Residential	NC	>80,000 - 150,000	Oil	4.259		63.295	18.08	38	45.207	
			Wood	20.827						
			LP	78.310	)					
		>150,000 - 340,000	Oil	8.728		129.723	37.07	71	92.651	
			Wood	42.684						
			LP	33.945						
		25,000 - 80,000	Oil	20.133	3	54.078	0.000	0	54.078	
			Wood	0.000						
			LP	62.336						
Commercial	Existing	>80,000 - 150,000	Oil	36.971	L	99.307	0.000	J	99.307	
			Wood	0.000						
			LP	127.75						
		>150,000 - 340,000	Oil	75.772	2	203.530	0.000	)	203.530	
			Wood	0.000						
			LP	23.728						
		25,000 - 80,000	Oil	0.000		25.256	1.327	7	23.929	
			Wood	1.528						
			LP	43.573						
Commercial	NC	>80,000 - 150,000	Oil	0.000		46.379	2.437	7	43.941	
			Wood	2.806						
			LP	89.302	2					
		>150,000 - 340,000	Oil	0.000		95.053	4.995	5	90.058	
			Wood	5.751						
AMMBRUSSYR, Res, AMMBRUSSYR, Com AMMBRUSSYR, Com AMMBRUSSYR, Com AMMBRUSSYR, Com AMMBRUSSYR, Com AMMBRUSSYR, Com AMMBRUSSYR, Com AMMBRUSSYR, Com AMMBRUSSY,	m m, LP m, OI m, Wood s, Wood	= FLH × (Capacity / 1,000 = ΔMMBblare, Comn, LP + = FLH × (Capacity / 1,000 = FLH × (Capacity / 1,000) = FLH ×	AMMBRusave, Comm 3,000) / OF / flasse, 3,000) / OF / flasse, 3,000) / OF / flasse, 3,000) / OF / flasse, 3,000) /OF / flasse, 80,000) /OF / flasse, 80,000) /OF / flasse, 80,000 / OF / flasse, 1,000 / fla	<sub>1</sub> , <sub>01</sub> + ΔN <sub>1</sub> , <sub>1</sub> , <sub>2</sub> × %6F <sub>1</sub> , <sub>2</sub> × %6F Wood × % %Pellet × % %Pellet × % %Pellet × %	MRBusere, C Pellet × 96Fe Pellet × 96Fe 96Fellet × 96Fi 96Fuelwood t × 96Fuelwood t × 96Fuelwood Residentia	enting systems;	%Ele			
					Commerci		2%		-	
			New Construction	n	Residentia	(8)	17%			
					Commerci		62%			
			L		1					
%Fuel <sub>LP</sub>	-	Percentage of buildings	assumed to use LF	P heating	systems; s	ee table below	for %Fue	I for each bu	ilding, customer,	
		and fuel type.								
			Building Type		Customer 1		uel Type		Fuel	
			Existing	F	Residential	)	Р	17	96	
						C	Dil	63	96	
						٧	Vood	19	%	
				(	Commercial	7) L	Р	62	%	
						C	Dil	36	96	
						V	Vood	09	6	
			New Construction	on F	Residential	)	Р	54	%	
						C	Dil	69	6	
						V	Vood	24	96	
				(	Commercial	9) L	Р	36	%	

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						Oil	0%	
						Wood	2%	
%Fueloii	-	Percentage of	buildings assu	med to use oil he	ating systems; see table	e within %Fuel	LP definition.	
%Fuel <sub>Wood</sub>					heating systems; see ta			
%Pellet				g load provided by				
				gs and 100% for t				
ΔkW <sub>Comm</sub>	-	Gross custome	r annual conn	ected load kW sav	ings for the measure (o	commercial cu:	stomers)	
∆kW <sub>Res</sub>	-	Gross custome	r annual conn	ected load kW sav	ings for the measure (r	esidential cust	omers)	
ΔkWh <sub>Comm</sub>		Gross custome	r annual kWh	savings for the m	easure (commercial cus	tomers)		
ΔkWh <sub>Res</sub>				-	easure (residential cust			
ΔMMBtu <sub>Net, Comm</sub>	-				the measure (commer		) after subtracting the	pellet
ΔMMBtu <sub>Net, Res</sub>	-	1	r annual MMB	tu fuel savings for	the measure (residenti	al customers)	after subtracting the p	ellet
ΔMMBtupenalty, Comm, Wood	-	Gross custome wood space he		tu fuel penalty for	the measure (commerce	tial customers	) for pellet systems dis	placing
∆MMBtu <sub>Penalty</sub> , <sub>Res</sub> , Wood	-	Gross custome wood space he		tu fuel penalty for	the measure (residenti	al customers)	for pellet systems disp	lacing
ΔMMBtu <sub>Save, Comm, LP</sub>	-	Gross custome	r annual MMB	tu fuel savings for	the measure (commer	cial customers	, LP baseline)	
ΔMMBtu <sub>Save, Comm</sub>	-	Gross custome	r annual MMB	tu fuel savings for	the measure (commer	cial customers	, oil baseline)	
OI .								
ΔMMBtuSave, Comm, Wood	1	uross custome	annuai MMB	w ruei savings for	the measure (commer	uai customers	, wood baseline)	
ΔMMBtuSave, Comm	-	Gross custome the pellet pena		tu fuel savings for	the measure (commer	cial customers	, total savings) before	applyin
ΔMMBtu <sub>Save</sub> , Res, LP	-	Gross custome	r annual MMB	tu fuel savings for	the measure (residenti	al customers,	LP baseline)	
ΔMMBtuSave, Res, Oil	-	Gross custome	r annual MMB	tu fuel savings for	the measure (residenti	al customers,	oil baseline)	
ΔMMBtu <sub>Save, Res</sub> ,	-	Gross custome	r annual MMB	tu fuel savings for	the measure (residenti	al customers,	wood baseline)	
Wood ΔMMBtu <sub>Save, Res</sub>		Gross custome	r annual MMR	tu fuel savinns for	the measure (residenti	al customers	total savinos) hefore a	pplving
x novogave, NES	-	pellet penalty	. annaan mirib		ere mousure (residenti			-profiling
η <sub>Pdlet</sub>	-		ew pellet heati	ng system, based	on HHV			
		= 86% <sup>[13]</sup>						
η <sub>Base</sub> , LP		Efficiency of ha	seline LP heat	ting system: see t	able below for ŋBase va	lues based on	building, customer, ar	nd fuel
"Ibble, LP		Building		Customer Ty			η <sub>Base</sub>	
		Existing		Residential <sup>[14</sup>			100%	
					LP		87.1%	
					Oil		84.2%	
					Wood		65%	
				Commercial <sup>[1</sup>	5) Electric		100%	
				Commercial <sup>(1</sup>			100%	
				Commercial <sup>(1</sup>	5) Electric		100%	
		New Co	nstruction	Commercial <sup>[1</sup>	5) Electric LP Oil Wood		100% 88% 84%	
		New Co	nstruction		5) Electric LP Oil Wood		100% 88% 84% 65%	
		New Co	nstruction		5) Electric LP Oil Wood 1 Electric LP Oil		100% 88% 84% 65% 3.7 COP 93.8% 86.3%	
		New Co	nstruction	Residential <sup>116</sup>	5) Electric LP Oil Wood 1 Electric LP Oil Wood		100% 88% 84% 65% 3.7 COP 93.8% 86.3% 75%	
		New Co	nstruction		5) Electric LP Oil Wood 1 Electric LP Oil Wood 7) Electric		100% 88% 84% 65% 3.7 COP 93.8% 86.3% 75% 3.5 COP	
		New Co	nstruction	Residential <sup>116</sup>	5) Electric LP Oil Wood 1 Electric LP Oil Wood		100% 88% 84% 65% 3.7 COP 93.8% 86.3% 75%	
		New Co	nstruction	Residential <sup>116</sup>	Bectric         LP           Oil         Wood           I         Bectric           UP         Oil           UP         Oil           UP         Oil           Wood         Bectric           Viol         Electric           UP         Oil           UP         UP           UP         Oil           UP         UP		100% 88% 84% 65% 3.7 COP 93.8% 86.3% 75% 3.5 COP 81%	
		New Co	nstruction	Residential <sup>116</sup>	S)         Bechric           LP         Oil           Oil         Wood           LP         Oil           UP         Oil           Viol         Bectric           Viol         Oil           Viol         UP           Oil         UP           Oil         Oil		100% 88% 84% 65% 3.7 COP 93.8% 86.3% 75% 3.5 COP 81% 83%	
Plane, Electric	-			Residential <sup>16</sup>	S)         Bechric           LP         Oil           Oil         Wood           LP         Oil           UP         Oil           Viol         Bectric           Viol         Oil           Viol         UP           Oil         UP           Oil         Oil		100% 88% 84% 65% 3.7 COP 93.8% 86.3% 75% 3.5 COP 81% 83%	
Nisse, Electric Tillase, Ol		Efficiency of ba	iseline electric	Residential <sup>15</sup> Commercial <sup>1</sup>	5) Bectric LP Oil Wood I Bectric UP Oil Wood I Vood Oil UP Oil Oil UP Oil UP Oil UP Oil Wood	o definition.	100% 88% 84% 65% 3.7 COP 93.8% 86.3% 75% 3.5 COP 81% 83%	
		Efficiency of ba	seline electric	Residential <sup>16</sup> Commercial <sup>1</sup>	S)         Bectric           LP         Oil           Viod         Bectric           UP         Oil           UP         Oil           Viod         District           Viod         Oil           Viod         Oil           UP         Oil           Viod         Oil           Viod         Oil	, definition.	100% 88% 84% 65% 3.7 COP 93.8% 86.3% 75% 3.5 COP 81% 83%	
ŊBase, OI		Efficiency of ba	seline electric seline oil heat	Residential <sup>16</sup> Commercial <sup>1</sup> heating system; see t weating system; see	S)         Bectric           LP         Oil           Oil         Wood           I         Electric           Oil         Bectric           Vioad         Oil           Vioad         Oil           Vioad         Oil           See table within n <sub>Rese, L</sub> , de definition of the see, Le definition of the see, Le definition of the see table within n <sub>Rese</sub> , Le definition of the see table within n <sub>Rese</sub> , Le definition of the see table within n <sub>Rese</sub> , Le definition of the see table within n <sub>Rese</sub> , Le definition of the see table within n <sub>Rese</sub> , Le definition of the see table within n <sub>Rese</sub> , Le definition of the see table within n <sub>Rese</sub> , Le definition of the see table within n <sub>Rese</sub> , Le definition of the see table within n <sub>Rese</sub> , Le definition of the see table within n <sub>Rese</sub> , Le definition of the see table within n <sub>Rese</sub> , Le definition of the see table within n <sub>Rese</sub> , Le definition of the see table within n <sub>Rese</sub> , Le definition of the see table within n <sub>Rese</sub> , Le definition of the see table with n n <sub>Rese</sub> , Le definition of the see table with n n <sub>Rese</sub> , Le definition of the see table with n n <sub>Rese</sub> , Le definition of the see table with n n <sub>Rese</sub> , Le definition of the see table with n n <sub>Rese</sub> , Le definition of the see table with n <sub>Rese</sub> , Le definition of the see table with n n <sub>Rese</sub> , Le definition of the see table with n n <sub>Rese</sub> , Le definition of the see table with n n <sub>Rese</sub> , Le definition of the see table with n n <sub>Rese</sub> , Le definition of the see table with n n <sub>Rese</sub> , Le definition of the see table with n n <sub>Rese</sub> , Le definition of the see table with n n <sub>Rese</sub> , Le definition of the see table with n n <sub>Rese</sub> , Le definition of the see table with n n <sub>Rese</sub> , Le definition of the see table with n n <sub>Rese</sub> , Le definition of the see table	, definition.	100% 88% 84% 65% 3.7 COP 93.8% 86.3% 75% 3.5 COP 81% 83%	
η <sub>Base</sub> , Oil η <sub>Base</sub> , Wood	-	Efficiency of bz	seline electric seline oil heat seline wood h art Btu/hr to M	Residential <sup>15</sup> Commercial <sup>15</sup> . heating system; see theating system; see the system; see th	S)         Bectric           LP         Oil           Oil         Wood           I         Electric           Oil         Bectric           Vioad         Oil           Vioad         Oil           Vioad         Oil           See table within n <sub>Rese, L</sub> , de definition of the see, Le definition of the see, Le definition of the see table within n <sub>Rese</sub> , Le definition of the see table within n <sub>Rese</sub> , Le definition of the see table within n <sub>Rese</sub> , Le definition of the see table within n <sub>Rese</sub> , Le definition of the see table within n <sub>Rese</sub> , Le definition of the see table within n <sub>Rese</sub> , Le definition of the see table within n <sub>Rese</sub> , Le definition of the see table within n <sub>Rese</sub> , Le definition of the see table within n <sub>Rese</sub> , Le definition of the see table within n <sub>Rese</sub> , Le definition of the see table within n <sub>Rese</sub> , Le definition of the see table within n <sub>Rese</sub> , Le definition of the see table within n <sub>Rese</sub> , Le definition of the see table within n <sub>Rese</sub> , Le definition of the see table with n n <sub>Rese</sub> , Le definition of the see table with n n <sub>Rese</sub> , Le definition of the see table with n n <sub>Rese</sub> , Le definition of the see table with n n <sub>Rese</sub> , Le definition of the see table with n n <sub>Rese</sub> , Le definition of the see table with n <sub>Rese</sub> , Le definition of the see table with n n <sub>Rese</sub> , Le definition of the see table with n n <sub>Rese</sub> , Le definition of the see table with n n <sub>Rese</sub> , Le definition of the see table with n n <sub>Rese</sub> , Le definition of the see table with n n <sub>Rese</sub> , Le definition of the see table with n n <sub>Rese</sub> , Le definition of the see table with n n <sub>Rese</sub> , Le definition of the see table with n n <sub>Rese</sub> , Le definition of the see table with n n <sub>Rese</sub> , Le definition of the see table with n n <sub>Rese</sub> , Le definition of the see table	, definition.	100% 88% 84% 65% 3.7 COP 93.8% 86.3% 75% 3.5 COP 81% 83%	
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5 F	esidential Spa	ice heat	Active	42.9%	57.1%	0.0%	0.0%	25.0%	0.0%		
17 0	ommercial Sp	ace Heat	Active	43.2%	52.3%	1.6%	3.0%	17.9%	0.6%		
Net Sav	ings Fac	tors									
Measures											
SHFBBIOM	Biomass Fuel	Switch									
Tracks [Ba	se Track]										
6012CNIR [	s base track]	C&I Retr	0								
6013PRES [	is base track]	Pres Equ	uip Rpl								
6036RETR	is base track]	Res Retr	ofit								
6014PRES (	is base track]	6014PRE	s								
Track Nam	e Track Nr.	Measure	Code Fi	ree Rider	Spill Over						
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Res Retrofit	6036RETR	SHFBBION	1 0.	.80	1.00						
		SHEBBION		80	1.05						

### Lifetimes

The expected measure life is assumed to be 20 years.<sup>[18]</sup>

### Measure Cost

For existing buildings, the measure cost is the cost of installation (labor and equipment) for a pellet boiler or furnace: \$20,000.<sup>[19]</sup>

For new construction, the measure cost is the incremental full installation cost difference (labor and equipment) between a new LP, oil, wood, or electric heating system and a new, qualifying peliet heating system. See table below for costs related to new construction.

Customer	Measure Cost
Residential <sup>(20)</sup>	\$13,322
Commercial <sup>[21]</sup>	\$11,764

### O&M Cost Adjustments

For existing buildings, the annual O&M cost is the incremental O&M cost difference between LP, oil, wood, or electric heating systems and a blended assumption of 90% pellet heat and 10% LP, oil, wood, or electric resistance heat.

For new construction, the annual O&M cost is the incremental O&M cost difference between LP, oil, wood, or electric heating systems and 100% pellet heat.

Annual O&M costs for pellet boilers and furnaces are assumed to be \$250.<sup>[22]</sup> See table below for O&M cost adjustments, which represent a penalty (increase in costs).

Customer	Building Type	O&M Cost Adjustment
Residential	Existing <sup>[23]</sup>	\$122
	NC[24]	\$141
Commercial	Existing <sup>[25]</sup>	\$159
	NC <sup>[26]</sup>	\$156

### Footnotes

- Energy & Research Solutions, "Emerging Technologies Research Report," (report prepared for the Regional Evaluation, Measurement, and Verification Forum, February 13, 2013): page 9-22.
- [2] Residential FLH for existing homes is a weighted average of FLH for boilers and furnances in existing homes. Boiler and furnance weightings are from NMR Group, VT SF Existing Homes Onsile Report, \* 2013, Table 5-4. FLH values were estimated by following a methodology outline in the Unform Methods Project using natural gas billing data provided by Vermont Gas Systems (VGS) for homes but participated in Efficiency Vermont's Residential how Longen Methods Project using natural gas billing data provided by Vermont Gas Systems (VGS) for homes but participated in Efficiency Vermont's Residential New Construction (RMC) program. Since capacity has not been collected through the Home Performance with DERGY 5TAR program it was not possible to perform the analysis with a more appropriate data set for this program. For Existing Homes, the RNC data was limited to only those homes with annual gas consumption greater than 258/us/sig fit in an attempt to remove the high performance/ low load homes in RNC. See VGS Usage Regression Work, 04182017.vtf for analysis.
- [3] Residential FLH for new construction is a weighted average of FLH for boilers and furnances in new homes. Boiler and furnace weightings from page 47, Table 47, NMR Group, "Vermont Residential New Construction Baseline Study Analysis of On-Site Audits (Darf Report), "Prepared by NMR Group for Vermont DPS, May 12, 2017. Combined applications, wood stores and furnaces, pellet avies, natural gas units, and heat pungs removed. Values for Efficiency Vermont Lead. FLH values were estimated by following a methodology outlined in the Linform Methods Project using natural gas billing data provided by Vermont Cass Systems (VGS) for homes that participated in Efficiency Vermont's Residential New Construction (RNC) program. Since capacity has not been collected through the Home Performance with DERGO'STAR program it was not possible to perform the analysis with a more appropriate data set for this program. See 'VGS Usage Regression Work, OH182017.Js/s for analysis. FLY values were estimated by following a methodology outerined in the Linform Methods Project using natural gas billing data provided by Vermont Sesidential New Construction (RNC) program. Since capacity has not been collected through the Home Performance with DERGO'STAR program is used possible to perform the analysis with a more appropriate data set for this program. See 'VGS Usage Regression Work, OH182017.Js/s for analysis. For Construction (RNC) program. Since capacity has not been collected through the Home Performance with DERGO'STAR program is new to possible to perform the analysis with a more appropriate data set for this program. See 'VGS Usage Regression Work, OH182017.Js/s for analysis.
- [4] Commercial FLH is a weighted average of commercial FLH values from New York Joint Ubilities, "New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs (Version 4)," April 29, 2016 and Vermont building data provided by Cadmus. See file EVT\_Commercial EFLH\_Analysis.ju/v01734s for exclusion dealits.
- [5] For electric energy and demand calculations, see file EVT\_Central Wood Pellet Boilers and Furnaces\_Analysis\_Jan 2018.xlsx.
- [6] Percentage of heating fuel types in existing Vermont homes from NMR Group, "Survey Analysis of Owners of Existing Homes in Vermont (Draft)," December 5, 2016; page 29, Table 38 (Efficiency Vermont data), Natural gas, coal, and solar were excluded. The report states that "all nine respondents who use electricity as their primary heating fuel report that they have electric resistance basebased rather than an electric heat pump." Percentage of cordwood (versus pellets) estimated as 15%. See file EVT\_Central Wood Pellet Bollers and Furnaces, Analysis, Jan 2018.xis
- [7] Percentage of heating system fuel types in existing Vermont commercial buildings based on data from Cadmus, "2016 Vermont Business Sector Market Characterization and Assessment Study," April 30, 2017, page 63, Figure 46 (Efficiency Vermont data). Natural gas, 'uninoum,' and 'other" heating systems were excluded. Percentage of electric resistance heating systems estimated at 1% based on Figure 47. See file EVT\_Central Wood Pellet Boliers and Furnaces\_Analysis\_Jan 2018.xisc.
- [8] Percentage of heating spitam fuel types in new residential buildings in Vermont based on data from NM-R Graug, "Vermont Residential New Construction Baseline Study Analysis of On-Site Audits (Draft Report)," Net 12, 2017; page 45, Table 46 (Efficiency Vermont data), Natural gas and peltes evolutional. See file ST/C-central Visco Pelte Based and Funzaes, Analysis, Jan 2018; Jan.
- [9] Percentage of heating system fuel types in new Vermont commercial buildings based on data from Cadmus, "2016 Vermont Business Sector Market Characterization and Assessment Study," April 30, 2017: page 177, Figure 128 (Efficiency Vermont data). Natural gas and "uninown," heating systems were excluded. The report states that "there" is made up primarily of wood-fired boilers, but according to the raw data provided by Cadmus to Efficiency Vermont, 2 of the systems in the decays are pelled system. These 2 systems were removed from the analysis. See file EVT\_Central Wood Pellet Boilers and Furraces\_Analysis\_an 2018.visx.
- [10] Based on pellet system models available from Renewable Energy Resource Center, "Small Scale Renewable Energy Incentive Program (SSREIP) Advanced Wood Pellet Heating System Eligible Equipment Inventory," June 6, 2016. See EVT\_Central Wood Pellet Bollers and Furnaces\_Analysis\_Jan 2018.vdsx for capacity bin calculations.
- [11] Oversizing factor determined from US Department of Energy, "Technical Support Document: Energy Efficiency Program for Consumer Products and Commercial and Industrial Equipment: Commercial Packaged Bollers," March 4, 2016: pages 7-3 and 7-10. Oversizing Factor = 1.1; 10% larger unit than required "based on hybrical sing practices."
- [12] For fossil fuel savings calculations, see file EVT\_Central Wood Pellet Boilers and Furnaces\_Analysis\_Jan 2018.xlsx
- [13] Weighted average efficiency of qualified models available on Renewable Energy Resource Center, "Small Scale Renewable Energy Incentive Progra

(SSREIP) Advanced Wood Pellet Heating System Eligible Equipment Inventory," June 6, 2016.

- [14] Efficiencies for existing residential LP and oil heating systems are a weighted average based on the percentage of boliers and furnaces used as singli major heating system in existing lvermont homes, from MMR Goog, "Vermont Single-Pamily Existing Homes Cristie Report," February 15, 2013: pages 58-61, Tables 5-9, 58 effic EVT\_CENTW WOOR Peller Boliers and Furnace, Analysia, Jan 2013. Suck, Pellet Systems in existing homes with electric space heating are assumed to replace electric resistance systems with an efficiency of 1.00. Efficiency of existing wood heating systems based on professional judgment.
- [16] Efficiencies for new residential electric, LP, and oil heating systems are based on data from NMR Group, "Vermont Residential New Construction Baseline Study Analysis of On-Site Audits (Daft Report), "May 12, 2012. Boiler, furnance, and heat pump weightings are from page 47, Table 47, and equipment efficiencies are rom pages 49-50, Tables 50-52, NMR Group, "Vermont Residential New Construction Baseline Study Analysis of On-Site Audits (Draft Report),"May 12, 2017. Oil boilers, combined appliances, wood stokes and furnances, pield stokes, natural gas units, and heat pumps were removed from boiler and furnace weighting calculations. Values for Efficiency Vermont used. Riske (DP) is a weighters. See file 2014 devrage based on the percentage of IP boilers and furnaces installed in new Vermont homes. Nakes (oil is the efficiency of a losses. See file Set Tedficancy Central Wood Pellet Boilers and Furnaces\_Analysis\_Jan 2018.dss. Efficiency of new wood heating systems based on professional judgment.
- [17] Efficiencies for new commercial LP and oil heating systems are an average of efficiencies for boilers <300,000 Buyhr and furnaces <225,000 Buyhr. Lowest efficiency available from AHEI debtases, except for oil furnaces <225 MBI and UP boilers <300 MBN, which were adjusted upward to better reflect the efficiencies available with those capacity bins. See reference file AHRI Boiler and Furnace Data.xisx. Efficiency of existing wood heating systems based on professional judgment.
- [18] Pellet boiler and furnace lifetime from Energy & Research Solutions, "Emerging Technologies Research Report," (report prepared for the Regional Evaluation, Measurement, and Verification Forum, February 13, 2013): page 9-20.
- [19] Pellet boller installed cost from Energy & Research Solutions, "Emerging Technologies Research Report," (report prepared for the Regional Evaluation, Neasurement, and Verification Forum, February 13, 2013): page 9-2. Pellet furnace installed costs are assumed to be similar to pellet boller costs.
- [20] The baseline full installation cost for residential NC is based on the percentage of each heating system in new Vermont homes from NMR Group, "Vermont Residential New Construction Baseline Study Analysis of On-Site Audits (DarR Report)," Prepared by MMR Group for Vermont DPS, May 12, 2017; page 47, Table 47 (Efficiency Vermont data). Combined appliances and natural agas and petile systems excelled. Full installation costs for baseline heating systems, except for cordwood furnaces, are the average of typical residential costs for years 2013 and 2020 from U.S. EIA, "Updated Buildings Sector Appliance and Equipment Costs and Efficiencies," November 2016. Cordwood furnaces are assumed to ons the same as petile thrances (Sc2000). See VET-Contral Wood Pattle Bailers and Turnaces, Analysia, and 2018.sks for measure cost calculations.
- [21] The baseline full installation cost for commercial NC is based on data from Cadmus, "2016 Vermont Business Sector Market Characterization and Assessment Study," Any 130, 2017. page 172, Figure 129 (AII" data) and page 181, Figure 131. Bollers are divided between programe (4M9) and wood (14%), and it is assumed that all furnaces are propame-fired. Full installation costs for baseline heating systems, except for cordwood bollers, are the average of bpical residential costs for years 2013 and 2020 from U.S. EU, "Updated Buildings Sector Appliance and Equipment Costs and Efficiencies," November 2016. Cordwood bollers, are assumed to cost the same as pellet bollers (\$20,000), See EVT\_Central Wood Pellet Bollers and Furnaces, Analysis, Jan 2018 Xins for measure cost calculations.
- [22] Pellet furnace and boiler O&M costs are assumed to be approximately the same as O&M costs for pellet stoves from U.S. EIA, "Updated Buildings Sector Appliance and Equipment Costs and Efficiencies," November 2016.
- [23] The baseline Q&M cost for existing homes is based on the percentage of each fuel type in existing Vermont homes. LP and oil systems are divided between boilers and furnaces. It is assumed that all wood heating systems are cordwood stores. Q&M costs for baseline heating systems, except for electric resistance, are from U.S. EX, "Updated Baidings Sector Appliance and Equipment Costs and Efficiencies," November 2016. According to the report, Q&M costs for electric resistance heating systems are negligible; \$10 was assumed in these calculations. See EVT\_Central Wood Peliet Boilers and Furnaces. Analysis\_Jan 2018.xtsx for Q&M cost calculations.
- [24] The baseline OBM cost for residential NC is based on the percentage of each heating system in new Vermont homes from NMR Group, Vermont Residential New Construction Baseline Study Analysis of On-Sila Audits (Crait Report), <sup>2</sup> Prepared by NMR Group for Vermont DFS, Navy 12, 2017: page 47, Table 47 (Efficiency Vermont data), Combined appliances and Instand gas and pellet systems exclude. OMR costs for baseline heating systems, except for condivood furnaces, are from U.S. EIA, <sup>3</sup>Updated Buildings Sector Appliance and Epuipment Costs and Efficiencies,<sup>3</sup> November 2016. Condivood furnaces, are from U.S. EIA, <sup>3</sup>Updated Buildings Sector Appliance and Epuipment Costs and Efficiencies,<sup>4</sup> November 2016. Condivood furnaces, Januare and to be the same as costs for pellet boliers (\$250). See EVT\_Central Wood Pellet Boliers and Furnaces, Analysis, Jan 2018.abs for OdM cost calculators.
- [25] The baseline Q&M cost for existing buildings is based on the percentage of each fuel type in existing Vermont buildings. UP and oil systems are divided between bollers and furnaces. Q&M costs for baseline heating systems, except for cordwood bollers and electric resistance, are from U.S. EIA, "Updated Buildings Sector Appliance and Equipment Costs and Efficiencies," November 2016. According to the report, Q&M costs for electric resistance heating systems are negligible; 310 was assumed in these calculations. See EVT\_Central Wood Pellet Bollers and Furnaces, Analysis, Jan 2018.viscs for Q&M cost calculations.
- [26] The baseline O&M cost for commercial NC is based on data from Cadmus, "2016 Vermont Business Sector Market Characterization and Assessment Study," April 30, 2017: page 178, Figure 129 ("All" data) and page 181, Figure 131. Boilers are divided between propane (44%) and wood (14%), and it is assumed that all furnaces are propane-fired. O&M costs for baseline heating systems, except for convoco boilers, are from U.S. EA, "Updated Buildings Sector Applicate and Equipment Costs and Efficiencies," November 2016. Corvodoro boiler costs are assumed to be the same as costs for pellet boilers (3250). See EVT\_Central Wood Pellet Boilers and Furnaces, Analysis\_Jan 2018.viscs for 0&M cost calculations.

# Air to Water Heat Pump

 Measure Number:
 VTE-C-14 c

 Portfolio:
 EVT TRM Portfolio 2020-06

 Status:
 Active

 Effective Data:
 2020/1/1

 End Date:
 [None]

 Program:
 Existing Homes

 End Use:
 HVAC

Update Summary Expanded the bin allocations for this measure from 2, 3, and 4+ ton bins to 2, 3, 4, 5, and 6 ton bins

- Referenced Documents

   IEEP Incremental Cost Study Report 2011
   VT SP Edisting Home Sonthe Report DRAFT 051217
   VT SP Edisting Homes Onsite Report DRAFT 051217
   Werv Vark Standard Approach for Estimating Energy Savign
   G25 Associates Measure Life Report Jan 2007
   IEEP Incremental Cost Study Mease II, Jan 2013
   Cadmus\_VT Rasiness Sector Market Characterization. Apr 1
   NREL\_Optimizing Hydronic System Performance\_Cdt 2013
   EVT\_Air to Water Heat Pump Analysis\_v11 ergy Efficiency Programs 2016
- on Apr 2017

Lesscription This measure claims savings for the installation of an air to water heat pump. Heating savings are claimed on the home's auxiliary fossil fuel hydronic heating system and accounts for the fossil fuel system providing supplemental heat at low outdoor air temperatures. The electric penalty is the result of the air to water heat pump operating in heating mode, down to 0°F outdoor air temperature, at which point the auxiliary heating system assumes the full heating load.

The heat pump extracts low temperature heat from outside air and transfers it to a fluid steam to be used by a hydronic distribution system. The characterization assumes a standard mode of operation regardless of installation, location, or application – residential or commercial. The installed air to water heat pump is interfaed to supportent the existing fossil fuel heating system and not completely replace it, and the characterization of this measure assumes a midstream program delivery method.

Air to water heat pumps are categorized as low temperature hydronic heating systems and typically operate at a maximum supply water temperature of 120°F. If an air to water heat pump is retrofitted on an existing high temperature hydronic ficsal fuel system, additional emitters are required in order to meet the design load of the building. The minimum qualification criteria for an air to water heat pump is to generate 110°F supply water at an outdoor temperature of 5°F with a COP of 1.7 or greater.

Program Type <u>Calculation Type</u>: Time of Sale (Market Opportunity) and Retrofit Program Delivery / Implementation Type; Midstream

# **Baseline Efficiencies**

Descenting EITICIENCIES For retofic reportement scenarios, the baseline condition is assumed to be the existing fossil fuel hydronic heating system. For market opportunities, baseline condition is assumed to be a code compliant fossil duel hydronic heating system. Sites with natural gas fossil fuel systems are excluded from participation in this measure and as a result, are not included in the characterization. ies, the

Table 1 - Residential Baseline Efficiency

Replacement Scenario	Equipment Fuel Type	Average Boiler Efficiency
	Fuel Oil	83.6%
RET <sup>[1]</sup>	Propane	87.8%
	Wood	65.0%
	Fuel Oil	86.3%
MOP <sup>[2]</sup>	Propane	93.4%
	Wood	75.0%

Table 2 - Commercial Baseline Efficiency

Replacement Scenario	Equipment Fuel Type	Average Boiler Efficiency
	Fuel Oil	85.0%
RET <sup>[3]</sup>	Propane	87.0%
	Wood	65.0%
	Fuel Oil	80.0%
MOP <sup>(4)</sup>	Propane	80.0%
	Wood	75.0%

### Efficient Equipment

The installed heat pump is assumed to meet the efficiency outlined in table 3, which represents the average efficiency of qualifying equipment used in the energy swings algorithm. The values in the following table are a result of weighted averages of available equipment from local distributos binned across Birlighou, Y weither data down to an outdoor air temperature of 0°F, averaged across 10°F, 110°F, and 120°F apply water temperatures. Table 3 - Residential and Commercial Air to Water Heat Pump Efficiency

Equipment	Rating Heating Capacity (Tons)	COP
	2.0	2.75
	2.5	2.76
	3.0	2.78
	3.5	2.90
Air to Mator Hoat Dump	4.0	3.03
Air to Water Heat Pump	4.5	2.87
	5.0	2.71
	5.5	2.80
	6.0	2.89
	Overall Average	2.83

## Algorithms

Electric Demand Savings Given the primary impact is on heating, demand impact is characterized for heating and as a penalty (increase in electric consumption).  $\Delta kW_{Penalty}$  $= \Delta kWh_{Penalty} / EFLH$ Symbol Table

Electric Energy S	avings
$\Delta kWh_{Penalty}$	= kBtuh x (-1/(COP x 3.412)) x EFLH
Symbol Table	

Fossi	Fuel Savings	
ΔMł	MBtu	= (48tuh / 1000) × EFLH × (1/AFUE)
Where	2:	
	$\Delta kW_{\text{Penalty}}$	<ul> <li>Total average winter coincident peak kW increase (deemed assumption for prescriptive)</li> </ul>
	$\Delta kWh_{Penalty}$	<ul> <li>Gross customer electric energy penalty (deemed assumption for prescriptive)</li> </ul>
	ΔMMBtu	<ul> <li>MMBtu savings for each fuel type (deemed assumption for prescriptive)</li> </ul>
	AFUE	<ul> <li>Annual Fuel Utilization Efficiency; the efficiency of the fossil fuel heating system (see tables 1 and 2 for more detail)</li> </ul>
	COP	= Coefficient of Performance for the installed air to water heat pump (see table 3 for more detail)
	EFLH	Equivalent full load heating hours     = 1,626 hours (residential) <sup>[7]</sup> = 1,062 hours (commercial) <sup>[8]</sup>
	kBtuh	<ul> <li>Average rated heating capacity (see table 5 for more detail as the average rated heating capacity varies over the different bin sizes)<sup>(1)</sup></li> <li>= 39.14 kBu/h</li> </ul>

## Table 4 - Boiler Fuel Type Distribution<sup>[5]</sup>

Replacement Scenario	Fuel Type	Residential	Commercial
	Fuel Oil	56.2%	46.8%
RET	Propane	39.6%	53.2%
	Wood	4.2%	0.0%
	Fuel Oil	14.8%	0.0%
MOP	Propane	74.1%	75.9%
	Wood	11.1%	24.1%

## Table 5 - Deemed Energy Savings Summary<sup>[6]</sup>

Sector	Rated Heating Capacity (Tons)	Rated Heating Capacity Range (Tons)	Average Rated Heating Capacity (kBtu/h)	∆kWh	ΔkW	ΔMMBtu_Oil	ΔMMBtu_LP	ΔMMBtu_Wood
	2.0	≥ 2.0 and < 2.5	25,833	-4,473	- 2.7511	17.7	26.1	4.5
	2.5	≥ 2.5 and < 3.0	29,495	-5,083	- 3.1262	20.2	29.8	5.1
	3.0	≥ 3.0 and < 3.5	33,157	-5,693	- 3.5013	22.8	33.5	5.7
	3.5	≥ 3.5 and < 4.0	40,371	-6,595	- 4.0561	27.7	40.8	7.0
Residential	4.0	≥ 4.0 and < 4.5	47,584	-7,497	- 4.6109	32.7	48.1	8.2
	4.5	≥ 4.5 and < 5.0	46,644	-7,770	- 4.7786	32.0	47.2	8.0
	5.0	≥ 5.0 and < 5.5	45,704	-8,042	- 4.9463	31.4	46.2	7.9
	5.5	≥ 5.5 and < 6.0	48,291	-8,216	- 5.0531	33.2	48.8	8.3
	6.0	≥ 6.0	50,877	-8,390	- 5.1599	34.9	51.4	8.8
	2.0	≥ 2.0 and < 2.5	25,833	-2,922	- 2.7511	11.6	32.8	6.8
	2.5	≥ 2.5 and < 3.0	29,495	-3,320	- 3.1262	13.2	37.4	7.7
	3.0	≥ 3.0 and < 3.5	33,157	-3,718	- 3.5013	14.8	42.1	8.7
	3.5	≥ 3.5 and < 4.0	40,371	-4,308	- 4.0561	18.1	51.2	10.6
Commercial	4.0	≥ 4.0 and < 4.5	47,584	-4,897	- 4.6109	21.3	60.3	12.4
	4.5	≥ 4.5 and < 5.0	46,644	-5,075	- 4.7786	20.9	59.2	12.2
	5.0	≥ 5.0 and < 5.5	45,704	-5,253	- 4.9463	20.4	58.0	12.0
	5.5	≥ 5.5 and < 6.0	48,291	-5,366	- 5.0531	21.6	61.2	12.6
	6.0	≥ 6.0	50,877	-5,480	- 5.1599	22.8	64.5	13.3

Load Shapes 5b Residential Space heat 17b Commercial Space Heat

Number	Name	Status	Winter On kWh	Winter Off kWh	Summer On kWh	Summer Off kWh	Winter kW	Summer kW
5	Residential Space heat	Active	42.9%	57.1%	0.0%	0.0%	25.0%	0.0%
17	Commercial Space Heat	Active	43.2%	52.3%	1.6%	3.0%	17.9%	0.6%

## Net Savings Factors

Measures SHFDAWHP Air to water heat pump - Fuel-fired Baseline

 Tracks [Base Track]

 6013/PST [is base track]
 Upstream - Commercial

 6032UPST [6032EPEP]
 Upstream - Residential

 Track Name
 Track Nr. Measure Code
 Free Rider Spill Over

 Upstream - Commercial 6013UPST/SHFDAWHP
 1.00
 1.00

Lifetimes The expected measure life is assumed to be 18 years.<sup>[10]</sup>

Measure Cost The incremental cost is based on the rated heating capacity and replacement scenario, as detailed in table 6 below. For market opportunity replacement scenarios, the incremental cost is based on an average of equipment list prices supplied by local distributors plus an additional \$1,336<sup>111</sup>, which is the estimated cost of low temperature hydronic emitters. If an air to water heat pump is retrofitted on an existing high temperature hydronic fossil fuel system, additional emitters are required in order to meet the design load of the building. The added costs of the emitters is assumed in both the market opportunity and the retrofit scenario. It is included in the market opportunity costs because the baseline assumption is a code compliant high temperature fossil fuel hydronic heating system and the low temperature emitters represent an added cost to facilitate the low temperature requirements of the air to water heat pump.

For retrofit replacement scenarios, the incremental cost assumes an additional installation cost of \$1,315<sup>[12]</sup>.

Table 6 - Incremental Costs

Rated Heating Capacity (Tons)	Retrofit Incremental Costs	Market Opportunity Incremental Costs	Overall Incremental Costs <sup>[6]</sup>
2.0	\$6,404	\$5,089	\$5,746
2.5	\$7,326	\$6,012	\$6,669
3.0	\$8,248	\$6,934	\$7,591
3.5	\$9,224	\$7,909	\$8,566
4.0	\$10,199	\$8,884	\$9,542
4.5	\$11,116	\$9,801	\$10,459
5.0	\$12,033	\$10,718	\$11,376
5.5	\$12,971	\$11,657	\$12,314
6.0	\$13,909	\$12,595	\$13,252

# Reference Tables

Sector	Rated Heating Capacity (Tons)	Item Codes
	2.0	RES-AWHP-2
	2.5	RES-AWHP-2.5
	3.0	RES-AWHP-3
	3.5	RES-AWHP-3.5
Residential	4.0	RES-AWHP-4
	4.5	RES-AWHP-4.5
	5.0	RES-AWHP-5
	5.5	RES-AWHP-5.5
	6.0	RES-AWHP-6
	2.0	COM-AWHP-2
	2.5	COM-AWHP-2.5
	3.0	COM-AWHP-3
	3.5	COM-AWHP-3.5
Commercial	4.0	COM-AWHP-4
	4.5	COM-AWHP-4.5
	5.0	COM-AWHP-5
	5.5	COM-AWHP-5.5
	6.0	COM-AWHP-6

### Footnotes

- [1] Based on the Based on the average findings from the, "Vermont Single-Family Existing Homes Onsite Report, Draft", NMR Group, Inc., December 2017 (page 44). As the efficiency of wood boilers was not detailed in the report, the value is based on professional judgement.
- "Vermont Residential New Construction Baseline Study Analysis of On-Site Audits", MIR Group, Inc., May 12, 2017 (pages 49-50). The efficiency of natural gas and programe bailers was combined and not included separately in the report. In order to incorporate the programe fuel type into the analysis, opted to use the combined efficiency values for observed natural gas and propane bailers. As the efficiency of wood bailers was not detail in the report, the value is based on professional judgement. [2]
- [3] Mean observed efficiency for boilers for existing commercial buildings, as sourced from; "2016 Vermont Business Sector Market Characterization and Assessment Study", Cadmus, April 2017 (page 65). The efficiency of natural gas and propane boilers was combined and not included separately in the report. In order to incorporate the propane lucit type into the analysis, VEC opted to use the combined efficiency values for observed natural gas and propane boilers. As the efficiency of wood boilers was not detailed in the report, the value is based on professional judgement.
- [4] Minimum efficiency requirements for gas- and oil-fired boilers <300,000 Btu/h, as sourced from the 2015 VT Commercial Bi (CBES). As the efficiency of wood boilers is not governed in code compliance, the value is based on professional judgement. ilding Energy Standards
- [5] As the program delivery method for this measure is midstream, the intention is the fuel type of the boiler being off-set will be unknown, and this necissitates a fuel type distribution of boilers being impacted by this measure. The MMBu energy savings are thus split across the different fuel types based on this saturation in the state of Vermont and is dependent on the building stock and sector. Sites utilizing natural gas fuel are excluded from participating in this measure and are removed from consideration in this drancetrization. The deviation for the fuel type distribution and the accompanying sources can be viewed in detail in the "EVT\_Air to Water Heat Pump Analysis\_v11.sds".
- Due to the implementation of this measure through a midstream delivery mechanism, the actual replacement scenario (retrofit vs. ma opportunity) will be unknown. As a result, the energy savings and incremental costs for the two replacement options were aggregated assumption that 50% of installs will be retrofits. [6] Due to the imple
- Residential EFUH is estimated from an 8,760 equivalent full load hours analysis. The analysis assumes the heating system provides heating below 57.5%, cocept in summer months May to August, and estimates savings based on incremental efficiency down to the lower heating limit of 0%. The analysis assumes the heat pump provides heating based on its rated capacity up to the estimate load. [7] Re
- [8] The commercial EFUH is sourced from the New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs, version 4, January 2017 (New York TRM). Hours are based on an average between the city of Massena and Albany; with it being an average between old and new building types and weighted by small commercial buildings.
- (9) The equipment capacity is sourced as a weighted average of available equipment from local manufacturers, rated at varying outdoor air temperatures and supply water temperatures, and birned across Burlington, VT weather data down to an outdoor air temperature of 0°F at specified load conditions. For more information on its derivation, places see: "PUT\_AIR to Water Heat Tum Pankiss," Lutd.xt.". The Inal-the interment capacitity equipment, operating conditions, efficiencies, and energy savings are interpolated based on the whole number-increment equipment.
- The measure life is assumed to be similar to the measure life for an air source heat pump. While boilers and other hydronic heating systems typically have measure lives occeeding 20 years, as a conservative estimate, the measure life for an air source heat pump was sourced from "Measure Life Report, Residential and commercial/hostmatil lighting and HANG Measure", IGR Societaes, June 2007. [10] The me
- [11] "Optimizing Hydronic System Performance in Residential Applications", NREL, October 2013 (page 8). The cost of low temperature hydronic emitters represents a straight average of the three efficiency scenarios incremental costs' that were modeled in the report.
- [12] The installation cost is sourced from estimates of two local manufacturers who compared the installation of air to water heat pumps to that of; (1) multi-head mini-split heat pumps, and (2) low temperature condensing boilers. As a result, the estimated installation cost for these two measure was sourced from NEEP Incremental Cost Studies (\$893 for a boiler and \$1,736 for a multi-head mini-split heat pump) and averaged accordingly

## Brushless Permanent Magnet (BLPM) Circulator Pump

Measure Number:	VII-C-3 d
Portfolio:	EVT TRM Portfolio 2018-06
Status:	Active
Effective Date:	2019/1/1
End Date:	[ None ]
Program:	Existing Homes
End Lice:	HVAC

Update Summary Reliability update: Updated and added a reference to incremental cost, as the existing measure never had a reference, just an estimate from years ago

# Referenced Documents 98 PIP High Perf Circ Pump\_2015 Final 2018-res-blpm-circ-pump-analysis-hdd60

# Description

Description
This measure characterization is for installing fractional horsepower circulator pumps with brushless permanent magnet pump (BLPM) motors. Typical applications induce baseboard and radiant floor heating systems that utilize a primary/secondary loop system in single-family residences. Circulator pumps that use BLPMs are more efficient because they lack brushes that add friction to the motor, as well as the ability to module their speed to match the load. This is possible because the drive senses the difference between the magnetic field of the rotating notar and the rotating magnetic field of the vinding in the motor statur. As the system flow demand changes (zones open or close), the drive senses the tarque difference and adjusts its speed by altering the frequency to the motor. BLPMs are especially efficient in no-load/low-load applications.

The Efficiency Vermont High Performance Circulator Pump (HPCP) Program is a program to promote the installation of efficient brushless permanent magnet motor (BLMM) circulator pumps with integrated variable speed controls in Vermont homes and businesses. The program is offered to HA/C distributors who self/sigh equipment in Vermont, and provides updream financial incertives at the wholesale level for qualifying circulator pumps sold for installation in a commercial facility or residential home in Vermont.

### Baseline Efficiencies

The baseline equipment is a circulator pump using a low-efficiency shaded pole motor. It is assumed that this pump is installed on the primary loop of a multi-loop system, and is running constantly when outside temperatures are 55% or lower during the winter heating season (October – April).

# Efficient Equipment

Inc										
	rithms ic Demand S	avings								
∆kV	1	= ΔkWh	/ HOURS							
Symt	ol Table									
Electr	ic Energy Sa	vings								
ΔkW	ſh	= HOURS	s x ((Watt	s <sub>Base</sub> – Wa	tts <sub>EE</sub> ) / 10	00) x ISR				
Symt	ol Table									
Midlif	Fuel Savings Adjustmen Savings									
Where	:									
	ΔkW	-	Gross cu	stomer cor	nnected loa	ad kW savir	ngs for the	measure	(kW)	
			= 0.0659	98 kW						
	ΔkWh	-	Gross cu	stomer an	nual KWh s	avings for	the measu	re (kWh)		
			= 87.5 k	Wh						
	HOURS	-	1,325[1]							
	ISR	-	In Servic	e Rate, or	the percer	ntage of un	its rebated	that actu	ally get used	
			= 90%[2]							
	Watts <sub>Base</sub>		Baseline	connected	kW					
			= 87.7 V	/atts[3]						
	Watts <sub>EE</sub>	-	Energy e	fficient cor	nnected kW	/				
			= 14.4 V							
	I Shapes idential Space	heat								
Numi	er N	ame	Status			Summer				
						On kWh		kW 25.0%	kW	
5	Residentia	I Space heat	Active	42.9%	57.1%	0.0%	0.0%	25.0%	0.0%	

### MTRCIRCZ BLPM Boiler Circ Motor - Res

Tracks [Base Track] 6032EPEP [is base track] Efficient Products - Residential

### Lifetimes

20 years - typical circulator pumps using shaded pole motors are expected to last around 15 years; circulator pump motors with ECMs typically operate at lower RPMs, thus producing less heat and extending the life of the motor.

### Measure Cost

The estimated in remental cost for this measure is \$127<sup>(4)</sup>.

## O&M Cost Adjustments

There are no O&M cost adjustments associated with this measure.

Persistence The persistence factor is assumed to be 1.

# Footnotes

[1] Efficiency Vermont performed a metering study to better understand run hours of high performance circulator pumps. Analysis can be found in 2018 RES BLPM CIRC PUMP Analysis, HDD60.xlsx.

- [2] In-Service Rate Study performed by Efficiency Vermont and Technical Advisory Group (TAG) 2015 agreement found the annual ISR to be 90%.
- [3] Efficiency Vermont performed a metering study to better understand watt draw. Analysis can be found in 2018 RES BLPM CIRC PUMP Analysis, HDG60.vlsx.

[4] These values are based on an incremental cost per watt of \$8.82. Analysis of baseline pump costs and high efficiency pump costs. Costs are found in Wild's Price Book - Pumps and systems for Building Services and Groundwater. Accessed 4/29/2018. http://www.wilousa.com/lieadmin/us/Price\_append/2016. WildSA\_ListPricing\_BuildingServices\_0216.pdf. Analysis can be found on Incremental Costs tab of 2018blpm-circ pump-analysis-hdd60.xdsx.

## **Residential Efficient Space Heating System**

Measure Number	VII-C-7 b
Portfolio:	EVT TRM Portfolio 2017-07
Status:	Active
Effective Date:	2018/1/1
End Date:	[ None ]
Program:	Existing Homes
End Use:	HVAC

Update Summary This is a reliability update that includes an updated VGS Data Regression Analysis for EFLH calculations, which aligns with the Advanced Thermostat measure. Average capacity of heating systems was updated to show actual data from VGS Data Regression. As costs are directly linked to capacity and efficiencies, the costs were also updated with this reliability update.

### Referenced Documents

- Referenced Documents DOG\_Small\_appends\_e NEPP Residential Roles 2011\_08\_18 NEPP Incremental Cost Study Report 2011 VTST FE bisting Homes Create Report, final 021513 Vursusgare-regission-work-0222017-visis residential-Ineating\_and\_cooling-systems-initiative\_cole EV/T\_RESTERTERT Space Heating\_Swings\_Inalysis\_July 2017 extensionation\_sharing\_ind\_cooling-systems-initiative\_cole EV/T\_RESTERTERT Space Heating\_Swings\_Inalysis\_July 2017 infrances\_prorp\_tsd\_2015-02-13 tuchricial-support-document---residential-holiers\_doe CostsFurmaceSbillers/EV

## Description

Description This measure applies to the installation of primary oil- or propane-fired boiler or furnace heating systems in residential existing homes applications. Fossi fued savings are realized due to the higher ARLE of the qualifying equipment. All systems must be installed per the VT Residential Bulding Energy Standrards and all boiler installations must incorporate high performance Circulator Pumps (electric savings for this will be claimed based on existing measure characterizations).

Intersace clanace landows and the second sec

### **Baseline Efficiencies**

andard efficiency oil- or propane-fired furnace or boiler with an AFUE provided below.

Efficient Equipment The installed oil or propane furnace or boiler must have an AFUE greater than those shown b

Unit Type	AFUE <sub>Base</sub>	AFUE <sub>Eff</sub>
Oil Boiler	85%	87%
LP Boiler	86.7%	95%
Oil Furnace	82.6%	87%
LP Furnace	88%	95%

Algorithms Electric Demand Savings

# Electric Energy Savings The electrical energy and der

and savings associated with high perform ance Circulator Pump is provided in a standalone chara

 Fossil Fuel Savings

 ΔΜΜΒΤU
 = (FLH × (Capacity / 1,000,000) × (1/AFUE<sub>Boxe</sub> - 1 /AFUE<sub>ERN</sub>)

Refer to the table of deemed savings in Measure Savings Summary section below

Midlife Adjustment For the Entry Replacement measure the initial baseline is the existing unit efficiency. A mid life baseline adjustment will be incorporated to account for the hypothetical new baseline replacement at the same AF4Ebase level provided below. It is assumed that this baseline shift will occur after a third of the measure life – so after 5 years for furnaces and 8.3 years for bollers.

Where	:		
	ΔΜΜΒΤΟ	-	Gross customer annual MMBtu fuel savings for the measure.
	1,000,000	-	Conversion from Btuh to MMBtu/hour.
	AFUE <sub>Base</sub>	-	Efficiency of baseline equipment in AFUE <sup>[1]</sup> .
			Refer to table above in Efficient Equipment section.
	AFUE <sub>Eff</sub>	-	Efficiency of new equipment in AFUE <sup>[2]</sup> .
			Refer to table above in Efficient Equipment section.
	Capacity	-	capacity of equipment to be installed $(\ensuremath{Btuh})^{(3)}$
			Unit Type Capacity (Btuh)
			Boiler 97,754
			Furnace 78,379
	FLH	-	Estimated average full load heating hours.
			= 714 for boilers and 922 for $furnaces^{[4]}$
Load N/A	i Shapes		

	Replace boiler, fuel	l oil		
SHRBPROP	Replace boiler, pro			
	Replace furnace, fu			
	Replace furnace, p			
racks [Bas				
5036RETR [is	s base track] Res	Retrofit		
	Track Nr. Measu 6036RETR SHRBFC			
	6036RETR SHRBPR		1.00	
Res Retrofit	6036RETR SHRFFC	DIL 1.00	1.00	
Res Retrofit	6036RETR SHRFPR	ROP 1.00	1.00	
ifetimes				
	F Type Measure	Lifetime <sup>[5]</sup>		
Furnaces	15			
Boilers				
builet s	23			
<b>leasure</b> he incremen		fficient equipme	nt are detailed below	<u>ه.</u>
			Incremental Cos	
Oil Boiler	\$4,316	\$4,642	\$326	
LP Boiler	\$4,894	\$6,843	\$1,948	
Oil Furnace	\$2,906	\$3,574	\$668	
LP Furnace	\$2,594	\$3,341	\$747	
D&M Cos I&M cost esti	t Adjustmer mates for baseline	<b>1ts</b> and efficient bo	ilers and furnaces are	cost in the midlife adjustment.
<b>D&amp;M Cos</b> &M cost esti Unit Type	<b>t Adjustmer</b> mates for baseline Baseline Annual O8	<b>1ts</b> and efficient bo	ilers and furnaces an ent Annual O&M Cost	
D&M Cos MRM cost esti Unit Type Boilers	t Adjustmer mates for baseline Baseline Annual O8 \$89.55	and efficient bo	illers and furnaces an ent Annual O&M Cost 15	
D&M Cos MRM cost esti Unit Type Boilers	t Adjustmer mates for baseline Baseline Annual O8 \$89.55	nts and efficient bo kM Cost Efficie \$92.5	illers and furnaces an ent Annual O&M Cost 15	
D&M Cos Mar cost esti Unit Type Boilers Furnaces	t Adjustmer mates for baseline Baseline Annual OB \$89.55 \$39.55	nts and efficient bo kM Cost Efficie \$92.5	illers and furnaces an ent Annual O&M Cost 15	
D&M Cost D&M cost esti Unit Type Boilers Furnaces Persister	t Adjustmer mates for baseline Baseline Annual OB \$89.55 \$39.55	nts and efficient bo &M Cost Efficient \$92.5 \$40.0	illers and furnaces an ent Annual O&M Cost 15	
D&M Cos B&M cost esti Unit Type Boilers Furnaces Persister he persisten	t Adjustmer mates for baseline Baseline Annual O8 \$89.55 \$39.55 ce factor is assume	nts and efficient book and costs efficient book and costs efficient book and costs efficient book and costs and cost	illers and furnaces an ent Annual O&M Cost 15	
D&M Cos RM cost esti Unit Type Boilers Furnaces Persister he persisten Measure	ct Adjustmer mates for baseline Baseline Annual OB 889.55 339.55 cee ce factor is assume Savings Sur	nts and efficient book and costs efficient book and costs efficient book and costs efficient book and costs and cost	illers and furnaces an ent Annual O&M Cost 15	
D&M Cos BRM cost esti Unit Type Boilers Furnaces Persisten he persisten Measure Unit Type	t Adjustmer mates for baseline mates for baseline Baseline Annual OB 489.55 539.55 539.55 cce ce factor is assume Savings Sur AMIBTU	nts and efficient book and costs efficient book and costs efficient book and costs efficient book and costs and cost	illers and furnaces an ent Annual O&M Cost 15	
D&M Cos &M cost esti Unit Type Boilers Furnaces Persister he persisten Unit Type Unit Type Oil Boiler	th Adjustmer mates for baseline Baseline Annual OB 589.55 \$39.55 tce ce factor is assume Savings Sur 1.9	nts and efficient book and costs efficient book and costs efficient book and costs efficient book and costs and cost	illers and furnaces an ent Annual O&M Cost 15	
D&M Cos Bollers Bollers Furnaces Persister he persisten Unit Type Oil Boller LP Boller	Adjustmer mates for baseline Baseline Annual OB 489.55 Advertise 439.55 Advertise Advertise Advertise 1.9 7.0	nts and efficient book and costs efficient book and costs efficient book and costs efficient book and costs and cost	illers and furnaces an ent Annual O&M Cost 15	
D&M Cos Boilers Furnaces Furnaces Persister Measure Unit Type Oil Boiler LP Boiler Oil Furnace	th Adjustment mates for baseline Baseline Annual OB 489.55 439.55 Ce factor is assume Ce factor is assume AMMBTU 1.9 7.0 4.4	nts and efficient book and costs efficient book and costs efficient book and costs efficient book and costs and cost	illers and furnaces an ent Annual O&M Cost 15	
D&M Cos Boilers Furnaces Furnaces Persister Measure Unit Type Oil Boiler LP Boiler Oil Furnace	Adjustmer mates for baseline Baseline Annual OB 489.55 Advertise 439.55 Advertise Advertise Advertise 1.9 7.0	nts and efficient book and costs efficient book and costs efficient book and costs efficient book and costs and cost	illers and furnaces an ent Annual O&M Cost 15	
D&M Cost est MM cost est Bollers Furnaces Persister Unit Type Unit Type OII Boller DI Boller DI Boller DI Poller	Adjustmer mates for baseline Baseline Annual OB 889.55 \$39.55 \$39.55 CCE Carbon is assumed AdMIBTU 1.9 7.0 6.1	nts and efficient book and costs efficient book and costs efficient book and costs efficient book and costs and cost	illers and furnaces an ent Annual O&M Cost 15	
D&M Cos MM cost est MM cost est Bollers Furnaces Persisten Heasure Unit Type OII Boler DI Boler OII Furnace	A Adjustmer mates for baseline mates for baseline Baseline Annual OB 889.55 339.55 339.55 CCE CE factor is assume AMMBTU 1.9 7.0 4.4 6.1	nts and efficient bo \$92.5 \$40.0 ad to be one.	illers and furnaces an ent Annual 08M Cost 15 16	
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D&M Cos A&M cost est bollers Furnaces Furnaces Furnaces Cost Cost Diffuence	Adjustmer mates for baseline Baseline Annual OB 889.55 CCE Case factor is assume AMMBTU 1.9 7.0 4.4 6.1	AM Cost Efficient bo AM Cost Efficient \$92.5 \$40.0 ad to be one. THE AMERICAN AND AND AND AND AND AND AND AND AND A	R Group Inc "Vermon ndard but represent a I on consideration of a	: provided below <sup>(7)</sup>
D&M Cos BM cost est M cost est Bollers Furnaces Persisten Unit Type Unit Type Unit Type OI Poller OI Poller OI Poller DI Prunace P Poller OI Prunace	th Adjustmer mates for baseline Baseline Annual OB 589.55 539.55 CCE Carlotor is assume AMMBTU 1.9 7.0 4.4 6.1 6.1 the average finding by above the Feder and or the Feder and or the feder	AM Cost Efficient bo AM Cost Efficient \$92.5 \$40.0 ed to be one. Immary ps from p60, NM al Minimum Statu developed based ers and furnaces	R Group Inc "Vermon ndard but represent a I on consideration of a	: provided below <sup>(7)</sup> :: Single-Family Existing Homes Onsite Report. Final 2/15/2013*. Note these are nestimate of what people are purchasing without Efficiency Vermont intervention. valiability of product, incremental cost etc and with input from EEN representatives. Regression work. See Cells AP11 and AP12 in vgs-usage-regression-work-
Alexandree Construction	Adjustmer mates for baseline Baseline Annual OB 889.55 439.55	AM Cost Efficient bo AM Cost Efficient \$40.0 ad to be one. The second secon	R Group Inc "Vermon ndard but represent a t on consideration of i e found in VGS Usage used for prescriptive ad in the Uniform Met and the VGS Usage used for prescriptive ad in the Uniform Met and's Residential Net ram (K was not possi- ti an analy as consu	Provided below <sup>(7)</sup> Single-Family Existing Homes Onsite Report. Final 2/15/2013*. Note these are n estimate of what people are purchasing without Efficiency Vermont intervention. Nealability of product, incremental cost etc and with input from EEN representatives. Regression work. See Cells AP11 and AP12 in vgs-usage-regression-work- savings purposes Tods Project using natural gas billing data provided by Vermont Gas Systems (VGS) Construction (RKD) program. Since capacity has not been collected through the to perform the analysis with a more appropriate data set for this program. The top on greater than 28 KBu/SF in an alterative to remove the high performance/ low
DBAM Cost ests MeM cost ests Bollers Furnaces Persister Measure Unit Type OII Boller Unit Type OII Boller DI Boller DI Boller DI Furnace DI Furnace DI Furnace DI Furnace DI Furnace DI Furnace DI Furnace DI Furnace	the Adjustmer mates for baseline asseline Annual OB 489.55 (CC) CC) CC) CC) CC) CC) CC) CC) CC) CC	AM Cost Efficient bo AM Cost Efficient \$92.5 \$40.0 ad to be one. THIMALE ad to be one. THIMALE ad to be one. THIMALE ad to be one. THIMALE ad to be one. THIMALE add to be one. THIMALE	R Group Inc "Vermon ndard but represent a sum of the second second a sum of the second second second a sum of the second	Provided below <sup>(7)</sup> Single-Family Existing Homes Onsite Report. Final 2/15/2013*. Note these are nestimate of what people are purchasing without Efficiency Vermont intervention. Wallability of product, incremental cost et and with input from EEN representatives. Regression work. See Cells AP11 and AP12 in vgs-usage-regression-work- savings purposes to Sproject using natural gas billing data provided by Vermont Cas Systems (VGS) V Construction (INK2) program. Since capacity has not been collected through the te porform the analysis with a more paropriate data set for this program. The priori greater than 25 kBu/SF in an attempt to remove the high performance/ low toc' for greater explanation and Cells AM11 and AM12 on EFL Filtered tab 'vgs-
DBAM Cost ests MeM cost ests Bollers Furnaces Persister He persisten Unit Type OII Boller Unit Type OII Boller DI Furnace DI Furnace	t Adjustmer mates for baseline Baseline Annual OB 889.55 CCE CE factor is assume AMMBTU 1.9 7.0 4.4 6.1 7.0 6.1 7.0 7.0 6.1 7.0 7.0 6.1 7.0 7.0 6.1 7.0 7.0 6.1 7.0 7.0 6.1 7.0 7.0 6.1 7.0 7.0 6.1 7.0 7.0 6.1 7.0 7.0 6.1 7.0 7.0 6.1 7.0 7.0 6.1 7.0 7.0 6.1 7.0 7.0 6.1 7.0 7.0 6.1 7.0 7.0 6.1 7.0 7.0 7.0 6.1 7.0 7.0 7.0 7.0 7.0 7.0 7.0 7.0 7.0 7.0	And efficient bo and efficient bo set of the set of the set of the set of the set of the set of the ad to be one. The set of the set	R Group Inc "Vermon ndard but represent a source for the source of the s	Provided below <sup>(7)</sup> Single-Family Disting Homes Onsile Report. Final 2/15/2013*. Note these are n estimate of what people are purchasing without Efficiency Vermont intervention. Nealability of product, incremental cost etc and with input from EEN representatives. Regression work. See Cells AP11 and AP12 in vgs-usage-regression-work- savings purposes Tods Project using natural gas biling data provided by Vermont Cas Systems (VGS) Construction (RKD) program. Since apachy has not been collected through the to perform the analysis with a more appropriate data set for this program. The top on greater than 28 KBu/SF in an attempt to remove the high performance/ low

[7] OBM Costs originate from 2015 DDE Technical Support documents for residential furnances and bollers: furnances, nogr. Isd. 2015-02-13.pdf and technical-support-document—residential-bollers\_doe.pdf. Please find the trend analysis on the OBM Costs sheet of the analysis document: CostsFurnacesbollersHeW Jack.

## Pellet & Wood Stoves

 Measure Number:
 VIII-6-15

 Portfolio:
 EVT TRM Portfolio 2018-08

 Status:
 Active

 Effective Data:
 2018/1/1

 End Date:
 [None]

 Program:
 Existing Homes

 End Use:
 HVAC

### Update Summary

## Referenced Documents

- Referenced Documents VT SF Existing Homes Onatle Report, final 021513 VGS Usage Regression Work, 04182017 NRR, Sauvey Analysis of Owners in Existing Homes in Vermont, Dec 2016 VT Res Saelier SFNC Onsite report DRAFT 051217 EA, Updated Bidg Sector Appliance & Explanment Costs\_June 2018 VT Detp of Finites Residential Fuel Assessment Report, Mar 2016 VT Detp of Finite Service, Neverther 2016 Fuel Proc Report UT Detp of Hulli Service, Neverther 2016 Fuel Proc Report EVT\_Pellet Wood Stoves, Analysis, Aug 2018\_v2

## Description

Desc. puton This is a refront measure that applies to the installation by an approved contractor of a new wood or pellet stove in a new or existing residential build it is assumed that the home will use a second space heating system in addition to the stove and that the stove will offset a portion of the existing heat system's fuel consumption.

- Stoves must be installed according to manufacturer's recommendations and meet the following minimum efficiency and emissions require
- 70% efficiency
   ≤2.0 of particulate matter less than 2.5 microns (PM<sub>2.5</sub>)<sup>[1]</sup>

This measure provides separate assumptions for replacement of existing wood stoves that are still operational. Existing stoves must be non-EPA certified or if EPA-certified, manufactured prior to 1998 and not meeting 2020 New Source Performance Standards.

### **Baseline Efficiencies**

For customers who are not replacing an existing wood stove, the baseline is a blend of LP, oil, wood, pellet, and electric heating systems, based on the percentage of each system installed as a primary heating source in existing Vermont homes for retrofits or in new Vermont homes for new construction (NC).

For customers replacing an existing wood stove, the baseline is an existing wood stove that is still operational. Existing stoves must be non-EPA ce or if EPA-certified, manufactured prior to 1998 and not meeting 2020 New Source Performance Standards.

### Efficient Equipment

ent must be a new wood or pellet stove installed according to manufacturer's recommendations and meeting minimum efficiency and The new equipment mu emissions requirements

In 2018 and forward, in TEPF-funded programs, EVT will not count the increased wood fuel use associated with biomass fuel switches from fossil fu Therefore, this measure does not apply a biomass heating penalty, except when the baseline is wood or pellets.

## Algorithms

New pellet or wood stove, not replacing existing wood stove: $\Delta kW$	$= \Delta kWh_{Net} / FLH_{Central}$
Replacing existing wood stove with new pellet stove: ΔkW	= $\Delta kWh_{Net}$ / FLH <sub>Stove</sub>

## Symbol Table

Electric Energy Savings The electric and demand savings from the use of a new pellet or wood stove in place of an existing electric central heating system and the electric and demand penalties from the use of a new pellet stove are electriced below.

### For customers that are not replacing existing wood stoves:

Measure Code	Item Code	Building Type	New Stove Type	∆kWh <sub>Save</sub>	∆kWh <sub>Penalty</sub>	∆kWh <sub>Net</sub>	ΔkW
SHFHWOOD	RES-STOVE-W-EH1	Existing	Wood	190.5	N/A	190.5	0.24423
SHFHWODP	RES-STOVE-P-EH1		Pellet	187.5	-175.0	12.5	0.01603
SHFHWOOD	RES-STOVE-W-NC1	NC	Wood	486.6	N/A	486.6	0.74290
SHFHWODP	RES-STOVE-P-NC1		Pellet	479.1	-175.0	304.1	0.46427

### For customers that are replacing existing wood stoves:

leasure Code	Item Code	Building Type	New Stove T	ype	∆kWh <sub>Save</sub>	∆kWh <sub>Penalty</sub>	ΔkWh <sub>Net</sub>	ΔkW
HRHWOOD	RES-STOVE-W-ER2	Existing	Wood		N/A	0.0	0.0	0.00000
HRHWODP	RES-STOVE-P-ER2	Existing	Pellet		N/A	-175.0	-175.0	-0.1250
New pellet stove,	not replacing existing wo	ood stove:	$\Delta kWh_{Net}$	= ∆kWh	<sub>Save</sub> - ΔkWh <sub>Pen</sub>	sity		
New wood stove,	not replacing existing wo	ood stove:	$\Delta kWh_{\text{Net}}$	= ∆kWh	Save			
Replacing existing	wood stove with new st	ove:	$\Delta kWh_{Net}$	= ∆kWh	Penalty			
∆kWh <sub>Save</sub>				= FLH <sub>Ce</sub> %stove		/ / 1,000,000) / r	Base, Electric ×	293.071 ×
∆kWh <sub>Penalty</sub>				= FLH <sub>Sto</sub>	ve × (Watts <sub>Stov</sub>	re / 1,000)		

SHFHWOOD

RES-STOVE-W-EH1

Fossil Fuel Savings The fuel savings from the use of a new pellet or wood stove in place of an LP, oil, wood, or pellet heating system or an existing wood stove, the fuel penalities from the use of a new pellet or wood stove, and net savings for each baseline fuel type are described below.

Baseline System Type

Oil

Wood

∆MMBtu<sub>Save</sub> (by fuel type

40.192

4.071

0.000

N/A

N/A

3.528

N/A

AMMBtur (total savings after applying penalty)

40.192

0.543

0.000

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For customers that are not replacing existing wood sto

Wood

			Existing			LP		10.495		N/A		10.495
SHFHWODP	RES-S EH1	TOVE-P-		Pellet		Oil		39.574		N/A		39.574
	641					Woo	-	4.008		N/A	10	4.008
					_	Pelle	ic.	0.000		3.42	8	-3.428 21.264
	0.00	TON				Oil		21.264		N/A		21.264
SHFHWOOD	RES-S W-NC			Wood		Woo	d	2.357	_	N/A 15.6	90	-4.095
						Pelle		4.042		15.0 N/A		4.042
			NC			LP	-	20.937		N/A		20.937
	RES-S	TOVE-P-				Oil		2.321		, N/A		2.321
SHFHWODP	NC1	IOVL-P-		Pellet		Woo	d	11.416		, N/A		11.416
						Pelle	t	3.979		15.2	46	-11.267
or customers th												
ajustment snou ustomer would i				AMMBtusav for the			re or the exi	sang wor	ΔMMBtu for the remainin	J <sub>Net</sub>	ΔMMBtu <sub>Net</sub>	sumed that the
Measure Code	Item Code	Building Type	New Stove Fuel Type	remaining life of the existing stove (first 10 years)	for the remain measu (next a years)	ning Ire life B	ΔMMBtu	Penalty	life of th existing stove (first 10 years)		for the remaining measure life (next 8 years)	Mid-Life Adjustment (applied after first 10 years)
SHRHWOOD	RES- STOVE- W-ER2	Existing	Wood	89.273	63.592		61.896		27.377		1.696	6.2%
	RES- STOVE- P-ER2		Pellet				60.142		29.131		3.450	11.8%
∆MMBtu <sub>Net</sub>							= \Delta MMBtus	<sub>Save</sub> - ΔΜ	MBtupenalt	y		
LP savings, no	it replacing	existing wo	od stove:	ΔММЕ	RUSave, LP		= FLH <sub>Centra</sub> el <sub>LP</sub>	al × (Capa	acity / 1,0	00,00	0) /n <sub>Base, LP</sub> × 9	%stove × %Fu
Oil savings, no	ot replacing	existing wo	ood stove:	ΔMMB	tu <sub>Save, Ol</sub>		= FLH <sub>Centra</sub> el <sub>OI</sub>	<sub>al</sub> × (Capi	acity / 1,0	00,00	0) /n <sub>Base, Oll</sub> × 9	%stove × %Fu
Wood savings,	, not replac	ing existing	wood stove:	ΔМ	1Btu <sub>Save, Wo</sub>	od	= FLH <sub>Centra</sub> Fuel <sub>Wood</sub>	al × (Capa	acity / 1,0	00,00	D) /n <sub>Base, Wood</sub> :	× %stove × %
Pellet savings,	not replac	ing existing	wood stove:	ΔММ	tusave, Pellet		= FLH <sub>Centra</sub> uel <sub>Pellet</sub>	₂I × (Capa	acity / 1,0	00,00	0) /n <sub>Base, Pellet</sub> ×	: %stove × %F
Penalty, not re	eplacing exi	sting wood	stowe.									
renardy, not re			JUTC.	ДММВ	tu <sub>Penalty</sub>		= FLH <sub>Centra</sub> Fuel <sub>Wood</sub> 4			00,00	0) /n <sub>New Stove</sub> ×	: %stove × (%
Savings, repla	icing existin	g wood sto	ve (first 10 ye	ars):	∆MMBtu <sub>Sav</sub>		Fuel <sub>Wood</sub> +	⊦%Fuel <sub>Pi</sub> al × (Capi	slet) acity / 1,0	00,00	0 ) /n <sub>Existing</sub> Stov	re × %stove
	icing existin	g wood sto	ve (first 10 ye	ars):			Fuel <sub>Wood</sub> +	⊦%Fuel <sub>Pi</sub> al × (Capi	slet) acity / 1,0	00,00		re × %stove
Savings, repla	icing existin	g wood sto g wood sto	ve (first 10 ye ve (next 8 yea	ears): ars):	∆MMBtu <sub>Sav</sub>		Fuelwood + = FLHCentra = FLHCentra	⊦%Fuel <sub>Pi</sub> al × (Capa al × (Capa	acity / 1,0 acity / 1,0	00,00	0 ) /n <sub>Existing</sub> Stov	re × %stove re × %stove
Savings, repla Savings, repla Penalty, replac	icing existin	g wood sto g wood sto	ve (first 10 ye ve (next 8 yea	ears): ars):	ΔMMBtu <sub>Sav</sub> ΔMMBtu <sub>Sa</sub>		Fuelwood + = FLHCentra = FLHCentra	⊦%Fuel <sub>Pi</sub> al × (Capa al × (Capa	acity / 1,0 acity / 1,0	00,00	0 ) /NExisting Stov 0 ) /NBaseline Stov	re × %stove re × %stove
Savings, repla Savings, repla Penalty, replac	icing existin	g wood sto g wood sto	ve (first 10 ye ve (next 8 yea ve:	ars): ars): ΔMI	ΔΜΜΒίυ <sub>Sav</sub> ΔΜΜΒίυ <sub>Sa</sub>	ve (	Fuelwood 4 = FLHCentra = FLHCentra	+ %Fuel <sub>Pi</sub> al × (Capi al × (Capi al × (Capi	slet) acity / 1,00 acity / 1,00	00,00	0 ) /NExisting Stov 0 ) /NBaseline Stov	re × %stove re × %stove
Savings, repla Savings, repla Penalty, replac	icing existin	g wood sto g wood sto g wood stov	ve (first 10 ye ve (next 8 yea ve:	ars): ars): ΔMI mes assumed	ΔΜΜΒίυ <sub>Sav</sub> ΔΜΜΒίυ <sub>Sa</sub> 18ίυ <sub>Penalty</sub>	ve (	Fuelwood 4 = FLHCentra = FLHCentra	+ %Fuel <sub>Pi</sub> al × (Capi al × (Capi al × (Capi	slet) acity / 1,00 acity / 1,00	00,00	0 ) /NExisting Stov 0 ) /NBaseline Stov	re × %stove re × %stove
Savings, repla Savings, repla Penalty, replac	icing existin	g wood sto g wood sto g wood stou = Perc	ve (first 10 ye ve (next 8 yea ve: centage of hor <b>ilding Type</b>	iars): ΔMI mes assumed	ΔΜΜΒίυ <sub>Sav</sub> ΔΜΜΒίυ <sub>Sa</sub> <sup>4</sup> Βίυ <sub>Penalby</sub> to have elect	ve (	Fuelwood 4 = FLHCentra = FLHCentra	+ %Fuel <sub>Pi</sub> al × (Capi al × (Capi al × (Capi	slet) acity / 1,00 acity / 1,00	00,00	0 ) /NExisting Stov 0 ) /NBaseline Stov	re × %stove re × %stove
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	ΔMMBtu <sub>Save</sub> , LP	-	Gross customer and	nual MN	1Btu fuel savings	for the measure (LF	baseline)		
	ΔMMBtu <sub>Save</sub> , oi = Gross customer annual MMBtu fuel savings for the measure (oil baseline)								
	ΔMMBtu <sub>Save</sub> , Pellet	-	Gross customer an	nual MN	1Btu fuel savings	for the measure (pe	ellet baseline)		
	ΔMMBtu <sub>Save</sub> , Wood	-	Gross customer an	nual MN	1Btu fuel savings	for the measure (w	ood baseline)		
	ΔMMBtu <sub>Save</sub>	-	Gross customer an	nual MN	1Btu fuel savings	for the measure (ca	lculated separately fo	each baseline fuel type)	
	1,000,000		Factor to convert B						
	293.071		Factor to convert M						
						an and a second state of the state of the			
	Capacity	-	Average capacity o Building Type Existing NC	Existing 91,562					
	FLH <sub>Central</sub>	-	Average full load h	eating h	ours of central s	pace heating system	ns in Vermont homes		
			Building Type	FLH	1	1			
			Existing	780					
			NC	655		]			
	FLH <sub>Stove</sub>	-	Average full load he = 1,400 <sup>[3]</sup>	eating h	ours of stoves				
	NBase, Pellet	-	Efficiency of baselir	ne pelle	t heating system	; see table within n <sub>B</sub>	ase. Wood definition		
	NBase, Electric		Efficiency of baselir	ne elect	ric heating syste	m: see table within r	News wood definition		
	NBase, LP					ee table within η <sub>Base</sub> ,			
	RBase, Oil	-				ee table within η <sub>Base</sub> ,			
	NBase, Wood	-		ne wood				on building type and fuel type	
			Building Type Existing <sup>(9)</sup>		Fuel Type Electric		n <sub>Base</sub>		
			2xisung(**)		LP		0.871		
					Oil		0.842		
					Wood		0.65		
			New Construction	[10]	Electric		3.7		
					LP		0.938		
					Oil		0.863		
					Wood		0.75		
					Pellet		0.76		
	Reaseline Stove	1	stove (10 years)	ne stove	that it is assum	ed a customer would	d install after the rema	ining life of the existing wood	
			= 0.73 <sup>[11]</sup>						
			Efficiency of existing wood stove that is being replaced						
	RExisting Stove		Efficiency of existin = 0.52 <sup>[12]</sup>	g wood	stove that is bei	ng replaced			
	NExisting Stove				stove that is bei	ng replaced			
		-	= 0.52 <sup>[12]</sup> Efficiency of new st	ove <sup>[13]</sup>	_	ng replaced			
			= 0.52 <sup>[12]</sup> Efficiency of new st New Stove Type	OVE <sup>[13]</sup>	_	ng replaced			
			= 0.52 <sup>[12]</sup> Efficiency of new st	ove <sup>[13]</sup>	_	ng replaced			
	New Store		= 0.52 <sup>[12]</sup> Efficiency of new st New Stove Type Wood Pellet	0.75 0.76	Stove	ng replaced			
		-	= 0.52 <sup>[12]</sup> Efficiency of new st New Stove Type Wood Pellet Energy consumption	0.75 0.76	Stove s) of new stove	ng replaced			
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	New Store	•	= 0.52 <sup>[12]</sup> Efficiency of new ste New Stove Type Wood Pellet Energy consumption New Stove Type	0.75 0.76 n (watte	Stove s) of new stove Wattsstove	ng replaced			
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1.02	Pitew Stove	•	= 0.52 <sup>[12]</sup> Efficiency of new ste New Stove Type Wood Pellet Energy consumptio New Stove Type Wood	0.75 0.76 n (watte	s) of new stove Wattsstove 0	ng replaced			
	New Store	•	= 0.52 <sup>[12]</sup> Efficiency of new ste New Stove Type Wood Pellet Energy consumptio New Stove Type Wood	0.75 0.76 n (watte	s) of new stove Wattsstove 0				
	Piew Stove WattSsteve d Shapes sidential Space heat	•	= 0.52 <sup>[12]</sup> Efficiency of new st New Stove Type Wood Pellet Energy consumption New Stove Type Wood Pellet	0.000 (13) 0.75 0.76 0.76	Stove s) of new stove Wattsgave 0 125 <sup>(1)</sup>				
5b Re	Preev Stove WattSstove dShapes sidential Space heat ber Name	•	= 0.52 <sup>[12]</sup> Efficiency of new st New Stove Type Wood Pellet Energy consumptio New Stove Type Wood Pellet	Vinto Off Ku	slove s) of new stove Wattsstove 0 125 <sup>(8)</sup> er Summer S vh on kWh of	ummer Wieter S	kW		
5b Re	Preev Stove WattSstove dShapes sidential Space heat ber Name	•	= 0.52 <sup>[2]</sup> Efficiency of new st  Type Wood Pellet Energy consumption New Stove Type Wood Pellet Status Winter On KWh	Vinto Off Ku	slove s) of new stove Wattsstove 0 125 <sup>(8)</sup> er Summer S vh on kWh of	ummer Wieter S	kW		
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Sb Rei Nurr 5 SHFF SHRU 5HFU SHFU 5HRU 7Trac 6034 6032 Trac	Pierew Stove WattsStove UWattsStove dShapes sidential Space heat ter Residential Space t Savings Fact sures WOOD Fuel switch, WOOD Replace spa WOOD Fuel switch, WOOD Replace spa topper tert and LUPST [6032EPEP] K Name Track N. MA	= = ors space ce hea LISF R Upstre easure	= 0.52 <sup>[22]</sup> Efficiency of new st  Type Type Wood Pellet Energy consumptio New Stove Type Wood Pellet Status Winter Pellet Pelle	Wint: 57.1%	stove	ummer Wieter S	kW		
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Sb Re Num 5 Nee SHFF SHRU SHFF SHRU SHFF SHRU CO34 CO34 CO34 CO34 CO34 CO34 CO34 CO34	Piecew Stove WattStoeve WattStoeve d Shapes sidential Space heat ber Name Residential Space t Savings Facto wrood Fuel switch, WOOD Fuel switch, Restort 6034LISF SH Retroft 6034LISF SH	= = ce hea space ce hea LISF R LISF R LISF R HWO RHWC	= 0.52 <sup>[12]</sup> Efficiency of new st  Type Type Wood Pellet Energy consumptio  Mod Pellet  Energy consumptio  Facture Wood Pellet  Status Winter On NWh t Active 42.9%  heater, wood heater, wood heater, wood heater, wood pellet etrofit am - Residential  Code Free Rider S  O  1.00 1  P  1.00 1	wint: wint: wint: wint: off ki 57.1%	stove	ummer Wieter S	kW		
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Sb Re Ner SHF SHF SHF SHF SHF SHF COS COS COS COS COS COS COS COS	Piecew Stove WattsStove WattsStove dShapes sidential Space heat ber Name Residential Space t Savings Facto sures WOOD Fuel switch, WOOD Fuel switch, WOOD Fuel switch, WOOD Fuel switch, WOOP Replace spa ks [8ase track] LISF [s base track] LISF [s base track] LISF [s base track] K Name Track H: MK Retroft (6034LISF SH Retrof	= = ors space ce hea space ce hea LISF R Upstre FHWO RHWC FHWO RHWC	= 0.52 <sup>[12]</sup> Efficiency of new st  Type Uvool Pellet Energy consumptio Pellet  Status Vwood Pellet  Status Vwood Pellet  Status Value Vood Pellet  au Active 42.9% Active 42.9% Active 42.9% Active 42.9% Active Active 42.9% Active Act	vove(13)     Pateway     0.75     0.75     0.75     0.75     0.75     0.75     0.75     0.75     0.75     0.75     0.00     0.00     0.00     0.00     0.00     0.00     0.00     0.00	Slove  Slove Slove Slove  Slove Slove  Slove  Slove  Slove Slove  Slove Slov	iummer Winter S	kw 3.0%		
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Sb Re Nur 5 S Ne SHF SHR SHF SHR SHF SHR COS COS SHF SHR SHR SHF SHR SHF SHR SHF SHR SHR SHF SHR SHR SHR SHF SHR SHR SHR SHR SHR SHR SHR SHR SHR SHR	Piecew Stove WattSStove dShapes sidential Space heat ber Name Residential Space t Savings Facto sures WOOD Fuel switch, WOOD Fuel switch, WOOD Replace spa ks [Ease Track] LISF [Is base track] LISF [Is base track] Khame Track Hr. MR Retroft 6034LISF SH Retroft 6034LI	= = ors space ce hea space ce hea LISF R Upstre FHWO RHWC FHWO RHWC	= 0.52 <sup>[12]</sup> Efficiency of new st  Type Uvool Pellet Energy consumptio Pellet  Status Vwood Pellet  Status Vwood Pellet  Status Value Vood Pellet  au Active 42.9% Active 42.9% Active 42.9% Active 42.9% Active Active 42.9% Active Act	vove(13)     Pateway     0.75     0.75     0.75     0.75     0.75     0.75     0.75     0.75     0.75     0.75     0.00     0.00     0.00     0.00     0.00     0.00     0.00     0.00	Slove  Slove Slove Slove  Slove Slove  Slove  Slove  Slove Slove  Slove Slov	iummer Winter S	kw 3.0%		
Sb Re Nur 5 SHFF SHFF SHFF SHFF SHFF SHFF CO34 6034 6034 CUSF LISF LISF LISF LISF Trace For e	Piecew Stove WattsStove WattsStove dShapes sidential Space heat ber Name Residential Space t Savings Facto sures WOOD Fuel switch, WOOD Fuel switch, WOOD Fuel switch, WOOD Fuel switch, WOOP Replace spa ks [8ase track] LISF [s base track] LISF [s base track] LISF [s base track] K Name Track H: MK Retroft (6034LISF SH Retrof	= = ors space ce hea space ce hea space ce hea space ce hea space	= 0.52 <sup>[23]</sup> Efficiency of new st  Type Wood Pellet Energy consumption  Energy consumpting  Energy consumption  Energy consum	Over         133           Difference         0.75           0.76         0.76           0.76         0.76           Solution         0.77           Solution <t< td=""><td>Sove        </td><td>Summer Winter S Mr Kwok kov 0% 25.0% C</td><td>kw 3.0%</td><td></td></t<>	Sove	Summer Winter S Mr Kwok kov 0% 25.0% C	kw 3.0%		
Sb Ref Num 5 SHFF SHRI SHFF SHRI SHFF SHRI COSA COSA COSA COSA COSA COSA COSA COSA	Pieces Stove WattSStove dShapes sidential Space heat ber Name Residential Space Resi	= = ors hea ors space ce hea space ce hea space s	= 0.52 <sup>[12]</sup> Efficiency of new st  Yupe Uvool Pellet Energy consumptio Pellet Vood Pellet	ipili         Over           ipili         Over </td <td>stave s) of new stove WattStave 0 125(8) er Summer 8 wh on Kwh 0 s 0.0% 0</td> <td>Aurmer Winter S MY KWN KW 0.0% 25.0% 0 have a remaining life</td> <td>EW 3.0%</td> <td></td>	stave s) of new stove WattStave 0 125(8) er Summer 8 wh on Kwh 0 s 0.0% 0	Aurmer Winter S MY KWN KW 0.0% 25.0% 0 have a remaining life	EW 3.0%		
Sb Ref Num 5 SHFF SHRI SHFF SHRI SHFF SHRI COSA CUSF CUSF CUSF CUSF CUSF CUSF CUSF CUSF	Piecew Stove WattSStove dShapes sidential Space heat ber Name Residential Space t Savings Facto sures WOOD Fuel switch, WOOD Fuel switch, WOOD Fuel switch, WOOD Fuel switch, WOOD Replace spa ts [63ae Track] LISF [is base track] Kinem Track R- MR Retroft 6034LISF SH Retroft 6034LISF	= = ors hea ors space ce hea space ce hea space s	= 0.52 <sup>[12]</sup> Efficiency of new st  Yupe Uvool Pellet Energy consumptio Pellet Vood Pellet	Over         133           Difference         0.75           0.76         0.76           0.76         0.76           Solution         0.77           Solution <t< td=""><td>stave s) of new stove WattStave 0 125(8) er Summer 8 wh on Kwh 0 s 0.0% 0</td><td>Summer Winter S 97 KWh KW 0 0% 25.0% 0 have a remaining If( or pellet stove:14)</td><td>kw 3.0%</td><td></td></t<>	stave s) of new stove WattStave 0 125(8) er Summer 8 wh on Kwh 0 s 0.0% 0	Summer Winter S 97 KWh KW 0 0% 25.0% 0 have a remaining If( or pellet stove:14)	kw 3.0%		

Pellet	\$3,366	\$340	\$694	\$4,400	
*Costs not includ	ed in "stove cost" or "installati	on cost," such as miscella	neous parts or recycling fees		
For early replace	ment of wood stoves, the assu	med deferred cost (after	10 years) of replacing existin	g equipment with a new baselin	e wood stov

meeting New Source Performance Standards is assumed to be \$2,655.<sup>[16]</sup>

## **O&M Cost Adjustments**

r or customers and are not repr	deing casting mood store	uud 1		
Building Type	New Stove Type	Annual Baseline O&M Cost (17)		Annual O&M Cost Adjustment (Penalty)
Existing	Wood	\$106	\$229	-\$123
Looung	Pellet	4100	\$298	-\$192
NC	Wood	\$125	\$236	-\$111
	Pellet		\$305	-\$180

For customers that are replacing existing wood stoves with new pellet or wood stoves

Annual Baseline O&M Cost <sup>101</sup>	New Stove Type	Annual O&M Costs with New Stove <sup>(10)</sup>	Annual O&M Cost Adjustment (Penalty)
\$192	Wood	\$192	\$0
	Pellet	\$260	-\$68

### Footnotes

- ent from EPA New Source Performance Standards for year 2020
- [2] FLH and capacity values estimated by following a methodology outlined in the Uniform Methods Project using natural gas billing data provided by Vermont Gas Systems (VGS) for homes that participated in Efficiency Vermont's Residential New Construction (RNC) program. Since capacity has not been collected through the home Performance with DERGY STAR program it was not possible to perform the analysis with a more appropriate data set for this program. For Existing Homes, the RNC data was limited to only those homes with annual gas consumption greater than 2548U/sq fit in an attempt to remove the high performance/ law load homes in RNC. See VOS Usage Respression Work, OHI32017.45 for analysis. For adsituting homes, final FLH and capacity values were calculated using boller and furnace weighting from MRR Group, VT SF Existing Homes Orable Report," 2013, page 87, Table 5-4. For new construction, weightings are from NRR Group, Vermont Residential New Construction Baseline Study Analysis of Or-Site Audits (Draft Report)," May 12, 2017, page 47, Table 47.
- [3] FLH for stoves estimated by the Biomass Energy Resource Center
- Percentage of heating system fuel types in existing Vermont homes from NMR Group, "Survey Analysis of Owners of Existing Homes in Vermont (Craft)" Describer 5, 2016: page 29, Table 38 (Efficiency Vermont data). Natural gas, coal, and solar were excluded. The report tables that "all nine responders two use electricity as their primary heating used reported that they have electric resistance basebased rather than an electric hat pump." Percentage of wood from boilers and funcaces (versus stores) estimated as 4% based on data received by Efficiency Vermont on 002/12/012 from the upcoming NMR Vermont Residential Markie Assessment. [4]
- [5] ntane of heating s on Baseline Study Analysis of On-Site Audits (Draft Report)," May 12, 2017: page 45, Table 46 (Efficiency Vermont data). Natural gas xcluded
- [6] %istove for wood stoves is calculating using: the percentage of primary (53%) versus supplemental (47%) cordwood users in Vermont and the annual number of cords burned by primary (4.8) versus supplemental (2.1) cordwood users from Vermont Department of FOressi, Parks, and Recreation, Vermont Residential Teal Assessment for the 2014-2015 feating 6 anneary annual heat load of 80.832 MIBBu for Vermont Residential Teal Assessment for the 2014-2015 feating 6 anneary annual heat load of 80.832 MIBBu for Vermont Residential heat load of 80.832 MIBBu for Vermont Residential best data of 2016 JUE (TI TEI III TAG agreement/84.2% of heating system efficiency Vermont Residential Market Assessment; and 22.0 MIBBu (ord Net Content from the Normeller 2016 VT Fuel Price Report. Nistove is calculated as (153% (4.8 cords)yr \* 22.0 MIBBu (ord \* 6% / 80.832)). See Nistove tab in file DYT\_Pellet Wood Store, Analysis, Aug 2018, v2.4% for calculation.
- [7] %stove for pellet stoves is calculating using: the percentage of primary (70%) versus supplemental (30%) pellet users in Vermont and the annual tors of pellet ls burned by primary (4.4) versus supplemental (3.3) pellet users from Vermont Department of Forests, Parks, and Recreation, Vermont Residential Fund the 2014-2015 kerning 5-32 markets, and an average annual hater load of 80.832 MMRU for Vermont homes (700 gallors/oil per year based on 2016 VT Tier III TAG agreement/84.2% oil heating system efficiency in existing VT homes); 77% stove efficiency based on data received by Efficiency Vermont on 08/21/2017 from the upcoming MMR Vermont Residential Market Assessment (Fast Assessment for Totel Pice Report, "Sisteve is calculated as ((70%) (4.4 homes)," 77%) stove efficiency based on table to homes); 70% stove and the accenter from the November 2016 Tot Fuel Pice Report, "Sisteve is calculated as ((70%) (4.4 homes)," and "77%) (80.832)), See %stove tab in file EVT\_pellet Wood Stove, Analysis, Aug 2018, v2.xbsr for calculation."
- [8] Typical pellet stove energy consumption at normal burn rates estimated by the Biomass Energy Resource Center. Includes ignitor, feed auger, and
- [9] Efficiencies of LP and oil heating systems in existing homes are a weighted average based on the percentage of boilers and furnaces used as single major heating system in existing Vermont homes from NMR Group, "Vermont Single-Family Existing Homes Onsite Report," February 15, 2013: pages 58-61, Tables 5-4, 5-8 and 5-9. Stokes in existing homes with electric space heating are assumed to replace electric resistance systems with an efficiency of 100. Efficiency of wood heating systems is based on professional judgment. See nBase & nExisting tab within file EVT\_Pellet Wood Stoke\_Analysis\_Aug 2018\_v2.x8x for calculations.
- [10] Efficiencies of electric, LP, and oil heating systems in new homes are based on data from NMR Group, "Vermort Residential New Construction Baseline Study Analysis of On-Site Audits (Daft Report), "New J2, 2012. Boiler, furnance, and heat pump weightings are from gage 47, Table 47, and equipment efficiencies are from pages 49-50, Tables 50-52. Oil boilers, combined appliances, wood stoves and furnaces, pellet stoves, natural gas units, and heat pumps were removed from tobier and furnace weighting calculations. Values for Efficiency Vermont used. Rese (D) is a weighted average based on the percentage of UP boilers and furnaces installed in new Vermont homes. Nase (oil) is the efficiency of oil boilers. Efficiencies of wood and pellet heating systems are the efficiencies of new stoves meeting 2020 NFSP and 70% efficiency requirements on EPX's list of certified wood heaters as of May 2018. See nBase & resisting tab within file EVT\_Pellet Wood Stove\_Analysis, Aug 2018\_v2.vdsx for calculations.
- [11] Efficiency of baseline stove is the average efficiency of stoves meeting 2020 NSPS requirements from EPA's list of certified store
- [12] Efficiency of existing wood stove being replaced is an estimate provided by the Biomass Energy Resource Center based on review of inform provided by the Alliance for Green Heat.
- [13] Average efficiency of new stoves meeting 2020 NSPS and 70% efficiency requirements on EPA list of certified wood heaters as of May 2018
- [14] Average of lifetimes provided for residential cordwood and pellet stoves in U.S. ElA, "Updated Buildings Sector Appliance and Equipment Costs and Efficiencies," June 2018.
- ble Energy Resource Center from December 2016 through April 2017. See Measure Cost tab within file EVT\_Pellet [15] A age costs from the R Wood Stove Analysis Aug 2018 v2.xlsx
- [16] Based on estimate that a baseline stove meeting NSPS standards costs 80% of an average stove meeting program requirem
- Baseline D&M costs for existing homes are based on the percentage of each heating system fuel type in existing Vermont homes from NMR Group, "Survey Analysis of Owners of Existing Homes in Vermont (Dealty" December 5, 2016; page 29, Table 38 (Efficiency Vermont data). LP and oil systems are weighted based on the percentage of baliers and furnaces in Vermont homes from NMR Group, VT SF Existing Homes (Storker Report, "2013, page 83, Table 5-4. Baseline ORM costs for new construction are based on the percentage of each heating system in new Vermont homes from NMR Group, "Vermont Residential New Construction Baseline Study Analysis of On-Site Audit (Draft Report)," Prepared by MRG Group for Vermont DFS, May 12, 2017; page 47, Table 47 (Efficiency Vermont dats). Combined appliances and natural gas and systems excluded. Costs for LP and oil boilers and furnaces, wood stoves, pellet stoves, and heat pumps are from U.S. EIA, "Updated Baildings Sector Appliance and Equipment Costs and Efficiencies," Nevember 2016. According to the report, O&M costs for electric resistance heating systems are negligible; \$10 was assumed in these calculations. Costs for control ob Dolers and furnaces are assumed to the same as costs for pellet boilers. See "O&M Costs" tab in file EVT\_Pellet & Wood Stoves\_Analysis, Jug 2013, v2Jxis for calculation.
- [18] O&M costs with new wood stove include the percentage of existing heat system O&M costs that are not displaced by the new stove (8 Cost \* (1 %istrow)), just the full O&M costs associated with the new stove. New stove O&M costs are from U.S. EIA, "typdated Baild Appliance and Equipment Costs and Efficiencies," Nevember 2016. See O&M Costs tab within file EVT\_Pellet Wood Stoves\_Analysis\_f 2018\_y2.vks for calculation.
- [19] Baseline and new O&M costs for customers replacing existing wood stoves are the full O&M costs for wood or pellet stoves from U.S. EIA. "Updated Buildings Sector Appliance and Equipment Costs and Efficiencies," November 2016.

= Number of preheats per day

Preheats

1

Effective Date: 20 End Date: [ M Program: Co	CI-CKE-CO tive 120/1/1	ova
Update Summa New Measure	ary	
Referenced Do • PGECOFST117 R5 • FSTC_ConveyorOv	Commerci	
number of products with Some manufacturers of	ith similar o offer an air-	as fired Conveyor Ovens installed in a commercial kitchen. Conveyor ovens are typically used for producing a limited ooking requirements at high production rates, such as pizzas, breads and pastries. curtain feature at either end of the cooking chamber that helps to keep the heated air inside the conveyor oven. The a wall and helps reduce both the idle energy of the oven and the resultant heat gain to the kitchen.
Program Type Calculation: Time of Sa Program Delivery / Imp	ale (Markel	
Baseline Efficie The baseline equipment		standard gas-fred conveyor oven.
Efficient Equip The efficient equipmen utilizing ASTM Standar	nt is a gas f	red conveyor oven with baking efficiency of at least 42% and idle energy rate less than or equal to 57,000 Blult/h,
Algorithms Electric Demand Sa Electric Energy Sav	ivings rings	
	t where not	ed are based on Work Paper PGECOFST117 Commercial Conveyor Over-Gas . leemed savings for this measure is 75.6 MMBu (Item Code CXE-CONV-NG or CXE-CONV-LP depending on fuel type)
ΔMMBtu	= (ΔPre	neatDaily8tu + ΔtdleDaily8tu +ΔCookingDaily8tu) × Days/1000000
ΔIdleDailyBtu		$ateGas_{base} \times (Hours - FoodCooleed/ProductionGas_{base} - (Preheats \times PreheatTime/60)) - (IdleRateGase_E \times (Hours - FoodProductionGase_E - (Preheats \times PreheatTime/50))$
ΔCookingDailyBtu	= (Food	$Cooked \times EFOOD_Gar/EFF_Ese) \cdot (FoodCooked \times EFOOD_Gar/EFF_EE)$
ΔPreheatDailyBtu	= (Preh	adEnergy <sub>Rose</sub> × Preheats) - (PreheatEnergy <sub>EE</sub> × Preheats)
Where:		
ΔCookingDailyE		Energy savings per day to cook food in gas conveyor oven (Btu)
∆IdleDailyBtu		Energy savings per day when gas conveyor oven is idle (Btu)
ΔMMBtu		Total gas savings for gas conveyor oven (MMBtu)
ΔPreheatDailyB		Energy savings per day when gas conveyor oven is preheating (Btu)
60		Converts minutes to hours
Days		Annual days of kitchen operation = 312 <sup>[1]</sup>
EFF <sub>Base</sub>	-	Cooking efficiency of baseline conveyor oven = 20%
EFFEE		Cooking efficiency of efficient conveyor oven = 42%
EFOOD <sub>Gas</sub>	-	ASTM energy to food for gas conveyor oven = 190 Btu/pizza
FoodCooked	-	Food cooked per day = 250 pizzas
Hours	-	Average daily hours of operation = 12 hours
IdleRateGas <sub>Base</sub>	e =	Idle energy rate of baseline gas conveyor oven = 70,000 Btu/hr
IdleRateGas <sub>EE</sub>	-	Idle energy rate of efficient gas conveyor oven = 57,000 Bu/hr
PreheatEnergy		Preheat energy of baseline gas conveyor oven = 35,000 Bu
PreheatEnergy	EE =	Preheat energy of efficient gas conveyor oven = 18,000 Bu

			1						
	PreheatTime	= Le	ngth of on	e preheat					
		-	15 minute	s					
	ProductionGase	= Pr	aduction c	anacity of I	analina ar	as conveyo			
	FIGUEUGIABS		150 pizzas		Jasenne ge	is conveyo	oven		
			100 bizzas	per nour					
	ProductionGas <sub>EE</sub>	= Pr	oduction c	apacity of (	efficient ga	is conveyor	oven		
		-	220 pizzas	s per hour					
	I Shapes	20							
Numb		.9	Status				Summer	Winter	
Numu	er name		Status	On kWh	Off kWh	On kWh	Off kWh	kW	kW
90	Restaurant Indoor	r Lighting	Active	40.7%	25.7%	20.2%	13.4%	63.0%	77.0%
		Ven							
CKLCC Frack 6013U	DNVE Gas Conveyor O s [Base Track] JPST [is base track] U	Jpstream			Rider Spill	Qver			
CKLCC Frack 6013U	DNVE Gas Conveyor O s [Base Track] JPST [is base track] U	Jpstream ck Nr. M	leasure C	ode Free	Rider Spill				
Track 6013U Upstre	DNVE Gas Conveyor O s [Base Track] JPST [is base track] U Irack Name Track	Jpstream ck Nr. M 3UPST C	leasure C	ode Free					
CKLCC Fracka 6013U Upstre Lifet Mea	INVE Gas Conveyor O s [Base Track] IPST [is base track] L Track Name Trac am - Commercial 6013 times	Jpstream ck Nr. M 3UPST C	leasure C	iode Free					
CKLCC Frack 6013U Upstre Lifet Mea: increm	RWE Gas Conveyor O       s [Base Track]       IPST [is base track]       IPST [is base track]       Track Name       Track Name       Track Name       Track Same       am - Commercial 6012       immes       e is assumed as 12 yes       sure Cost       ental costs are assumed as 10 yes       tottes	Jpstream ck Nr. M 3UPST C ars <sup>(2)</sup>	klCONVE \$2,230 pe	tode Free 1.00	1.00				
CKLCC Frack 6013U Upstree Lifet Meas Meas Meas Doth	RWE Gas Conveyor O       s [Base Track]       IPST [is base track]       IPST [is base track]       Track Name       Track Name       Track Name       Track Same       am - Commercial 6012       immes       e is assumed as 12 yes       sure Cost       ental costs are assumed as 10 yes       tottes	Jpstream ck Nr. M 3UPST C ars <sup>[2]</sup> ed to be	kLCONVE \$2,230 pe in the PS8	tode Free 1.00	1.00		rmont seaso	onal oper	ation and kitchens not operating every day. Assumes

[3] Based on Pacific Gas & Electric Company Work Paper PGECOFST117 "Commercial Conveyor Oven - Gas", May 2014.

## **ENERGY STAR Commercial Dishwasher**

I

End Use: Kitchen Equipment

## Update Summary

Referenced Documents

Description This measure describes savings from an ENERGY STAR dishwasher installed in a commercial kitchen. As per the ENERGY STAR specification, savings are provided for high and low temperature under counter, stationary single tank door, single tank conveyor and multiple tank conveyor dishwashers, as well as high temperature topic, pan and utempi dishwasher types. Savings are also dependent on the building's water and/or booster tank heating fuel.

## Program Type <u>Calculation:</u> Time of Sale (Market Opportunity)

Program Delivery / Implementation Type: Mid stream

Baseline Efficiencies Baseline is assumed to be a new distwasher of equivalent type that is non ENERGY STAR qualified.

## Efficient Equipment

	High Temp Effici	ency Requirement	s Low Temp Efficier	ncy Requirements
Dishwasher Type	Idle Energy Rat	e Water	Idle Energy Rate	Water
		Consumption		Consumption
Under Counter	≤ 0.50 kW	≤ 0.86 GPR	≤ 0.50 kW	≤ 1.19 GPR
Stationary Single Tank Door	≤ 0.70 kW	≤ 0.89 GPR	≤ 0.60 kW	≤ 1.18 GPR
Pot, Pan, and Utensil	≤ 1.20 kW	≤ 0.58 GPSF	≤ 1.00 kW	≤ 0.58 GPSF
Single Tank Conveyor	≤ 1.50 kW	≤ 0.70 GPR	≤ 1.50 kW	≤ 0.79 GPR
Multiple Tank Conveyor	≤ 2.25 kW	≤ 0.54 GPR	≤ 2.00 kW	≤ 0.54 GPR

GPSF: Gallons per square foot of rack

Algorithms Electric Demand Savings All assumptions are taken from the ENERGY STAR Commercial Kitchen Equipment Calculator except where otherwise noted. 

∆kW	= 2	∆kWh / (H	Hours × Days)							
Symbo	I Table									
Vater	Savings									
∆Wab	er = (	(WaterU	seBase - Waterl	UseEff) × (Rad	cksWashed × I	Days)) / 748				
Symbo	il Table									
lectric	Energy Savings									
∆kWh	1	= ΔBu	ildingEnergyElec	tric + ΔBooste	erEnergyElectr	ic + ∆IdleEne	ergy			
ΔBuild	dingEnergyElectric	= (ΔW	/ater $\times$ 748 $\times$ $\Delta$	TinWaterHeat	ter × 1.0 × 8.2	?)/(ElectricWa	aterHeaterEff	× 3,412)		
ΔBoos	sterEnergyElectric	= (ΔW	/ater × 748 × ∆	TinBoosterHea	ater $\times$ 1.0 $\times$ 8.	.2)/(ElectricB	loosterHeater	Eff × 3,412)		
∆IdleE	Energy	= (Idle	eDrawBase - Idle	eDrawESTAR)	) × ((Hours × I	Days) - (Days	s × RacksWas	shed × Wash	Time/60))	
Symbo	I Table									
ossil F	uel Savings									
ΔMME		= ∆Build	ingEnergyFuel +	⊢∆BoosterEne	rgyFuel					
ΔBuild	dingEnergyFuel	= (∆Wat	ter × 748 × ∆Tir	nWaterHeater	× 1.0 × 8.2)/	(FuelWaterE	ff × 1,000,00	J)		
ΔBoos	sterEnergyFuel	= (∆Wat	ter × 748 × ∆Tir	nBoosterHeate	er × 1.0 × 8.2)	)/((FuelBoost	erHeaterEff)	× 1,000,000)		
Vhere:	ΔBoosterEnergyElect		Crease allocateire a		loshi kosta	- heater (his	h komporati a	. diakuna akan		
-	ABOOSterEnergyElect			-					s oniy)	
4	∆BoosterEnergyFuel	-	Gross fuel savi	ngs from fuel	booster heate	r (high temp	erature dishw	rashers only)		
1	∆BuildingEnergyElect	tric =	Gross electric s	savings from e	electric building	g water heat	er			
1	∆BuildingEnergyFuel	-	Gross fuel savi	ngs from fuel	building water	heater				
4	∆IdleEnergy	-	Gross electric s	savings when	dishwasher is	idle				
4	ΔkW	-	Gross demand	savings for th	is measure					
4	∆kWh	-	Gross electric s	savings for thi	s measure					
1	ΔMMBtu	-	Gross fuel savi	ngs for this m	easure					
4	∆TinBoosterHeater	-	= Inlet water t = 40 F for boo							
	∆TinWaterHeater	-	= Inlet water t							
			= 70 F for built	ding water he	aters					

Δ	Water	-	Total wa	ater savin	gs for	this i	measure (co	f)									
1	,000,000	-	Converts	s Btu to M	MBtu												
1	.0		Specific	heat of w	ater	(Bhu/II	b/F)										
	.412	_	Comunit	s Btu to k	Arla												
3	,412			s Btu to k • 3412 Bti													
_																	
6				s minutes													
7	48			on from g		s to C	CF.										
			748 gall	ons = 1 C	CF												
8	.2	-	Density (	of water (	lb/ga	I)											
D	lays	-	Days of	dishwash	er op	eratio	n										
			= 312[1]														
E	lectricBoosterHeaterI	Eff =	Efficienc	y of Elect	ric Bo	oster	Heater										
			= 98%														
E	lectricWaterHeaterEf	f =	Efficienc	y of Elect	ric bu	ilding	water heate	er									
			= 98%														
F	uelBoosterHeaterEff	-	Efficienc	y of Fuel	boost	er wa	iter heater										
			= 80%														
F	uelWaterEff	-	Efficienc	y of Fuel	buildi	ng wa	ater heater										
			= 80%														
н	lours	-	Hours of	operatio	n per	day											
			= 18 hor	urs													
k	fleDrawBase	-	Idle pow	ver draw	(kW)	of bas	seline dishw	asher									
			= See ta	able below	v for	defau	lts										
k	deDrawESTAR	-	Idle pow	ver draw	(kW)	of EN	ERGY STAR	dishwa	sher								
			= See ta	able below	v for	defau	lts										
R	acksWashed	-	Number	of racks	wash	ed per	r day										
			= See ta	able below	v for	defau	lts										
V	/ashTime			r wash cy													
			= See ta	able below	v for	defau	lts										
v	/aterUseBase						of baseline	dishw	asher								
			= See ta	able below	v for	defau	lts										
v	/aterUseEff						of ENERGY	STAR	dishwashe	r							
			= See ta	able below	v for	defau	lts										
	I	RacksWa	ished	WashTin	e	W	/aterUse	1	IdleDraw	1							
			ashersAll	l Dishwas	hers		NERGY STAF			AR							
Ur	ider Counter	75	Low T	emperati 2		L.73	1.19	0.5	0.5	-							
	y Single Tank Door	280		1.5		2.1	1.18	0.6	0.6								
	Tank Conveyor Tank Conveyor	400 600		0.3		1.31 1.04	0.79	1.6 2	1.5 2								
l le	der Counter	75	High T	emperati 2		1.09	0.86	0.76	0.5	-							
Stationar	y Single Tank Door	280		1	:	1.29	0.89	0.87	0.7								
	Tank Conveyor Tank Conveyor	400		0.3		).87 ).97	0.7	1.93	1.5 2.25	_							
	Pan, and Utensil	280		3		0.7	0.54	1.2	1.2	-							
Default s	avings are provided t	elow. h	ased on l	building v	ater	heat	for low term	o unite	and buildin	ig and l	booster w	ater heat fe	or high tem	p unite			
		.,					g Water Hea						g Water He				I
<u> </u>	Dishwasher type		∆kWh	ΔkW		MBtu	∆Water		mCode	∆kWh		∆MMBtu	∆Water	R	emCod		
															DISH-N DISH-L		
	Under Count	er	2,171	0.3865		D	17	CKE-I	DISH-E-L1	0	0.0000	9	17		DISH-C		
															DISH-N		
	Stationary Single	Tank	13,807	2.4585		D	107	CKE-I	DISH-E-L2	0	0.0000	58	107		DISH-L		
Low	Door					-				-				CKE-	DISH-C	DL-L2	
Temp														CKE-	DISH-N	IG-L3	
	Single Tank Con	veyor	11,648	2.0740		D	87	CKE-I	DISH-E-L3	499	0.0889	47	87	CKE-	DISH-L	.P+L3	
															-DISH-0		
															DISH-N		
	Multi Tank Conv	eyor	16,080	2.8632		D	125	CKE-I	DISH-E-L4	0	0.0000	67	125		DISH-L		
														UKE-	DISH-C	л.=L4	I
	Electric Build	ing Wate	er Heater	. Flectric	EL	othic	Building wat	er Hes	ter, Fuel	Fuel	Building 14	/ater Heate	r. Electric	Er.	el Build	ing W*	10
		Boost		,			Booste			. Jel		looster	.,		unu	Boo:	
Dishwa typ	AKWN AKW	∆MMBtu	u∆Water	ItemCode	ΔkW	′h ∆k	.W ∆MMBtu	∆Wate	ritemCode	∆kWh	ΔkW ΔMI	MBtu∆Wate	eritemCode	∆kWh	ΔkW	∆ммв	tı.
1 T		1	1	-	1	T			1		-	-	-	1	_		1

		ric Bui		iter Heati ster	er, Electric	Elect	tric Buil	ding wa Boosti		er, Fuel	Fuel	Buildir	ig Water Boost		Electric	Fu	el Build	ing Wate Boost		r, Fuel
Dishwasher type	ΔkWl	h ∆k\	V AMMI	tu∆Wate	ritemCode	ΔkWh	∆kW	∆MMBtu	∆Water	ItemCode	∆kWh	∆kW	ΔMMBtu	∆Water	ItemCode	∆kWh	ΔkW	∆MMBtu	∆Water	ItemCoo
Unde Counte	2 710	0.48	26 0	7	CKE- DISH-EE- H1	2,182	0.3885	2	7	CKE- DISH- ENG-H1 CKE- DISH- ELP-H1	1,786	D.3180	4	7	CKE- DISH- NGE-H1 CKE- DISH- LPE-H1 CKE- DISH- OLE-H1	1,257	0.2239	6	7	CKE- DISH- NGNG+F DISH- DISH- CKE- DISH- OLNG+F OLIP-H
Station: Single Tank Door	10 14	11.80	57 0	47	CKE- DISH-EE- H2	6,710	1.1949	14	47	CKE- DISH- ENG-H2 CKE- DISH- ELP-H2	4,138	0.7367	25	47	CKE- DISH- NGE-H2 CKE- DISH- LPE-H2 CKE- DISH-	707	0.1259	39	47	CKE- DISH- NGNG-F DISH- LPLP-H CKE- DISH- OLNG-F

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																OLE-H2					CKE- DISH- OLLP-H2
High Temp	Single Tank Conveyor	7,874	1.4021	0	28	CKE- DISH-EE- H3	5,791	1.0312	9	28	CKE- DISH- ENG-H3 CKE- DISH- ELP-H3	4,229	0.7531	15	28	CKE- DISH- NGE-H3 CKE- DISH- UPE-H3 CKE- DISH- OLE-H3	2,147	0.3822	24	28	CKE- DISH- NGNG-H3 CKE- DISH- LPLP-H3 CKE- DISH- OLNG-H3 CKE- DISH- OLLP-H3
	Multi Tank Conveyor	23,428	4.1716	0	108	CKE- DISH-EE- H4	15,526	2.7646	33	108	CKE- DISH- ENG-H4 CKE- DISH- ELP-H4	9,599	1.7093	58	108	CKE- DISH- NGE-H4 CKE- DISH- LPE-H4 CKE- DISH- OLE-H4	1,697	0.3022	91	108	CKE- DISH- NGNG-H4 CKE- DISH- LPLP-H4 CKE- DISH- OLNG-H4 CKE- DISH- OLLP-H4
	Pot, Pan, and Utensil	2,830	0.5039	0	14	CKE- DISH-EE- H5	1,801	0.3207	4	14	CKE- DISH- ENG-H5 CKE- DISH- ELP-H5	1,029	0.1832	8	14	CKE- DISH- NGE-H5 CKE- DISH- LPE-H5 CKE- DISH- OLE-H5	0	0.0000	12	14	CKE- DISH- NGNG-H5 CKE- DISH- LPLP-H5 CKE- DISH- OLNG-H5 CKE- DISH- OLIP-H5

## Load Shapes

umber	Name	Status			Summer On kWh	Summer Off kWh	Winter kW	Summer kW	
D Re	staurant Indoor Lighting	Active	40.7%	25.7%	20.2%	13.4%	63.0%	77.0%	
sures	ngs Factors								
.CDISH E	NERGY STAR Commerci	al Dishwa	sher						
acks [Bas	e Track]								
	base track] Upstream	- Comme	rcial						
Track N	ame Track Nr. M	easure C	ode Free	Rider Spil	l Over				
	ommercial 6013UPST CK	1.CDISH	1.00	1.00	)				
ostream - C									
ostream - C									
ostream - C									
fetimes	measure life is provided	below <sup>[2]</sup> :							
fetimes e assumed			quipment	Life					
fetimes e assumed	measure life is provided		quipment	Life					
fetimes e assumed Ur	measure life is provided ishwasher Type nder Counter	10	quipment		eacure	Cost			
fetimes e assumed Ur ow	measure life is provided <b>ishwasher Type</b> Inder Counter ationary Single Tank Do	10 or 15	quipment	м	easure		ete are pe	coded below <sup>[3]</sup> :	
fetimes e assumed Ur ow	measure life is provided ishwasher Type nder Counter	10	quipment	м	sumed incr	emental co		ovided below <sup>[3]</sup> :	
fetimes e assumed D Ur ow St iemp Si	measure life is provided <b>ishwasher Type</b> Inder Counter ationary Single Tank Do	10 or 15	quipment	м	sumed incr			ovided below <sup>(3)</sup> :	ost

Low Temp	Stationary Single Tank Door Single Tank Conveyor	15 20	Measur Assumed in	e Cost cremental costs are provide	d below <sup>(3)</sup> :	
	Multi Tank Conveyor	20	0	ishwasher Type	Incremental Cost	
	Under Counter	10		Under Counter	\$234	Footnotes
	Stationary Single Tank Door	15	Low Temp	Stationary Single Tank Door	\$662	
High Temp	Single Tank Conveyor	20		Single Tank Conveyor	\$O	
Temp	Multi Tank Conveyor	20	_	Multi Tank Conveyor	\$970	
	Pot, Pan, and Utensil	10		Under Counter	\$2025	
		1		Stationary Single Tank Door	\$995	
			High Temp	Single Tank Conveyor	\$2050	
				Multi Tank Conveyor	\$970	
				Pot, Pan, and Utensil	\$1710	

[1] Reduced from 365 days assumed in the ENERGY STAR calculator to account for seasonal operation and kitchers not operating every day. Assumes an average of 6 days per week operation.

[2] Lifetime from ENERGY STAR Commercial Kitchen Equipment Savings Calculator which cites reference as "EPA/FSTC research on available models, 2013"

[3] Based on assumption provided in the ENERGY STAR Commercial Kitchen Equipment Savings Calculator.

## **ENERGY STAR Fryer**

Measure Number: CE-CKE-FRYER a Portfolio: Status: Active Effective Date: 2020/1/1 End Date: [ hone ] Program: Commercial & Industrial End Use: Kitchen Equipment

## Update Summary

Referenced Documents

Description
This measure applies to electric or natural gas fired ENERGY STAR certified fryers installed in a commercial kitchen. ENERGY STAR fryers offer shorter
cock times and higher production rates through advanced burner and heat exchanger designs, and fry pot insulation reduces standay losses, resulting in
lower ide energy rates.

Standard-sized ENERGY STAR fryers are up to 30% more efficient, and large-vat ENERGY STAR fryers are up to 35% more efficient, that

## Program Type <u>Calculation:</u> Time of Sale (Market Opportunity)

Program Delivery / Implementation Type: Mid stream

Baseline Efficiencies The baseline equipment is a new electric or gas fryer that is non ENERGY-STAR certified.

Efficient Equipment
The efficient Equipment is a ENERGY STAR certified fryer meeting the idle energy and cooking efficiency specifications in ENERGY STAR Version 3.0
(effective October 1, 2016), provided below:

Frver Capacity	Electric Efficien	cy Requirements	Natural Gas Efficiency Requirements			
	Idle Energy Rate	Cooking Efficiency	Idle Energy Rate	Cooking Efficiency		
Standard Open Deep-Fat Fryer	≤ 800 W	≥ 83%	≤ 9,000 Btu/hr	> 50%		
Large Vat Open Deep-Fat Fryer	≤ 1,100 W	≥ 80%	≤ 12,000 Btu/hr			

Algorithms Electric Demand Savings All assumptions are taken from the ENERGY STAR Commercial Kitchen Equipment Calculator except where otherwise noted.

		= ∆kV	/h/(Hour	s × Days)	
Symbol Table					
Electric Energy	/ Savi	ngs			
∆kWh		= (ΔI	dleDaily	kWh +∆CookingDai	ykWh) × Days/1000
ΔIdleDailykWh			leRateEle ectric <sub>EST</sub>		- FoodCooked/ProductionElectric_Base) - ( $EleRateElectric_{ESTAR} \times (Hours - FoodCooked/ProductionElectric_{Base})$
ΔCookingDailyk	dWh	= (Fc	odCooke	ed × EFOOD <sub>Electric</sub> /	$ElectricEFF_{Base}$ ) - (FoodCooked × EFOOD <sub>Electric</sub> /ElectricEFF <sub>ESTAR</sub> )
Jsing assumption	is provi	ded, th	e deeme	d savings for this r	neasure is as follows;
	is provi ΔkWh	<u> </u>		d savings for this r Itemcode	neasure is as follows;
Fryer Type	ΔkWh	ΔkW	∆MMBtu	-	neasure is as follows;
Fryer Type Electric Standard	ΔkWh 2,672	∆kW 0.5353	ΔMMBtu 0	Itemcode	neasure is as follows;
Fryer Type Electric Standard Electric Large Val	ΔkWh 2,672	ΔkW 0.5353 0.5790	ΔMMBtu 0 0	Itemcode CKE-FRYER-ES	neasure is as follows;
Using assumption Fryer Type Electric Standard Electric Large Val Gas Standard	ΔkWh 2,672	ΔkW 0.5353 0.5790	ΔMMBtu 0	Itemcode CKE-FRYER-ES CKE-FRYER-ELV	neasure is as follows;
Fryer Type Electric Standard Electric Large Val	ΔkWh 2,672 t2,168	ΔkW 0.5353 0.5790	ΔMMBtu 0 0	Itemcode CKE-FRYER-ES CKE-FRYER-ELV CKE-FRYER-NGS	neasure is a follows;
Fryer Type Electric Standard Electric Large Val	ΔkWh 2,672 t2,168	ΔkW 0.5353 0.5790 0	ΔMMBtu 0 0	Itemcode CKE-FRYER-ES CKE-FRYER-ELV CKE-FRYER-NGS CKE-FRYER-LPS	neasure is as follows;

Fossil Fuel Savings	
ΔMMBtu	$= (\Delta k die Daily8ku + \Delta Cooking Daily8ku) \times Days/1000000$
ΔIdleDailyBtu	$= (IdleRateGas_{Bose} \times (Hours - FoodCooled/ProductionGas_{Bose}) - (IdleRateGas_{ESTAR} \times (Hours - FoodCooled/ProductionGas_{EST} AR)$
ΔCookingDailyBtu	$= (FoodCooked \times EFOOD_{Gat}/GateFF_{Bate}) - (FoodCooked \times EFOOD_{Gat}/GateFF_{ESTAR})$

ΔCookingDailyBtu	-	Energy savings per day to cook food in gas fryer (Btu)
ΔCookingDailykWh	-	Energy savings per day to cook food in electric fryer (kWh)
ΔIdleDailyBtu	-	Energy savings per day when gas fryer is idle (Btu)
ΔIdleDailykWh	-	Energy savings per day when electric fryer is idle (kWh)
ΔkW	-	Total demand savings for electric fryers (kWh)
ΔkWh	-	Total electric savings for electric fryers (kWh)
ΔMMBtu	-	Total gas savings for gas fryers (MMBtu)
1000	-	Converts watts to kilowatts
Days	-	Annual days of kitchen operation
		= 312 days <sup>[1]</sup>
EFOODElectric	-	ASTM energy to food for electric fryer
		= 167 Wh/lb

	EFOOD <sub>Gas</sub>	-	ASTM energy to food for gas fryer = 570 Btu/lb	
	ElectricEFF <sub>Base</sub>	-	Cooking efficiency of baseline electric fryer = 75% for standard fryers	
			= 70% for large vat fryers	
	ElectricEFF <sub>ESTAR</sub>	-	Cooking efficiency of ENERGY STAR electric fryer	
			= 83% for standard fryers = 80% for large vat fryers	
	FoodCooked		Food cooked per day	
			= 150 lbs	
	GasEFF <sub>Base</sub>	-	Cooking efficiency of baseline gas fryer	
			= 35% for standard and large vat fryers	
	GasEFF <sub>ESTAR</sub>	1	Cooking efficiency of ENERGY STAR gas fryer = 50% for standard and large vat fryers	
	Hours		Average daily hours of operation	
	TING 5		= 16 hours for standard fryers	
			= 12 hours for large vat fryers	
	IdleRateElectric <sub>Base</sub>	-	Idle energy rate of baseline electric fryer	
			= 1200 W for standard fryers	
	IdleRateElectric <sub>ESTAR</sub>		= 1350 W for large vat fryers Idle energy rate of ENERGY STAR electric fryer	
	IUIERAUEEIECU ICESTAR	1	= 800W for standard fryers	
			= 1100 for large vat fryer	
	IdleRateGas <sub>Base</sub>	-	Idle energy rate of baseline gas fryer	
			= 14,000 Btu/hr for standard fryers	
	10.0.0.0		= 16,000 Btu/hr for large vat fryers	
	IdleRateGas <sub>ESTAR</sub>	1	Idle energy rate of ENERGY STAR gas fryer = 9,000 Btu/hr for standard fryers	
			= 12,000 Btu/hr for large vat fryers	
	ProductionElectric <sub>Base</sub>	-	Production capacity of baseline electric fryer = 65 lb/hr for standard fryers	
			= 100 lb/hr for large vat fryers	
	ProductionElectric <sub>ESTAR</sub>	-	Production capacity of ENERGY STAR electric fryer	
			= 70 lb/hr for standard fryers	
			= 110 lb/hr for large vat fryers	
	ProductionGas <sub>Base</sub>	1	Production capacity of baseline gas fryer	
			= 60 lb/hr for standard fryers = 100 lb/hr for large vat fryers	
	ProductionGas <sub>ESTAR</sub>		Production capacity of ENERGY STAR gas fryer	
			= 65 lb/hr for standard fryers	
			= 110 lb/hr for large vat fryers	
	d Shapes testaurant Indoor Lighting			
Num			Status Winter Winter Summer Summer Winter	r Summer
90		iahtir	Status         Winter         Winter         Summer         Summer         Winter           On kWh         Off kWh         On kWh         Off kWh         On kWh         Off kWh         kW           vg         Active         40.7%         25.7%         20.2%         13.4%         63.0%	kW 77.0%
		.g	,	
	t Savings Factors	5		
CKLF	RYER Energy Star Fryer			
	ks [Base Track]			
6013	UPST [is base track] Ups	trea	n - Commercial	
	Track Name Track eam - Commercial 6013U		Measure Code Free Rider Spill Over CKLFRYER 1.00 1.00	
	t <b>imes</b> ne is assumed as 12 years	<sub>5</sub> [2]		
	asure Cost			
Increi Fuel	mental costs are assumed			
Elect	Fryer Type Incremental Standard \$276	COS		
-	Large vat \$1150 Standard \$1,860			
Gas	Large vat \$1,850		]	
	notes			
	educed from 365 days ass verage of 6 days per week		d in the ENERGY STAR calculator to account for seasonal oper ration.	ation and kitchens not operating every day. Assu
	ased on ENERGY STAR cal			
	ased on ENERGY STAR Ca			

## **Commercial Steam Cooker**

Measure Numbe	CI-CKE-STEAM a
Portfolio:	
Status:	Active
Effective Date:	2020/1/1
End Date:	[ None ]
Program:	Commercial & Industrial
End Use:	Kitchen Equipment

### Update Summary easure

- Referenced Documents

  ENERGY STAR CKE Calculator\_Oct 2016

  ENERGY STAR\_Commercial Steam Cookers\_Pr
  PRECOFSTIOH R6 Steam Cookers\_Commercial
  EVT\_Steam Cooker\_Analysis\_May 2020\_v2

Description This measure involves the installation of an ENERGY STAR electric, natural gas, or propane commercial steam cooker. Energy savings are dependent on steam cooker pan capacity and corresponding maximum idle rate at heavy load cooking capacity. ENERGY STAR steam cookers consume less energy than conventional units because of improved insulation and a more efficient steam delivery system. In order to qualify for participation, the installed DERRO'S TAR steam cookers steam delivery system. In order to qualify for participation, the installed DERRO'S TAR steam cooker mast meet the INERGY STAR version 1.2 product specifications, effective August 1, 2003. The energy avaings detailed in this characterization assume that the efficient equipment and baseline equipment have the same capacity (number of pans). Unless otherwise models, the default values inputed into the energy savings algorithms are sourced from the "ENERGY STAR Commercial Kitchen Equipment Calculator - Steam Cooker Calculations (October 2016)".

Program Type Calculation Type: Time of Sale (Market Opportunity) Program Delivery / Implementation Type: Midstream

Baseline Efficiencies The baseline equipment is assumed to be a non-ENERGY STAR, conventional commercial steam cooker.

Efficient Equipment
The efficient equipment is an ENERGY STAR commercial steam cooker, meeting the ENERGY STAR version 1.2 qualifying critera.[1]

Energy Efficiency	Requirements for Electric Steam Cooke	rs
Pan Capacity	Heavy Load Cooking Energy Efficiency	Idle Rate (watts)
3-pan	50%	400
4-pan	50%	530
5-pan	50%	670
6-pan and larger	50%	800
o-pari anu iarger	30%	000

Energy Efficiency	Requirements for Gas Steam Cookers	
Pan Capacity	Heavy Load Cooking Energy Efficiency	Idle Rate (watts)
3-pan	38%	6,250
4-pan	38%	8,350
5-pan	38%	10,400
6-pan and larger	38%	12,500

### Algorithms

∆kWh

Electric Demand Savi	ıgs
ΔkW	= ΔkWh / (Hours × Days)
Symbol Table	
Vater Savings	
ΔCCF	= ((Water <sub>Bose</sub> - Water <sub>EE</sub> ) x Hours x Days) / 748
Symbol Table	
lectric Energy Savin	35
ΔkWh	= $\Delta$ Energy Savings (kWh) × Days
ΔEnergy Savings (kWh	) = ( $\Delta Idle$ Energy + $\Delta Preheat$ Energy + $\Delta Cooking$ Energy)
ΔIdle Energy	$= ((((1 \circ CSM_{NB,Res}) \times Idle_{Rese} + CSM_{NB,Res} \times P_{Ches} \times E_{Food} / Eff_{Base}) \times (Hours - (Food / PC_{Base}) - (FrehealtNamber × 0.2, 5))) - (((1 \circ CSM_{NEE}) \times Idle_{E} + CSM_{NEE} \times PC_{EE} \times E_{Food} / Eff_{EE}) \times (Hours - (Food / PC_{EE}) - (PrehealtNamber × 0.25))))$
∆Preheat Energy	= (Preheats <sub>kumber</sub> × Preheats <sub>wings</sub> )
ΔCooking Energy	$= ((1 \ / \ Eff_{Base}) - (1 \ / \ Eff_{EE})) \times Food \times E_{Food}$
Symbol Table	
ossil Fuel Savings	
ΔMMBtu	= ΔEnergy Savings (MMBtu) / 1,000,000 × Days
/here:	
ΔCCF	<ul> <li>Gross customer annual water savings for the measure</li> </ul>
ΔCooking Energy	<ul> <li>Energy savings associated with the steam cooker's primary cooking function, the duration when it is directly inputted energy into the food product</li> </ul>
∆Energy Savings (kWh)	= Electric daily kWh energy savings
ΔEnergy Savings (MMBtu)	<ul> <li>Fossil fuel daily MMBtu energy savings</li> </ul>
∆Idle Energy	<ul> <li>Energy savings associated with the steam cooker's idle operations, while it is maintaining or holding at a stabilized operating condition or temperature</li> </ul>
ΔkW	<ul> <li>Gross customer connected load kW demand savings</li> </ul>

= Gross customer annual kWh energy savings

ΔMMBtu	<ul> <li>Gross customer annual MMBtu energy savings</li> </ul>
ΔPreheat Energy	<ul> <li>Energy savings associated with the steam cooker's pre-heat cycle</li> </ul>
0.25	<ul> <li>Duration of the preheat cycle in hours<sup>[4]</sup></li> </ul>
1,000,000	= Conversion factor from Blu to MMBtu
748	= Constant to convert from gallons to CCF
CSM <sub>%Base</sub>	<ul> <li>Percentage of time baseline steamer is in manual steam mode</li> </ul>
	= 40%
CSM <sub>%EE</sub>	<ul> <li>Percentage of time efficient steamer is in manual steam mode</li> </ul>
	= 40%
Days	<ul> <li>Number of days per year the commercial steam cooker is operated</li> </ul>
	= 312 days <sup>(3)</sup>
EFood	<ul> <li>Amount of energy absorbed by the food during cooking</li> </ul>
	= 0.0308 kW/lb for electric steam cookers = 105 Btu/lb for gas steam cookers
Eff <sub>Base</sub>	Baseline steamer heavy load cooking efficiency
	= 30% for electric steam cookers = 15% for gas steam cookers
Eff <sub>FF</sub>	
Eπ <sub>EE</sub>	<ul> <li>Efficient steamer heavy load cooking efficiency</li> <li>50% for electric steam cookers</li> </ul>
	= 38% for gas steam cookers
Food	= Quantity of food cookers per day
1000	= 100 lbs/day
Hours	= Daily operating hours per day
	= 12 hours
Idle <sub>Base</sub>	<ul> <li>Baseline steam cooker idle energy rate. See tables below for default values depending on equipment capacity</li> </ul>
	(number of pans) and fuel type.
Idle <sub>EE</sub>	<ul> <li>Efficient steam cooker idle energy rate. See tables below for default values depending on equipment capacity (number of pans) and fuel type.</li> </ul>
PCBase	<ul> <li>Baseline steam cooker production capacity. See tables below for default values depending on equipment capacity (number of pans) and fuel type.</li> </ul>
PCEE	= Efficient steam cooker production capacity. See tables below for default values depending on equipment capacity
	(number of pans) and fuel type.
Preheat <sub>Number</sub>	<ul> <li>Number of preheat cycles per day</li> </ul>
	= 1
Preheatsavings	<ul> <li>Preheat energy savings per preheat cycle</li> </ul>
	= 0.5 kWh/day for electric steam cookers
	= 11,000 Btu/day for gas steam cookers
WaterBase	<ul> <li>Water consumption rate of the baseline steam cooker in gallons per hour. See tables below for default values depending on equipment capacity (number of pans) and fuel type.</li> </ul>
Water <sub>EE</sub>	<ul> <li>Water consumption rate of the efficient steam cooker in gallons per hour. See tables below for default values depending on equipment capacity (number of pans) and fuel type.</li> </ul>
	acpointing on equipment dipacity (number or parts) and role type.

## Default Algorithm Values

Idle<sub>Base</sub>

Number of Pans	Gas Idle	Electric Id
3	11,000	1.00
4	14,667	1.33
5	18,333	1.67
6	22,000	2.00
Unknown <sup>[2]</sup>	21,542	1.70

### PCBase

Number of Pans	Gas PC	Electric P
per pan	23.3	23.3
3	69.9	69.9
4	93.2	93.2
5	116.5	116.5
6	139.8	139.8
Unknown <sup>[2]</sup>	136.9	118.8

### Idle<sub>EE</sub>

Number of Pans	Gas Idle	Electric Idle
3	6,250	0.40
4	8,333	0.53
5	10,417	0.67
6	12,500	0.80
Unknown <sup>[2]</sup>	12,240	0.68

## PCEE

Gas PC	Electric PC
20.0	16.7
60.0	50.1
80.0	66.8
100.0	83.5
120.0	100.2
117.5	85.2
	20.0 60.0 80.0 100.0 120.0

### WaterBase

Number of Pans	Gas Water Rate (GPH)	Electric Water Rate (GPH)
per pan	5.83	5.83
3	17.49	17.49
4	23.32	23.32
5	29.15	29.15
6	34.98	34.98
Unknown <sup>[2]</sup>	34.25	29.73

Waterer

Number of Deser							
Number of Pans	Gas Water Rate	e (GPH) Electr	ic Water Rate (GPH)				
per pan	0.51	0.40					
3	1.53	1.20					
4	2.04	1.60					
5	2.55	2.00					
6	3.06	2.40					
Unknown[2]	3.00	2.04					
Load Shape 90b Restaurant In							
Number	Name		Winter Winter On kWh Off kWh		r Winter Summer h kW kW		
90 Restau	urant Indoor Ligh	tina Active	40.7% 25.7%	20.2% 13.4%	63.0% 77.0%		
-	se track] Upstre		cial ode Free Rider Spill	Over			
6013UPST (is ba	se track] Upstre	. Measure Co		Over			
6013UPST [is ba	se track] Upstre	. Measure Co	ode Free Rider Spill	Over			
6013UPST [is ba	se track] Upstre	. Measure Co	ode Free Rider Spill	Over			
6013UPST [is ba Track Nam Upstream - Comr Lifetimes	se track] Upstre e Track Nr mercial 6013UPS	. Measure Co T CKLSTEAM	ode Free Rider Spill				
Track Nam Upstream - Comr Lifetimes	se track] Upstre e Track Nr mercial 6013UPS	. Measure Co T CKLSTEAM	ode Free Rider Spill				
6013UPST [is ba Track Nam Upstream - Comr Lifetimes The expected mea Measure Co	e Track] Upstre e Track Nr mercial 6013UPS <sup>-</sup> asure life of a co	Measure Co	m cooker is 12 years	(5)	tural gas steam cooke	r5,[6]	
6013UPST [is ba Track Nam Upstream - Comr Lifetimes The expected mea Measure Co	e Track] Upstre e Track Nr mercial 6013UPS <sup>-</sup> asure life of a co	Measure Co	m cooker is 12 years	(5)	tural gas steam cooke	rs.(6)	
6013UPST [is ba Track Nam Upstream - Comr Lifetimes The expected mea Measure Co	e Track N mercial 6013UPS <sup>-</sup> asure life of a co ost remental cost is s Tables	Measure Co CKLSTEAM	m cooker is 12 years	(5)	tural gas steam cooke	rs.(6)	
6013UPST [is ba Track Nam Upstream - Comr Lifetimes The expected mea Measure CC The assumed incr Reference	e Track N mercial 6013UPS <sup>-</sup> asure life of a co ost remental cost is s Tables	Measure Co CKLSTEAM mmercial stear 53400 for an el	m cooker is 12 years	(5) and \$2270 for a nat	tural gas steam cooke	ng.(4)	
6013UPST (is ba Track Nam Upstream - Com Lifetimes The expected mea Measure Co The assumed incr Reference : Deemed Energy	e Track N mercial 6013UPS asure life of a co ost emental cost is s and Demand S Electric Steam	Measure Co T CRLSTEAM mmercial stear \$3400 for an el savings Cooker	de Free Rider Spill 1.00 1.00 m cooker is 12 years lectric steam cooker	(5) and \$2270 for a nat	-	<b>15</b> (0)	
6013UPST (is ba Track Nam Upstream - Com Lifetimes The expected mea Measure Co The assumed incr Reference : Deemed Energy	e Track N mercial 6013UPS asure life of a co ost emental cost is s and Demand S Electric Steam	Measure Co T CRLSTEAM mmercial stear \$3400 for an el savings Cooker	de Free Rider Spill 1.00 1.00 m cooker is 12 years lectric steam cooker	(5) and \$2270 for a nat	pane Steam Cooker	<b>rs</b> (0	
6013UPST (is ba Track Nam Upstream - Comr Lifetimes The expected men Measure Co Measure Co Reference Reference Reference Number of Pans	e Track N e Trac	Measure Co T CRLSTEAM mmercial steam 53400 for an el 53400 for an el	m cooker is 12 years electric steam cooker Water Savings (ccf	(5) and \$2270 for a nal Natural Gas / Pro	pane Steam Cooker Water Savings (ccf)	75 (Q	
6013UPST (is ba Track Nam Upstream - Com Lifetimes The expected me Measure Co The assumed incr Reference Deemed Energy Number of Pans 3	e Track N postre mercial 6013UPS' asure life of a co ost emental cost is \$ Tables and Demand S Electric Steam ( AWMh Savings 8,112	Measure Co T CRLSTEAM mmercial steam 53400 for an el savings Cooker AW Savings 2.1667	de Free Rider Spill 1.00 1.00 m cooker is 12 years lectric steam cooker Water Savings (ccf 81.5	(5) and \$2270 for a nat Natural Gas / Pro AMMBu Savings 68.3	pane Steam Cooker Water Savings (ccf) 79.9	<b>5</b> (6)	
6013UPST (is ba Track Nam Upstream - Comr Lifetimes The expected mea Measure CC The assumed incr Reference - Seemed Energy Number of Pans 3 4	e Track N mercial 6013UPS asure life of a co ost Tables and Demand S Electric Steam dXWh Savings 8,112 10,546	Measure Co T CRLSTEAM mmercial stear 53400 for an el 53400 for an el 6400 for an	de Pree Rider Spill 1.00 1.00 m cooker is 12 years lectric steam cooker Water Savings (cdf 81.5 108.7	(5) Natural Gas / Pro AMMEU Savings 87.6	pane Steam Cooker Water Savings (ccf) 79.9 106.5	75.(0)	

## Item Codes

Number of Pans	Electric Steam Cooker	Natural Gas Steam Cooker	Propane Steam Cooker
3	CKE-STEAM-E3	CKE-STEAM-NG3	CKE-STEAM-PG3
4	CKE-STEAM-E4	CKE-STEAM-NG4	CKE-STEAM-PG4
5	CKE-STEAM-E5	CKE-STEAM-NG5	CKE-STEAM-PG5
6+	CKE-STEAM-E6	CKE-STEAM-NG6	CKE-STEAM-PG6
Unknown	CKE-STEAM-EUNK	CKE-STEAM-NGUNK	CKE-STEAM-PUNK

Footnotes
[1] ENERGY STAR Product Specifications for Commercial Steam Cooker, v1.2, effective August 2003.

[2] The unknown cateogry is based on a weighted average of available products on the ENERGY STAR, "Commercial Steam Cookers Qualified Products List," as accessed on January 23, 2018

[3] The number of days per year is based on the assumption that the restaurant will be open six out of seven days per week

[4] Pacific Gas and Electric, "Commercial Steam Cookers, Food Service Equipment Workpaper PGECOFST104 R6," 2016

[5] The measure life is sourced from the ENERGY STAR Commercial Kitchen Equipment Calculator - Steam Cooker Calculations (October 2016).

[6] The incremental cost is sourced from the ENERGY STAR Commercial Kitchen Equipment Calculator - Steam Cooker Calculations (October 2016).

## **ENERGY STAR Combination Oven**

Measure Number: CC+KTH+COMB a Portfolio: Status: Active Effective Date: 2020/1/1 End Date: [None] Program: Commercial & Industrial End Use: Kitchen Equipment

Update Summary This is version one of the TRM characterization

Referenced Documents Linked below are the FNERGY STAR® Program Requirements Product Specification for Commercial Overs, Eligibility Criteria Version 2.2, which define the efficient and eligible equipment and the Savings Calculator for ENERGY STAR Certified Commercial Kitchen Equipment, from which impact algorith and assumptions are referenced.

Commercial Ovens Final Version 2.2
 commercial\_kitchen\_equipment\_calculator\_Combi

### Description

A combination oven is a device that combines the function of hot air convection (oven mode), saturated and superheated steam heating (steam mode), and combination convection/steam mode for moist heating, to perform steaming, baking, roasting, rethermalizing, and proofing of various food products. In general, the term combination oven is used to describe this type of equipment, which is self-contained. The combination oven is also referred to as a combination equivalence combination oven.

Half- and full-size gas combination overs with a pan capacity  $\geq$  6; and half- and full-size electric combination overs with a pan capacity  $\geq$  5 and  $\leq$  20 are eligible for DRENG TARE certification by achieving both convection mode and steam mode side and cooking energy efficiency levels. Cooking energy efficiency represents the anount of energy absorbed by the food product compared to the total energy used by the oven during the cooking process. The idle energy rate represents the energy used by the oven while it is maintaining or holding at a stabilized temperature.

Combination ovens are commonly classified and referred to by size category:

Half-Size Combination Oven: A combination oven capable of accommodating a single 12 x 20 x 2 ½-inch steam table pan per rack position, loaded from front-to-back or lengthwise. Full-Size Combination Oven: A combination oven capable of accommodating two 12 x 20 x 2 ½-inch steam table pans per rack pos side, from front-to-back or lengthwise.

2/3-Size Combination Oven: A combination oven capable of accommodating a single 12 x 10 x 2 ½-inch steam table pan per rack position, lo front-to-back or lengthwise.

Note: 2/3-size combination ovens are ineligible for ENERGY STAR certification, as are gas (natural or propane) combination ovens with a pan capacity of < 6 and electric combination ovens with a pan capacity < 5 and > 20.

This measure is an eligible combination oven that has achieved ENERGY STAR certification by meeting Version 2.2 eligibility criteria.

## Program Type <u>Calculation</u>: Time of Sale (Market Opportunity)

Program Delivery / Implementation Type: Mid stream

This characterization was developed for measure implementation by way of a midstream program with commercial kitchen equipment dealers Units rebated through the program will map to one of the fifteen products summarized in the Reference Tables section below.

### **Baseline Efficiencies**

The baseline condition is a combination oven (electric, natural gas, or propane) that is not ENERGY STAR certified.

## Efficient Equipment

nation oven (electric, natural gas, or propane) that has achieved ENERGY STAR certification by meeting Version The efficient condition 2.2 eligibility criteria.<sup>[1]</sup>

Algorithms Electric Demand Savings Intuitively and as suggested by the algorithm for energy savings, instantaneous electric demand is not constant during the operation of a combination one - demand is higher during times of cooking compared to idle. However, in an upstream program model, specific unit use patterns will be not be known. To align with the savings loadshape choice for commercial cooking equipment - 900 Restaurant Indoor Lighting - which assumes consistent instantaneous demand savings, demand savings for a combination oven is estimated as the average over the entire operational period.

Symbol Table

ectric Energy Savings	
∆kWh	$= ((Idle_{Base} - Idle_{EStar}) + (Cooking_{Base} - Cooking_{EStar})) / 1,000 \times Days$
dle <sub>Base</sub>	$= ConvectionIdle_{Base} + SteamIdle_{Base}$
ooking <sub>Base</sub>	= ConvectionCooking_Base + SteamCooking_Base
e <sub>EStar</sub>	$= ConvectionIdle_{EStar} + SteamIdle_{EStar}$
oking <sub>EStar</sub>	$= ConvectionCooking_{EStar} + SteamCooking_{EStar}$
eRate <sub>EStar</sub>	= A × Pans + B
amCooking <sub>Base</sub>	= Steam $\times$ Food $\times$ $E_{Food}$ / $Eff_{Base}$
vectionCooking <sub>Base</sub>	= Convection $\times$ Food $\times$ $E_{Food}$ / $Eff_{Base}$
amCooking <sub>EStar</sub>	= Steam × Food × $E_{Food}$ / Eff <sub>EStar</sub>
rvectionCooking <sub>EStar</sub>	= Convection $\times$ Food $\times$ $E_{Food}$ / Eff_Estar
amIdle <sub>Base</sub>	$= Steam \times IdleRate_{Base} \times (Hours - (Food / Capacity_{Base}))$
nvectionIdle <sub>Base</sub>	$= Convection \times IdleRate_{Base} \times (Hours - (Food / Capacity_{Base}))$
amIdle <sub>EStar</sub>	= Steam $\times$ IdleRate <sub>EStar</sub> $\times$ (Hours - (Food / Capacity <sub>EStar</sub> ))
wectionIdle <sub>EStar</sub>	= Convection × IdleRate <sub>EStar</sub> × (Hours - (Food / Capacity <sub>EStar</sub> ))

mbol Table sil Fuel Savings						
	llea~	e - Idle <sub>EStar</sub> ) + (Cool	king <sub>Base</sub> - Cooking <sub>ESt</sub>	tar)) / 1,000.0	100 × Days	
mbol Table ter Savings						
vater savings are expected.						
re:						
ΔkW	-	Gross electric dem	and savings (kW).			
ΔkWh	-	Gross annual elect	ric energy savings (	kWh).		
ΔMMBtu	-	Gross annual natu	ral gas or propane e	energy saving	s (MMBtu).	
1,000,000	-	Conversion factor,	from Btu to MMBtu.			
1,000	-	Conversion factor,	from W to kW.			
A	-		ent on energy sourci ropane equipment).		on mode. Units	are Watts (electric equipment) or Btu/hour
		Energy Source	Operation Mode	A[3]	1	
		Electric	Steam	133 Watts		
			Convection	80 Watts		
		Gas*	Steam	200 Btu/hou		
		*Includes both nat	Convection tual gas and propan	150 Btu/hou e	IF	
В	-	Adder, dependent gas and propane e		nd operation	mode. Units are	Watts (electric equipment) or Btu/hour (natural
		= Energy Source	Operation Mode	B[3]	1	
		Energy Source Electric	Operation Mode Steam	640 Watts		
			Convection	498.9 Watts	_	
		Gas*	Steam	6,511 Btu/h		
		*Includes both pat	Convection tual gas and propan	5,425 Btu/h e	our	
Capacity <sub>Base</sub>	_				/hour Depende	nt on energy source, operation mode and pan
CapacityBase	-	capacity.	y or baseline unit. o		, ioui : Depende	in on energy source, operation mode and part
		Energy Source		Pans	Capacity	3ase <sup>(4)</sup>
		Electric	Steam	< 15 ≥ 15	126	
			Convection	< 15	79	
				≥ 15	166	
		Gas*	Steam	< 15 ≥15 and <3	195 0 211	
				≥15 and <3 ≥ 30	579	
			Convection	< 15	125	
				≥15 and <3		
		*Includes both nat	tual gas and propan	≥ 30 e	392	
Capacity <sub>EStar</sub>	-	Production capacit mode and pan cap		ertified unit.	Units are in lbs/	hour. Dependent on energy source, operation
		= Energy Source	Operation Mode	Pans	CapacityEst	ariq
		Electric	Steam	< 15	177	arva
				≥ 15	349	
			Convection	< 15	119	
		Gas*	Steam	≥ 15 < 15	201 172	
		385	Steam	< 15 ≥15 and <3		
				≥ 30	640	
			Convection	< 15	124	
				≥15 and <3 ≥ 30	0 210 394	
		*Includes both nat	tual gas and propan		557	
Convection	-	Percentage of food = 50% <sup>[4]</sup>	d cooked in convection	on mode.		
		hours (electric equ	uipment) or Btu (nati	ural gas and	propane equipm	
ConvectionCooking <sub>EStar</sub>		are Watt-hours (el	lectric equipment) o	r Btu (natural	gas and propar	hile operating in convection mode. Units ne equipment).
ConvectionIdle <sub>EStar</sub>		equipment) or Btu Daily idle energy o	(natural gas and pro	opane equipr	nent). tified unit while	operating in convection mode. Units are Watt-
Cooking <sub>Base</sub>	-					ient). nours (electric equipment) or Btu (natural gas
Cooking <sub>EStar</sub>	-	Daily cooking ener			certified unit. U	Inits are Watt-hours (electric equipment) or Btu
Days	•	Annual days the co = 312 days/year <sup>[5]</sup>	onvection oven is in	operation.		
EFood	-					Vatts-hours/lbs (electric equipment) or y source and operation mode.
		Energy Source	Operation Mode Steam	3	EFood <sup>[4]</sup> 30.8 Wh/lbs	
			Convection	1	73.2 Wh/lbs	

			1			1	
		Gas*	Steam Convection		105 Btu/lbs 250 Btu/lbs		
		*Includes both nat	tual gas and propar		2 30 Blu/IDS	J	
Eff <sub>Base</sub>	-		rcentage of energy				arted to the specified load, int. Dependent on energy sour
		Energy Source	Operation Mode	e Eff <sub>Base</sub> [6]			
		Liccure	Convection	72%			
		Gas*	Steam	39%			
		*Includes both nat	Convection tual gas and propar	52% ne			
Eff <sub>EStar</sub>	-	Cooking energy ef	ficiency of ENERGY pressed as a percer	STAR certified			of energy imparted to the the cooking event. Dependent
		1	Operation Mode	1			
		Electric	Steam Convection	55% 76%			
		Gas*	Steam	41%			
			Convection	56%			
			tual gas and propar				
Food		Pounds of food co	oked per day (lbs).	Dependent or	n energy source	and pan capacity	
		Energy Source	Pan Capacity	ood <sup>[4]</sup>			
		Electric		100			
				:50			
		Gas*		100			
			≥ 30 4	100			
			tual gas and propar	ne			
Hours	-	Operating hours p					
7.41.		= 12 hours/day. <sup>[2]</sup>			11-24	have the	
Idle <sub>Base</sub> Idle <sub>EStar</sub>		and propane equip	oment).				equipment) or Btu (natural gas ours (electric equipment) or E
LICES LA			ropane equipment;			one are maan	ours (create equipment) or a
		pan capacity.	Operation Mode	1	Idles	<sub>ise</sub> [6]	y source, operation mode and
		Electric	Steam	< 15 ≥ 15		(Watts) (Watts)	
			Convection	< 15	1,320	(Watts)	
				≥ 15	2,280	(Watts)	
		C*	Channel	1.45			
		Gas*	Steam	< 15 ≥15 and <3	18,65	5 (Btu/hour) 2 (Btu/hour)	
		Gas*	Steam	1	18,65 30 24,56		
		Gas*	Steam Convection	≥15 and <3 ≥ 30 < 15	18,65 30 24,56 43,30 8,747	2 (Btu/hour) D (Btu/hour) (Btu/hour)	
		Gas*		≥15 and <3 ≥ 30	18,65 24,56 43,30 8,747 30 7,823	2 (Btu/hour) D (Btu/hour) (Btu/hour) (Btu/hour)	
				≥15 and <3 ≥ 30 < 15 ≥15 and <3 ≥ 30	18,65 24,56 43,30 8,747 30 7,823	2 (Btu/hour) D (Btu/hour) (Btu/hour)	
IdleRate <sub>EStar</sub>	-	*Includes both nat Idle energy rate of maintaining or hol are Watts (electric operation mode ar	Convection ual gas and propai FENERGY STAR cer ding at a stabilized equipment) or Bu nd pan capacity.	≥15 and <3 ≥ 30 < 15 ≥15 and <3 ≥ 15 and <3 ≥ 30 retified unit. Idk operating con yhour (natura	18,65           30         24,56           43,30         8,747           30         7,823           13,00         13,00           e energy rate is dition or tempel gas and propagation         10,00	2 (Btu/hour) 0 (Btu/hour) (Btu/hour) 0 (Btu/hour) 0 (Btu/hour) 10 (Btu/hour) the rate of oven rature. Also calle ne equipment). D	energy consumption while it i d standby energy rate. Units bependent on energy source, mmoniate as per the &STM F-
IdleRate <sub>EStar</sub> Pans	•	*Includes both nat Maintaining or hol are Watts (electric operation mode as Pan capacity, the t 1495-05 standard In addition to ener efficiency and idle For the purpose of the following table	Convection Lual gas and propan equipment of the set of the set of the equipment of the set of the set of the specification. Unumber of steam to specification. I daiming savings, This approach sta	≥15 and <2 ≥ 30 < 15 ≥15 and <2 ≥ 30 re tified unit. Idl operating con /hour (natura able pans the or ration mode, E ements are de pan capacity n ikes a balance	18,65 30 24,56 43,30 6,747 30 7,823 13,00 e energy rate is dition or tempe g gas and prope combination over ENERGY STAR s tetermined by pa anges and dee a with granulari	2 (Bu/hour) 3 (Bu/hour) 3 (Bu/hour) (Bu/hour) (Bu/hour) 0 (Bu/hour) 0 (Bu/hour) 0 (Bu/hour) 0 (Bu/hour) 10 (Bu/hour) 1	d standby energy rate. Units Rependent on energy source, mmodate as per the ASTM F- stablishing cooking energy continuous function. se in algotitms) are used per implementability.
		*Includes both nat lafe energy rate of maintaining or holi are Watts (electric operation mode ar electric are water and and a addition to ener efficiency and idle refores y and idle For the purpose of the following table Aker that capacity assignments were	Convection Last gas and propan (* BERGY 5 TAR car ding at a stabilized equipment) or Base and pan capacity. Number of steam ta specification. gy source and open energy rate requir (daming savings). This approach sta ranges and demen made based on the made based on the made based on the made based on the specification.	≥15 and <3 ≥ 30 < 15 ≥15 and <3 ≥ 30 ≥ 30 re tified unit. Idit operating con operating con operating con operating con operating con operating con operating con operating con operating con tified unit. Idit operating con operating con oper	18,65 18,65 13,00 8,747 30 7,823 13,00 13,00 13,00 13,00 13,00 13,00 13,00 13,00 13,00 13,00 13,00 13,00 13,00 13,00 13,00 13,00 14,566 14,566 14,	2 (Bu/hour) 3 (Bu/hour) 3 (Bu/hour) (Bu/hour) (Bu/hour) 1 (Bu/hour) 1 (Bu/hou	d standby energy rate. Units Dependent on energy source, mmodate as per the ASTM F- establishing cooking energy continuous function. see in algoithms) are used per
	•	*Includes both nal life energy rate of maintaining or hol are VHats (electric are VHats (electric are VHats (electric are VHats (electric are VHATs (electric Par capacity, the 1495-05 standard In addition to ener efficiency and ide The of the purpose of the following table <i>Note that capacity</i> assignments were weighted in certita	Convection Lual gas and propan ENERGY STAR cast ding at a stabilized equipment of Ba di pan capacity. This approach star and deams and deams made based on the ranges and deams in ranges and deams in ranges and deams	≥15 and <3 ≥ 30 < 15 ≥15 and <3 ≥ 30 > 30 > 30 > 30 > 30 > 30 > 30 > 30 >	18,65 30 24,56 43,30 8,747 30 7,823 13,00 e energy rate is energy rate is energy rate is and prope gas and prope gas and prope combination or temp stermined by pa ranges and dees a with granulari ot necessarily in ( ENERGY STAR	2 (Bu/hour) 3 (Bu/hour) 3 (Bu/hour) (Bu/hour) (Bu/hour) 1 (Bu/hour) 1 (Bu/hou	d standby energy rate. Units bependent on energy source, mmodate as per the ASTM F- establishing cooking energy continuous function. see in algoithms) are used per implementability.
		*Includes both nat lafe energy rate of maintaining or holi are Watts (electric operation mode ar electric are water and and a addition to ener efficiency and idle refores y and idle For the purpose of the following table Aker that capacity assignments were	Convection Lual gas and propan ENERGY STAR cast ding at a stabilized equipment of Ba di pan capacity. This approach star and deams and deams made based on the ranges and deams in ranges and deams in ranges and deams	≥15 and <2 ≥ 30 < 15 ≥15 and <2 ≥ 30 < 15 ≥ 15 and <2 ≥ 30 view of the second	18,65 18,65 13,00 8,747 30 7,823 13,00 13,00 13,00 13,00 13,00 13,00 13,00 13,00 13,00 13,00 13,00 13,00 13,00 13,00 13,00 13,00 14,566 14,566 14,	2 (Bu/hour) 3 (Bu/hour) 3 (Bu/hour) (Bu/hour) (Bu/hour) 1 (Bu/hour) 1 (Bu/hou	d standby energy rate. Units bependent on energy source, mmodate as per the ASTM F- establishing cooking energy continuous function. see in algoithms) are used per implementability.
	•	*Includes both nat Idle energy rate of maintaining or hol maintaining or hol peration mode an Pan capacity, the i 1495-05 standard In addition to ener efficiency and life for the purpose of the following table Able that capacity assignments were weighted in cetta Energy Source	Convection Lal gas and propan ENERGY STAR cer (in gas and propan ENERGY STAR cer (in gas a stabilized equipment) or Bits (in gas a stabilized equipment) or Bits (in gas and energy rate requir (in gas and eng) eng) eng) eng) eng) eng) eng) eng)	≥15 and <2 ≥ 30 < 15 ≥ 15 and <2 ≥ 30 re tified unit. Idle operating con /hour (natura) while pans the or ration mode, f ements are de pan capacity r likes a balance of values do n e actual list or cities. Cat y Range 8 10	18,65           24,56           43,30           8,747           30         7,823           13,00           e energy rate is iddition or temper id gas and propa           combination or ways energy rate is energy	2 (Bu/hour) 3 (Bu/hour) 3 (Bu/hour) (Bu/hour) (Bu/hour) 1 (Bu/hour) 1 (Bu/hou	d standby energy rate. Units bependent on energy source, mmodate as per the ASTM F- establishing cooking energy continuous function. see in algoithms) are used per implementability.
		*Includes both nat Idle energy rate of maintaining or hol maintaining or hol peration mode an Pan capacity, the i 1495-05 standard In addition to ener efficiency and life for the purpose of the following table Able that capacity assignments were weighted in cetta Energy Source	Convection Later and proper Letter of the REGY STAR car Le	≥15 and <2 ≥ 30 < 15 ≥15 and <2 ≥ 30 and <15 ≥ 15 and <2 ≥ 30 and vertified unit. Idli operating con thour (natura whour (natura) whour (nat	18,65           30         24,56           43,30         8,747           80         7,823           13,00         7,823           13,00         13,00           comparison of temperature         10           gas and proparation         10           10         12	2 (Bu/hour) 3 (Bu/hour) 3 (Bu/hour) (Bu/hour) (Bu/hour) 1 (Bu/hour) 1 (Bu/hou	d standby energy rate. Units bependent on energy source, mmodate as per the ASTM F- establishing cooking energy continuous function. see in algoithms) are used per implementability.
	•	*Includes both nat Idle energy rate of maintaining or hol maintaining or hol peration mode an Pan capacity, the i 1495-05 standard In addition to ener efficiency and life for the purpose of the following table Able that capacity assignments were weighted in cetta Energy Source	Convection Lal gas and propan ENERGY STAR cer (in gas and propan ENERGY STAR cer (in gas a stabilized equipment) or Bits (in gas a stabilized equipment) or Bits (in gas and energy rate requir (in gas and eng) eng) eng) eng) eng) eng) eng) eng)	≥15 and <2 ≥ 30 < 15 ≥ 15 and <2 ≥ 30 retrified unit. Idle operating con thour (natura able pans the or ration mode, £ ements are de pan capacity pr ikkes a balance dr values do n e actual ist or rities.	18,65           18,65           18,65           13,00           8,747           30           7,823           13,00           13,00           e energy rate is iddition or tempe ig gas and propa           combination or way           exempt rate is energy rate is energy rate is energy rate is energy rate is anges and deere with <i>greanulari</i> of <i>energy strake</i> Pans           6           10	2 (Bu/hour) 3 (Bu/hour) 3 (Bu/hour) (Bu/hour) (Bu/hour) 1 (Bu/hour) 1 (Bu/hou	d standby energy rate. Units bependent on energy source, mmodate as per the ASTM F- establishing cooking energy continuous function. see in algoithms) are used per implementability.
	-	*Includes both nat Idle energy rate of maintaining or hol maintaining or hol peration mode an Pan capacity, the i 1495-05 standard In addition to ener efficiency and life for the purpose of the following table Able that capacity assignments were weighted in cetta Energy Source	Convection  Convection  Lati gas and propan  (ENERGY STAR cer  (initial gas and propan  (initial gas and gas	≥15 and <3     ≥30			
		*Includes both nat Idle energy rate of maintaining on the maintaining on the rate Vatts (electric operation mode at 1495-05 standard 1495-05 standard Pan capacity, the Pan capacity, the efficiency and the ficinery and the the following table Able that capacity assignments were weighted in cettal Energy Source Electric	Convection Last gas and propan EXERGY STAR card and gas and propan EXERGY STAR card and gas and propan equipment) or flag at a stabilized equipment) or flag at a stabilized equipment) or flag at a stabilized equipment of flag at a stabilized eq	≥15 and <2     ≥30	18,65           30         24,55           43,30         8,747           80         7,823           31,00         7,823           30         7,823           13,00         8,747           combination over temperation over temperating tempera	2 (Bu/hour) 3 (Bu/hour) 3 (Bu/hour) (Bu/hour) (Bu/hour) 1 (Bu/hour) 1 (Bu/hou	d standby energy rate. Units bependent on energy source, mmodate as per the ASTM F- establishing cooking energy continuous function. see in algoithms) are used per implementability.
	-	*Includes both nat Idle energy rate of maintaining on the maintaining on the rate Vatts (electric operation mode at 1495-05 standard 1495-05 standard Pan capacity, the Pan capacity, the efficiency and the ficinery and the the following table Able that capacity assignments were weighted in cettal Energy Source Electric	Convection  Convection  ENERGY STAR cc  and gas and propan  ENERGY STAR cc  and gas and propan  ENERGY STAR cc  and gas and propan  energy reate recails  f claiming savings,  This approach st  angles and cc  panety reate recails  Pan Capa  Pan Capa Pan Ca	≥15 and <3     ≥30	18,65           18,65           24,56           43,30           8,747           30           7,823           31,000           eenergy rate is idition or tempe gas and proparation over sentermined by parages and dee with granulario to necessarily or necessarily renergy strate 6           Pans           6           10           12           14           20           9	2 (Bu/hour) 3 (Bu/hour) 3 (Bu/hour) (Bu/hour) (Bu/hour) 1 (Bu/hour) 1 (Bu/hou	d standby energy rate. Units bependent on energy source, mmodate as per the ASTM F- establishing cooking energy continuous function. see in algoithms) are used per implementability.
	-	*Includes both nel Idle energy rate of maintaining on bio- maintaining on bio- new tasks (electric operation mode ai 1495-05 standard In addition to ener efficiency and idle For the purpose of the following table Are that capazito assignments were weighted in certia Energy Source Electric Gas*	Convection Convection EXERCY STAR cc diagram and propara EXERCY STAR cc diagram and propara EXERCY STAR cc diagram and propara exercited and a stability and a stability as solution of statem to a stability and a stability and a stability as every rate require t claiming swings. This approach st arranges and dense exercited and a stability and a stability and a stability as a sta	≥15 and <2     ≥3	18,65           30         24,56           43,30         8,747           80         7,823           30         7,823           30         7,823           31,000         8,8747           80         7,823           31,3,00         8,8747           combination ov tempping ig as and proping in the proproproping in the proproproping in the proproproping i	2 (Bu/hour) 3 (Bu/hour) 3 (Bu/hour) (Bu/hour) (Bu/hour) 1 (Bu/hour) 1 (Bu/hou	d standby energy rate. Units bependent on energy source, mmodate as per the ASTM F- establishing cooking energy continuous function. see in algoithms) are used per implementability.
	•	*Includes both nal Idle energy rate of minitariang or hold are VAtis (electric operation mode an Pan capacity, the r 1456 of standard In addition to ener- efficiency and idle the following table Able that capacity assignments were weighted in certain Energy Source Bectric Gas* *Includes both nal Percentage of foco	Convection  Convection  ENERGY STAR cc  and gas and propan  ENERGY STAR cc  and gas and propan  ENERGY STAR cc  and gas and propan  equipment) or Bit  and a stabilized  equipment) or Bit  and pan capacity.  This approach st  and capacity  f claiming savings.  This approach st  and capacity  Pan Capa  A st  and capacity  Pan Capa  A st  and capacity  A st  A	≥15 and <2     ≥3     3	18,65           30         24,56           43,30         8,747           80         7,823           30         7,823           30         7,823           31,000         13,000           combination or temped         13,000           combination or temped         14,000           combination or temped         14,000           combination or temped         10,000           combination or temped         12,000           10         12           14         20           9         14           20         32	2 (Bu/hour) 3 (Bu/hour) 3 (Bu/hour) (Bu/hour) (Bu/hour) 1 (Bu/hour) 1 (Bu/hou	d standby energy rate. Units bependent on energy source, mmodate as per the ASTM F- establishing cooking energy continuous function. see in algoithms) are used per implementability.
Pans	-	*Includes both nal life energy rate of maintaining or hold maintaining or hold are Vatific (electric operation mode an Pan capacity, the r 1495-05 standard In addition to ener efficiency and idle the following table Able that capacity assignments were weighted in certai Energy Source Bectric Gas* *Includes both nal Percentage of foco = 50% <sup>(4)</sup>	Convection EXERCY STAR cc diag as and propan EXERCY STAR cc diag at a stabilized equipment) or BLs diag at a stabilized equipment) or BLs diag at a stabilized equipment) or BLs equipment) or BLs equipment e	≥15 and <2     ≥30	18,65           30         24,55           43,30         8,747           80         7,823           13,00         7,823           13,00         8,747           20         7,823           13,00         13,00           combination or temps         13,00           combination or temps         14           combination over the second of the	2 (Bu/hour) 3 (Bu/hour) 3 (Bu/hour) (Bu/hour) 4 (Bu/hour) 4 (Bu/hour) 4 the rate of oven rature. Asso called and a statume. Asso called and a statume. Asso called and a statume. Asso pecifications for on a capacity via a control of the statume of the statume of the statume of the statume of the statume statume of the statume of the statume and the statume of the statume of the statume statume of the statume of the statume of the statume statume of the statume of the statume of the statume of the statume statume of the statume of the sta	d standby energy rate. Units bependent on energy source, mmodate as per the ASTM F- establishing cooking energy continuous function. see in algoithms) are used per implementability.
Pans Pans Steam SteamCookingtuse	-	*Includes both nat Idle energy rate of maintaining on the maintaining on the Pan capacity, the Pan capa	Convection  Convection  ENERGY STAR cc diagram  FEREGY STAR cc diagram  FEREGY STAR cc diagram  FEREGY STAR cc diagram  FEREGY and regard  and capacity  specification.  y source and ope energy retar regard  f claiming savings,  . This approach st arranges and demonstrates  FEREGY and regard  FEREG	≥15 and <3     ≥30	18,65           18,65           24,56           43,30           8,747           30           7,823           31,000           cenergy rate is sidilion or temple (gas and propared) (gas and propared) (gas and propared) (gas and propared) (gas and dee) (gas and d	2 (Bu/hour) 2 (Bu/hour) 2 (Bu/hour) 2 (Bu/hour) 2 (Bu/hour) 3 (Bu/hour) 4 (Bu/hour) 5 (Bu	d standby energy rate. Units lependent on energy source, mmodate as per the ASTM F- stabilishing cooking energy continuous function. see in algoithms) are used per mighementabilix. <i>this is due to the fact that</i> <i>ent, which is more heavily</i> uhits are Watt-hours (electric
Pans	-	*Includes both nel *Includes both nel ilite energy rate of maintaining on bin maintaining on bin maintaining on bin rate Vatak (electric operation mode ai 1495-05 standard In addition to ener efficiency and idle For the purpose of the following table Are that capacity assignments were weighted in certai Renergy Source Electric Gas*  *Includes both nel Percentage of foce = 50%(-1) Daily cooking ener hours (electric equipment) of Bu	Convection Convection EXERCY STAR credition EXERCY STAR credition and gas and propara EXERCY STAR credition and a stabilized equipment) or Bits of staam ta based on ta percent stability and based on the percent stability and based on ta percent stability and ta percent stability	≥15 and <2 ≥ 30 < 15 ≥15 and <7 ≥ 30 ≥ 15 and <7 ≥ 30 ≥ 15 and <7 ≥ 30 ≈ titled unit. Idl operating con operating con operatin	18,65           18,65           24,56           43,30           6,747           30         7,823           13,00           combination over temperating and deere with granular           eventy STAR steemined by parages and deere with granular           vittig and the steemined by parages and deere with granular           9           12           14           20           9           14           20           32           40           while operating ment).           certified unit v propane equip	2 (Bu/hour) 2 (Bu/hour) 2 (Bu/hour) 2 (Bu/hour) 2 (Bu/hour) 2 (Bu/hour) 1 (Bu	d standby energy rate. Units Rependent on energy source, mmodate as per the ASTM F- stabilishing cooking energy ontinuous function. se in algoittmis) are used per implementability. this is due to the fact that and, which is more heavily

St	eamIdle <sub>EStar</sub> =					STAR certif gas and pr			ing in steam mode. Units are Watt-
	fe Savings Adjust e savings adjustments are		to this mea	isure.					
Load S 90b Resta	hapes urant Indoor Lighting								
Number	Name	Status				Summer Off kWh	Winter kW	Summer kW	
90	Restaurant Indoor Lightin	ng Active	40.7%	25.7%	20.2%	13.4%	63.0%	77.0%	
Measure	s B Energy Star Commerce	ial Combina	ition Oven						
	Base Track]								
6013UPS	T [is base track] Upstrea	m - Comme	rcial						
Tra	ck Name Track Nr.	Measure C	ode Free	Rider Spil	Over				
Upstream	- Commercial 6013UPST	CKLOCOMB	1.00	1.00					
Lifetin									
Equipment	t lifetime is 12 years. <sup>[7]</sup>								

Measure Cost The incremental cost for an ENERGY STAR certified unit is \$0.<sup>(8)</sup>

## Operation and Maintenance Cost Adjustments No operation and maintenance cost adjustments are applicable to this mer

Reference Tables The following table shows the algorithm outcomes and correcsponding ItemCode: For full derivation of values, see Referenced Document commercial\_kitchen\_equipu

	Pan	1			1			1	-		1				1	1		1	
Energy Source			Convection Idle <sub>Base</sub>	SteamIdle <sub>Base</sub>	ConvectionIdle <sub>EStar</sub>	SteamIdle <sub>EStar</sub>	ConvectionCooking <sub>Base</sub>	SteamCooking <sub>Base</sub>	Conve	ectionCooking <sub>EStar</sub>	SteamCooking <sub>EStar</sub>	Idle <sub>Base</sub>	Idle <sub>EStar</sub>	Cooking <sub>Base</sub>	Cooking <sub>EStar</sub>	ΔkWh	ΔkW	ΔMMBtu	ltemCode
	> 5 and ≤ 8	6	6,249.1	27,385.4	5,050.3	7,815.6	10,166.7	6,285.7		9,631.6	5,600.0	33,634.5	12,865.8	16,452.4	15,231.6	6,860.7	1.83246	N/A	CI-KTN- CMBI-E06
	> 8 and ≤ 10	10	6,249.1	27,385.4	6,701.4	10,707.0	10,166.7	6,285.7		9,631.6	5,600.0	33,634.5	17,408.4	16,452.4	15,231.6	5,443.4	1.45391	N/A	CI-KTN- CMBI-E10
Electric	> 10 and ≤ 12	<sup>d</sup> 12	6,249.1	27,385.4	7,526.9	12,152.7	10,166.7	6,285.7		9,631.6	5,600.0	33,634.5	19,679.6	16,452.4	15,231.6	4,734.8	1.26464	N/A	CI-KTN- CMBI-E12
	> 12 and ≤ 17	14	6,249.1	27,385.4	8,352.5	13,598.4	10,166.7	6,285.7		9,631.6	5,600.0	33,634.5	21,950.9	16,452.4	15,231.6	4,026.2	1.07537	N/A	CI-KTN- CMBI-E14
	> 17 and ≤ 20	<sup>d</sup> 20	11,963.1	48,569.3	11,287.6	18,618.1	12,708.3	7,857.1		12,039.5	7,000.0	60,532.5	29,905.6	20,565.5	19,039.5	10,031.7	2.67940	N/A	CI-KTN- CMBI-E20
	> 6 and ≤ 12	9	45,484.400	102,368.821	35,186.290	45,034.023	48,076.923	26,923.077		44,642.857	25,609.756	147,853.221	80,220.314	75,000.000	70,252.613	N/A	N/A	22.583	CI-KTN- CMBI- NG09
	> 12 and ≤ 18	14	45,484.400	102,368.821	39,081.452	50,452.628	48,076.923	26,923.077		44,642.857	25,609.756	147,853.221	89,534.080	75,000.000	70,252.613	N/A	N/A	19.677	CI-KTN- CMBI- NG14
Natural Gas	> 18 and ≤ 24	<sup>d</sup> 20	41,381.892	132,821.052	45,535.119	58,322.769	60,096.154	33,653.846		55,803.571	32,012.195	174,202.944	103,857.888	93,750.000	87,815.767	N/A	N/A	23.799	CI-KTN- CMBI- NG20
	> 24 and ≤ 32	<sup>d</sup> 32	71,367.347	244,843.178	56,159.645	73,431.313	96,153.846	53,846.154		89,285.714	51,219.512	316,210.525	129,590.957	150,000.000	140,505.226	N/A	N/A	61.188	CI-KTN- CMBI- NG32
	> 32 and ≤ 40	<sup>d</sup> 40	71,367.347	244,843.178	62,750.508	82,531.313	96,153.846	53,846.154		89,285.714	51,219.512	316,210.525	145,281.820	150,000.000	140,505.226	N/A	N/A	56.292	CI-KTN- CMBI- NG40
	> 6 and ≤ 12	9	45,484.400	102,368.821	35,186.290	45,034.023	48,076.923	26,923.077		44,642.857	25,609.756	147,853.221	80,220.314	75,000.000	70,252.613	N/A	N/A	22.583	CI-KTN- CMBI-P09
	> 12 and ≤ 18	14	45,484.400	102,368.821	39,081.452	50,452.628	48,076.923	26,923.077		44,642.857	25,609.756	147,853.221	89,534.080	75,000.000	70,252.613	N/A	N/A	19.677	CI-KTN- CMBI-P14
Propane	≤ 24	20	41,381.892	132,821.052	45,535.119	58,322.769	60,096.154	33,653.846		55,803.571	32,012.195	174,202.944	103,857.888	93,750.000	87,815.767	N/A	N/A	23.799	CI-KTN- CMBI-P20
	> 24 and ≤ 32	32	71,367.347	244,843.178	56,159.645	73,431.313	96,153.846	53,846.154		89,285.714	51,219.512	316,210.525	129,590.957	150,000.000	140,505.226	N/A	N/A	61.188	CI-KTN- CMBI-P32
	> 32 and ≤ 40	<sup>d</sup> 40	71,367.347	244,843.178	62,750.508	82,531.313	96,153.846	53,846.154		89,285.714	51,219.512	316,210.525	145,281.820	150,000.000	140,505.226	N/A	N/A	56.292	CI-KTN- CMBI-P40

## Footnotes

See complete qualification criteria in reference file Commercial Ovens Final Version 2.2. See Referenced Document Commercial Ovens Final Version 2.2.

[2] Assumption consistent with the Savings Calculator for ENERY STAR Certified Commercial Kitchen Equipment (version updated February 2015), which references. EPA & Food Service Technology Center (FSTC) research on average use, 2013. See Referenced Document commercial\_kitchen\_equipment\_calculator\_Combi.

[3] As specified in ENERGY STAR<sup>®</sup> Program Requirements Product Specification for Commercial Ovens, Eligibility Criteria Version 2.2. See Referenced Document Commercial Ovens Final Version 2.2.

[4] Assumption consistent with the Savings Calculator for ENERY STAR Certified Commercial Kitchen Equipment (version updated February 2015). See Referenced Document commercial\_kitchen\_equipment\_calculator\_combi.

[5] Assumes operation 6 out of 7 days per week. 6 days/week x 52 week/year = 312 days/year.

[6] Assumption consistent with the Savings Calculator for ENERY STAR Certified Commercial Kitchen Equipment (version updated February 2015), which references EPA research on available models, 2013. See Referenced Document commercial\_kitchen\_equipment\_calculator\_Combi.

[7] Assumption consistent with the Savings Calculator for ENERY STAR Certified Commercial Kitchen Equipment (version updated February 2015), which references FSTC research on available models, 2009. See Referenced Document commercial\_kitchen\_equipment\_calculator\_combi.

[8] Assumption consistent with the Savings Calculator for ENERY STAR Certified Commercial Kitchen Equipment (version updated February 2015), which references Difference between a similar ENERGY STAR and non-qualifying model, EPA research using AutoQuotes, 2013. See Referenced Document commercial, Utchen, equipment, calculator. Combi.

## **ENERGY STAR Convection Oven**

measure number	CI-RTN-CONV a
Portfolio:	
Status:	Active
Effective Date:	2020/1/1
End Date:	[ None ]
Program:	Commercial & Industrial
End Use:	Kitchen Equipment

Update Summary This is version one of the TRM characterization

Referenced Documents Liked below are the DERGY STAR® Program Requirements Product Spedification for Commercial Ovens, Eligibility Criteria Version 2.2, which the efficient and eligible equipment and the Savings Calculator for ENERGY STAR Certified Commercial Kitchen Equipment, from which impact a and assumptions are referenced. hich impact algorit

ENERGY STAR CKE Calculator\_Oct 2016
 Commercial Ovens Final Version 2.2
 commercial\_kitchen\_equipment\_calculat

### Description

Description Commercial convection overs are the most widely used appliances in the foodservice industry. These are the workforses of the commercial kitchen, with a wide variety of uses from baking and roasting to warming and reheating. In addition to traditional uses, convection overs are used for nearly all types of food preparation, including foods byically prepared using other types of appliances (e.g., griddles, fryers, etc.). Commercial overs that have earned the BERG/STAR are about 20 percent more energy efficient than standard models.

A convection oven is general-purpose oven that cools food by forcing hot dry air over the surface of the food product. The rapidly moving hot air strips away the layer of cooler air next to the food and enables the food to absorb the heat energy. For consistency with ENERGY STAR definitions, convection overs <u>do not</u> include overs that have the ability to heat the cooking covity with saturated or superheated steam. However, convection overs may have molisture injection capabilities (c.g., baking overs and molisture-assist overs). Overs that include a hold feature are eligible under this specification as long as convection is the only method used to fully cook the food.

### Convection ovens are classified by size category:

Half-Size Convection Oven: A convection oven that is capable of accomm dating half-size sheet pans measuring 18 x 13 x 1-inch

Full-Size Convection Oven: A convection oven that is capable of accommodating standard full-size sheet pans measuring 18 x 26 x 1-inch.

This measure is a convection oven that has achieved ENERGY STAR certification by meeting Version 2.2 eligibility criteria

Full- and half-size electric convection ovens, and full-size gas (natural gas or propane) convection ovens are eligible to earn ENERGY STAR certification. Certification is earned by meeting minimum cooking energy efficiency, as well as a maximum idle energy rates. Cooking energy efficiency represents the amount of energy absorbed by the food product compared to the total energy used by the rown during the cooking process. The idle energy rate represents the energy used by the own while it is miniating or holding at a stabilized temperature.

Program Type <u>Calculation</u>: Time of Sale (Market Opportunity)

Program Delivery / Implementation Type: Mid stream

This characterization was developed for measure implementation by way of a midstream program with commercial kitchen equip Units rebated through the program will map to one of the four products summarized in the Reference Tables section below.

### **Baseline Efficiencies**

The baseline condition is a convection oven (electric, natural gas, or propane) that is not ENERGY STAR certified.

## Efficient Equipment

tion oven (electric, natural gas, or propane) that has achieved ENERGY STAR certification by meeting Version The efficient condition 2.2 eligibility criteria.<sup>[1]</sup>

Algorithms
Electric Demand Savings
Institution of the algorithm for energy savings, instantaneous electric demand is not constant during the operation of a convection or a
- demand is higher during times of cooking compared to idle. However, in an upstream program model, specific unit use patterns will be not be know
To align with the savings toaddapace choice for commercial cooking equipment - 90b Restaurant hodor Lighting - which assumes consistent instantan
demand saving, a convection over a estimated as the average over the entire operational period.

ΔkW	= ((Idle <sub>Base</sub> - Idle <sub>EStar</sub> ) + (Cooking <sub>Base</sub> - (Cooking <sub>EStar</sub> )) / 1,000 / Hours	
Symbol Table		
Electric Energy Sa	avings	
∆kWh	$= ((Idle_{Base} - Idle_{EStar}) + (Cooking_{Base} - Cooking_{EStar})) / 1,000 \times Days$	
Idle <sub>Base</sub>	= IdleRate <sub>Base</sub> × (Hours - (Food / Capacity <sub>Base</sub> ))	
Cooking <sub>Base</sub>	= Food $\times$ Er <sub>rood</sub> / Eff <sub>Base</sub>	
Idle <sub>EStar</sub>	= IdleRate <sub>EStar</sub> × (Hours - (Food / Capacity <sub>EStar</sub> ))	
Cooking <sub>EStar</sub>	= Food $\times$ Erood / Eff <sub>EStor</sub>	
Symbol Table		
Fossil Fuel Saving	S	
ΔMMBtu	$= ((Idle_{Base} - Idle_{EStar}) + (Cooking_{Base} - Cooking_{EStar})) / 1,000,000 \times Days$	
Symbol Table		
Water Savings No water savings are Where:	expected.	
ΔkW	<ul> <li>Gross electric demand savings (kW).</li> </ul>	
ΔkWh	<ul> <li>Gross annual electric energy savings (kWh).</li> </ul>	
ΔMMBtu	<ul> <li>Gross annual natural gas or propane energy savings (MMBtu).</li> </ul>	
1,000,000	<ul> <li>Conversion factor, from Btu to MMBtu.</li> </ul>	
1,000	<ul> <li>Conversion factor, from W to kW.</li> </ul>	
Capacity <sub>EStar</sub>	<ul> <li>Production capacity of ENERGY STAR certified unit. Units are in lbs/hour.</li> </ul>	

			Energy Source	Size Class	Capacity <sub>EStar</sub> [3]	
			Electric	Half-Size		
			Electric		50	
				Full-Size	90	
			Gas*	Full-Size	86	
			*Includes both nat	ual gas and	propane	
	Capacity <sub>Base</sub>	-	Production capacit	y of baseline	unit. Units are in Ib	/hour.
			-			
			Enorgy Source	Size Class	Capacity <sub>Base</sub> [3]	
			Electric	Half-Size	45	
				Full-Size	90	
			Gas*	Full-Size	83	
			*Includes both nat	ual gas and	propane	
	Cooking <sub>Base</sub>	-			ion of baseline unit.	Units are Watt-hours (electric equipment) or Btu (natural gas and
			propane equipmen	ıt).		
	Cooking <sub>EStar</sub>	-	Daily cooking ener	av consumpti	ion of ENERGY STAR	certified unit. Units are Watt-hours (electric equipment) or Btu
			(natural gas and p			
	Days	-	Annual days the co	onvection ove	n is in operation.	
			= 312 days/year <sup>[4]</sup>			
	-			- h h d - h		Den 1999 and Malle barrielle and the fail of the sector of the
	EFood		Btu/lbs (natural ga			king. Units are Watts-hours/lbs (electric equipment) or
			bayibb (natarar ga	o una propar	ie equipmenty.	
			-			
			Energy Source	EFood <sup>[3]</sup>		
			Electric	73.2 Wh/I	hs	
			Gas*	250 Btu/lb		
			*Includes both nat		-	
			Linduce bour fide			
	Eff <sub>Base</sub>	-	Cooking energy eff	ficiency of ba	seline unit. A measu	re of the quantity of energy imparted to the specified load,
						the oven during the cooking event.
			-			
			Enorm: C	Size Cha	Eff. [3]	
			Energy Source			
			Electric	Half-Size	68%	
				Full-Size	65%	
			Gas*	Full-Size	44%	
			*Includes both nat			
	Eff <sub>EStar</sub>	-				d unit. A measure of the quantity of energy imparted to the
			specified load, exp	ressed as a	percentage of energ	y consumed by the oven during the cooking event.
			-			
			Energy Source	Size Class	Eff (5)	
			1			
			Electric	Half-Size	71%	
				Full-Size	71%	
			Gas*	Full-Size	46%	
			*Includes both nat	ual gas and	propane	
	Food	-	Pounds of food con	oked per day	(Ibs).	
			= 100 lbs. <sup>[3]</sup>			
	Hours	-	Operating hours p	ar day		
	10015					
			= 12 hours/day. <sup>[2]</sup>			
	Idle <sub>Base</sub>	-	Daily idle energy o	onsumption o	of baseline unit. Unit	s are Watt-hours (electric equipment) or Btu (natural gas and
			propane equipmer			
	IdleEStar	-	(natural gas and p			tified unit. Units are Watt-hours (electric equipment) or Btu
			(natarar gas ana p	opune equip	inciny.	
	IdleRate <sub>EStar</sub>	-				e energy rate is the rate of oven energy consumption while it is
						dition or temperature. Also called standby energy rate. Units
			are Watts (electric	equipment)	or Btu/hour (natura	gas and propane equipment).
			-			
			Energy Source	Size Class	Idlesstar <sup>[5]</sup>	
			Electric	Half-Size	1,000 (Watts)	
				Full-Size	1,600 (Watts)	
			Gas*		12,000 (Btu/hour)	
			*Includes both nat	ual gas and	propane	
	IdleRatesse		Idle eperav rate th	e haseline	nit. Idle energy rate	is the rate of oven energy consumption while it is maintaining or
	IuleRateBase					rature. Also called standby energy rate. Units are Watts (electric
			equipment) or Btu	/hour (natura	I gas and propane e	quipment).
			-			
			1-	-		
			Energy Source			
			Electric	Half-Size	1,030 (Watts)	
				Full-Size	2,000 (Watts)	
			Gas*		15,100 (Btu/hour)	
			*Includes both nat			
	Life Savings A					
	-life savings adjustme			measure.		
Load	l Shapes					
	staurant Indoor Lightin	g				
			W!	ter Wint-	r Summer Sum	ner Winter Summer
Numb	er Name		Status On k	Wh Off kW	h On kWh Off k	ner Winter Summer Wh kW kW
90	Restaurant Indoor	Linh	ing Active 40.7	% 25.7%	20.2% 13.49	6 63.0% 77.0%
50	Residuranci indoor	Ligin	ang Acove 40.7	/0 23.770	20.270 13.47	0.010 77.070
Net	Savings Facto	rs				
	-					
Measu			eiel Cenus - V			
CKLOC	CONV Energy Star Co	nmer	ual convection Ove	211		
Track	s [Base Track]					
	S [Base Frack] PST [is base track] U	netro	am - Commorcial			
00130	. Ст ць разе стаску Ц	həruc	an - commercial			
-	mack Name		Manerine Co. t.	roo Pid		
т	rack Name Tra	:k Nr	Measure Code F	ree Rider S	pill Over	

Upstream - Commercial 6013UPST CKLOCONV 1.00 1.00

Lifetimes Equipment lifetime is 12 years.<sup>[7]</sup>

### Measure Cost

The incremental cost for an ENERGY STAR certified unit is \$388 for an electric unit and \$170 for a gas unit.<sup>(8)</sup>

Operation and Maintenance Cost Adjustments curo

Energy Source		Idle <sub>Base</sub>	Idle <sub>EStar</sub>	Cooking <sub>Base</sub>	Cooking <sub>EStar</sub>	ΔkW	ΔkWh	ΔMMBtu	ItemCode
	Full- Size	21,777.8 Wh	17,422.2 Wh	11,261.5 Wh	10,309.9 Wh	0.44227	1,655.9	N/A	ci-ktn- conv- eful
	Half- Size	10,071.1 Wh	10,000.0 Wh	10,764.7 Wh	10,309.9 Wh	0.04383	164.1	N/A	ci-ktn- Conv- Ehal
	Full- Size	163,007.229 Btu	130,046.512 Btu	56,818.182 Btu	54,347.826 Btu	N/A	N/A	11.054	CI-KTN- CONV- NGFL
Pronanel	Full- Size	163,007.229 Btu	130,046.512 Btu	56,818.182 Btu	54,347.826 Btu	N/A	N/A	11.054	CI+KTN+ CONV+ PFUL

Footnotes

See complete qualification criteria in reference file Commercial Ovens Final Version 2.2. See Referenced Document Commercial Ovens Final Version 2.2.

[2] Assumption consistent with the Savings Calculator for ENERY STAR Certified Commercial Ritchen Equipment (version updated 2016), which references EPA & Food Service Technology Center (FSTC) research on average use, 2013. See Referenced Document commercial Litchen, equipment, calculator, Convection.

[3] Assumption consistent with the Savings Calculator for ENERY STAR Certified Commercial Kitchen Equipment (version updated 2016). See Referenced Document commercial Jötchen equipment, calculator, Convection.

[4] Assumes operation 6 out of 7 days per week. 6 days/week x 52 week/year = 312 days/year.

[5] As specified in ENERGY STAR<sup>®</sup> Program Requirements Product Specification for Commercial Ovens, Eligibility Criteria Version 2.2. See Referenced Document Commercial Ovens Final Version 2.2.

[6] Assumption consistent with the Savings Calculator for ENERY STAR Certified Commercial Kitchen Equipment (version updated 2016), which references EPA research on available models, 2013. See Referenced Document commercial\_kitchen\_equipment\_calculator\_Convection

[7] Assumption consistent with the Savings Calculator for ENERY STAR Certified Commercial Kitchen Equipment (version updated 2016), which references FSTC research on available models, 2009. See Referenced Document commercial\_kitchen\_equipment\_calculator\_Convection.

[3] Assumption consistent with the Savings Calculator for ENERY STAR Certified Commercial Kitchen Equipment (version updated 2016), which references Difference between a similar ENERGY STAR and non-qualifying model, EPA research using AutoQuotes, 2013. See Referenced Document commercial kitchen, eauinment calculator Communion

## **ENERGY STAR Griddle**

Measure Number: (CF-KTN-GRID ) Portfolio: EVT TRM Portfolio 2020-05 Status: Active Effective Date: 2020/1/1 End Date: [None] Program: Commercial & Industrial End Use: Kitchen Equipment

## Update Summary

- Referenced Documents

  DEFR2014-EU-Lable-update\_2014-02-05.stsx

  commercial\_Natchen\_equipment\_calculator\_Gridde
  DEFRSY STAR Commercial Criddes Specification VI.2
  DEE Energy Savings Potential RDD Opportunities for Comm Bidg Applia
  California Public Utilidie Commission MeasureDataSpec Comm Gridde
  DEFRSY STAR Conflict Commercial-griddle\_2020-06-29

  ENERGY STAR Commercial Griddle Analysis 2020

Description
This measure applies to single-sided (electric or gas fired) and double-sided (electric and dual fuel) ENERGY STAR griddles installed in a collarchen.

A commercial griddle is as an appliance designed for cooking food in oil or its own juices by direct contact with a thermostatically controlled hot surface. Single-Sided griddles consist of one bottom plate and are fired by either electric or gas (natural or propane). In addition to the bottom plate, Double-Sided Commercial Griddles have an upper plate which wangs down over the food, cooking a to hosh discs. One by eoth these griddles have a gas-fired lower plate and an electric top plate and are therefore considered Dual Fuel. The other type of Double-Sided griddles are entrely electric. Compared to standard equipment, ENERGY STAR qualified commercial griddles have lower tile Energy Rates, greater Production Capacity and higher Cooking Efficiency, which results in less wasted energy.

## Program Type Calculation Type: Market Opportunity - TOS

Program Delivery / Implementation Type: Midstream

### Baseline Efficiencies

The baseline equipment is an existing single-sided (natural gas or electric) or double-sided (dual fuel or electric) griddle that's not ENERGY STAR certified and is at end of use.

Efficient Equipment
To qualify for this measure the installed equipment must be a single or double-sided gas or electric ENERCY STAR griddle with a tested heavy load
Cooking Energy Efficiency of at test 70 % (electric), 38 % (gas) and a hormalized falle Energy Rate less than or equal to 2,650 Bu/hr / f<sup>2</sup> (gas) or 320
W / f<sup>2</sup> (electric) cooking surface. ENERCY STAR Monthle testing must be performed in accordance with ASTM F1275 and ASTM F1605, the Standard
Test Methods for Single and Double-sided Griddles, respectively.

Algorithms Electric Demand Si	avings	
ΔkW	= ΔkWh / (Hours x Days)	
Symbol Table		
Electric Energy Sar For double-sided, dua savings and half are e	I fuel griddles, assume that h	alf of the MMBu savings calculated according to the algorithm above are gas (natural or propane)
ΔkWh	= (ΔIdleDailyWh + ΔCool	singDailyWh) x Days / 1,000
ΔIdleDailyWh	= (IdleRateElectric <sub>BASE</sub> x apacity <sub>ENERGYSTAR</sub> x Area	Area x (Hours – (LB)(Capacity <sub>BASE</sub> x Area))))) – (IdleRateElectric <sub>ENERGYSTAR</sub> x Area x (Hours – (LB)( ))))
ΔCookingDailyWh	= (LB x EFOOD <sub>ELECTRIC</sub> /E	ffbase) - (LB x EFOOD <sub>electric</sub> /Eff <sub>estar</sub> )
∆kWh <sub>Dual Fuel</sub>	= (ΔMMBtu x 50%) x 293	
Symbol Table		
Fossil Fuel Savings		
ΔMMBtu	= (ΔIdleDailyBtu + ΔCook	ngDailyBtu) x Days / 1,000,000
∆MMBtu <sub>Dual Fuel</sub>	= ΔMMBtu x 50%	
∆IdleDailyBtu	= (IdleRateGas <sub>BASE</sub> x Are <sub>STAR</sub> x Area))))	a x (Hours – (LB/(Capacity <sub>BASE</sub> x Area)))))- (LdleRateGas <sub>ESTAR</sub> x Area x (Hours – (LB/(Capacity <sub>ENERG</sub>
ΔCookingDailyBtu	= (LB x EFOOD <sub>GAS</sub> /Eff <sub>BAS</sub>	e) ~ (LB X EFOOD <sub>GAS</sub> /Eff <sub>ESTAR</sub> )
Where:		
∆CookingDaily	Btu = Gross Dail	y Gas Energy Savings, while in Cooking mode (Btu).
ΔCookingDaily	Wh = Gross Dail	y Electric Energy Savings, while in Cooking mode (Wh).
∆IdleDailyBtu	= Gross Dail	y Gas Energy Savings, while in Idle mode (Btu).
ΔIdleDailyWh	= Gross Dail	Y Electric Energy Savings, in Idle mode (Wh).
ΔkW	= Gross Elec	tric Demand Savings (kW). For Deemed values, please see the Reference Table.
∆kWh <sub>Dual Fuel</sub>	= Gross Ann	ual Electric Energy Savings, <b>Dual Fuel</b> (KWh). For Deemed values, please see the Reference Table
ΔkWh		ual Electric Energy Savings, <b>Electric single-side &amp; Electric double-sided</b> (NMh). For Deemed ase see the Reference Table.
∆MMBtu <sub>Dual Fu</sub>		ual Natural Gas or Propane Energy Savings for the Gas portion of the <b>Dual Fuel</b> Griddles (MMBtu). alues, please see the Reference Table.
ΔMMBtu		ual Natural Gas or Propane Energy Savings for <b>Single-Sided Gas</b> Griddles (MMBtu). For Deemed asee see the Reference Table
1,000,000	= Conversio	n factor, from Btu to MMBtu.

	1,000	-	Conversion factor, from W to kW.	
	293	-	Conversion factor, from MMBtu to kWh.	
	50%	-	Savings split between electric and gas for Dual Fuel, Double-Sided Griddles <sup>[3]</sup> .	
	Area	-	Area of the bottom cooking surface (ft²) = 6 ft² $^{(2)}$	
	Capacity <sub>BASE</sub>	-	Production Capacity of a baseline unit <sup>4</sup> .           Energy Source         (lbs/hr/sq ft)           Bectric         5.83           Gas *         4.17           * Includes both natual gas and propane	
	Capacityenergystar	-	Production Capacity of ENERGY STAR <sup>(3)</sup> certified unit.           Energy Source         (/bs;/hr/sq /t)           Electric         6.67           Gas *         7.50           Double-Sided, Electric (8.17%)         8.17%)           Publicks both naturi gas and propane	
	Days	-	Annual days the griddle is in operation. = 312 days <sup>[1]</sup>	
	Eff <sub>BASE</sub>	-	Cooking Energy Efficiency of a baseline griddle <sup>(4)</sup> . This is the ratio of energy absorbed by the food product to the total energy supplied to the griddle during cooking. Electric = 65% Gas = 32%	
	Eff <sub>ESTAR</sub>	-	Cooking Energy Efficiency of an ENERGY STAR certified griddle <sup>10</sup> . This is the ratio of energy absorbed by the food product to the total energy supplied to the griddle during cooking. Electric = 70% Gas = 38% Double-Sided, Electric Only = 75% <sup>[7]</sup>	
	EFOODelectric	-	Amount of energy absorbed by the food during cooking <sup>[2]</sup> . = 139 Whylb	
	EFOOD <sub>GAS</sub>	-	Amount of energy absorbed by the food during cooking <sup>[2]</sup> . Includes both natual gas and propane. = 475 Btu/lb	
	Hours	-	Average Operating Hours per Day = 12 hours / day <sup>[2]</sup>	
	IdleRateElectric <sub>BASE</sub>	-	Akrmalized Idle Energy Rate of the baseline electric* models <sup>4</sup> . = 400 W/ft <sup>2</sup> *indudes single and double side griddles	
	IdleRateElectric <sub>ENERGYSTAR</sub>	-	Abrmalized Idle         Energy Rate of the ENERGY STAR certified electric model <sup>[5]</sup> .           # of sides         Idle Rate           Single-Sided         200 W/R <sup>2</sup> Double-Sided         293 W/R <sup>2</sup>	
	IdleRateGas <sub>BASE</sub>	-	Normalized Idle Energy Rate of the baseline gas* model <sup>(4)</sup> . = 3,500 Ru/hr/R <sup>2</sup> * Includes both natual gas and propane	
	IdleRateGas <sub>ESTAR</sub>	-	Normalized Idle Energy Rate of the ENERGY STAR certified gas* model <sup>[5]</sup> = 2,650 Btu/hr/ft <sup>2</sup> * Includes both natual gas and propane	
	LB	-	Pounds of food cooked per day. = 100 lbs / day <sup>(2)</sup>	
Load 90b Res	Shapes staurant Indoor Lighting			
Numb			Winter         Winter         Summer         Winter         Summer           On KWh         Off KWh         On KWh         Off KWh         Off KWh         KW           Active         40.7%         25.7%         20.2%         13.4%         63.0%         77.0%	
Measu CKLGR Tracks 6013U	IDL Energy Star Griddle (Base Track) PST [is base track] Upstre rack Name Track Nr.	Mea	Commercial ssure Code Free Rider Spill Over GRIDL 1.00 1.00	
Lifet The exp	imes bected measure life is assur	med f	n be 12 years <sup>(9)</sup> .	
	sure Cost ental costs are assumed to	be as	: follows:	
Fuel Ty	Number of Heated I			
Gas *	Single	449		
		662	0) 11]	
Electric	uel * Double \$	877	2)	
* Inclu	des both natual gas and pro	opane		
	Cost Adjustment		ustments are applicable to this measure.	

### Reference Table

Energy Source	# of sides	ΔkW	ΔkWh	ΔMMBtu	ItemCode
Electric	Single-Sided	0.4360	1,632	n/a	CI-KTN-GRID-ELSN
Natural Gas	Single-Sided	n/a	n/a	11.22	CI-KTN-GRID-NGSN
Propane	Single-Sided	n/a	n/a	11.22	CI-KTN-GRID-PPSN
Electric / Natural Gas	Double-Sided	0.4391	1,644	5.61	CI-KTN-GRID-NGDB
Electric / Propane	Double-Sided	0.4391	1,644	5.61	CI-KTN-GRID-PPDB
Electric	Double-Sided	0.6075	2,274	n/a	CI-KTN-GRID-ELDB

Footnotes

- Assumes operation 6 out of 7 days per week. 6 days/week x 52 week/year = 312 days/year
- [2] Assumption consistent with the ENERY STAR Certified Commercial Kitchen Equipment Savings Calculator (version updated October 2016). Please see Referenced Document.
- [3] As per DOE workpaper Energy Savings Potential and RD&D Opportunities for Commercial Building Appliances (pg.166) these models have a "secon heating plate that is lowered on top of the food and used to simultaneously cook both sides." Given the equipment Energy Source breakdown, it is therefore reasonable to assume the savings are split 50% gas versus electric. Please see Referenced Document.
- [4] Assumption consistent with the ENERY STAR Certified Commercial Kitchen Equipment Savings Calculator (version updated October 2016). Baseline equipment specifications source Food Service Technology Center (FSTC) research on available models, 2011. Please see Referenced Document.
- [5] As specified in ENERGY STAR® Program Requirements Product Specification for Commercial Griddles, Eligibility Criteria Version 1.2. See Referenced Documen
- [6] California Public Utilities Commission. Work Paper SWF5004-01. FOOD SERVICE, Commercial Griddle Electric & Gas. Please see Referenced Document. Excel File Name = MeasureDataSpec, Sheet Name = Measure Specific Constants, Cell = C18, "Production Capacity (lbs/hr)". 2018.
- [7] California Public Utilities Commission. Work Paper SWF5004-01. FOOD SERVICE, Commercial Griddle Bectric & Gas. Please see Referenced Document. Excel File Name = Measurchulaspec, Sheet Name = Measure Specific Constants, Cell = C17, "Heavy Load Cooking Energy Efficiency, Energy Efficient Model (%)". 2018.
- [8] California Public Ublities Commission. Work Paper SWFS004-01. FOOD SERVICE, Commercial Griddle Electric & Gas. Please see Referenced Document. Excel file Name = NeasureDataSpec, Sheet Name = Measure Specific Constants, Cell = C15, "Normalized Idle Energy Rate, Energy Efficient Model (watts per ft\*). 2018.
- [9] California Public Utilities Commission. Database for Energy Efficient Resources. Effective Useful Life Table (2014). Please see Referenced Document. Excel File Name = MeasureDataSpec, Sheet Name = READL\_EUL, Cells = D48 & D53.
- [10] California Public Utilities Commission. Work Paper SWF5004-01. FOOD SERVICE, Commercial Griddle Electric & Gas. Please see Referenced Document. Eucol File Name = MeasureDataSpec, Sheet Name = Measure Support Table, Cell = AK "Incremental Cost". 2018.
- [11] Derived from California Energy Wise, Gas Double-Sided Griddle Energy Savings Calculator. California Public Utilities Commission. Accessed June 2020: https://caenergy.wise.com/calculators/natural-pas-double-crificlies/#calc
- [12] Derived from California Energy Wise, Electric Double-Sided Griddle Energy Savings Calculator. California Public Utilities Commission. Accessed June
- [13] Please see Referenced .xcl Document: ENERGY STAR Commercial Griddle Analysis\_2020 for full calculations

## **ENERGY STAR Hot Food Holding Cabinet**

Measure Number	CI-KTN-HFHC a
Portfolio:	
Status:	Active
Effective Date:	2020/1/1
End Date:	[ None ]
Program:	Commercial & Industrial
End Use:	Kitchen Equipment

Update Summary This is version one of the TRM characterization

Referenced Documents Linked below are the DIRKRYSTAR® Program Requirements Product Specification for Commercial Hot Food Holding Cabinets, Eligibility Criteria Version 2.0, which defines the efficient and legible engineement and the Savings Calculator for ENERGY STAR Certified Commercial Hitchen Equipment, from which impact algorithms and assumptions are referenced.

- EPA\_Commercial Kitchen Equipment Calculator\_Oct 2016
   ENERGY STAR CKE Calculator\_Oct 2016
   Commercial\_HFHC\_Program\_Requirements\_2.0
   commercial\_kitchen\_equipment\_calculator\_HFHC

## Description

Description A commercial hot food holding cabinets (HFHC) is a heated, fully enclosed compartment with one or more solid or transparent doors designed to maintain the temperature of hot food that has been cooked using a separate appliance. HFHC's are used to extend the amount of time foodservice operators can hold food prior to eximp. Reparating food in advance can free up cooking resources to perform other tasks, allowing hot food holding equipment to increase speed of service, particularly during peak service hours of the day.

This measure is a hot food holding cabinet that has achieved ENERGY STAR certification by meeting Version 2.0 eligibility criteria

NOTE: there are very few (if any) non-electric HFHC offerings within the market. ENERGY STAR certified units currently consist of electric only equipment. ENERGY STAR certified hot food hoding cabinets often incorporate better insulation which reduces heat loss, offer better temperature uniformity within the cabinet from top to bottom, and keeps the external cabinet cooler. In addition, many certified holding cabinets may include energy saving devices such as magnetic door gaskets, auto-door closures, or Dutch doors.

## Program Type <u>Calculation</u>: Time of Sale (Market Opportunity)

Program Delivery / Implementation Type: Mid stream

This characterization was developed for measure implem tation by way of a mid eam program with commercial kitchen equipment d Units rebated through the program will map to one of the nine products summarized in the Reference Tables section below.

### **Baseline Efficiencies**

The baseline condition is a hot food holding cabinet that is not ENERGY STAR certified.

### Efficient Equipment

is a hot food holding cabinet that has achieved ENERGY STAR certification by meeting Version 2.0 eligibility criteria.<sup>[1]</sup>

	rithms	Savings			
ΔkV		10-	ase - Idle <sub>EStar</sub> ) / 1000		
Sym	bol Table				
	r Savings iter savings are	e expected.			
Elect	ric Energy Sa	avings			
ΔkV	Vh	= (IdleR	$ate_{Base}$ - IdleRate <sub>EStar</sub> ) / 1000 × Hours × Day	s	
Idle	Rate <sub>Base</sub>	= 40 × 1	/olume		
Idle	Rate <sub>EStar</sub>	= (A × \	/olume) + B		
Sym	bol Table				
	I Fuel Saving sil fuel impacts		erized for this measure.		
Where	2:				
	ΔkW	-	Gross electric demand savings (kW).		
	ΔkWh	-	Gross annual electric energy savings (kWh)		
	1000	-	Conversion factor, from W to kW.		
	40	-	Volumetric baseline idle energy rate, (Watt	s/ft3)[2]	
	A	-	Volumetric idle energy rate of ENERGY STA	R certified un	t, (Watts/ft <sup>3</sup> ), dependent on Volume category. <sup>[3]</sup>
			Product Interior Volume (Cubic Feet)	A	1
			0 < Volume < 13	21.5	1
			13 ≤ Volume < 28	2.0	1
			28 ≤ Volume	3.8	]
	В		Constant, (Watts), dependent on Volume ca	ategory. <sup>[3]</sup>	
			Product Interior Volume (Cubic Feet)	в	
			0 < Volume < 13	0	
			13 ≤ Volume < 28	254.0	
			28 ≤ Volume	203.5	
	Days	-	Annual days the HFHC is in operation		
			= 312 days/year <sup>[4]</sup>		
	Hours	-	Operating hours per day		
			= 15 hours/day <sup>[5]</sup>		

leRate <sub>EStar</sub>	-			ied unit. Idle energy rate is the rate of applian set point. Units are Watts.	nce energy consumption while
olume	-	Interior volume of qualification crite		ood holding cabinet, in cubic feet, as measure	ed by ENERGY STAR Version
		ENERGY STAR sp	pecifications recognize	three distinct size classes for establishing max	imum idle energy rates:
		Product Inter	ior Volume (Cubic Fe	et)	
		0 < V < 13			
		13 ≤ V < 28			
		28 ≤ V			
		For the purpose first and second approach strikes	class and five for the th a balance with granula	e ENERGY STAR categories are broken out into nird class), and a deemed value is assigned pe ritly in savings and implementability.	
		For the purpose first and second	of claiming savings, the class and five for the ti	<ul> <li>ENERGY STAR categories are broken out into hird class), and a deemed value is assigned pa</li> </ul>	
		For the purpose first and second approach strikes	of claiming savings, the class and five for the th a balance with granula	e ENERGY STAR categories are broken out into nird class), and a deemed value is assigned pe ritly in savings and implementability.	
		For the purpose first and second approach strikes Size Class	of claiming savings, the class and five for the th a balance with granula Size Category	E ENERGY STAR categories are broken out into irid class), and a deemed value is assigned po irity in savings and implementability. Deemed Size* (cubic feet (ft <sup>3</sup> ))	
		For the purpose first and second approach strikes Size Class 0 < V < 13	of claiming savings, the class and five for the ti a balance with granula Size Category 0 < V < 6.5	ENERGY STAR categories are broken out init irid class), and a deemed value is assigned po irity in savings and implementability. Deemed Size* (cubic feet (ft <sup>3</sup> )) 3.25	
		For the purpose first and second approach strikes Size Class 0 < V < 13 0 < V < 13	of claiming savings, the class and five for the ti a balance with granula <b>Size Category</b> 0 < V < 6.5 $6.5 \le V < 13$	ENERGY STAR categories are broken out init irid class), and a deemed value is assigned po irity in savings and implementability. Deemed Size* (cubic feet (ft <sup>3</sup> )) 3.25 9.75	
		For the purpose first and second approach strikes Size Class 0 < V < 13 0 < V < 13 $13 \le V < 28$	of claiming savings, the class and five for the tl a balance with granula <b>Size Category</b> 0 < V < 6.5 $6.5 \le V < 13$ $13 \le V < 20.5$	BERRY STAR categories are broken out intr intri class), and a deemed value is assigned purity in savings and implementability.     Beemed Size* (cubic feet (R <sup>3</sup> )) 3.25 9.75 16.75	
		For the purpose first and second approach strikes Size Class 0 < V < 13 0 < V < 13 $13 \le V < 28$ $13 \le V < 28$	of claiming savings, the       class and five for the tl       a balance with granula       Size Category $0 < V < 6.5$ $6.5 \le V < 13$ $13 \le V < 20.5$ $20.5 \le V < 28$	BERRY STAR categories are broken out init irid class), and a deemed value is assigned por inity in savings and implementability.     Deemed Size* (cubic feet (R <sup>3</sup> ))     3.25     9.75     16.75     24.25	
		For the purpose first and second approach strikes 0 < V < 13 0 < V < 13 $13 \le V < 28$ $13 \le V < 28$ $28 \le V$	of claiming savings, the class and five for the ti a balance with granula <b>Size Category</b> 0 < V < 6.5 $6.5 \le V < 13$ $13 \le V < 20.5$ $20.5 \le V < 28$ $28 \le V < 48$	BERRY STAR categories are broken out init irid class), and a deemed value is assigned purity in savings and implementability.           Decemed Size* (cubic feet (R³))           3.25         9.75           16.75         24.25           38         38	
		For the purpose first and second approach strikes 0 < V < 13 0 < V < 13 $13 \le V < 28$ $13 \le V < 28$ $28 \le V$ $28 \le V$	of claiming savings, th class and five for the th a balance with granula Size Category 0 < V < 6.5 $6.5 \le V < 13$ $13 \le V < 20.5$ $20.5 \le V < 28$ $28 \le V < 48$ $48 \le V < 68$	BRRGY STAR categories are broken out intr ind class), and a deemed value is assigned pro- tive in savings and implementability. Beened Size* (cubic feet (R <sup>3</sup> )) 3.25 9.75 16.75 24.25 38 58	

Mid-Life Savings Adjustment No mid-life savings adjustments are applicable to this measure.

# Load Shapes 90b Restaurant Indoor Lighting

Number Name Status Winter Winter Summer Summer Winter Summer Restaurant Indoor Lighting Active 40.7% 25.7% 20.2% 13.4% 63.0% 77.0% 90

## Net Savings Factors

Measures CKLHFOOD Energy Star Hot Food Holding Cabinet

Tracks [Base Track] 6013UPST [is base track] Upstream - Commercial

 Track Name
 Track Nr.
 Measure Code
 Free Rider Spill Over

 Upstream - Commercial 6013UPST\_CKLHFOOD
 1.00
 1.00

Lifetimes Equipment lifetime is 12 years.<sup>[6]</sup>

Measure Cost The incremental cost for an ENERGY STAR certified unit is \$902.<sup>[7]</sup>

Operation and Maintenance Cost Adjustments e cost adi

### Reference Tables

Size Category	Deemed Volume (ft <sup>3</sup> )	Idle <sub>Base</sub> (W)	Idle <sub>EStar</sub> (W)	ΔkWh	ΔkW	ItemCode
0 < V < 6.5	3.25	130.000	69.875	281.4	0.06013	CI-KTN-HFHC-003
6.5 ≤ V < 13	9.75	390.000	209.625	844.2	0.18038	CI-KTN-HFHC-009
13 ≤ V < 20.5	16.75	670.000	287.500	1790.1	0.38250	CI-KTN-HFHC-016
20.5 ≤ V < 28	24.25	970.000	302.500	3123.9	0.66750	CI-KTN-HFHC-024
28 ≤ V < 48	38.00	1520.000	347.900	5485.4	1.17210	CI-KTN-HFHC-038
48 ≤ V < 68	58.00	2320.000	423.900	8873.7	1.89610	CI-KTN-HFHC-058
68 ≤ V < 88	78.00	3120.000	499.900	12262.1	2.62010	CI-KTN-HFHC-078
$88 \le V < 108$	98.00	3920.000	575.900	15650.4	3.34410	CI-KTN-HFHC-098
108 ≤ V	111.00	4440.000	625.300	17852.8	3.81470	CI-KTN-HFHC-111

## Footnotes

See complete qualification criteria in reference file Commercial\_HFHC\_Program\_Requirements\_2.0. See Referenced Document Commercial\_HFHC\_Program\_Requirements\_2.0.

[2] Assumption consistent with the Savings Calculator for ENERY STAR Certified Commercial Ritchen Equipment (version updated 2016), which references Rood Service Technology Center (FSTC) research on available models, 2011. See Referenced Document commercial Jitchen equipment, Calculator, FFIC.

[3] As specified in ENERGY STAR<sup>®</sup> Program Requirements Product Specification for Commercial Hot Food Holding Cabinets, Eligibility Criteria Version 2.0. See Referenced Document Commercial\_HFHC\_Program\_Requirements\_2.0.

[4] Assumes operation 6 out of 7 days per week. 6 days/week x 52 week/year = 312 days/year.

[5] Assumption consistent with the Savings Calculator for ENERY STAR Certified Commercial Kitchen Equipment (version updated 2016), which references FSTC research on average use, 2011. See Referenced Document commercial\_kitchen\_equipment\_calculator\_HFHC.

[6] Assumption consistent with the Savings Calculator for ENERY STAR Certified Commercial Kitchen Equipment (version updated 2016), which references FSTC research on available models, 2009. See Referenced Document commercial kitchen\_equipment\_calculator\_HFHC.

[7] Assumption consistent with the Savings Calculator for ENERY STAR Certified Commercial Kitchen Equipment (version updated 2016), which references Difference between a similar ENERGY STAR and non-qualifying model, EPA research using AutoQuotes, 2012. See Referenced

Document commercial\_kitchen\_equipment\_calculator\_HFHC.

Measure Number	CI-KTN-ROVN a
Portfolio: E	VT TRM Portfolio 2020-06
Status: A Effective Date: 2	ctive 120/1/1
End Date: [	None ]
	iommercial & Industrial itchen Equipment
. ,	
Ipdate Summ	ary
<ul> <li>DEER EUL Table_</li> <li>PGECOFST109 R</li> </ul>	vings Potential RDD Opportunities for Comm Bidg Appliances_2015 2014-02-05 5 Commercial Rack Oven - Gas_2016 holigy Assessment Section 7: Ovens
	to gas fired high efficiency Rack Overs (Double) installed in a commercial kitchen.
arious designs [and] nechanism to spin th ivesre items. <sup>[1]</sup> 'here is no current fo	for high-volume institutional operations, consist of roll-in racks which hold between 10 to 15 pans and utilize "heat exchangers of a power blower which circulates heat wently throughout the cooling cavity" [15.5 one models have options such as a rotating e rack or a steam injection system to mimic a combination overi <sup>2</sup> ]. They are capable of producing thousands of identical or many sideral baseline, so the measure was developed using ASTM Standard Test Method for the Performance of Commercial Rack Overse
F2093). While ENER	37 STAR standards do exist, the number of certified products on the current market is extremely limited.
Program Type Calculation Type: Ma	ket Opportunity - TOS
rogram Delivery / Ir	<i>ndementation Type</i> : Midstream
Baseline Effic	
he baseline equipm	ent is a new gas rack oven – double oven with a Cooking-Energy Efficency of 30% <sup>[3]</sup> .
Efficient Equi	pment
he efficient equipme	nt is a new gas rack oven – double oven with a Cooking-Energy Efficiency ≥ 50% tested utilizing the ASTM Standard Test Method
	of Commercial Rack Ovens (F2093) <sup>(4)</sup> . The Idle Energy Rate should not exceed 35,000 Btu/hr. imited market, this measure was not developed using ENERGY STAR specifications.
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VA Electric Energy Sa VA Sossil Fuel Saving: Il assumptions, exce Ising assumptions pr uel type).	- vings - vings - viner noted, are based on Work Paper PGEC0FST109 R6 *Commercial Rack Oven - Gas*. ovided, the deemed savings for this measure is <b>180.65 MMBku</b> . (BemCode = CF-KTI+ROVH-NG or CF-KTI+ROVH-LP depending or
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LBFOOD	, ,	<ul> <li>Estimated Pound</li> </ul>	ds of Food Cooked p	ver Day				
		= 1,200 lb /d						
Ne		<ul> <li>Number of Preh</li> <li>= 1 / day</li> </ul>	eats per day					
Prehea	t <sub>BASE</sub>	<ul> <li>Preheat Energy</li> </ul>	of baseline gas rack	coven.				
		= 100,000 Btu						
Prehea	tee	<ul> <li>Preheat Energy</li> <li>= 85,000 Btu</li> </ul>	of baseline gas rack	coven.				
Prehea	tTime	= Estimated time of	of each Preheat					
		= 20 minutes						
.oad Sha	nes							
	t Indoor Lighting							
Number	Name		inter Winter S hkWh OffkWh (	Summer Summer W On kWh Off kWh		mmer kW		
90 Res	taurant Indoor L	ighting Active 40	.7% 25.7% 2	0.2% 13.4% 63	.0% 77.	.0%		
CKLORACK R	Track]	stream - Commercia	I					
CKLORACK R Tracks [Base 6013UPST [is Track N	e Track] base track] Ups ame Track	stream - Commercia K Nr. Measure Code IPST CKLORACK		Ver				
CRLORACK R 'racks [Base 6013UPST [is Track N Jpstream - Cc iffetimes quipment lifet Measure I noremental co	e Track] base track] Up: ame Track mmmercial 6013U ime is 12 years <sup>(1)</sup> cost sts for an Energ	x Nr. Measure Code	Free Rider Spill C					
CRLORACK R Tracks [Bass GO13UPST [is Track N Jpstream - Cc iffetimes quipment lifet Measure to to remental co Reference	e Track] base track] Up: ame Track immercial 6013U ime is 12 years <sup>(1)</sup> Cost ests for an Energ e Table	Nr. Measure Code	Free Rider Spill C 1.00 1.00	128 per oven. <sup>[7]</sup>				
CRLORACK R racks [Base Gol3UPST [is Track N Jpstream - Co .ifetimes quipment lifet Measure incremental co Referenc the following t Energy	e Track] base track] Upr ame Track immercial(6013U ime is 12 years) Cost ests for an Energy e Table able shows the a	Nr. Measure Code PST CKLORACK	Free Rider Spill C 1.00 1.00 assumed to be \$4, and corresponding 3	128 per oven. <sup>[7]</sup>	Διω	ΔkWh	ΔMMBtu	RemCode
CRLORACK R racks [Base 5013UPST [is Track N Ipstream - Co ifetimes quipment iffet deasure i coremental co Reference he following t Energy Source Natural Gas	e Track] base track up ame Track immercial 60130 immers 12 years <sup>(1)</sup> Cost e Table able shows the <i>a</i> Size Class Double Oven	<ul> <li>Nr. Measure Code PST/CALORACK</li> <li>e),</li> <lie),< li=""> <lie),< td=""><td>Pree Rider Spill C           1.00         1.00           assumed to be \$4,           and corresponding           AddeDalyBtu           188,000</td><td>128 per oven.<sup>[7]</sup> RemCode:</td><td><u>ΔKW</u> N/A</td><td>ΔkWh</td><td>180.65</td><td>CI-KTN-ROVN-NG</td></lie),<></lie),<></ul>	Pree Rider Spill C           1.00         1.00           assumed to be \$4,           and corresponding           AddeDalyBtu           188,000	128 per oven. <sup>[7]</sup> RemCode:	<u>ΔKW</u> N/A	ΔkWh	180.65	CI-KTN-ROVN-NG
Track N Upstream - Co Lifetimes Equipment lifet Measure	base track] Ups base track] Ups mmercial 6013U ime is 12 years <sup>(1)</sup> Cost	Nr. Measure Code	Free Rider Spill C					
CRLORACK R racks [Bass 6013UPST [is Track N Upstream - Cc Lifetimes quipment lifet Measure incremental co Referenc The following t Energy Natural Gas	e Track] base track Up ame Track mmercial 6013U ime is 12 years <sup>(1)</sup> Cost e Table able shows the <i>i</i> size Class	<ul> <li>Nr. Measure Code PST/CALORACK</li> <li>e),</li> <lie),< li=""> <lie),< td=""><td>Free Rider Spill C       1.00     1.00       assumed to be \$4,       and corresponding:       ΔIdleDailyBtu</td><td>128 per oven.<sup>[7]</sup> RemCode: ΔCookingDailyBtu</td><td></td><td></td><td></td><td></td></lie),<></lie),<></ul>	Free Rider Spill C       1.00     1.00       assumed to be \$4,       and corresponding:       ΔIdleDailyBtu	128 per oven. <sup>[7]</sup> RemCode: ΔCookingDailyBtu				
CRLORACK R racks [Bass 6013UPST [is Track N Upstream - Cc Lifetimes quipment lifet Measure incremental co Referenc The following t Energy Natural Gas	e Track] base track up ame Track immercial 60130 immers 12 years <sup>(1)</sup> Cost e Table able shows the <i>a</i> Size Class Double Oven	<ul> <li>Nr. Measure Code PST/CALORACK</li> <li>e),</li> <lie),< li=""> <lie),< td=""><td>Pree Rider Spill C           1.00         1.00           assumed to be \$4,           and corresponding           AddeDalyBtu           188,000</td><td>128 per oven. [7] RemCode: ACcookingDailyBtu 376,000</td><td>N/A</td><td>N/A</td><td>180.65</td><td>CI-KTN-ROVN-NG</td></lie),<></lie),<></ul>	Pree Rider Spill C           1.00         1.00           assumed to be \$4,           and corresponding           AddeDalyBtu           188,000	128 per oven. [7] RemCode: ACcookingDailyBtu 376,000	N/A	N/A	180.65	CI-KTN-ROVN-NG
CRLORACK R Fracks [Bass 6013UPST [is Track N Upstream - Cc Lifetimes Equipment lifet Measure 1 Incremental co Reference Reference Netural Gas Propane	e Track] base track up ame Track immercial 6013U immercial 6013U cost cost e Table able shows the <i>a</i> Size Class Double Oven	<ul> <li>Nr. Measure Code PST/CALORACK</li> <li>e),</li> <lie),< li=""> <lie),< td=""><td>Pree Rider Spill C           1.00         1.00           assumed to be \$4,           and corresponding           AddeDalyBtu           188,000</td><td>128 per oven. [7] RemCode: ACcookingDailyBtu 376,000</td><td>N/A</td><td>N/A</td><td>180.65</td><td>CI-KTN-ROVN-NG</td></lie),<></lie),<></ul>	Pree Rider Spill C           1.00         1.00           assumed to be \$4,           and corresponding           AddeDalyBtu           188,000	128 per oven. [7] RemCode: ACcookingDailyBtu 376,000	N/A	N/A	180.65	CI-KTN-ROVN-NG
CALORACK R fracks [Bass 6013UPST [is Track N Upstream - Cc Lifetimes quipment lifet Measure I Incremental co Reference the following t Energy Natural Gas Propane	track] Upt base track] Upt mme is 12 years <sup>(1)</sup> ime is 12 years <sup>(1)</sup> <b>Cost</b> <b>e Table</b> able shows the <i>a</i> <b>Size Class</b> Double Oven Double Oven	Nr. Measure Code IST OLDRACK	Prece Rider Spill C           1.00         1.00           assumed to be \$4,           and corresponding <b>4.1deDatyBtu</b> 188,000           198,000	128 per oven. [7] RemCode: ACcookingDailyBtu 376,000	N/A N/A	N/A	180.65	CI-KTN-ROVN-NG
CRLORACK R Tracks [Bass 6013UPST [is Track N Upstream - Cc Lifetimes Equipment lifet Measure 1 incremental co Reference The following t Energy Natural Gas Propane Dottoles 1] FSTC Over	track]     track     track	N. Measure Code BST OLDRACK 9. PEriodent model are algorithm outcomes in <b>APreheatDailyBt</b> 15,000 15,000	Pree Rider Spill C           1.00         1.00           assumed to be \$4,           and corresponding <b>UddeDatyBtu</b> 188,000           198,000           Ovens, pg 7. Pleas	128 per oven. <sup>[7]</sup> RemCode: <b>ACookingDailyBtu</b> 376,000 376,000	N/A N/A	N/A N/A	180.65 180.65	CI-KTN-ROVN-NG CI-KTN-ROVN-LP

[4] Based on Pacific Gas & Electric Company Work Paper PGECOFST109 R6 "Commercial Rack Oven - Gas", April 2016. Table 4 "Measure Test Results for Energy Efficinet Commercial Rack Ovens", pg. 2. *Hease see Referenced Documents*.

[5] Assumes operation 6 out of 7 days per week. 6 days/week x 52 week/year = 312 days/year.

[6] California Public Utilities Commission. Database for Energy Efficient Resources. Effective Useful Life Table (2014). Please see Referenced Document.

[7] Based on Pacific Gas & Electric Company Work Paper PGECOFST109 R6 "Commercial Rack Oven - Gas", April 2016. App A Table "Equipment Incremental Cost Data for Energy Efficient Rack Ovens", pp. 11. Please see Referenced Documents.

			R Dishwasher	
Measure Numbe Portfolio:			folio 2017-07	
Status:	Active		1010 2017-07	
Effective Date: End Date:	2018/1/1 2022/12/			
Program:			w Construction	
End Use:	Kitchen E	Guip	nent	
Update Sun	nmarv			
		er m	easure has been updated according to the 3-year reliability	y review schedule.
• DEER2014-EL				
ACEEE_Better	r Appliances	_Ma	2013	
EVI_ENERGY	STAK DISH	wasn	er_Analysis_June2017_v4	
Description				
		ashe	r meeting the ENERGY STAR/CEE Tier 1 efficiency specific	ations is installed in place of a model meeting the federal
standard				
Algorithms				
Electric Deman	d Savings			
ΔkW	= Δ	kWh	/ (Ncycles × Hours/Cycle)	
Symbol Table				
Electric Energy	Savings			
ΔkWh				_EE) × %Distwasher × (%Fuel_DHW, oil + %Fuel_DHW, p
	ropi	ane -	%Fuel_DHW, natural gas))	
Symbol Table				
Fossil Fuel Savi				
ΔMMBtu	= ((	(kWh	_Base - kWh_EE) × %DHW × 3,412 × ηElectric_DHW / ηF	uel_DHW) / 1,000,000
Symbol Table				
Water Savings				
ΔCCF	= (0	Sallor	is/Cycle_Base - Gallons/Cycle_EE) × Ncycles / 748	
Where:				
%DHW		-	Percentage of total energy consumption used for water h	eating (deemed, dependent on dishwasher type)
			Dishwasher Type	%DHW <sup>(3)</sup>
			Standard	45%
			Standard Compact	45% 54%
%Dishwas	sher	-	Compact Percentage of total energy consumption used for dishwas	54% sher operation (deemed, dependent on dishwasher type)
%Dishwas	sher	-	Compact Percentage of total energy consumption used for dishware Dishwasher Type	54% sher operation (deemed, dependent on dishwasher type) %dDishwasher(3)
%Dishwas	sher	-	Compact Percentage of total energy consumption used for distwase Dishwasher Type Standard	54% sher operation (deemed, dependent on dishwasher type) %Dishwasher(1) 55%
		-	Compact Percentage of total energy consumption used for dishwas Dishwasher Type Standard Compact	54% she operation (deemed, dependent on dishwasher type) %Dishwasher(1) 55% 46%
%Dishwas %Electric		-	Compact Percentage of total energy consumption used for distwase Dishwasher Type Standard	54% she operation (deemed, dependent on dishwasher type) %Dishwasher(1) 55% 46%
	_DHW	•	Compact Percentage of total energy consumption used for dishwase Dishwasher Type Standard Compact Percentage of DRW savings assumed to be electric (deer = 24% <sup>[4]</sup>	54%5 sher operation (deemed, dependent on dishwasher type) %6Dishwasher(1) 55% 46%5 end)
%Electric	_DHW	•	Compact Percentage of total energy consumption used for dishwase Dishwasher Type Standard Compact Percentage of DHW savings assumed to be electric (deer	54%5 sher operation (deemed, dependent on dishwasher type) %6Dishwasher(1) 55% 46%5 end)
%Electric	_DHW	-	Compact Percentage of total energy consumption used for dishwase Dishwasher Type Standard Compact Percentage of DHW savings assumed to be electric (deer = 24% <sup>2</sup> Percentage of DHW savings assumed to be non electric	54%6 54%6 54%6 55% 55% 46% 6% 6% 6% 6% 6% 6% 6% 6% 6% 6% 6% 6% 6
%Electric	_DHW	-	Compact Percentage of total energy consumption used for dishwase Distrivasher Type Standard Compact Percentage of DHW savings assumed to be electric (deer = 24% 9 Percentage of DHW savings assumed to be non electric DHM NeutType Oil Natural Gas	54%6         54%6           sher operation (deemed, dependent on dishwasher type)         %6Dishwasher(3)           \$5%6         46%6           ned)         (deemed, dependent on DRW fuel type)           \$%Fuel_DRW(*1)         10%6           14%6         14%6
%Electric	_DHW	-	Compact Percentage of total energy consumption used for dishware Dishwasher Type Standard Compact Percentage of DHW savings assumed to be electric (deer = 24%) <sup>G</sup> Percentage of DHW savings assumed to be non electric: DHW Ruel Type Oil	54%6 54%6 sher operation (deemed, dependent on dishwasher type) 960bhwasher(3) 55%6 46%6 red) (deemed, dependent on DHW fuel type) 96Puel_DHW(4) 10%6
%Electric	_DHW		Compact Percentage of total energy consumption used for dishwase Dishwasher Type Standard Compact Percentage of DHW savings assumed to be electric (deer = 24%G1 Percentage of DHW savings assumed to be non electric DHW Fuel Type Ool Natural Cas Fropane Customer water savings in hundreds of cubic feet for the	54%6         54%6           sker operation (deemed, dependent on dishwasher type)         %6Dishwasher(3)           55%6         46%6           46%6
%Electric	_DHW	-	Compact Percentage of total energy consumption used for dishwase Dishwasher Type Standard Compact Percentage of DHW savings assumed to be electric (deer = 24%) Percentage of DHW savings assumed to be non electric DHW Fuel Type Ool Natural Gas Fropane Customer water savings in hundreds of cubic feet for the See Reference Tables section for deemed savings values	54%6         54%6           sker operation (deemed, dependent on dishwasher type)         %6Dishwasher(3)           55%6         46%6           46%6
%Electric %Fuel_DF	_DHW	-	Compact Percentage of total energy consumption used for dishwase Dishwasher Type Standard Compact Percentage of DHW savings assumed to be electric (deer = 24% d Percentage of DHW savings assumed to be non electric DHW Fuel Type Oil Netural Cass Propane Customer water savings in hundreds of cubic feet for the See Reference Tables section for deemed savings values Gross customer connected load kW savings for the meass	54%6         54%6           94DBstwasher(*)         94DBstwasher(*)           55%         46%6           46%6         56%           ecol         96Destwasher(*)           (deemed, dependent on DHW fuel type)         96Destwasher(*)           10%6         14%6           52%6         14%6           52%6         14%6           urescure (output)         46%6
96Flectric 96Fuel_DF ACCF	_DHW	-	Compact Percentage of total energy consumption used for dishwase Dishwasher Type Standard Compact Percentage of DHW savings assumed to be electric (deer = 24%) Percentage of DHW savings assumed to be non electric DHW Fuel Type Ool Natural Cas Propane Customer water savings in hundreds of cubic feet for the See Reference Tables section for deemed savings values Gross customer connected load KW savings for the meas See Reference Tables section for deemed savings values	54%6         54%6           %4D/shwasher(*)         55%           46%6         52%           (deemed, dependent on DHW fuel type)         %6/support           %6/support         10%6           10%6         14%6           52%         14%6           sz%6
%Electric	_DHW	-	Compact Percentage of total energy consumption used for dishwase Dishwasher Type Standard Compact Percentage of DRW savings assumed to be electric (deer = 24%) <sup>61</sup> Percentage of DRW savings assumed to be non electric DHW favore Type Oil Natural Cas Propane Customer water savings in hundreds of cubic feet for the See Reference Tables section for deemed savings values Gross customer annual kWh savings for the measure (cu	54%6           96DIstiwasher 11           55%6           46%6           46%6           66           96Distiwasher 11           55%6           46%6           10%           10%6
%Electric_DP %Fuel_DP ΔCCF Δ&W	_DHW	-	Compact Percentage of total energy consumption used for dishwase Dishwasher Type Standard Compact Percentage of DRW savings assumed to be electric (deer = 24%d <sup>-1</sup> Percentage of DRW savings assumed to be on electric DRW Ruel Type Oil Natural Cass Propane Customer water savings in hundreds of cubic feet for the See Reference Tables section for deemed savings values Gross customer annual KWh savings for the measure (ou See Reference Tables section for deemed savings values	54%5  sher operation (deemed, dependent on dishwasher type)  %Dishwasher(1)  55%  46%  46%  46%  (deemed, dependent on DHW fuel type)  %  %  %  (deemed, dependent on DHW fuel type)  %  %  %  %  %  %  %  %  %  %  %  %  %
96Flectric 96Fuel_DF ACCF	_DHW	-	Compact  Compact  Percentage of total energy consumption used for distivuant  Distrivusher Type  Standard  Compact  Percentage of DHW savings assumed to be electric (deer = 24%9 <sup>4</sup> Percentage of DHW savings assumed to be non electric  DHW fuel Type  Oil  Natural Cas  Propane  Customer water savings in hundreds of cubic feet for the See Reference Tables section for deemed savings values Gross customer cannetad bad kW savings for the measure (os se Reference Tables section for deemed savings values Gross customer annual MMBu savings for the measure (os See Reference Tables section for deemed savings values Gross customer annual MMBu savings for the measure (os See Reference Tables section for deemed savings values Gross customer annual MMBu savings for the measure (os See Castomer annual MMBu savings for the measure (os See Reference Tables section for deemed savings values Gross customer annual MMBu savings for the measure (os See Reference Tables section for deemed savings values Gross customer annual MMBu savings for the measure (os See Reference Tables section for deemed savings values Gross customer annual MMBu savings for the measure (os See Reference Tables section for deemed savings values Gross customer annual MMBu savings for the measure (os See Reference Tables section for deemed savings values Gross customer annual MMBU savings for the measure (os See Reference Tables section for deemed savings values Gross customer annual MMBU savings for the measure (os See Reference Tables section for deemed savings values Gross customer annual MMBU savings for the measure (os See Reference Tables section for deemed savings values Gross customer annual MMBU savings for the measure (os See Reference Tables section for deemed savings values Gross customer annual MMBU savings for the measure (os See Reference Tables section for deemed savings values Gross customer annual MMBU savings for the measure (os See Reference Tables section for deemed savings values Gross customer annual MMBU savings for the measure (os See R	54% she operation (deemed, dependent on dishwasher type)
%Electric, %Fuel_DF ACCF AXW AXWh AMMBu	_DHW	-	Compact  Compact  Percentage of total energy consumption used for distivuant  Distrivusher Type  Standard  Compact  Percentage of DHW savings assumed to be electric (deer = 24%9 <sup>4</sup> Percentage of DHW savings assumed to be non electric  DHW fuel Type  Oil  Natural Cas  Propane  Customer water savings in hundreds of cubic feet for the See Reference Tables section for deemed savings values Gross customer cannetad bad KW savings for the measure (or See Reference Tables section for deemed savings values Gross customer annual KMh savings for the measure (or See Reference Tables section for deemed savings values Gross customer annual KMh savings for the measure (or See Reference Tables section for deemed savings values Gross customer annual KMh savings for the measure (or See Reference Tables section for deemed savings values Gross customer annual KMh savings for the measure (or See Reference Tables section for deemed savings values Gross customer annual KMh savings for the measure (or See Reference Tables section for deemed savings values Gross customer annual KMh savings for the measure (or See Reference Tables section for deemed savings values Gross customer annual KMh savings for the measure (or See Reference Tables section for deemed savings values Gross customer annual KMh savings for the measure (or See Reference Tables section for deemed savings values Gross customer annual KMh savings for the measure (or See Reference Tables section for deemed savings values Gross customer annual KMh savings for the measure (or See Reference Tables section for deemed savings values Gross customer annual KMh savings for the measure (or See Reference Tables section for deemed savings values Gross customer annual KMh savings for the measure (or See Reference Tables section for deemed savings values Gross customer annual KMh savings for the measure (or See Reference Tables section for deemed savings values Gross customer annual KMh savings for the measure (or See Reference Tables section for deemed savings values Gross Customer a	54% she operation (deemed, dependent on dishwasher type)
%Electric_DP %Fuel_DP ΔCCF Δ&W	_DHW	-	Compact  Compact  Percentage of total energy consumption used for distivuant  Distrivusher Type  Standard  Compact  Percentage of DHW savings assumed to be electric (deer = 24%9 <sup>4</sup> Percentage of DHW savings assumed to be non electric  DHW fuel Type  Oil  Natural Cas  Propane  Customer water savings in hundreds of cubic feet for the See Reference Tables section for deemed savings values Gross customer cannetad bad kW savings for the measure (os se Reference Tables section for deemed savings values Gross customer annual MMBu savings for the measure (os See Reference Tables section for deemed savings values Gross customer annual MMBu savings for the measure (os See Reference Tables section for deemed savings values Gross customer annual MMBu savings for the measure (os See Castomer annual MMBu savings for the measure (os See Reference Tables section for deemed savings values Gross customer annual MMBu savings for the measure (os See Reference Tables section for deemed savings values Gross customer annual MMBu savings for the measure (os See Reference Tables section for deemed savings values Gross customer annual MMBu savings for the measure (os See Reference Tables section for deemed savings values Gross customer annual MMBu savings for the measure (os See Reference Tables section for deemed savings values Gross customer annual MMBU savings for the measure (os See Reference Tables section for deemed savings values Gross customer annual MMBU savings for the measure (os See Reference Tables section for deemed savings values Gross customer annual MMBU savings for the measure (os See Reference Tables section for deemed savings values Gross customer annual MMBU savings for the measure (os See Reference Tables section for deemed savings values Gross customer annual MMBU savings for the measure (os See Reference Tables section for deemed savings values Gross customer annual MMBU savings for the measure (os See Reference Tables section for deemed savings values Gross customer annual MMBU savings for the measure (os See R	54% she operation (deemed, dependent on dishwasher type)
96Electric 96Fuel_DF ΔCCF ΔKW ΔKWh ΔMMBu ŋElectric	DHW DHW	-	Compact Percentage of total energy consumption used for dishwase Dishwasher Type Standard Compact Percentage of DHW savings assumed to be electric (deer = 24% 4 Percentage of DHW savings assumed to be non electric DMW fuel Type Oil Nehtural Cas Propane Customer water savings in hundreds of cubic feet for the See Reference Tables section for deemed savings values Gross customer annual KWH savings for the measure (o Ges Reference Tables section for deemed savings values Gross customer annual KWH savings for the measure (o See Reference Tables section for deemed savings values Gross customer annual KWH savings for the measure (o See Reference Tables section for deemed savings values Gross customer annual KWH savings for the measure (o See Reference Tables section for deemed savings values Gross customer annual KWH savings for the measure (o See Reference Tables section for deemed savings values Gross customer annual KWH savings for the measure (o See Reference Tables section for deemed savings values Gross customer annual KWH savings for the measure (o See Reference Tables section for deemed savings values Gross customer annual KWH savings for the measure (o See Reference Tables section for deemed savings values Gross customer annual KWH savings for the measure (o See Reference Tables section for deemed savings values Gross customer annual KWH savings for the measure (o See Reference Tables section for deemed savings values Gross customer annual KWH savings for the measure (o See Reference Tables section for deemed savings values Gross customer annual KWH savings for the measure (o See Reference Tables section for deemed savings values Gross customer annual KWH savings for the measure (o See Reference Tables section for deemed savings values Gross customer annual KWH savings for the measure (o See Reference Tables section for deemed savings values Gross customer annual KWH savings for the measure (o See Reference Tables section for deemed savings values Gross customer annual KWH savings for the measure (o See Refe	54%  she operation (deemed, dependent on dishwasher type)
%Electric, %Fuel_DF ACCF AXW AXWh AMMBu	DHW DHW	-	Compact Percentage of total energy consumption used for dishwase Distrivasher Type Standard Compact Percentage of DHW savings assumed to be electric (deer = 24% 4 Percentage of DHW savings assumed to be non electric DHW Neal Type Oil Natural Gas Propane Customer water savings in hundreds of cubic feet for the See Reference Tables section for deemed savings values Gross customer annual KWh savings for the measure (customer	54%  she operation (deemed, dependent on dishwasher type)
96Electric 96Fuel_DF ΔCCF ΔKW ΔKWh ΔMMBu ŋElectric	DHW DHW	-	Compact  Compact  Percentage of total energy consumption used for dishwase  Dishwasher Type  Standard  Compact  Percentage of DHW savings assumed to be electric (deer = 24%G1  Percentage of DHW savings assumed to be electric (deer = 24%G1  Percentage of DHW savings assumed to be non electric  DHW Fuel Type  Ool Natural Cas  Propane  Customer angle section for deemed savings values Gross customer annual KWh savings for the measure (or See Reference Tables section for deemed savings values Gross customer annual MMBu savings for the measure (or See Reference Tables section for deemed savings values Gross customer annual MMBu savings for the measure (or See Reference Tables section for deemed savings values Recovery efficiency of electric water heater (deemed) = 0.98 <sup>G</sup> Recovery efficiency of fuel water heater (deemed, depenter	54%6 sher operation (deemed, dependent on dishwasher type) 54/Dishwasher(1) 55% 46%6 16%6 16%6 16%6 16%6 16%6 17%6 10%6 14%5 52%6 10%6 14%5 52%6 14%5 52%6 14%5 10%6 14%5 10%6 14%5 10%6 14%5 10%6 14%5 10%6 14%5 10%6 14%5 10%6 14%5 10%6 14%5 10%6 14%5 10%6 14%5 10%6 14%5 10%6
96Electric 96Fuel_DF ΔCCF ΔKW ΔKWh ΔMMBu ŋElectric	DHW DHW	-	Compact  Compact  Percentage of total energy consumption used for dishwase  Dishwasher Type  Standard  Compact  Percentage of DHW savings assumed to be electric (deer = 24%G1  Percentage of DHW savings assumed to be electric (deer = 24%G1  Percentage of DHW savings assumed to be non electric  DHW Fuel Type  Ooi Natural Cas  Fropane  Customer avater savings in hundreds of cubic feet for the See Reference Tables section for deemed savings values Gross customer annual KMH savings for the measure (o See Reference Tables section for deemed savings values Gross customer annual KMH savings for the measure (o See Reference Tables section for deemed savings values Gross customer annual KMHs usavings for the measure (see Reference Tables section for deemed savings values Gross customer annual KMHs usavings for the measure (see Reference Tables section for deemed savings values Gross customer annual KMHs usavings for the measure (see Reference Tables section for deemed savings values Gross customer annual KMHs usavings for the measure (see Reference Tables section for deemed savings values Gross customer annual KMHs usavings for the measure (see Reference Tables section for deemed savings values Gross customer annual KMHs usavings for the measure (see Reference Tables section for deemed savings values Recovery efficiency of electric water heater (deemed) = 0.98 <sup>(7)</sup> Recovery efficiency of fuel water heater (deemed, depen DHW Fuel Type	54%6           54%6           54%6           55%6           46%6           55%           46%6           600           (deemed, dependent on DHW fuel type)           56/bull_DHW <sup>61</sup> 10%6           14%6           52%6           14%8           52%6           14%9           52%6           ure (output)           4           4           output)           4           4           0utput)           4     <
96Electric 96Fuel_DF ΔCCF ΔKW ΔKWh ΔMMBu ŋElectric	DHW DHW	-	Compact  Compact  Percentage of total energy consumption used for dishwase  Dishwasher Type  Standard  Compact  Percentage of DHW savings assumed to be electric (deer = 24% d  Percentage of DHW savings assumed to be non electric  DHW fuel Type  Oil  Natural Cass Propane  Customer water savings in hundreds of cubic feet for the See Reference Tables section for deemed savings values Gross customer annual MMR savings for the measure (or See Reference Tables section for deemed savings values Gross customer annual MMR savings for the measure (or See Reference Tables section for deemed savings values Gross customer annual MMR savings for the measure (or See Reference Tables section for deemed savings values Gross customer annual MMR savings for the measure (or See Reference Tables section for deemed savings values Gross customer annual MMR savings for the measure (or See Reference Tables section for deemed savings values Gross customer annual MMR savings for the measure (or See Reference Tables section for deemed savings values Gross customer annual MMR savings for the measure (or See Reference Tables section for deemed savings values Gross customer annual MMR savings for the measure (or See Reference Tables section for deemed savings values Gross customer annual MMR savings for the measure (or See Reference Tables section for deemed savings values Gross customer annual MMR savings for the measure (or See Reference Tables section for deemed savings values Case Customer annual MMR savings for the measure (or See Reference Tables section for deemed savings values Case Customer annual MMR savings for the measure (or See Reference Tables section for deemed savings values Case Customer annual MMR savings for the measure (or See Reference Tables section for deemed savings values Case Customer annual MMR savings for the measure (or Case Customer annual MMR savings for the measure (or Case Customer annual MMR savings for the measure (or Case Customer annual MMR savings (or Case Customer annual MMR savings (or Case Customer a	54%6           56%6           560/bitwasher(1)           55%           46%6           67           60           60           60           60           60           60           60
96Electric 96Fuel_DF ΔCCF ΔKW ΔKWh ΔMMBu ŋElectric	_DHW	-	Compact Compact Compact Compact Percentage of total energy consumption used for distwase Distwasher Type Standard Compact Percentage of DHW savings assumed to be electric (deer = 24%9' Percentage of DHW savings assumed to be non electric DHW fuel Type Oil Natural Cas Propane Customer water savings in hundreds of cubic feet for the See Reference Tables section for deemed savings values Gross customer connected load kW savings for the measure (o See Reference Tables section for deemed savings values Gross customer annual KMh savings for the measure (o See Reference Tables section for deemed savings values Gross customer annual KMh savings for the measure (o See Reference Tables section for deemed savings values Gross customer annual KMh savings for the measure (o See Reference Tables section for deemed savings values Gross customer annual KMh savings for the measure (o See Reference Tables section for deemed savings values Gross customer annual KMh savings for the measure (o See Reference Tables section for deemed savings values Gross customer annual KMh savings for the measure (o See Reference Tables section for deemed savings values Gross customer annual KMh savings for the measure (o See Reference Tables section for deemed savings values Gross customer annual KMh savings for the measure (o See Reference Tables section for deemed savings values Gross customer annual KMh savings for the measure (o See Reference Tables section for deemed savings values Gross customer annual KMh savings for the measure (o See Reference Tables section for deemed savings values Gross customer annual KMh savings for the measure (o See Reference Tables section for deemed savings values Gross customer annual KMh savings for the measure (D See Reference Tables section for deemed savings values Gross customer annual KMh savings for the measure (D See Reference Tables section for deemed savings values Gross customer annual KMh savings for the measure (D See Reference Tables section for deemed savings values Gross customer annual KMh savin	54%         54%           sher operation (deemed, dependent on dishwasher type)         960bitwasher(1)           55%         46%           46%
96Electric, 96Fuel_DF ACCF AXW AXWh AMMBLu nFuel_DH	_DHW	-	Compact  Compact  Percentage of total energy consumption used for distivas  Distivasher Type  Standard  Compact  Percentage of DHW savings assumed to be electric (deer = 24%9'4  Percentage of DHW savings assumed to be non electric  DHW fuel Type  Oil  Natural Cas  Propane  Customer water savings in hundreds of cubic feet for the See Reference Tables section for deemed savings values Gross customer connected load KW savings for the measure (o See Reference Tables section for deemed savings values Gross customer annual KMh savings for the measure (o See Reference Tables section for deemed savings values Gross customer annual KMh savings for the measure (o See Reference Tables section for deemed savings values Gross customer annual KMh savings for the measure (o See Reference Tables section for deemed savings values Gross customer annual KMh savings for the measure (o See Reference Tables section for deemed savings values Gross customer annual KMh savings for the measure (o See Reference Tables section for deemed savings values Gross customer annual KMh savings for the measure (o See Reference Tables section for deemed savings values Gross customer annual KMh savings for the measure (o See Reference Tables section for deemed savings values Gross customer annual KMh savings for the measure (o See Reference Tables section for deemed savings values Gross customer annual KMh savings for the measure (o See Reference Tables section for deemed savings values Gross customer annual KMh savings for the measure (o See Reference Tables section for deemed savings values Gross customer annual KMh savings for the measure (o See Reference Tables section for deemed savings values Gross customer annual KMh savings for the measure (D See Reference Tables section for deemed savings values Gross customer annual KMh savings for the measure (D See Reference Tables section for deemed savings values Gross customer annual KMh savings for the measure (D See Reference Tables section for deemed savings values Gross customer annual KMh savings	54%         54%           sher operation (deemed, dependent on dishwasher type)         960bitwasher(1)           55%         46%           46%
96Electric, 96Fuel, DF ACCF AXW AMMBL nFuel, DH	_DHW	-	Compact Compact Compact Compact Percentage of total energy consumption used for distwase Distwasher Type Standard Compact Percentage of DHW savings assumed to be electric (deer = 24%9' Percentage of DHW savings assumed to be non electric DHW fuel Type Oil Natural Cas Propane Customer water savings in hundreds of cubic feet for the See Reference Tables section for deemed savings values Gross customer connected load KW savings for the measure (o See Reference Tables section for deemed savings values Gross customer annual KMh savings for the measure (o See Reference Tables section for deemed savings values Gross customer annual KMh savings for the measure (o See Reference Tables section for deemed savings values Gross customer annual KMh savings for the measure (o See Reference Tables section for deemed savings values Gross customer annual KMh savings for the measure (o See Reference Tables section for deemed savings values Gross customer annual KMh savings for the measure (o See Reference Tables section for deemed savings values Gross customer annual KMh savings for the measure (o See Reference Tables section for deemed savings values Gross customer annual KMh savings for the measure (o See Reference Tables section for deemed savings values Gross customer annual KMh savings for the measure (o See Reference Tables section for deemed savings values Gross customer annual KMh savings for the measure (o See Reference Tables section for deemed savings values Gross customer annual KMh savings for the measure (o See Reference Tables section for deemed savings values Gross customer annual KMh savings for the measure (o See Reference Tables section for deemed savings values Gross customer annual KMh savings for the measure (D See Reference Tables section for deemed savings values Gross customer annual KMh savings for the measure (D See Reference Tables section for deemed savings values Gross customer annual KMh savings for the measure (D See Reference Tables section for deemed savings values Gross customer annual KMh savin	54%         54%           sher operation (deemed, dependent on dishwasher type)         960bitwasher(1)           55%         46%           46%
96Electric, 96Fuel, DF 44CCF 444W 444Wh 44	_DHW	-	Compact Compact Compact Compact Percentage of total energy consumption used for distwase Distwasher Type Standard Compact Percentage of DHW savings assumed to be electric (deer = 24%9' Percentage of DHW savings assumed to be non electric DHW fuel Type Oil Natural Cas Propane Customer water savings in hundreds of cubic feet for the See Reference Tables section for deemed savings values Gross customer connected load KW savings for the measure (o See Reference Tables section for deemed savings values Gross customer annual KMh savings for the measure (o See Reference Tables section for deemed savings values Gross customer annual KMh savings for the measure (o See Reference Tables section for deemed savings values Gross customer annual KMh savings for the measure (o See Reference Tables section for deemed savings values Gross customer annual KMh savings for the measure (o See Reference Tables section for deemed savings values Gross customer annual KMh savings for the measure (o See Reference Tables section for deemed savings values Gross customer annual KMh savings for the measure (o See Reference Tables section for deemed savings values Gross customer annual KMh savings for the measure (o See Reference Tables section for deemed savings values Gross customer annual KMh savings for the measure (o See Reference Tables section for deemed savings values Gross customer annual KMh savings for the measure (o See Reference Tables section for deemed savings values Gross customer annual KMh savings for the measure (o See Reference Tables section for deemed savings values Gross customer annual KMh savings for the measure (D See Reference Tables section for deemed savings values Gross customer annual KMh savings for the measure (D See Reference Tables section for deemed savings values Gross customer annual KMh savings for the measure (D See Reference Tables section for deemed savings values Gross customer annual KMh savings for the measure (D See Reference Tables section for deemed savings values Gross customer annual KMh savin	54%         54%           ther operation (deemed, dependent on dishwasher type)         9606thwasher(1)           55%         46%           46%
96Electric, 96Fuel, DF 44CCF 444W 444Wh 44	DHW	-	Compact Compact Compact Compact Compact Distwesher Type Standard Compact Percentage of DHW savings assumed to be electric (deer 2 49% <sup>2</sup> ) Percentage of DHW savings assumed to be non electric DHW fuel Type Oil Natural Cas Propane Oil Natural Cas Propane Customer water savings in hundreds of cubic feet for the See Reference Tables section for deemed savings values Gross customer connected load kW savings for the measure (o See Reference Tables section for deemed savings values Gross customer annual MMBu savings for the measure (o See Reference Tables section for deemed savings values Gross customer annual MMBu savings for the measure (o See Reference Tables section for deemed savings values Gross customer annual MMBu savings for the measure (o See Reference Tables section for deemed savings values Gross customer annual MMBu savings for the measure (o See Reference Tables section for deemed savings values Gross customer annual MMBu savings for the measure (o See Reference Tables section for deemed savings values Gross customer annual MMBu savings for the measure (o See Reference Tables section for deemed savings values Gross customer annual MMBu savings for the measure (o See Reference Tables section for deemed savings values Gross customer annual MMBu savings for the measure (o See Reference Tables section for deemed savings values Gross customer annual MMBu savings for the measure (D See Reference Tables section for deemed savings values Gross customer annual MMBu savings for the measure (D See Reference Tables section for deemed savings values Gross customer annual MMBu savings for the measure (D See Reference Tables section for deemed savings values Gross customer annual MMBu savings for the measure (D I Natural Cas Propane Conversion factor from Bu to MMBu (constant) Conversion factor from Bu to KWh (constant) Conversion factor from Bu	54%         54%           ther operation (deemed, dependent on dishwasher type)         9606hwasher(1)           55%         46%           46%
96Electric, 96Fuel, DF 44CCF 444W 444Wh 44	DHW	-	Compact Compact Compact Percentage of total energy consumption used for dishwas Dishwasher Type Standard Compact Percentage of DHW savings assumed to be electric (deer 2 445/9 Percentage of DHW savings assumed to be electric (deer 2 445/9 Percentage of DHW savings assumed to be non electric DHW Fuel Type OII Netural Cas Propane Customer annual KMN savings for the measure (customer vater savings in hundreds of cubic feet for the See Reference Tables section for deemed savings values Gross customer annual KMNs anyings for the measure (customer annual KMN savings for the measure (customer annual KMNs anyings for the measure (customer and and KMNs anyings for the measure (customer and and KMNs anyings for the measure (customer and and KMNs anying for the measure (customer and anying for the measur	54%6           54%6           ster operation (deemed, dependent on dishwasher type)           56/06/Washer(1)           55%6           46%6           10%6           10%6           10%6           14%9           52%6           10%6           14%9           52%6           wre (output)           4.           output)           4.           dent on DHW fuel type) <b>rise_DMW*1 rise_DMW*1</b> 0.80           0.74           0.84           sther (deemed, dependent on dishwasher type)           Gallons/Ocycle_Base <sup>(1)</sup> 5.0
96Electric, 96Fuel, DF 44CCF 444W 444Wh 44	DHW	-	Compact Compact Percentage of total energy consumption used for dishwas Dishwasher Type Standard Compact Percentage of DHW savings assumed to be electric (deer 2 49% 4 Percentage of DHW savings assumed to be electric (deer 2 49% 4 Percentage of DHW savings assumed to be non electric DHW Neal Type Oil Natural Cas Propane Customer water savings in hundreds of cubic feet for the See Reference Tables section for deemed savings values Gross customer annual KWN savings for the measure (customer annual KWN savings for	54%         54%           sher operation (deemed, dependent on dishwasher type)         960Shwasher(3)           55%         46%           46%         10%           46%         10%           10%         10%           10%         10%           10%         10%           10%         10%           10%         10%           10%         10%           10%         10%           10%         10%           10%         10%           10%         10%           10%         10%           10%         10%           10%         10%           10%         10%           10%         10%           dett on DHW fuel bype)         10%           10%         0.80           0.74         0.84           sher (deemed, dependent on dishwasher type)           Galbons/Cycle_Base <sup>(1)</sup>
96Electric, 96Fuel, DF 44CCF 444W 444Wh 44	_DHW HW DHW W ycle_Base	-	Compact Compact Percentage of total energy consumption used for dishwase Dishwasher Type Standard Compact Percentage of DHW savings assumed to be electric (deer = 24%54 Percentage of DHW savings assumed to be electric (deer = 24%54 Percentage of DHW savings assumed to be non electric DHW Fuel Type OGI Natural Cas Propane Customer and the savings of cubic feet for the See Reference Tables section for deemed savings values Gross customer annual KWh savings for the measure (o See Reference Tables section for deemed savings values Gross customer annual KMN savings for the measure (o See Reference Tables section for deemed savings values Gross customer annual MMBu savings for the measure (o See Reference Tables section for deemed savings values Gross customer annual MMBu savings for the measure (o See Reference Tables section for deemed savings values Gross customer annual MMBu savings for the measure (o See Reference Tables section for deemed savings values Gross customer annual MMBU savings for the measure (o See Reference Tables section for deemed savings values Gross customer annual MMBU savings for the measure (o See Reference Tables section for deemed savings values Gross customer annual MMBU savings for the measure (o See Reference Tables section for deemed savings values Gross customer annual MMBU savings for the measure (o See Reference Tables section for deemed savings values Gross customer annual MMBU savings for the measure (o See Reference Tables section for deemed savings values Gross customer annual MMBU savings for the measure (o See Reference Tables section for deemed savings values Convery efficiency of fuel water heater (deemed) = 0.98*7 Recovery efficiency of fuel water heater (deemed) Comversion factor from Bu to MMBU (constant) Conversion factor from Bu to MMBU (constant) C	54%6         Stablehwasher(1)         55%6         46%6         10%6         10%6         10%6         14%8         52%6         46%6         10%6         14%8         52%6         46%6         10%6         14%8         52%6         ure (output)         4         40         0utput)         4         4         0utput)         4         0utput)         5         0utput)         4         0utput)         5         0.80         0.74         0.84         0.74         0.84         5.0         3.5         sher (deemed, dependent on dishwasher hype)
96Electric, 96Fuel, DF 4CCF 4AW 4AW 4AW 4AW 8Eu 76Electric, 76Electric, 76Electric, 77Electric, 748 6allone/C	_DHW HW DHW W ycle_Base	-	Compact Compact Compact Compact Compact Distwesher Type Standard Compact Percentage of DMW savings assumed to be electric (deer 2 49% <sup>2</sup> ) Percentage of DMW savings assumed to be electric (deer 2 49% <sup>2</sup> ) OI NetherType OI OI NetherType OI OI NetherType OI Compact Propane Compact Tables section for deemed savings values Gross customer connected load KW savings for the measure (o See Reference Tables section for deemed savings values Gross customer connected load KW savings for the measure (o See Reference Tables section for deemed savings values Gross customer connected load KW savings for the measure (o See Reference Tables section for deemed savings values Gross customer connected load KW savings for the measure (o See Reference Tables section for deemed savings values Gross customer annual MMBtu savings for the measure (o See Reference Tables section for deemed savings values Gross customer annual MMBtu savings for the measure (o See Reference Tables section for deemed savings values Gross customer annual MMBtu savings for the measure (o See Reference Tables section for deemed savings values Gross customer annual MMBtu savings for the measure (o See Reference Tables section for deemed savings values Gross customer annual MMBtu (constant) OI NetherType OI OI NetherType OI OI NetherType Conversion factor from Btu to MMBtu (constant) Distwasher Type Distwashe	54%           ther operation (deemed, dependent on dishwasher type)           960Eshwasher[1]           55%           46%           end)           (deemed, dependent on DFW fuel hype)           967euE_DEW(*)           10%           14%           52%           were (output)           4.           tput)           4.           tput)           5.           64ent on DFW fuel hype)           10%           10%           14%           52%           rec (output)           4.           tput)           5.           10%           10%           10%           10%           11%           coutput)           5.           10%           0.60           0.74           0.84           10%           10%           5.0           3.5           10%           10%           10%           10%           10%           10%
96Electric, 96Fuel, DF 4CCF 4AW 4AW 4AW 4AW 8Eu 76Electric, 76Electric, 76Electric, 77Electric, 748 6allone/C	_DHW HW DHW W ycle_Base	-	Compact Compact Percentage of total energy consumption used for dishwase Dishwasher Type Standard Compact Percentage of DHW savings assumed to be electric (deer = 24%54 Percentage of DHW savings assumed to be electric (deer = 24%54 Percentage of DHW savings assumed to be non electric DHW Fuel Type OGI Natural Cas Propane Customer and the savings of cubic feet for the See Reference Tables section for deemed savings values Gross customer annual KWh savings for the measure (o See Reference Tables section for deemed savings values Gross customer annual KMN savings for the measure (o See Reference Tables section for deemed savings values Gross customer annual MMBu savings for the measure (o See Reference Tables section for deemed savings values Gross customer annual MMBu savings for the measure (o See Reference Tables section for deemed savings values Gross customer annual MMBu savings for the measure (o See Reference Tables section for deemed savings values Gross customer annual MMBU savings for the measure (o See Reference Tables section for deemed savings values Gross customer annual MMBU savings for the measure (o See Reference Tables section for deemed savings values Gross customer annual MMBU savings for the measure (o See Reference Tables section for deemed savings values Gross customer annual MMBU savings for the measure (o See Reference Tables section for deemed savings values Gross customer annual MMBU savings for the measure (o See Reference Tables section for deemed savings values Gross customer annual MMBU savings for the measure (o See Reference Tables section for deemed savings values Convery efficiency of fuel water heater (deemed) = 0.98*7 Recovery efficiency of fuel water heater (deemed) Comversion factor from Bu to MMBU (constant) Conversion factor from Bu to MMBU (constant) C	54%6         Stablehwasher(1)         55%6         46%6         105%         46%6         (deemed, dependent on DHW fuel type)         Stablehwasher(1)         Stablehwasher(1)         (deemed, dependent on DHW fuel type)         Stablehwasher(1)         10%6         14%6         52%6         ure (output)         4         40         output)         4         4         64         0.00put)         5         10%6         10%6         14%6         50         0.80         0.74         0.84         scher (deemed, dependent on dishwasher type)         (allons/Cycle_Base <sup>(5)</sup> )         5.0         3.5         sher (deemed, dependent on dishwasher type)

Hours/Cycle	-	Dishwasher runtime (hours) per cycle	
		= 2.1 hours <sup>[1]</sup>	
kWh_Base	-	Annual energy consumption of baseline dishwasher (dee	med, dependent on dishwasher type)
		Dishwasher Type	kWh_Base(5)
		Standard	307
		Compact	222
kWh_EE	-	Annual energy consumption of efficient dishwasher (deer	med, dependent on dishwasher type)
		Dishwasher Type	kWh_EE <sup>(6)</sup>
		Standard	259.0
		Compact	181.6
Ncycles	-	Number of dishwasher cycles per year (deemed)	
		= 175 cycles/year <sup>[2]</sup>	

Baseline Efficiencies
The baseline reflects the minimum federal efficiency standards for dishwashers effective May 30, 2013, as presented in the table below.

Dishwasher Type	Maximum kWh/year	Maximum gallons/cycle
Standard	307	5.0
Compact	222	3.5

High Efficiency The efficienc equipment is defined as a dishwasher meeting the efficiency specifications of ENERGY STAR version 6.0, effective January 29, 2016, which are indentical to CEE Tier 1 specifications.

Dishwasher Type	Maximum kWh/year	Maximum gallons/cycle
Standard (≥ 8 place settings + six serving pieces)	270	3.5
Compact (< 8 place settings + six serving pieces)	203	3.1

## **Operating Hours**

# Load Shapes 8a Residential DHW conserve

 Number
 Name
 Status
 Winter
 Winter
 Summer
 Summer
 Winter
 Manner
 Summer
 Summer
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 Summer
 Summer</t

## Net Savings Factors

Measures CKLSEDRP Energy Star dishwasher, standard CKLCEDRP Energy Star Dishwasher Compact

## Tracks [Base Track] 6038VESH [is base track] RNC VESH

 Track Name
 Track Nr.
 Measure Code
 Free Rider Spil Over

 RNC VESH
 6038/VESH CKLSEDRP
 0.90
 1.10

 RNC VESH
 6038/VESH CKLCEDRP
 0.90
 1.10

Persistence The persistence factor is assumed to be one.

### Lifetimes 11 years<sup>[9]</sup>

Analysis period is the same as the lifetime.

Measure Cost			
Dishwasher Type	Baseline Cost	ENERGY STAR Cost	Incremental Cost <sup>[10]</sup>
Standard	\$255.63	\$331.30	\$75.67
Compact	\$290.13	\$308.62	\$18.49

O&M Cost Adjustments There are no operation and maintenance cost adjustments for this measure.

# Fossil Fuel Description Fossil fuel savings are presented for each dishwasher type in the Reference Table section below.

Reference Tables

Savings for each disnwasher type	e below.(**)				
	Dishwasher Type	Dishwasher Type			
Savings Type	Standard	Compact			
ΔkWh	31.7	23.6			
ΔkW	0.08549	0.06373			
ΔMMBtu (oil)	0.0089	0.0092			
ΔMMBtu (natural gas)	0.0135	0.0139			
ΔMMBtu (propane)	0.0445	0.0457			

Δ(	CCF (water savings)	0.43	0.20				
00	tnotes						
1]	Average cycle length for all dish Performance, Features, and Price					Better Appliances: An Ana	lysis of
[2]	Dishwasher cycles per year base Administration. See file EVT_EP					ed by the U.S. Energy Info	ormation
[3]	%DHW and %Dishwasher based STAR Dishwasher_Analysis_Jun		5. DOE, Final Rule Life-C	yde Cost (LCC) :	Spreadsheet. See "%E	OHW" tab within file EVT_I	ENERGY
[4]	Based on data received by Effici	ency Vermont on	08/21/2017 from the up	coming NMR Ver	mont Residential Mark	et Assessment.	
[5]	Federal appliance standards effe	ective May 30, 20	13				
[6]	Average of products available or Dishwasher_Analysis_June 2017		ualified products list, Ju	ne 2017. See "P	er Unit Savings" tab wi	thin file EVT_ENERGY STA	\R
[7]	Review of AHRI database shows	that electric wat	er heaters have a recov	ery efficiency of 9	18%.		
[8]	nFuel_DHW based on a weighte Baseline Study Analysis of On-S Dishwasher_Analysis_June 2017	ite Reports," Febr					

- [9] Measure lifetime from California DEER. See file DEER2014-EUL-table-update\_2014-02-05.xlsx.
- [10] Costs are based on data from U.S. DOE, Final Rule Life-Cycle Cost (LCC) Spreadsheet. See "Costs" tab within file EVT\_ENERGY STAR Dishwasher\_Analysis\_June 2017\_v4.visx for cost calculation details.

[11] See file EVT\_ENERGY STAR Dishwasher\_Analysis\_June 2017\_v4.xlsx for savings calculation details.

## **Multi Family Common Area Clothes Dryer**

Measure Numbe	r: CI-LAU-CACD a
Portfolio:	
Status:	Active
Effective Date:	2020/1/1
End Date:	[ None ]
Program:	Multifamily
End Use:	Laundry

Update Summary
New multifamily dothes dryer measure. Almost all common area laundry in the target multifamily market use residential sized units, therefore this
common area measure is based on the residential measure but with a lowered number of cycles per unit assumption,

- Referenced Documents 2011-04-18, TSD, Chapter, 8, Life-Orde, Cost, and, Payback, Period, Analyses efficiency-common-laundry-areas-sahf-2017/0327 MF Clothes Dryer Analysis

### Description

— Sach patient Install in a multi family common area a residential-grade clothes driver meeting minimum qualifying efficiency standards for ENERGY STAR (standard sized or compact), ENERGY STAR Most Efficient Hybrid Heat Pumps (all standard sized) and ENERGY STAR Most Efficient Full Heat Pumps (all compact units), based on Combined Energy Factor (CEF), as described below under Hgh Efficiency. This is characterized as a market opportunity and an early replacement measure.

The CEF measures energy consumption of the total driver cycle (standby usage, driver heating and operation) in units of weight (bbs) of dothing dried per KMh of electricity; the higher the number, the greater the efficiency. In the case of gas dryers, the CEF combines both the gas and electric usage into a single CEF metric also measured in units of weight of dothing inde per KMh of electricity.

Program Type Program Delivery / Implementation Type: Downstream

### **Baseline Efficiencies** Market Opportunity

The baseline combined energy factor (CEF) was derived in the ENERGY STAR Version 1.0 analysis by multiplying 2015 federal standards by the average change in a dryers' assessed CEF between the required (Appendix D1) and optional (Appendix D2) test procedure required by the ENERGY STAR eligibility requirements. This gives 3.11 CEF for standard electric dryers, 3.01 for compact 120V dryers, 2.73 for verted 240V dryers and 2.13 for compact vertiless dryers.

Early Replacement:

Let in requirements in this case is the efficiency of the existing unit for its assumed remaining life (4 years) and the new baseline as defined above for the remainder of the measure (remaining 3 years). The Federal baseline for clothes dryes prior to 2015 had been in place since 1994. The standard was 3.01 EF for electric units. Comparing new units Combined Energy Fador (which include accounting for standar) loads in addition to active drying energy [s doal (which include accounting for standar) loads in addition to active drying energy [s doal (which include accounting for standar) loads in addition to active drying energy [s doal (which include accounting for standar) loads in addition to active drying energy [s doal (which include accounts)] for active drying energy [s doal(which with accounts)] for active drying ener

Applying the same ratio of old standard to new is applied to the new standard for compact units to estimate an existing baseline of 2.91CEF for compact 120V dryers, 2.64 for vented 240V dryers and 2.06 for compact ventless dryers.

Efficient Equipment High efficiency is defined as any model meeting or exceeding ENERGY STAR or ENERGY STAR Most Efficient criteria, as defined in the follow Combined Energy Factor (CEF)

	Lbs / kWh	
	ENERGY STAR	ENERGY STAR Most Efficient
Standard Sized	>= 3.93	>= 4.3
Compact 120V	>= 3.8	>= 4.3
Compact 240V Ventled	>= 3.45	>= 4.3
Compact 240V Ventless	>=2.68	>= 3.7

Energy savings estimates are based on the resulting product from multiplying the average CEF of units purchased through the Efficiency Vermont program during 2017 and 2018. An additional waste heat calculation has been incorporated in to the final savings determination. This accurst for the unit's waste heat either being predominately vented to outside or remaining in the home and reducing the heating demands (rotably in ventelses hybrid and full heat pump models).

Algorithms Electric Demand Savings Energy and Demand savings per unit served by the clothes dryer are presented in the reference tables below, and are dependent on the fuel type of the DHW system and the dryer.

Savings per MF unit are consistent with assumptions in the Efficient Product measure (see measure for write up of savings methodolo number of of cycles per year per unit is reduced from 265 (assumed for in-unit multi family) to 112 (common area multi family) as pre ology), h Savings per MF unit are then multiplied by the #units served / #washers. Note only units without in-unit clothes washers should be counted.

ΔkW	= ΔkWPer MF unit × NumUnits / NumDryers
ΔkWPer MF unit	= See table below of savings based on Efficient Products measure with lowered $N_{\rm Cycles}$ assumption.
Symbol Table	
Electric Energy Sav	ings
ΔkWh	= $\Delta kWhPer MF Unit \times NumUnits / NumDryers$
$\Delta kWhPer MF Unit$	= See table below of savings based on Efficient Products measure with lowered NCycles assumption
Symbol Table	
ossil Fuel Savings	
ΔMMBtu	= $\Delta$ MMBtu Per MF Unit × NumUnits / NumDryers
ΔMMBtu Per MF Unit	= See table below of savings based on Efficient Products measure with lowered NCycles assumption
Where:	

AW         =         Gross customer connected load kW savings for the measure           AWh         =         Total gross customer annual kWh savings for the measure           AWhPer MF Unit         =         Gross customer annual kWh savings per MF unit           AWHPer MF Unit         =         Gross customer annual kWh savings per MF unit           AMMBRU Per MF Unit         =         Gross customer connected load kW savings per MF unit           AMMBRU Per MF Unit         =         Total gross fuel savings for the measure           AMMBRU         =         Total gross fuel savings for the measure           AMMBRU         =         Total gross fuel savings for the measure           Number of Cycles per year per unit = 112 <sup>11</sup> =           Number of clobes dryers in central laundry facility         =           Number of residential units (apartments) served by the central laundry facility         =			
AWMPer MF Unit     =     Gross customer annual KWh savings per MF unit       AWMPer MF unit     =     Gross customer conceted load KW savings per MF unit       AMMBRu Per MF Unit     =     Gross fuel savings per MF unit       AMMBRu     =     Total gross fuel savings for the measure       NCycles     =     Number of Cycles per year per unit = 112 <sup>[1]</sup> NumDrypers     =     Total number of clothes drypers in central laundry facility	ΔkW	-	Gross customer connected load kW savings for the measure
AWMPer MF unit     =     Gross customer connected load kW savings per MF unit       AMMBu Per MF Unit     =     Gross fuel savings per MF unit       AMMBu     =     Total gross fuel savings for the measure       NCycles     =     Number of Cycles per year per unit = 112 <sup>(1)</sup> NumDryers     =     Total number of clothes dryers in central laundry facility	ΔkWh	-	Total gross customer annual kWh savings for the measure
AMMBAU Per MF Unit     =     Gross fuel savings per MF unit       AMMBAU     =     Total gross fuel savings for the measure       NCycles     =     Number of Cycles per year per unit = 112 <sup>(1)</sup> NumDryers     =     Total number of clothes dryers in central laundry facility	∆kWhPer MF Unit	-	Gross customer annual kWh savings per MF unit
ΔMMBtu     = Total gross fuel savings for the measure       NCycles     = Number of Cycles per year per unit = 112 <sup>[1]</sup> NumDryers     = Total number of clothes dryers in central laundry facility	∆kWPer MF unit	-	Gross customer connected load kW savings per MF unit
NCycles     =     Number of Cycles per year per unit = 112 <sup>[1]</sup> NumDryers     =     Total number of clothes dryers in central laundry facility	ΔMMBtu Per MF Unit	-	Gross fuel savings per MF unit
= 112 <sup>[1]</sup> NumDryers = Total number of clothes dryers in central laundry facility	ΔMMBtu	-	Total gross fuel savings for the measure
NumDryers = Total number of clothes dryers in central laundry facility	NCycles	-	Number of Cycles per year per unit
			= 112 <sup>(1)</sup>
NumUnits = Number of residential units (apartments) served by the central laundry facility	NumDryers	-	Total number of clothes dryers in central laundry facility
	NumUnits	-	Number of residential units (apartments) served by the central laundry facility

ware

## Mid Life Savings Adjustment

The follow mid life savings adjustments are applied to the annual savi	ngs for early re	placement mea	asures after 4
Efficiency Level	Electric	Fossil	
Enciency Level	Adjustment	Adjustment	
ENERGY STAR	86%	94%	
ENERGY STAR Most Efficient Hybrid	92%	100%	
ENERGY STAR Most Efficient Full Heat Pump	96%	93%	

## Load Shapes

1344 MF C	Joininion Area Launury							
Number	Name	Status	Winter On kWh	Winter Off kWh	Summer On kWh	Summer Off kWh	Winter kW	Summer kW
134	MF Common Area Laundry							

	ings Fac	ctors			
Measures					
	Energy Star	Clothes Dryer			
CKLESETA	Energy Star	Most Efficient Cl	othes Dryer		
CKLERESD	Early Replace	ement ENERGY :	STAR Clothe	s Dryer	
CKLERETD	Energy Star	Most Efficient Cl	othes Dryer,	, Early Repla	acement
Tracks [Bas	se Track]				
6018LINC [is	base track	] LIMF NC			
6019MFNC [	is base trac	k] MF Mkt NC			
6017PRES [i	s base track	() 6017PRES			
6017CUST [	s base trac	k1 6017CUST			
602000EC [i	c baco traci	() 6020PRES			
		k] 6020CUST			
00200051 [	s base u ao	kj 6020C051			
Track Name	Track Nr.	Measure Code	Free Rider	Spill Over	
LIMF NC	6018LINC	CKLESDRY	1.00	1.00	
LIMF NC		CKLESDRY CKLESETA	1.00 1.00	1.00 1.00	
LIMF NC	6018LINC	CKLESETA			
LIMF NC MF Mkt NC	6018LINC	CKLESETA CKLESDRY	1.00 0.95	1.00	
LIMF NC MF Mkt NC MF Mkt NC 6017PRES	6018LINC 6019MFNC 6019MFNC 6017PRES	CKLESETA CKLESDRY CKLESETA CKLESDRY	1.00 0.95 0.95 1.00	1.00 1.10 1.10 1.00	
LIMF NC MF Mkt NC MF Mkt NC 6017PRES 6017PRES	6018LINC 6019MFNC 6019MFNC 6017PRES 6017PRES	CKLESETA CKLESDRY CKLESETA CKLESDRY CKLESETA	1.00 0.95 0.95 1.00 1.00	1.00 1.10 1.10 1.00 1.00	
LIMF NC MF Mkt NC MF Mkt NC 6017PRES 6017PRES 6017CUST	6018LINC 6019MFNC 6019MFNC 6017PRES 6017PRES 6017CUST	CKLESETA CKLESDRY CKLESETA CKLESDRY CKLESDRY	1.00 0.95 0.95 1.00 1.00 1.00	1.00 1.10 1.10 1.00 1.00 1.00	
LIMF NC MF Mkt NC 6017PRES 6017PRES 6017CUST 6017CUST	6018LINC 6019MFNC 6019MFNC 6017PRES 6017PRES 6017CUST 6017CUST	CKLESETA CKLESDRY CKLESDRY CKLESDRY CKLESDRY CKLESDRY CKLESETA	1.00 0.95 0.95 1.00 1.00 1.00 1.00	1.00 1.10 1.10 1.00 1.00 1.00 1.00	
LIMF NC MF Mkt NC 6017PRES 6017CUST 6017CUST 6020PRES	6018LINC 6019MFNC 6019MFNC 6017PRES 6017PRES 6017CUST 6017CUST 6020PRES	CKLESETA CKLESDRY CKLESETA CKLESDRY CKLESETA CKLESDRY CKLESETA CKLESDRY	1.00 0.95 0.95 1.00 1.00 1.00 1.00 0.90	1.00 1.10 1.10 1.00 1.00 1.00 1.00 1.00	
LIMF NC MF Mkt NC 6017PRES 6017PRES 6017CUST 6017CUST	6018LINC 6019MFNC 6019MFNC 6017PRES 6017CUST 6017CUST 6020PRES 6020PRES	CKLESETA CKLESDRY CKLESETA CKLESDRY CKLESETA CKLESDRY CKLESETA CKLESDRY	1.00 0.95 0.95 1.00 1.00 1.00 1.00	1.00 1.10 1.10 1.00 1.00 1.00 1.00	
LIMF NC MF Mkt NC 6017PRES 6017PRES 6017CUST 6017CUST 6020PRES 6020PRES 6020CUST	6018LINC 6019MFNC 6019MFNC 6017PRES 6017CUST 6017CUST 6020PRES 6020PRES	CRLESETA CRLESDRY CRLESETA CRLESDRY CRLESETA CRLESDRY CRLESETA CRLESDRY CRLESETA CRLESDRY	1.00 0.95 0.95 1.00 1.00 1.00 1.00 0.90 0.90	1.00 1.10 1.10 1.00 1.00 1.00 1.00 1.00	
LIMF NC MF Mkt NC 6017PRES 6017CUST 6017CUST 6017CUST 6020PRES 6020CUST 6020CUST	6018LINC 6019MFNC 6019MFNC 6017PRES 6017CUST 6017CUST 6020PRES 6020PRES 6020CUST	CRLESETA CRLESETA CRLESETA CRLESETA CRLESETA CRLESETA CRLESETA CRLESETA CRLESETA CRLESETA	1.00 0.95 0.95 1.00 1.00 1.00 1.00 0.90 0.90 0.90	1.00 1.10 1.10 1.00 1.00 1.00 1.00 1.00	

6017PRES	6017PRES	CKLERESD	1.00	1.00
6017CUST	6017CUST	CKLERESD	1.00	1.00
6020PRES	6020PRES	CKLERESD	0.90	1.00
6020CUST	6020CUST	CKLERESD	0.90	1.00
LIMF NC	6018LINC	CKLERETD	1.00	1.00
MF Mkt NC	6019MFNC	CKLERETD	0.95	1.00
6017PRES	6017PRES	CKLERETD	1.00	1.00
6017CUST	6017CUST	CKLERETD	1.00	1.00
6020PRES	6020PRES	CKLERETD	0.90	1.00
6020CUST	6020CUST	CKI FRETD	0.90	1.00

# Lifetimes 12 years<sup>[2]</sup>

Analysis period is the same as the lifetime.

For early replacement the existing unit is assumed to have a remaining life of 4 years (1/3 of the measure life).

## Measure Cost

		Early Replacement Full Install Cost
NERGY STAR	\$61	\$528
NERGY STAR Most Efficient	\$412	\$879

oct for this

years had the existing unit not been

## O&M Cost Adjustments

nce cost adjustments for this measure.

Prescriptive Savings Tables
Deemed savings for this measure are provided below. For ENERGY STAR. It is the weighted (by product in program) average of Standard ENERGY STAR
units and Compact 240V Vertiless ENERGY STAR. ENERGY STAR Note Efficient Hydrid Heat Pump and Standard sized. ENERGY STAR Note Efficient Full
Heat Pump is the weighted (by product in program) average of Compact 120V Full Heat Pump and Compact 240V Vertiless Full Heat Pump.

	∆kWh per MF	∆kW per MF		∆MMBtu per	MF unit		
		unit	unit	NG	LP	Oil	Wood
ENERGY STAR	MFCCKLDRYES	68	0.6043	-0.001	-0.002	-0.004	-0.004
ENERGY STAR Most Efficient Hybrid	MFCCKLDRYETA2	128	1.1399	0.07	0.14	0.23	0.27
ENERGY STAR Most Efficient Full Heat Pump	MFCCKLDRYETA3	205	1.8341	-0.01	-0.00	-0.01	-0.07

For Early Replacment measures, the first four years will assume the following savings before applying the midlife adjustment provided above

 AdVM per JAW per MF
 AdVM per JAW per MF

 AdVM per MF unit
 AdVM per MF
 AdVMB per MF unit

 ENERGY STAR
 MFCOLDERES
 79
 0.7010
 -0.001
 -0.002
 -0.004
 -0.004

 ENERGY STAR Most Efficient Hybrid
 MFCOLDERES
 79
 0.7010
 -0.001
 -0.002
 -0.004
 -0.004

 ENERGY STAR Most Efficient Hybrid
 MFCOLDEREST
 139
 1.2369
 0.67
 0.14
 0.23
 0.27

 ENERGY STAR Most Efficient Full Heat Pump
 MFCOLLERENT
 215
 1.9158
 0.00
 0.00
 0.01
 0.06

## Footnotes

[1] A 2001: National Research Study: "A National Study of Water & Energy Consumption in Multifamily Housing; In-Apartment Washers vs Common Area Laundry rooms", found that residents with in-unit washers do 5.22 loads per week on average, while residents using common area laundry do 2.16 loads per week.

[2] Based on average lifetime in DOE Buildings Data Book http://buildingsdatabook.eren.doe.gov/TableView.aspx?table=5.7.15

[3] See "MF Clothes Dryer Analysis.xlsx", "Incremental Cost" tab. Based on DOE Life-Cycle Cost and Payback Period analysis Table 8.3.1.

### **Multi Family Common Area Clothes Washer**

 Measure Number:
 CELAU-CACW a

 Portfolio:
 EVT TRM Portfolio 2020-05

 Status:
 Active

 Effective Date:
 2020/1/1

 End Date:
 [None]

 Program:
 Multfamily

 End Use:
 Laundry

Update Summary New multifamily clothes washer measure - either residential or commercial grade Created new loadshape for MF Common Area Laundry.

### Referenced Documents

- efficiency-common-laundry-areas-sahf-20170327
   DOE Life-Cycle Cost and Payback Period Tool
   MF Common Area Commercial Clothes Washer\_ 2 isher\_ 2020

#### Description

Install in a multi family common area a residential or commercial-grade clothes washer meeting minimum qualifying efficiency stands STAR/CEE Tier 1 or CEE Tier 2. Efficiency levels are defined below. This is characterized as a market opportunity and an early replace ndards of ENERGY

Program Type Calculation Type: Market Opportunity and Early Replacement Program Delivery / Implementation Type: Downstream

### **Baseline Efficiencies**

Market Opportunity

Baseline efficiency is a residential or commercial-grade clothes washer meeting the appropriate federal standard

Leasence mixed by a resolution of commerciary place concernation mecany use ppropriate reader standard. The baseline efficiency is determined according to the Integrated Modified Energy Factor (IMEP) for residential units and MEF<sub>20</sub> for Commercial units. These raints take tind accord the nation electrical energy, the hot valet energy consumption required per dothes washer cycle, and the energy required for removal of the remaining moisture by a dothes dryer (plus for residential units only the combined low-power mode energy consumption) The federal standard baseline for Residential sized units as of January 2018 is >=1.84 IMEF and <=4.7 IWF for front loading units and >=1.57 IMEF and <=6.5 IWF for top loading units.

The federal standard baseline for Commercial grade units as of January 2018 is >=2.0 MEF and <=4.1 IWF for front loading units and >=1.35 MEF and <=8.8 TWF for top loading up

#### Early Replacement Baseline

The baseline in this case is the efficiency of the existing unit for its assumed remaining life (3 years) and the new baseline as defined above for the remainder of the measure (remaining 11 years).

For Residential units, the eligibility for this measure in the second process of the second second on the second second or units that a 2001 DOE market assessment was 1.16MBEr. Converting NERNO STAR conversion tool copied in to the reference calculation spreadsheet "MF Common Area Commercial Collines Washer 2020 Ms", provides the assumption for existing units of U.91 MBEF for thost bading machines and 0.74 IMEF for top-loading. Similarly converting 12.87 WF to IMF gives 13.3 IMF for front loading and 13.2 IMF for top loading machines and 0.74 IMEF for top-loading. Similarly converting 12.87 WF to IMF gives 13.3 IMF for front loading and 13.2 IMF for top loading machines and 0.74 IMEF for top-loading.

For Commercial units, the eligibility for this measure is limited to pre-2013 non-Energy Star units. The Federal baseline for clothes washers prior to 2013 was 1.26 MEF. The same ENERGY STAK conversion tool is used to estimate converting MEF to MEFs\_providing the assumption for evidence for front loading multicles and 0.48 MEF for top-loading. Stalling's converting SME V To Two Heading and 9.9 MF for top loading and the same stall stall and the same stall stall be same s units

#### High Efficiency

tial grade units, high efficiency is defined as any model meeting or exceeding ENERGY STAR, CEE Tier 2 or CEE Advanced Tier as defined in the following table:

Efficiency Level	Integrated Modil Factor (IMEF)	fied Energy	Integrated Water Factor (IWF)			
	Front Loading	Top Loading	Front Loading	Top Loading		
ENERGY STAR	>= 2.76	>= 2.06	<= 3.2	<= 4.3		
CEE TIER 2	>= 2.92	n/a	<= 3.2	n/a		

For Commercial grade units, high efficiency is defined as any model meeting or exceeding ENERGY STAR criteria - >=2.2 MEF<sub>12</sub> and <=4.0 IWF.

### Algorithms

Electric Demand Savings Energy and Demand savings unit served by the clothes washer are presented in the reference tables below, and are dep the DHW system and the dryer. ent on the fuel type of

Savings per MF unit are then multiplied by the #units served / #washers. Note only units without in-unit clothes washers should be counted.

For Residential grade units the savings per MF unit are consistent with assumptions in the Efficient Product measure (see measure for write up of s methodogy), however number of of cycles per year per unit is reduced from 265 (assumed for in-unit multi family) to 112 (common area multi family) as presented below.

For Commercial grade units savings are calculated as described below

ΔkW	= ΔkW Per MF unit × NumUnits / NumWashers
Commercial Units Market Opportunity:	= $\Delta kWh$ Per MF Unit <sub>com MO</sub> / Hours
$\Delta kW \text{ Per MF unit}_{Com MO}$	
Commercial Units Market Opportunity:	= $\Delta kWh$ Per MF Unit <sub>Com ER</sub> / Hours
$\Delta kW \text{ Per MF unit}_{Com \ ER}$	
Residential grade units:	= See table below of savings based on Efficient Products measure with lowered $N_{\rm Cycles}$ assumption
$\Delta kW$ Per MF Unit $_{Res}$	
Symbol Table	
Electric Energy Savings	
ΔkWh	= ΔkWh Per MF Unit × NumUnits / NumWashers
Commercial Units Market Opportunity:	= (Capacity × 1/MEF <sub>22</sub> base × Ncycles × (%CWbase + (%DHWbase × %Electric_DHW) + (%Dryerbase × %Electric_Dryer))) - (Capacity × 1/MEF <sub>22</sub> eff × Ncycles × (%CWeff + (%DHWeff × %Electric_DHW) + (% Dwareff × %Electric_Dree)))

ΔkWh Per MF Unit <sub>Com MO</sub>		oryeren ∧ nubecunc_oryer)))
ZKWITPELPIL ONICOm MO		
Commercial Units Early Re ΔkWh Per MF Unit <sub>Com ER</sub>	placement:	= (Capacity × 1/MEF <sub>12</sub> exist × Noycles × (%CWbase + (%DHWbase × %Electric_DHW) + (%Dryerbase × %Electric_Dryer))) · (Capacity × 1/MEF <sub>12</sub> eff × Noycles × (%CWeff + (%DHWeff × %Electric_DHW) + (% Dryereff × %Electric_Dryer)))
Residential grade units:		= See table below of savings based on Efficient Products measure with lowered $N_{\rm Cycles}$ assumption
$\Delta kWh$ Per MF $Unit_{Res}$		
Symbol Table		
AMMBtu		= ΔΜΜΒω Per MF Unit × NumUnits / NumWashers
Commercial Units Market 0		= (Cgpacity × 1/MEF_base × Nxycles × (%DHWase × %Euel_DHW × R_eff) + (%Dryerbase × %Euel _Dryer))) - (Capacity × 1/MEF_teff × Nxycles × ((%DHWeff × %Euel_DHW × R_eff) + (%Dryereff × %Eu el_Dryer)))) × MHBu_convert
Commercial Units Early Re ΔMMBtu Per MF Unit <sub>Com ER</sub>		= ((Capacity × 1/MET_pekist × Nxycles × ((%DHWbase × %Fuel_DHW × R_eff) + (%Dryerbase × %Fuel _Dryer))) - (Capacity × 1/MET_peff × Nxycles × ((%DHWeff × %Fuel_DHW × R_eff) + (%Dryereff × %Fu el_Dryer))))× MHBu_convert
Residential grade units:		= See table below of savings based on Efficient Products measure with lowered $N_{Cycles}$ assumption
∆MMBtu Per MF Unit <sub>Res</sub>		
Symbol Table		
Water Savings		
ΔCCF		= $\Delta$ CCF per MF unit × NumUnits / NumWashers
Commercial Units Market (	Opportunity:	= ((Capacity × (IWFbase - IWFeff)) × Ncycles) / GallonsPerCCF
ΔCCF Per MF unit <sub>Com MO</sub>		
Commercial Units Early Re	placement:	= ((Capacity × (IWFexist - IWFeff)) × Ncycles) / GallonsPerCCF
$\Delta \text{CCF}$ Per MF unit_{Com ER}		
Residential grade units:		= See table below of savings based on Efficient Products measure with lowered $N_{Cycles}$ assumption
$\Delta CCF$ Per MF unit_{Res}		
Where:		
%CWbase	= = Pero	entage of total energy consumption used for operating Clothes Washer (baseline) $^{\left( 2\right) }$
	= 7%	
%CWeff	= = Pero = 3.9%	entage of total energy consumption used for operating Clothes Washer (efficient)
%DHWbase	= = Pero = 28.1	entage of total energy consumption used for water heating (baseline) %
%DHWeff	= = Pero = 15.5	entage of total energy consumption used for water heating (efficient)
%Dryerbase	= = Pero	entage of total energy consumption used for dryer operation (baseline)
%Dryereff	= 64.9 = = Pero	% intage of total energy consumption used for dryer operation (efficient)
%Electric_DHW	= 80.6 = = Pero	% intage of water savings assumed to be electric
	= (1 if	electric, 0 if gas) Assumed to be known
%Electric_Dryer		entage of dryer savings assumed to be electric
are of any		electric, 0 if gas) Assumed to be known
%Fuel_DHW		tage of DHW savings assumed to be non electric natural gas, propane or oil, 0 if electric) Assumed to be known
%Fuel_Dryer		age of dryer savings assumed to be non electric
		natural gas or propane, 0 if electric) Assumed to be known
ΔCCF Per MF unit <sub>Com ER</sub>		innual customer water (CCF) savings per MF unit for a commercial grade clothes washer as an early ment measure
∆CCF Per MF unit <sub>Com MO</sub>		nnual customer water (CCF) savings per MF unit for a commercial grade clothes washer as an market inity measure
$\Delta \text{CCF}$ Per MF $\text{unit}_{\text{Res}}$	= Gross a	nnual customer water (CCF) savings per MF unit for a residential grade clothes washer
ΔCCF per MF unit	= Gross a	nnual customer water (CCF) savings per MF unit
ΔCCF	= annual	customer water savings per clothes washer in CCF (hundreds of cubic feet)
$\Delta kW \text{ Per MF unit}_{Com}$ ER	<ul> <li>Gross a measu</li> </ul>	nnual customer kW savings per MF unit for a commercial grade clothes washer as an early replacement e
ΔkW Per MF unit <sub>Com</sub>		nnual customer kW savings per MF unit for a commercial grade clothes washer as market nity measure
$\Delta kW$ Per MF $\text{Unit}_{\text{Res}}$	= Gross a	nnual customer KW savings per MF unit for a residential grade clothes washer.
∆kW Per MF unit	= Gross a	nnual customer kW savings per MF unit
ΔkW	= Gross a	nnual customer kW savings per clothes washer for the measure
Unit <sub>Com ER</sub>	<ul> <li>Gross a measu</li> </ul>	nnual customer kWh savings per MF unit for a commercial grade clothes washer as an early replacement e
ΔkWh Per MF Unit <sub>Com MO</sub>		innual customer kWh savings per MF unit for a commercial grade clothes washer as a market inity measure
$\Delta kWh$ Per MF Unit <sub>Res</sub>	= Gross a	nnual customer kWh savings per MF unit for a residential grade clothes washer.

∆kWh Per MF Unit	-	Gross annual customer kWh savings per MF unit
ΔkWh	-	Gross annual customer kWh savings per clothes washer for the measure
ΔMMBtu Per MF Unit <sub>Com ER</sub>	-	Gross annual customer MMBtu savings per MF unit for a commercial grade clothes washer as an early replacement measure
ΔMMBtu Per MF Unit <sub>Com MO</sub>	-	Gross annual customer MMBtu savings per MF unit for a commercial grade clothes washer as a market opportunity measure
∆MMBtu Per MF Unit <sub>Res</sub>	-	Gross annual customer MMBtu savings per MF unit for a residential grade clothes washer.
ΔMMBtu Per MF Unit	-	Gross annual customer MMBtu savings per MF unit
ΔMMBtu	-	Gross annual customer MMBtu savings per clothes washer for the measure
Capacity	-	= Clothes Washer capacity (cubic feet) = 3.3 cu ft <sup>(3)</sup>
GallonsPerCCF	-	Gallons per CCF =748
Hours	-	assumed annual run hours of clothes washer per MF unit $= 112^{[1]} \label{eq:masses}$
IWFbase	-	Integrated Water Factor of baseline unit = 4.1 IWF for front loading units and 8.8 IWF for top loading units
IWFeff	-	Integrated Water Factor of efficient unit = 4.0 IWF
IWFexist	-	Integrated Water Factor of existing unit = 9.8 IWF for front loading units and 9.9 IWF for top loading units
MEF <sub>12</sub> base	-	Modified Energy Factor (based on Appendix J2 testing protocol) of baseline unit = 2.0 MEFfor front loading units and 1.35 MEFfor top loading units
MEF <sub>32</sub> eff	-	Modified Energy Factor (based on Appendix J2 testing protocol) of efficient unit = 2.2 $\mbox{MEF}_{12}$
MEF <sub>12</sub> exist	-	Modified Energy Factor (based on Appendix 12 testing protocol) of existing unit = 1 MEF <sub>22</sub> for front loading machines and 0.84 MEF <sub>22</sub> for top-loading.
MMBtu_convert	-	Convertion factor from kWh to MMBu (Constant) = 0.003413
Ncycles	-	Number of Cycles per year per unit $= 112^{[4]} \label{eq:constraint}$
NumUnits	-	number of residential units (apartments) served by the central laundry facility
NumWashers	-	total number of clothes washers in central laundry facility
R_eff	-	Recovery efficiency factor = 1.26 <sup>[3]</sup>

A			Winter	Winter	Summ	er	er Summer	er Summer Winter
Number	Name	Status	On kWh	Off kWh	On kWh		Off kWh	Off kWh kW
134 1	IF Common Area Laundry	Active	42.0%	28.8%	16.9%		12.3%	12.3% 11.6%
Net Sav	vings Factors							
Measures								
CKLESWRP	Energy Star Clothes Was	her						
CKLCWASH	Commercial efficient clot	hes wash	er					
CKLC2WRP	Energy Star clothes wash	ner CEE T	ier 2					
Tracks [Ba								
6018LINC [	s base track] LIMF NC							
6019MFNC	[is base track] MF Mkt NC							
6017PRES	is base track] 6017PRES							
6017CUST	[is base track] 6017CUST							
6020PRES	is base track] 6020PRES							
6020CUST	is base track] 6020CUST							
Track Nam	e Track Nr. Measure Co	de Free I	Rider Spil	l Over				
LIMF NC	6018LINC CKLESWRP	1.00	1.00					
LIMF NC	6018LINC CKLCWASH	1.00	1.00					
LIMF NC	6018LINC CKLC2WRP	1.00	1.00					
MF Mkt NC	6019MFNC CKLESWRP	0.95	1.00					
MF Mkt NC	6019MFNC CKLCWASH	0.95	1.00					
MF Mkt NC	6019MFNC CKLC2WRP	0.95	1.00					
6017PRES	6017PRES CKLESWRP	1.00	1.00					
6017PRES	6017PRES CKLCWASH	1.00	1.00					
6017PRES	6017PRES CKLC2WRP	1.00	1.00					
6017CUST	6017CUST CKLESWRP	1.00	1.00					
6017CUST	6017CUST CKLCWASH	1.00	1.00					
6017CUST	6017CUST CKLC2WRP	1.00	1.00					
6020PRES	6020PRES CKLESWRP	0.90	1.00					
	6020PRES CKLCWASH	0.90	1.00					
6020PRES		0.00	1.00					
6020PRES 6020PRES	6020PRES CKLC2WRP	0.90						
		0.90	1.00					
6020PRES	6020CUST CKLESWRP							

Lifetimes 14 years<sup>(3)</sup> (same as in DPS screening of Efficiency Ublity programs). Early Replacement: The existing unit is assumed to have a remaining life of 3 years. Analysis period is the same as the lifetime.

### Measure Cost

The measure cost for this measure is provided below:									
	Residential Grade <sup>[7]</sup>		Commercial Grade <sup>[8]</sup>						
Efficiency	Market Opportunity Incremental	Early Replacement Full Install	Market Opportunity Incremental	Early Replacement Full Install					
Level	Cost	Cost	Cost	Cost					
ENERGY STAR	\$124	\$1,263	\$942	\$2,095					
CEE TIER 2	\$170	\$1,309	N/A	N/A					
	cement measures, the deferred bas sumed to be \$1,139 for Residential of			ad the existing unit not been					

O&M Cost Adjustments There are no operation and maintenance cost adjustments for this measure.

Reference Tables Customer Energy Savings Per MF Unit served, by Water Heater and Dryer Fuel Type<sup>(9)</sup> Item Codes provided at end.

## Market Opportunity:

#### Ele

Efficiency		RES GRADE	COMMERCIAL GRADE	RES GRADE	COMMERCIAL GRADE
Level	Dryer/DHW Fuel Combo	∆kWH Per MF unit	ΔkWH Per MF unit	∆kW Per MF unit	∆kW Per MF unit
Level		Weighted Average	Weighted Average	Weighted Average	Weighted Average
	Electric Dryer/Electric DHW	44.2	91.8	0.3947	0.8193
ENERGY	Electric Dryer/Fuel DHW	44.5	45.2	0.3970	0.4032
STAR	Fuel Dryer/Electric DHW	9.4	58.3	0.0842	0.5201
	Fuel Dryer/Fuel DHW	9.7	11.7	0.0865	0.1040
	Electric Dryer/Electric DHW	94.6	n/a	0.8443	n/a
CEE TIER 2	Electric Dryer/Fuel DHW	47.6	n/a	0.4254	n/a
LEE HER Z	Fuel Dryer/Electric DHW	51.9	n/a	0.4631	n/a
	Fuel Dryer/Fuel DHW	4.9	n/a	0.0442	n/a

MMBtu Savings:

			RES GRADE	COMMERCIAL GRADE
Efficiency	Fuel Claimed	Configuration	∆MMBtu Per MF unit	∆MMBtu Per MF unit
Level			AMMBbs Per MF unit         MMBBs Per Weighted Average         Meighted A           NV         0.00         0.00           HW         0.00         2.00           EN         0.00         2.00           Start         0.00         2.00           EN         0.00         2.00           D.00         0.20         1.1           D12         0.31         0.12           D40         0.12         0.31           WW         0.12         0.31           WW         0.12         0.31           WM         0.00         V/a           D40W         0.20         V/a           MW         0.20         V/a           MW         0.20         V/a           D40W         0.20         V/a           D40W         0.20         V/a           D40W         0.35         V/a           D40W         0.35         V/a           D40W         0.15         V/a	Weighted Average
	n/a	Electric Dryer/Electric DHW	0.00	0.00
	Propane	Electric Dryer/Propane DHW	0.00	0.20
	Natural Gas	Electric Dryer/Natural Gas DHW	0.00	0.20
	Oil	Electric Dryer/Oil DHW	0.00	0.20
ENERGY	Propane	Propane Dryer/Electric DHW	0.12	0.11
STAR	Propane	Propane Dryer/Propane DHW	0.12	0.31
	Oil	Propane Dryer/Oil DHW	0.12	0.31
	Natural Gas	Natural Gas Dryer/Electric DHW	0.12	0.11
	Natural Gas	Natural Gas Dryer/Natural Gas DHW	0.12	0.31
	Oil	Natural Gas Dryer/Oil DHW	0.12	0.31
	n/a	Electric Dryer/Electric DHW	0.00	n/a
	Propane	Electric Dryer/Propane DHW	0.20	n/a
	Natural Gas	Electric Dryer/Natural Gas DHW	0.20	n/a
	Oil	Electric Dryer/Oil DHW	0.20	n/a
CEE TIER 2	Propane	Propane Dryer/Electric DHW	0.15	n/a
CEE TIER 2	Propane	Propane Dryer/Propane DHW	0.35	n/a
	Oil	Propane Dryer/Oil DHW	0.35	n/a
	Natural Gas	Natural Gas Dryer/Electric DHW	0.15	n/a
	Natural Gas	Natural Gas Dryer/Natural Gas DHW	0.35	n/a
	Oil	Natural Gas Dryer/Oil DHW	0.35	n/a

Water Savings:

	RES GRADE	COMMERCIAL GRADE
Efficiency Level	ΔCCF Per MF unit	ΔCCF Per MF unit
	Weighted Average	Weighted Average
ENERGY STAR	0.5	2.1
CEE TIER 2	1.0	n/a

### Early Replacement:

Efficiency Level	Dryer/DHW Fuel Combo	RES GRADE ΔkWH Per MF unit replacing:		RES GRADE Mid Life Adjustment Replacing:		COMMERCIAL GRADE ΔkWH Per MF unit replacing:		COMMERCIAL GRADE Mid Life Adjustment Replacing:				COMMERCIAL GRADE ΔkW Per MF un replacing:	
		Front	Тор	Front	Тор	Front	Тор	Front	Тор	Front	Тор	Front	Тор
	Electric Dryer/Electric DHW	299.5	416.3	15%	11%	199.0	268.5	46%	34%	2.674	3.717	1.777	2.397
ENERGY STAR	Electric Dryer/Fuel DHW	252.5	215.7	18%	21%	122.3	172.2	37%	26%	2.254	1.926	1.092	1.538
STAR	Fuel Dryer/Electric DHW	78.4	210.6	12%	4%	95.9	120.3	61%	48%	0.700	1.881	0.856	1.074
	Fuel Dryer/Fuel DHW	31.4	10.1	31%	96%	19.2	24.1	61%	48%	0.281	0.090	0.171	0.215
	Electric Dryer/Electric DHW	349.9	466.6	27%	20%	n/a	n/a	n/a	n/a	3.124	4.166	n/a	n/a
CEE TIER	Electric Dryer/Fuel DHW	255.7	218.9	19%	22%	n/a	n/a	n/a	n/a	2.283	1.954	n/a	n/a
2	Fuel Dryer/Electric DHW	120.9	253.1	43%	20%	n/a	n/a	n/a	n/a	1.079	2.260	n/a	n/a
	Fuel Drver/Fuel DHW	26.7	5.3	19%	93%	n/a	n/a	n/a	n/a	0.238	0.048	n/a	n/a

MMBtu Sav

			RES	GRADE	RES GRA	ADE	COMMERCIA	L GRADE	COMM	IERCIAL GRADE
Efficiency	Fuel	Configuration	ΔMMBtu Per MF unit		Mid Life Adjustment		ΔMMBtu Per MF unit		Mid Life Adjustment	
Level	Claimed	Configuration		acing:	Replacir		replaci			teplacing:
			Front	Тор	Front	Top	Front	Top	Front	Тор
	n/a	Electric Dryer/Electric DHW	0.00	0.00	n/a	n/a	0.00	0.00	n/a	n/a
	Propane	Electric Dryer/Propane DHW	0.20	0.86	-1%	0%	0.33	0.41	61%	48%
	Natural Gas	Electric Dryer/Natural Gas DHW	0.20	0.86	-1%	0%	0.33	0.41	61%	48%
	Oil	Electric Dryer/Oil DHW	0.20	0.86	-1%	0%	0.33	0.41	61%	48%
ENERGY	Propane	Propane Dryer/Electric DHW	0.75	0.70	16%	17%	0.35	0.51	33%	23%
STAR	Propane	Propane Dryer/Propane DHW	0.96	1.56	12%	8%	0.68	0.92	46%	34%
	Oil	Propane Dryer/Oil DHW	0.96	1.56	12%	8%	0.68	0.92	46%	34%
	Natural Gas	Natural Gas Dryer/Electric DHW	0.75	0.70	16%	17%	0.35	0.51	33%	23%
	Natural Gas	Natural Gas Dryer/Natural Gas DHW	0.96	1.56	12%	8%	0.68	0.92	46%	34%
	Oil	Natural Gas Dryer/Oil DHW	0.96	1.56	12%	8%	0.68	0.92	46%	34%
	n/a	Electric Dryer/Electric DHW	0.00	0.00	n/a	n/a	n/a	n/a	n/a	n/a
	Propane	Electric Dryer/Propane DHW	0.40	1.07	50%	19%	n/a	n/a	n/a	n/a
	Natural Gas	Electric Dryer/Natural Gas DHW	0.40	1.07	50%	19%	n/a	n/a	n/a	n/a
	Oil	Electric Dryer/Oil DHW	0.40	1.07	50%	19%	n/a	n/a	n/a	n/a
CEE TIER	Propane	Propane Dryer/Electric DHW	0.78	0.73	19%	20%	n/a	n/a	n/a	n/a

2	Propane	Propane Dryer/Propane DHW	1.19	1.79	29%	19%	n/a	n/a	n/a	n/a
	Oil	Propane Dryer/Oil DHW	1.19	1.79	29%	19%	n/a	n/a	n/a	n/a
	Natural Gas	Natural Gas Dryer/Electric DHW	0.78	0.73	19%	20%	n/a	n/a	n/a	n/a
	Natural Gas	Natural Gas Dryer/Natural Gas DHW	1.19	1.79	29%	19%	n/a	n/a	n/a	n/a
	Oil	Natural Gas Dryer/Oil DHW	1.19	1.79	29%	19%	n/a	n/a	n/a	n/a

Water savings

The weighted average savings are provided below, based on weighting the first year savings for 3 years and the reduced savings for the remaining 11 years. Note the screening tool currently does not allow mid life adjustments to be applied to water savings.

	RES G	RADE	COMMERC	IAL GRADE
	∆CCF Pe	r MF unit	∆CCF Pe	r MF unit
Efficiency	repla	cing:	repla	cing:
Level	Front	Тор	Front	Тор
	Weighted	Weighted	Weighted	Weighted
	Average	Average	Average	Average
ENERGY	0.8	0.7	2.3	2.3
STAR	0.0	0.7	2.5	2.5
CEE TIER 2	1.3	1.3	n/a	n/a

### Market Opportunity Item Codes:

Efficiency	Fuel Claimed	Configuration	RES GRADE	COMMERCIAL GRADE
Level	Fuel Claimed	Conliguration	Weighted Average	Weighted Average
	n/a	Electric Dryer/Electric DHW	MFCRCKLESAEEWRP	MFCCCKLESAEEWRP
	Propane	Electric Dryer/Propane DHW	MFCRCKLESAELWRP	MFCCCKLESAELWRP
	Natural Gas	Electric Dryer/Natural Gas DHW	MFCRCKLESAENWRP	MFCCCKLESAENWRP
	Oil	Electric Dryer/Oil DHW	MFCRCKLESAEOWRP	MFCCCKLESAEOWRP
ENERGY	Propane	Propane Dryer/Electric DHW	MFCRCKLESALEWRP	MFCCCKLESALEWRP
STAR	Propane	Propane Dryer/Propane DHW	MFCRCKLESALLWRP	MFCCCKLESALLWRP
	Oil	Propane Dryer/Oil DHW	MFCRCKLESALOWRP	MFCCCKLESALOWRP
	Natural Gas	Natural Gas Dryer/Electric DHW	MFCRCKLESANEWRP	MFCCCKLESANEWRP
	Natural Gas	Natural Gas Dryer/Natural Gas DHW	MFCRCKLESANNWRP	MFCCCKLESANNWRP
	Oil	Natural Gas Dryer/Oil DHW	MFCRCKLESANOWRP	MFCCCKLESANOWRP
	n/a	Electric Dryer/Electric DHW	MFCRCKLT2AEEWRP	n/a
	Propane	Electric Dryer/Propane DHW	MFCRCKLT2AELWRP	n/a
	Natural Gas	Electric Dryer/Natural Gas DHW	MFCRCKLT2AENWRP	n/a
	Oil	Electric Dryer/Oil DHW	MFCRCKLT2AEOWRP	n/a
CEE TIER 2	Propane	Propane Dryer/Electric DHW	MFCRCKLT2ALEWRP	n/a
CEE TIER 2	Propane	Propane Dryer/Propane DHW	MFCRCKLT2ALLWRP	n/a
	Oil	Propane Dryer/Oil DHW	MFCRCKLT2ALOWRP	n/a
	Natural Gas	Natural Gas Dryer/Electric DHW	MFCRCKLT2ANEWRP	n/a
	Natural Gas	Natural Gas Dryer/Natural Gas DHW	MFCRCKLT2ANNWRP	n/a
	Oil	Natural Gas Dryer/Oil DHW	MFCRCKLT2ANOWRP	n/a

#### Early Replacement Item Codes:

Efficiency	Fuel		RES GRADE			AMMBtu Per MF unit
evel	ruei Claimed	Configuration	∆MMBtu Per MF unit		COMMERCIAL GRADE	AMMBLU PER MIF UNIC
evei	Claimed		Front	Тор	Front	Тор
	n/a	Electric Dryer/Electric DHW	MFCRCWESFEREE	MFCRCWESTEREE	MFCCCWESFEREE	MFCCCWESTEREE
	Propane	Electric Dryer/Propane DHW	MFCRCWESFEREL	MFCRCWESTEREL	MFCCCWESFEREL	MFCCCWESTEREL
	Natural Gac	Electric Dryer/Natural Gas DHW	MFCRCWESFEREN	MFCRCWESTEREN	MFCCCWESFEREN	MFCCCWESTEREN
	Oil	Electric Dryer/Oil DHW	MFCRCWESFEREO	MFCRCWESTEREO	MFCCCWESFEREO	MFCCCWESTEREO
NERGY	Propane	Propane Dryer/Electric DHW	MFCRCWESFERPE	MFCRCWESTERPE	MFCCCWESFERPE	MFCCCWESTERPE
TAR	Propane	Propane Dryer/Propane DHW	MFCRCWESFERPP	MFCRCWESTERPP	MFCCCWESFERPP	MFCCCWESTERPP
IAK	Oil	Propane Dryer/Oil DHW	MFCRCWESFERPO	MFCRCWESTERPO	MFCCCWESFERPO	MFCCCWESTERPO
	Natural Gac	Natural Gas Dryer/Electric DHW	MFCRCWESFERNE	MFCRCWESTERNE	MFCCCWESFERNE	MFCCCWESTERNE
		Natural Gas Dryer/Natural Gas DHW	MFCRCWESFERNN	MFCRCWESTERNN	MFCCCWESFERNN	MFCCCWESTERNN
	Oil	Natural Gas Dryer/Oil DHW	MFCRCWESFERNO	MFCRCWESTERNO	MFCCCWESFERNO	MFCCCWESTERNO
	n/a	Electric Dryer/Electric DHW	MFCRCWT2FEREE	MFCRCWT2TEREE	n/a	n/a
	Propane	Electric Dryer/Propane DHW	MFCRCWT2FEREL	MFCRCWT2TEREL	n/a	n/a
		Electric Dryer/Natural Gas DHW	MFCRCWT2FEREN	MFCRCWT2TEREN	n/a	n/a
	Oil	Electric Dryer/Oil DHW	MFCRCWT2FEREO	MFCRCWT2TEREO	n/a	n/a
EE TIER	Propane	Propane Dryer/Electric DHW	MFCRCWT2FERPE	MFCRCWT2TERPE	n/a	n/a
EE LIER	Propane	Propane Dryer/Propane DHW	MFCRCWT2FERPP	MFCRCWT2TERPP	n/a	n/a
	Oil	Propane Dryer/Oil DHW	MFCRCWT2FERPO	MFCRCWT2TERPO	n/a	n/a
		Natural Gas Dryer/Electric DHW	MFCRCWT2FERNE	MFCRCWT2TERNE	n/a	n/a
		Natural Gas Dryer/Natural Gas DHW	MFCRCWT2FERNN	MFCRCWT2TERNN	n/a	n/a
	Oil	Natural Gas Dryer/Oil DHW	MFCRCWT2FERNO	MFCRCWT2TERNO	n/a	n/a

### Footnotes

[1] Assumes 1 hour per cycle.

- [2] All base and efficient energy breakdown are based on ENERGY STAR Commercial Appliance calculator assumptions. See "MF Common Area Commercial Clothes Washer 2020.xls".
- [3] Based on average capacity from CEC Database for commercial grade clothes washers, accessed 2/2020. See "MF Common Area Commercial Clothes Washer 2020.xls".
- [4] A 2001 National Research Study: "A National Study of Water & Energy Consumption in Multifamily Housing; In-Apartment Washers vs Common Area Laundry rooms", found that residents with in-unit washers do 5.22 loads per week on average, while residents using common area laundry do 2.16 loads per week.
- [5] To account for the different efficiency of electric and Natural Gas hot water heaters (gas water heater: recovery efficiencies ranging from 0.74 to 0.85 (0.78 used), and electric water heater with 0.98 recovery efficiency). Therefore a factor of 0.98/0.78 (1.26) is applied.
- [6] Based on DOE Life-Cycle Cost and Payback Period Excel-based analytical tool.
- [7] Based on inflating cost data from Life-Cycle Cost and Payback Period Excel-based analytical tool. See Efficient Product measure
- [5] Incremental cost is based on weighted average incremental costs (90% moving from inefficient top loader to high efficient front loader, and 10% moving from inefficient front loader to high efficient front loader, and 10% moving from inefficient front loader to high efficient front loader, and 10% front NBCC, SAFE': "Efficiency Opportunities in Multifamily common Area Laundry Facilities". Session costs were estimated using an intermet shop and then full install cost estimated by adding baseline and incremental. See 'MF Common Area Commercial Clothes Washer 2020.x6' for calculation.
- [9] Where dryer and DHW use different fossil fuels, savings are combined under the DHW fossil fuel because a single measure can only have one fuel type for screening purposes and the DHW savings are larger than the Dryer savings.

### **ENERGY STAR Clothes Dryer**

Measure Number	IV-A-2 d
Portfolio:	EVT TRM Portfolio 2019-01
Status:	Active
Effective Date:	2019/1/1
End Date:	[ None ]
Program:	Efficient Products Program
End Use:	Laundry

### Update Summary

- Update Summary: R-e-analysis of savings based on units participating in the EVT Program. Addition of Compact units and savings. Removal of Emerging Technology Award as a category and replacing with ENERCY STAR Most Efficient Hybrid (Standard sized) and ENERCY STAR Most Efficient Full Head Fung (Compact sized). Removal of gas drivers.

### Applicable Markets

Applicable Platkets
Efficient Products
Residential New Construction
Multifamily In Unit New Construction
Multifamily In Unit Retrofit
Low Income Single Family Retrofit
Existing Homes Retrofit

### Referenced Documents

- e-Cycle\_Cost\_and\_Payback\_Period\_Area
- 2011-04-18\_TSD\_Chapter §\_UIE-Orde\_Cost\_and\_Payback, Period\_ BERKOTSTAR Diral 2 Version 1
   BERKOTSTAR Final Version 1 Ocches Dryers Program Requireme Appendix 12 To Subpart DOF Part 430—Unitem Trest Nethod For M Washers
   EREKOTSTAR: Dryer Specification NEEA Annended comments Mar 21 VT SF Existing Homes Onsite Report DRAFT 122117 nents Mar 26 2013
- VT SF Existing names status
   2018 Clothes Dryer Analysis\_ v2

### Description

Colhes drypes exceeding minimum qualifying efficiency for ENERGY STAR (standard sized or compact), ENERGY STAR Most Efficient Hybrid Heat Pumps (all standard sized) and ENERGY STAR Most Efficient Full Heat Pumps (all compact units), based on Combined Energy Factor (CEF), as described below (all stanuaru sizeu) an under High Efficiency.

The CEF measures energy consumption of the total driver cycle (standby usage, driver heating and operation) in units of weight (lbs) of dothing dried per KMh of electricity; the higher the number, the greater the efficiency. In the case of gas dryers, the CEF combines both the gas and electric usage into a single CEF metric also measured in units of weight of dothing dride per KMh of electricity.

#### **Baseline Efficiencies** Market Opportunity

The baseline combined energy factor (CEF) was derived in the ENERGY STAR Version 1.0 analysis by multiplying 2015 federal standards by the average change in a dryers' assessed CEF between the required (Appendix D1) and optional (Appendix D2) test procedure required by the ENERGY STAR eligibility enginements. This gives 3.11 CEF for standard electric dryers, 3.01 for compact 1200 dryers, 2.751 for verted 2400 dryers and 2.13 for compact ventiless dryers.

#### Early Replacement

Early Reparament: The baseline in this case is the efficiency of the existing unit for its assumed remaining life (4 years) and the new baseline as defined above for the remainder of the measure (remaining 8 years). The Federal baseline for clothes dryers prior to 2015 had been in place since 1994. The standard was 3.01 EF for electric units. Comparing new units Combined Energy Factor (which include accounting for standby loads in addition to active drying energy) with older units Energy Factor (which only accounts for active drying energy) is complicated further by significant changes in testing procedures over the years. However, there hasn't been significant change in actual clothes dryer performance over the past decades and using these EF without any adjustment is consistent with this, only representing approximately 3% lower efficiency than the new baseline, and is used as an estimate o existing unit efficiency. se EF

Applying the same ratio of old standard to new is applied to the new standard for compact units to estimate an existing baseline of 2.91CEF for compact 120V dryers, 2.64 for vented 240V dryers and 2.06 for compact ventless dryers.

Efficient Equipment High efficiency is defined as any model meeting or exceeding ENERGY STAR or ENERGY STAR Most Efficient criteria, as defined in the following table:

	Combined Energy Fact Lbs / kWh	or (CEF)
	ENERGY STAR	ENERGY STAR Most Efficient
Standard Sized	>= 3.93	>= 4.3
Compact 120V	>= 3.8	>= 4.3
Compact 240V Ventled	>= 3.45	>= 4.3
Compact 240V Ventless	>=2.68	>= 3.7

Energy savings estimates are based on the resulting product from multiplying the average CEF of units purchased through the Efficiency Vermont program during 2017 and 2018. An additional waste heat calculation has been incorporated in to the final savings determination. This accounts for the unit's wasta heat either being predominately verted to outside or remaining in the home and reducing the heating demands (notably in vertices hybrid and full heat purp models).

Algorithms Electric Demar		
ΔkW	= ΔkWh/He	rs
Symbol Table		
Electric Energy	Savings	
Market Opport	unity: ∆kWh <sub>unit</sub>	= Weight × (1/CEF <sub>base</sub> – 1/CEF <sub>eff</sub> ) × %Washer × N
Early Replacer	nent: ΔkWh <sub>unit</sub>	= Weight $\times$ (1/CEF $_{exist}$ – 1/CEF $_{eff}$ ) $\times$ %Washer $\times$ N
∆kWh <sub>W asteHeat</sub>		$= \Delta kWh_{Heat} + \Delta kWh_{Cool}$
		$\Delta kWh_{Heat} = kWh_{HeatBase} - kWh_{HeatEff}$

			kWh <sub>Heat</sub> = (%HeatSpa	ce × WHH+ × %Hea	itSource × %	Conditioned	× Dryer C	onsumptic	on)/COPHea	it
			$\Delta kWh_{Cool} = kWh_{CoolBase}$	- kWh <sub>CoolEff</sub>						
			kWh <sub>Cool</sub> = (%HeatSpa	ace × WHCF × %Co	oling × %Cor	nditioned × E	Oryer Cons	umption)/	COPCool	
∆kW	/h		= $\Delta kWhUnit + kWhVentles$	ss +∆kWhWasteHea	at					
Symb	ool Table									
Fossil	Fuel Savings									
ΔMM	(Btu <sub>WasteHeat</sub>	= MMBtu <sub>W</sub>	asteHeatBase - MMBtu <sub>WasteHeatEt</sub>	Ŧ						
		MMBtu <sub>w</sub>	$V_{astel+eat} = (\%HeatSpace \times W)$	'HHF × %HeatSourc	e × %Conditi	oned × Drye	r Consump	ption × 0.0	003412)/ ŋł	Heat
ΔMM	1Btu	= \Delta MMBtu	Ventless +∆MMBtuWasteHea	it						
Where										
mare	%Conditioned	= F	Portion of homes with dryer i	n conditioned space						
			= 73% <sup>[2]</sup>							
	%Cooling		Percent of homes with centra = 2% <sup>[3]</sup>	I cooling						
	%HeatSource	= F	Portion of homes with fuel so	urce <sup>[4]</sup> :						
				Fuel Source		homes (%H	eatSource	)		
				Electric Natural Gas	2% 12%					
				Propane gas	24%					
				Fuel Oil	35%					
				Wood	26%					
	%HeatSpace	= F	Proportion of dryer heat ener	gy remaining in spa	ce:					
				Unit Type		%HeatSp	ace		1	
				Vented		5%			]	
				Ventless		100%			]	
	%Washer		Reduction in dryer savings fro = Values provided in table be		washers <sup>(5)</sup>					
			Efficiency Level	1014			% Ener	gy Reduc	ction from	ī
							Paired I	Efficient \	Washers	
			Vented Units Ventless Units				14% 16%			_
		l	ventiess Units				10%			
	ΔkWh	- 1	Fotal gross customer annual	kWh savings for the	measure					
	ΔkW	= 0	Gross customer connected loa	ad kW savings for th	ne measure					
	$\Delta kWh_{Cool}$	= I	impact of waste heat on cooli	ing loads						
	$\Delta kWh_{Heat}$	= I	impact of waste heat on heat	ing loads						
	$\Delta kWh_{unit}$	= 0	Gross electric savings for ope	ration of clothes dry	/er					
	$\Delta kWh_{WasteHeat}$	= 0	Gross electric savings relating	) to waste heat impa	acts					
	ΔkWh	= 1	Fotal gross customer annual	kWh savings for the	measure					
	∆MMBtu <sub>WasteHeat</sub>	= +	leating impact associated wit	th waste heat of uni	t					
	ΔMMBtu	- 1	Fotal gross fuel savings for th	e measure						
	ΔMMBtuVentless	= +	NAC In-direct fossil fuel savi	ngs from ventless d	ryer, by fuel t	type <sup>[14]</sup>				
			Values provided in table belo	w for Ventless drye	rs; zero for a	ll others				
			Marchine Harbe		NG	LP	Oil		Wood	
			Ventless Units		0.05	0.05	0.1	17	0.08	
	∆MMBtuWasteHe		Gross fuel savings relating to							
	ηHeat	= E	Efficiency of heating system <sup>[1</sup>	5]:						
				Fuel Source	Heating el	fficiency (ŋH	eat)			
				Natural Gas	89.1%					
				Propane gas	87.7%					
				Fuel Oil	82.9%					
				Wood	65%					
	∆kWhUnit	= 0	Gross electric savings from op	peration of the cloth	es dryer					
	CEF <sub>base</sub>		Combined Energy Factor of b		n full cycle te	sting of conv	entional d	ryers <sup>(6)</sup>		
			/alues provided in table below	N				1		
			Efficiency Level					CEF (lbs/kV	Vh)	
			STANDARD BASELINE - ENER	RGY STAR Version 1	.0 Estimated	Baseline		3.11		
			COMPACT 120V BASELINE -				2	3.01		
		ŀ	COMPACT Vented 240V BAS					2.73		
			COMPACT Ventless 240V BA Baseline	SELINE - ENERGY S	TAR Version :	1.0 Estimate	1	2.13		
	CEF <sub>eff</sub>		Combined Energy Factor of el	fficient unit						
			/alues provided in table below	w <sup>[7]</sup> . Note categories	s indicating N	/A do not cu	rrently hav	ve any pro	duct meetir	ng the
			Efficiency Level					CEF		
			Enciency Level					LEF		

			(lbs/kWh)
		Standard ENERGY STAR	3.93
		Standard ENERGY STAR Most Efficient (Hybrid Heat Pump)	5.05
		Standard Heat Pump	N/A
		Compact 120V ENERGY STAR	N/A
		Compact Vented 240V ENERGY STAR	N/A
		Compact Ventless 240V ENERGY STAR	2.73
		Compact 120V ENERGY STAR Most Efficient (Full Heat Pump)	7.02
		Compact Vented 240V ENERGY STAR Most Efficient (Full Heat Pump)	N/A
		Compact Ventless 240V ENERGY STAR Most Efficient (Full Heat Pump)	10.25
CEFewist		Combined Energy Factor of existing unit <sup>(8)</sup>	
		Values provided in table below	
			CEE
		Efficiency Level	
			(lbs/kWh)
		STANDARD BASELINE - ENERGY STAR Version 1.0 Estimated Baseline	3.01
		COMPACT 120V BASELINE - ENERGY STAR Version 1.0 Estimated Baseline	2.91
		COMPACT Vented 240V BASELINE - ENERGY STAR Version 1.0 Estimated Baseline	2.64
		COMPACT Ventless 240V BASELINE - ENERGY STAR Version 1.0 Estimated Baseline	2.06
COPCool		Coefficient of Performance of cooling system	
		= 3.0 <sup>(9)</sup>	
OPHeat			
JOPHeat		Coefficient of Performance of heating system	
		= 1.5 <sup>[10]</sup>	
Pryer Consumption	-	Estimated annual consumption of dryer used in calculation of waste heat impacts.	
		= Weight * 1/CEF * (1 - %Washer) * N	
lours	_	Assumed annual run hours of clothes dryer	
lours	1		
		= Ncycles * 1 Hour	
		= 322 <sup>[1]</sup>	
Wh <sub>CoolBase</sub>		Waste heat impacts on cooling for baseline unit	
Wh <sub>CoolEff</sub>	-	Waste heat impacts on cooling for efficient unit	
(Wh <sub>HeatBase</sub>	-	Waste heat impacts on heating for baseline unit	
:Wh <sub>HeatEff</sub>	-	Waste heat impacts on heating for efficient unit	
kWh <sub>Ventless</sub>	-	${\rm HVAC}$ In-direct electric savings from ventless dryer not having to reheat make-up ${\rm air}^{\rm [4]}$	5739]
		= 3 kWh for ventless dryers; 0 kWh for all others	
1MBtu <sub>W astelleat</sub>	-	Heating impact associated with waste heat of baseline or efficient unit	
MMBtu <sub>W astell eatBase</sub>		Waste heat impacts on heating for baseline unit	
MMBtuw aster HeatEff		Waste heat impacts on heating for efficient unit	
MADe comune	_	Conversion foreign faith to MMDby	
4MBtu_convert		Conversion factor from kWh to MMBtu	
		=0.003413	
leydes	-	Number of Cycles per year	
		=322[11]	
		Average clothes dryer load weight (lbs) based on DOE average test load size of pairer	lwachor
Malahk	-	Average clothes dryer load weight (lbs) based on DOE average test load size of pairer =10.4 lbs for standard units, 6.6 lbs for compact units <sup>[12]</sup>	u wasner.
Weight			
Weight		= 10.4 lbs for standard drifts, 0.0 lbs for compact drifts.	
Weight	-	Portion of waste heat that results in increased cooling	
	-		
VHCF	-	Portion of waste heat that results in increased cooling $= 0.188^{(13)} \label{eq:results}$	
	-	Portion of waste heat that results in increased cooling	

### Mid Life Covinge Adjuste

The follow mid life savings adjustments are applied to the annual savin	gs for early re	placement me
Efficiency Level	Electric Adjustment	Fossil Adjustment
ENERGY STAR	86%	94%
ENERGY STAR Most Efficient Hybrid	92%	100%
ENERGY STAR Most Efficient Full Heat Pump	96%	93%

## Load Shapes 9a Residential Clothes Washe

Number	Name	Status	Winter On kWh	Winter Off kWh	Summer On kWh	Summer Off kWh	Winter kW	Summer kW
9	Residential Clothes Washer	Active	42.0%	28.8%	16.9%	12.3%	4.4%	3.3%

### Net Savings Factors

Net Savings Flower Measures CALSERY Energy Star Clothes Dryer CALSERA Energy Star Most Efficient Clothes Dryer CALERED Early Replacement ENERGY STAR Clothes Dryer CALERED Energy Star Most Efficient Clothes Dryer, Early Replacement

# Tracks [Base Track] 6032EPEP [is base track] Efficient Products - Residential 6034LISF [is base track] LISF Retrofit 6036RETR [is base track] Res Retrofit 6036HPES [6036RETR] HPwES EVT 6013EPEP [6032EPEP] Efficient Products - Commercial

Track Name	Track Nr.	Measure Code	Free Rider	Spill Over
Efficient Products - Residential	6032EPEP	CKLESDRY	0.90	1.10
Efficient Products - Residential	6032EPEP	CKLESETA	1.00	1.20
LISF Retrofit	6034LISF	CKLESDRY	1.00	1.00
LISF Retrofit	6034LISF	CKLESETA	1.00	1.00
Res Retrofit	6036RETR	CKLESDRY	0.90	1.00
Res Retrofit	6036RETR	CKLESETA	0.90	1.00
Efficient Products - Residential	6032EPEP	CKLERESD	1.00	1.00
LISF Retrofit	6034LISF	CKLERESD	1.00	1.00
Res Retrofit	6036RETR	CKLERESD	1.00	1.00
Efficient Products - Residential	6032EPEP	CKLERETD	1.00	1.00
LISF Retrofit	6034LISF	CKLERETD	1.00	1.00
Res Retrofit	6036RETR	CKLERETD	1.00	1.00

#### Lifetimes 12 years<sup>[17]</sup>

Analysis period is the same as the lifetim

For early replacement the existing unit is assumed to have a remaining life of 4 years (1/3 of the measure life).

#### Measure Cost

The incremental cost and full install cost for this measure is provided in the table below<sup>[18]</sup>:

Efficiency Level	Market Opportunity Incremental Cost	Early Replacement Full Install Cost
ENERGY STAR	\$61	\$528
ENERGY STAR Most Efficient	\$412	\$879

For early replacement measures, the deferred baseline replacement cost that would have been incurred after 4 years had the existing unit not been replaced is assumed to be \$467.

### O&M Cost Adjustments

There are no operation and maintenance cost adjustments for this measure.

## Prescriptive Savings Tables

FreeSch parke Servings Tearless en provided below. For ENERGY STAR it is the weighted (by product in program) average of Standard ENERGY STAR units and Compact 240V Verless ENERGY STAR. ENERGY STAR Most Efficient Hybrid Heat Pump are all Standard sized. ENERGY STAR Most Efficient Hybrid Heat Pump is the weighted (by product in program) average of Compact 240V Verless Full Heat Pump are

	Item Code	ΔkWh	ΔkW	ΔMMBtu				
	20KWVII	ZIKVV	NG	LP	Oil	Wood		
ENERGY STAR	EPCKLDRYES	195	0.6045	-0.003	-0.006	-0.010	-0.011	
ENERGY STAR Most Efficient Hybrid	EPCKLDRYETA2	364	1.1313	0.14	0.27	0.43	0.46	
ENERGY STAR Most Efficient Full Heat Pump	EPCKLDRYETA3	587	1.8229	-0.06	-0.13	-0.19	-0.12	

For Early Replacment measures, the first four years will assume the following savings before applying the midlife adjustment provided above

		kWh	kW	MMBtu					
	Item Code	KVVII	KVV	NG	LP	Oil	Wood		
ENERGY STAR	EHCKLDERES	226	0.7010	-0.004	-0.007	-0.011	-0.012		
ENERGY STAR Most Efficient Hybrid	EHCKLDERBT	396	1.2284	0.14	0.27	0.43	0.46		
ENERGY STAR Most Efficient Full Heat Pump	EHCKLDERHT	613	1.9033	-0.06	-0.13	-0.20	-0.13		

### Footnotes

[1] Approximately one hour per cycle based upon NEEA data, see Table 1, page 6 of 'NEEA comments on ENERGY STAR Dryer Specification'.

- [2] NEEP Study lound 16 of 22 sites had the dryer in a heated space; NEEP, Energy & Resource Solutions "Electric Dryer Baseline Research", p8. http://www.neep.org/sites/default/files/Microsoft%2DPowerPoint%2D-%2DRyee%2DDyee%2DPyee%2DPyee%2DPyee%2DPyee%2DFyee
- [3] Based on 'Vermont Single-Family Existing Homes Onsite Report', NMR Group Inc, 2017, Table 55.
- [4] Split of primary heating fuels from the VT SF Existing Homes Onsite Report Table 40. (NMR Group, Inc. 2017).
- [5] The percentage of energy reduction reflects the amount of dryer energy already captured by the performance of efficient dothes washers. The effective performance of paired dothes washers for both the DNERGY STAR and DNERGY STAR Most Efficient dryers reflect the market share and relative remaining moisture context for dothes washers both in-program (rebated) and out-of-program (non-rebated). See "2018 Clothes Dryer Analysis\_v2.vlsv" tab "EVF Dryer Estimates" and "Washer Dryer Overlap".
- (6) The baseline was derived in the ENERGY STAR Version 1.0 analysis by multiplying 2015 federal standards by the average change in a dryers' assessed CEF between the required (Appendix D1) and optional (Appendix D2) test procedure required by the ENERGY STAR eligibility requirements. This gives 3.11 CEF for standard electric dryers, 3.01 for compact 120V dryers, 7.27 for vertard-240V dryers and 2.11 for compact ventiless dryers. 23ee "2018 clothes dryer analysis\_V2.vis" tabs "3. Elec. Standard Piot", "4. Elec. Compact 120V Piot" and "5. Elec Compact 240V Piot".
- [7] Efficient unit CEF is based upon the average of units participating in the EP program in 2017 and 2018 that meet the relevent criteria. For Most Efficient units, to better reflect the performance of the units, the average NEA latoratory testing results using the DDE Appendix D2 Test procedure were utilized. See '2017 to YTP 2018' lab in '2018 Other Dyer Analyse, 2485'.
- [8] Based on the federal baseline for clothes dryers prior to 2015, which had been in place since 1994. The standard was 3.01 EF for standard electric units. The ratio of old standard to new is applied to the new standard for compact units to estimate an existing baseline.
- (9) Average efficiency of AC system is 11.4 SEER (based on 'Vermont Single Family Existing Homes Onsite Report', NMR Group Inc, 2017, Table 55). Convert to ER: (-0.02 \* SEER2) + (1.12 \* SEER) = 10.3 EER (calculation from Wassmer, M. (2003). A Component-Based Model for Residential Air Conditioner and Heat Pump Ferry Calculations: Matters Thesis, University of Colorado at Boulder). Convert to COP: EER/3.412 = 3.0 COP
- [10] The COP used here is an assumption based upon a 50/50 split between resistance COP 1.0 and average Heat Pump effective COP of 2.0.
- [11] [1] Weighted average of 322 clothes washer cycles per year based on the Efficiency Vermont 2014 Technical Resource Manual clothes washer measure characterization. A field evaluation completed by NEEA in 50 homes in the Northwest found a higher number of annual clothe (337) than currently represented in the RECS data. Federal standard employs a 0.91 field use factor, based on RECS 2009 survey data suggesting not all clothes washer loads are dried. However, NEEA found a higher number of dryer loads, noting users may not have consolidated their loads to the edent IEA assumed. http://www.energystar.gov/sites/default/like/specs//ERECM%205TAR%20Dryer%205pecification%20NEEA%20Amended%20cmments%20Mar%2026%202013.pdf. Page 7.
- [12] Based on average of ENERGY STAR qualified dryers and available paired washer model capacity information. This average capacity is then used to look up the average load size in the U.S. DOE clothes washer test procedure (10 CFR 430, Subpart B, Appendix J2 Table 5.1), see 2018 Clothes Dryer Analysis, v2.x8x
- [13] Based on bin analysis of annual cooling hours for Burlington, VT using TMY3 data: 1650/8760 = 18.8%, see "2018 Clothes Dryer Analysis.xlsx"
- [14] HVAC In-direct savings for ventless dryers are based on the penetration of heating fuel types and corresponding efficiencies identified in the 'Vermont Single-Family Evisting Homes Onsite Report', NMR Group Inc, 2017, see 'HVAC Inputs' tab in '2018 Clothes Dryer Analysis\_V2.vlsv.
- [15] Weighted efficiencies based on VT SF Existing Homes Onsite Report Table 43, 46 and 47. (NMR Group, Inc. 2017). Efficiency for homes using wood or pellet strives based on review of EPA-Certified wood stoves (U.S. Environmental Protection Agency n.d.)
- [16] Based on bin analysis of annual heating hours for Burlington, VT using TMY3 data: 4885 / 8760 = 55.8%, see "Heating Penalty" tab in "2018 Clothes Dryer Analysis.xlsx"

 [17] Based on average lifetime in DOE Buildings Data Book http://buildingsdatabook.eren.doe.gov/TableView.aspx?table=5.7.15

 [18] See '2018 Clothes Dryer Analysis \_v2.x6x', "Incremental Cost" tab. Based on DOE Life-Cycle Cost and Payback Period analysis Table

 8.1.1, http://www.regulations.gov/contentStreamer/bdjectdid=9000006490Cdee128disposition-attachmertific-metodf

### **Efficient Clothes Washers**

Portfolio:	EVT TRM Portfolio 2019-10	
Status:	Active	
Effective Date:	2019/1/1	
End Date:	[ None ]	
Program:	Efficient Products Program	
End Use:	Laundry	

Applicable Market	ts	
	Applicable Markets	
	Efficient Products	
	Residential New Construction	
	Multifamily In Unit New Construction	
	Multifamily In Unit Retrofit	
	Low Income Single Family Retrofit	
	Existing Homes Retrofit	

Update Summary Included a biended and weighted deemed savings table for a low income single-family voucher program. The voucher's have a value of \$1,200 and the custome is responsible for any additional costs. Due to the make of the program, collecting dryer and DMV fuel information is not possible. Due to the program layout, assuming the majory of participants will be early replacement scenarios. The only revisions are in the addition of three deemed savings table under the early replacement options, KW, kWh, and MMBu.

- Referenced Documents Copy of EERE-2008-BT-STD-0019-0043 VT SF Existing Homes Onsite Report DRAFT 122117 2019 Clothes Washer Savings\_ 08292019

#### Description

A new clothes washer exceeding minimum qualifying efficiency standards established as ENERGY STAR/CEET ier 1, CEE Tier 2 or CEE Advanced Tier as of 1/1/2018, as defined below is purchased, installed in new construction (Market Opportunity) or is installed within an existing home having incentivized the early replacement of an inefficient unit (Early Replacement):

Efficiency Level	Integrated Modified Energy Factor (IMEF)		Integrated Water Factor (IWF)			
	Front Loading	Top Loading	Front Loading	Top Loading		
ENERGY STAR	>= 2.76	>= 2.06	<= 3.2	<= 4.3		
CEE TIER 2	>= 2.92	n/a	<= 3.2	n/a		
CEE ADVANCED TIER	>= 3.1	n/a	<= 3.0	n/a		

The Integrated Modified Energy Factor (IMEF) measures energy consumption of the total isundry cycle (unit operation, washing and drying) and the per-cycle standby and off mode energy consumption; the higher the number, the greater the efficiency.

The Integrated Water Factor (IWF) is the number of gallons needed for each cubic foot of laundry. A lower number indicates lower consumption and more efficient use of water

In 2019, a low mome single-family oucher program was incorporated into this measure's characterization. Customers will receiver a voucher that will cover the full cost of a new clothes washer, appliance delivery, and the removal of an existing unit, up to \$1,200. The deemed savings for this program was specifically separated and put in their own table due to the implementation of the program where collecting driver and DHW fuel information not possible. The savings in these table presented a weight daverage of early replacement options leveraging fuel and equipment saturation from the, "Vermont Single-Family Existing Homes On-Site Report", MRR, December 2017.

Program Type Calculation Type: Market Opportunity: Time of Sale / Market Opportunity: New Construction / Early Replacement Program Delivery / Implementation Type: Downstream / Upstream

### **Baseline Efficiencies**

#### Market Opportunity

The baseline efficiency is determined according to the Integrated Modified Energy Factor (IMEF) that takes into account the energy and water requir per clothes washer cycle, including energy required by the clothes drype per clothes washer cycle and standby/off mode consumption. The Federal baseline MFE as d'anaury 2018 is 1.46 for fort loading units and 1.57 for the loading units.

Early Repla

Early Replacement assemine. The baseline in this case is the efficiency of the existing unit for its assumed remaining life (3 years) and the new baseline as defined above for the remainder of the measure (remaining 11 years). Eligibility for this measure is limited to pre-2004 non-Energy Star units. The Federal baseline for clothes washes prior to 2004 was 0.817 MEF, and the average value of units tested in a 2001 100E market assessment was 1.164/HEF. Converting HEF to IMEF using an ENREGY TAR conversion to clopel in to the reference calculation preadsheet "2019 Clothes Washer Savings.xts", provides the assumption for existing units of 0.74 MEF for top-loading and 0.91 MEF for front loading machines.

Efficient Equipment High efficiency is defined as any model meeting or exceeding ENERGY STAR, CEE Tier 2 or CEE Advanced Tier standards as of 2/5/2018, as provided in High efficience table above.

### Algorithms

Electric Deman	d Savings
ΔkW	$= \Delta kWh/Hours$
Symbol Table	
Electric Energy	Savings
ΔkWh	= (Capacity × 1/IMEFbase × Ncycles × (%CWbase + (%CHWbase × %Electric_DHW) + (%Dryerbase × %Electric_Dryer))) - ( Capacity × 1/IMEFeff × Ncycles × (%CWeff + (%CHWeff × %Electric_DHW) + (%Dryereff × %Electric_Dryer)))
Symbol Table	
Fossil Fuel Savi	ngs
ΔMMBtu	= ((Capacity × 1/IMEFbase × Ncycles × ((%bHWbase × %Fuel_DHW × R_eff) + (%b7yerbase × %Fuel_Dryer)))) - (Capacity × 1/IMEFeff × Ncycles × ((%bHWeff × %Fuel_DHW × R_eff) + (%b7yereff × %Fuel_Dryer)))) × MMBu_convert
Symbol Table	
Water Savings	
ΔWater (CCF)	= ((Capacity $\times$ (IWFbase - IWFeff)) $\times$ Ncycles) / GallonsPerCCF
Where:	
%CWbase	<ul> <li>Percentage of total energy consumption for baseline Clothes Washer operation (Deemed, dependent on efficiency level – see table below)</li> </ul>

er required

%CWef		= Percentage of total en level - see table below)		sumption	for efficient C	othes	Washer ope	ration (De	eemed, de	pendent on ef	iciency
%DHWbase		= Percentage of total en level – see table below)		sumption	used for wate	r heat	ting by baseli	ne unit (E	Deemed, d	ependent on e	fficiency
%DHWeff		= Percentage of total en level – see table below)		sumption	used for wate	r heat	ting by efficie	nt unit ((	Deemed, d	dependent on e	fficiency
%Dryerbase		= Percentage of total ba table below)	aseline en	ergy cons	umption for d	ryer o	peration (De	emed, de	pendent o	n efficiency lev	el – see
%Dryereff		= Percentage of total eff table below)	ficient ene	ergy cons	umption for di	yer o	peration (Dee	emed, dej	pendent or	n efficiency lev	el – see
					Percentage	of T	otal Energy	Consum	nption[2]		
					%CW	%D	HW	%Dryer	r		
				Standard	8%	20%	6	72%			
			ENERGY		5%	25%	6	70%			
			CEE TIER		10%	3%		87%			
			Advanced	d lier	10%	3%		87%			
%Electric_DHW	-	= Percentage of DHW sa	-		be electric (Di	emec			et)		
				ficient Pr	roducts		%Electric_E 25.0%	HM(3)	_		
				INC			24% if unkr	Iown	_		
				Aultifamily	/ New on and Retrofi		Assumed al known	ways			
				0150 000			NIOWIT				
%Electric_Dryer	-	= Percentage of dryer si	_		be electric (D	eeme			et)		
				ficient Pr	roducts		%Electric_E	a yer(3)			
				INC	-		76% if unkr	iown			
				Aultifamily	/ New on and Retrofi		Assumed al known	ways			
			Ľ		and red off	-					
%Fuel_DHW		= Percentage of DHW sa	avings ass	sumed to	be non electri	: [3] (I	Deemed, der	endent o	n market)		
		Market	,		DHW Fuel		%Fuel_DHW	]	)		
		Efficient Prod	ucts		Natural Gas		26%				
				-	Propane Oil	+	27% 20%	-			
		RNC			Natural Gas		14%				
					Propane Oil	+	52% 10%	-			
					JII	1	1070	_			
		Multifamily New Const	truction a	nd	Assumed a	lways	known				
%Fuel Drver		Retrofit					known				
%Fuel_Dryer			avings ass				known				
%Fuel_Dryer		Retrofit = Percentage of dryer sa	avings ass n market)	sumed to		S <sup>[3]</sup>					T
%Fuel_Dryer		Retrofit = Percentage of dryer sa	avings ass 1 market)	sumed to Market	be Natural Ga	s <sup>[3]</sup>	Dryer fuel			s_Dryer	Į
%Fuel_Dryer		Retrofit = Percentage of dryer sa	avings ass 1 market)	sumed to	be Natural Ga	s <sup>[3]</sup>					Ĩ
%Fuel_Dryer		Retrofit = Percentage of dryer sa	avings ass 1 market)	sumed to Market	be Natural Ga	s <sup>(3)</sup>	Dryer fuel Natural Gas LP Gas Natural Gas		:	11% 15% 8%	
%Fuel_Dryer		Retrofit = Percentage of dryer sa	avings ass n market) Effic	sumed to Market	lucts	s <sup>(3)</sup>	Dryer fuel Natural Gas LP Gas Natural Gas LP Gas	ned alway		11% 15%	T + + +
%Fuel_Dryer		Retrofit = Percentage of dryer sa	avings ass a market) Effic	Market	lucts	s <sup>(3)</sup>	Dryer fuel Natural Gas LP Gas Natural Gas LP Gas	ned alway		11% 15% 8%	
96Fuel_Dryer		Retrofit = Percentage of dryer sa	avings ass n market) Effic Mul Co	Market Market cient Prod RNC Itifamily N onstructio	lee Natural Ga	S[3]	Dryer fuel Natural Gas LP Gas LP Gas LP Gas Assurr	ned alway		11% 15% 8%	- - - -
		Retrofit = Percentage of dryer si (Deemed, dependent on	avings ass in market) Effic Mul Co ected load	Market ient Prod RNC Itifamily N onstructio	lee Natural Ga	s <sup>[3]</sup>	Dryer fuel Natural Gas LP Gas LP Gas LP Gas Assurr	ned alway		11% 15% 8%	
ΔKW	-	Retroft = Percentage of dryer si (Deemed, dependent on gross customer connect	avings ass n market) Effic Mul Co ected load	Market cient Prod RNC Itifamily N onstructio	kew with the measure (Ou	s <sup>[3]</sup>	Dryer fuel Natural Gas LP Gas Natural Gas LP Gas Assurr (Output)	ned alway		11% 15% 8%	-
ΔΑΨ	-	Retroft = Percentage of dryer si (Deemed, dependent on gross customer conne gross customer annual k = gross customer annual = gross customer annual = gross customer annual	avings ass market) Effic Co ected load	Market Market RNC Itifamily N RNC Itifamily N RNC Itifamily N RNC RNC RNC RNC RNC RNC RNC RNC RNC RN	lucts	s[3] asure ttput)	Dryer fuel Natural Gas LP Gas Natural Gas LP Gas Assurr (Output) put)	ned alway		11% 15% 8%	-
akw akwh ammBtu	-	Retroft = Percentage of dyers si (Deemed, dependent on gross customer conne gross customer annual k = gross customer annual = gross customer annual = gross customer annual = gross customer annual	avings ass market) Effic Co cocted load	Market Market RNC Itifamily N RNC Itifamily N RNC Itifamily N RNC RNC RNC RNC RNC RNC RNC RNC RNC RN	lucts	s[3] asure ttput)	Dryer fuel Natural Gas LP Gas Natural Gas LP Gas Assurr (Output) put)	ned alway		11% 15% 8%	-
۵۸۷۷ ۵۸۷۷h ۵۸۹۹Bu ۵۵۷ater (CCF)	-	Retroft = Percentage of dryer si (Deemed, dependent on gross customer conne gross customer annual k = gross customer annual = gross customer annual = gross customer annual	avings ass In market) Effic Mult CC Sected load In MBBu savin al MMBBu savin al MABBu savin Sector (cubic	Market ient Prod RNC Itifamily N kW savin kW savings for savings for feet)	lee Natural Ga	s <sup>[3]</sup> asure ttput) (Out;	Dryer fuel Natural Gas LP Gas Natural Gas LP Gas Assurr (Output) put)	ed alway		11% 15% 8%	
ΔKW ΔKWh ΔMMBtu ΔWater (CCF) Capacity	-	Retrofit = Percentage of dryer si (Deemed, dependent on (Deemed, dependent on gross customer annual i = gross customer annual i = gross customer annual = gross customer annual = gross customer annual = gross customer annual = Gothes Washer capac = 4.13 <sup>[4]</sup> (Deemed) For Shift Model Approac	avings ass In market) Effic Mult CC Sected load In MBBu savin al MMBBu savin al MABBu savin Sector (cubic	Market ient Prod RNC Itifamily N kW savin kW savings for savings for feet)	lee Natural Ga	s <sup>[3]</sup> asure ttput) (Out;	Dryer fuel Natural Gas LP Gas Natural Gas LP Gas Assurr (Output) put)	ned alway		11% 15% 8%	
ΔKW ΔKWh ΔMMBtu ΔWater (CCF) Capacity	-	Retroft = Percentage of dryer si (Deemed, dependent on gross customer conne gross customer annual k = gross customer annual = gross customer annua = Gothes Washer capac = 4.13 <sup>(4)</sup> (Deemed)	avings ass In market) Effic Mult CC Sected load In MBBu savin al MMBBu savin al MABBu savin Sector (cubic	Market ient Prod RNC Itifamily N kW savin kW savings for savings for feet)	lee Natural Ga	s <sup>[3]</sup> asure ttput) (Out;	Dryer fuel Natural Gas LP Gas Natural Gas LP Gas Assurr (Output) put)	eed alway		11% 15% 8%	
۵۸۷۷ ۵۸۷۷h ۵۸۹۹Bu ۵۵۷ater (CCF)	-	Retrofit = Percentage of dyser si (Deemed, dependent on (Deemed, dependent on = gross customer annual k = gross customer ann	avings ass market) Effic Co Scted load I MMBu s avin Al MMBu s avin al water si Sity (cubic	Market Market RNC RNC RNC RNC RNC RNC RNC RNC RNC RNC	lew void the measure (Ocore measure (Ocore measure (Core measure (Core measure the measure ted Capacity) <sup>3</sup>	s <sup>[3]</sup> asure ttput) e (Out;	Dryer fuel Natural Gas LP Gas Assum (Output) put)			11% 15% 8%	
۵۸۷۷ ۵۸۷۷h ۵۸۹۹Btu ۵۷۷ater (CCF) Capacity GallonsPerCCF	-	Retroft Percentage of dyrer si Percentage of dyrer si Percentage of dyrer si Percentage of dyrer si Percentage of dyrers si Percentage of the dyrer si Percentage of the dyrer set of the dyrer s	avings ass market) Effic Sected load sected load al MARL s al water si al water si city (cubic sours of cl Mark	Market Market RNC RNC RNC RNC RNC RNC RNC RNC RNC RNC	be Natural Ga	s[3] asure ttput) e (Out; l, dep	Dryer fuel Hetural Gas LP Gas Assum (Output) put) put)	arket) Hours <sup>[1]</sup>		11% 15% 8%	
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۵۸۷۷ ۵۸۷۷h ۵۸۹۹Btu ۵۷۷ater (CCF) Capacity GallonsPerCCF	-	Retofit = Percertage of dryers is (Deemed, dependent on gross customer conne gross customer annual i = gross customer annual = gross customer annual = gross customer annual = Gothes Washer capac = 4.13 <sup>(4)</sup> (Deemed) For Shift Model Approac Gailons per CCF = 748 = assumed annual run h = integrated Modified Er	avings ass er market) Effic ected load KWh savin Co co coted load al MMBu s avin al MMBu s avin	Market ient Prod RNC RNC RNC RNC RNC RNC RNC RNC	be Natural Ga	asure ttput) (Outp l, dep	Dryer fuel Netural Gas LP Gas Assum (Output) put) put) put) put) put) put) put	arket) Hours <sup>[1]</sup> 322 265	IS known	11% 15% 8% 16%	
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			= 1.	26 <sup>(8)</sup>									
	Life Saving												
For m	id-life savings ad	justmer	nts, pleas	e see the	reference	tables bel	ow.						
Load	d Shapes												
9a Res	sidential Clothes	Washer											
Num	her N	ame		Status	Winter	Winter	Summer	Summer	Winter		r		
							On kWh						
9	Residential	Clothes	Washer	Active	42.0%	28.8%	16.9%	12.3%	4.4%	3.3%			
	Savings Fa	ictor	s										
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6032	EPEP [is base tra	ck] Ef	fficient Pr	oducts - R	esidential								
6034	LISF [is base trac	k] LI	SF Retrol	fit									
6036	RETR [is base tra	ck] R	es Retrofi	t									
6038	VESH [is base tra	ck] R	NC VESH										
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Lifetimes 14 years<sup>(9)</sup>(same as DPS screening of Efficiency Utility program). Analysis period is the same as the lifetime. Early Replacement: The existing unit is assumed to have a remaining life of 3 years

Measure Cost The incremental cost for this measure is provided in the table below 10]

Efficiency Level	Market Opportunity Incremental Cost	Early Replacement Full Install Cost
ENERGY STAR	\$124	\$1,263
CEE TIER 2	\$170	\$1,309
CEE Advanced Tier	\$179	\$1,318

For early replacement measures, the replaced is assumed to be \$1,139. res, the deferred baseline replacement cost that would have been incurred after 3 years had the existing unit not been

O&M Cost Adjustments There are no standard operation and maintenance cost adjustments used for this measure

Prescriptive Savings Tables The following tables provide the Prescriptive Savings values. See '2019 Clothes Washer Analysis\_01082019.xls' for details.

## kWh Savings

Market Opportunity: sed on values provided above where DHW and Dryer fuels are unknown is pro

			Effici	ent Products A	∆kWH				RNC ΔkWH	
Efficiency Level	Front	Item Code	Тор	Item Code	Weighted Average	Item Code	Front	Тор	Weighted Average	Item Code
ENERGY STAR	118.9	EPESFCW	95.0	EPESTCW	101.6	EPESACW	119.6	97.5	103.6	RNCCKLESAWRP
CEE TIER 2	138.8	EPT2FCW	n/a	n/a	138.8	EPT2ACW	139.9	n/a	139.9	RNCCKLT2AWRP
CEE ADVANCED TIER	158.6	EPT3FCW	n/a	n/a	158.6	EPT3ACW	160.2	n/a	160.2	RNCCKLT3AWRP

The unit specific kWh savings when DHW and Dryer fuels are known is provided below (see MMBtu table for Item Codes):

Efficiency Level	Drver/DHW Fuel Combo		RI	NC AkWH	Multifarr	ily New	Construction In Unit ∆kWH
Enciency Level	biyer/bnw Fuer Combo	Front	Тор	Weighted Average	Front	Тор	Weighted Average
	Electric Dryer/Electric DHW	245.4	81.7	127.1	201.6	67.2	104.4
ENERGY STAR	Electric Dryer/Fuel DHW	111.3	134.1	127.8	91.5	110.2	105.0
ENERGI STAR	Fuel Dryer/Electric DHW	145.7	-18.3	27.1	119.8	-15.1	22.3
	Fuel Dryer/Fuel DHW	11.6	34.0	27.8	9.6	28.0	22.9
	Electric Dryer/Electric DHW	271.8	n/a	271.8	223.3	n/a	223.3
CEE TIER 2	Electric Dryer/Fuel DHW	137.0	n/a	137.0	112.5	n/a	112.5
CEE LIEK 2	Fuel Dryer/Electric DHW	149.1	n/a	149.1	122.5	n/a	122.5
	Fuel Dryer/Fuel DHW	14.2	n/a	14.2	11.7	n/a	11.7
	Electric Dryer/Electric DHW	298.2	n/a	298.2	245.1	n/a	245.1
CEE ADVANCED TIER	Electric Dryer/Fuel DHW	162.7	n/a	162.7	133.6	n/a	133.6
JEE ADVANCED TIEK	Fuel Dryer/Electric DHW	152.4	n/a	152.4	125.2	n/a	125.2

### Fuel Dryer/Fuel DHW 16.8 n/a 16.8 13.8 n/a 13.8

### Early Replacement:

The first year savings are provided below, with a mid life adjustment to be applied after 3 years to bring the savings in line with a new replacement as provided above [12](see MMBu table for Item Codes):

Efficiency Level	Dryer/DHW Fuel Combo	Single		Early Replacement \kWH placing:	Multi		Jnit Early Replacement ΔkWH eplacing:	Ν		e Adjustment eplacing:
		Front	Тор	Weighted Average	Front	Тор	Weighted Average	Front	Тор	Weighted Average
	Electric Dryer/Electric DHW	860.9	1196.5	872.7	707.3	983.1	717.0	15%	11%	15%
ENERGY STAR	Electric Dryer/Fuel DHW	725.8	620.0	722.0	596.3	509.4	593.3	18%	21%	18%
	Fuel Dryer/Electric DHW	225.5	605.5	238.8	185.2	497.5	196.2	12%	4%	11%
	Fuel Dryer/Fuel DHW	90.4	29.0	88.2	74.3	23.8	72.5	31%	96%	32%
	Electric Dryer/Electric DHW	1005.6	1341.2	1017.4	826.3	1102.0	836.0	27%	20%	27%
CEE TIER 2	Electric Dryer/Fuel DHW	734.9	629.1	731.2	603.9	516.9	600.8	19%	22%	19%
	Fuel Dryer/Electric DHW	347.4	727.4	360.8	285.5	597.7	296.5	43%	20%	41%
	Fuel Dryer/Fuel DHW	76.8	15.4	74.6	63.1	12.6	61.3	19%	93%	19%
CEE ADVANCED	Electric Dryer/Electric DHW	1032.1	1367.7	1043.9	848.0	1123.7	857.7	29%	22%	29%
TIFR	Electric Dryer/Fuel DHW	760.6	654.8	756.9	625.0	538.0	621.9	21%	25%	21%
LEK	Fuel Dryer/Electric DHW	350.8	730.8	364.2	288.2	600.4	299.2	43%	21%	42%
	Fuel Dryer/Fuel DHW	79.3	18.0	77.2	65.2	14.8	63.4	21%	94%	22%

Efficiency Level	Item Code	Low In		ngle Family Voucher am ΔkWH	Mid Life Adjustment Replacing:				
		Front	Тор	Weighted Average	Front	Top	Weighted Average		
ENERGY STAR	LICWESVOU	595.0	613.4	609.3	19%	32%	29%		
CEE TIER 2	LICWT2VOU	632.9	651.2	632.9	22%	35%	22%		
CEE ADVANCED TIER	LICWT3VOU	652.7	671.1	652.7	24%	37%	24%		

## Market Opportunity: kW Savings:

The prescriptive kW s	saving	s base	ed on values provid	led ab	ove v	where DHW and Dry
Efficiency Level	Ef	ficient	Products AkW		R	NC ΔkW
Enciency Level	Front	Тор	Weighted Average	Front	Тор	Weighted Average
ENERGY STAR	0.369	0.295	0.316	0.371	0.303	0.322
CEE TIER 2	0.431	n/a	0.431	0.434	n/a	0.434
CEE ADVANCED TIER	0.493	n/a	0.493	0.498	n/a	0.498

The unit specific kW savings when DHW and Dryer fuels are known is provided below:

Efficiency Level	Drver/DHW Fuel Combo		R	NC AkW	Multifan	nily New	Construction In Unit ∆kW
Enciency bever	bryer/briw rider combo	Front	Тор	Weighted Average	Front	Тор	Weighted Average
	Electric Dryer/Electric DHW	0.762	0.254	0.395	0.762	0.254	0.395
ENERGY STAR	Electric Dryer/Fuel DHW	0.346	0.417	0.397	0.346	0.417	0.397
ENERGI STAR	Fuel Dryer/Electric DHW	0.453	0.057	0.084	0.453	-0.057	0.084
	Fuel Dryer/Fuel DHW	0.036	0.106	0.086	0.036	0.106	0.086
	Electric Dryer/Electric DHW	0.844	n/a	0.844	0.844	n/a	0.844
CEE TIER 2	Electric Dryer/Fuel DHW	0.425	n/a	0.425	0.425	n/a	0.425
CLL HLK 2	Fuel Dryer/Electric DHW	0.463	n/a	0.463	0.463	n/a	0.463
	Fuel Dryer/Fuel DHW	0.044	n/a	0.044	0.044	n/a	0.044
	Electric Dryer/Electric DHW	0.926	n/a	0.926	0.926	n/a	0.926
CEE ADVANCED TIER	Electric Dryer/Fuel DHW	0.505	n/a	0.505	0.505	n/a	0.505
CEE ADVANCED TIER	Fuel Dryer/Electric DHW	0.473	n/a	0.473	0.473	n/a	0.473
	Fuel Dryer/Fuel DHW	0.052	n/a	0.052	0.052	n/a	0.052

### Early Replacement:

The first year savings are provided below, with the mid life adjustment specified in the kWh table to be applied after 3 years to bring the savings in line with a new replacement as provided above:

		Single	Family	Early Replacement ∆kW	Multifan	nily In Ur	it Early Replacement ΔkW
Efficiency Level	Dryer/DHW Fuel Combo		1	Replacing:		1	Replacing:
		Front	Тор	Weighted Average	Front	Тор	Weighted Average
	Electric Dryer/Electric DHW	2.674	3.717	2.711	2.674	3.717	2.711
ENERGY STAR	Electric Dryer/Fuel DHW	2.254	1.926	2.243	2.254	1.926	2.243
ENERGI STAR	Fuel Dryer/Electric DHW	0.700	1.881	0.742	0.700	1.881	0.742
	Fuel Dryer/Fuel DHW	0.281	0.090	0.274	0.281	0.090	0.274
	Electric Dryer/Electric DHW	3.124	4.166	3.160	3.124	4.166	3.160
CFE TIER 2	Electric Dryer/Fuel DHW	2.283	1.954	2.271	2.283	1.954	2.271
CEE LIEK 2	Fuel Dryer/Electric DHW	1.079	2.260	1.121	1.079	2.260	1.121
	Fuel Dryer/Fuel DHW	0.238	0.048	0.232	0.238	0.048	0.232
	Electric Dryer/Electric DHW	3.206	4.248	3.243	3.206	4.248	3.243
CEE ADVANCED TIER	Electric Dryer/Fuel DHW	2.363	2.034	2.351	2.363	2.034	2.351
LEE ADVANCED TIER	Fuel Dryer/Electric DHW	1.090	2.270	1.131	1.090	2.270	1.131
	Fuel Dryer/Fuel DHW	0.246	0.056	0.240	0.246	0.056	0.240

Efficiency Level	Item Code	Low Income Single Family Voucher Program ∆kW							
cificiency Level	ttern code	Front	Тор	Weighted Average					
ENERGY STAR	LICWESVOU	1.848	1.905	1.893					
CEE TIER 2	LICWT2VOU	1.966	2.023	1.966					
CEE ADVANCED TIER	LICWT3VOU	2.028	2.085	1.758					
MMRTH Savinger									

Market Opportunity: The prescriptive MMBtu savings where DHW and Dryer fuels are unknown is provided below

Efficiency Level	Configuration	Efficient	Products	ΔMMBtu	RI	VC AMM	Btu
Enclency bever	connguiation	NG	LP	Oil	NG	LP	Oil
	Front	0.19	0.21	0.12	0.11	0.35	0.06
ENERGY STAR	Тор	-0.02	-0.01	-0.05	0.00	-0.06	-0.02
	Weighted Average	0.04	0.05	0.00	0.03	0.05	0.00
	Front	0.20	0.22	0.12	0.11	0.37	0.06
CEE TIER 2	Тор	n/a	n/a	n/a	n/a	n/a	n/a
	Weighted Average	0.20	0.22	0.12	0.11	0.37	0.06
	Front	0.21	0.23	0.12	0.12	0.38	0.06
CEE ADVANCED TIER	Тор	n/a	n/a	n/a	n/a	n/a	n/a
	Weighted Average	0.21	0.23	0.12	0.12	0.38	0.06

The unit specific MMBtu savings when DHW and Dryer fuels are known is provided below:

Efficiency Level	Configuration	Fuel Claimed			RNC AMMBb	u	Multifamily	New Constr AMMBtu	uction In Unit
Enciency Level	Configuration	Fuel Claimeu	Front	Тор	Weighted Average	Item Code	Front	Тор	Weighted Average
	Electric Dryer/Electric DHW	n/a	0.00	0.00	0.00	RNCCKLESAEEWRP	0.00	0.00	0.00
	Electric Dryer/Propane DHW	Propane	0.58	-0.23	0.00	RNCCKLESAELWRP	0.47	-0.19	0.00
	Electric Dryer/Natural Gas DHW	Natural Gas	0.58	-0.23	0.00	RNCCKLESAENWRP	0.47	-0.19	0.00
	Electric Dryer/Oil DHW	Oil	0.58	-0.23	0.00	RNCCKLESAEOWRP	0.47	-0.19	0.00
	Propane Dryer/Electric DHW	Propane	0.34	0.34	0.34	RNCCKLESALEWRP	0.28	0.28	0.28
ENERGY STAR	Propane Dryer/Propane DHW	Propane	0.92	0.12	0.34	RNCCKLESALLWRP	0.75	0.10	0.28
	Propane Dryer/Oil DHW	Oil	0.92	0.12	0.34	RNCCKLESALOWRP	0.75	0.10	0.28
	Natural Gas Dryer/Electric DHW	Natural Gas	0.34	0.34	0.34	RNCCKLESANEWRP	0.28	0.28	0.28
	Natural Gas Dryer/Natural Gas DHW	Natural Gas	0.92	0.12	0.34	RNCCKLESANNWRP	0.75	0.10	0.28

	Natural Gas Dryer/Oil DHW	Oil	0.92	0.12	0.34	RNCCKLESANOWRP	0.75	0.10	0.28
	Electric Dryer/Electric DHW	n/a	0.00	n/a	0.00	RNCCKLT2AEEWRP	0.00	n/a	0.00
	Electric Dryer/Propane DHW	Propane	0.58	n/a	0.58	RNCCKLT2AELWRP	0.48	n/a	0.48
	Electric Dryer/Natural Gas DHW	Natural Gas	0.58	n/a	0.58	RNCCKLT2AENWRP	0.48	n/a	0.48
	Electric Dryer/Oil DHW	Oil	0.58	n/a	0.58	RNCCKLT2AEOWRP	0.48	n/a	0.48
	Propane Dryer/Electric DHW	Propane	0.42	n/a	0.42	RNCCKLT2ALEWRP	0.34	n/a	0.34
CEE TIER 2	Propane Dryer/Propane DHW	Propane	1.00	n/a	1.00	RNCCKLT2ALLWRP	0.82	n/a	0.82
	Propane Dryer/Oil DHW	Oil	1.00	n/a	1.00	RNCCKLT2ALOWRP	0.82	n/a	0.82
	Natural Gas Dryer/Electric DHW	Natural Gas	0.42	n/a	0.42	RNCCKLT2ANEWRP	0.34	n/a	0.34
	Natural Gas Dryer/Natural Gas DHW	Natural Gas	1.00	n/a	1.00	RNCCKLT2ANNWRP	0.82	n/a	0.82
	Natural Gas Dryer/Oil DHW	Oil	1.00	n/a	1.00	RNCCKLT2ANOWRP	0.82	n/a	0.82
	Electric Dryer/Electric DHW	n/a	0.00	n/a	0.00	RNCCKLT3AEEWRP	0.00	n/a	0.00
	Electric Dryer/Propane DHW	Propane	0.58	n/a	0.58	RNCCKLT3AELWRP	0.48	n/a	0.48
	Electric Dryer/Natural Gas DHW	Natural Gas	0.58	n/a	0.58	RNCCKLT3AENWRP	0.48	n/a	0.48
	Electric Dryer/Oil DHW	Oil	0.58	n/a	0.58	RNCCKLT3AEOWRP	0.48	n/a	0.48
	Propane Dryer/Electric DHW	Propane	0.50	n/a	0.50	RNCCKLT3ALEWRP	0.41	n/a	0.41
CEE ADVANCED TIER	Propane Dryer/Propane DHW	Propane	1.08	n/a	1.08	RNCCKLT3ALLWRP	0.89	n/a	0.89
	Propane Dryer/Oil DHW	Oil	1.08	n/a	1.08	RNCCKLT3ALOWRP	0.89	n/a	0.89
	Natural Gas Dryer/Electric DHW	Natural Gas	0.50	n/a	0.50	RNCCKLT3ANEWRP	0.41	n/a	0.41
	Natural Gas Dryer/Natural Gas DHW	Natural Gas	1.08	n/a	1.08	RNCCKLT3ANNWRP	0.89	n/a	0.89
	Natural Gas Dryer/Oil DHW	Oil	1.08	n/a	1.08	RNCCKLT3ANOWRP	0.89	n/a	0.89

Early Replacement:

		Fuel	Singl	e Family Early R	epla	cement ∆MMBtu	Mu	Itifamily In Unit AMN			Mid Adius	
Efficiency Level	Configuration	Claimed		Repla	cing:			Repla			Repla	
		Claimed	Front	Item Code	Тор	Item Code	Front		Top	Item Code	Front	
	Electric Dryer/Electric DHW	n/a	0.00			EHCWESTEREE				MFCWESTEREE	n/a	n/
	Electric Dryer/Propane DHW	Propane	0.58	EHCWESEEREL	_	EHCWESTEREL	0.48	MECWESFEREL		MFCWESTEREL	-1%	0
	Electric Dryer/Natural Gas	Natural	0.50	Enerrebi Ener	-	chevres renee	0.10	in circor circo	2.01	in circorence	170	ľ
	DHW	Gas	0.58	EHCWESFEREN	2.48	EHCWESTEREN	0.48	MFCWESFEREN	2.04	MFCWESTEREN	-1%	04
	Electric Dryer/Oil DHW	Oil	0.58	EHCWESFEREO	2 49	EHOWESTEREO	0.48	MECWESEEREC	2 04	MFCWESTEREO	-1%	04
	Propane Dryer/Electric DHW	Propane	2.17	CHEWEDI ERED	2.02		1.78	in entest entes	1.66	I CHEDTERED	16%	17
ENERGY STAR	Propane Dryer/Propane DHW	Propane	2.75		4.50		2.26		3.69		12%	8
	Propane Dryer/Oil DHW	Oil	2.75		4.50		2.26		3.69		12%	8
	Natural Gas Dryer/Electric	Natural										
	DHW	Gas	2.17		2.02		1.78		1.66		16%	17
	Natural Gas Drver/Natural	Natural										
	Gas DHW	Gas	2.75		4.50		2.26		3.69		12%	8
	Natural Gas Drver/Oil DHW	Oil	2.75		4.50		2.26		3.69		12%	8
	Electric Drver/Electric DHW	n/a	0.00	EHCWT2FEREE	0.00	EHCWT2TEREE	0.00	MFCWT2FEREE	0.00	MFCWT2TEREE	n/a	n
	Electric Dryer/Propane DHW	Propane	1.16	EHCWT2FEREL	3.06	EHCWT2TEREL	0.96	MFCWT2FEREL	2.52	MFCWT2TEREL	50%	19
	Electric Dryer/Natural Gas	Natural	1.16	EHCWT2FEREN	3.06	EHCWT2TEREN	0.96	MFCWT2FEREN	2.52	MFCWT2TEREN	50%	19
	Electric Drver/Oil DHW	Oil	1.16	EHCWT2FEREO	3.06	EHCWT2TEREO	0.96	MFCWT2FEREO	2.52	MFCWT2TEREO	50%	19
	Propane Dryer/Electric DHW	Propane	2.25		0.09		1.85		1.72		19%	20
CEE TIER 2	Propane Dryer/Propane DHW	Propane	3.41		5.16		2.80		4.24		29%	19
	Propane Drver/Oil DHW	Oil	3.41		5.16		2.80		4.74		29%	19
	Natural Gas Dryer/Electric	Natural			-							
	DHW	Gas	2.25		2.09		1.85		1.72		19%	20
	Natural Gas Dryer/Natural	Natural			L							
	Gas DHW	Gas	3.41		5.16		2.80		4.24		29%	19
	Natural Gas Dryer/Oil DHW	Oil	3.41		5.16		2.80		4.24		29%	19
	Electric Dryer/Electric DHW	n/a	0.00	EHCWT3FEREE;	0.00	EHCWT3TEREE	0.00	MFCWT3FEREE	0.00	MFCWT3TEREE	n/a	nj
	Electric Dryer/Propane DHW	Propane	1.17	EHCWT3FEREL	3.07	EHCWT3TEREL	0.96	MFCWT3FEREL	2.52	MFCWT3TEREL	50%	19
	Electric Dryer/Natural Gas DHW	Natural Gas	1.17	EHCWT3FEREN	3.07	EHCWT3TEREN	0.96	MFCWT3FEREN	2.52	MFCWT3TEREN	50%	19
	Electric Dryer/Oil DHW	Oil	1.17	EHCWT3FEREO	3.07	EHCWT3TEREO	0.96	MFCWT3FEREO	2.52	MFCWT3TEREO	50%	19
CEE ADVANCED	Propane Dryer/Electric DHW	Propane	2.33		2.17		1.91		1.79		21%	23
TIFR	Propane Dryer/Propane DHW	Propane	3.49		5.24		2.87		4.30		31%	21
LIEK	Propane Dryer/Oil DHW	Oil	3.49		5.24		2.87		4.30		31%	21
	Natural Gas Dryer/Electric	Natural	2.33		2.17		1.91		1.79		21%	23
	Natural Gas Drver/Natural	Natural			-		-		-			$\vdash$
	Gas DHW	Gas	3.49		5.24		2.87		4.30			21
	Natural Gas Dryer/Oil DHW	Oil	3.49		5.24		2.87		4.30		31%	21

Efficiency Level	Dryer/DHW Fuel Combo	Single Family Early Replacement ΔMMBtu Unknown Type and DHW Fuel DHW Fuel			Repla	amily In Un acement ΔM Type and I DHW Fuel	IMBtu DHW Fuel	Fuel Mid Life Adjustment	Item Code		
		NG	LP	Oil	NG	LP	Oil		Single Family	Multi Family	
ENERGY STAR	Electric Dryer/Electric DHW				N/A				EHCWESAEREE	MFCWESAEREE	
STAK	Electric Dryer/Fuel DHW	0.231	0.240	0.177	0.190	0.197	0.146	0%	EHCWESAEREU	MFCWESAEREU	
CEE TIER	Electric Dryer/Electric DHW				N/A				EHCWT2AEREE	MFCWT2AEREE	
2	Electric Dryer/Fuel DHW	0.438	0.455	0.337	0.360	0.374	0.277	47%	EHCWT2AEREU	MFCWT2AEREU	
CEE ADVANCED	Electric Dryer/Electric DHW				N/A	-			EHCWT3AEREE	MFCWT3AEREE	
TIER	Electric Dryer/Fuel DHW	0.440	0.456	0.338	0.361	0.375	0.278	47%	EHCWT3AEREU	MFCWT3AEREU	

				come Sin		Mid Life Adjustment		
Efficiency Level	Configuration	Item Code	Vouche	r Prograr	n ∆MMBtu	Replaci	ng:	
			NG	LP	Oil	NG	LP	Oil
	Front		0.39	0.48	0.12	9%	10%	-1%
ENERGY STAR	Тор		0.87	0.97	0.50	4%	5%	0%
	Weighted Average	LICWESVOU	0.76	0.86	0.41	5%	6%	0%
	Front		0.55	0.65	0.23	36%	34%	50%
CEE TIER 2	Тор		1.03	1.14	0.61	19%	19%	19%
	Weighted Average	LICWT2VOU	0.55	0.65	0.23	36%	34%	50%
	Front		0.56	0.66	0.23	37%	35%	50%
EE ADVANCED TIER	Тор		1.04	1.15	0.61	20%	20%	19%
	Weighted Average	LICWT3VOU	0.56	0.66	0.23	37%	35%	50%

## Water Savings:

Market Opportunity: The prescriptive water savings for each efficiency level are presented below:

			-,					
	Effi	Multif	Multifamily New Construction					
Efficiency Level	ΔW	/ater (CCF p	er year)	ΔWater (CCF per year)				
	Front Loading	Top Loading	Weighted Average	Front Loading	Top Loading	Weighted Average		
ENERGY STAR	2.8	0.8	1.3	2.4	0.8	1.2		
CEE TIER 2	2.8	n/a	2.8	2.4	n/a	2.4		
CEE ADVANCED TIER	3.2	n/a	3.2	2.7	n/a	2.7		

Early Replacement:

The weighted average savings are provided below, based on weighting the first year savings for 3 years and the reduced savings for the remaining 11 years. Note the screening tool currently does not allow mid life adjustments to be applied to water savings.

	Single	Family Early Replacen	Multifamily Early Replacement						
	Δ	Water (CCF per year)		ΔWater (CCF per year)					
Efficiency Level	Weigh	ted Average for Scree	ning	Weighted Average for Screening					
Eniciency Level		Replacing:		Replacing:					
	Front Loading	Tankar	Weighted	Front Loading	Top Loading	Weighted			
	Front Loading	Top Loading	Average	Front Loading	I op Loading	Average			
ENERGY STAR	5.7	4.1	4.5	4.8	3.5	3.8			
CEE TIER 2	6.0	6.0	6.0	5.1	5.0	5.1			
CEE ADVANCED TIER	6.4	6.4	6.4	5.4	5.3	5.4			

Footnotes

[1] Assume one hour per cycle.

- [2] The percentage of total energy consumption that is used for the machine, heating the hot water or by the dryer is different depending on the efficiency of the unit. Values are based on a weighted average of top loading and front loading units (based on available product from the CEC Appliance database), 6/18/2017 and consumption data from the latest Life-Cycle Cost and Payback Period Excel-based analytical tool. See "2019 Cothes Washer Analysis.xls" for the calculation.
- [3] Based on data received by Efficiency Vermont on 08/21/2017 from the upcoming NMR Vermont Residential Market Assessment.
- [4] Based on the average clothes washer volume of all standard sized units (greater than 2.5 cu ft) that pass the new Federal Standard on the California Energy Commission (CEC) database of Clothes Washer products accessed on 08/18/2017.
- [5] Note that the baseline and efficient model may be different in different locations.
- (6) Weighted average of 322 dothes washer cycles per year. 2009 Residential Energy Consumption Survey (RECS) national sample survey of housing appliances section: http://www.eia.gov/consumption/residential/data/2009/
- [7] EVT found the average household size in MF buildings from the 2010 Census data (1.6 people, compared to 2.3 for single family) and using the values for number of loads for different household sizes (from DOE Technical Support Document U.S. Department of Energy, Final Rule Technical Support Document (TSD): Exergy Efficiency Standards for Comsumer Products: Content Wasters, December, 2000, Page 7-6) and the 322 used for single families we estimate the number of loads for a MF building to be 265. See 2019 Clothes Waster Analysis.ds' for calculation.
- [8] To account for the different efficiency of electric and Natural Gas hot water heaters (gas water heater: recovery efficiencies ranging from 0.74 to 0.85 (0.78 used), and electric water heater with 0.98 recovery efficiency). Therefore a factor of 0.98(0.78 (1.26) is applied.
- [9] Based on DOE Life-Cycle Cost and Payback Period Excel-based analytical tool.
- [10] Based on inflating cost data from Life-Cycle Cost and Payback Period Excel-based analytical tool,. See '2019 Clothes Washer Analysis.xls' for details.
- [11] Note that the baseline savings for all cases (Front, Top and Weighted Average) is based on the weighted average baseline IMEF (as opposed to assuming Front baseline for Front efficient unit). The reasoning is that the support of the program of more efficient units (which are predominately front baseline) will result in some participants withing from planned purchase of a long bade.
- [12] Note for early replacement we are assuming the baseline unit configuration is always known but are using the weighted average IMEF for the efficient case for simplicity.

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Referenced Documents <ul> <li></li></ul>		mentation and HEff assumption.
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	enced Do	ocuments
	Lighting Con Lighting Cont	trols Summary of Findings rols in Commercial Buildings 2012
	Analysis of D	Daylighting Requirements_Aug 2013
	cation Assess	ment of Bi-Level LED Parking Lot Lighting
<ul> <li>EVEL tigbing Control Assamptions, 2019</li> <li>EVEL tigbing Control Assamptions, 2017 × ISR × WHFq</li> <li>Symbol Table</li> <li>EVELT tigbing Control Assamptions, 2019</li> <li>EVELT tigbing Control Assamptions, 2017 × ISR × WHFq</li> <li>Symbol Table</li> <li>EVELT tigbing Control Assamptions, 2017 × ISR × WHFq</li> <li>Symbol Table</li> <li>EVELT tigbing Control Assamptions, 2017 × ISR × WHFq</li> <li>EVELT tigbing Control Assamptions, 2018 × ICIRS × SVG × OTF × ISR × WHFq</li> <li>EVELT tigbing Control Assamptions, 2018 × ICIRS × SVG × OTF × ISR × WHFq</li> <li>EVELT tigbing Control Assamptions, 2018 × ICIRS × EVEL × ISR × WHFq</li> <li>EVELT tigbing Control Assamptions, 2018 × ICIRS × EVEL × ISR × WHFq</li> <li>EVELT tigbing Control Assamptions, 2018 × ICIRS × EVEL × ISR × WHFq</li> <li>EVELT tigbing Control Assamptions, 2018 × ICIRS × EVEL × ISR × WHFq</li> <li>EVELT tigbing Control Assamptions, 2018 × ICIRS × E</li></ul>	CaseStudy-Wa	almart_OccupancySensors
Description         Controls for interfor 8 detrice lighting, including occupancy sensors and daylight sensors.           Program Type Time of Sale / Resolt         This Tabl applies only to Prescriptive Projects, or those projects less than 10,000 Square Feet and less than 250 rebate-digible lems, by agreeme DrS., Analysis of Occupancy Sensors and Daylight dimming on custom projects will be calculated on a custom basis using the actual sets conditions much groups between appropriate.           High Efficiency         Controls where appropriate.           Algorithms         Electric Demand Savings           Electric Demand Savings         Electric Demand Savings           Symbol Table         Electric Demand Savings           Bayling Such as occupancy sensors and daylight dimming.         Electric Demand Savings           Symbol Table         Electric Demand Savings           Bayling Such as cocupancy sensors and daylight dimming.         Electric Demand Savings           Bayling Such as occupancy sensors and daylight dimming.         Electric Demand Savings           Bayling Such as occupancy sensors and daylight dimming.         Electric Demand Savings           Bayling Such as occupancy sensors and Daylight Demand SVG X OTF × ISR × WiFe         Symbol Table           Bayling Such as occupancy sensors and Daylight Demand SVG X OTF × ISR × WiFe         Symbol Table           Where:         Electric Demand Such As SVG × OTF × ISR × WiFe         Electric Demand Such As SVG × OTF × ISR × WiFe <t< td=""><td>ighting Contr</td><td>ol Assumptions_2019</td></t<>	ighting Contr	ol Assumptions_2019
Controls for interior 8 exterior lighting, including occupancy sensors and daylight sensors.         Program Type Thr of Sale / Reform         Baseline Efficiencies         The TWA applies only to Prescriptive Projects, or those projects less than 10,000 Square Feet and less than 250 relate-eligible items, by agreeme SPS. Analysis of Occupancy Sensors and Daylight Dimming on custom projects will be calculated on a custom basis using the actual site conditions including existing controls where appropriate.         High Efficiency Controlled lighting such as occupancy Sensors and daylight dimming.         AWM <ul> <li>eWe_constate × SVG × OTF × SSR × WHFg</li> <li>Synchol Table</li> </ul> Bestrice Cherny Savings <ul> <li>eWe_constate × SVG × OTF × SSR × WHFg</li> <li>Synchol Table</li> </ul> MWm <ul> <li>eWe_constate × SVG × OTF × SSR × WHFg</li> <li>Synchol Table</li> </ul> MWm <ul> <li>eWe_constate × SVG × OTF × SSR × WHFg</li> <li>Synchol Table</li> </ul> Mwret <ul> <li>eWe_constate × SVG × OTF × SSR × WHFg</li> <li>eWe_constate × SVG × OTF × SSR × WHFg</li> <li>genes customer connected baldings.</li> <li>dMMfTU<sub>0</sub>m</li> <li>e (dMM / WHFg) × 0.003413 × (1 - OA) × AR × HF × DFH / HET</li> </ul> Meet <ul> <li>genes customer annual WM savings for the measure. This number represents the maximum summer W</li></ul>	ighting WHF	Research Prescriptive_2020
Program Type Time of Sale // Retrofit Downstream         Baseline Efficiencies         This TM spalles only to Prescriptive Projects, or those projects less than 10.000 Square Freet and less than 250 robate-eligible items, by agreeme Profit and Sale of Occupancy Sensors and Darlight Dimming on custom projects will be calculated on a custom basis using the actual site conditions including existing controls where appropriate.         High Efficiency Controlled lighting such as occupancy sensors and darlight dimming.         Add/// image: Sale of Doccupancy Sensors and Darlight Dimming on custom projects will be calculated on a custom basis using the actual site conditions including existing controls where appropriate.         Add/// image: Sale occupancy sensors and darlight dimming.         Add/// image: Sale occupancy sensors and Darlight Dimming on custom Projects will be calculated on a custom basis using the actual site conditions including existing controls where appropriate.         Add// image: Sale occupancy Sensors and Darlight Dimming on Custom Projects PS SNG × OTF × ISR × WHFg Symbol Table <ul> <li>MMRTU<sub>MIN</sub></li> <li>= (MAMh / WHFg) × 0.003413 × (1 - OA) × AR × HF × DFH / HEFI</li> </ul> More: <ul> <li>(AddWh / WHFg) × 0.003413 × (1 - OA) × AR × HF × DFH / HEFI</li> <li>AddWh</li> <li>= gross customer annual WM savings for the measure. This number represents the maximum summer VM savings - including the reduced cooling toad from the more efficient lighting.</li> </ul> AdWh       = gross customer annual WMB savings for the measure (includes the reduced cooli		exterior liablina, including occupancy sensors and daylight sensors.
Time of Sale / Retroit         Downstream         Baseline Efficiencies         This TRM applies only to Prescriptive Projects, or those projects less than 10,000 Square Feet and less than 250 rebate-eligible items, by agreeme DFS. Analysis of Occupancy Sensors and Daylight Dinning on custom projects will be calculated on a custom basis using the actual site conditions including easing controls where appropriate.         High Efficiency         Controlled lighting such as occupancy sensors and daylight dimming.         Algorithms         Electric Demand Savings         dWW       = KWconnected × SVG × OTF × ISR × WHFg         Symbol Table         Electric Energy Savings         dWM       = KWconnected × HOURS × SVG × OTF × ISR × WHFg         Symbol Table         Bettric Energy Savings         dWM       = (dWM / WHF_g) × 0.003413 × (1 – OA) × AR × HF × DFH / HEff         Where:		
Downstream           Baseline Efficiencies           This TRN applies only to Prescriptive Projects, or those projects less than 10,000 Square Feet and less than 250 rebate-eligible items, by agreeme PRS. Analysis of Occurany Sensors and Daylight Dimming on castom projects will be calculated on a custom basis using the actual site conditions including existing controls where appropriate.           High Efficiency         Controlled lighting such as occupancy sensors and daylight dimming.           Algorithms         Electric Demand Savings           MW         = WW_connected × SVG × OTF × ISR × WHFg           Symbol Table         = WW_connected × SVG × OTF × ISR × WHFg           Symbol Table         = WW_connected × BVG × OTF × ISR × WHFg           Symbol Table         = WW/connected × DVG × OTF × ISR × WHFg           Where:         = (dWMh / WHFg) × 0.0024113 × (1 – OA) × AR × HF × DFH / HEff           Where:         = gross customer connected load WJ savings for the measure. This number represents the maximum summer WL savings – including the reduced cooling load from the more efficient lighting.           MWh         = gross customer annual WMh savings for the measure (includes the reduced cooling load from the more efficient in phrase)           AlWh         = gross customer annual WMh savings for the measure (includes the reduced cooling load from the more efficient in phras)           AWH         = gross customer annual WMh savings for the measure (includes the reduced cooling load from the more efficient in phras)           AWH		
This TRN applies only to Prescriptive Projects, or those projects less than 10,000 Square Feet and less than 250 rebate-eligible items, by agreeme PFS. Analysis of Occurancy Sensors and Dolyight Dimming on custom projects will be calculated on a custom basis using the actual site conditions including existing controls where appropriate.		
This TRM applies only to Prescriptive Projects, or those projects less than 10,000 Square Feet and less than 250 rebute-eligible items, by agreeme PES. Analysis of Coursency Sensors and Davidt Dimming on custom projects will be calculated on a custom basis using the actual site conditions including existing controls where appropriate.		
High Efficiency         Controlled lighting such as occupancy sensors and daylight dimming.         Algorithms         Electric Demand Savings         AW <ul> <li>Womenedad</li> <li>SVRG X OTF X ISR X WHFa</li> <li>Symbol Table</li> </ul> Electric Demand Savings <ul> <li>MW</li> <li>Womenedad</li> <li>SVRG X OTF X ISR X WHFa</li> <li>Symbol Table</li> </ul> Electric Energy Savings <ul> <li>MWhTum</li> <li>Womenedad</li> <li>MURETUMM</li> <li> <li>(AWN / WHFa) X OLOGALI3 X (1 – OA) X AR X HF X DFH / HEff</li> </li></ul> Where: <ul> <li>Gaving = including the reduced cooling load from the more efficient lighting.</li> <li>AWN</li> <li> <li>             gross customer connected load WV savings for the measure. This number represents the maximum summer fWL savings - including the reduced cooling load from the more efficient lighting.</li> <li> <ul> <li> <li>                  AWN</li> <li>                  gross customer connected load WV savings for the measure (includes the reduced cooling load from the more efficient lighting.</li> <li>                  AWN</li> <li>                  gross customer annual KWh savings for the measure (includes the reduced cooling load from the more efficient lighting.</li> <li>                 APAIETUMH</li> <li>                  Gross customer annual KWh savings for the measure (includes the reduce</li></li></ul></li></li></ul>	applies only t	to Prescriptive Projects, or those projects less than 10,000 Square Feet and less than 250 rebate-eligible items, by agreement with
Algorithms           Electric Demand Swips           Zymbol Table           Zentric Energy Savings           ZwW         = MW_connected × SVG × OTF × ESR × WHFg           Symbol Table         = MW_connected × BVG × OTF × ESR × WHFg           Symbol Table         = MW_connected × HOURS × SVG × OTF × ESR × WHFg           Symbol Table         = (dxWh / WHFg) × 0.003413 × (1 – OA) × AR × HF × DFH / HEff           MMETUWRt         = (dxWh / WHFg) × 0.003413 × (1 – OA) × AR × HF × DFH / HEff           MWRETUWRt         = gross customer connected load KW savings for the measure. This number represents the maximum summer KW savings - including the reduced cooling load from the more efficient lighting.           MWR         = gross customer annual KWh savings for the measure. This number represents the maximum summer KW savings - including the reduced cooling load from the more efficient lighting.           MWR         = gross customer annual kWh savings for the measure (includes the reduced cooling load from the more efficient lighting.)           MWRT         = Gross customer annual kWh savings for the measure (includes the reduced cooling load from the more efficient lighting.)           MWRT         = gross customer annual kWh savings for the measure (includes the reduced cooling load from the more efficient lighting.)           MWRT         = Gross customer annual kWh savings for the measure (includes the reduced cooling load from the more efficient lighting.)           DPH         = Percent of lighting		
Algorithms           Electric Demand Savings           ZwW         = KW <sub>connected</sub> × SVG × OTF × ISR × WHF <sub>d</sub> Symbol Table         = KW <sub>connected</sub> × SVG × OTF × ISR × WHF <sub>d</sub> ZwM         = KW <sub>connected</sub> × SVG × OTF × ISR × WHF <sub>d</sub> Symbol Table         = KW <sub>connected</sub> × HOLRS × SVG × OTF × ISR × WHF <sub>d</sub> ZwM         = KW <sub>connected</sub> × HOLRS × SVG × OTF × ISR × WHF <sub>d</sub> Symbol Table         = (AWh / WHF <sub>d</sub> ) × 0.003413 × (1 – OA) × AR × HF × DFH / HEff           Where:         = (AWh / WHF <sub>d</sub> ) × 0.003413 × (1 – OA) × AR × HF × DFH / HEff           MW         = gross customer connected load KW savings for the measure. This number represents the maximum summer KW savings - including the reduced cooling load from the more efficient lighting.           AWW         = gross customer annual KWh savings for the measure (includes the reduced cooling load from the more efficient lighting.)           AWH         = gross customer annual kWh savings for the measure (includes the reduced cooling load from the more efficient lighting.)           AMWh         = gross customer annual kWh savings for the measure (includes the reduced cooling load from the more efficient lighting.)           DMHBTUwr         = Gross customer annual kWh savings for the measure (includes the reduced cooling load from the more efficient is building within 15 feet of exterior wall. The ASHRAE heating factor applies to perimeter zone heat, therefore it r be adjutated to accound freqlyting unceased usage for the measure from the reducion in lighting in		
Electric Demand Savings  AWV  W  W  W  W  W  W  W  W  W  W  W  W		
AVV         = WWconnected         SVIG × OTF × ISR × WHFa           Symbol Table         = WWconnected         × POLRS × SVG × OTF × ISR × WHFa           ZWM         = WWconnected         = WWconnected         × POLRS × SVG × OTF × ISR × WHFa           ZWM         = WWconnected         = WWconnected         × POLRS × SVG × OTF × ISR × WHFa           ZWM         = WWconnected         = WWconnected         × POLRS × SVG × OTF × ISR × WHFa           ZWM         = WWconnected         = WWconnected         × POLRS × SVG × OTF × ISR × WHFa           WMWTUWH         = (dWWh / WHFa) × OL003413 × (1 – OA) × AR × HF × DFH / HEff            WMWTUWH         = gross customer connected load WV savings for the measure. This number represents the maximum summer fWa savings – including the reduced cooling load from the more efficient lighting.           MWH         = gross customer annual KWh savings for the measure (includes the reduced cooling load from the more efficient lighting).           AWH         = gross customer annual KWh savings for the measure (includes the reduced cooling load from the more efficient lighting).           AWH         = gross customer annual KWh savings for the measure (includes the reduced cooling load from the more efficient lighting).           AR         = Typical aspect ratio factor; the default value is 60%4 and is based on the typical sagare footage of commercial buildings.           DFH         = Percent of lighting in heated spaces. For pres		
Symbol Table           Electric Energy Savings           ZWM         = KWconnected           Symbol Table         = Symbol Table           Heating is assumed typical for commercial buildings.		vings
Bit Christian          = WWconnected × HOURS × SVG × OTF × ISR × WHFe         Symbol Table          Symbol Table           Both Patting is assumed typical for commercial buildings.            DMMBTU <sub>WH</sub> gross customer connected load KW savings for the measure. This number represents the maximum summer KW         savings - including the reduced cooling load from the more efficient lighting.             DMM = gross customer annual KWh savings for the measure. This number represents the maximum summer KW         savings - including the reduced cooling load from the more efficient lighting.             DMM = gross customer annual KWh savings for the measure (includes the reduced cooling load from the more efficient         lighting)             DMMBTU <sub>WH</sub> = Gross customer annual KWh savings for the measure (includes the reduced cooling load from the more efficient         lighting)             DMMBTU <sub>WH</sub> = Gross customer annual KWh savings for the measure (includes the reduced cooling load from the more efficient         lighting)             DMMBTU <sub>WH</sub> = Gross customer annual kWh savings for the measure (includes the reduced cooling load from the more efficient         lighting)             DMMBTU <sub>WH</sub> = Gross customer annual kWh savings for the measure (includes the reduced cooling load from the more efficient         lighting)             DMMBTU <sub>WH</sub> = Gross customer efficient         lighting in the control to the controwall. The SARIARE heating factor opicis (in pastrestab		= kW <sub>connected</sub> $\times$ SVG $\times$ OTF $\times$ ISR $\times$ WHF <sub>d</sub>
AWh         = KWconnected × HOURS × SVG × OTF × ISR × WHF <sub>e</sub> Symbol Table         Symbol Table           Heating is assumed spical for commercial buildings.         AMMBTU <sub>WH</sub> (AWM WHETU <sub>WH</sub> )         = (AKW / WHF <sub>a</sub> ) × 0.003413 × (1 – OA) × AR × HF × DFH / HET           Where:	Table	
Adv         =         Gross customer connected load KW savings for the measure. This number represents the maximum summer KW savings – including the reduced cooling load from the more efficient lighting.           AdW         =         (AWM)         WHFg) × 0.002413 × (1 – 0A) × AR × HF × DFH / HEIT           Where:           AdW         =         (AWM)         WHFg) × 0.002413 × (1 – 0A) × AR × HF × DFH / HEIT           AdW         =         gross customer connected load KW savings for the measure. This number represents the maximum summer KW savings – including the reduced cooling load from the more efficient lighting.           AWH         =         gross customer annual KWh savings for the measure (includes the reduced cooling load from the more efficient lighting)           AMHBTU <sub>WH</sub> =         Gross customer annual KWh savings for the measure (includes the reduced cooling load from the more efficient lighting)           AdWh         =         gross customer annual KWh savings for the measure (includes the reduced cooling load from the more efficient lighting)           AMHBTU <sub>WH</sub> =         Gross customer annual KWh savings for the measure (includes the reduced cooling load from the more efficient lighting)           AR         =         Typical aspect ratio factor; the default value is Gross if and is based on the typical sagare footage of commercial building within 15 feet of electric wall. The ASHRAE heating factor applies to perimeter zone heat, therefore it r be adjusted to account for lighting in near coneas.	Energy Sav	ings
Adverting Increased Usage         Earling is assumed spical for commercial buildings.           IMMAGTU <sub>WH</sub> = (akWh / WHF <sub>0</sub> ) × 0.003413 × (1 – OA) × AR × HF × DFH / HEIT           Where:		= kW <sub>connected</sub> × HOURS × SVG × OTF × ISR × WHF <sub>e</sub>
Dil heating is assumed hpical for commercial buildings.         ΔMMBTU <sub>UN1</sub> = (ΔkWh / WHF <sub>0</sub> ) × 0.003413 × (1 – OA) × AR × HF × DFH / HEff         Where:		
Where:		
AkW         =         gross customer connected load kW savings for the measure. This number represents the maximum summer KM savings – including the reduced cooling load from the more efficient lighting.           AkWh         =         gross customer annual kWh savings for the measure (includes the reduced cooling load from the more efficient lighting.           AkWh         =         gross customer annual kWh savings for the measure (includes the reduced cooling load from the more efficient lighting)           AMMETUwn         =         Gross customer annual kating MMBTU fuel increased usage for the measure from the reduction in lighting heat builting within 15 feet of vector with T. KA SHARAE heating factor applies to perimeter zone heat, therefore it r be adjusted to account for lighting in core zones.           DFH         =         Percent of lighting in heated spaces. For prescriptive lighting, assumed to be 95%           HEFf         =         Average heating system efficiency. For prescriptive lighting, assumed to be 95%           HEF         =         ASHRAE heating factor of 0.39 for lighting waste heat for Burlington, Vermont <sup>(1)</sup> HDIRS         =         The lighting operating hours are collected from the prescriptive application form. If not available, then assume h per year from the table tilded Lighting Operating Hours by Building Type.           JSR         In service rate, or the percentage of units rebated that accually get used. For prescriptive measures, this is assis to be 96%. <sup>(1)</sup> Witcomentad         =         KW lighting load connected to control.	U <sub>WH</sub>	= ( $\Delta$ KWh / WHF <sub>e</sub> ) × 0.003413 × (1 – OA) × AR × HF × DFH / HEIF
AkW         =         gross customer connected load kW savings for the measure. This number represents the maximum summer KM savings – including the reduced cooling load from the more efficient lighting.           AkW         =         gross customer annual kWh savings for the measure (includes the reduced cooling load from the more efficient lighting.           AkWh         =         gross customer annual kWh savings for the measure (includes the reduced cooling load from the more efficient lighting)           AMMBTU <sub>WH</sub> =         Gross customer annual keating MMBTU fuel increased usage for the measure from the reduction in lighting heat builting with in 516 fetch vertice val. The KAHAE heating factor applies to perimeter zone heat, therefore it r be adjusted to account for lighting in neated spaces. For prescriptive lighting, assumed to be 95%           DFH         =         Percent of lighting in heated spaces. For prescriptive lighting, assumed to be 95%           HEFf         =         ASHRAE heating factor of 0.39 for lighting waste heat for Burlington, Vermont <sup>(4)</sup> HOLRS         =         The lighting operating hours are collected from the prescriptive application form. If not available, then assume h per year from the table tided Lighting Operating hours by Building Type.           SR         In service rate, or the percentage of units rebated that accually get used. For prescriptive measures, this is assis to be 96%. <sup>(1)</sup> Witcomented         =         KW lighting load connected to control. For multi-level and perimeter switching in the Comprehensive Track the		
AWh         =         gross customer annual KWh savings for the measure (includes the reduced cooling load from the more efficient lighting)           AMHBTU <sub>RH</sub> =         Gross customer annual heating MMBTU fuel increased usage for the measure from the reduction in lighting heat AR           AR         =         Typical aspect ratio factor; the default value is GRM4 <sup>4</sup> and is based on the typical square footage of commercial building within 15 feet of exterior wall. The ASHRAE heating factor applies to perimeter zone heat, therefore it r be adjusted to account for lighting in heated spaces. For prescriptive lighting, assumed to be 95%           DFH         =         Percent of lighting in heated spaces. For prescriptive lighting, assumed to be 95%           HEff         =         Astreage heating system efficiency. For prescriptive lighting, assumed to be 96.8% in existing buildings. <sup>[5]</sup> HEF         =         ASHRAE heating factor of 0.39 for lighting waste heat for Burlington, Vermont <sup>[6]</sup> HOURS         =         The lighting operating hours are collected from the prescriptive application form. If not available, then assume h per year from the table titled Lighting Operating Hours by Building Type.           JSR         In service rate, or the percentage of units rebated that accually get used. For prescriptive measures, this is assis to be 95%. <sup>[1]</sup> Wd <sub>commented</sub> =         KW lighting load connected to control. For multi-level and perimeter switching in the Comprehensive Track the	dW.	= gross customer connected load kW savings for the measure. This number represents the maximum summer kW
Injeting)         Interview           AMMBITUM:H         =         Gross customer annual heating MMBITU fuel increased usage for the measure from the reduction in lighting heat           AR         =         Typical aspect ratio factor; the disfull value is GrO% <sup>41</sup> and is based on the typical square footage of commercial building within 15 feet of deterior wall. The ASHRAE heating factor applies to perimeter zone heat, therefore it r be adjusted to account for lighting in near zones.           DFH         =         Percent of lighting in heated spaces. For prescriptive lighting, assumed to be 95%           HEff         =         AsHRAE heating factor of 0.39 for lighting mosts theat for Burlington, Vermont <sup>61</sup> HOURS         =         The lighting operating hours are collected from the prescriptive application form. If not available, then assume h per year from the table titled Lighting Operating hours by Building Type.           ISR         In service rate, or the percentage of units rebated that accually get used. For prescriptive measures, this is assi           WConnected         =         KW lighting load connected to control. For multi-level and perimeter switching in the Comprehensive Track the		
AR       = Typical aspect ratio factor; the default value is 60% <sup>4</sup> and is based on the typical square footage of commercial building within 15 feet of exterior wall. The ASHRAE heating factor applies to perimeter zone heat, therefore it r be adjusted to account for lighting in new zones.         DFH       = Percent of lighting in heated spaces. For prescriptive lighting, assumed to be 95%         HEIf       = Average heating system efficiency. For prescriptive lighting assumed to be 86.8% in existing buildings. <sup>[3]</sup> HF       = ASHRAE heating factor of 0.39 for lighting waste heat for Burlington, Vermont <sup>6</sup> HOURS       = The lighting operating hours are collected from the prescriptive application form. If not available, then assume here year from the table titled Lighting Operating Hours by Building Type.         DSR       In service rate, or the percentage of units rebated that actually get used. For prescriptive measures, this is assit to be 98% <sup>1</sup> . <sup>(1)</sup> WConnected       = KW lighting load connected to control. For multi-level and perimeter switching in the Comprehensive Track the		lighting)
building within 15 feet of exterior wall. The ASHRAE heating factor applies to perimeter zone heat, therefore it r be adjusted to account for lighting in core zones.           DFH         =         Percent of lighting in heated spaces. For prescriptive lighting, assumed to be 95%           HEIf         =         Average heating system efficiency. For prescriptive lighting assumed to be 86.8% in existing buildings. <sup>[3]</sup> HF         =         ASHRAE heating factor of 0.39 for lighting waste heat for Burlington, Vermont <sup>(6)</sup> HOURS         =         The lighting operating hours are collected from the prescriptive application form. If not available, then assume h per year from the table titled Lighting Operating Hours by Building Type.           ISR         In service rate, or the percentage of units rebated that actually get used. For prescriptive measures, this is assi           Weconsected         =         KW lighting load connected to control. For multi-level and perimeter switching in the Comprehensive Track the		<ul> <li>Gross customer annual heating MMBTU fuel increased usage for the measure from the reduction in lighting heat.</li> </ul>
HEIf       = Average heating system efficiency. For prescriptive lighting assumed to be 86.8% in existing buildings. <sup>[5]</sup> HF       = ASHRAE heating factor of 0.39 for lighting waste heat for Burlington, Vermont <sup>[6]</sup> HOURS       = The lighting operating hours are collected from the prescriptive application form. If not available, then assume her year from the table titled Lighting Operating Hours by Building Type.         ISR       = In service rate, or the percentage of units rebated that actually get used. For prescriptive measures, this is assist to be 98%. <sup>[11]</sup> WConnected       = KW lighting load connected to control. For multi-level and perimeter switching in the Comprehensive Track the	٤	<ul> <li>Typical aspect ratio factor; the default value is 60%<sup>31</sup> and is based on the typical square footage of commercial building within 15 feet of exterior wall. The ASHRAE heating factor applies to perimeter zone heat, therefore it must be adjusted to account for lighting in core zones.</li> </ul>
HF       = ASHRAE heating factor of 0.39 for lighting waste heat for Burlington, Vermont <sup>43</sup> HOURS       = The lighting operating hours are collected from the prescriptive application form. If not available, then assume her year from the table titled Lighting Operating Hours by Building Type.         ISR       Is service rate, or the percentage of units rebated that actually get used. For prescriptive measures, this is assume to be \$9%, <sup>(1)</sup> WConnected       = KW lighting load connected to control. For multi-level and perimeter switching in the Comprehensive Track the	-н	<ul> <li>Percent of lighting in heated spaces. For prescriptive lighting, assumed to be 95%</li> </ul>
HOURS         = The lighting operating hours are collected from the prescriptive application form. If not available, then assume her year from the table titled Lighting Operating Hours by Building Type.           ISR         = In service rate, or the percentage of units rebated that actually get used. For prescriptive measures, this is assue to be 98%. <sup>[1]</sup> WConnected         = KW lighting load connected to control. For multi-level and perimeter switching in the Comprehensive Track the	Eff	<ul> <li>Average heating system efficiency. For prescriptive lighting assumed to be 86.8% in existing buildings.<sup>[5]</sup></li> </ul>
per year from the table titled Lighting Operating Hours by Building Type.           ISR         = In service rate, or the percentage of units rebated that actually get used. For prescriptive measures, this is assi to be 98%. <sup>[1]</sup> KW <sub>connected</sub> = KW lighting load connected to control. For multi-level and perimeter switching in the Comprehensive Track the		
to be 99%. <sup>[1]</sup> Wi <sub>connected</sub> = KW lighting load connected to control. For multi-level and perimeter switching in the Comprehensive Track the		per year from the table titled Lighting Operating Hours by Building Type.
		to be 98%. <sup>[1]</sup>
savings is applied to all interior lighting kW load.	Vconnected	<ul> <li>kW lighting load connected to control. For multi-level and perimeter switching in the Comprehensive Track the savings is applied to all interior lighting kW load.</li> </ul>
OA = Outside Air - the average percent of the supply air that is Outside Air, assumed to be 25%[7]	4	= Outside Air - the average percent of the supply air that is Outside Air, assumed to be $25\%$ . <sup>(7)</sup>
	TF	<ul> <li>Operational Testing Factor. OTF = 1.0 for all occupancy sensors and for daylight dimming controls when the project understand Constitution or communications used into a 0.00 for drift fide formion controls when the project</li> </ul>
undergoes Operational Testing or commissioning services, 0.80 for daylight dimming controls otherwise. SVG = % of annual lighting energy saved by lighting control; determined on a site-specific basis or refer to table by cor		undergoes Operational Testing or commissioning services, 0.80 for daylight dimming controls otherwise. 9% of annual lighting energy saved by lighting control; determined on a site-specific basis or refer to table by control
type	/G	
lighting in existing buildings, the default value is $1.102$ . <sup>[2]</sup> The cooling savings are only added to the summer per savings. For refrigerated case lighting, the value is $1.29$ (calculated as (1 + (1.0 / 3.5))). Based on the assumpt		
		We set the set factor for demand to account for cooling savings from efficient lighting. For prescriptive commercial lighting in existing buildings, the default value is 1.102 <sup>[2]</sup> . The cooling savings are only added to the summer peak savings. For refrigrented case lighting, the value is 1.29 (calculated as (1 + (1.0 / 3.5))). Based on the assumption that all lighting in refrigrented cases is methanically cooled, with storial 3.5 <sup>24</sup> . COO Perfiguention system efficiency, the value of the first of the same efficiency.
WHF <sub>e</sub> = Waste heat factor for energy to account for cooling savings from efficient lighting. For prescriptive commercial	HFd	Waste heat factor for demand to account for cooling savings from efficient lighting. For prescriptive commercial lighting in existing buildings, the default value is 1.102. <sup>[2]</sup> The cooling savings are only added to the summer peak savings. For refrigerated case lighting, the value is 1.29 (calculated as (1 + (1.0) 7.5))). Based on the assumption that all lighting in refrigerated cases is mechanically cooled, with typical 3.5 <sup>10</sup> . Cool Performation system efficiency, and assuming 100% of lighting heat needs to be mechanically cooled at time of summer peak.

typical 3.5 COP refrigeration system efficiency.

Load Shapes For Interior lighting applications, # 12 (Commercial Indoor Lighting-Blended) for demand and lighting energy savings and #15 (Commercial A/C) for cooling energy savings. For Exterior lighting applications, #13 (Commercial Outdoor Lighting)

For Exterio	xterior lighting applications, #13 (Commercial Outdoor Lighting)										
	r refrigerated and freezer case lighting applications, # 87 (Grocery/Conv. Store Indoor Lighting) for demand and lighting energy savings and #: ommercial Refrigeration) for refrigeration and freezer (cooling bonus) energy savings.										
12d Commercial Indoor Lighting - Bended 13a Commercial Oxtdoor Lighting 14a Commercial Arthogenation 15c Commercial A/C 56 Forcesry(Cow, Store Indoor Lighting											
Number	Name	Status	Winter On kWh		Summer On kWh	Summer Off kWh	Winter kW	Summer kW			
12	Commercial Indoor Lighting - Blended	Active	48.8%	19.5%	22.2%	9.5%	46.9%	67.9%			
13	Commercial Outdoor Lighting	Active	20.5%	50.6%	6.1%	22.8%	70.2%	3.7%			
14	Commercial Refrigeration	Active	33.0%	32.6%	17.0%	17.4%	69.0%	77.2%			
15	Commercial A/C	Active	18.0%	10.0%	46.0%	26.0%	0.0%	34.2%			
87	Grocery/Conv. Store Indoor Lighting	Active	39.7%	26.7%	19.7%	13.9%	84.7%	90.8%			

### Net Savings Factors

Measures						
	Exterior Occu	upancy Sensors				
LECOCCRE Refrigerator Case Controls						
LECOCCFR Freezer Case Controls						
LECOCCDL Fixture-Mounted Dual Occupancy & Daylight Sensor						
LECOCCFX Fixture-Mounted Occupancy Sensor						
LECOCCRM	Remote-Mou	inted Occupancy	Sensor			
LECDAYFX	Fixture-Mour	nted Daylight Se	nsor			
LECOCCIN	Integrated O	ccupancy Senso	r			
		Occupancy Sens				
		nted Daylight Se				
		ual Occupancy 8		incor		
	-					
LECDULRM	Remote-Mou	inted Dual Occup	ancy & Day	ight Sensor		
Tracks [Bas	a Track]					
6012CNIR [is		C&I Retro				
	-					
	-	Cust Equip Rpl				
6013PRES [is	base track]	Pres Equip Rpl				
Transfe Marrie	Track M.	Measure Code	Free Bider	6 mill ()		
C&I Retro	6012CNIR		0.89	1.00		
C&I Retro	6012CNIR I		0.89	1.00		
C&I Retro	6012CNIR I		0.89	1.00		
C&I Retro	6012CNIR		0.89	1.00		
Cust Equip Rp			0.97	1.00		
Cust Equip Rp	6013CUST	LECOCCRE	0.97	1.00		
Cust Equip Rp			0.97	1.00		
Cust Equip Rp	6013CUST	LECOCCDL	0.97	1.00		
Pres Equip Rp			0.98	1.00		
Pres Equip Rp			0.98	1.00		
Pres Equip Rp			0.98	1.00		
Pres Equip Rp			0.98	1.00		
C&I Retro	6012CNIR		0.89	1.00		
Cust Equip Rp Pres Equip Rp			0.97 0.98	1.00		
C&I Retro	6012CNIR I		0.98	1.00		
Cust Equip Rp			0.89	1.00		
Pres Equip Rp			0.98	1.00		
C&I Retro	6012CNIR		0.89	1.00		
Cust Equip Rp	6013CUST	LECDAYFX	0.97	1.00		
Pres Equip Rp			0.98	1.00		
C&I Retro	6012CNIR		0.89	1.00		
Cust Equip Rp			0.97	1.00		
Pres Equip Rp			0.98	1.00		
C&I Retro	6012CNIR		0.89	1.00		
Cust Equip Rp			0.97	1.00		
Pres Equip Rp C&I Retro	6013PRES I 6012CNIR I		0.98 0.89	1.00 1.00		
Cal Retro			0.89	1.00		
Pres Equip Rp			0.97	1.00		
C&I Retro	6012CNIR I		0.98	1.00		
Cust Equip Rp			0.97	1.00		
Pres Equip Rp			0.98	1.00		
C&I Retro	6012CNIR		0.89	1.00		
Cust Equip Rp			0.97	1.00		
Pres Equip Rp	6013PRES	LECDULRM	0.98	1.00		

Lifetimes Controls – 10 years. Analysis period is the same as the lifetime.

## Measure Cost

Lighting Control Type	Cost
Wall Switch Occupancy Sensor	\$55
Fixture-Mounted Occupancy Sensor	\$67
Remote-Mounted Occupancy Sensor	\$125
Fixture-Mounted Daylight Sensor	\$50
Remote-Mounted Daylight Sensor	\$65
Integrated Occupancy Sensor	\$40
Integrated Dual Occupancy & Daylight Sensor	\$50
Fixture-Mounted Dual Occupancy & Daylight Sensor	\$100
Remote-Mounted Dual Occupancy & Daylight Sensor	\$125

 Refrigerator Case Occupancy Sensor
 \$60

 Freezer Case Occupancy Sensor
 \$60

 Exterior Occupancy Sensor
 \$82

See 'EVT Lighting Control Assumptions\_2019.xlsx'; "Cost" sheet for more information

### **O&M Cost Adjustments**

Reference Tables Default Controlled Location / Application % Savings (SVG)<sup>[8]</sup> Lighting Control Type Measure Code Item Code Vattage Wall Switch Occupancy Sensor LECOCCWS CEO-WOS-ZZ-1N Inter Fixture-Mounted Occupancy Senso LECOCCFX CEO-FMOS-1N Remote-Mounted Occupancy Sensor LECOCCRM 24% 338 Interio CEO-ROS-ZZ-1N Fixture-Mounted Daylight Se LECDAYFX CEO-FDAY-ZZ-1N Remote-Mounted Daylight Sensor LECDAYRM Interio 239 CEO-RDAY-ZZ-1N Integrated Occupancy Sensor for LED Interior Fixtures < 10,000 Lumens LECOCCIN 24% 31 Interior CEO-INTGOC-A Integrated Occupancy Sensor for LED Interior Fixtures >= 10,000 LECOCCIN Interior CEO-INTGOC-B 24% 118 umens N/A \* Verified Daylight Savings Integrated Dual Occupancy & Daylight Sensor for LED Interior Fixtures < 10,000 Lumens 38% No Verified Daylight Savings LECOCCID 31 Interi CEO-INTGDL-A 24% N/A \* Verified Daylight Savings 38% Integrated Dual Occupancy & Daylight Sensor for LED Interior Fixtures >= 10,000 Lumens LECOCCID 118 No Verified Daylight CEO-INTGDL-B 24% Savings N/A \* Verified Daylight Savings Fixture-Mounted Dual Occupancy & Daylight Sensor for LED Interior Fixtures < 10,000 Lumens 38% LECOCCDL 31 No Verified Daylight Savings CEO-DUALOC-3 24% N/A \* Verified Daylight Savings 38% Fixture-Mounted Dual Occupancy & Daylight Sensor for LED Interior Fixtures >= 10,000 Lumens LECOCCDL 118 Interio No Verified Daylight CEO-DUALOC-2 24% vings N/A \* Verified Daylight Savings 38% Remote-Mounted Dual Occupancy 8 Daylight Sensor for LED Interior Fixtures LECDULRM 239 No Verified Daylight Savings CEO-RDUAL-ZZ-A 24% ivings Refrigerator Case Occupancy Sensor 40% LECOCCRE CEO-RFR-CS-1N Case 92 Freezer Case Occupancy Sensor LECOCCFR Case 40% CEO-FRZ-CS-1N 90 Exterior Occupancy Sensor LECOCCEX 41% 86 CEO+EXT-OS-1N Exterior Note all Prescriptive measures will as ime no veri daylighting savings, so nly custor sures where davlid

savings value

### Lighting Operating Hours by Building Type

Building Type	Annual Hours
Grocery/Convenience Store	6,019
Hospital	4,007
K-12 Schools	2,456
Lodging/Hospitality	4,808
Manufacturing	4,781
Office	3,642
Public Assembly	3,035
Public Safety	3,116
Religious	2,648
Restaurant	4,089
Retail	4,103
Service	3,521
University/College	3,416
Warehouse	4,009
Exterior	3,338

From <u>C&Llighting Load Shape Project FINAL Report</u>, July 19, 2011, prepared by KEMA for NEEP. See document NEEP CI Lighting L5 FINAL Report\_ver 5,7-19-11.pdf. Exterior Lighting hours based on estimated mix of photocell-controlled lighting (12 hpd) and switch-controlled lighting.

### Footnotes

[1] 2005 TAG agreement.

[2] The default waste heat factor for demand and energy is from KEMA, "NEEP C&I Lighting Loadshape Project, KEMA," 2011. The report modeled the energy savings per building type and the associated energy, demand, and coincident demand interactive effects. A description of how the interactive effects were developed is on page 28 of the report, including details about how temperature bahrace points, equipment efficiencies, and heat to space factors influenced each building's designated interactive effects. The building types were weighted for the NE-North Weather climate zone in order to come up with a single prescriptione default value (Foto the demand and energy lighting waste heat factors. For more information, please see the spreadsheet, "EVT Lighting WHF Research, Prescriptive, 2020.xis/".

[3] Assumes 3.5 COP for medium temp cases based on the average of standard reciprocating and discus compressor efficiencies with Saturated Suction Temperatures of 20% and a condensing temperature of 90%.

- [4] The typical aspect ratio is sourced from PNNL, "Analysis of Daylighting Requirements within ASHRAE Standard 90.1, PNNL," 2013, from the Executive Summary on page v. The aspect ratio is sourced from 1 of 16 PNNL prototype building models. The 60% default value is from the medium office building model.
- [5] Average APLE of the HYAC heating equipment is based on the weighted average of existing commercial heating systems, as sourced from the '2016 VT Business Sector Market Characterization and Assessment Study', Cadmus, April 2017 (page 65). For more information, please see the spreadsheet, "EVT Lighting WHF Research\_Prescriptive\_2020.xlsx".
- [6] From "Calculating lighting and HVAC interactions", Table 1, ASHRAE Journal November 1993.
- [7] 2009 ASHRAE Handbook Fundamentals (p. 16.2); "Conventional all-air air-handling systems for commercial and institutional buildings have approximately 10 to 40% outside air."

[8] Interior controls % savings based on LBNL, Williams et al, "Lighting Controls in Commercial Buildings", 2012, p172. Case occupancy sensors are based on case studies of controls installed in Wal-Mart and Krogers refrigerator/freezer LED case lighting controls and exterior sensors are based upon data from "Application Assessment of B-Level LED Parking Lc Lighting" p6. See "EVT Lighting Control Assumptions, 2019.visit for more information.

[9] Based on Efficiency Vermont data from program year 2017. See 'EVT Lighting Control Assumptions\_2019.xls'; "TRM Table" sheet for details on calculations.

### **LED ENERGY STAR Fixtures**

Measure Number: CR-LTG-LEDESF b								
Portfolio:								
Status:	Active							
Effective Date:	2021/1/1							
End Date:	[ None ]							

[None] Efficient Products Program Program: End Use: Lighting

## Update Summary The measure has been updated to:

- Since EISA backstop not enacted, language updated.
   Baseline watts now based on weighted mix (from DOE forecast), with midlife adjusment now based upon replacement lamp forecast
   Laakage rate applied to all measures now for simplicity.
   Costs and OSM Impacts calculated based on weighted baseline mix.

- 3 year assumptions calculated
   Dropship program definition provided. Downlight fixture has been added to the offerings. New Item Code for low income drop ship added.

ard, Cape Light Co

#### Referenced Documents

- Referenced Documents
  Calculating Uptitying and HVAC Interactions. ASHRAE
  O Calculating Uptitying and HVAC Interactions. ASHRAE
  MRG Group, Inc., "Nerthwast Residential Uptiting Hours-of-Use Study," prepared for CT Every Efficiency Board
  Every Efficiency Advisory Council, Nethraal Grid MA, Netional Grid RJ, NYSERDA, Northeast Utilities, Nay 5, 2
  R, Call, LeD, Ioars
  UMF-Chapter 21-residential Lighting-evaluation-protocol
  PMRL, Analysis of Dokylghting Requirements\_Aug 2013
  NEEP\_CLUghting Loadshape, Jul 2011
  Cadmus, UT Bases Setor Market Characterization, Apr 2017
  ENERGY STAR Light Fature, Calling Fan Calculator
  EVIT Lighting WR Beasen't Previous/tem\_2020
  2021-2023 EVIT ESTAR Fotures Analysis

### Description

A DEBKY STAR Marking LED foture is purchased and installed in place of an incandescent or halogen finture. This measure is broken into three DEBKY STAR finture types- holor Fotures (including track lighting, wall-wash, sconces, calling and fan lights, task and under cabinet fintures), Outdoor Fintures (including flood light, hanging lights, scorthy/path lights, outdoor porch lights), and Downlight Fintures. Assumptions are provided for the following markets: Efficient Products and SMATLIGHT.

Market	Description				
Efficient Products (Residential and Commercial)	This is for retail sales for Residential or Commercial customers.				
SMARTLIGHT (Residential and Commercial)	In reference to PIP #67a: Upstream Distributor Incentive Model, Efficiency Vermont offers "upstream" incentives to Vermont Electrical Distributors for certain eligible LED fixtures.				
Dropship (Residential and Commercial)	Product (a downlight fluture) is ordered via the EVT website by building owners, weatherization contractors or EVT staff. A distributor ships the products to the customer, rine of charge. The building owner must confirm that the product will be installed and EVT reserve the right to inspect at a later date.				

## Program Type Calculation Type: Time of Sale

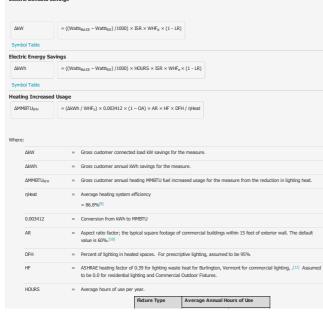
Program Delivery/Implementation Type: Midstream / Downs

### **Baseline Efficiencies**

The baseline condition is a weighted average mix of baseline LED, CFL, Halogen and Incandescent as provided by DOE Lighting Forecast.

Efficient Equipment High efficiency is an ENERGY STAR-qualified LED foture meeting the requirements in Version 2.1 of the ENERGY STAR Specification for Solid State Luminaires.

## Algorithms Electric Demand Savings



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							utdoor I			044 <mark>(8)</mark>			3,960				
						C	ownligh	t Fixture	es 98	6(7)			3,523				
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ISR			In service rate or the percentage of units rebated that actually get used $= 95\% (^{1})$														
LR				e Rate to	accou	nt for	bulbs so	old to cu	stomers	outsid	e of th	e progra	am area	1			
			= 0.015														
OA				Air - the			rcent of	the sup	ply air th	at is C	utside	Air, ass	sumed t	o be 25%	,[12]		
Watts <sub>B</sub>	ASE	-	_	e connect	ed kW	(3)	Fivt	ure Typ	10	R	solino	Watts					
			riogra	ini i ype				ure ryp			13611116	2022	2	2023			
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								vnlight F		51		49.2		46.9			
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			Comm			heunh		door Fix		32		32.1		31.4	_		
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-				neat facto	r for e	F	Market Residen Comme Outdoor Comme	tial rcial (ex Fixture rcial Ou	kcept is) <sup>(5)</sup>	avings	<b>WHF</b>	2	: lighting	ı, depend	ing on	mark	et and fixtu
_				neat facto	r for e	F	Market Residen Comme Outdoor	tial rcial (ex Fixture rcial Ou	kcept is) <sup>(5)</sup>	avings	WHF, 1.0	2	lighting	ı, depend	ing on	mark	et and fixtu
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ing the default staff for orgaram Type Efficient Products, MARTLIGHT Products, MARTLIGHT	calculation Fixtures Indoor Fixtures Outdoor Fixtures Indoor Fixtures Outdoor Fixtures Outdoor Fixtures	e kW, k details): ΔkW 0.0332 0.0271 0.0305 0.0153	wh anc Δkwh 32.4 55.5 30.0 52.6 54.8	2021 00	Year           of Adj           2024           2024           2024           2024           2024	Adj 0.63 0.71 0.63	Магкеt Residen Comme Fixtures ach fixtu akW 0.0309 0.0256 0.0258 0.0144	ibial           tical (e)           Fixture           rcial (a)           jac           ΔkWh           30.2           52.3           27.9           49.5           50.3	ксерt (s) <sup>177</sup> tidoor 2022 ФММВци 0 0 0 0 0 0 0 0	ket ar- of Adj 2025 2025 2025 2025	WHF,           1.0           1.036           1.0           e prov           0.6           0.56           0.69           0.60	ided bel ΔkW 0.0286 0.0261 0.0135 0.0140	ΔkWh 27.9 49.1 25.8 46.5 48.1	е *2021-2 2023 ФММВш 0 0 0 0 0.0290 0	2023 ES of Adj 2026 2026 2026 2026	Adj 0.65 0.61 0.65 0.61	Item Coc EPR-SSL-1 23W RES- UPLEDFX EPR-SSL-1 17W RES- UPLEDFX DSLBLLED DSLBLLED DSLBLLED DSLBLLED EPC-SSL-1 23W BES-UPLED
ing the default alayisis sta <sup>+</sup> for orgram Type Efficient MARTLGHT Residential Efficient	Calculation Fixture Type Indoor Fixtures Outdoor Fixtures Downlight Fixtures Indoor Fixtures Outdoor	ne kW, k details)3 0.0332 0.0271 0.0305 0.0153	wh anc Δkwh 32.4 55.5 30.0 52.6 54.8	2021 	Year           of Adj           2024           2024           2024           2024           2024	Adj 0.63 0.71 0.63	Market Residen Comme Outdoo Comme Fixtures ach fixtures 0.0309 0.0256 0.02583 0.0283	ibial           ticial (e)           Fixture           rcial Qu	ксерt is) <sup>107</sup> and mar 2022 <u>Ф</u> МИВЦ 0 0 0 0 0	ket ar- of Adj 2025 2025 2025 2025	WHF,           1.0           1.036           1.0           e prov           0.6           0.56           0.69           0.60	a ided bel ΔkW 0.0286 0.0240 0.0261 0.0135	ΔkWh 27.9 49.1 25.8 46.5 48.1	е "2021-2 2023 ДММВШ 0 0 0 0 0 0 0 0 0	2023 ES of Adj 2026 2026 2026 2026	Adj 0.65 0.61 0.65 0.61	Fidure EPR-SSL-1 23W RES- UPLEDFX EPR-SSL-1 17W EPR-SSL

Baseline Adjustment The natural growth of LED market share, has and will continue to grow over the lifetime of the LED measures installed. Therefore a forecast of the baseline growth of LED lamps has been developed, based upon historical growth rates provided via CREED LightTracker data for no-program states, and review of projections provided by the Department of Energy. This forecast is used to estimate how baseline replacement lamps would change over the lifetime of the LED fature. A single mid-life adjustment is calculated that results in an equivalent net present value of lifetime savings as the forecast decline in annual savings. The appropriate adjustments as a percentage of the base year savings for each fature type are provided in the table above

Load	Sha	•

Load Shapes									
Fixture Type	Loadshape								
Indoor Fixtures	Residential Indoor Lighting								
Downlight Fixtures	nasiacitati zitotor tagitung								
Outdoor Fixtures	Residential Outdoor Lighting								
Indoor Fixtures	Commercial EP Lighting with cooling								
Downlight Fixtures	bonus								
	Indoor Fixtures Downlight Fixtures Outdoor Fixtures Indoor Fixtures								

	Outdoor Fixtures			Commercial Outdoor Lighting					
1a Reside	tesidential Indoor Lighting								
2a Reside	Residential Outdoor Lighting								
	3a Commercial Outdoor Lighting								
101c Com	mercial EP Lighting with cooling bonus								
Number	Name	Status	Winter On kWh		Summer On kWh	Summer Off kWh	Winter kW	Summer kW	
1	Residential Indoor Lighting	Active	36.9%	35.0%	13.0%	15.1%	29.8%	8.2%	
2	Residential Outdoor Lighting	Active	20.5%	50.6%	6.1%	22.8%	34.6%	1.8%	
13	Commercial Outdoor Lighting	Active	20.5%	50.6%	6.1%	22.8%	70.2%	3.7%	

### Net Savings Factors

Measures	
LFHRDLED	LED Recessed Surface or Pendant Downlight
LFHLEDOU	LED Outdoor Fixture
LFHLEDIN	LED Indoor Fixture
Tracks [B;	ase Track]

6013UPST [is base track] Upstream - Commercial 6032EPEP [is base track] Efficient Products - Residential 6032UPST [6032EPEP] Upstream - Residential 6013EPEP [6032EPEP] Efficient Products - Commercial

#### Lifetimes

### Lifetime is a function of the rated life<sup>[13]</sup> and average hours of use of the luminaire<sup>[14]</sup>

Fixture Type	Rated Life (Hours)	Lifetime (Years)				
	,	Residential	Commercial			
Indoor Fixtures	48,000	15.0	13.1			
Outdoor Fixtures	48,000	15.0	12.1			
Downlight Fixtures	49,000	15.0	13.9			

Persistence The persistence factor is assumed to be one.

### Measure Cost

		Fixture 1	Incremental	Cost	
		2021	2022	2023	1
Residential	Indoor Fixtures	\$13	\$12	\$11	
	Outdoor Fixtures	\$14	\$13	\$13	
	Downlight Fixtures	\$7	\$7	\$6	
	Indoor Fixtures	\$7	\$6	\$6	7
Commercial	Outdoor Fixtures	\$8	\$8	\$7	7
	Downlight Fixtures	\$3	\$3	\$3	7

O&M Cost Adjustments To account for the shift in baseline due to replacement lamps, the levelized baseline replacement cost over the lifetime of the LED is calculated. The key assumptions used in this calculation are documented below.

	Replacement Lamp Cost	s	Annumod	Lifetime (ha		
	Omnidirectional E	irectional	Assumed	Liteurne (nu	uisj	
LED	\$5.00	10.00	1			
CFL	\$2.50	4.50	10,000			
Halogen	\$1.25	3.50	1,000			
Incandescent	\$0.50	3.50	1,000			
The calculation re	esults in the following assu	mptions of ea	quivalent an	nual baselir	ne replacement co	ost (see "2021-2023 ESTAR Fixture Analysis.xls" for
calculation details	5)					
1	1	An	nual O&M (	Cost	1	
1		2021	2022	2023		
1	Indoor Fixtures	\$0.25	\$0.23	\$0.21		

		2021	2022	2023
1	Indoor Fixtures	\$0.25	\$0.23	\$0.21
Residential	Outdoor Fixtures	\$0.36	\$0.33	\$0.30
	Downlight Fixtures	\$1.08	\$0.96	\$0.84
1	Indoor Fixtures	\$0.11	\$0.09	\$0.07
Commercial	Outdoor Fixtures	\$0.11	\$0.09	\$0.07
	Downlight Fixtures	\$0.09	\$0.07	\$0.07

### Footnotes

- Efficiency Vermont removes savings claims for lamps that have been returned. The 95% ISR assumes that 5% of fixtures are never installed. EVT plan to review this assumption for future iterations.
- [2] A leakage rate of 1.5% was agreed to by EVT and DPS during October 2017 TAG. This value is an estimate based on leakage rates used by other programs, geographic factors, and a consideration of similar lighting programs in surrounding service territories.
- [3] Weighted average baseline wats based on US Department of Energy, "Energy Savings Forecast of Solid State Lighting in General Illumination Applications", December 2019, See "2021-2023 ESTAR Fixture Analysis.xids" for calculation details
- [4] Based on average of the ESTAR fixtures on the QPL accessed 10/2020. See file "2021-2023 ESTAR Fixture Analysis.xls" for calculation details.
- [5] The default waste heat factors for demand and energy for commercial indoor fixtures are from KEMA, "NEEP C&I Lighting Loadshape Project, KEMA," 2011. The report modeled the energy savings per building type and the associated energy, demand, and coincident demand interactive effects. A description of how the interactive effects were developed is on page 28 of the report, Including details about how temperature balance points, equipment efficiencies, and heat to space factors influenced each building's designated interactive effects. The building types were weighted for the Ne-horth Weather clinites zero in order to come up with a single prescriptive dedux tabus for both demand and energy lighting waste heat factors. For more information, please see the spreadsheet, "EVT Lighting WFF Research, Prescriptive, 2020.dsx".
- [6] Commercial hours based on 3-year weighted average for fixtures rebated through Efficiency Vermont's Business Energy Services prescrip program, through 12/14/2015. See Rx\_C&L\_LED\_hours.x6x for analysis
- [7] Based on weighted average of Residetial Indoor: household average 2.7 hours of use per day. NMR, "Northeast Residential Lighting Hours-of-Use Study", 5/5/2014. Page 34, Table 3-1, and Residential Task/Under Cabinet: Estimated at 2 hours per day.
- [8] Based on a household exterior average 5.6 hours of use per day. NMR, "Northeast Residential Lighting Hours-of-Use Study", 5/5/2014. Page 34, Table 3-1.
- [9] Average AFUE of the MAAC heating equipment is based on the weighted average of existing commercial heating systems, as sourced from the "2016 VT Business Sector Market Characterization and Assessment Study", Cadmus, April 2017 (page 65). For more information, please see the spreadsheep. "DrV Lighting WHE Research, Prescripting-2020.sks".
- [10] The ASHRAE heating factor applies to perimeter zone heat, therefore it must be adjusted to account for lighting in core zones. The typical aspect ratio is sourced from PNNL, "Analysis of Daylighting Requirements within ASHRAE Standard 90.1, PNNL," 2013, from the Executive Summary on page

- v. The aspect ratio is sourced from 1 of 16 PNNL prototype building models. The 60% default value is from the medium office building model. For more information, please see the spreadsheet, "EVT Lighting WHF Research\_Prescriptive\_2020.xlsx".
- [11] From "Calculating lighting and HA/AC Interactions", Table 1, ASHRAE Journal November 1993. For more information, please see the spreadsheet, "EVT Lighting WHF Research\_Prescriptive\_2020.x5x".
- [12] 2017 ASHRAE Handbook Fundamentals (p. 16.3): "Conventional all-air air-handling systems for commercial and institutional buildings often have approximately 10 to 40% outside air." For more information, please see the spreadsheet, "EVT Lighting WHF Research\_Prescriptive\_2020.xis.".
- [13] Average rated lives are based on the average rated lives of fixtures available on the ENERGY STAR qualifying list as of 10/2020.
- [14] Lifetimes are capped at 15 years even when the rated life/hours of use are higher.
- [15] LED costs are based on program data. See "2021-2023 ESTAR Fixture Analysis.xls" for calculation details.

### **LED Other Fixtures**

### Measure Number: CR-LTG-LEDOF c Portfolio: Status: Active Effective Date: 2021/1/1 End Date: Program:

[ None ] Efficient Products Program Lighting End Use:

### Update Summary

Updating the efficient wattage based on DLC listed fixtures meeting the new 5.0 standard.

#### Referenced Documents

- Looy An Nex HMOL Industrications, ASHRAE
   PINL, Analysis of Daylighting Requirements, Aug 2013
   NEEP, CL Lighting Incodesigne, JJA 2011
   Cadmus, VT Business Sector: Market Characterization, Apr 2017
   DIVICL, MA CL Loptersmu Lighting In-Storage Lamps Follow-up Study\_Mar 2015
   EVT Lighting WHF Research Prescriptine, 2020
   EVT\_LED Other Futures, Analysis 2021
   LED Other Futures, Analysis 2021

tals

### Description

Description
The measures included in this TRM are LED lighting technologies intended for installation on retrofit, market opportunity, and new construction projects.
ED lighting systems have source efficacies (lumens per wait) that can match or exceed efficacies of incandescent, compact fluorescent, linear
fluorescent and HD lighting. In addition, LED's inherent directionality reduces or eliminates the need for a reflector to direct light, thereby reducing or
eliminating future efficiency (losses. Eligible measures include new futures and retrofit kits. Measures may be offered through the commercial lighting
induces the efficiency termstructure on-hine rebeta application (CAI Rebeta Form), or under the SMARTLI34T program
("midstream" incentives to Vermont electrical distributors) or through the custom Multfamily programs. The current offering of future technologies and
programs are provided below but are subject to change and the attached analysis file provides savings results for any combination of future, program
and cortrol.

## Program Type Calculation Type: Time of Sale

Program Delivery/Implementation Type: Midstream / Downs

### **Baseline Efficiencies**

All measures assume a market opportunity baseline fixture with equivalent lumens (Standard T8, T5, Metal Halide, CFL or Incandescent dependent on fixture type) as provided in Reference Tables below<sup>11</sup>.

The baseline in Multifamily New Construction programs incorporates the 2015 Vermont RBES requirement that 75% of fatures have high efficacy la The baseline is made up of 75% high efficacy as defined by the RBES and consistent with the C&I baseline, and 25% baseline EISA-qualified watta that produce similar lumen output. The 2020 Vermont RBES requirement that 90% of fatures have high efficacy lamps will be assumed as baseline 2022.

High Efficiency Eligible LED products include LED case fixtures, LED Linear/Troffer fixtures, LED Low and High Bay fixtures and LED exterior fixtures, grouped in to lume bins as provided in Reference Tables below.. All fixtures must be listed on the DesignLights Consortium Qualified Products List.

#### Algorithms Electric Demand Savings ΔkW = ((Watts<sub>BASE</sub> - (Watts<sub>EE</sub> × (1 - Control%Savings)))) /1000) × ISR × WHF<sub>d</sub> Symbol Tal Electric Energy Savings ∆kWh = ((Watts\_{BASE} - (Watts\_{EE} × (1 - Control%Savings))) / 1000) × HOURS × ISR × WHF<sub>e</sub> Symbol Table Heating Increased Usage Oil heating is assumed typical for commercial buildings. = ( $\Delta$ kWh / WHF<sub>e</sub>) × 0.003412 × (1 – OA) × AR × HF × DFH / ηHeat **AMMBTUWH** Symbol Ta Waste Heat Adjustment Fonling savings are incorporated into the electric savings algorithm with the waste heat factor (WHF). Where: ΔkW = Gross customer connected load kW savings for the measure ΔkWh = Gross customer annual kWh savings for the measure ΔMMBTU<sub>WH</sub> = Gross customer annual heating MMBTU fuel increased usage for the measure from the reduction in lighting heat = Average heating system efficiency, For prescriptive lighting, assumed to be 86.8% in existing buildings ηHeat 0.003412 = Conversion from kWh to MMBTU Aspect ratio factor; the typical square footage of commercial buildings within 15 feet of exterior wall. The default value is 60%.<sup>[13]</sup> AR Control%Savings = Percent savings for fixtures with integrated controls Fixtures without Integrated Controls Fixtures with Integrated Occupancy Sensor Controls Fixtures with Integrated Dual Occupancy & Daylight Sensor Controls with Verified Daylight savings Fixtures with Integrated Dual Occupancy & Daylight Sensor Controls without Verified Daylight saving Prescriptive Fixtures with Integrated Controls DFH Percent of lighting in heated spaces. For prescriptive lighting, assumed to be 95% except agriculture, refrigerated case and exterior fixtures which are assumed to be 0%.

HF = ASHRAE heating factor of 0.39 for lighting waste heat for Burlington, Vermont for commercial lighting. [14]

0%

7/10

749

HOURS

ad to be 0.0 fee multifemily and a

nnual lighting hours ccation: Implementation C&I Rebate Form Smartlight Multifamily						
Implementation	Customer or Location Type	LED Category	Operating Hours			
&I Rebate Form	C&I	Collected from p	rescriptive form			
		All Interior Fixtures	986[5]			
	Residential	All Exterior Fixtures	2044 <sup>[6]</sup>			
		LED Case Fixtures	5950			
Smartlight		LED Linear / Troffers	3458			
	C&I <sup>[7]</sup>	LED High & Low Bay Fixtures	3325			
		LED Exterior Fixtures	3789			
	In-unit		1204.5 <sup>[8]</sup>			
	Indoor Hallway / Stairway or Corridor		8760			
Multifamily	Laundry and other Common Areas	All Fixtures	4380 <sup>(9)</sup>			
	Exterior Tenant Controlled		2007.5 <sup>[10]</sup>			
	Exterior Master Controlled		3960 <sup>[11]</sup>			

ISR	-	In service rate, or the percentage of units rebated that actually get use $95\%^{(2)}$ .	d. For all	categories of fixtures, the ISR is				
OA	-	Outside Air - the average percent of the supply air that is Outside Air, a	ssumed to	o be 25%[15]				
Watts <sub>BASE</sub>	-	Baseline connected wattage from table located in Reference Tables see	tion.					
Watts <sub>EE</sub>	-	Energy efficient connected wattage from table located in Reference Tab	les sectio	n.				
WHFd	-	Waste heat factor for demand to account for cooling savings from effici- type.	or demand to account for cooling savings from efficient lighting, depending on market and fixture					
		Market	WHFd					
		Residential and Multifamily	1.0					
		Commercial (except Exterior and Refrigerated Case Fixtures) [3]	1.102					
		Refrigerated Case Fixtures <sup>[4]</sup>	1.29					

Commercial Exterior Fixtures 1.0 Waste heat factor for energy to account for cooling savings from efficient lighting, dep WHFe nding on market and fixture type. Market WHFe 1.0 Residential and Multifamily Commercial (except Exterior and Refrigerated Case Fixtures) [3] 1.036

> 1.29 1.0

Midlife Baseline Adjustment The Milliamily blended baseline assumption includes 25% EISA compliant halogen bulb. To account for shifting baselines it is assumed that the savings become 100% of the TS or CFL baseline from 2023. Therefore a midlife baseline adjustment as provided below will be applied in 2023:

LED Category	LED Measure Description	Midlife Adjustment in 202
LED Linear / Troffer	LED Linear / Troffers, <=3000 lumens	26%
LED LINEAR / TRUTIERS	LED Linear / Troffers, 3001-4500 lumens	41%
LED Exterior Fixtures	LED Exterior Fixtures, <= 2,000 lumens	70%
LED EXTENUT FIXURES	LED Exterior Fixtures, 2,001-5,000 lumens	64%

Refrigerated Case Fixtures [4]

Commercial Exterior Fixtures

Load Shapes For C&I Rebate Form interior lighting use #12 (Commercial Indoor Lighting-Bended) for demand and lighting energy savings and where C&I coolin savings are characterized, use #15 (Commercial A/C) cooling energy savings.

For exterior lighting C&I applications; #13 (Commercial Outdoor Lighting)

For Residential or in-unit multifamily applications; #1 (Residential Indoor Lighting). For multifamily common area fixtures applications; #12 (Commercial Indoor Lighting-Blended).

For multifamily hallway / stairway or corridor: #25 Flat (8760 hours)

For C&I Smartlight; #101 (Commercial EP Lighting with Cooling Bonus) [16]

For C&I Smartlight refrigerated and freezer case lighting applications, # 87 (Grocery/Conv. Store Indoor Lighting)

For C&I Rebate Form refrigerated and freezer case lighting applications, # 87 (Grocery/Conv. Store Indoor Lighting) for demand and lighting energy savings and #14 (Commercial Refrigeration) for refrigeration and freezer (cooling bonus) energy savings.

savings and #14 (Commercial Reingeration) for 1a Residential Indoor Lighting 2a Residential Outdoor Lighting 12d Commercial Indoor Lighting 13a Commercial Outdoor Lighting 14a Commercial Relingeration 15c Comme

13         Commercial Outdoor Lighting         Active         20.5%         50.6%         6.1%         22.8%         70.2%         3.7%           14         Commercial Refriguration         Active         33.0%         32.6%         17.0%         17.4%         69.0%         77.2%	Number	Name	Status	Winter On kWh		Summer On kWh		Winter kW	Summer kW
12         Commercial Indoor Lighting - Blended         Active         48.8%         19.5%         22.2%         9.5%         46.9%         67.9%           13         Commercial Outdoor Lighting         Active         20.5%         50.6%         61.9%         22.8%         70.2%         3.7%           14         Commercial Refrigeration         Active         33.0%         32.6%         17.4%         69.0%         7.2%	1	Residential Indoor Lighting	Active	36.9%	35.0%	13.0%	15.1%	29.8%	8.2%
13         Commercial Outdoor Lighting         Active         20.5%         50.6%         6.1%         22.8%         70.2%         3.7%           14         Commercial Refrigeration         Active         33.0%         32.6%         17.0%         17.4%         69.0%         77.2%	2	Residential Outdoor Lighting	Active	20.5%	50.6%	6.1%	22.8%	34.6%	1.8%
14         Commercial Refrigeration         Active         33.0%         32.6%         17.0%         17.4%         69.0%         77.2%	12	Commercial Indoor Lighting - Blended	Active	48.8%	19.5%	22.2%	9.5%	46.9%	67.9%
	13	Commercial Outdoor Lighting	Active	20.5%	50.6%	6.1%	22.8%	70.2%	3.7%
	14	Commercial Refrigeration	Active	33.0%	32.6%	17.0%	17.4%	69.0%	77.2%
15 Commercial A/C Active 18.0% 10.0% 46.0% 26.0% 0.0% 34.2%	15	Commercial A/C	Active	18.0%	10.0%	46.0%	26.0%	0.0%	34.2%
87 Grocery/Conv. Store Indoor Lighting Active 39.7% 26.7% 19.7% 13.9% 84.7% 90.8	87	Grocery/Conv. Store Indoor Lighting	Active	39.7%	26.7%	19.7%	13.9%	84.7%	90.8%
101 Commercial EP Lighting with cooling bonus Active 47.7% 19.2% 23.0% 10.1% 33.8% 68.1%	101	Commercial EP Lighting with cooling bonus	Active	47.7%	19.2%	23.0%	10.1%	33.8%	68.1%

### **Net Savings Factors**

Measures

LFHRCLED LED Refrigerated Case Lighting LFHHBLED LED High- and Low-Bay Fixtures LFHEXLED LED Exterior Fixtures LBLHDLED LED HID Lamp Replacement-Type B/C (direct-wired) LFHLEDEX LED Exterior DLC Fixtures SMARTLIGHT LFHLEDHB LED High- and Low-Bay Fixtures SMARTLIGHT LFHLEDRC LED Refrigerated Case Lighting SMARTLIGHT LFHLTLED LED Linear and Troffer Fixtures LFHLEDLT LED Linear and Troffer Fixtures SMARTLIGHT

Tracks [Base Track] 6013PRES [is base track] Pres Equip Rpl 6013UPST [is base track] Upstream - Commercial 6018LINC [is base track] LIMF NC 6019MFNC [is base track] MF Mkt NC 6017CUST [is base track] 6017CUST 6020CUST [is base track] 6020CUST 6032UPST [6032EPEP] Upstream - Residential

### Lifetimes

Estimated as the rated lifetime (50,000 hours as required by DLC) divided by annual operating hours. Measure lifetime is capped at 15 years. Analysis period is the same as lifetime.

#### Measure Cost

All measure costs are assumed to be incremental costs vs. the market opportunity baselines. LED costs are based on recent Efficiency Vermont experience and cost estimates provided by the U.S. Department of Energy<sup>(2)</sup>. Refer to Reference Tables section of this document for incremental measure cost data.

For Integrated Controls, in addition to the Fixture cost provided below a Control adder is applied (consistent with Lighting Controls assumptions)<sup>[18]</sup> Incom

	Lighting Control Type	Cost Adder
ſ	Integrated Occupancy Sensor	\$40
	Integrated Dual Occupancy & Daylight Sensor	\$50
	Prescriptive Fixture with Integrated Control	\$45

O&M Cost Adjustments See worksheet "Rx Table" within the reference file EVT\_LED Other Fixtures\_Analysis\_2021.xlsx for details

LED New and Baseline Assumptions										
LED Category	LED Measure Description	LED Lamp Life (hrs)	LED Lamp Replacement Cost	LED Driver Life (hrs)	LED Driver Replacement Cost	Baseline Lamp Life (hrs)	Baseline Lamp Replacement Cost Combined	Baseline Ballast Life (hrs)	Baseline Ballast Replacement Cost Combined	
LED Case	LED Refrigerated Case Light, Horizontal or Vertical, <= 1700 lumens	50,000	\$40.52	70,000	\$40.00	24,000	\$6.17	40,000	\$31.00	
Fixtures	LED Refrigerated Case Light, Horizontal or Vertical, > 1700 lumens	50,000	\$64.51	70,000	\$40.00	18,000	\$13.17	40,000	\$56.00	
LED Linear	LED Linear / Troffers, <=4,500 lumens	50,000	\$88.37	70,000	\$40.00	24,000	\$21.20	40,000	\$35.00	
/ Troffers	LED Linear / Troffers, >4,500 lumens	50,000	\$117.13	70,000	\$40.00	24,000	\$19.41	40,000	\$36.08	
	LED Low-Bay Fixtures, <= 10,000 lumens	50,000	\$113.51	70,000	\$62.50	18,000	\$64.50	40,000	\$92.50	
LED High & Low Bay Fixtures	LED High-Bay Fixtures, 10,001- 15,000 lumens	50,000	\$185.39	70,000	\$62.50	18,000	\$86.00	40,000	\$92.50	
	LED High-Bay Fixtures, >15,000 lumens	50,000	\$267.24	70,000	\$62.50	18,000	\$147.50	40,000	\$128.26	
	LED Exterior Fixtures, <= 5,000 lumens	50,000	\$66.72	70,000	\$62.50	13,292	\$30.19	40,000	\$72.61	
LED Exterior Fixtures	LED Exterior Fixtures, 5,001- 10,000 lumens	50,000	\$124.05	70,000	\$62.50	15,000	\$63.00	40,000	\$112.50	
	LED Exterior Fixtures, >10,000 lumens	50,000	\$266.02	70,000	\$62.50	15,000	\$70.33	40,000	\$127.15	

#### Reference Tables

See worksheet "NX TABLE" within the reference file EVT\_LED Other Fixtures\_Analysis\_2021.xksx for details. Calculation of average DLC 5.0 Standard LED wattage for each category is provided in "LED Other Fixtures\_DLC Average\_2021"

LED New ar	nd Baseline Assumpt	tions								
LED Category	LED Measure Description	WattsEE (DLC Blended)	Baseline Description	WattsBASE	Delta Watts (DLC Blended)	EE Cost	Baseline Cost	Incremental Cost	Rx Measure Code	Smartlight Measure Code
LED Case	LED Refrigerated Case Light, Horizontal or Vertical, <= 1700 lumens	10.1	T8 1L-F32 w/ Elec - 4'	32.0	21.9	\$57.21	\$20	\$37 \$77 with Integrated Occupancy Sensor	LFHRCLED	LFHLEDRC
Fixtures	LED Refrigerated Case Light, Horizontal or Vertical, > 1700 lumens	26.4	T5HO 1L-F54T5HO - 4'	59.0	32.6	\$67.87	\$30	\$38 \$78 with Integrated Occupancy Sensor	LFHRCLED	LFHLEDRC
								\$53		

.ED Linear	LED Linear / Troffers, <=4500 Iumens	29.5	Weighted Mix	64.7	35.2	\$105.08	\$52.41	\$93 with Integrated Occupancy Sensor \$103 with Integrated Dual Sensor \$98 with Rx Integrated Control	LFHLTLED	LFHLEDLT
Troffers	LED Linear / Troffers, >4500 Iumens	43.7	Weighted Mix	91.9	48.2	\$134.58	\$57.61	\$77 \$117 with Integrated Occupancy Sensor \$127 with Integrated Dual Sensor \$122 with Rx Integrated Control	LFHLTLED	LFHLEDLT
	LED Low-Bay Fixtures, <= 10,000 lumens	52.9	T8HO 3L-F48/HO Low-Bay	157.0	104.1	\$148.16	\$75	\$73 \$113 with Integrated Occupancy Sensor \$123 with Integrated Dual Sensor \$118 with Rx Integrated Control	LFHHBLED	LFHLEDHB
ED High & ow Bay ixtures	LED High-Bay Fixtures, 10,001- 15,000 lumens	95.8	T8HO 4L-F48/HO High-Bay	196.0	100.2	\$223.54	\$100	\$124 \$164 with Integrated Occupancy Sensor \$174 with Integrated Dual Sensor \$169 with Rx Integrated Control	LFHHBLED	LFHLEDHB
	LED High-Bay Fixtures, >15,000 lumens	172.1	Weighted Mix	336.2	164.1	\$339.94	\$135.76	\$204 \$244 with Integrated Occupancy Sensor \$254 with Integrated Dual Sensor \$249 with Rx Integrated Control	LFHHBLED	LFHLEDHB
	LED Exterior Fixtures, <= 5,000 lumens	21.0	Weighted Mix	75.7	54.6	\$165.75	\$42.92	\$123 \$163 with Integrated Occupancy Sensor \$173 with Integrated Dual Sensor \$168 with Rx Integrated Control	LFHEXLED	LFHLEDEX
ED xterior ixtures	LED Exterior Fixtures, 5,001- 10,000 lumens	61.7	175W Pulse Start Metal Halide	198.9	137.2	\$336.39	\$90	\$246 \$286 with Integrated Occupancy Sensor \$296 with Integrated Dual Sensor \$291 with Rx Integrated Control	LFHEXLED	LFHLEDEX
	LED Exterior Fixtures, > 10,000 lumens	178.2	Weighted Mix	363.4	185.2	\$509.76	\$133.96	\$376 \$416 with Integrated Occupancy Sensor \$426 with Integrated Dual Sensor \$421 with Rx Integrated Control	LFHEXLED	LFHLEDEX

LED Category	LED Measure Description	(DLC	WattsEE (DLC Standard)	WattsEE (DLC Premium)	Baseline Descripti	on	WattsBASE	Delta Watts (DLC Blended)	Delta Watts (DLC Stand	: v 0	elta Vatts DLC remium)	Increm	ental C		easure ode
LED Linear	LED Linear / Troffers, <=3000 lumens	20.7	21.1	20.2	Tube 1L- Elec - 2')	+ 3 * 53W	63.8	43.0	42.6		3.5	\$46 \$86 wit Occupa \$96 wit Dual Se \$91 wit Integra	ncy Sei h Integ ensor h Rx	nsor rated Ll	HLTLED
/ Troffers	LED Linear / Troffers, 3001- 4500 lumens	32.1	34.6	29.9	F32 w/ E	5 * T8 2L- lec - 4') + 3 * 72W )	98.3	66.1	63.7	6	8.4	\$44 \$84 wit Occupa \$94 wit Dual Se \$89 wit Integra	ncy Sei h Integ insor h Rx	nsor rated Ll	HLTLED
LED	LED Exterior Fixtures, <= 2,000 lumens	13.2	13.2	13.1	MF: (0.7 4-pin CFI (0.25 * halogens	L) + 2 * 53W	61.8	48.5	48.5	4	8.7	\$85 \$125 w Integra Occupa \$135 w Integra Sensor \$130 w Integra	ted ncy Ser ith ted Dua ith Rx	JI I	HEXLED
Exterior Fixtures	LED Exterior Fixtures, 2,001- 5,000 lumens	31.4	32.7	28.2	Metal Ha	2 * 150W	160.2	128.8	127.5	1	32.0	\$111 \$151 w Integra Occupa \$161 w Integra Sensor \$156 w Integra	ted ncy Sei ith ted Dua ith Rx	ы ы	HEXLED
Deemed sa	wings are provid	ed below:							1						
NO INTEGR	A TED CONTROL	LS													
ED New a	nd Baseline Assu	motione				C&I Rebate	e Form	Smart	light C8	\$I	1	Smar	tlight R	ES	r
LED New a			ption		[		pt on hours	∆kWh	ΔkW	ΔMMBt	ultemcod	ie∆kWh	∆kW	∆MMBb	litemcoo
ED Case	LED Refrig Vertical, <		se Light, H mens	orizontal or		BES+LED-R	FR11	159.9	D.0269	0.0000	BES- UPLED- RF11				
Fixtures	LED Refrig Vertical, >		se Light, H nens	orizontal or		BES+LED-R	FR12	238.1	D.0400	0.0000	BES- UPLED- RF12				
.ED Linear		/ Troffer	s, <=4500	lumens	BES-LED-LT		Г-А	119.9	0.0369	0.0759	LT-A	33.0	0.0335	0.0000	RES- UPLED- LT-A
Troffers	LED Linear	/ Troffer	s, >4500 lu	mens		BES-LED-LT	г-в	163.9	0.0504	0.1037	BES- UPLED-	45.1	0.0458	0.0000	RES- UPLED-

LED Case						KF11				
Fixtures	LED Refrigerated Case Light, Horizontal or Vertical, > 1700 lumens	BES-LED-RFR12	238.1	0.0400	0.0000	BES- UPLED- RF12				
						BES-	-			RES-
	LED Linear / Troffers, <=4500 lumens	BES-LED-LT-A	110.0	0.0260			22.0	0.0225	0.0000	UPLED-
LED Linear /	LED Linear / Troners, <=4500 fumeris	DC3*LED*L1*A	119.9	0.0509	0.0759	LT-A	55.0	0.0555	0.0000	LT-A
Troffers						BES-	-			RES-
	LED Linear / Troffers, >4500 lumens	BES-LED-LT-B	163.9	n 0504			45.1	0 0458	0.0000	UPLED-
						LT-B				LT-B
						BES-				RES-
	LED Low-Bay Fixtures, <= 10,000 lumens	BES-LED-LB-A	340.5	0.1089	0.2154	UPLED-	97.5	0.0989	0.0000	UPLED-
						LB-A				LB-A
LED High & Low						BES-				RES-
Bay Fixtures	LED High-Bay Fixtures, 10,001-15,000 lumens	BES-LED-HB-A	327.9	0.1049	0.2074	UPLED-	93.9	0.0952	0.0000	UPLED-
bay Fixtures						HB-A				HB-A
						BES-				RES-
	LED High-Bay Fixtures, >15,000 lumens	BES-LED-HB-D	537.1	0.1718			153.7	0.1559	0.0000	UPLED-
						HB-D				HB-D
						BES-				RES-
	LED Exterior Fixtures, <= 5,000 lumens	BES-XTR-A	196.7	0.0519			106.1	0.0519	0.0000	UPLED-
			-			XTR-A	<u> </u>		<u> </u>	KTR-A

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LED Exterior Fixtures	LED Exterior Fixtures, 5,001-10,000 lumens BE	S-XTR-B	493.90.13030.	.0000 UPLED		0.1303	0.0000	UPLED- KTR-B
	LED Exterior Fixtures, > 10,000 lumens BE	S-XTR-G	666.80.17600.	BES- 0000 UPLED XTR-G		0.1760	0.0000	RES- UPLED- KTR-G
WITH INTEGRA	TED CONTROLS							
		C&I Rx	Smartlight C&I	I	Smar	tlight R	ES	
LED New and Ba	seline Assumptions	Itemcode						
LED Category	LED Measure Description	Savings dept on hours	∆kWh∆kW ∆I	MMBtuitemco	ide∆kWł	n∆kW	∆MMBtı	Itemcod
LED Case	LED Refrigerated Case Light, Horizontal or Vertical, <= 1700 lumens	BES-LED-RFR11IC	177.50.02980.	BES- 0000 UPLED RF111				
Fixtures	LED Refrigerated Case Light, Horizontal or Vertical, > 1700 lumens	BES-LED-RFR12IC	284.20.04780.	BES- 0000 UPLED RF121				
LED Linear /	LED Linear / Troffers, <=4500 lumens	BES-LED-LT-AIC	144.00.04430.	BES- 0911 UPLED LT-AIO		0.0402	0.0000	RES- UPLED- LT-AIC
Troffers	LED Linear / Troffers, >4500 lumens	BES-LED-LT-BIC	199.60.06140.	BES- 1263 UPLED LT-BIO	F	0.0557	0.0000	RES- UPLED- LT-BIC
	LED Low-Bay Fixtures, <= 10,000 lumens	BES-LED-LB-AIC	382.10.12220.	8ES- 2417 UPLED LB-AIC		0.1109	0.0000	res- Upled- LB-AIC
LED High & Low Bay Fixtures	LED High-Bay Fixtures, 10,001-15,000 lumens	BES-LED-HB-AIC	403.10.12900.	.2550 UPLED HB-AIO		0.1170	0.0000	res+ Upled+ HB-AIC
	LED High-Bay Fixtures, >15,000 lumens	BES-LED-HB-DIC	672.30.21510.	4253 UPLED HB-DIO		0.1952	0.0000	RES+ UPLED+ HB+DIC
	LED Exterior Fixtures, <= 5,000 lumens	BES-XTR-AIC	214.80.05670.	.0000 UPLED		0.0567	0.0000	RES- UPLED- KTR-AC
LED Exterior Fixtures	LED Exterior Fixtures, 5,001-10,000 lumens	BES-XTR-BIC	547.20.14440.	BES-	- 295.2	20.1444	0.0000	RES+ UPLED+ KTR+BC
	LED Exterior Fixtures, > 10,000 lumens	BES-XTR-GIC	820.70.21660.	BES- 0000 UPLED		0.2166	0.0000	RES- UPLED- KTR-GC

### Deemed MF savings are provided below:

					Multifamily Stairway o	- Indoor Ha Corridor		Multifamily - Laundry and other Common Areas		
LED Category	LED Measure Description	∆kWh	ΔkW	∆MMBtu	∆kWh	ΔkW	∆MMBtu	∆kWh	ΔkW	∆MMBtu
LED Linear	LED Linear / Troffers, <=3000 lumens	27.4	0.0228	0.0000	199.5	0.0228	0.0000	99.8	0.0228	0.0000
/ Troffers	LED Linear / Troffers, 3001-4500 lumens	48.7	0.0405	0.0000	354.4	0.0405	0.0000	177.2	0.0405	0.0000

		Multifamily Controlled	- Exterior T		Multifamily Controlled	- Exterior N	laster
LED Category	LED Measure Description	∆kWh	ΔkW	∆MMBtu	∆kWh	۵kW	ΔMMBtu
LED	LED Exterior Fixtures, <= 2,000 lumens	75.7	0.0377	0.0000	149.3	0.0377	0.0000
Exterior Fixtures	LED Exterior Fixtures, 2,001-5,000 lumens	192.3	0.0958	0.0000	379.3	0.0958	0.0000

### Footnotes

- See worksheet "WattsBase (Lumen Analysis)" within the reference file EVT\_LED Other Fixture\_Analysis\_2021.xlsx for details. The follow methodology was used in establishing lumen bins and baseline/LED lumen equivalency:
- Define lumen bin ranges that are consistent sizes while reasonably balancing the distribution of DLC qualified products across the bins. Regular/consistent bin increments are preferred in order to reduce confusion for both customers and EVT implementation staff. Define baseline technology types for each tumen bin using actual equipment and not a hypothecial calculate baseline. Calculate the delivered lumens for each baseline technology. [Baseline delivered lumens = lamp dy x mean lamp lumens x ballast factor x

- Educate efficiency).
   Educate the EED initial lumm output that would be opticated to the baseline. Note that EED futures have no balact factor and future efficiency).
   Educate the EED initial lumm output that would be opticated to the baseline. Note that EED futures have no balact factor and future efficiency is not applicable due to absolute photometry. (EED initial lummes = baseline delivered lummer (EED lumm maintrance). Every attempt will be made to reasonably content the LED lumm output within a lumm thin, however the goals of consistent thin increments and baselines made up of actual equipment will result in some ED lumm value is up uncerted within a lumm thin a
- [2] Efficiency Vermont removes savinos claims for lamps that have been returned. The 95% ISR assumes that 5% of fixtures are never installed. EVT plan to review this assumption for future iterations.
- (3) The default waste heat factors for demand and energy for commercial indoor fixtures are from KEMA, "NEEP C&I Lighting Loadshape Project, KEMA," 2011. The report modeled the energy savings per building type and the associated energy, demand, and coincident demand interactive effects. A description of how the interactive effects were developed is on page 26 of the report, including details about how temperature balance points, equipment efficiencies, and heat to space factors influenced each building's designated interactive effects. The building types were weighted for the NF-North Weather climate zone in order to come us with a single prescriptive default value for both demand and energy lighting waste heat factors. For more information, please see the spreadsheet, "EVT Lighting WHF Research\_Prescriptive\_2020.stsc".
- (4) Calculated as (1 + (1,0 / 3,5)). Based on the assumption that all lighting in refrigerated cases is mechanically cooled, with a typical 3.5 COF Calculated to (L + (Lof) > 3.)), assess on the assessing 100% of big data an again git in the generate Labels is interstanding to conserve and explore a 3.5 COP for medium temp cases based on the average of standard reciprocating and discus compressor efficiencies with Saturated Suction Temperatures of 20% rad a contensing temperature of 90%.
- [5] Operating hours for all Residential LED Fixtures are based on a household average 2.7 hours of use per day. NMR, "Northeast Res Hours-of-Use Study", 5/5/2014. Page 34, Table 3-1. ntial Lighting
- [6] Based on a household exterior average 5.6 hours of use per day. NMR, "Northeast Residential Lighting Hours-of-Use Study", 5/5/2014. Page 34, Table 3-1
- [7] Operating hours for Commercial LED Fixtures are based on Efficiency Vermont data for prescriptive applications from 2016 through May 2019. See "EVTLightingHours16-19.xks"
- [5] Based on average daily hours of use of 3.3, from Table 3-5, page 43, value for Living Space for Lipstate New York, from NMR Group, Inc., Northeast Residential Lighting Hours-of-Use Study.
- [9] Assumes 12 hours per day.
- [10] Based on average daily hours of use of 5.5 exterior, from Table 3-1, page 34 for Upstate New York from NMR Group, Inc., Northeast Residential Lighting Hours-of-Use Study.
- [11] Commercial hours based on 3-year weighted average for fixtures rebated through Efficiency Vermont's Business Energy Services prescriptive program, through 12/14/2015. See Rx\_C81\_LED\_hours.xlsx for analysis
- [12] Average AFUE of the HVAC heating equipment is based on the weighted average of existing commercial heating systems, as sourced from the "2016 VT Business Sector Market Characterization and Assessment Study", Cadmus, April 2017 (page 65). For more information, please see the spreadtheet, "EVT lighting WFM Research, Prescripting, 2020.sks".
- [13] The ASHRAE heating factor applies to perimeter zone heat, therefore it must be adjusted to account for lighting in core zones. The typical aspect ratio is sourced from PNU, "Analysis of Daylighting Requirements within ASHRAE Standard 90.1, PNU," 2013, from the Executive Summary on page v. The aspect ratio is sourced from To 16 J FONR\_protophe building models. The 60% default value is from the medium office building model. For more information, please see the spreadsheet, "EVT Lighting WHF Research\_Prescriptive\_2020.xts/".
- [14] From "Calculating lighting and HVAC Interactions", Table 1, ASHRAE Journal November 1993. For more information, please see the spreadsheet, "EVT Lighting WHF Research. Prescriptive\_2020.xlsx".
- [15] 2017 ASHRAE Handbook Fundamentals (p. 16.3): "Conventional all-air air-handling systems for commercial and institutional buildings often have approximately 10 to 40% outside air." For more information, please see the spreadsheet, "EVT Lighting WHF Research\_Prescriptive\_2020.xlsr".

[16] Based on Commercial "Small" Lighting coincidence factors from KEMA; "C&I Lighting Load Shape Project Final Report," July 19, 2011, prepared for the Regional Evaluation, Measurement and Verification Form, submitted to NEEP. The winter coincidence factor has been adjusted to remove the cooling borus from winter peak demand.

[17] See worksheet "EE Cost (EVT Program Data)" within the reference file EVT\_LED Other Fixture\_Analysis\_2021.xlsx for details.

[18] Estimate based on 2018 Integrated Control research

### **LED Other Lamps**

Measure Number: CR-LTG-LEDOL c Portfolio: Status: Active Effective Date: 2021/1/1 End Date: [None ] Program: Efficient Products Program End Use: Lighting

- Update Summary
  Update efficient wattage due to DLC standard 5.0
  Update efficient wattage due to DLC standard 5.0
  Update efficient values and Pin Base Lamps removed as these h
  will continue to be valiable through Smartflight collecting customer information.
  Applying leakage rate to TLEDs through EP and Smartflight to streamline measures. wed as these have not been and will not be offered through this p

- Referenced Documents
   PIP #67a: Upstream Distributor Incentive Model
- PP #67a: Updream Distributor Incentive Model
   Calculating Lighting and HMAC Interactions, JoSRAE
   NAR Group, Inc., "Northeast Readential Lighting Hours-of-Use Study," prepared for CT Energy Efficiency Barro
  Energy Efficiency Advisory Council, National Grid HA, National Grid RJ, NYSERDA, Northeast Utilities, May 5, 2
   PNNL, Analysis C Disbylishing Requirements, Jug 2013
   NEEP\_CLI Lighting Loadshape, Jul 2011
   EVIC Lightsman Experiments, Jul 2017
   DN Ca, JMA CL Updream Lighting Informatic Damator Energy Protocol, Oct 2017
   OW CG, AM Lightersman Lighting Informative Impact Rehation PX015, Nev 2017
   NREL, UMP Chapter & Res Lighting Protocol, Oct 2017
   EVIC Lighting UMF Research Prescriptive\_2020
   ED Other Lamp Analysis 2021
   ELC\_112020, Other Lamps

Description Efficiency Vermont will offer relates for LED lamps to residential or commercial customers at participating retail locations. The eligible technologies are LED lines Redencement Lamps, LED HID Replacement Lamps, and LED Pin-Basse CFL Replacement Lamps. Refer to the ENERGY STAR Integratis Screw Based SSL (LED) Lamps measure for Screw Base LED Lamp savings.

Measures may be offered through the commercial lighting standard rebate form, through the efficiencyvermont.com on-line rebate application, under the SMARTLIGHT program ("midstream" incentives to Vermont electrical distributors).

## Program Type Calculation: Time of Sale (Market Opportunity)

Program Delivery / Implementation Type: Midstream, Downstream

### **Baseline Efficiencies**

Daseniero ELTIDicar Replacement Lamps (TLEDs) are the equivalent Standard T8s, for LED HID Replacement Lamps the baseline is Metal Halid for LED Pin-Base, the baseline is pin-base CFLs.

Refer to the "Wattage Assumptions, Deemed Savings, and Measure Costs" tables in the Reference Tables section for lighting baseline efficiencies and savings.

High Efficiency
The efficiencs is LED Linear Replacement Lamps (TLEDs), LED HID Replacement Lamps and LED Pin-Base lamps within various lumen ranges,
DLC 5.0 standards. Refer to the "Wattage Assumptions, Deemed Savings, and Measure Costs" tables in the Reference Tables section for efficient lighting wattage and

	orithms ric Demand Sa	winge				
ΔkV			ts <sub>BASE</sub> – Watts <sub>EE</sub> ) /10	$100) \times ISR \times WHF_d \times (1 - LR)$	)	
Symi	bol Table					
Elect	ric Energy Sav	ings				
∆kV	Vh	= ((Wat	ts <sub>BASE</sub> – Watts <sub>EE</sub> ) / :	1000) × HOURS × ISR × WH	$F_e \times (1 - LR)$	
Sym	bol Table					
	ing Increased ating is assumed		commercial buildings	5.		
ΔΜΙ	MBTU <sub>WH</sub>	= (∆kWł	$1 / WHF_e) \times 0.00341$	$2 \times (1 - OA) \times AR \times HF \times DR$	FH / ηHeat	
Where	2:					
	ΔkW	-	Gross customer cor	nnected load kW savings for t	he measure	
	ΔkWh	-	Gross customer and	nual kWh savings for the mea	isure	
	$\Delta MMBTU_{WH}$	-	Gross customer an	nual heating MMBTU fuel incr	eased usage for the measure	e from the reduction in lighting heat.
	ηHeat	-	Average heating sy	stem efficiency, For prescript	ive lighting, assumed to be 8	6.8% in existing buildings. <sup>[11]</sup>
	0.003412	-	Conversion from kV	Vh to MMBTU		
	AR	-	Aspect ratio factor; value is 60%. <sup>[12]</sup>	the typical square footage of	f commercial buildings within	15 feet of exterior wall. The default
	DFH	-	Percent of lighting i	n heated spaces. For prescr	iptive lighting, assumed to be	95%
	HF	-	ASHRAE heating fa be 0.0 for residenti		e heat for Burlington, Vermor	t for commercial lighting. <sup>[13]</sup> Assumed to
	HOURS	-	Annual lighting hou	rs of use per year. See table	e below.	
			LED Category	Customer Type	Operating Hours	
			All	C&I Rx	Collected from prescriptive form	
			LED Linear Replacement	Commercial EP and Smartlight	3554 <sup>[6]</sup>	
				Residential EP and Smartlight	986[7]	
			LED HID Replacement	Commercial Smartlight	3614 <sup>[8]</sup>	
			Lamps	Residential Smartlight	2044 <sup>[9]</sup>	

		Pin Base Lamps	Commercial	Smartlight	3100 <sup>(10)</sup>			
			Residential S	Smartlight	986 <sup>[7]</sup>			
ISR	- 1	In service rate, or th	e percentage o	f units rebate	ed that actually ge	et used. See tat	ble below.	
		LED Category	Customer T	уре	ISR			
		LED Linear Replacement	Commercial		0.92[1]			
			Residential		0.97 <sup>[2]</sup>			
		LED HID Replacement Lamps	Commercial		0.846 <sup>(3)</sup>			
			Residential		0.97 <sup>(2)</sup>			
		Pin Base Lamps	Commercial		0.846 <sup>[3]</sup>			
			Residential		0.97 <sup>[2]</sup>			
LR	-	Leakage Rate to ac	count for bulbs	sold to custo	mers outside of t	he program area	1	
		Lamp type		Leakage Ra	te			
		LED Linear Replace	ement	0.015 <sup>[4]</sup>				
		LED HID Replacem	ent Lamps	0				
		Pin Base Lamps		0				
OA	-	Dutside Air - the ave	erage percent o	f the supply a	ir that is Outside	Air, assumed to	) be 25%.[14]	
WattsBASE	- 1	Baseline connected	Watts from tabl	e located in F	Reference Tables	Section.		
Watts <sub>EE</sub>	- 1	Energy efficient con	nected Watts fro	om table loca	ted in Reference	Tables Section.		
WHFd							g. For prescriptive co al lighting is assumed	
WHFe							. For prescriptive con al lighting is assumed	

Load Shapes For prescriptive interior lighting C&I use # 12 (Commercial Indoor Lighting-Bended) for demand and lighting energy savings and where C&I cooling savings are characterized, use #15 (Commercial A/C) cooling energy savings. For prescriptive exterior lighting C&I applications; #13 (Commercial Outdoor Lighting)

For Residential or in-unit multifamily applications; #1 (Residential Indoor Lighting). For Residential Exterior applications; #2 (Residential Outdoor Lighting).

For C&I Smartlight; #101 (Commercial EP Lighting with Cooling Bonus)<sup>[15]</sup>

Ta Residential Indoor Lighting 2a Residential Outdoor Lighting 2a Residential Outdoor Lighting 12d Commercial Indoor Lighting - Bended 13a Commercial Outdoor Lighting 15c Commercial A/C 101c Commercial EP Lighting with cooling bonus

Number	Name	Status	Winter On kWh		Summer On kWh		Winter kW	Summer kW
1	Residential Indoor Lighting	Active	36.9%	35.0%	13.0%	15.1%	29.8%	8.2%
2	Residential Outdoor Lighting	Active	20.5%	50.6%	6.1%	22.8%	34.6%	1.8%
12	Commercial Indoor Lighting - Blended	Active	48.8%	19.5%	22.2%	9.5%	46.9%	67.9%
13	Commercial Outdoor Lighting	Active	20.5%	50.6%	6.1%	22.8%	70.2%	3.7%
15	Commercial A/C	Active	18.0%	10.0%	46.0%	26.0%	0.0%	34.2%
101	Commercial EP Lighting with cooling bonus	Active	47.7%	19.2%	23.0%	10.1%	33.8%	68.1%

### Net Savings Factors

Measures	
LBLT8LED LED Linear Replacement Lamp (TLED)	
LBLHDLED LED HID Lamp Replacement-Type B/C (direct-wired)	
LBUPBLED LED Pin-based Replacement Lamp for CFLs (using existing	g t
Tracks [Base Track] 6013PRES [is base track] Pres Equip Rol	

oorbinites [is base didek]	i i co cquip ripi
6013UPST [is base track]	Upstream - Commercial
6032EPEP [is base track]	Efficient Products - Residential
6032UPST [6032EPEP]	Upstream - Residential
6013EPEP [6032EPEP]	Efficient Products - Commercial

Lifetimes Measure lifetime is the rated lifetime (50,000 hours as required by DLC) divided by annual operating hours. Measure lifetime is capped at 15 years. LED Category Customer Type Measure Lifetime

llast)

LED Linear Replacement	Commercial	14.1		
	Residential	15		
LED HID Replacement	Commercial	13.8		
Lamps	Residential	15		
Pin Base Lamps	Commercial	15		
	Residential	15		

## Measure Cost

Assumptions, Deemed Savings, and Measure Costs" tables in the Reference Tables section for measure costs

#### **O&M Cost Adjustments**

, where in the Reference Tables section for O&M cost adjustme

See EVT\_LED Other Lamp\_Analysis\_ 2021.xfsx for analysis and references. Efficient wattage based on average of lamps on DLC QPL accessed 11/2020 (see 'DLC\_112020\_Other Lamps.xfs'). Deemed Savings and Measure Costs

LED Linear Repla	acement La	amps (TLED)	Wattage A	Assumptions, Dee	emed Savi	ngs, and	Measure	Costs				
EE Measure Description	WattsEE	Baseline Description	Watts <sub>Base</sub>	Market	∆kW	∆kWh	∆MMBtu	EE Cost	Baseline Cost	Incremental Cost	Measure Code	Item Code
				C&I Rx	0.01374	Dept on	Hours					BES-LEDLIN-/
LED Linear Replacement	15.7	Weighted mix	29.5	C&I EP and Smartlight	0.01374	45.9	0.029	\$18.71	\$6.62	\$12.09	LBLT8LED	Bes-Upledli A
Lamp (TLED)		ITIIX		Res EP and Smartlight	0.01314	13.0 0.000						RES- UPLEDLIN-A
LED HID Replace	ment Lam	ps Wattage	Assumption	ns, Deemed Savi	ngs, and N	leasure (	Costs					
EE Measure Description	WattsEE	Baseline Description	Watts <sub>Base</sub>	Market	∆kW	∆kWh	∆MMBtu	EE Cost	Baseline Cost	Incremental Cost	Measure Code	Item Code
LED HID				C&I Rx	0.07484	Dept on	Hours					BES-MOG-A
Replacement		100W		C&I Smartlight	0.07484	254.3	0.161	\$73.63 \$		\$54.00		BES-UPMOG-
Lamps Type B/C, <= 5,000 Iumens	33.3	Metal Halide	113.6	Res Smartlight	D.07786	159.2	0.000		\$20.00			RES-UPMOG-
LED HID				C&I Rx	0.12715	Dept on	Hours				LBLHDLED	BES-MOG-B
Replacement		175W Pulse		C&I Smartlight	0.12715	432.0	0.273	1	\$25.00	\$68.00		BES-UPMOG-
Lamps Type B/C, 5,001- 10.000 lumens	62.5	Start Metal Halide		Res Smartlight	0.13229	270.4	0.000	\$93.45				RES-UPMOG-
LED HID				C&I Rx	0.18896	Dept on	Hours					BES-MOG-E
Replacement		at shared		C&I Smartlight	0.18896	642.0	0.406	1				BES-UPMOG-
Lamps Type B/C, >10,000 lumens	119.3	Weighted Mix	322.0	Res Smartlight	0.19660	401.8	0.000	\$172.39	\$124.73	\$48.00		RES-UPMOG-
LED Pin-Base CF	L Replace	ment Lamps	Wattage A	ssumptions, Dee	med Savir	igs, and I	Measure C	losts				
EE Measure Description	WattsEE	Baseline Description	Watts <sub>Base</sub>	Market	∆kW	∆kWh	∆MMBtu	EE Cost	Baseline Cost	<b></b>	Measure Code	Item Code
ED Pin-Base				C&I Rx	0.00953	Dept on	Hours					BES-PIN-D
CFL		Weighted		C&I Smartlight	0.00953	27.8	0.018					BES-UPPIN-D
Replacement Lamp	9.8	Mix	20.0	Res Smartlight	0.00992	9.8	0.000	\$19.69	\$5.93	\$13.76	LBLPBLED	RES-UPPIN-D

#### O&M Adjustments

ED Linear Replacement Lamps (TLE	O) O&M Assumption	s		
EE Measure Description	LED Lamp Life	LED Lamp Replacement	Baseline Lamp Life	Baseline Lamp Replacement Cost Combined
EE Measure Description	(hrs)	Cost	(hrs)	baseline tamp Replacement Cost Combined
ED Linear Replacement Lamp	50.000	\$18.71	23.445	\$6.62
(TLED)	50,000	\$10.71	23,443	\$0.02

LED HID Replacement Lamps O&M Assump	tions	-				
EE Measure Description	LED Lamp	Replacement	Lamp Life	Replacement Cost	Ballast Life	Baseline Ballast Replacement Cost Combined
LED Mogul Base HID Replacement Lamps Type B/C, <= 5,000 lumens	50,000	\$75.00	15,000	\$58.00	40,000	\$102.50
LED Mogul Base HID Replacement Lamps Type B/C, 5,001-10,000 lumens	50,000	\$108.78	15,000	\$63.00	40,000	\$112.50
LED Mogul Base HID Replacement Lamps Type B/C, >10,000 lumens	50,000	\$172.39	15,000	\$69.11	40,000	\$124.73
n						

LED Pin-Base CFL Replacement Lamp	s O&M Assumptions			
EE Measure Description	LED Lamp Life (hrs)	LED Lamp Replacement Cost	Baseline Lamp Life (hrs)	Baseline Lamp Replacement Cost Combined
LED Pin-Base CFL Replacement	50,000	\$19.69	10.000	\$5.93
Lamp	50,000	\$19.09	10,000	\$3.95

#### Footnotes

3-year ISR for commercial LED linear lamps from DW GL, "Impact Evaluation of PY2015 Massachusetts Commercial and Industrial Upstream Lighting Initiative," November 22, 2017, page 32, Table 4-2.

- Commercial LED HID Replacement Lamps and Pin Base Lamps ISR is the 3-year ISR for LED lamps from DNV GL, "Ma Industrial Upstream Lighting Program: "In Storage" Lamps Follow-Up Study," March 27, 2015, page 5 [3]
- [4] Leakage Rate to account for LED Linear Replacement Lamps sold to customers outside of the program area via the EP program. LED HID Replacement Lamps and Phi Base Lamps are part of the Smartlight Program and end user information is collected at point of sale. The leakage rate of 1.5% was agreed to by EVT and DBS during Oddber 2017 FAG. This value is an estimate based on leakage rates used by other programs, geographic factors, and a consideration of similar lighting programs in surrounding service territories.
- The default waste heat factors for demand and energy for commercial indoor fixtures are from KEMA, "NEEP C&I Lighting Loadshape Project, KEMA," 2011. The report modeled the energy savings per building type and the associated energy, demand, and coincident demand interactive effects. A description of how the interactive effects were developed is on page 28 of the report, including details about how temperature balance points, equipment efficiencies, and heat to space factors influenced each building's designated interactive effects. The building types were weighted for the Ne-North Weather dimate zone in order to zone up with a single prescriptive default value for both demand and energy lighting waste heat factors. For more information, please see the spreadsheet, "EVT Lighting WHF Research\_Prescriptive\_2020.dsc". [5]
- [6] Operating hours for Commercial LED Linear Replacements are based on Efficiency Vermont data for prescriptive applications from 2015 through May 2017.
- Operating hours for Residential LED Linear Replacement Lamps, LED Troffers, and Pin Base Lamps are based on a household average 2.7 hours of use per day. NMR, "Northeast Residential Lighting Hours-of-Use Study", 5/5/2014. Page 34, Table 3-1. [7] Op
- [8] Operating hours for LED HID Replacement Lamps are based on Efficiency Vermont data for prescriptive applications from 2015 through October 2018.
- [9] Operating hours for Residential LED HID Replacement Lamps based on household exterior average 5.6 hours of use per day. NMR, "Northeast Residential Lighting Hours-of-Use Study", 5/5/2014. Page 34, Table 3-1.
- [10] Operating hours for Commercial Pin Base Lamps based on review of Efficiency Vermont custom QA projects.
- [11] Average AFUE of the HMAC heating equipment is based on the weighted average of existing commercial heating systems, as sourced from the "2016 VT Business Sector Market Obrarcterization and Assessment Study", Cadmus, April 2017 (page 65). For more information, please see the spreadsheet, "EVT Lighting WFR Research, Prescription, 2020.sks".
- [12] The ASHRAE heating factor applies to perimeter zone heat, therefore it must be adjusted to account for lighting in core zones. The typical aspect Inter-provencientary tabuta appress to planitete zante inate, une textel 4 initias to education of actional rule (zoness, in et power and expected) rule in a source of non NML, "Navajas educational expectation of the source of
- [13] From "Calculating lighting and HACI Interactions", Table 1, ASHRAE Journal November 1993. For more information, please see the spreads "EVT Lighting WHF Research, Prescriptive\_2020.xis.".

The ISR calculation for residential lamps follows the lifetime ISR approach from NRL, "Chapter 6: Residential Lighting Protocol," Oct 2017 from the Uniform Methods Protocol. The LMP protocol recommends truncating the ISR at the measure's EISA sunset date (date the program plans to end the measure based on the EISA backstop). EVT accounts for the shifting baseline through a mid-life adjustment and caps installations at 10 years for all many categories. The installation trajectory is from NMR Group, PLRPC Study 17-9 2017-18 Residential Lighting Merick Assessment Study, "March 28, 2016/ Study of bulks are installation trajectory is from NMR Group, Inc., "Efficiency Maine Retail Lighting Program Overall Evaluation assumes that 32% of bulks are installed in year 1 and 18 percent of bulks still in storage are installed in each subacquirt year. The calculation also assumes that 32% of bulks are installed in year 1 and 18 percent of bulks are submitted in each subacquirt year. The calculation Report FINL, "416/2015, page 14, Table 2-1, 95% from NMR Group, Inc., "Efficiency Maine Retail Lighting Program Overall Evaluation Report FINL," 416/2015, page 14, Table 2-1, 95% from NMR Group, Inc., "Connecticut ED Lighting Study Report (1814) FINL, "128/2016, page 10) and a discount rate of 3.00% based on the Vermont societal cost test. See file EVT\_SMARTLIGHT\_Dec 2018 v4.xisx for calculation details. [2]

[14] 2017 ASHRAE Handbook Fundamentals (p. 16.3): "Conventional all-air air-handling systems for commercial and institutional buildings often have approximately 10 to 40% outside air." For more information, please see the spreadsheet, "EVT Lighting WHF Research\_Prescriptive\_2020.dsx".

[15] Based on Commercial "Small" lighting coincidence factors from KEMA; "C&I Lighting Load Shape Project Final Report," July 19, 2011, prepared for the Regional Evaluation, Measurement and Verification Form, submitted to NEEP. The winter coincidence factor has been adjusted to remove the cooling bonus from winter peak demand.

### LED ENERGY STAR Screw Based Lamps

Measure Number:	CR-LTG-LEDSB b
Portfolio:	
Status:	Active
Effective Date:	2021/1/1
End Date:	[ None ]
Program:	Efficient Products Program
End Use:	Lighting

- Update Summary The following revisions have been made to the measu
- Intercolomy prevaluation where deal instance to de investance.
   Since ESRA backstop not encicted, ingrauge updated.
   Baseline watts now based on weighted mix (therefore NTG =1), and midlife adjuarment based upon replacen
   Smartight and EP are combined (now applying approved leakage rate to both programs)
   Costs updated and OBM impacts calculated based on weighted baseline mix.
   3 year assumptions calculated

#### Referenced Documents

- Calculating Lighting and HVAC Interactions\_ASHRAE
   KEMA Inc., "Impact Evaluation of the Massachusetts Upstream Lightin
   NMR, "Northeast Residential Uptioning House-of-Like Study", 5/5/2014.
   NMR\_R154 CT LED Lighting Study\_Final Report\_1 Program FINAL REPORT", February 2014

- reme, (LLS4 CT LED Lighting Study, Final Report, 1 PNNL, Analysis of Davighting Requirements, Aug 2013 NEPP, CL Lighting Loadshape, Jul 2011 Cadmus, VT Backness Sector Market Characterization, J CEE, Residential Lighting Initiative, Oct 2017 EVT Lighting WFF Research Prescriptive, 2020 2019\_sist-energy-savings-forecast on\_Apr 2017

- National Grid Smart Lighting System Re
   2021-2023\_EVT Lamp Analysis

### Description

Description An ENERGY STAR Integrated Screw Based SSL (LED) Lamp (specification effective October 2017) is installed in place of a baseline incandescent or halogen lamp. This measure is broken down in to Omnidirectional (e.g. A-Type lamps), becontive (e.g. Globes and Candelsaha Bala) and Drectonal (PAR Lamps, Reflectors, NBLS), Further, each hulb type is broken down into Comontum for Energy Efficiency (CED) playing specification ters 1 and 2<sup>11</sup> For programs that track DERGY STAR-qualified distributed builts but lack sufficient data to identify bulbs as either CEE Tier 1 or 2, an ENERGY STAR 2.1 Stander bire is provided. The blended teri is an average of the CEE ties, weighted by RVT sales data. Note that CEE Tier 1 meets the minimum ERERGY STAR 2.1 requirements and Tie 2 conceds the specification.

ent lamp fore

Assumptions are provided for the following markets: Efficient Products Retail, Efficient Products Free, Low Income, SMARTLIGHT, Residential Direct Install, and Home Energy Visit ENERGY STAR LED Bub Dropship.

Market	Description
Efficient Products Retail (Residential and Commercial)	This is for retail sales for Residential or Commercial customers.
Efficient Products Free	An LED lamp is received free of charge at an Efficiency Vermont event or as part of a targeted campaign and is installed in a Residential fixture.
Low Income	Inclusive of the traditional Foodbanks, but also can include other organizations that provide "free" bulbs and provide documentation stating that clientele are in an applicable income bracket.
SMARTLIGHT (Residential and Commercial)	In reference to PIP #67a: Upstream Distributor Incentive Model Efficiency Vermont offers "upstream" incentives to Vermont electrical distributors for certain eligible LED lamps.
Residential Direct Install	LED lamp is physically installed by an efficiency program representative through a direct install program
LED Dropship	An EVT consultant visits a residential home, identifies high use sockets with inefficient (incandescent or halogen) buits, and places an order with a local distributor for replacement efficient LEDs. A distributor ships products to customer, free of charge. Instructions for which builts are to be installed and where are included in the package.

Program Type Program Delivery / Implementation Type: Midstream, Direct Install, Free

Baseline Efficiencies Federal legislation stemming from the Energy Independence and Security Act of 2007 began the phasing out of omnidirectional incandescent bulbs. From 2012, 100W incandescents could no longer be manufactured, followed by restrictions on 75W in 2013 and 60W/40W in 2014.

Additionally, an ESA backstop provision was included that would require replacement baseline lamps to meet an efficacy requirement of 45 lumens/watt on higher beginning on 1/1/202. Newer, in December 2019, DOE issued a final determination for General Service Incandescent Lamps (GSLs), finding that this more stringert standard was not economically justified.

The natural growth of LED market share however, has and will continue to grow over the lifetime of the LED measures installed. Therefore a forecas the baseline growth of LED has been developed, based upon historical growth rates provided via CREED LightTracker data for no-program states, an review of projections provided by the beautiment of Energy. ast of

This baseline forecast is used to estimate a weighted average baseline wattage for the next three years, and also used to estimate how replacement lamps would change over the lifetime of the LED. A single mid-life adjustment is calculated that results in an equivalent net present value of lifetime savings as the forecast decime in annual savings.

Note that by using the estimated weighted average baseline, the NTG for this measure should be 1.0.

#### High Efficiency

age is assumed to be a CEE Tier 1 or Tier 2 qualified lamp. ENERGY STAR 'Blended' values should be used if the CEE Tier is unknown. See "2021-2023 EVT Lamp Analysis.xls" for details.

## Algorithms Electric Demand Savings



Symbol Table Heating Penalty

thore																			
/here:																			
ΔkW											neasure.								
ΔkWh			oss cust				-												
ΔММВ	ГU <sub>WH</sub>							IBTU fu	el incr	rease	ed usage	for the	mea	sure	from the	reduc	tion ir	n ligh	iting heat.
ηHeat			verage h 86.8% <sup>[1</sup>		j systi	em ef	haency												
0.0034	12	= C(	onversion	n from	n kWh	to M	MBTU												
AR			Aspect ratio factor; the typical square footage of commercial buildings within 15 feet of exterior wall. The default value is 659% <sup>21</sup> .																
Conne	cted	= 1	if Conne	cted L	amp,	0 if r	ot												
Conne	ctedkWhSavings		W/h Swings from connected capabilities $= 5.1^{(4)} \label{eq:spin}$																
DFH		= Pe	ercent of	lighti	ng in	heate	d space:	s. For	presci	riptiv	e lighting	, assur	ned t	o be	95%				
HF			5HRAE h be 0.0 f					lighting	wast	e hea	at for Bur	lington	, Veri	mont	for com	mercia	l light	ing.[1	15] Assumed
HOURS	5	= Av	verage h	ours o	of use	per y	/ear.												
		_	Market						iual H	lour	5								
			Commen		oct In	stall i	vterior	3,97											
		L	Residenti				DAUGHION	986											
ISR		= In	service	rate o	or the	perce	entage o	funits	rehate	ed th	at actual	lv aet u	ised.						
			ependen									, 3							
		_	Market				1	SR											
						eter B													
		ľ	Residenti	al Dir	ect In	stall	,	97%[8]											
			Efficient					)7% <sup>[9]</sup>			_								
			SMARTLI Low Inco Dropship	me, a			I),												
		1	Efficient	Produ				34.6%	.0]										
			Efficient					70%[11]											
				riouu	0.011	ee	ĺ	0.00											
LR		= 14	akane R	ate tr	acco	unt fr	r bulbs	cold to	rusto	merc	outside	of the r	nroar	am a	rea				
LK			0.015 <sup>[12</sup>									or ure j	progr		i ca				
		-	0 for Eff	icient	Prod	ucts F	ree, Lov	/ Incom	ie, Re	eside	ntial Dire	ect Insta	all, ar	nd LE	D Dropsh	iip			
OA															d to be 2				
StudyL	EDW		D Watta 11.5 W	ge fro	om Co	innec	ted Stud	y. Used	to ad	ljust	study fin	dings ri	elativ	e to l	ED watta	age of	meas	ure.	
Watts																			
aus	ASE	= Ba	aseline o	onnec	ted k	W. Se	e assum	ptions	in tab	ile be	low.								
Watts											low. table bel	ow.							
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	Connected	Tier 1 CEE	10.9	20.4	19.8	19.2	0.00945	37.6		0.75	0.00895	35.6		0.7 1	0.00842	33.5		0.71	SLCDIREC1 EPCDIREC2
		Tier 2 Blended	10	26.6	25.3	23.9	0.01168	11.5	-		0.01073	10.6	_		0.00974	9.6	-	Η	SLCDIREC2 FREEOMNIE
	Omnidirectional	CEE Tier 1	9.4	25	23.7	22.4	0.01094	10.8	2024	0.42	0.01005	9.9	2025	0.4	0.00912	9	2026	0.39	FREEOMNI
		CEE Tier 2	12.9	34.9	33.2	31.3	0.01540	15.2			0.01415	13.9			0.01285	12.7			FREEOMNE
		Blended	4.7	19.7	18	16.9	0.01053	10.4			0.00937	9.2			0.00859	8.5		H	FREEDECO
	Decorative	CEE Tier 1	5	19.6	18	16.9	0.01024	10.1	2024	0.66	0.00912	9	2025	0.74	0.00835	8.2	2026	0.8	FREEDECO
		CEE Tier 2	4.3	19.8	18.1	16.9	0.01083	10.7			0.00964	9.5			0.00883	8.7	1		FREEDECO.
		Blended	9.7	17.9	17.4	16.9	0.00578	5.7			0.00541	5.3			0.00504	5		Η	FREEDIREE
	Directional	CEE Tier 1	9.5	17.5	17	16.5	0.00561	5.5	2024	0.59	0.00526	5.2	2025	0.59	0.00490	4.8	2026	0.59	FREEDIRE1
	Directorial	CEE	10.9	20.4	19.8	19.2	0.00667	6.6	2021	0.55	0.00625	6.2	2025	0.55	0.00582	5.7	1020		ERFEDIRE2
Efficient Products Free		Tier 2 Blended	10	26.6	25.3	23.9	0.01613	15.9			0.01522	15			0.01421	14		$\vdash$	FREEOMNIC
	Omnidirectional	CEE	9.4	25	23.7		0.01512	14.9			0.01431	14.1			0.01329	13.1	1		FREEOMNIC
	Connected	Tier 1 CEE							2024	0.54			2025	0.54			2026	0.55	
		Tier 2	12.9	34.9	33.2			20.9			0.01999	19.7			0.01867	18.4			FREEOMNIC
		Blended CEE	4.7	19.7	18	16.9	0.01258	12.4			0.01147	11.3			0.01065	10.5	-		FREEDECOC
	Decorative Connected	Tier 1	5	19.6	18	16.9	0.01248	12.3	2024	0.7	0.01136	11.2	2025	0.77	0.01055	10.4	2026	0.83	FREEDECOC
		CEE Tier 2	4.3	19.8	18.1	16.9	0.01279	12.6			0.01157	11.4			0.01076	10.6			FREEDECOC
		Blended	9.7	17.9	17.4	16.9	0.01015	10			0.00974	9.6			0.00944	9.3		H	FREEDIREC
	Directional	CEE Tier 1	9.5	17.5	17	16.5	0.00984	9.7	2024	0.73	0.00954	9.4	2025	0.74	0.00913	9	2026	0.74	FREEDIREC
	Connected	CEE	10.9	20.4	19.8	19.2	0.01157	11.4	[		0.01116	11			0.01076	10.6	1		FREEDIREC
		Tier 2 Blended	10	26.6	25.3	23.9	0.01594	15.7	-		0.01465	14.4	_		0.01330			$\vdash$	DSNOMNIE
		CEE	9.4	25	23.7	22.4	0.01493	14.7			0.01372	13.5			0.01245	12.3	1		DSNOMNII
	Omnidirectional	Tier 1 CEE							2024	U.42			2025	0.4			2026	0.39	<u> </u>
		Tier 2	12.9	34.9	33.2		0.02102	20.7			0.01931	19			0.01754	17.3			DSNOMNIZ
Non Low		Blended CEE	4.7	19.7	18		0.01437	14.2			0.01279	12.6			0.01172	11.6	1		DSNDECOE
Income	Decorative	Tier 1	5	19.6	18	16.9	0.01397	13.8	2024	0.66	0.01244	12.3	2025	0.74	0.01140	11.2	2026	0.8	DSNDEC01
Dropship		CEE Tier 2	4.3	19.8	18.1	16.9	0.01478	14.6			0.01316	13			0.01206	11.9			DSNDECO2
		Blended	9.7	17.9	17.4	16.9	0.00789	7.8	-		0.00739	7.3			0.00688	6.8		Η	DSNDIREB
	Directional	CEE Tier 1	9.5	17.5	17	16.5	0.00766	7.5	2024	0,50	0.00718	7.1	2025	0.50	0.00669	6.6	2026	0.50	DSNDIRE1
	Directional	CEE	10.9	20.4	19.8	19.2	0.00910	9	2024	0.35	0.00853	8.4	2025	0.35	0.00795	7.8	2020	0.35	DSNDIRE2
		Tier 2 Blended	10.5	31.3	29.9	28.2	0.02071	20.4	-		0.01930	19	_		0.01774	17.5			LIFOMNIB
		CEE	9,4	29.3	29.9		0.02071	19.1			0.01930	17.8			0.01774	16.4	1		LIFOMNI
	Omnidirectional	Tier 1 CEE	9.4	29.3	28	20.5	0.01936	19.1	2024	0.42	0.01806	17.8	2025	0.41	0.01660	16.4	2026	0.41	LIFOMINII
		Tier 2	12.9	41.1	39.2	37.1	0.02734	26.9			0.02546	25.1			0.02341	23.1			LIFOMNI2
		Blended	4.7	30.4	24	20.9	0.02496	24.6			0.01874	18.5			0.01580	15.6			LIFDECOB
	Decorative	CEE Tier 1	5	30	23.8	20.8	0.02427	23.9	2024	0.66	0.01822	18	2025	0.74	0.01536	15.1	2026	0.8	LIFDECO1
		CEE	4.3	30.8	24.2	21.1	0.02569	25.3			0.01929	19			0.01626	16	1		LIFDECO2
		Tier 2 Blended	9.7	24.8	19.4	18.3	0.01469	14.5	-		0.00947	9.3	_		0.00832	8.2		H	LIFDIREB
		CEE	9.5	24.2	18.9	17.8	0.01427	14.1			0.00920	9.1			0.00808	8			LIFDIRE1
	Directional	Tier 1 CEE							2024	0.59			2025	0.59			2026	0.59	
Low Income Retail and		Tier 2	10.9	28.4	22.1		0.01697	16.7			0.01094	10.8			0.00961	9.5			LIFDIRE2
Dropship		Blended	10	31.3	29.9	28.2	0.02516	24.8			0.02374	23.4			0.02222	21.9	1		LIFOMNICE
		CEE																	
	Omnidirectional Connected	CEE Tier 1	9.4	29.3	28	26.5	0.02354	23.2	2024	0.54	0.02222	21.9	2025	0.54	0.02080	20.5	2026	0.55	LIFOMNIC:
			9.4 12.9	29.3 41.1	28 39.2	26.5 37.1	D.02354 D.03318	23.2 32.7	2024	0.54	0.02222	21.9 30.8	2025	0.54	0.02080	20.5 28.8	2026	0.55	
		Tier 1 CEE Tier 2 Blended							2024			-	2025	0.54		28.8	2026	0.55	
	Connected	Tier 1 CEE Tier 2 Blended CEE	12.9	41.1	39.2	37.1	0.03318	32.7			0.03125	30.8	2025		0.02922	28.8			LIFOMNICZ
	Connected	Tier 1 CEE Tier 2 Blended CEE Tier 1 CEE	12.9 4.7 5	41.1 30.4 30	39.2 24	37.1 20.9	0.03318 0.02709	32.7 26.7	2024		0.03125	30.8 20.5			0.02922 0.01786 0.01766	28.8 17.6 17.4	2026		LIFOMNIC
	Connected	Tier 1 CEE Tier 2 Blended CEE Tier 1 CEE Tier 2	12.9 4.7 5 4.3	41.1 30.4 30 30.8	39.2 24 23.8 24.2	37.1 20.9 20.8 21.1	0.03318 0.02709 0.02648 0.02760	32.7 26.7 26.1 27.2			0.03125 0.02080 0.02050 0.02121	30.8 20.5 20.2 20.9			0.02922 0.01786 0.01766 0.01816	28.8 17.6 17.4 17.9			LIFOMNIC: LIFDECOCI LIFDECOCI
	Connected	Tier 1 CEE Tier 2 Blended CEE Tier 1 CEE Tier 2 Blended CEE	12.9 4.7 5	41.1 30.4 30 30.8 24.8	39.2 24 23.8 24.2 19.4	37.1 20.9 20.8 21.1 18.3	0.03318 0.02709 0.02648	32.7 26.7 26.1 27.2 18.8	2024	0.7	0.03125 0.02080 0.02050 0.02121 0.01380	30.8 20.5 20.2 20.9 13.6	2025	0.77	0.02922 0.01786 0.01766 0.01816 0.01268	28.8 17.6 17.4 17.9 12.5	2026	0.83	LIFOMNIC2 LIFDECOCE
	Connected Decorative Connected	Tier 1 CEE Tier 2 Blended CEE Tier 1 CEE Tier 2 Blended CEE Tier 1	12.9 4.7 5 4.3 9.7 9.5	41.1 30.4 30 30.8 24.8 24.2	39.2 24 23.8 24.2 19.4 18.9	37.1 20.9 20.8 21.1 18.3 17.8	0.03318 0.02709 0.02648 0.02760 0.01908 0.01857	32.7 26.7 26.1 27.2 18.8 18.3		0.7	0.03125 0.02080 0.02050 0.02121 0.01380 0.01350	30.8 20.5 20.2 20.9 13.6 13.3		0.77	0.02922 0.01786 0.01766 0.01816 0.01268 0.01238	28.8 17.6 17.4 17.9 12.5 12.2		0.83	LIFOMNIC LIFDECOCI LIFDECOCI LIFDECOCI LIFDIRECE LIFDIRECE
	Connected Decorative Connected Directional	Tier 1 CEE Tier 2 Blended CEE Tier 1 CEE Tier 2 Blended CEE	12.9 4.7 5 4.3 9.7	41.1 30.4 30 30.8 24.8	39.2 24 23.8 24.2 19.4 18.9	37.1 20.9 20.8 21.1 18.3 17.8	0.03318 0.02709 0.02648 0.02760 0.01908	32.7 26.7 26.1 27.2 18.8	2024	0.7	0.03125 0.02080 0.02050 0.02121 0.01380	30.8 20.5 20.2 20.9 13.6	2025	0.77	0.02922 0.01786 0.01766 0.01816 0.01268	28.8 17.6 17.4 17.9 12.5	2026	0.83	LIFOMNIC: LIFDECOCI LIFDECOCI LIFDECOCI LIFDIRECE LIFDIRECE
	Connected Decorative Connected Directional	Tier 1 CEE Tier 2 Blended CEE Tier 1 CEE Tier 2 Blended CEE Tier 1 CEE Tier 2 Blended Blended	12.9 4.7 5 4.3 9.7 9.5 10.9 10	41.1 30.4 30 30.8 24.8 24.2 28.4	39.2 24 23.8 24.2 19.4 18.9 22.1	37.1 20.9 20.8 21.1 18.3 17.8 20.8	0.03318 0.02709 0.02648 0.02760 0.01908 0.01908 0.01857 0.02182 0.04113	32.7 26.7 26.1 27.2 18.8 18.3 21.5 40.5	2024	0.7	0.03125 0.02080 0.02050 0.02121 0.01380 0.01350 0.01583 0.04095	30.8 20.5 20.2 20.9 13.6 13.3 15.6 40.4	2025	0.77	0.02922 0.01786 0.01766 0.01816 0.01268 0.01238 0.01451 0.04075	28.8 17.6 17.4 17.9 12.5 12.2 14.3 40.2	2026	0.83	LIFOMNICZ LIFDECOCE LIFDECOCZ LIFDECOCZ LIFDIRECE
	Connected Decorative Connected Directional	Tier 1 CEE Tier 2 Blended CEE Tier 1 CEE Tier 2 Blended CEE Tier 1 CEE Tier 2 Blended CEE	12.9 4.7 5 4.3 9.7 9.5 10.9 10	41.1 30.4 30 30.8 24.8 24.2 28.4	39.2 24 23.8 24.2 19.4 18.9 22.1	37.1 20.9 20.8 21.1 18.3 17.8 20.8	0.03318 0.02709 0.02648 0.02760 0.01908 0.01908 0.01857 0.02182 0.04113	32.7 26.7 26.1 27.2 18.8 18.3 21.5 40.5	2024	0.7	0.03125 0.02080 0.02050 0.02121 0.01380 0.01350 0.01583	30.8 20.5 20.2 20.9 13.6 13.3 15.6 40.4	2025	0.77	0.02922 0.01786 0.01766 0.01816 0.01268 0.01238 0.01451 0.04075	28.8 17.6 17.4 17.9 12.5 12.2 14.3 40.2	2026	0.83	LIFOMNIC: LIFDECOCI LIFDECOCI LIFDECOCI LIFDIRECI LIFDIRECI LIFDIRECI DIIOMNII
	Connected Decorative Connected Directional Connected	Tier 1 CEE Tier 2 Blended CEE Tier 1 CEE Tier 2 Blended CEE Tier 2 Blended CEE Tier 2 Blended CEE Tier 1 CEE	12.9 4.7 5 4.3 9.7 9.5 10.9 10	41.1 30.4 30 30.8 24.8 24.2 28.4	39.2 24 23.8 24.2 19.4 18.9 22.1	37.1 20.9 20.8 21.1 18.3 17.8 20.8	0.03318 0.02709 0.02648 0.02760 0.01908 0.01857 0.02182	32.7 26.7 26.1 27.2 18.8 18.3 21.5 40.5 41.1	2024	0.7	0.03125 0.02080 0.02050 0.02121 0.01380 0.01350 0.01583 0.04095	30.8 20.5 20.2 20.9 13.6 13.3 15.6 40.4 40.9	2025	0.77	0.02922 0.01786 0.01766 0.01816 0.01268 0.01238 0.01451 0.04075	28.8 17.6 17.4 17.9 12.5 12.2 14.3 40.2 40.7	2026	0.83	LIFOMNIC: LIFDECOCI LIFDECOCI LIFDECOCI LIFDIRECE LIFDIRECE LIFDIRECE DIIOMNIZ
	Connected Decorative Connected Directional Connected Omnidirectional	Tier 1 CEE Tier 2 Blended CEE Tier 1 CEE Tier 2 Blended CEE Tier 1 CEE Tier 2 Blended CEE Tier 2 CEE Tier 3 CEE Tier 3 CEE Tie Tier 3 CEE Tier 3 CEE Tier 3 CEE	12.9 4.7 5 4.3 9.7 9.5 10.9 10 9.4	41.1 30.4 30 30.8 24.8 24.2 28.4	39.2 24 23.8 24.2 19.4 18.9 22.1	37.1 20.9 20.8 21.1 18.3 17.8 20.8	0.03318 0.02709 0.02648 0.02760 0.01908 0.01857 0.02182 0.04113 0.04170	32.7 26.7 26.1 27.2 18.8 18.3 21.5 40.5 41.1	2024	0.7	0.03125 0.02080 0.02050 0.02121 0.01380 0.01350 0.01583 0.04095 0.04152	30.8 20.5 20.2 20.9 13.6 13.3 15.6 40.4 40.9 37.5	2025	0.77	0.02922 0.01786 0.01766 0.01816 0.01268 0.01238 0.01238 0.01451 0.04075 0.04132	28.8 17.6 17.4 17.9 12.5 12.2 14.3 40.2 40.7 37.3	2026	0.83	LIFOMNIC: LIFDECOCI LIFDECOCI LIFDECOCI LIFDIRECI LIFDIRECI LIFDIRECI DIIOMNII DIIOMNII
	Connected Decorative Connected Directional Connected Omnidirectional	Tier 1 CEE Tier 2 Blended CEE Tier 1 CEE Tier 2 Blended CEE Tier 1 CEE Tier 2 Blended CEE Tier 2 CEE Tier 3 CEE Tier 3 CEE TIE TIE TIE TIE TIE TIE TIE TIE TIE	12.9 4.7 5 4.3 9.7 9.5 10.9 10 9.4 12.9	41.1 30.4 30 30.8 24.2 28.4 52.4	39.2 24 23.8 24.2 19.4 18.9 22.1	37.1 20.9 20.8 21.1 18.3 17.8 20.8 52	0.03318 0.02709 0.02648 0.02760 0.01908 0.01857 0.02182 0.04113 0.04170 0.03823	32.7 26.7 26.1 27.2 18.8 18.3 21.5 40.5 41.1 37.7 34	2024	0.7	0.03125 0.02080 0.02050 0.02121 0.01380 0.01350 0.01583 0.04095 0.04152 0.03805 0.03443	30.8 20.5 20.2 20.9 13.6 13.3 15.6 40.4 40.9 37.5 33.9	2025	0.77	0.02922 0.01786 0.01766 0.01816 0.01268 0.01238 0.01451 0.04075 0.04132 0.03785	28.8 17.6 17.4 17.9 12.5 12.2 14.3 40.2 40.7 37.3 33.9	2026	0.83	LIFOMNIC: LIFDECOCI LIFDECOC LIFDECOCI LIFDIRECI LIFDIRECI DIIOMNII DIIOMNII DIIOMNII DIIOMNII
	Connected Decorative Connected Directional Connected Omnidirectional	Tier 1 CEE Tier 2 Blended CEE Tier 1 CEE Tier 2 Blended CEE Tier 1 CEE Tier 2 Blended CEE Tier 2 Blended CEE Tier 1 CEE Tier 2 CEE Tier 2 CEE Tier 2 CEE CEE CEE Tier 1 CEE CEE CEE CEE Tier 2 CEE CEE CEE CEE CEE CEE CEE CEE CEE CE	12.9 4.7 5 4.3 9.7 9.5 10.9 10.9 9.4 12.9 4.7 5	41.1 30.4 30 30.8 24.2 28.4 52.4	39.2 24 23.8 24.2 19.4 18.9 22.1	37.1 20.9 20.8 21.1 18.3 17.8 20.8 52	0.03318 0.02709 0.02648 0.02760 0.01908 0.01857 0.02182 0.04113 0.04170 0.03823 0.03446 0.03413	32.7 26.7 26.1 27.2 18.8 18.3 21.5 40.5 41.1 37.7 34 33.6	2024	0.7	0.03125 0.02080 0.02050 0.02121 0.01380 0.01583 0.04095 0.04152 0.03805 0.03443 0.03410	30.8 20.5 20.2 13.6 13.3 15.6 40.4 40.9 37.5 33.9 33.6	2025	0.77	0.02922 0.01786 0.01766 0.01816 0.01268 0.01238 0.01451 0.04075 0.04075 0.03785 0.03785 0.033439	28.8 17.6 17.4 17.9 12.5 12.2 14.3 40.2 40.7 37.3 33.9 33.6	2026	0.83	LIFOMNIC: LIFDECOCI LIFDECOCI LIFDECOCI LIFDIRECE LIFDIRECE DIIOMNII DIIOMNI2 DIIOMNI3 DIIDECO1 DIIDECO1
	Connected Decorative Connected Directional Connected Omnidirectional	Tier 1 CEE Tier 2 Blended CEE Tier 1 CEE Tier 2 Blended CEE Tier 1 CEE Tier 2 Blended CEE Tier 2 Blended CEE Tier 2 Blended CEE Tier 2 CEE Tier 3 CEE Tier 3 CEE TIE 3 CEE CEE TIE 3 CEE TIE CEE TIE C CEE TIE CEE TIE CEE CEE TIE CEE TI	12.9 4.7 5 4.3 9.7 9.5 10.9 9.4 12.9 4.7 5 4.3	41.1 30.4 30 30.8 24.2 28.4 52.4	39.2 24 23.8 24.2 19.4 18.9 22.1	37.1 20.9 20.8 21.1 18.3 17.8 20.8 52	0.03318 0.02709 0.02648 0.02760 0.01908 0.01857 0.02182 0.04113 0.04170 0.03823 0.03823 0.03423 0.03413	32.7 26.7 26.1 27.2 18.8 18.3 21.5 40.5 41.1 37.7 34 33.6 34.3	2024	0.7	0.03125 0.02080 0.02050 0.02121 0.01380 0.01350 0.01583 0.04095 0.04152 0.03805 0.03405 0.03443 0.03410	30.8 20.5 20.2 20.9 13.6 13.3 15.6 40.4 40.9 37.5 33.9 33.6 34.3	2025	0.77	0.02922 0.01786 0.01766 0.01816 0.01268 0.01238 0.01451 0.04475 0.04475 0.03785 0.03785 0.03785 0.03439 0.03406	28.8 17.6 17.4 17.9 12.5 12.2 14.3 40.2 40.7 37.3 33.9 33.6 34.2	2026	0.83	LIFOMNIC: LIFDECOCI LIFDECOCI LIFDECOCI LIFDIRECE LIFDIRECE DIIONNII DIIONNIZ DIIONNIZ DIIONNIZ DIIDECO2 DIIDECO2
	Connected Decorative Connected Directional Connected Omnidirectional	Tier 1 CEE Blended CEE Tier 2 Blended CEE Tier 2 Blended CEE Tier 1 CEE Tier 2 Blended CEE Tier 1 CEE Tier 2 Blended CEE Tier 2 Blended CEE Tier 2 Blended CEE Tier 2 CEE Tier 2 CEE CEE CEE CEE CEE CEE CEE CEE CEE CE	12.9 4.7 5 4.3 9.7 9.5 10.9 10 9.4 12.9 4.7 5 4.3 9.7	41.1 30.4 30 24.8 24.2 28.4 52.4 40.2	39.2 24 23.8 24.2 19.4 18.9 22.1 52.2 40.2	37.1 20.9 20.8 21.1 18.3 17.8 20.8 52 40.1	0.03318 0.02709 0.02648 0.02760 0.01908 0.01857 0.02182 0.04113 0.04170 0.03823 0.03823 0.03446 0.03413 0.034481	32.7 26.7 26.1 27.2 18.8 18.3 21.5 40.5 41.1 37.7 33.6 34.3 324.6	2024 2024 2024 2024	0.7	0.03125 0.02080 0.02050 0.02121 0.01380 0.01350 0.04095 0.04095 0.03405 0.03443 0.03443 0.03448 0.03478	30.8 20.5 20.2 20.9 13.6 13.3 15.6 40.4 40.9 37.5 33.9 33.6 34.3 24.6 24.8	2025	0.77	0.02922 0.01786 0.01766 0.01816 0.01268 0.01238 0.01451 0.04075 0.04075 0.03405 0.03439 0.03406 0.03474	28.8 17.6 17.4 17.9 12.5 12.2 14.3 40.2 40.7 37.3 33.9 33.6 34.2 24.6	2026	0.83	LIFOMNIC: LIFDECOCI LIFDECOCI LIFDECOCI LIFDIRECI LIFDIRECI LIFDIRECI DIIOMNII DIIOMNII DIIOMNII DIIOMNII DIIDECOI DIIDECOI DIIDECOI DIIDECOI
	Connected Decorative Connected Directional Connected Omnidirectional	Tier 1 CEE Biended CEE Tier 2 Blended CEE Tier 1 CEE Tier 2 Blended CEE Tier 1 CEE Tier 2 Blended CEE Tier 1 CEE Tier 2 Blended CEE Tier 2 Blended CEE Tier 2 Blended CEE Tier 1 CEE Tier 2 Blended CEE Tier 1 CEE Tier 2 Blended CEE Tier 1 CEE Tier 2 Blended CEE Tier 1 CEE Tier 2 Blended CEE Tier 1 CEE Tier 1 CEE Tier 1 CEE Tier 1 CEE Tier 2 Blended CEE Tier 1 CEE Tier 1 CEE CEE Tier 1 CEE Tier 1 CEE Tier 1 CEE Tier 1 CEE Tier 2 CEE Tier 1 CEE Tier 2 CEE Tier 1 CEE Tier 2 CEE Tier 2 CEE Tier 1 CEE Tier 2 CEE Tier 2 CEE Tier 2 CEE Tier 2 CEE Tier 2 CEE Tier 2 CEE Tier 2 CEE Tier 2 CEE Tier 2 CEE Tier 1 CEE Tier 1 CEE Tier 1	12.9 4.7 5 4.3 9.7 9.5 10.9 10.9 10.9 4.7 5 4.3 9.7 9.5	41.1 30.4 30 24.8 24.2 28.4 52.4 40.2	39.2 24 23.8 24.2 19.4 18.9 22.1	37.1 20.9 20.8 21.1 18.3 17.8 20.8 52 40.1	0.03318 0.02709 0.02648 0.02760 0.01908 0.01857 0.02182 0.04113 0.04170 0.03823 0.03446 0.03413 0.03441 0.03441 0.03421 0.03481	32.7 26.7 26.1 27.2 18.8 18.3 21.5 40.5 41.1 37.7 34 33.6 34.3 24.6 24.8	2024	0.7	0.03125 0.02080 0.02050 0.02121 0.01380 0.01350 0.04095 0.04152 0.03805 0.03413 0.03410 0.03410 0.03478 0.02497	30.8 20.5 20.2 20.9 13.6 13.3 15.6 40.4 40.9 37.5 33.9 33.6 34.3 24.6 24.8	2025	0.77	0.02922 0.01786 0.01766 0.01816 0.01268 0.01238 0.01451 0.04075 0.04132 0.03406 0.03439 0.03440 0.03440 0.03474 0.02497 0.02518	28.8 17.6 17.4 17.9 12.5 12.2 14.3 40.2 40.7 37.3 33.9 33.6 34.2 24.6 24.8	2026	0.83	LIFOMNIC LIFDECOCI LIFDECOCI LIFDECOCI LIFDIRECI LIFDIRECI DIIORICI DIIONNIZ DIIONNIZ DIIONNIZ DIIOECOI DIIDECOI DIIDECOI DIIDECOI
ow Income* and	Connected Decorative Connected Directional Connected Decorative	Tier 1 CEE Bended CEE Tier 1 CEE Tier 1 CEE Tier 2 Bended CEE Tier 2 Bended CEE Tier 2 Bended CEE Tier 2 Bended CEE Tier 2 Bended CEE Tier 2 Bended CEE Tier 2 CEE Tier 3 CEE Tier 3 CEE TIE TIE TIE C	12.9 4.7 5 4.3 9.7 9.5 10.9 9.4 12.9 4.7 5 4.3 9.7 9.5 10.9	41.1 30.4 30 24.8 24.2 28.4 52.4 40.2	39.2 24 23.8 24.2 19.4 18.9 22.1 52.2 40.2	37.1 20.9 20.8 21.1 18.3 17.8 20.8 52 40.1	0.03318 0.02709 0.02648 0.02760 0.01908 0.01857 0.02182 0.04113 0.04170 0.03823 0.03413 0.03413 0.03413 0.03413 0.03481 0.02497 0.02519 0.02519	32.7 26.7 26.1 27.2 18.8 18.3 21.5 40.5 41.1 37.7 34 33.6 34.3 24.6 24.8 23.5	2024 2024 2024 2024	0.7	0.03125 0.02080 0.02050 0.02121 0.01380 0.01583 0.04095 0.04152 0.03805 0.03413 0.03410 0.03414 0.03410 0.03478 0.02518	30.8 20.5 20.2 20.9 13.6 13.3 15.6 40.4 40.9 37.5 33.9 33.6 34.3 24.6 24.8 23.5	2025	0.77	0.02922 0.01786 0.01766 0.01268 0.01451 0.01451 0.04075 0.03405 0.03439 0.03406 0.03474 0.02497 0.02518	28.8 17.6 17.4 17.9 12.5 12.2 14.3 40.2 40.7 37.3 33.9 33.6 34.2 24.6 24.8 23.5	2026	0.83	LIFOMNIC LIFDECOCI LIFDECOCI LIFDECOCI LIFDECOCI LIFDIRECI LIFDIRECI DIIONNII DIIONNII DIIONNII DIIONNII DIIONNII DIIOECOI DIIDECOI DIIDECOI DIIDECOI DIIDECOI DIIDECOI DIIDECOI DIIDECOI DIIDECOI
ow Income* and Residential Krect Install	Connected Decorative Connected Directional Omnidirectional Decorative Directional	Tier 1           CEE           Tier 2           Blended           CEE           Tier 1           CEE           Tier 2           Blended           CEE           Tier 1           CEE           Tier 2           Blended           CEE           Tier 1           CEE           Tier 2           Blended           CEE           Tier 1           CEE           Tier 1           CEE           CEE           Tier 1           CEE           CEE           CEE           CEE           CEE	12.9 4.7 5 4.3 9.7 9.5 10.9 10 9.4 12.9 4.7 5 4.3 9.7 9.5 10.9 10.9 10.9	41.1 30.4 30 24.8 24.2 28.4 52.4 40.2	39.2 24 23.8 24.2 19.4 18.9 22.1 52.2 40.2	37.1 20.9 20.8 21.1 18.3 17.8 20.8 52 40.1	0.03318 0.02709 0.02648 0.02760 0.01908 0.01857 0.02182 0.04113 0.03823 0.03823 0.03823 0.03823 0.03824 0.03823 0.03823 0.03823 0.03823 0.02519 0.02383 0.04556	32.7 26.7 26.1 18.8 18.3 21.5 40.5 41.1 37.7 34 33.6 34.3 24.6 24.8 23.5 44.9	2024 2024 2024 2024	0.7	0.03125 0.02080 0.02050 0.02121 0.01380 0.01583 0.04095 0.04152 0.03805 0.03413 0.03410 0.03410 0.03478 0.02497 0.02518 0.02383 0.04546	30.8 20.5 20.2 13.6 13.3 15.6 40.4 40.9 37.5 33.9 33.6 34.3 24.6 24.8 23.5	2025	0.77	0.02922 0.01786 0.01766 0.01816 0.01268 0.01451 0.01451 0.04455 0.03439 0.03406 0.03474 0.02497 0.02518 0.022518	28.8 17.6 17.4 17.9 12.5 12.2 14.3 40.2 40.7 37.3 33.9 33.6 34.2 24.6 24.8 23.5 44.6	2026	0.83	LIFOMINIC LIFDECOCI LIFDECOCI LIFDECOCI LIFDECOCI LIFDIRECE LIFDIRECE DEIOMINI DEIOMINIE DEIOMINIE DEIOMINIE DEIDECOI DIE
ow Income* and Residential Krect Install	Connected Decorative Connected Directional Connectional Decorative Directional Directional Omnidirectional	Tier 1 CEE Jier 2 Blended CEE Tier 1 CEE Tier 2 Blended CEE Tier 1 CEE Tier 2 Blended CEE Tier 2 CEE Tier 1 CEE Tier 2 CEE Tier 1 CEE Tier 1 CEE Tier 2 CEE Tier 1 CEE Tier 1 CEE Tier 2 CEE Tier 1 CEE Tier 2 CEE Tier 1 CEE Tier 3 CEE Tier 3 CE	12.9 4.7 5 4.3 9.7 9.5 10.9 9.4 12.9 4.7 5 4.3 9.7 9.5 10.9	41.1 30.4 30 30.8 24.8 24.2 28.4 52.4 40.2 35.4	39.2 24 23.8 24.2 19.4 18.9 22.1 52.2 40.2	37.1 20.9 20.8 21.1 18.3 17.8 20.8 52 40.1 35.4	0.03318 0.02709 0.02648 0.02760 0.01908 0.01857 0.02182 0.04113 0.04170 0.03823 0.03413 0.03413 0.03413 0.03413 0.03413 0.03413	32.7 26.7 26.1 27.2 18.8 18.3 21.5 40.5 41.1 37.7 34 33.6 34.3 24.6 24.8 23.5	2024 2024 2024 2024	0.7	0.03125 0.02080 0.02050 0.02121 0.01380 0.01583 0.04095 0.04152 0.03805 0.03413 0.03410 0.03414 0.03410 0.03478 0.02518	30.8 20.5 20.2 20.9 13.6 13.3 15.6 40.4 40.9 37.5 33.9 33.6 34.3 24.6 24.8 23.5 44.8	2025	0.77	0.02922 0.01786 0.01766 0.01268 0.01451 0.01451 0.04075 0.03405 0.03439 0.03406 0.03474 0.02497 0.02518	28.8 17.6 17.4 17.9 12.5 12.2 14.3 40.2 40.7 37.3 33.9 33.6 34.2 24.6 24.8 23.5 44.6	2026	0.83	LIFOMMIC LIFORMIC LIFOECOC LIFOECOC LIFOECOC LIFORECC LIFORECC DIDRECI
ow Income* and Residential Krect Install	Connected Decorative Connected Directional Omnidirectional Decorative Directional	Tier 1 CEE Tier 2 Blended CEE Tier 1 CEE Tier 2 Blended CEE Tier 1 CEE Tier 2 Blended CEE Tier 2 Blended CEE Tier 2 Blended CEE Tier 2 Blended CEE Tier 2 Blended CEE Tier 2 Blended CEE Tier 2 CEE Tier 2 CEE CEE Tier 2 CEE Tier 2 CEE Tier 2 CEE Tier 2 CEE Tier 2 CEE Tier 2 CEE Tier 2 CEE Tier 2 CEE	12.9 4.7 5 4.3 9.7 9.5 10.9 10 9.4 12.9 4.7 5 4.3 9.7 9.5 10.9 10.9 10.9	41.1 30.4 30 30.8 24.8 24.2 28.4 52.4 40.2 35.4	39.2 24 23.8 24.2 19.4 18.9 22.1 52.2 40.2 35.4	37.1 20.9 20.8 21.1 18.3 17.8 20.8 52 40.1 35.4	0.03318 0.02709 0.02648 0.02760 0.01908 0.01857 0.02182 0.04113 0.03823 0.03823 0.03823 0.03823 0.03824 0.03823 0.03823 0.03823 0.03823 0.02519 0.02383 0.04556	32.7 26.7 26.1 18.8 18.3 21.5 40.5 41.1 37.7 34 33.6 34.3 24.6 24.8 23.5 44.9	2024 2024 2024 2024 2024	0.7	0.03125 0.02080 0.02050 0.02121 0.01380 0.01583 0.04095 0.04152 0.03805 0.03413 0.03410 0.03410 0.03478 0.02497 0.02518 0.02383 0.04546	30.8 20.5 20.2 20.9 13.6 13.3 15.6 40.4 40.9 37.5 33.9 33.6 24.6 24.8 23.5 44.8 45.1	2025	0.77	0.02922 0.01786 0.01766 0.01816 0.01268 0.01451 0.01451 0.04455 0.03439 0.03406 0.03474 0.02497 0.02518 0.022518	28.8 17.6 17.4 17.9 12.5 12.2 14.3 40.7 37.3 33.9 33.6 34.2 24.6 24.8 23.5 44.6	2026	0.83	LIFOMNICCI LIFOECOCO LIFOECOCO LIFOECOCO LIFOECOCO LIFOECOCO LIFOERECCI DID
ow Income* and Residential Krect Install	Connected Decorative Connected Directional Omnidirectional Directonal Directonal Omnidirectional	Tier 1 CEE Tier 2 Blended CEE CEE CEE Tier 2 Blended CEE Tier 2 Blended CEE Tier 2 Blended CEE Tier 2 Blended CEE Tier 2 Blended CEE CEE Tier 2 Blended CEE Tier 2 Blended CEE CEE Tier 2 Blended CEE CEE Tier 2 Blended CEE Tier 2 Blende CEE Tier 2 Blen	12.9 4.7 5 4.3 9.7 9.5 10.9 10 9.4 12.9 4.7 5 4.3 9.7 9.5 4.3 9.7 9.5 10.9 10 9.4	41.1 30.4 30 30.8 24.8 24.2 28.4 52.4 40.2 35.4	39.2 24 23.8 24.2 19.4 18.9 22.1 52.2 40.2 35.4	37.1 20.9 20.8 21.1 18.3 17.8 20.8 52 40.1 35.4	0.03318 0.02709 0.02648 0.02760 0.01908 0.01857 0.02182 0.04113 0.03413 0.03446 0.03413 0.03441 0.02497 0.02519 0.02519 0.04556 0.04557	32.7 26.7 26.1 18.8 18.3 21.5 40.5 41.1 37.7 34 33.6 34.3 24.6 24.8 23.5 44.9 45.2	2024 2024 2024 2024 2024	0.7	0.03125 0.02080 0.02121 0.01380 0.01350 0.01350 0.04095 0.04152 0.03403 0.03403 0.03443 0.03478 0.02497 0.02518 0.04546 0.04576	30.8 20.5 20.2 20.9 13.6 13.3 15.6 40.4 40.9 37.5 33.9 33.6 24.6 24.8 23.5 44.8 45.1	2025	0.77	0.02922 0.01786 0.01786 0.01268 0.01238 0.01451 0.04132 0.03475 0.03474 0.02497 0.03474 0.02497 0.02518 0.034526	28.8 17.6 17.4 17.9 12.5 12.2 14.3 40.2 40.7 37.3 33.9 33.6 24.6 24.8 23.5 44.6 44.9 43	2026	0.83	LIFOMNICCL LIFOECOCC UFDECOCC LIFDECOCC LIFOECOCC LIFORECE LIFORECE LIFORECE DIDOMNICC DIDOMNICC DIDOMNICC DIDORE2 DID
ow Income* and Residential Krect Install	Connected Decorative Connected Directional Connected Decorative Directional Directional Directional Directional Directional Decorative Directional Decorative	Tier 1 CEE Tier 2 Bended CEE Tier 1 Tier 1 CEE Tier 2 Bended CEE Tier 2 CEE Tier 2 CEE Tier 2 Bended CEE Tier 2 Bended CEE Tier 2 Bended CEE Tier 2 Bended CEE Tier 2 Bended CEE Tier 2 CEE Tier 2 CEE Tier 2 CEE Tier 2 CEE Tier 2 Bended CEE Tier 2 Bended CEE Tier 2 CEE Tier 2 CEE Tier 2 CEE Tier 2 Bended CEE Tier 2 Bended CEE Tier 2 CEE Tier 2 CEE	12.9 4.7 5 4.3 9.7 9.5 10.9 9.4 12.9 4.7 5 4.3 9.7 9.5 10.9 10.9 10.9 10.9 10.9 10.9 10.9 10.9	41.1 30.4 30 24.8 24.2 28.4 52.4 40.2 35.4	39.2 24 23.8 24.2 19.4 18.9 22.1 52.2 40.2 35.4	37.1 20.9 20.8 21.1 18.3 17.8 20.8 52 40.1 35.4	0.03318 0.02709 0.02648 0.02760 0.01908 0.01857 0.02182 0.04113 0.04170 0.03823 0.04170 0.03823 0.04519 0.02497 0.022519 0.02383 0.04556 0.04587 0.04044	32.7 26.7 26.1 18.8 18.3 21.5 40.5 41.1 37.7 34 33.6 24.6 24.8 23.5 44.9 45.2 43.4	2024 2024 2024 2024 2024 2024	0.7	0.03125 0.02080 0.02121 0.01380 0.01350 0.01350 0.01350 0.04095 0.04152 0.03413 0.03410 0.03478 0.02497 0.02518 0.02383 0.04546 0.04576	30.8 20.5 20.2 13.6 13.3 15.6 40.4 40.9 37.5 33.9 33.6 24.6 24.8 23.5 44.8 45.1 43.2 36 35.8	2025 2025 2025 2025 2025 2025	0.77	0.02922 0.01786 0.01766 0.01288 0.01238 0.01451 0.04516 0.03409 0.03406 0.03474 0.02518 0.03472 0.02518 0.02558 0.04556	28.8 17.6 17.4 17.9 12.5 12.2 14.3 40.2 40.7 33.9 33.6 34.2 24.6 24.8 23.5 44.6 44.9 43 36	2026 2026 2026 2026 2026	0.83	LIFOMRICC LIFORCOCC UFDECOC LIFORCOCC LIFORCOCC LIFORCCCC DIFORCOCCC DIFORCOCCCC DIFORCOCCCC DIFORCOCCCC DIFORCOCCCC DIFORCOCCCC DIFORCOCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
w Income* and Residential Krect Install	Connected Decorative Connected Directional Decorative Directional Decorative Directional Connected	Tier 1 CEE Tier 2 Blended CEE CEE CEE Tier 2 Blended CEE Tier 2 Blended CEE Tier 2 Blended CEE Tier 2 Blended CEE Tier 2 Blended CEE CEE Tier 2 Blended CEE Tier 2 Blended CEE CEE Tier 2 Blended CEE CEE Tier 2 Blended CEE Tier 2 Blende CEE Tier 2 Blen	12.9 4.7 5 4.3 9.7 9.5 10.9 10 9.4 12.9 4.7 5 4.3 9.5 10.9 10 9.5 10.9 10 9.5 10.9 10 9.5 10.9 10 9.5 5 10.9	41.1 30.4 30 30.8 24.2 28.4 52.4 40.2 35.4	39.2 24 23.8 24.2 19.4 18.9 22.1 52.2 40.2 35.4	37.1 20.9 20.8 21.1 18.3 17.8 20.8 52 40.1 35.4	0.03318 0.02769 0.02648 0.02760 0.01908 0.01857 0.02182 0.04113 0.03413 0.03441 0.03413 0.03441 0.03413 0.03441 0.03413 0.03441 0.03451 0.04556 0.04557 0.04564 0.04557	32.7 26.7 26.1 18.8 18.3 21.5 40.5 41.1 37.7 34 33.6 34.3 24.6 24.8 23.5 24.6 24.8 23.5 24.6 24.8 23.5 24.6 24.8 23.5 24.6 24.8 23.5 24.6 24.8 23.5 24.6 24.8 23.5 24.6 24.8 23.5 24.6 24.8 23.5 24.6 24.8 23.5 24.6 24.8 24.5 24.5 24.5 24.5 24.5 24.5 24.5 24.5	2024 2024 2024 2024 2024	0.7 0.73 0.42 0.66 0.59 0.54 0.54	0.03125 0.02080 0.02050 0.02121 0.01380 0.01583 0.04095 0.04152 0.03413 0.03413 0.03413 0.03413 0.03410 0.03478 0.02497 0.02518 0.02383 0.04546 0.04576 0.04384 0.03653 0.03633	30.8 20.5 20.2 20.9 13.6 40.4 40.9 37.5 33.9 33.6 24.6 24.8 45.1 43.2 35.8	2025	0.77	0.02922 0.01786 0.01766 0.01816 0.01288 0.01451 0.04455 0.03785 0.03474 0.02382 0.03474 0.02382 0.03474 0.02382 0.04556 0.04556 0.04556 0.04556 0.04363 0.03653 0.03633	28.8 17.6 17.4 17.9 12.5 12.2 14.3 40.2 40.7 37.3 33.9 33.6 24.6 24.8 23.5 24.6 24.8 23.5 44.6 44.9 43 36 35.8	2026	0.83	LIFOMRICC LIFORECOC UFDECOC LIFORECOC LIFORECOC DIDOMNE DIDOMNE DIDOMNE DIDOMNE DIDOMNE DIDORO DIDREOD DIDREOD DIDREOD DIDREOD
w Income* and Residential Krect Install	Connected Decorative Connected Directional Connected Decorative Directional Decorative Directional Connected Decorative D	Tier 1 CEE Bended CEE Tier 2 Bended CEE CEE Tier 2 Bended CEE Tier 2 CEE Tier 3 CEE Tier 3 C	12.9 4.7 5 4.3 9.7 9.5 10.9 9.5 10.9 4.7 5 4.3 9.7 9.5 10.9 10.9 10.9 9.4 12.9 9.4 12.9 4.7 5 4.3 12.9 4.3	41.1 30.4 30 30.8 24.2 28.4 52.4 40.2 35.4	39.2 24 23.8 24.2 19.4 18.9 22.1 52.2 40.2 35.4	37.1 20.9 20.8 21.1 18.3 17.8 20.8 52 40.1 35.4	0.03318 0.02709 0.02648 0.02760 0.01908 0.01857 0.02182 0.04113 0.04170 0.03823 0.04170 0.03823 0.04170 0.03823 0.04170 0.03823 0.04556 0.04556 0.04557 0.04404 0.03653 0.03633 0.03673	32.7 26.7 26.1 27.2 18.8 18.3 21.5 40.5 41.1 37.7 34 33.6 24.6 24.8 23.5 24.6 24.8 23.5 44.9 45.2 43.4 35.8 35.8	2024 2024 2024 2024 2024 2024	0.7 0.73 0.42 0.66 0.59 0.54	0.03125 0.02080 0.02050 0.02121 0.01380 0.01350 0.01583 0.04095 0.04152 0.034152 0.034152 0.034152 0.034152 0.03478 0.02497 0.02518 0.04546 0.04546 0.04546 0.04546 0.04546 0.04384 0.03653 0.03633	30.8 20.5 20.2 20.9 13.6 40.4 40.9 37.5 33.9 33.6 24.6 24.8 45.1 43.2 35.8 35.8 36.2	2025 2025 2025 2025 2025 2025	0.77	0.02922 0.01786 0.01766 0.01816 0.01288 0.01451 0.04451 0.04455 0.03785 0.03474 0.02497 0.02518 0.034526 0.04556 0.04556 0.04556 0.04556 0.04363 0.03653	28.8 17.6 17.4 17.9 12.5 12.2 14.3 40.2 40.7 37.3 33.9 33.6 34.2 24.6 24.8 23.5 44.6 44.9 43 36 35.8 36.1	2026 2026 2026 2026 2026	0.83	LIFOMRICC LIFORCOC LIFORCOC LIFORCOC LIFORCOC LIFORCCC DIDORNEL DI
w Income* and Residential Krect Install	Connected Decorative Connected Directional Connected Decorative Directional Decorative Directional Decorative Directional Decorative Connected	Tier 1 CEE Tier 2 Bended CEE Tier 1 CEE Bended CEE Tier 2 Bended CEE Tier 2 CEE Tier 2 CEE CEE Tier 2 CEE CEE CEE Tier 2 CEE CEE Tier 2 CEE CEE Tier 2 CEE CEE Tier 2 CEE CEE Tier 2 CEE Tier 2 CEE	12.9 4.7 5 4.3 9.7 9.5 10.9 10 9.4 12.9 4.7 5 4.3 9.7 9.5 10.9 10 9.4 12.9 10 9.4 12.9 10 9.4 12.9 4.7 5 10.9 10 9.4 12.9 10 9.4 12.9 10 9.4 12.9 10 9.4 12.9 10 9.4 12.9 10 9.7 10 9.4 12.9 10 9.7 10 9.4 10 9.7 10 9.4 10 9.7 10 9.7 10 9.7 10 9.7 10 9.7 10 9.7 10 9.7 10 9.7 10 9.7 10 9.7 10 9.7 10 9.7 10 9.7 10 9.7 10 9.7 10 9.4 10 9.7 10 9.4 10 9.7 10 9.4 10 10 9.4 10 10 9.4 10 10 10 9.4 10 10 10 10 10 10 10 10 10 10 10 10 10	41.1 30.4 30 30.8 24.2 28.4 52.4 40.2 35.4	39.2 24 23.8 24.2 19.4 18.9 22.1 52.2 40.2 35.4	37.1 20.9 20.8 21.1 18.3 17.8 20.8 52 40.1 35.4	0.03318 0.02709 0.02648 0.02760 0.01908 0.01857 0.02182 0.04113 0.04170 0.03823 0.04170 0.03823 0.04170 0.03823 0.04556 0.04587 0.040404 0.03653 0.06533 0.03673 0.03673	32.7 26.7 26.1 27.2 18.8 18.3 21.5 40.5 41.1 37.7 34 33.6 24.6 24.8 23.5 24.8 23.5 44.9 45.2 44.9 45.2 43.4 35.8 35.8	2024 2024 2024 2024 2024 2024	0.7 0.73 0.42 0.66 0.59 0.54	0.03125 0.02080 0.02050 0.02121 0.01380 0.01350 0.01583 0.04095 0.04152 0.034152 0.034152 0.034152 0.034152 0.03478 0.02497 0.02518 0.04546 0.04546 0.04546 0.04546 0.04546 0.04546 0.04546 0.04546 0.04546 0.04546 0.04546	30.8 20.5 20.2 20.9 13.6 13.3 15.6 40.4 40.9 37.5 33.9 33.6 24.6 24.8 23.5 44.8 45.1 43.2 36 35.8 36.2 28.9	2025 2025 2025 2025 2025 2025	0.77	0.02922 0.01786 0.01786 0.01786 0.01816 0.01288 0.01451 0.04075 0.04132 0.04075 0.04132 0.04075 0.04132 0.04075 0.04132 0.04075 0.04526 0.04556 0.04556 0.04363 0.03653 0.03633 0.03663 0.02933	28.8 17.6 17.4 17.9 12.5 12.2 14.3 40.2 40.7 37.3 33.9 33.6 34.2 24.6 24.8 23.5 44.6 44.9 43 36 35.8 36.1 28.9	2026 2026 2026 2026 2026	0.83	LIFOMRICC LIFORCOC LIFORCOC LIFORCOC LIFORCOC LIFORRECC LIFORRECC DIDRECOC DIDRECOC DIDRECOC DIDRECOC DIDRECOC DIDRECOC DIDRECOC DIDRECOC
ow Income* and Residential Krect Install	Connected Decorative Connected Directional Connected Decorative Directional Decorative Directional Connected Decorative D	Tier 1 CEE Disended CEE Tier 1 CEE Tier 1 CEE Tier 1 CEE Tier 1 CEE Tier 1 CEE Tier 2 Bendede CEE Tier 1 CEE Tier 2 Bendede CEE Tier 2 Bendede CEE CEE Tier 2 Bendede CEE CEE Tier 2 Bendede CEE CEE CEE CEE CEE CEE CEE Tier 2 Bendede CEE CEE CEE Tier 2 Bendede CEE CEE Tier 2 Bendede CEE CEE Tier 2 Bendede CEE CEE Tier 2 Bendede CEE CEE Tier 2 Bendede CEE CEE CEE Tier 2 Bendede CEE CEE CEE Tier 2 Bendede CEE CEE CEE CEE CEE CEE CEE CEE CEE CE	12.9 4.7 5 4.3 9.7 9.5 10.9 9.5 10.9 4.7 5 4.3 9.7 9.5 10.9 10.9 10.9 9.4 12.9 9.4 12.9 4.7 5 4.3 12.9 4.3	41.1 30.4 30 24.8 24.2 28.4 52.4 40.2 35.4 40.2 52.4	39.2 24 23.8 24.2 19.4 18.9 22.1 52.2 40.2 35.4	37.1 20.9 20.8 21.1 18.3 17.8 20.8 52 40.1 35.4 52 40.1	0.03318 0.02709 0.02648 0.02760 0.01908 0.01857 0.02182 0.04113 0.04170 0.03823 0.04170 0.03823 0.04170 0.03823 0.04170 0.03823 0.04556 0.04556 0.04557 0.04404 0.03653 0.03633 0.03673	32.7 26.7 26.1 27.2 18.8 18.3 21.5 40.5 41.1 37.7 34 33.6 24.6 24.8 23.5 24.6 24.8 23.5 44.9 45.2 43.4 35.8 35.8	2024 2024 2024 2024 2024 2024	0.7 0.73 0.42 0.66 0.59 0.54	0.03125 0.02080 0.02050 0.02121 0.01380 0.01350 0.01583 0.04095 0.04152 0.034152 0.034152 0.034152 0.034152 0.03478 0.02497 0.02518 0.04546 0.04546 0.04546 0.04546 0.04546 0.04384 0.03653 0.03633	30.8 20.5 20.2 20.9 13.6 40.4 40.9 37.5 33.9 33.6 34.3 24.6 24.8 23.5 44.8 45.1 43.2 36 35.8 36.2 28.9 29	2025 2025 2025 2025 2025 2025	0.77 0.74 0.74 0.59 0.54 0.77	0.02922 0.01786 0.01766 0.01816 0.01288 0.01451 0.04451 0.04455 0.03785 0.03474 0.02497 0.02518 0.034526 0.04556 0.04556 0.04556 0.04556 0.04363 0.03653	28.8 17.6 17.4 17.9 12.5 12.2 14.3 40.2 40.7 37.3 33.9 33.6 34.2 24.6 24.8 23.5 44.6 44.9 43 36 35.8 36.1 28.9	2026 2026 2026 2026 2026	0.83	LIFORMICCUP
ow Income* and Residential Krect Install	Connected Decorative Connected Directional Decorative Directional Direct	Tier 1 CEE DEndedde CEE Tier 1 CEE Tier 1 CEE Tier 2 Bendedd CEE Tier 2 Bended CEE Tier 2 CEE Tier 2 Bended CEE Tier 2 Bended CEE Tier 2 CEE Tier 2 Bended CEE Tier 2 CEE Tier 2 CEE Tier 2 Bended CEE Tier 2 Bended CEE Tier 2 CEE Tier 2 CEE Tier 2 CEE Tier 2 CEE Tier 2 Bended CEE Tier 2 CEE Tier 2 CEE CEE CEE CEE CEE CEE CEE CEE CEE CE	12.9 4.7 5 4.3 9.7 9.5 10.9 10 9.4 12.9 4.7 5 4.3 9.7 9.5 10.9 10 9.4 12.9 10 9.4 12.9 10 9.4 12.9 4.7 5 10.9 10 9.4 12.9 10 9.4 12.9 10 9.4 12.9 10 9.4 12.9 10 9.4 12.9 10 9.7 10 9.4 12.9 10 9.7 10 9.4 10 9.7 10 9.4 10 9.7 10 9.7 10 9.7 10 9.7 10 9.7 10 9.7 10 9.7 10 9.7 10 9.7 10 9.7 10 9.7 10 9.7 10 9.7 10 9.7 10 9.7 10 9.4 10 9.7 10 9.4 10 9.7 10 9.4 10 10 9.4 10 10 9.4 10 10 10 9.4 10 10 10 10 10 10 10 10 10 10 10 10 10	41.1 30.4 30 24.8 24.2 28.4 52.4 40.2 35.4 40.2 52.4	39.2           24           23.8           24.2           19.4           18.9           22.1           52.2           40.2           35.4           52.2           40.2           40.2	37.1 20.9 20.8 21.1 18.3 17.8 20.8 52 40.1 35.4 52 40.1	0.03318 0.02709 0.02648 0.02760 0.01908 0.01857 0.02182 0.04113 0.04170 0.03823 0.04170 0.03823 0.04170 0.03823 0.04556 0.04587 0.040404 0.03653 0.06533 0.03673 0.03673	32.7 26.7 26.1 27.2 18.8 18.3 21.5 40.5 41.1 37.7 34 33.6 24.6 24.8 23.5 24.8 23.5 44.9 45.2 44.9 45.2 43.4 35.8 35.8	2024 2024 2024 2024 2024 2024 2024	0.7 0.73 0.42 0.66 0.59 0.54	0.03125 0.02080 0.02050 0.02121 0.01380 0.01350 0.01583 0.04095 0.04152 0.034152 0.034152 0.034152 0.034152 0.03478 0.02497 0.02518 0.04546 0.04546 0.04546 0.04546 0.04546 0.04546 0.04546 0.04546 0.04546 0.04546 0.04546	30.8 20.5 20.2 20.9 13.6 13.3 15.6 40.4 40.9 37.5 33.9 33.6 24.8 24.8 24.8 24.8 24.8 24.8 24.8 24.8	2025 2025 2025 2025 2025 2025 2025	0.77 0.74 0.74 0.59 0.54 0.77	0.02922 0.01786 0.01786 0.01786 0.01816 0.01288 0.01451 0.04075 0.04132 0.04075 0.04132 0.04075 0.04132 0.04075 0.04132 0.04075 0.04526 0.04556 0.04556 0.04363 0.03653 0.03633 0.03663 0.02933	28.8 17.6 17.4 12.5 12.2 14.3 40.2 40.7 33.3 33.9 33.6 34.2 24.6 24.8 23.5 44.6 44.9 43 36 35.8 36.1 28.9 29 29	2026 2026 2026 2026 2026 2026	0.83	LIFORMICCUL LIFOECOCC LIFOECOCC LIFOECOCC LIFORCECC LIFORCECC LIFORRECE LIFORRECE DIDRECOCC DIDRECOCC DIDRECOCC DIDRECOCC DIDRECOCC
ow Income* and Residential Krect Install	Connected Decorative Connected Directional Connected Decorative Directional Decorative Directional Decorative Directional Decorative Directional Decorative Connected Directional Directio	Tier 1.1 CEE Tier 2. Bi8ndeded CEE Tier 1. CEE Tier 2. Bi8ndeded CEE Tier 2. Bi8ndeded CEE Tier 2. Bi8ndeded CEE Tier 2. Bi8ndeded CEE Tier 3. CEE Tier 4. CEE Tier 4. CEE Tie	12.9 4.7 5 4.3 9.7 9.5 10.9 10 9.4 12.9 4.7 5 4.3 9.7 9.5 10.9 10 9.4 12.9 9.5 10.9 10 9.4 12.9 4.3 9.7 9.5 10.9 10 9.5 10.9 10 9.5 10.9 10 9.4 12.9 10.9 10 9.4 12.9 10.9 10 9.4 12.9 10.9 10 9.4 12.9 10.9 10 9.4 12.9 10.9 10 9.4 12.9 10.9 10 9.4 12.9 10.9 10 9.4 12.9 10.9 10 9.4 12.9 10.9 10 9.4 12.9 10 9.5 10.9 10 9.4 12.9 10 9.5 10.9 10 9.5 10.9 10 9.5 10.9 10 9.5 10.9 10 9.5 10.9 10 9.5 10.9 10 9.5 10.9 10 9.5 10.9 10 10.9 10 10.9 10 10.9 10 10.9 10 10.9 10 10.9 10.9	41.1 30.4 30 24.8 24.2 28.4 52.4 40.2 35.4 40.2 52.4	39.2           24           23.8           24.2           19.4           18.9           22.1           52.2           40.2           35.4           52.2           40.2           40.2	37.1 20.9 20.8 21.1 18.3 17.8 20.8 52 40.1 35.4 52 40.1	0.03318 0.02709 0.02648 0.02760 0.01908 0.01908 0.01857 0.02182 0.04113 0.04170 0.03823 0.03413 0.03413 0.03413 0.03413 0.03413 0.03413 0.03451 0.02519 0.02519 0.02533 0.04564 0.04644 0.03653 0.03653 0.03633 0.03673 0.02933	32.7 26.7 26.7 26.1 18.8 18.3 21.5 40.5 41.1 37.7 34 33.6 24.6 24.8 23.5 24.6 24.8 23.5 44.9 45.2 43.4 35.8 36.2 28.9 29 28.3	2024 2024 2024 2024 2024 2024 2024	0.73 0.42 0.66 0.59 0.54 0.73 0.73	0.03125 0.02080 0.02050 0.02121 0.01380 0.01350 0.01583 0.04095 0.04152 0.03413 0.03413 0.03413 0.03410 0.03478 0.02497 0.02518 0.04576 0.04576 0.04584 0.04576 0.04584 0.04576 0.04584 0.04585 0.04586 0.0458	30.8 20.5 20.2 20.9 13.6 13.3 15.6 40.4 40.9 37.5 33.9 33.6 24.6 24.8 23.5 24.6 24.8 45.1 43.2 36 35.8 36.2 28.9 29 28.3	2025 2025 2025 2025 2025 2025 2025	0.77 0.74 0.74 0.59 0.54 0.77	0.02922 0.01786 0.01786 0.01816 0.01268 0.01238 0.01451 0.04075 0.04132 0.03439 0.03439 0.03406 0.03474 0.02497 0.02518 0.02497 0.04556 0.045666 0.045666 0.04566666666666666666666666666666666666	28.8 17.6 17.4 17.9 12.5 12.2 14.3 40.2 40.7 37.3 33.9 33.6 24.6 24.8 23.5 24.6 24.8 23.5 44.6 44.9 43 36 35.8 36.1 28.9 29 29 28.3	2026 2026 2026 2026 2026 2026	0.83	LIFORMICCUPERCENT LIFECCOL LIFECCOL LIFECCOL LIFECCOL LIFECCOL LIFECCOL LIFERCE DIDRECOL DIDR
ow Income* and Resciontal Interior	Connected Decorative Connected Directional Connected Decorative Directional Decorative Directional Decorative Directional Decorative Directional Decorative Connected Directional Directio	Tier 1. 2 CEF Tier 2. Blended CEF Tier 1. CEF Tier 2. Blended CEF Tier 2. Blended CEF Tier 2. Blended CEF Tier 2. Blended CEF Tier 1. CEF Tier 2. Blended CEF Tier 2. CEF Tier 3. CEF Tier	12.9 4.7 5 4.3 9.7 9.5 10.9 10 9.4 12.9 4.7 5 4.3 9.7 9.5 10.9 10 9.4 12.9 4.7 5 10.9 10 9.4 12.9 4.3 9.7 9.5 10.9 10 9.5 10.9 10 9.5 10.9 10 9.5 10.9 10 9.5 10.9 10 9.4 10.9 10 9.4 10.9 10 9.4 10.9 10 9.4 10.9 10 9.4 10.9 10 9.4 10.9 10 9.4 10.9 10 9.4 10.9 10 9.4 10.9 10 9.4 10.9 10 9.4 10.9 10 9.4 10.9 10 9.4 10.9 10 9.4 10.9 10 9.4 10.9 10 9.5 10.9 10 9.5 10.9 10 9.5 10.9 10 9.5 10.9 10 9.5 10.9 10 9.5 10.9 10 9.5 10.9 10 9.5 10.9 10 9.5 10.9 10.9 10 10.9 10.9 10 10.9 10.9 10.	41.1 30.4 30.8 24.8 24.2 28.4 40.2 35.4 40.2 35.4	39.2           24           23.8           24.2           19.4           18.9           22.1           52.2           40.2           35.4           52.2           40.2           40.2	37.1 20.9 20.8 21.1 18.3 17.8 20.8 52 40.1 35.4 40.1 35.4	0.03318 0.02709 0.02648 0.02760 0.01908 0.01908 0.01857 0.02182 0.04113 0.04170 0.03823 0.03413 0.03413 0.03413 0.03413 0.03413 0.03413 0.03451 0.02519 0.02533 0.04654 0.04644 0.03653 0.06533 0.03673 0.02933 0.02943 0.02943	32.7 26.7 26.1 27.2 18.8 18.3 21.5 40.5 41.1 37.7 34 33.6 24.6 24.8 23.5 24.6 24.8 23.5 24.9 45.2 43.4 36 35.8 36.2 28.9 29 28.3 84.1	2024 2024 2024 2024 2024 2024 2024	0.73 0.42 0.66 0.59 0.54 0.73 0.73	0.03125 0.02080 0.02050 0.02121 0.01380 0.01350 0.01350 0.01583 0.04055 0.04152 0.03410 0.03410 0.03410 0.03410 0.03418 0.02497 0.02518 0.04576 0.04384 0.04576 0.04384 0.04576 0.04384 0.04576 0.04384 0.04576 0.04384 0.04576 0.04384 0.04576 0.04384 0.04576 0.04384 0.04576 0.04384 0.04576 0.04578 0.02933 0.02943 0.02872	30.8 20.5 20.2 20.9 13.6 40.4 40.9 37.5 33.9 33.6 24.6 24.8 45.1 43.2 23.5 44.8 45.1 43.2 36 35.8 36.2 28.9 29 28.3 38.37	2025 2025 2025 2025 2025 2025 2025	0.77 0.74 0.74 0.59 0.54 0.77 0.74	0.02922 0.01786 0.01766 0.01766 0.01816 0.01268 0.01258 0.01258 0.01258 0.01451 0.03405 0.03406 0.03406 0.03474 0.02497 0.02518 0.03406 0.04556 0.04566 0.04556 0.04566 0.04556 0.045566 0.045566 0.04566 0.045566 0.045666 0.045666 0.04566666666666666666666666666666666666	28.8 17.6 17.4 17.9 12.5 12.2 14.3 40.2 40.7 37.3 33.9 33.6 24.6 24.8 23.5 44.6 44.9 43 36 35.8 36.1 28.9 29 29 28.3 83.3	2026 2026 2026 2026 2026 2026	0.83	LIFOMRICC LIFOEDOC LIFOEDOC LIFOEDOC LIFORRECC LIFORRECC LIFORRECC DIDRECC DIDRECC DIDRECC DIDRECC DIDRECC DIDRECC DIDRECC DIDRECC DIDRECC DIDRECC DIDRECC DIDRECC DIDRECC
ow Income* and Resciontal Interior	Connected Decorative Connected Directional Connected Directional Decorative Directional Decorative Directional Decorative Connected Directional Direct	Tier 1.2 CEE Tier 2.2 Blended CEE Tier 2.8 Blended CEE Tier 1. CEE Tier 2.2 Blended CEE Tier 1. CEE Tier 1. CEE Blended CEE Tier 2.8 Blended CEE Tier 3.8 Blended CEE Tier 3.8 Bl	12.9 12.9 4.7 5 4.3 9.7 9.5 10.9 10 9.4 12.9 4.7 5 4.3 9.7 9.5 10.9 10 9.4 12.9 10 9.4 12.9 10 9.4 12.9 10 9.4 12.9 10 9.4 12.9 10 9.5 10.9 10 9.5 10.9 10 9.5 10.9 10 9.5 10.9 10 9.5 10.9 10 9.5 10.9 10 9.5 10.9 10 9.5 10.9 10 9.5 10.9 10 9.5 10.9 10 9.5 10.9 10 9.5 10.9 10 9.5 10.9 10 9.5 10.9 10 9.5 10.9 10 9.5 10.9 10 9.5 10.9 10 9.5 10.9 10 9.5 10.9 10.9 10.9 10.9 10.9 10.9 10.9 10.9	41.1 30.4 30.8 24.8 24.2 28.4 40.2 35.4 40.2 35.4	39.2           24           23.8           24.2           19.4           18.9           22.1           52.2           40.2           35.4           52.2           40.2           35.4           35.4	37.1 20.9 20.8 21.1 18.3 17.8 20.8 52 40.1 35.4 40.1 35.4	0.03318 0.02709 0.02648 0.02760 0.01908 0.01908 0.01857 0.02182 0.04113 0.04120 0.03823 0.04120 0.03823 0.04120 0.03823 0.04566 0.04587 0.04004 0.03653 0.03653 0.03673 0.02943 0.02943 0.02872 0.04113	32.7 26.7 26.1 27.2 18.8 18.3 21.5 40.5 41.1 37.7 34 33.6 24.6 24.8 23.5 24.6 24.8 23.5 24.9 45.2 43.4 36 35.8 36.2 28.9 29 28.3 84.1	2024 2024 2024 2024 2024 2024 2024 2024	0.73 0.73 0.42 0.59 0.54 0.73 0.73 0.73 0.73	0.03125 0.02080 0.02050 0.021211 0.0380 0.01380 0.01380 0.04095 0.04152 0.03805 0.04152 0.03805 0.04152 0.03805 0.04152 0.02497 0.02518 0.02518 0.02518 0.04576 0.04384 0.04576 0.04384 0.03653 0.03653 0.03673 0.02943 0.02943 0.02872 0.04095	30.8 20.5 20.2 20.9 13.6 40.4 40.9 37.5 33.9 33.6 24.6 24.8 23.5 44.8 45.1 43.2 36 35.8 36.2 28.9 29 28.3 83.7 84.9	2025 2025 2025 2025 2025 2025 2025 2025	0.77 0.74 0.74 0.59 0.54 0.77 0.74	0.02922 0.01786 0.01766 0.01766 0.01268 0.01268 0.01238 0.01451 0.04556 0.03470 0.03406 0.03474 0.02497 0.02518 0.03429 0.03406 0.03476 0.04556 0.04566 0.04566 0.04566 0.04566 0.04566 0.04566 0.04566 0.04566 0.04566 0.04566 0.04566 0.04566 0.04566 0.04566 0.04566 0.045666 0.045666 0.04566666666666666666666666666666666666	28.8 17.6 17.4 17.9 12.5 12.2 14.3 40.2 40.7 33.9 33.6 24.6 24.8 23.5 44.6 44.9 43 36 35.8 36.1 28.9 29 28.3 83.3 84.5	2026 2026 2026 2026 2026 2026	0.83	LIFOMRICC LIFOECOC LIFOECOC LIFOECOC LIFORECC LIFORRECC LIFORRECC DIDRECC DIDRECCC DIDRECCC DIDRECCC DIDRECCC DIDRECCC DIDRECCC DIDRECCC DIDRECCC DIDRECCC
ow Income* and Resciontal Interior	Connected Decorative Connected Directional Connected Directional Decorative Directional Decorative Directional Decorative Connected Directional Direct	Tier 1. Description of the second sec	12.9 12.9 4.7 5 4.3 9.7 9.5 10.9 10.9 4.7 5 4.3 9.7 9.5 10.9 10 9.4 12.9 4.7 5 10.9 10 9.4 12.9 4.7 5 10.9 10 9.4 12.9 10.9 10 9.4 12.9 10.9 10 9.4 12.9 10.9 10 9.4 12.9 10.9 10 9.5 10 10 10 10 10 10 10 10 10 10 10 10 10	41.1 30.4 30.8 24.8 24.2 28.4 40.2 35.4 40.2 35.4	39.2           24           23.8           24.2           19.4           18.9           22.1           52.2           40.2           35.4           52.2           40.2           35.4           35.4	37.1 20.9 20.8 21.1 18.3 17.8 20.8 52 40.1 35.4 40.1 35.4	0.03318 0.02709 0.02769 0.02760 0.01908 0.01857 0.02182 0.04113 0.04170 0.03823 0.03446 0.03413 0.03445 0.03413 0.02497 0.02519 0.02519 0.02559 0.04404 0.03653 0.036555 0.036555 0.036555 0.0365555 0.03655555555555555555555555555555555555	32.7 26.7 26.1 27.2 18.8 18.3 21.5 40.5 41.1 37.7 34 33.6 24.6 24.8 23.5 44.9 45.2 43.4 35.8 36.2 28.9 28.3 84.1 85.2 78.1	2024 2024 2024 2024 2024 2024 2024 2024	0.73 0.73 0.42 0.59 0.54 0.73 0.73 0.73 0.73	0.03125 0.02080 0.02080 0.02121 0.01380 0.01583 0.04095 0.03150 0.04152 0.03805 0.03443 0.03443 0.03443 0.02497 0.02518 0.04384 0.04384 0.04364 0.03653 0.03653 0.03653 0.03653 0.03653 0.03653 0.03653 0.03653 0.03653 0.03653 0.03653 0.02943 0.02943 0.02943	30.8 20.5 20.2 20.9 13.6 40.4 40.9 37.5 33.9 33.6 34.3 24.6 24.8 45.1 43.2 23.5 44.8 45.1 43.2 36 35.8 36.2 28.9 29 28.3 83.7 84.9 77.8	2025 2025 2025 2025 2025 2025 2025 2025	0.77 0.74 0.74 0.59 0.54 0.77 0.74	0.02922 0.01786 0.01786 0.01786 0.01786 0.01288 0.01288 0.01288 0.01288 0.01288 0.01288 0.01287 0.04075 0.04122 0.04556 0.04565 0.04556 0.04565 0.04556 0.04556 0.04556 0.04556 0.04556 0.04556 0.04556 0.04565 0.04565 0.04565 0.04565 0.04565 0.04565 0.04565 0.04565 0.04565 0.04576 0.04576 0.04757000000000000000000000000000000000	28.8 17.6 17.4 17.9 12.5 12.2 14.3 40.2 40.7 37.3 33.9 33.6 24.6 24.8 23.5 44.6 44.9 43 36 135.8 36.1 28.9 29 28.3 83.3 84.5 77.4	2026 2026 2026 2026 2026 2026	0.83	LIFOMNICCUP
ow Income* and Resciontal Interior	Connected Decorative Connected Directional Connected Directional Decorative Directional Decorative Directional Decorative Directional Decorative Directional Directional Directional Directional Connected Directional Directi	Tier 1. DEP GEE Tier 2. Bended CEE CEE Tier 1. CEE Tier 1. CEE CEE CEE CEE CEE CEE CEE CEE CEE CE	12.9           12.9           4.7           5           4.3           9.7           9.5           10.9           10           9.4           12.9           4.3           9.7           9.5           10.9           4.3           9.7           9.5           10.9           10           9.4           10.9           10.9           4.3           9.7           9.5           4.3           9.7           9.5           10.9           10.9           10.9           10.9           10.9           10.9           10.9           12.9           12.9           12.9           12.9           12.9           12.9           12.9           12.9           12.9           12.9           12.9           12.9	41.1 30.4 30 24.8 24.2 28.4 52.4 40.2 52.4 40.2 52.4 40.2 52.4	39.2       24       23.8       24.2       19.4       23.8       24.2       19.4       52.2       40.2       35.4       52.2       40.2       35.4       52.2       40.2       55.2.2	37.1 20.9 20.8 21.1 18.3 17.8 20.8 52 40.1 35.4 40.1 35.4 52 40.1 35.4	0.03318 0.02709 0.02769 0.02760 0.01908 0.01857 0.02182 0.04113 0.04170 0.03823 0.04567 0.02487 0.02487 0.02487 0.04556 0.04576 0.04567 0.04567 0.04567 0.04567 0.04576 0.04576 0.04576 0.04576 0.04576 0.04576 0.04576 0.04576 0.04576 0.04576 0.04576 0.04576 0.04576 0.04576 0.04576 0.04576 0.04770 0.04700 0.04770000000000	32.7 26.7 26.1 27.2 18.8 40.5 41.1 37.7 34 33.6 24.6 24.8 23.5 44.9 45.2 43.4 45.2 43.4 45.2 43.4 35.8 36.2 28.9 29 28.3 84.1 85.2 78.1 70.4		0.77 0.73 0.42 0.59 0.54 0.77 0.73 0.74 0.74 0.74 0.74 0.74 0.74 0.74 0.74	0.03125 0.02080 0.02080 0.02050 0.02121 0.01380 0.01583 0.04095 0.04152 0.03805 0.04432 0.03443 0.02497 0.02518 0.04576 0.04576 0.04384 0.04586 0.04586 0.04587 0.02933 0.02933 0.02943 0.02943 0.02943 0.02943	30.8 20.5 20.2 20.9 13.6 40.4 40.9 37.5 33.9 33.6 24.6 24.8 23.5 44.8 45.1 43.2 24.6 24.8 23.5 24.6 24.8 23.5 24.6 24.8 35.8 36.2 28.9 29 28.3 36.2 29 28.3 77.8 84.9 77.8	2025 2025 2025 2025 2025 2025 2025 2025	0.77	0.02922 0.01786 0.01786 0.01766 0.01768 0.01768 0.01288 0.01288 0.01288 0.01451 0.04075 0.04132 0.03439 0.03439 0.03453 0.04556 0.04565 0.04556 0.04566 0.04556 0.04556 0.04556 0.04556 0.04556 0.04556 0.04556 0.04556 0.04556 0.045666 0.04566666666666666666666666666666666666	28.8 17.6 17.4 17.9 12.5 12.2 14.3 40.2 40.7 37.3 33.9 33.6 24.6 24.8 23.5 24.6 44.9 43 35.8 36.1 28.9 29 28.3 83.3 84.5 77.4 70.3	2026 2026 2026 2026 2026 2026 2026	0.83 0.74 0.39 0.59 0.55 0.83 0.74 0.41	LIFORMICCI LIFOECOCC LIFOECOCC LIFOECOCC LIFORECC LIFORECC LIFORECC LIFORECC LIFORECC DIDRECC DIDRECC DIDRECC DIDRECC DIDRECC DIDRECCC DIDRECCC DIDRECCC DIDRECCC DIDRECCC
ow Income* and Direct Install Interior	Connected Decorative Connected Directional Connected Directional Decorative Directional Decorative Directional Decorative Connected Directional Direct	Tier 1.1 CEE Tier 2.2 Bendeed CEE Tier 1. CEE Tier 1. CEE Bendeed CEE Tier 1. CEE Tier 2. Bendeed CEE Tier 1. CEE Tier 1. CEE Tier 2. Bendeed CEE Tier 2. Bendeed CEE Tier 1. CEE Tier 2. Bendeed CEE Tier 2. CEE Tier 3. CEE Tier 3. CEE	12.9 4.7 5 4.3 9.7 9.5 10.9 10 9.4 12.9 9.4 7 4.7 5 4.3 9.7 9.5 10.9 10 9.4 12.9 9.4 12.9 9.4 12.9 9.5 10.9 10 9.4 12.9 10.9 10 9.4 12.9 10.9 10 9.4 12.9 10.9 10 9.5 10.9 10.9 10.9 10.9 10.9 10.9 10.9 10.9	41.1 30.4 30 24.8 24.2 28.4 52.4 40.2 52.4 40.2 52.4 40.2 52.4	39.2           24           23.8           24.2           19.4           18.9           22.1           52.2           40.2           35.4           52.2           40.2           35.4           35.4	37.1 20.9 20.8 21.1 18.3 17.8 20.8 52 40.1 35.4 40.1 35.4 52 40.1 35.4	0.03318 0.02709 0.02648 0.02709 0.01908 0.01857 0.01857 0.01857 0.01857 0.01857 0.01857 0.04133 0.03413 0.03413 0.03413 0.02497 0.02933 0.0	32.7 26.7 26.1 27.2 18.8 18.3 21.5 40.5 41.1 37.7 34 33.6 24.6 24.8 23.5 44.9 45.2 45.2 45.2 45.2 45.2 28.9 29 28.3 84.1 36.2 29 29 28.3 84.1 70.4 69.8 17.2 18.8 18.3 19.5 10	2024 2024 2024 2024 2024 2024 2024 2024	0.77 0.73 0.42 0.59 0.54 0.77 0.73 0.74 0.74 0.74 0.74 0.74 0.74 0.74 0.74	0.03125 0.02080 0.02050 0.02121 0.01380 0.01350 0.01583 0.04035 0.04152 0.03403 0.03410 0.03410 0.03410 0.03410 0.034546 0.04576 0.04384 0.02633 0.03633 0.03633 0.03633 0.02933 0.02933 0.02934 0.02944 0.029	30.8 20.5 20.2 20.9 13.6 13.3 15.6 40.4 40.9 37.5 33.9 33.6 34.3 24.6 24.8 23.5 44.8 45.1 43.2 24.6 24.8 45.1 43.2 36 35.8 36.2 28.9 29 28.3 83.7 84.9 77.8 84.9 77.8	2025 2025 2025 2025 2025 2025 2025 2025	0.77	0.02922 0.01786 0.01786 0.01786 0.01816 0.01816 0.01288 0.01451 0.04075 0.04132 0.03439 0.03439 0.03439 0.03453 0.04556 0.04566 0.04556 0.04556 0.04556 0.04556 0.04556 0.045666 0.045666 0.04566666666666666666666666666666666666	28.8 17.6 17.4 17.9 12.5 12.2 14.3 40.2 40.7 37.3 33.9 33.6 24.6 24.8 23.5 44.6 44.9 43 36 135.8 36.1 28.9 29 28.3 38.3 38.4 5 77.4 70.3 69.6	2026 2026 2026 2026 2026 2026	0.83 0.74 0.39 0.59 0.55 0.83 0.74 0.41	LIFORMICCIONAL LIFORCOCO LIFORCOCO LIFORCOCO LIFORCOCO LIFORCOCO LIFORCOCO DIDRECO DIDRECOCOCO DIDRECOCO DIDRECOCO DIDRECOCO DIDRECOCO DIDRECOCO DIDRECOCO DIDRECOCO DIDRECOCO DIDRECOCO DIDRECOCO DIDRECOCO DIDRECOCO DIDRECOCO DIDRECOCO DIDRECOCOCO DIDRECOCOCO DIDRECOCOCO DIDRECOCOCO DIDRECOCOCO DIDRECOCOCO DIDRECOCOCOCOCOCOCOCOCOCOCOCOCOCOCOCOCOCOCO
ow Income* and Direct Install Interior	Connected Decorative Connected Directional Connected Directional Decorative Directional Decorative Directional Decorative Directional Decorative Directional Directional Directional Directional Connected Directional Directi	Tier 1. 2005 CEE CEE CEE CEE CEE CEE CEE CEE CEE CE	12.9 4.7 5 4.3 9.7 9.5 10.9 9.5 10.9 10 9.4 7 4.7 5 4.3 9.7 9.5 10.9 10 9.4 12.9 9.5 10.9 10 9.4 12.9 9.5 10.9 10 9.4 12.9 9.5 10.9 10.9 10 9.5 10.9 10.9 10.9 10.9 10.9 10.9 10.9 10.9	41.1 30.4 30 24.8 24.2 28.4 52.4 40.2 52.4 40.2 52.4 40.2 52.4	39.2       24       23.8       24.2       19.4       23.8       24.2       19.4       52.2       40.2       35.4       52.2       40.2       35.4       52.2       40.2       55.2.2	37.1 20.9 20.8 21.1 18.3 17.8 20.8 52 40.1 35.4 40.1 35.4 52 40.1 35.4	0.03318 0.02709 0.02648 0.02709 0.02648 0.02760 0.01908 0.01857 0.02182 0.04170 0.04170 0.04170 0.04823 0.04587 0.04787 0.0478	32.7 26.7 26.1 18.8 18.3 21.5 40.5 41.1 37.7 34 33.6 34.3 24.6 24.8 24.6 24.8 24.9 45.2 44.9 45.2 43.4 35.8 36.2 28.9 29 28.3 84.1 85.2 78.1 70.4 69.8 71.1		0.73	0.03125 0.02080 0.02050 0.02121 0.01380 0.01350 0.01583 0.04095 0.04152 0.03843 0.03443 0.03443 0.03443 0.0344546 0.04576 0.04576 0.04576 0.04576 0.04576 0.04576 0.04384 0.02633 0.02633 0.02945 0.02945 0.02	30.8           20.5           20.2           20.9           13.6           40.4           40.9           37.5           33.9           33.6           34.3           22.5           44.8           45.1           43.2           36           35.8           36.2           28.9           29           28.3           83.7           84.9           77.8           70.4           69.7           71.1	2025 2025 2025 2025 2025 2025 2025 2025	0.77	0.02922 0.01786 0.01786 0.01786 0.01786 0.01268 0.01258 0.01451 0.044075 0.044075 0.044075 0.044075 0.04407 0.02382 0.03456 0.04475 0.02497 0.02497 0.02497 0.02497 0.02497 0.04075 0.04075 0.04075 0.04075 0.04075 0.04075 0.04075 0.04075 0.04075 0.04075	28.8 17.6 17.4 17.9 12.5 12.2 14.3 40.2 40.7 37.3 33.9 33.6 24.6 24.8 23.5 44.6 44.9 43 36 35.8 36.1 28.9 29 29 28.3 83.3 84.5 77.4 70.3 69.6 71	2026 2026 2026 2026 2026 2026 2026	0.83 0.74 0.39 0.59 0.55 0.83 0.74 0.41	LIFORMICZI LIFOECOCCU LIFOECOCCU LIFOECOCCU LIFOECOCCU LIFORRECE LIFORRECE LIFORRECE DIDORNE D
ow Income* and Resciontal Interior	Connected Decorative Connected Directional Connected Directional Decorative Directional Decorative Directional Decorative Directional Decorative Directional Directional Directional Directional Connected Directional Directi	Tier 1. Bended CEE Tier 2. Bended CEE Tier 2. Bended CEE Tier 3. C	12.9 4.7 5 4.3 9.7 9.5 10.9 10 9.4 12.9 9.4 7 4.7 5 4.3 9.7 9.5 10.9 10 9.4 12.9 9.4 12.9 9.4 12.9 9.5 10.9 10 9.4 12.9 10.9 10 9.4 12.9 10.9 10 9.4 12.9 10.9 10 9.5 10.9 10.9 10.9 10.9 10.9 10.9 10.9 10.9	41.1 30.4 30 24.8 24.2 28.4 52.4 40.2 52.4 40.2 52.4 40.2 52.4	39.2       24       23.8       24.2       19.4       23.8       24.2       19.4       52.2       40.2       35.4       52.2       40.2       35.4       52.2       40.2       55.2.2	37.1 20.9 20.8 21.1 18.3 17.8 20.8 52 40.1 35.4 40.1 35.4 52 40.1 35.4	0.03318 0.02709 0.02648 0.02760 0.01908 0.01857 0.02182 0.0413 0.03463 0.03463 0.03464 0.03463 0.03463 0.04556 0.04556 0.04556 0.04556 0.04556 0.04563 0.03653 0.03653 0.03653 0.03653 0.03653 0.03653 0.03653 0.03653 0.03653 0.03653 0.03653 0.03653 0.03653 0.03653 0.03653 0.03654 0.03653 0.03653 0.03653 0.03653 0.03654 0.03653 0.03655 0.03653 0.03653 0.03653 0.03655 0.03755 0.03755 0.03755 0.03755 0.03755 0.03755 0.03755 0.03755 0.03755 0.03755 0.03755 0.03755 0.03755 0.03755 0.03755 0.03755 0.037555 0.037555 0.037555 0.037555 0.0375555 0.03755555555555555555555555555555555555	32.7 26.7 26.1 27.2 18.8 18.3 21.5 40.5 41.1 37.7 34 33.6 24.6 24.8 23.5 44.9 45.2 45.2 45.2 45.2 45.2 28.9 29 28.3 84.1 36.2 29 29 28.3 84.1 70.4 69.8 17.2 18.8 18.3 19.5 10		0.77 0.73 0.66 0.79 0.79 0.79 0.70 0.70 0.70 0.70 0.71 0.72 0.72 0.72 0.72 0.72 0.75 0.75 0.75 0.75 0.75 0.75 0.75 0.75	0.03125 0.02080 0.02050 0.02121 0.01380 0.01350 0.01533 0.04095 0.04135 0.04135 0.03443 0.03443 0.03443 0.03443 0.02497 0.02518 0.04576 0.04576 0.04576 0.04576 0.04578 0.03653 0.03653 0.03653 0.03653 0.03653 0.03653 0.02943 0.02943 0.02943 0.03443 0.03443 0.03443	30.8 20.5 20.2 20.9 13.6 13.3 15.6 40.4 40.9 37.5 33.9 33.6 24.6 24.8 23.5 44.8 45.1 43.2 23.5 44.8 45.1 43.2 28.9 28.9 28.3 36.2 28.9 29 28.3 38.7 84.9 77.8 70.4 69.7 71.1 51	2025 2025 2025 2025 2025 2025 2025 2025	0.77	0.02922 0.01786 0.01786 0.01786 0.01816 0.01816 0.01288 0.01451 0.04075 0.04132 0.03439 0.03439 0.03439 0.03453 0.04556 0.04566 0.04556 0.04556 0.04556 0.04556 0.04556 0.045666 0.045666 0.04566666666666666666666666666666666666	28.8 17.6 17.4 17.9 12.5 12.2 14.3 40.2 40.7 37.3 33.9 33.6 24.6 24.8 23.5 44.6 44.9 43 36 35.8 36.1 28.9 29 29 28.3 83.3 84.5 77.4 70.3 69.6 71	2026 2026 2026 2026 2026 2026 2026	0.83 0.74 0.39 0.59 0.55 0.83 0.74 0.41	LIFORMICCIENT LIFOECOCC LIFOECOCC LIFOECOCC LIFOECOCC LIFORRECE LIFORRECE LIFORRECE LIFORRECE LIFORRECE DIDIRECOCCC DIDIRECOCCC DIDIRECOCCC DIDIRECOCCC DIDIRECOCCC DIDIRECOCCC DIDIRECOCCC DIDIRECOCCC DIDIRECOCCC DIDIRECOCCC DIDIRECOCCC DIDIRECOCCC DIDIRECOCCC DIDIRECOCCC DIDIRECOCCC DIDIRECOCCCC DIDIRECOCCCC DIDIRECOCCCC DIDIRECOCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
w Income* and seciental Interior	Connected Decorative Connected Directional Connected Directional Decorative Directional Decorative Directional Decorative Directional Decorative Directional Directional Directional Directional Connected Directional Directi	Tier 1. 2005 CEE CEE CEE CEE CEE CEE CEE CEE CEE CE	12.9 4.7 5 4.3 9.7 9.5 10.9 9.5 10.9 10 9.4 7 4.7 5 4.3 9.7 9.5 10.9 10 9.4 12.9 9.5 10.9 10 9.4 12.9 9.5 10.9 10 9.4 12.9 9.5 10.9 10.9 10 9.5 10.9 10.9 10.9 10.9 10.9 10.9 10.9 10.9	41.1.1 30.4 30 30.8 24.8 24.2 28.4 40.2 28.4 40.2 35.4 40.2 52.4 40.2 52.4 40.2	39.2       24       23.8       24.2       19.4       23.8       24.2       19.4       52.2       40.2       35.4       52.2       40.2       35.4       52.2       40.2       55.2.2	20.9 20.8 21.1 18.3 20.8 52 40.1 35.4 40.1 35.4 40.1	0.03318 0.02709 0.02648 0.02709 0.01908 0.01857 0.02182 0.04170 0.04170 0.04170 0.04823 0.04130 0.04587 0.04587 0.04587 0.04587 0.04587 0.04583 0.04583 0.04583 0.04587 0.04787 0.0478	32.7 26.7 26.1 18.8 18.3 21.5 40.5 41.1 37.7 34 33.6 34.3 24.6 24.8 24.6 24.8 24.9 45.2 44.9 45.2 43.4 35.8 36.2 28.9 29 28.3 84.1 85.2 78.1 70.4 69.8 71.1		0.73	0.03125 0.02080 0.02050 0.02121 0.01380 0.01350 0.01583 0.04095 0.04152 0.03843 0.03443 0.03443 0.03443 0.0344546 0.04576 0.04576 0.04576 0.04576 0.04576 0.04576 0.04384 0.02633 0.02633 0.02945 0.02945 0.02	30.8 20.5 20.2 20.9 13.6 15.6 40.4 40.9 37.5 33.9 33.6 24.6 24.8 23.5 44.8 45.1 43.2 24.6 24.8 35.8 45.1 43.2 28.9 29 28.3 36.2 28.9 29 28.3 38.7 84.9 77.8 84.9 77.8 84.9 77.8 84.9 77.8 84.9 77.8 84.9 77.8 84.9 77.8 84.9 77.8 84.9 77.8 84.9 77.8 84.9 77.8 84.9 77.8 84.9 77.8 84.9 77.8 84.9 77.8 84.9 77.8	2025 2025 2025 2025 2025 2025 2025 2025	0.77	0.02922 0.01786 0.01786 0.01786 0.01786 0.01268 0.01258 0.01451 0.044075 0.044075 0.044075 0.044075 0.04407 0.02382 0.03456 0.04475 0.02497 0.02497 0.02497 0.02497 0.02497 0.04075 0.04075 0.04075 0.04075 0.04075 0.04075 0.04075 0.04075 0.04075 0.04075	28.8 17.6 17.4 17.9 12.5 12.2 14.3 40.2 40.7 37.3 33.9 33.6 24.6 24.8 23.5 44.6 44.9 43 36 35.8 36.1 28.9 29 29 28.3 83.3 84.5 77.4 70.3 69.6 71 51	2026 2026 2026 2026 2026 2026 2026	0.83	LIFOMMICCU LIFOECOCU LIFOECOCU LIFOECOCU LIFOECOCU LIFORECE DIDINECI DIDINI

Direct Install		Blended	10				0.04330	88.5			0.04310	88.1			0.04291	87.7			DIXOMNIC1
Exterior	Omnidirectional Connected	CEE Tier 1	9.4	52.4	52.2	2.2 52	0.04374	89.4	2024	0.54	0.04354	89	2025	0.54	0.04335	88.6	2026	0.55	DIXOMNIC2
	Connected	CEE Tier 2	12.9				0.04105	83.9			0.04085	83.5			0.04066	83.1			DEXOMNEC3
		Blended	4.7				0.03547	72.5			0.03542	72.4			0.03542	72.4			DIXDECOC1
	Decorative Connected	CEE Tier 1	5	40.2	40.2	40.1	0.03523	72	2024	0.7	.7 0.03518	71.9	71.9 2025	0.77	0.03513	71.8	2026	0.83	DIXDECOC2
		CEE Tier 2	4.3				0.03576	73.1			0.03571	73			0.03567	72.9			DIXDECOC3
		Blended	9.7				0.02705	55.3			0.02705	55.3			0.02705	55.3			DIXDIREC1
	Directional Connected	CEE Tier 1	9.5	35.4	4 35.4 35.	35.4	0.02725	55.7	2024	0.73	0.02725	55.7	2025	50.74	0.02725	55.7	2026	0.74	DIXDIREC2
		CEE Tier 2	10.9				0.02617	53.5			0.02617	53.5			0.02617	53.5			DIXDIREC3
*Low Income	Itemcodes deline	eated by	prefix Ll	L															

Using default values, the MMBu prefixes of each commercial bulb type are provided betw. Penalty values are not provided for residential markets because Efficiency Vermont does not calculate interactive effects for residential lighting.Oil heating is assumed typical for commercial buildings.

Program Type	Lamp Type	ENERGY STAR 2.1 / CEE Tier	ΔMMBtu
	Omnidirectional	Blended	0.039
	Connected	CEE Tier 1	0.037
Efficient	Connected	CEE Tier 2	0.051
Products Retail	Decorative	Blended	0.034
and	Connected	CEE Tier 1	0.033
SMARTLIGHT	connected	CEE Tier 2	0.035
(Commercial)	Directional	Blended	0.021
	Connected	CEE Tier 1	0.02
	connected	CEE Tier 2	0.024

## Baseline Adjustment

Baseline Adjustment The natural growth of LED market share, has and will continue to grow over the lifetime of the LED measures installed. Therefore a forecast of the baseline growth of LED lamps has been developed, based upon historical growth rates provided via CREED LightTracker data for no program states, and review of projections provided by the Department of Energy. This forecast is used to estimate how baseline replacement lamps would change over the lifetime of the LED fature. A single mid-life adjustment is aculated that results in an equivalent net present value of lifetime savings as the forecast decline in annual savings. The appropriate adjustments as a percentage of the base year savings for each future type are provided in the table above

## **Operating Hours**

See Algorithm Section above

Load Shapes Residential: Loadshape #1: Residential Indoor Lighting Commercial: Loadshape #101: Commercial EP Lighting with Cooling Bonus<sup>[17]</sup>

## 1a Residential Indoor Lighting 101c Commercial EP Lighting with cooling bonus

Number	Name	Status	Winter On kWh	Winter Off kWh	Summer On kWh	Summer Off kWh	Winter kW	Summer kW
1	Residential Indoor Lighting	Active	36.9%	35.0%	13.0%	15.1%	29.8%	8.2%
101	Commercial EP Lighting with cooling bonus	Active	47.7%	19.2%	23.0%	10.1%	33.8%	68.1%

## Net Savings Factors

Measures LBLLEDSC LED Screw Base Lamp

### Tracks [Base Track]

ITACKS [Dase ITACK]				
6013UPST [is base track]	Upstream - Co	ommercial		
6032EPEP [is base track]	Efficient Produ	ucts - Residential		
6034LISF [is base track]	LISF Retrofit			
6036RETR [is base track]	Res Retrofit			
6038VESH [is base track]	RNC VESH			
6017PRES [is base track]	6017PRES			
6017CUST [is base track]	6017CUST			
6020PRES [is base track]	6020PRES			
6020CUST [is base track]	6020CUST			
6032UPST [6032EPEP]	Upstream - Re	esidential		
6013EPEP [6032EPEP]	Efficient Produ	ucts - Commercia	1	
Track Name	Track Nr	Measure Code	Free Rider	Snill Over
Upstream - Commercial				1.00
Efficient Products - Resider	ntial 6032EPEP	LBLLEDSC	0.94	1.25
LISF Retrofit	6034LISF	LBLLEDSC	1.00	1.00
Res Retrofit	6036RETR	LBLLEDSC	0.90	1.00
RNC VESH	6038VESH	LBLLEDSC	0.88	1.10
6017PRES	6017PRES	LBLLEDSC	1.00	1.00
6017CUST	6017CUST	LBLLEDSC	1.00	1.00
6020PRES	6020PRES	LBLLEDSC	0.90	1.00

6020CUST	6020CUST	LBLLEDSC	0.90	1.00
Efficient Products - Residential	6032EPEP	LBLLEDSC	0.95	1.05
Upstream - Commercial	6013UPST	LBLLEDSC	0.95	1.05
Upstream - Commercial	6013UPST	LBLLEDSC	0.90	1.00
Efficient Products - Residential	6032EPEP	LBLLEDSC	0.90	1.00
Efficient Products - Residential	6032EPEP	LBLLEDSC	0.85	1.00
Upstream - Commercial	6013UPST	LBLLEDSC	0.85	1.00
Efficient Products - Residential	6032EPEP	LBLLEDSC	0.80	1.00
Upstream - Commercial	6013UPST	LBLLEDSC	0.80	1.00

Persistence The persistence factor is assumed to be one.

## Lifetimes

Lifedine is a function of the average hours of the funithalite.										
Lamp Type	ENERGY STAR 2.1 / CEE Tier	Rated Life (Hours)	Residential Interior (Years)	Residential Exterior (Years)	Commercial (Years)					
	Blended	21,764	15.0	10.6	5.5					

Omnidirectional	CEE Tier 1	20.696	15.0	10.1	5.2
		,			
	CEE Tier 2	25.073	15.0	12.3	6.3
	Blended	20.494	15.0	10.0	5.2
Decorative	CEE Tier 1	21.124	15.0	10.3	5.3
		· ·			
	CEE Tier 2	19.414	15.0	9.5	4.9
	Blended	25.299	15.0	12.4	6.4
Directional	CEE Tier 1	25.126	15.0	12.3	6.3
	CEE Tier 2	25,457	15.0	12.5	6.4
Rated life' based on CEE Tier/EN	ERGY STAR 2.1 qualfy	ing product average-rat	ed-life weighted b	y EVT Efficient Pr	oducts sales data.

'Rated life' based on CEE Tier/ENERGY STAR 2.1 qualfying product av capped at 15 years (although their rated life/hours may be higher).

## Measure Cost

cost for this measure is dependent on the baseline mix and provided in the table below:<sup>[18]</sup> The increm

Lamp Type	/ CEE Tier	2021	2022	2023
	Blended	\$1.55	\$1.42	\$1.30
Omnidirectional	CEE Tier 1	\$1.39	\$1.28	\$1.17
	CEE Tier 2	\$1.70	\$1.57	\$1.43
	Blended	\$1.36	\$1.21	\$1.11
Decorative	CEE Tier 1	\$1.23	\$1.09	\$1.00
	CEE Tier 2	\$1.50	\$1.33	\$1.22
	Blended	\$0.89	\$0.83	\$0.77
Directional	CEE Tier 1	\$0.80	\$0.75	\$0.70
	CEE Tier 2	\$0.98	\$0.91	\$0.85
Omnidirectional	Blended	\$11.55	\$11.42	\$11.30
Connected	CEE Tier 1	\$10.39	\$10.28	\$10.17
connected	CEE Tier 2	\$12.70	\$12.57	\$12.43
Decorative	Blended	\$11.36	\$11.21	\$11.11
Connected	CEE Tier 1	\$10.23	\$10.09	\$10.00
connected	CEE Tier 2	\$12.50	\$12.33	\$12.22
Directional	Blended	\$20.89	\$20.83	\$20.77
Connected	CEE Tier 1	\$18.80	\$18.75	\$18.70
connecteu	CEE Tier 2	\$22,98	\$22.91	\$22.85

Lamp Type	ENERGY STAR 2.1 / CEE Tier	Direct Install Cost
	Blended	\$7.67
Omnidirectional	CEE Tier 1	\$6.90
	CEE Tier 2	\$8.44
	Blended	\$7.67
Decorative	CEE Tier 1	\$6.90
	CEE Tier 2	\$8.44
	Blended	\$12.67
Directional	CEE Tier 1	\$11.40
	CEE Tier 2	\$13.94
Omnidirectional	Blended	\$17.67
Omnidirectional Connected	CEE Tier 1	\$15.90
connected	CEE Tier 2	\$19.44
Decorative	Blended	\$17.67
Connected	CEE Tier 1	\$15.90
connected	CEE Tier 2	\$19.44
Print and a second	Blended	\$32.67
Directional Connected	CEE Tier 1	\$29.40
connected	CEE Tier 2	\$35.94

O&M Cost Adjustments To account for the shift in baseline due to replacement lamps, the levelized baseline replacement cost over the lifetime of the LED is calculated. The key assumptions used in this calculation are documented below.

	Omnidirectional	Decorative		Assumed Lifetime (hours)
LED	\$5.00	\$5.00	\$10.00	
CFL	\$2.50	\$3.00	\$4.50	10,000
Halogen	\$1.25	\$1.75	\$3.50	1,000
Incandescent	\$0.50	\$1.75	\$3.50	1,000

## The calculation results in the following assumptions of equivalent annual baseline replace

Lamp Type		O&M RES		O&M C&I				
camp type	2021	2022	2023	2021	2022	2023		
Omnidirectional	\$0.30	\$0.28	\$0.25	\$0.57	\$0.53	\$0.48		
Decorative	\$0.56	\$0.49	\$0.45	\$1.00	\$0.89	\$0.81		
Directional	\$0.35	\$0.33	\$0.31	\$0.67	\$0.63	\$0.59		
Omnidirectional Connected	\$0.30	\$0.28	\$0.25	\$0.57	\$0.53	\$0.48		
Decorative Connected	\$0.56	\$0.49	\$0.45	\$1.00	\$0.89	\$0.81		
Directional Connected	\$0.35	\$0.33	\$0.31	\$0.67	\$0.63	\$0.59		

## Fossil Fuel Description

## ating Increa

Water Descriptions

water Descriptions
There are no water algorithms or default values for this measure.

### Footnotes

Consortium for Energy Efficiency, "Residential Lighting Initiative", October 2017.

- [2] For details on calculations, see "2021-2023 EVT Lamp Analysis.xls".
- [3] The default waste heat factors for demand and energy for commercial indoor fixtures are from KEMA, "NEEP C&I Lighting Loadshape Project, KEMA," 2011. The report modeled the energy savings per building type and the associated energy, demand, and coincident demand interactive effects. A description of how the interactive effects were developed is on page 28 of the report, including details about how temperature balance points, equipment efficiencies, and heat to space factors influenced each building's designated interactive effects. The building types were weighted for the NR-North Weather climate zone in order to come up with a single rescriptive default value for both demand and energy lighting waste heat factors. For more information, please see the spreadsheet, "EVT Lighting WHF Research\_Prescriptive\_2020.slsx".
- [4] Based on "Home Energy Management System/ Cmart Lighting Pilot for National Grid's Massachusetts and Rhode Island Residential Energy Efficiency Programs", Final Report, National Grid, March 2019
- [5] Commercial hours of use from Impact Evaluation of the Massachusetts Upstream Liphting Program, FINAL REPORT. KEMA Inc., "Impact Evaluation of the Massachusetts Upstream Liphting Program FINAL REPORT", February 2014. Page 1-8, Section 1.2.3.3.
- [6] Based on a household exterior average 5.6 hours of use per day. NMR, "Northeast Residential Lighting Hours-of-Use Study", 5/5/2014. Page 34, Table 3-1.

- [7] Based on a household average 2.7 hours of use per day. NMR, "Northeast Residential Lighting Hours-of-Use Study", 5/5/2014. Page 34, Table 3-1.
- [8] ISR for Residential Direct Install based on Illinois Technical Reference Manual for Energy Efficiency, Version 6.0, which accounts for bulb failures during the first year.
- [9] The SR calculation for Efficient Products Retail, SMARTLIXHT (residential), Low Ixcome, and LED Dropship follows the lifetime SR approach from NEE, "Chapter 6: Residential Lighting Protocol," Or 2.2012 from the Uniform Methods Protocol. The LMP protocol recommends for the shifting baseline through a mid-life adjustment and caps installations at 10 years for all lamp categories. The Installation trajectory is from NMR Group, "RLPNC Study 17-9 2017-18 Residential Lighting Protocol," March 28, 2018, page 37. NMR observed that 22% of bulks are installed in year 2 and 19% in year. 3 NMR's recommend lifetime SR methodologi assumes that 23% of bulks are installed in year 2 and 19% in year. 3 NMR's recommend lifetime SR methodologi assumes are installed in earls along the residue of year 2 and 19% in year. 3 NMR's recommend lifetime SR methodologi assumes are listed to the year 2 and 19% proving from NMR Group, "RLPNC Study 17-9 2017-18 Residential Lighting Program Overall Evaluation Report FINAL", 416(2015), Rape V, Table 1, and 80% from NMR Group, Inc., "Connection Lighting Study Report (RLSH) FINAL", 128/2016, page V, Table 1, and 80% from NMR Group, Inc., "Connection Lighting Study Report (RLSH) FINAL", 128/2016, page V, Table 1, and 80% from NMR Group, Inc., "Connection Lighting Study Report (RLSH) FINAL", 128/2016, page V, Table 1, and 80% from NMR Group, Inc., "Connection Lighting Study Report (RLSH) FINAL", 128/2016, page V, Table 1, and 80% from NMR Group, Inc., "Connection Lighting Study Report (RLSH) FINAL", 128/2016, page V, Table 1, and 80% from NMR Group, Inc., "Connection Lighting Study Report (RLSH) FINAL", 128/2016, page V, Table 1, and 80% from NMR Group, Inc., "Connection Lighting Study Report (RLSH) FINAL", Table 2, Ta
- [10] Commercial ISR is the 3-year ISR for LED lamps from DNV GL, "Massachusetts Commercial and Industrial Upstream Lighting Program: "In Storage" Lamps Follow-Up Study," March 27, 2015, page 5
- [11] Source for EP Free ISR: The 1st year ISR value for both CFL and LED bubs in efficiency kits is 59% in the Ilinois Technical Reference Manual for Energy Efficiency, Version 6.0 ("Free bubs provided without request, with little or no education. Based on Impact and Process Evaluation of 2013 (PY6) Ameren Ilinois Company Residential CFL bistribution Program", Report Table 11 and Appendix B.\*). Efficiency Vermont assumes the ISR for free LED bubs is higher than for free CFL bubs.
- [12] A leakage rate of 1.5% was agreed to by EVT and DPS during October 2017 TAG. This value is an estimate based on leakage rates used by other programs, geographic factors, and a consideration of similar lighting programs in surrounding service territories.
- [13] Average AFLE of the HVAC heating equipment is based on the weighted average of existing commercial heating systems, as sourced from the "2016 VT Business Sector Market Characterization and Assessment Study", Cadmus, April 2017 (page 65). For more information, please see the spreadsheet, "EVT Lighting WHF Research\_Prescriptive\_2020.xlsx".
- [14] The ASHRAE heating factor applies to perimeter zone heat, therefore it must be adjusted to account for lighting in core zones. The typical aspect ratio is sourced from PNU, "Analysis of Darlphting Requirements within ASHRAE Standard 90.1, PNU," 2013, from the Executive Summary on page v. The aspect ratio is sourced from PNU, "Analysis of Darlphting WHF Research, Prescriptive, 2020.x6x".
- [15] From "Calculating lighting and HVAC Interactions", Table 1, ASHRAE Journal November 1993. For more information, please see the spreadsheet, "EVT Lighting WHF Research\_Prescriptive\_2020.vlsv".
- [16] 2017 ASHRAE Handbook Fundamentals (p. 16.3): "Conventional all-air air-handling systems for commercial and institutional buildings often have approximately 10 to 40% outside air." For more information, please see the spreadsheet, "EVT Lighting WHF Research\_Prescriptive\_2020.dsx".
- [17] Based on Commercial "Small" Lighting coincidence factors from KEMA; "C&L Lighting Load Shape Project Final Report," July 19, 2011, prepared for the Regional Evaluation, Neasurement and Verification Form, submitted to NEEP. The writter coincidence factor has been adjusted to remove the cooling bonch from writter pask demand.
- [18] Costs are based on 2019/2020 EVT sales data for LED bulbs. See reference file "2021-2023 EVT Lamp Analysis.xls"

## **Interior Agriculture LED Grow Light**

Measure Number	VII-C-17 a
Portfolio:	EVT TRM Portfolio 2019-02
Status:	Active
Effective Date:	2019/1/1
End Date:	[ None ]
Program:	Efficient Products Program
End Use:	Lighting

## Update Summary

- Referenced Documents VT SF Existing Homes Onsite Report DRAFT 122117 Energy Trust of Oregon Res Grow Light Research\_Evergre EVT\_LED Ag Grow Light Analysis Apr 2019 cs\_May 2018

Description This measure is for the installation of LED grow lights for residential agricultural purposes in interior spaces. The assumption is the installed LEDs will be used for horticulture applications.

LEDs are a growing option for cultivating plants, and represent a significant efficiency increase over traditional HD grow lights. Different from LEDs designed for visual applications and illuminating spaces for the human eye, grow lights efficacy are measured by their photosynthetic photon flux density (PFP), instead of lumens. LEDs also offer interactive conject synthese treduction in waste heat from an HID foture, which typically require an additional cooling source to maintain design cultivation temperatures and plant health.

# Baseline Efficiencies The baseline is assumed to be a high pressure sodium (HPS) lamp, which is the established grow light for horticulture applications. The lowest bin of energy savings has a mix of linear fluorescent futures typically used for starters and seedlings.

Efficient Equipment The efficient equipment is an equivalent LED grow light that is considered a suitable replacement based on industry research and manufacturer specifications.

	orithms ric Demand Si	avings	
∆kV	v	= ((Wat	$t_{SBASE}$ - Watts <sub>EE</sub> ) / 1000) x WHF <sub>d</sub>
Sym	bol Table		
Elect	ric Energy Sa	vings	
ΔkV	Vh	= ((Wat	$\text{ts}_{\text{BASE}}$ - Watts_{EE}) / 1000) x Hours x WHF_e
Sym	bol Table		
Fossi	l Fuel Savings	5	
Where	2:		
	ΔkW	-	Gross customer connected load kW savings for this measure
	$\Delta kWh \qquad = \qquad {\rm Gross\ customer\ annual\ kWh\ savings\ for\ this\ measure}$		Gross customer annual kWh savings for this measure
	Hours	-	Annual lighting hours of use per year. This number is dependent on the quantity of production cycles of the plant per year. = $1,377$ hours per cycle <sup>[3]</sup>
	Watts <sub>BASE</sub>		Connected wattage of the baseline lighting fixture. Please refer to the equivalent baseline wattage in the reference tables section.
	Watts <sub>EE</sub>	-	Connected wattage of the energy efficient lighting fixture. Please refer to the installed efficient wattage in the reference tables section.
	WHFd	-	Waste heat factor for demand to account for cooling interactive savings from efficient lighting. The waste heat factor varies based on the size of the baseline and efficient light fixture and the amount of waste heat that needs to be displaced. Please refer to the demand waste heat factor in the reference tables section.
	$WHF_{\mathbf{e}}$	-	Waste heat factor for energy to account for cooling interactive savings from efficient lighting. The waste heat factor

varies based on the size of the baseline and efficient light fixture and the amount of waste heat that needs to be displaced. Please refer to the energy waste heat factor in the reference tables section.

## Deemed Algorithm Assumptions - Wattage

Measure	Bin Range	Baseline Description	Watts Base	Watts EE
Panel LED	LED < 131W	T8 and T5HO 4' 2-4L fixtures	132	69
LED 200W	LED $\geq$ 132W and < 221W	400W HPS	460	180
LED 300W	LED $\geq$ 222W and < 417W	600W HPS	665	318
LED 600W	LED $\geq$ 418W and < 840W	1000W HPS	1,085	588

## Deemed Algorithm Assumptions - Waste Heat Factors<sup>[1]</sup>

Measure	With Co	ooling(2)	Without	Cooling	Unknown <sup>[3]</sup>		
medsure	WHFd	WHFe	WHFd	WHFe	WHFd	WHFe	
Panel LED	1.16	1.16	1	1	1.04	1.04	
LED 200W	1.36	1.36	1	1	1.08	1.08	
LED 300W	1.41	1.41	1	1	1.09	1.09	
LED 600W	1.46	1.46	1	1	1.11	1.11	

## Deemed Energy and Demand Savings

				2 Cycle Ind	2 Cycle Indoor 3		3 Cycle Indoor		4 Cycle Indoor		Unknown <sup>[4]</sup>	
Measure	Cooling	∆kW Savings	∆kWh Savings	∆kW Savings	∆kWh Savings	∆kW Savings	∆kWh Savings	∆kW Savings	∆kWh Savings	∆kW Savings	∆kWh Savings	
Panel LED		0.073	101	0.073	201	0.073	302	0.073	402	0.073	334	
LED 200W	With Cooling 0.489 0.726	0.381	524	0.381	1048	0.381	1573	0.381	2097	0.381	1739	
LED 300W		0.489	674	0.489	1347	0.489	2021	0.489	2694	0.489	2234	
LED 600W		0.726	999	0.726	1998	0.726	2997	0.726	3996	0.726	3314	
Panel LED		0.063	87	0.063	173	0.063	260	0.063	347	0.063	288	
LED 200W		0.280	386	0.280	771	0.280	1156	0.280	1542	0.280	1279	

0.347 478 0.347 955 0.347 1433 0.347 1911 0.347 1585	I FD	Coolina												
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Image         Image <th< td=""><td>LED</td><td></td><td>0.497</td><td>684</td><td>0.497</td><td>136</td><td>8</td><td>0.497</td><td>2053</td><td>0.497</td><td>273</td><td>37</td><td>0.497</td><td>2270</td></th<>	LED		0.497	684	0.497	136	8	0.497	2053	0.497	273	37	0.497	2270
Image: book of the stand of the st	Panel		0.066	90	0.066	180		0.066	271	0.066	361		0.066	299
Image         Marker         Application         Appl	LED		0.302	416	0.302	833		0.302	1249	0.302	166	i5	0.302	1381
Lift BOOW         Q         Size         Size         Q        Q         Q        Q        <	LED	Unknown	0.378	521	0.378	104	1	0.378	1562	0.378	208	13	0.378	1727
Code         Image:	LED		0.552	760	0.552	151	9	0.552	2278	0.552	303	18	0.552	2519
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Number         Number         Number         Number         Or         VM         Or         VM         Or         VM         DV         MV         EV           128         Residential Indoor Ag, Grow Light (1 cycle)         Active         61.96         25.96         51.96         52.76         77.96         92.096           130         Residential Indoor Ag, Grow Light (1 cycle)         Active         41.09         12.276         26.196         27.96         92.096           Interview Colspan="4">Interview Colspan="4"           Interview Colspan	28a Resid 29a Resid	ential Indoor /	Ag. Grow Lig	ht (2-3 cycles										
129       Residential Indoor Ag. Grow Light (2-3 cycles) Active 61.8% 24.3% 8.3% 5.6% 77.9% 0.0%         130       Residential Indoor Ag. Grow Light (4+ cycles) Active 44.0% 17.2% 26.1% 12.7% 77.9% 93.0%         Net Savings Factors         Kessures         Life AGROW Light (4+ cycles) Active 44.0% 17.2% 26.1% 12.7% 77.9% 93.0%         Note Savings Factors         Kessures         Life AGROW Light Colspan="2">Colspan="2"         Colspan="2"         Measure Cols intercemental costs vs. the market opportunity baselines.         Colspan="2"         Colspan="2"         Measure Cols         Colspan="2"         <	Number		Name			Status							r	
13         Residential Indoor Ag, Grow Light (4+ cycles)         Active         44.0%         17.2%         26.1%         12.7%         79.7%         93.0%	128	Residential In	door Ag. Gro	w Light (1 cy	vcle)	Active	65.0%	25.8%	5.1%	4.1%	0.0%	0.0%		
Net Savings Factors           Measure Survey         Track Row Light           Track Row Light         Track Nom Track N. Measure Code Free Rider Spill Over           S032EPPP [is base track]         Efficient Products - Residential           S032EPPP [is base track]         Efficient Products - Residential 6032EPPP JPHAGROW 1.00           Image: Survey Code         Track Nom Track No. Measure Code Free Rider Spill Over           Efficience         Image: Survey Code           Iffetimes         Image: Survey Code           Image: Survey Code         Image: Survey Code           Iffetimes         Image: Survey Code           Image: Survey Code         Image: Survey Code           Image: Survey Code         Survey Code           Image: Survey Survey Code         Survey Code           Image: Survey Code	129	Residential In	door Ag. Gro	w Light (2-3	cycles)	Active	61.8%	24.3%	8.3%	5.6%	77.9%	0.0%		
Net Savings Factors           Measure Code Gree Rider Spil Over           Track Nm Track N. Measure Code Free Rider Spil Over           Track Nm Track N. Measure Code Free Rider Spil Over           Track Nm Track N. Measure Code Free Rider Spil Over           Track Nm Track N. Measure Code Free Rider Spil Over           Track Nm Track N. Measure Code Free Rider Spil Over           Track Nm Track N. Measure Code Free Rider Spil Over           Track Nm Track N. Measure Code Free Rider Spil Over           Track Nm Track N. Measure Code Free Rider Spil Over           Track Nm Track N. Measure Code Free Rider Spil Over           Internet Products - Residential 6032EPPP ILPHAGNOV         L.00         L.00           Internet Track Nm Track Nm Measure Code Free Rider Spil Over           Internet Code           Internet Code           Measure Code           Resident Code           Measure Code         Beseline Lamp Life Replacement Code           Replacement Code         Replacement Code           Replacement Code         Replacement Code           Store         Store           Replacement Code	130	Residential In	door Ag. Gro	w Light (4+	cycles)	Active	44.0%	17.2%	26.1%	12.7%	77.9%	93.0%		
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Normental Cost           Measure         Incremental Cost           S27         527           D2000         527           D2000         527           D2000         527           D2000         5425           D2000         560           SMUCTICE Section 1000           Measure         ED Lamp Life         Cost         Baseline Lamp Life         Baseline Ballast Life         Baseline Ballast Life         Replacement Cost         Replacement Cost         Replacement Cost         Replacement Cost         Statistical Section 2000         547         Statistical Section 2000         547         Statistical Section 2000         Stat			sumed to be	incremental	costs vs	, the mar	ket onnor	tunity hase	ines.					
Nature         Operating in the image of the image			Samea to be	inci ci inci idai	00000 4.		net oppor	curity busic						
Panel LED         \$27           ED 200W         \$270           ED 200W         \$275           LED 600W         \$425           LED 600W         \$600           Statistical Colspan="4">Baseline Lamp Life (hours)         Baseline Ballast (														
ED 200W         \$270           ED 200W         \$425           ED 300W         \$425           ED 600W         \$600           Second Seco			Cost											
LED 300V         \$425           LED 600V         \$425           LED 600V         \$400 <b>EAC Lock Justment</b> Cost         Replacement Cost         (hours)         Baseline Ballest Life (hours)         Baseline Ballest (hours)         Baseline Balest (hours)         Baseline Balest (hours)		4												
LED GOW         5500           SkH Cost Adjustment         Session           Measure (Fours)         LED Replacement Cost         Baseline Lamp Life (hours)         Baseline Ballast (hours)         Baseline Ballast (hours)         Baseline Ballast Replacement Cost         Baseline Ballast (hours)         Baseline Ballast Life (hours)         Baseline Ballast (hours)         Baseline Ballast (hours)<														
Bit Acts + Adjustment           Measure         LED Lamp Life         LED Replacement         Baseline Lamp Life         Baseline Ballast         Baseline Ballast           Measure         (flours)         Cost         (flours)         Replacement Cost         (flours)         Replacement Cost           Parele         50,000         \$90         27,000         \$29         55,000         \$47           D200W         50,000         \$496         24,000         \$31         40,000         \$205           D200W         50,000         \$768         24,000         \$47         40,000         \$229           D200W         50,000         \$1,388         24,000         \$80         40,000         \$255           Contexture           Replacement, May Data           Replacement, May Data           D300W         50,000         \$1,388         24,000         \$80         40,000         \$255		4.00												
Measure (hours)         LED Replacement Cost         Baseline Lamp Life (hours)         Baseline Ballast (hours)         Baseline Ballast (hours)         Baseline Ballast Replacement Cost         Baseline Ballast (hours)         Baseline Ballast Replacement Cost           Panel (ED)         50,000         \$99         27,000         \$29         55,000         \$47           LED         50,000         \$496         24,000         \$31         40,000         \$205           LED         50,000         \$768         24,000         \$47         40,000         \$229           LED         50,000         \$1,388         24,000         \$40         40,000         \$255           Image and demand waste heat factors account for only the cooling interactive savings from the efficient lighting. For the "Energy Trust of On Residential Lighting Report", Every reen Economics, May 2018; "Despite the fact that LEDs produce less excess heat than on-the types of lighting, the veen to statistically significant differences in the frequency of supplemental heating equipment as they were emptyed in similar faction between result, coted to exclude waste heating interactive fields requences and by were emptyed in similar faction between	LED 600W	\$600												
Measure (hours)         LED Replacement Cost         Baseline Lamp Life (hours)         Baseline Ballast (hours)         Baseline Ballast (hours)         Baseline Ballast Replacement Cost         Baseline Ballast (hours)         Baseline Ballast Replacement Cost           Panel (ED)         50,000         \$99         27,000         \$29         55,000         \$47           LED         50,000         \$496         24,000         \$31         40,000         \$205           LED         50,000         \$768         24,000         \$47         40,000         \$229           LED         50,000         \$1,388         24,000         \$40         40,000         \$255           Image and demand waste heat factors account for only the cooling interactive savings from the efficient lighting. For the "Energy Trust of On Residential Lighting Report", Every reen Economics, May 2018; "Despite the fact that LEDs produce less excess heat than on-the types of lighting, the veen to statistically significant differences in the frequency of supplemental heating equipment as they were emptyed in similar faction between result, coted to exclude waste heating interactive fields requences and by were emptyed in similar faction between														
Measure Parel ED         Cost         (pours)         Replacement Cost         (hours)         Replacement Cost           Parel ED         50,000         \$90         27,000         \$29         55,000         \$47           LED         50,000         \$495         24,000         \$31         40,000         \$205           LED         50,000         \$768         24,000         \$477         40,000         \$229           LED         50,000         \$778         24,000         \$477         40,000         \$229           LED         50,000         \$1,388         24,000         \$490         40,000         \$255           Image: Second S	& M Cost	Adjustment	:											
Panel LD         50,000         \$90         27,000         \$29         55,000         \$47           DDD 2000W         50,000         \$496         24,000         \$31         40,000         \$205           DDD 2000W         50,000         \$768         24,000         \$47         40,000         \$229           LED 2000W         50,000         \$1,388         24,000         \$80         40,000         \$255									lost		Ballast L			
30,000         \$496         24,000         \$31         40,000         \$205           LED DB         50,000         \$768         24,000         \$47         40,000         \$229           LED DB         50,000         \$1,388         24,000         \$47         40,000         \$225           LED DB         50,000         \$1,388         24,000         \$80         40,000         \$255           Residential Lighting Report", Evergreen Economics, May 2018; "Despite the fact that LEDs produce less excess heat than other types of lighting, the vero enstatistically significant differences in the frequency of supplemental heating equipment as the vero enshare on ensities on estimic that on better were emptyed in similar fashion between	Panel													
LED 300W         \$5,000         \$768         24,000         \$47         40,000         \$229           ED 600W         \$0,000         \$1,388         24,000         \$80         40,000         \$255	LED	50,000	\$496		24,000		\$31			40,000		\$20	15	
LED 600W         50,000         \$1,388         24,000         \$80         40,000         \$255           In the energy and demand waste heat factors account for only the cooling interactive savings from the efficient lighting. Per the "Energy Trust of Orr Residential Lighting Report", Evergreen Economics, May 2018; "Despite the fact that LEDs produce less excess heat than other types of lighting, the were no statistically significant differences in the frequency of supplemental heating equipment sub ever employed in similar fashion between result, optiot boucked waste heating interactive (FEGS to supplemental heating equipment sub ever employed in similar fashion between result, optiot boucked waste heating interactive (FEGS to supplemental heating equipment sub ever employed in similar fashion between the substance of the substance	LED	50,000	\$768		24,000		\$47			40,000		\$22	9	
both         The energy and demand waste heat factors account for only the cooling interactive savings from the efficient lighting. For the "Energy Trust of Orr Residential Lighting Report," Evergreen Economics, May 2018; "Despite the fact that LEDs produce less excess heat than other types of gloting, th were no statistically significant differences in the frequency of supplemental heating equipment used by LED-using and non-LED using growers. As result, optiot becaulte waste heating interactive effects for supplemental heating equipment as they were employed in similar fashion between	LED	50,000	\$1,388		24,000		\$80			40,000		\$25	5	
] The energy and demand waste heat factors account for only the cooling interactive savings from the efficient lighting. Per the "Energy Trust of Orr Residential Lighting Report", Evergreen Economics, May 2018; "Despite the fact that LEDs produce less excess heat than other types of lighting, th were no statistically significant differences in the frequency of supplemental heating equipment used by LED-using and non-LED using growers. As result, optiot beacide waste heating interactive effects for supplemental heating equipment used by LED-using and non-LED using growers. As	600W													
The energy and demand waste heat factors account for only the cooling interactive savings from the efficient lighting. Per the "Energy Trust of On Residential Lighting Report", Evergreen Economics, May 2018; "Despite the fact that LEBs produce less excess heat than other types of lighting, th were no statistically significant differences in the frequency of supplemental heating equipment used by LED-using and non-LED using growers. As result, optiot buckle waste heating interactive effects for supplemental heating equipment used by LED-using and non-LED using growers. As														
Residential Liphting Report, Evergreen Economics, May 2018; "Despite the fact that LEDs produce less excess heat than other types of liphting, the were no statistically significant differences in the frequency of supplemental heating equipment used by LED-using and non-LED using growers. As result, opted to exclude waste heating interactive effects for supplemental heating equipment as they were employed in similar fashion between the supplementation of the supplemental heating experiments and the supplementation of the	otnote	s												
Besidential Lighting Report, Evergreen Economics, May 2018; "Despite the fact that LEDs produce less occess heat than other types of lighting, were no statistically significant differences in the frequency of supplemental heating equipment used by LED-using and non-LED using growers. As result, optide to exclude waste heating interactive effects for supplemental heating equipment as they were employed in similar fashion between the supplemental heating interactive effects for supplemental heating equipment as they were employed in similar fashion between the supplemental heating interactive effects for supplemental heating equipment as they were employed in similar fashion between the supplemental heating interactive effects for supplemental heating equipment as they were employed in similar fashion between the supplemental heating interactive effects for supplemental heating equipment as they were employed in similar fashion between the supplemental heating interactive effects for supplemental heating equipment as they were employed in similar fashion between the supplemental heating interactive effects for supplemental heating equipment as they were employed in similar fashion between the supplemental heating interactive effects for supplemental heating equipment as they were employed in similar fashion between the supplemental heating interactive effects for supplemental heating equipment as they were employed in similar fashion between the supplemental heating interactive effects for supplemental heating equipment as they were employed in similar fashion between the supplemental heating interactive effects for supplemental heating equipment as they were employed in similar fashion between the supplemental heating interactive effects for supplemental heating equipment as the supplemental heating equipment as														
result, opted to exclude waste heating interactive effects for supplemental heating equipment as they were employed in similar fashion between														
paseline and emclent scenarios.				ating interact	tive effe	cts for sup	oplementa	al heating e	quipment a	s they wer	e employ	ed in simil	ar fashion b	etween
	baseline	and efficient	scenarios.											

[2] The cooling interactive effects were calculated assuming mechanical cooling is needed to displace the excess heat given off by the baseline fixtures. The mechanical cooling equipment is assumed to be a window air conditioner with a capacity of 8,160 Btu/h and an efficiency of 10.1 EER as sourced from the average of existing equipment from the "Vermont Single-Family Existing Homes Onsite Report", MRN, December 2017. The meckes heat needed to be displaced from the baseline fixture is calculated assuming the lamp's efficacy in being able to covert input values to output light. It is assumed that high pressure sodium lamps convert 30% of the input wattage into light; 70% for fluorescent lamps; and 85% for LEDs.

assume use may pressure solution imple curves 1.5% or use inplx watage not play. (Area to indexectin tailing, and 5% to LEDAs Courses), Depted to base the cooling interactive effects on a window arconditioner as its the typical portable cooling diversaries. Cooling interactive effects were not assessed on a certral system as only 2% of existing residences in Vermont have certral at conditioning, per the previously referenced NRR report. Additionally, it was assumed that the measure replacements contrain would result in negligible impacts to any fans or other ventilation system as air movement across plants aid in their health and growth and would not be impacted by the lighting.

- [3] The default or unknown interactive effects assume that 23.2% of customers will use some sort of mechanical cooling. This value is sourced from "Energy Trust of Oregon Residential Grow Light Research", Evergreen Economics, May 2018.
- [4] The default or unknown quantity of plant production cycles is assumed to be 3.3 cycles per year. This value is sourced from survey respondents of the "Energy Trust of Oregon Residential Grow Light Research", Evergreen Economics, May 2018. It respresents a weighted average from survey respondents, taking into account quantity of cycles and location, as 100% of interior operations will leverage lights; 0% of exterior operations; and 47% growing in greenhouses will use lights
- (5) The lighting run hours per cycle is sourced from "Energy Trusy of Oregon Residential Grow Light Research", Evergreen Economics, May 2018. The run hours per day and length in weeks per plant growth stage was sourced as a weighted average of survey respondents. The results were as follows; 10.3 hours per day for the secling stage which runs on average for 1.5 weeks; 156 hours per day for the secling stage which runs on average for 1.5 weeks; 156 hours per day for the vegetative stage which runs on average 3.5 weeks; and 15.8 hours per day for the flowering stage which runs on average for 1.5 weeks.

## Flexible Load Management: Electric Vehicle Supply

## Equipment

Measure Number: RS-MSC-FLMEVS a Portfolio: Status: Active

Status: Active Effective Date: 2021/1/1 End Date: [ None ] Program: Residential & Multifamily End Use: Miscellaneous

## Update Summary This is version 1.0 of the characterization

## Referenced Documents

- on Electrification 2019
- GMP eCharger Pilot Update 2020
   ISO NE Update on the 2020 Transportal
   Pages from GMPExhibits
   VELCO 2020 Long-Term System Load
   EVT TRM FLM EVSE Analysis Dec 2021

### Description

Electric vehicle supply equipment load flexibility is enabled through controls and supporting hardware that safely disconnect charging of vehicle from grid. Electric vehicle supply equipment load flexibility is enabled through controls and supporting hardware that safely disconnect charging is a large demand on a residential is load profile and disconnecting this load during pask periods can provide benefits for the grid. This measure accounts for the demand that can be reduced by disconnecting the charge during the peak periods. The resource must be capable of being connected to an active distribution utility grid-management program such that it can be dispatched during peak times. Installation of controls is considered a Market Opportunity activity.

### Program Type

Calculation Type: Market Opportunity Program Delivery/Implementation Type:v Downstream

## **Baseline Efficiencies**

Baseline is an electric vehicle supply equipment without control equipment and therefore no grid interactivity.

## Efficient Equipment

The efficient components The efficient controls defined as electric vehicle supply equipment that either had controls enabled or has been retrofitted with controls and necessary supporting hardware that would enable a distribution utility to control its electric load draw. It has the ability to be grid interactive, meaning It's capabable of providing grid balancing services as determined by the distribution utility.

### Algorithms

Electric Demand Savings No electric demand savings are claimed. Data will be collected and shared over 2021-2023 to understand if and how distribution utilities are able to utilize this resource. EVI is committed to collecting the necessary data to understand any demand savings and their seasonal coincidence factors.

Flexible Load kW As defined by PIP #125 Flexible Load Management (FLH), <u>Flexible Load kW</u> is the maximum amount of demand reduction available to be contro at least one hour between 4pm and 10pm on any day in any season, measured and reported in units of kW.

At best, controls could allow complete shutoff of electric vehicle supply equipment for any given hour and therefore Flexible Load kW is estimated by considering the typical power draw of an electric vehicle charger during the hours between 4pm and 10pm. 
 Electric Vehicle Supply Equipment
 Measure Code
 Item Code
 Flexible Load KW Credit (KW)<sup>[1]</sup>

 Level 2 Charger with Controller
 FLMEQPEV
 FLM-RESEVSE1
 0.49

Electric Energy Savings No energy savings are claimed, or necessarily expected. EVT is committed to tracking and reporting kWh impacts for participants and will make appropriate revisions to claimed energy impact when more is understood.

Fossil Fuel Savings

## None.

Load Shapes This is a nla

 ler loadshape until data collection can inform a more appropriate choice. 25a Flat (8760 hours)

## Number Name Status Winter Winter Summer Summer Summer</t

Flat (8760 hours) Active 31.7% 34.9% 15.9% 17.5% 100.0% 100.0% 25

## Net Savings Factors

Measures FLMEQPEV Flexible Load Management - Electric Vehicle Charging Stations

Tracks [Base Track] 6036RETR [is base track] Res Retrofit

 Track Name
 Track Nr.
 Measure Code
 Free Rider
 Spill Over

 Res Retrofit
 6036RETR FLMEQPEV
 1.00
 1.00

## Lifetimes

The expected measure life for the EV charger is assumed to be 10 years<sup>[2]</sup>

## Measure Cost The assumed incremental cost of a charger with a controller is \$227.15.<sup>[3]</sup>

## Footnotes

- CIT The flobble KW calculation is derived from reviewing three sources of New England sourced EVSE controller analysis, which include studies from Green Nountain Power, VBLCD, and SD-NE. These analyses can be found in the analysis file: EVT TRM FLM EVSE Analysis Dec 2021.dsx and in the referenced documents of this measure dranactrization.
- [2] Based on Northwest Power and Conservation Council, Regional Technical Forum workbook for Level 2 Electric Vehicle Charger version 1.1. approv Nay 2019. https://tf.mccouncil.org/measure/level-2-electric-vehicle-charger. Other sources reviewed can be found on the Measure Life tab of the analysis document: IVT TRM FM IN EVSE Analysis Exerc 2021.stsc.
- [3] A review of nine electric vehicle chargers that are either remote accessed or not remote accessed are reviewed. The average cost of a charger with remote access is subtracted from the average cost for a charger without remote access. Analysis can be found on Cost tab of EVT TRM FUM EVSE Analysis Bic 2021 Jax

Portfolio:	
	r: (VI-M-1 a) EVT TRM Portfolio 2018-01
	Active
Effective Date: End Date:	
End Date: Program:	[ None ] Residential New Construction
End Use:	Miscellaneous
Update Sun	imary
New measure	
	Documents Aureau_ACS Table DP04 Vermont_2015
DeOreo_Resid	fential End Uses of Water Study 2013 Update_2014
	nse Labeled Products_Dec 2017 tial End Uses of Water Exec Summany_Apr 2016
	allins_Green Building Practice Summary_Mar 2011
Description	
This measure cha	racterizes the installation of a WaterSense labeled toilet in a new home.
Algorithms	
Water Savings Using the default a	assumptions provided below, water savings are:
∆CCF = ((1.38 - 1	.28) × 5 × 2.33 / 2.5 × 365) / 748 = 0.23 CCF
ΔCCF	= ((GPF <sub>base</sub> - GPF <sub>iow</sub> ) × # flushes × # people / toilets/home × usedays/year) / 748
Where:	
# flushes	<ul> <li>Average number of toilet flushes per person per day</li> </ul>
	= 5 <sup>(1)</sup>
# people	<ul> <li>Average number of people per household</li> <li>= 2.33<sup>[2]</sup></li> </ul>
ΔCCF	= Gross customer annual water savings for the measure
748	<ul> <li>Constant to convert from gallons to CCF</li> </ul>
GPF <sub>base</sub>	= Gallons per flush (gpf) of baseline toilet = 1.38 gpf <sup>(3)</sup>
GPFlow	= Flow rate (gpm) of low flow toilet = 1.28 gpf <sup>(c)</sup>
toilets/hor	
usedays/y	ear = Days toilet is used per year
	= 365
Baseline Eff	ficiancias
	collet that uses 1.38 gallons per flush (gpf). <sup>[3]</sup>
Efficient Eq	uipment iton is a toilet that uses 1.28 opf. <sup>[4]</sup>
rne emclenic condi	uun is a uunet uud taes 1120 guu 9
Load Shape There are no load	S shapes associated with this measure.
	s Factors
-	
	flow toilet
Measures WATLFTLT Low Tracks [Base Ti	
Measures WATLFTLT Low Fracks [Base Tr 6038VESH [is base	rack]e track] RNC VESH
Measures WATLFTLT Low Fracks (Base Ti 6038VESH (is bas Track Name Trac	rack]
Measures WATLFTLT Low Tracks [Base Tri 6038VESH [is base Track Name Trai RNC VESH 6033 Persistence	rack] ne track] RNC VESH ck Nr. Measure Code Free Rider Spill Over svESH_WATLFTLT 1.00 1.00
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Measures WATLFILT Low Iracks [Base Ti 6038VESH [is base Track Name Tra- RNC VESH 6031 Persistence Fine persistence for Lifetimes The measure life i Measure Co	rack] le track] RNC VESH ck Nr. Measure Code Free Rider Spill Over evesHWATLFTLT 1.00 1.00 e incor is assumed to be one. Is assumed to be 30 years. <sup>16</sup>
Measures WATLFILT Low WATLFILT Low Tracks [Base Ti 6038/VESH [is base Track Name Tra- Track Name Tra- Name Tra- Na	rack] le track] RNC VESH ck Nr. Measure Code Free Rider Spill Over svesh(WATLPTLT 1.00 1.00 ctors is assumed to be one. is assumed to be 30 years. <sup>1(4)</sup>
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Masures WATLFILT Low Fracks [Base Tr 6039VESH [6 base CO39VESH [6 base Track Name Tra- rack Name Tra- RNC VESH 6031 Persistence for Persistence for the persistence for Lifetimes The measure life I Measure Co The incremental co potnotes I) Water Researce I) Water Researce I) Water Researce	rack] le track] RNC VESH ck IV. Measure Code Free Rider Spill Over EVESHWATLFTLT 1.00 1.00 e la assumed to be one. is assumed to be 30 years. <sup>[6]</sup> st st st st st st st st st st
VARIANCE AND A CONTRACT AND A CONTRA	rack] et rack] RK VESH          ck Nr. Measure Code Free Rider Spill Over svesh(WATLFTLT 1.00 1.00          sk assumed to be one.         a ctor is assumed to be one.         sk assumed to be 30 years. <sup>1(6)</sup> st assumed to be 30 years. <sup>1(6)</sup> chtor, "Residential End Uses of Water, Version 2: Executive Report," April 2016, page 9.         rape household size of owner-occupied versus renter-occupied

See file EPA\_WaterSense Labeled Products\_Dec 2017.xlsx.

- [5] Average number of toilets per home from the Water Research Foundation, "Residential End Uses of Water Study 2013 Update," 2014, page 128.
- [6] Toilet lifetime from Wisdom Blake Home Inspections: http://www.metrohome.us/information\_kit\_files/life.pdf and ATD Home Inspection: http://www.atdhomeinspection.com/advice/average-product-life/ is 50 years. EVT caps measure lifetimes at 30 years.

[7] Measure cost assumption from City of Fort Collins, "Green Building Practice Summary," March 21, 2011, page 2. The document states "Information from the EPA Water-Green web site: 'Water-Greene®) labeled balets are not more expensive than regular tailets. Mail testing results have shown no correlation between price and performance. Prices for tailets can range from less than \$100 to more than \$1,000. Much of the variability in price is due to style, not functional design."

Maple Sap	Vacuum Pump	VFD	
Status:     Active       Effective Date:     2018/1/1       End Date:     [ None ]	Portfolio 2017-11 al & Industrial		
Update Summary • Due to the relatively low v update based on aggregal based on an average from • I drilled down on the meas	e savings claims and cost data from pri a custom pilot projects implemented from sure savings and costs from these prior	or custom projects. The original character	ggregates from a per unit basis to a per
Referenced Docum     Maple-Sap-VFD-Analysis_			
	d to the vacuum pump in a maple sap e ing an inefficient method such as a diffe	extraction system that allows operators to rential pressure relief valve.	manage system pressure by reducing
Estimated Measure	Impacts Average Annual MWH Savings per unit	Average number of measures per year <sup>[1]</sup>	Average Annual MWH Savings per year
Maple Sap Vacuum Pump VFD	1.81	18	32.52
Symbol Table Electric Energy Savings	//#x#P		
AkWh = kW	h/HP x HP		
Savings estimates are the ave	gross customer connected load kW     gross customer average annual kM     horsepower of the motor to which     0.12 <sup>(2)</sup> 155 <sup>(2)</sup>	Vh savings for the measure	11, and 2012, see Maple Sap
VFD_Analysis_v2.xls Baseline Efficiencie The baseline reflects a made	<b>S</b> sap extraction system without a VFD eq	uipped vacuum pump,	
High Efficiency	allation and use of a VFD equipped vacu		
<b>Operating Hours</b> N/A			
	atus Winter Winter Summer S On kWh Off kWh On kWh (		
	tive 51.2% 48.8% 0.0% (	0.0% 0.0% 0.0%	
Net Savings Factor Measures MTCSAPVP Maple Sap Vacu Tracks [Base Track] 6013CUST [is base track] Cu 6013PRES [is base track] Pr	um Pump VFD ist Equip Rpl		
Persistence The persistence factor is assur	med to be one.		
Lifetimes 15 years.			
Measure Cost \$159/HP <sup>[2]</sup>			

## O&M Cost Adjustments

ossil Fu	el Description		
here are no	fossil-fuel algorithms or default	savings for this measure.	

7.5	1,163	0.90	\$1,193
10	1,550	1.20	\$1,590
15	2,325	1.80	\$2,385
20	3,100	2.40	\$3,180
25	3,875	3.00	\$3,975

Footnotes
[1] Assumes that there will be ~50% more Rx measures per year than the average number of custom measures per year in 2010 and 2011, see Maple
Sap VFD\_Analysis.xls

[2] Derived from Efficiency Vermont custom data 2010-2011, see Maple Sap VFD\_Analysis.ds

## **Notched V-Belts**

Measure Number	I-A-11 a
Portfolio:	EVT TRM Portfolio 2018-1
Status:	Active
Effective Date:	2019/1/1
End Date:	[ None ]
Program:	Commercial & Industrial
End Use:	Motors

### Update Summary easure

- tch V-Belts Jun 2010
- Referenced Documents

   DERX014-EUk-table-updata\_2014-02-05-Jssx
   USDOE EERE\_Motor System Tip-Replace V-bells with Cogged
   UT Cogged V-Bells PTI\_V-Carran
   USDOE\_Ind. Motor Market Opp. Assessment, Dec 2002
   Gates Rubber, Gate Co. Announces New EPDM Molded Netch
   ACEEE\_Midatema Cogged V-Bell Rink Program\_2015
   UT Cogged V-Bell, Ruhajsa, Two 2018
   PGECOHVC144 R1 Cogged V-belts

### Description

Description This measure is the replacement of smooth v-belts with notched v-belts on electric motors in the industrial and commercial sectors that use belt drives. Notched v-belts have slots that run perpendicate to the belt's length, which help reduce the bending resistance of the belt. As a result, they run coder and have an improved efficiency ore standard v-belts. Overall efficiency is denoted from the start of the vertex of the belt is not, periodically re-tensioned. For the purposes of this measure characterization, notched and cogged v-belts are considered identical and the terms can be used interchangeably to describe the type of v-belt.

### **Baseline Efficiencies**

The baseline ent is sm ooth v-belts on electric motors in the industrial and commercial sector that use belt drives.

## Efficient Equipment

The efficient equipment is the installation of notched v-belts on electric motors in the industrial and commercial sector that use belt drives V-belts are usually referred to in the following groups:

- \*\* and "IP belts are typically trated for smaller horesepower motors. The "A" belt is 1/2 inch width by 5/16 inch thickness and the "B" belt is larger, 21/32 inch wide and 12/32 inch thick so it can carry more power. V-belts come in a wide variety of lengths where 20 to 100 inches is typical.
   \*C" and "D" belts are primarily for larger industrial applications with high power transmission requirements and are approximately and you have the second of these belts typical, the vice second of these belts typically have an "X" added to the designation. For example, a typical "A" whet is replaced by a nother "X". Because nother vices restance to benefing. Lower transmission efficiency, lowers the waste heat, and allows the belt to last longer than a smooth belt.

ΔkWh	e	= kW <sub>Motor</sub> x E	SF						
lectric Ene ΔkWh									
ΔkWh									
ΔkWh Symbol Tabl	rgy Sav								
Symbol Tabl		= kWh <sub>Motor</sub> x	ESF						
	e								
ossil Fuel S	avings								
Vhere:									
ΔkW		= Gros	s customer conne	cted load kV	V savings f	or this mea	sure		
ΔkWh		= Gros	s customer annua	l kWh saving	gs for this r	neasure			
ESF		= Ener	gy savings factor						
kW <sub>Mot</sub>	or		nected load of the	motor <sup>[2]</sup>					
		see	table 1 for deeme	d assumptio	ns				
kWh <sub>M</sub>	otor		ual energy consum						
		see	table 1 for deeme	d assumption	ns				
		porithm Assum	-						
Belt Type Type A		Hp Size Range ≤ 18 hp	kW <sub>Motor</sub> 2,630		kWh <sub>Motor</sub> 8,300				
Type B		10  mp 10  mp  and  10  mp	18.924		83,548				
Type C		p and $\leq$ 150 hp	47.150		266,775				
able 2 - Dee	emed En	ergy and Dem	and Savings						
Belt Type Ib	em Code	∆kW Savings	∆kWh Savings						
Type A V	BELTA1	0.053	166						
Type B V	BELTB2	0.379	1,671						
Type C V	BELTC3	0.943	5,336						

MTDV/DELT										
PHIKADELI	F Notched v-t	pelt								
Tracks [B	ase Track]									
6013PRES	[is base track	() Pres Equ	uip Rpl							
6013UPST	[is base track	k] Upstrear	n - Commercia							
Trac	k Name	Track Nr. 1	Measure Code	Free Rider	Spill Over					
Pres Equip	Rpl	6013PRES	MTRVBELT	0.85	1.00					
Upstream	<ul> <li>Commercial</li> </ul>	6013UPST N	MTRVBELT	0.85	1.00					
Lifetim										
		based on a	n estimate helt	life of 74 00	0 bours <sup>[4]</sup>	The lifetime in yea	are vary hace	d on the helt	tune designat	ion and applica
	Measure Life		ii esuinate beit	iiie oi 24,00	10 110ui 5- 7.	The meane in yea	iis vaiy base	a on the beit	type, designat	son, and applica
Belt Type	Lifetime (yea	irs)								
Type A	8									
Type B	6									
Type C	4									
Type C										
Type C										
Measu	re Cost							4-1		
Measu The increm	nental cost for		re is represente	ed in the tab	le below an	d varies based on	the belt type	, designation,	and application	on.
Measu The increm			re is represente	ed in the tab	le below an	d varies based on	the belt type	, designation,	and application	on.
Measui The increm Table 4 - 1	nental cost for	Cost <sup>[5]</sup>	re is represente	ed in the tab	le below an	d varies based on	the belt type	, designation,	and applicatio	on.
Measui The increm Table 4 - 1	nental cost for Incremental	Cost <sup>[5]</sup>	re is represente	ed in the tab	le below an	d varies based on	the belt type	, designation,	and application	on.
Measui The increm Table 4 - 1 Belt Type	incremental	Cost <sup>[5]</sup>	re is represente	ed in the tab	le below an	d varies based on	the belt type	, designation,	and application	on.
Measur The increm Table 4 - 1 Belt Type Type A	Incremental Incremental \$5.74	Cost <sup>[5]</sup>	re is represente	ed in the tab	le below an	d varies based on	the belt type	, designation,	and application	on.
Measur The increm Table 4 - J Belt Type Type A Type B	Incremental Incremental \$5.74 \$8.82	Cost <sup>[5]</sup>	re is represente	ed in the tab	le below an	d varies based on	the belt type	, designation,	and application	on.
Measur The increm Table 4 - J Belt Type Type A Type B	Incremental Incremental \$5.74 \$8.82	Cost <sup>[5]</sup>	re is represente	ed in the tab	le below an	d varies based on	the belt type	, designation,	and application	on.
Measul The increm Table 4 - J Belt Type A Type A Type C	Incremental \$5.74 \$8.82 \$14.66	Cost <sup>[5]</sup>	re is represente	ed in the tab	le below an	d varies based on	the belt type	, designation,	and application	ən.
Measur The increm Table 4 - J Belt Type Type A Type B Type C	Incremental s5.74 \$8.82 \$14.66	Cost								
Measur The increm Table 4 - 1 Belt Type Type A Type B Type C Ootnote	Incremental cost for Incremental \$5.74 \$8.82 \$14.66 ES 6 energy savin	Cost	sourced from a	1 U.S. DOE E	Energy Effici	ency and Renewat	ole Energy en	vergy savings	resource, "Mo	tor System Tip
Measur The increm Table 4 - 1 Belt Type Type A Type B Type C Ootnote 1] The 2% #5, Rej	Incremental cost for Incremental \$5.74 \$8.82 \$14.66 ES 6 energy savin place V-Belts	Cost <sup>[5]</sup> Cost gs factor is with Cogged	sourced from a	a U.S. DOE E us Belt Drives	inergy Effici		ole Energy en 2005. This is	nergy savings a relatively co	resource, "Mo mservative es	tor System Tip

- [2] The average connected load and energy consumption of the impacted motor is sourced from a motor market assessment conducted by the U.S. Department of Energy; "United Stated Industrial Electric Motor Systems Market Opportunity Assessment", U.S. DOE, December 2002 (page B-2)
- [3] The net savings factors are sourced from DEER 2014 and the PG&E workpaper, "HVAC Fans Cogged V-belt Replacement, PGECOHVC144, May 2014".
- [4] The measure life, in hours, is sourced from DEER 2014 ("DEER2014-EUL-table-update\_2014-02-05.xfsx"; Database for Energy Efficiency Resources (DEER))
- [5] Incremental cost is sourced from EVT product pricing and research on notched V-belts for type A and B applications. Type C V-belts were interpolated based on the findings for Type A and Belts. For more information, please see "EVT Cogged V-Belt Market Research\_McCarran.xlsx" and "EVT Cogged V-Belt NPT\_McCarran.pdx".

## **Milk Vacuum Pump VFD**

Neasure Number: (EA.S.d.) Portfolio: EVT TIMP Portfolio 2019-04 Status: Active Effective Date: 2019/1/1 End Date: [None] Program: Commercial & Industrial End Use: Motors

Updates Summary Updates made to connected load (KW) savings; energy savings (KWh); and incremental costs. Per request from the program implementation team, milk transfer pump VFD savings were removed from the measure characterization. Laadshape, persistance factor, net to gross savings factors, and lifetime all remained the same and were not updated.

Deemed values were originally sourced from a straight average of custom projects from 2003 to 2011. TRM update included incorporating custom projects from 2012 through 2018 into the data set. This increased the data set from 207 projects to 225, a 8.7% increase.

From 2012 through 2018, there were 132 prescriptive projects, or approximately 19 measures incentivized per year. Due to the relatively low participation numbers, optet to keep the measure update similarly how impact. Instead of over-hauling the measure for a prescriptive algorithm appr or a scaled approach kinsing motor horsepower, opted to minihain the same deemed saving approach that was previously used.

## Referenced Documents

 EVT\_Milk Pump D\_Analysis\_Apr 2019

### Description

Description A mik vacuum pump for a dairy farms operates during the milk harvest and equipment rinsing periods. The vacuum pump creates negative air pressure that draws milk from the cow and transfers it to either a milk receiver jar or for bulk storage. A variable frequency drive (VFD) equipped on a milk vacuum pump is used to reduce pump speed in order to adjust and deliver the amount of vacuum needed in the milk partir. A VFD offers energy savings for the milk vacuum pump with the pumping needs fall below peak levels. Electricity is saved relative to a system that pumps at a constant rate. A VFD milk vacuum pump typically replaces old equipment when it reaches the end of its useful life.

	rithms acuum Pump	VFD Electric E	emand Savings	
ΔkW	r	= 3.06 kW		
Symb	ol Table			
Milk V	acuum Pump	VFD Electric E	nergy Savings	
ΔkW	ſh	= 8,303 kWh		
Where	:			
	ΔkW	= gros	s customer connected load kW savings for the measure	
	ΔkWh	= gros	s customer average annual kWh savings for the measure	
Saving	s estimates are	the average savi	ngs claimed for EVT custom projects from 2003 through 2	018, see "EVT_Milk Pump VFD_Analysis_Mar 2019.x
Base	eline Effici	encies		
The ba	seline case is a	non-VFD equippe	d milk vacuum pump.	
While t	hese technologi	ies would be base	line for new construction, farmers typically re-use old equ	ipment when extensively renovating old facilities. Ne
constru	uction due to co	nstruction of new	facilities is rare and EVT staff has only heard of one case	(between 2006 and 2012) where a new construction

project resulted in purchase of new equipment. Vermont Commercial and Residential code adhering, and as a result, do not stipulate or require VFDs on milk harvest vacuum pumps

High Efficiency The efficient case is a milk vacuum pump equipped with a VFD equipped.

### **Operating Hours** N/A

## Load Shapes

Load shapes were developed based on actual data for EVT custom projects installed through the EVT dairy farm program from 2008 through 2011. For more information see; "EVT\_Milk Pump VFD\_Analysis\_Mar 2019.xks". The milk vacuum pump load profile is based on 94 custom projects. 61b Milk Vacuum Pump

### Number Name Status Winter Winter Summer Summer Winter Summer Milk Vacuum Pump Active 36.9% 30.1% 18.2% 14.8% 63.4% 28.7% 61

## **Net Savings Factors**

Item Code DF-XFER-VAC

Measures MTCDFVFD Dairy Milk Pump VFD

## Tracks [Base Track]

6013CUST [is base track] Cust Equip Rpl 6013PRES [is base track] Pres Equip Rpl

# Track Name Track Nr. Measure Code Free Rider Spill Over Cust Equip Rpl 6013CUST MTCDFVFD 0.94 1.00 Pres Equip Rpl 6013PRES MTCDFVFD 1.00 1.00

Persistence The persistence factor is assumed to be one.<sup>[1]</sup>

Lifetimes 10 years.

Measure Cost \$3,998<sup>[2]</sup> Milk vacuum pump VFD:

O&M Cost Adjustments There are no standard operation and maintenance cost adjustments used for this measure.

Fossil Fuel Description There are no fossil fuel algorithms or default values for this measure.

Footnotes

FOUNDOLES
[1] National Grid evaluated persistence in 1999 of VFDs installed in 1995 and estimated a factor of 97%. Given that the discounted value of a 3% degradation in 5 years is minimal, no persistence reduction has been applied.

[2] Values derived from Efficiency Vermont custom data 2003-2018; see, "EVT\_Milk Pump VFD\_Analysis\_Mar 2019.xls"

## **Comprehensive Thermal Measure**

 Measure Number:
 III.F-5.6

 Portfolio:
 EVT TRM Portfolio 2018-12

 Status:
 Active

 Effective Date:
 2018/1/1

 End Obte:
 [None]

 Program:
 Multfamily

 End Use:
 Multfamily

Update Summary December 2018 - this update aligns TRM content with how the 2018 program and process operates

## Referenced Documents

MeasureCost\_Steventwino
 EVT Multifamily New Const

## Description

Description This measure characterization describes the analytical approach for a package of shell and HVAC measures performed to meet the requirements of the Efficiency Vermont Multifamily New Construction and Major Rehabilitation Program. The program incentives projects meeting requirements for one of three tracks: Electric Only, Efficiency Vermont Certified, and High-Performance.

This characterization is intended to capture a high level analytical approach for the program. Typically, all components of an analysis with the exception of incremental cost assignment is performed on a site-specific, custom basis. Thus, the utility of this characterization in relation to project analysis is limited to establishing incremental costs.

## Estimated Measure Impacts

### Algorithms

Energy and Demand Savings Energy (Wih and MMBtu) and Demand (WI) savings will be calculated on a custom basis, typically using EVT's QLoss tool. Historically REMRate was employed for analytical purposes, however recert guidance from the program's developer has autioned against using it to model larger multifamily buildings. To do so confidently, individual units would need to be modeled separately, which is politibieviey expensive for EVT from a resource standpoint. For a fee, REMRate will be used upon customer request, if for example ENERGY STAR certification is being pursued.

### Baseline Efficiencies

Baseline Entruciencies Vermont's 2015 selectival Baiking Energy Standards (30 V.S.A. § 51) apply and serve as baseline project requirements, except in instances where 2015 Commercial Building Energy Standards apply. RES 2015 gives five prescriptive package options to meet compliance. For any project, the relevant baseline as chosen and indicated by the customer is used to estimate impacts. In practice, it has been observed that the majority of customers chose Package 4.

### High Efficiency

High ETRICIENCY Minimum program requirements must be met to qualify for incertive (see referenced document EVT Multifamily New Construction Minimum Requirements). Actual project-specific specifications will be used for impact analysis.

## **Operating Hours**

Load Shapes Custom loadshapes will be used as appropriate and necessary. Typically, however, measures use one of the following default loadshapes 7a Residential DHW insulation 5b Residential Space heat

11b	Residentia	I A/C	

Number	Name	Status			Summer On kWh			Summer kW
7	Residential DHW insulation	Active	31.7%	34.9%	15.9%	17.5%	100.0%	100.0%
5	Residential Space heat	Active	42.9%	57.1%	0.0%	0.0%	25.0%	0.0%
11	Residential A/C	Active	6.6%	3.8%	51.1%	38.6%	0.0%	16.0%

## **Net Savings Factors**

Measures TSHCOMPH Comprehensive Thermal Measure REMRate Calculated Heating TSHCOMPC Comprehensive Thermal Measure REMRate Calculated Cooling HWECOMP1 Comprehensive Thermal Measure REMRate Calculated DHW

Tracks [Base Track] 6018LINC [is base track] LIMF NC 6019MFNC [is base track] MF Mkt NC

Persistence The persistence factor is assumed to be one.

### Lifetimes

ent with lifetime estimates used by Efficiency Vermont in the state screening tool.) Heating Savings: 2 AC Savings: 15 years 25 years DHW Savings: 15 years Analysis period is the same as the lifetime

## Measure Cost

EVI Certined Comprehensive In	ermai Pa	скаде				
	Increme	ntal Cost /	Assumptio	n Per Unit		
Number of Units	1-5	6-10	11-15	16-20	21-25	26+
Heating Savings (heating system and shell upgrades)	\$ 2,554	\$2,159	\$1,764	\$1,369	\$974	\$500
Air Conditioning Savings (AC systems)	\$300	\$270	\$240	\$211	\$181	\$145

DHW Savings	\$0	\$0	\$0	\$0	\$0	\$0			
Total Cost (with cooling)	\$2,854	\$2,429	\$2,004	\$1,580	\$1,155	\$731			
Total Cost (without cooling)	\$2,554	\$2,159	\$1,764	\$1,369	\$974	\$500			
iotes:									
. Incremental costs used are based on ssociated with alternate decisions that									wed efficiency levels.
. DHW Savings has a zero measure cos oiler. The incremental cost of the boile						n indire	t tank off a 849	% boiler or	an indirect tank off a
. Incremental costs were modeled usin nd cost estimator. See 'MeasureCost_S uildings than larger buildings so the pe	stevePitki r unit cos	n6-15-11.	xls' for ma	ore inform	ation. Cl	early the	incremental co	st per unit	is much higher for sn
	Incr	remental	Cost Assur	mption (E\	/T Certifi	ed to Hig	h-Performance	) per unit	
Number of Units	1-5		6-10	11-15	16-	20	21-25 2	26+	
Staged 95% AFUE gas boilers	\$0		\$1	\$2	\$4		\$5 \$	6	
Staged 91% AFUE oil boilers	\$84	0 :	\$698	\$555	\$43	3	\$271 \$	128	
Staged 85% AFUE pellet boilers	\$1,7	760	\$1,711	\$1,661	\$1,	612	\$1,562 \$	1,513	
Indirect DHW off a 95% gas boiler	\$0	:	\$0	\$0	\$0		\$0 \$	60	
Indirect DHW off a 91% oil boiler	\$0		\$0	\$0	\$0		\$0 \$	0	
Central AC - 15 SEER, 12.5 EER (CEE T	F2) \$22	0	\$187	\$154	\$12	1	\$88 \$	55	
3 ACH50 (0.4 cfm50/sq ft)	\$76	7	\$679	\$591	\$50	12	\$414 \$	325	
These costs will be included above the E	EVT Certif	fied level	costs if the	ese measu	ures are i	ncluded	in the project.		
0&M Cost Adjustments									
Fossil Fuel Description									

Footnotes

## **ENERGY STAR Retail Products Platform**

Measure Number	RS-MLT-ESRPP d
Portfolio:	
Status:	Active
Effective Date:	2021/1/1
End Date:	[ None ]
Program:	Efficient Products Prog

oducts Program End Use: Multiple End Uses

### Update Summary Updates to:

- vpwwwch W.
   Remove V1 ReRGY STAR Air Cleaners (only V2 now supported)
   Updates to Refigerators Basic is now ESTAR and ESTAR Most Efficient, Advanced is Emerging Technology Award which are units with natural
   refigerant and therefore GHS savings are assigned.
   Updates to Ferzeers-Basic ESTAR and Advanced is ESTAR Most Efficient and Emerging Technology Award. Those qualified as ETA are units with
   natural refrigerant and therefore GHS savings are assigned.

## Referenced Documents

- Ref effective
   Conservation

   epa-typ-product-analysis-ext-2017
   ODE Energy Conservation Standards for Dehumidifiers, July 2012

   2019 Clothes Dyner RPP Calculations
   2019-energy-star-certified-televisions-analysis

   2019 Clothes Washer RPP Calculations
   2019-energy-star-certified-televisions-analysis

   Most Efficient Room ALC\_ESRP
   And Efficient Room ALC\_ESRP

   Air Cleanner ESRP
   VTD Dehumidifier Analysis nov 2019- final

   2021 ESRP Presers
   2021 ESRP Freezers

Description This measure describes the ENERGY STAR Retail Products Platform (ESRPP), an initiative facilitated by the U.S. Environmental Protection Agency. This program will engage retailers through midstream/tupstream incentive payments to increase the demand for and supply of the most energy efficient residential plug-load and appliance products on the market, driving greater sales of select EBRGY STAR certified products to customers. With a combination of incentives and engagement, retailers will asort, stock, and promote more energy efficient models than they would have absent the program. Covered products include sound bars, freezers, refrigerators, portable dehunidifiers, clothes dryers, clothes washers, room air cleaners, and room air conditioners. This measure applies to Time of Sale program delivery.

## Program Type Calculation Type: Time of Sale

Program Delivery/Implementation Type: Midstream

## **Baseline Efficiencies**

Product	Baseline Efficiency	High Efficiency
ENERGY STAR Sound Bars	Weighted average of electric energy consumption <sup>[1]</sup> for both non-ENERGY STAR and ENERGY STAR models	50% more efficient <sup>[2]</sup> than ENERGY STAR Version 3.0 specification, effective May 1, 2013
ENERGY STAR and ENERGY STAR Most Efficient Televisions	Average of non ENERGY STAR units from California Appliance Database.	ENERGY STAR Version 8.0, effective March 1, 2019 and ENERGY STAR Most Efficient.
Freezers (Basic)	Federal standard, effective September 15, 2014	ENERGY STAR Version 5.0 specification, effective September 15, 2014
Freezers (Advanced)	Federal standard, effective September 15, 2014	ENERGY STAR Most Efficient or ENERGY STAR Emerging Technology Award (with Natural Refrigerant)
Refrigerators (Basic)	Federal standard, effective September 15, 2014	ENERGY STAR Version 5.0 specification, effective September 15, 2014 and ENERGY STAR Most Efficient.
Refrigerators (Advanced)	Federal standard, effective September 15, 2014	ENERGY STAR Emerging Technology Award (with Natural Refrigerant)
Clothes Dryer (Basic)	The baseline combined energy factor (CEP) was derived in the ENERGY STAR Version 1.0 analysis by multiplying 2015 federal standards by the average change in a dryers' assessed CEF between the required (Appendix D1) and optional (Appendix D2) test procedure required (Appendix D1) and optional (Appendix D2) test procedure required by the ENERGY STAR eligibility requirements.	ENERCY STAR Version 1.0 specification, effective January 1, 2015
Clothes Dryer (Advanced)	As above	ENERGY STAR Most Efficient criteria (weighted by 2018-2019 ESRPP sales average of Hybrid and Full Heat Pump is used).
Clothes Washers (Basic)	Federal standard, effective January 1, 2018	ENERGY STAR Version 8.0 specification, effective February 5, 2018.
Clothes Washers (Advanced)	As above	ENERGY STAR Most Efficient.
ENERGY STAR Room Air Cleaners	Room air cleaners that do not meet ENERGY STAR efficiency requirements	ENERGY STAR V2.0 units effective July 1, 2020.
Room Air Conditioners (Basic)	Federal standard, effective June 1, 2014	ENERGY STAR Version 4.0 specification, effective October 26, 2015.
Room Air Conditioners (Advanced)	As above	ENERGY STAR Most Efficient.
Portable Dehumidifiers (Basic)	Federal standard, effective June 1, 2019	ENERGY STAR Version 5.0 specification, effective October 31, 2019.
Portable Dehumidifiers (Advanced)	As above	ENERGY STAR Most Efficient.

Efficient Equipment See 'Baseline & Efficient' table within "Baseline Efficiencies" section.

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a matrix       a matrix         a matrix       a m	electric Demand Saving	s															
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Reference with a construction of a con																	
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			Wh consum	ption and th	e kWh and	kW saving	s for eac	h product	t are p	rovide	ed in	the table	below. <sup>[5]</sup>				
	Product			kWh <sub>BASE</sub>		kWh <sub>EE</sub>		∆kWh	ΔkW		ΔGH	G	Item Code				
	ENERGY STAR +50% Sound	l Bars		48.7		24.7		24.0	0.002	274	N/A		ESRPP-SBAR				
	ENERGY STAR Television							37.8	0.019	993	N/A		ESRPP-TVES				
	ENERGY STAR Most Efficient	t Tolovis	sion	See '2019 E	nergy Star (			55.6	0.025	131	N/Δ		ESRPP-TVME				
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											NY A		ESRPP*FR22				
Bactic       No.1       No.1 <thno.1< th="">       No.1       No.1</thno.1<>	ENERGY STAR Most Efficien	t		479.3		393.5		85.8	0.010	)1	N/A		ESRPP-FRZ5				
	Freezers (Advanced) -																
Baseling of the order Baseling of Standard and Mark       Print Part Part Part Part Part Part Part Par	ENERGY STAR Emerging Te	chnolog	y Award	479.3		393.5		85.8	0.010	)1	8.86		ESRPP-FRZ6				
BaseDor STARe Benerging Technology Anall       Pd 4       Pri B       P 2 6       D006       B 5       EXPREMENDAD         Dates: Dyne (Busic)       Bit spreaddate Start (2019) Cates: Dyne (BP 7 4       2       <		STAR M	lost	544.1		492.9		51.2	0.006	50	N/A		ESRPP-RFRT1				
Description         Description <thdescription< th=""> <thdescription< th=""></thdescription<></thdescription<>	Refrigerators (Advanced)																
Control Type (BHC)         Decision Action         Point         Allos by (A Added S)         No. B         No. B         No. B         Separation         Sepa	NERGY STAR Emerging Te	chnolog	y Award	743.4		670.8		72.6	0.008	36	8.86		ESRPP-RFRAD				
All All Control         All Control         All Control         All Control         All Control         Control <thcontrol< th="">         Contro         Con</thcontrol<>	Clothes Drver (Basic)					Clothes Dr	yer RPP	195	0.604	15			55000 CO4				
Autor (a)         Exclusion with (b)         Exclusion with (c)         (c)        (c)	/ (Jic)	_				<b>C</b> 1-1					w/A		CORPT-CD1				
Control Watchers (USUC)         Ope Calculations. Mol         Dials         Vial         Vial         Spectry (Vial)           Control Watchers (Molecul)         Spectry (Vial)	Clothes Dryer (Advanced)					Clothes Dr	yer RPP	427	1.326	53	N/A		ESRPP-CDME				
Prove second states in the second state is a second state	Tothes Washare (Pasia)					Clothes W	asher	134 6	0.41	2							
Control         Spin Control	LIVUIRES VVIDENELS (BEISIC)							134.0	0.418	,	N/A		ESRPP-CWT1				
Best of STAR 4 Room Air Cleanes         Best of Star 2	Clothes Washers (Advanced	i)				Clothes W	asher	158.4	0.492	2	N/A		ESRPP-CWME				
Nome         Note         Note <th< td=""><td>ENERGY STAR v2 Room Air</td><td>Cleaner</td><td></td><td></td><td></td><td>285</td><td></td><td></td><td>0.177</td><td></td><td></td><td></td><td></td></th<>	ENERGY STAR v2 Room Air	Cleaner				285			0.177								
Normal Conditioners (Advanced)     Bes Proceedings for Zord Society     2 2     2 7     N A     StepP HADE       Vertable Dehumdlifers (Baik)     Headysis Nov 2013 Jack     9     0.66     N A     StepP HADE       Vertable Dehumdlifers (Baik)     Headysis Nov 2013 Jack     9     0.66     N A     StepP HADE       Symbol Tile     StepP HADE     StepP HADE     9     0.66     N A     StepP HADE       Symbol Tile     StepP HADE     StepP HADE     9     0.66     N A     StepP HADE       Symbol Tile     StepP HADE     StepP HADE     9     0.66     N A     StepP HADE       Symbol Tile     StepP HADE     StepP HADE     Note Tile     Note Tile     Note Tile     Note Tile       Symbol Tile     StepP HADE     StepP HADE     Note Tile							_					_					
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Vertable Dolumidities (Bails)         wayles No 2013.ax/         92         0.05         WA         ESEP-OL441           Vertable Dolumidities (Advanced)         See gread/bails (V/ Defamidities         139         0.055         WA         ESEP-OL441           AdWh         = KMPaue         State of the second to the secon				2020.xlsx'					-			_					
Order De De UNUMBERS (VANISCE)         Madyeis Nov 2013.dx/         137         With 3         V/A         ESERP.04.4402           AWM         = WMPuse - 4.W/Hz         - <t< td=""><td>Portable Dehumidifiers (Bas</td><td>ic)</td><td></td><td></td><td></td><td></td><td></td><td>99</td><td>0.061</td><td>L</td><td>N/A</td><td></td><td>ESRPP-DHUM</td></t<>	Portable Dehumidifiers (Bas	ic)						99	0.061	L	N/A		ESRPP-DHUM				
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Market Procession of the servers are 1%         The prescriptive annual MRBus awings per unit for dothes by-yer 1040 003 003 003 004 0040 0040 0040 004	ΔkWh =	kWh <sub>Base</sub>	- kWh <sub>EE</sub>														
Market Procession of the servers are 1%         The prescriptive annual MRBus awings per unit for dothes by-yer 1040 003 003 003 004 0040 0040 0040 004	Symbol Table																
Image: Note: State Clothes Dyne:       0.030       0.033       0.005       0.011         DERCY STAR Clothes Dyne:       0.030       0.033       0.005       0.011       0.011         DERCY STAR Mott Efficient Clothes Hype 2784       0.083       0.154       0.233       0.094         DERCY STAR Clothes Washers = re:       10       0.12       0.41       0.41         DERCY STAR Clothes Washers = 0.22       0.25       0.13       0.14       0.15	Fossil Fuel Savings																
	The prescriptive annual MM	Btu savi	ngs per uni	t for clothes	dryers are:								_				
Image: Note the series of the series										-							
The prescriptive annual MMBu savings per unit for dothes washers are: <b>bERGY STAR</b> Clothes Washers <u>1010         112         044         044         <u>044         044         044         044         </u></u>		har see a											_				
Note:         Note: <th< td=""><td></td><td></td><td></td><td></td><td></td><td>-0.0300</td><td>-0</td><td>.003 -0</td><td>.006</td><td>-0.01</td><td>.0</td><td>0.011</td><td>-</td></th<>						-0.0300	-0	.003 -0	.006	-0.01	.0	0.011	-				
Note:         Note: <th< td=""><td></td><td></td><td></td><td></td><td>Clothes Dry</td><td>-0.0300</td><td>-0</td><td>.003 -0</td><td>.006</td><td>-0.01</td><td>.0</td><td>0.011</td><td>_</td></th<>					Clothes Dry	-0.0300	-0	.003 -0	.006	-0.01	.0	0.011	_				
BRENCY STAR Clothes Washers         0.10         0.12         0.41           NEW Close Star Clothes Washers         0.22         0.23         0.33		ENERG	SY STAR M	ist Efficient		-0.0300 er0.784	-0	.003 -0	.006	-0.01	.0	0.011	_				
Product Efficient Clothes Washers         0.2         0.13           Mean Subject         Product Efficient Clothes Washers - 2.4 CCF         Product Efficient Clothes Washers - 2.4 CCF           Mean         e Gross customer connected load KW savings for the measure         Product Efficient Clothes Washers - 3.5 CCF           Meme         AW         e Gross customer connected load KW savings for the measure         Product Efficient Clothes Washers - 3.5 CCF           Meme         Average hours of use per year; see table below. Except where otherwise noted, see standalone measur references.         Product Briss         9.700           MURE         Product STAR Mode Efficient Clothes Washers - 3.5 CCF         Product Briss         9.701           MURE         Gross customer annual WM savings for the measure         Product Briss         9.701           MURE         Average hours of use per year; see table below. Except where otherwise noted, see standalone measur references.         Product Briss         9.701           Mures         a Norther MORES         9.701         1.0991         Product Briss         9.701           Mures         a Residential Conditioners         9.701         1.0991         Product Briss         9.701           Mures         a Residential Conditioners         9.701         1.0991         Product Briss         9.701           Mures         a Residental Co	The prescriptive annual MM	ENERG	SY STAR M	ist Efficient		-0.0300 er0.784	-0	.003 •0 083 0.	.006	-0.01 0.253	0	0.011	_				
Mater Savings         Image: Control of the Water savings per unit for dothes washers are:           DERROY STAR Cobines Washers - 2.4 CCF           NERROY STAR Not Efficient Clothes Washers - 3.5 CCF           Mater Savings           Product Target Savings           Mater Savings           Mater Savings           Product Target Savings           Mater Savings           Mater Savings           Mater Savings           Product Target Savings           Mater Savings           Mater Savings           Mater Savings           Mater Savings <t< td=""><td>The prescriptive annual MM</td><td>ENERG Btu savii</td><td>GY STAR Mo</td><td>ist Efficient</td><td>washers at</td><td>-0.0300 er0.784</td><td>-0</td><td>.003 -0 083 0. NG</td><td>.006 154</td><td>-0.01 0.253</td><td>0 3 0 Oil</td><td>0.011</td><td></td></t<>	The prescriptive annual MM	ENERG Btu savii	GY STAR Mo	ist Efficient	washers at	-0.0300 er0.784	-0	.003 -0 083 0. NG	.006 154	-0.01 0.253	0 3 0 Oil	0.011					
The prescription annual Water savings per unit for dothes washers are:         NERKY STAR Clothes Washers - 2.4 CCF         Where:         AW       =       Gross customer connected load KW savings for the measure         AWN       =       Gross customer annual WMs savings for the measure         AWN       =       Gross customer annual KWh savings for the measure         AWN       =       Gross customer annual KWh savings for the measure         HOURS       =       Average hours of use per year; see table below. Except where otherwise noted, see standalone measure references.         Yound Bars       8,760         Tablevisions       1,808 <sup>11</sup> /1         Receiver 1       9,747         Border 1       Border 1         Border 1       Border 1         Border 1       9,849 <sup>11</sup> Room Air Conditioners       141         Border 1       Border 1         Room Air Conditioners       141         Brower       =       Energy efficient KWh consumption per year         KWRes:       =       Energy efficient KWh consumption per year         KMRes:       =       Energy efficient KWh consumption per year         KMRes:       =       Energy efficient KWh consumption per year         KMRes:       =       Ene	The prescriptive annual MM	ENERG Btu savir	SY STAR Mo ngs per uni ENERGY ST	ist Efficient t for clothes AR Clothes '	washers ar Washers	-0.0300 er0.784	+0 0.1	.003 -0 083 0. <b>NG</b> 0.10	.006 154 LF 0.	-0.01 0.253	0 - 3 0 <b>Oil</b> 0.04	0.011 1.294	-				
BRENCY STAR Cluthes Washers - 2.4 CCF         Nerre:         AW       =       Gross customer connected load kW savings for the measure         AWN       =       Gross customer annual KWh savings for the measure         AWN       =       Gross customer annual KWh savings for the measure         AWN       =       Gross customer annual KWh savings for the measure         AWN       =       Gross customer annual KWh savings for the measure         HORS       =       Average hours of use per year; see table below. Except where otherwise noted, see standalone measure         Meme       =       Average hours of use per year; see table below. Except where otherwise noted, see standalone measure         Meme       =       Besteintel Conditioners       8.477         Techesions       1.389       Techesions       1.398         Techesions       1.498       Techesions       1.498         Dether Whene       =       Besteintel Conditioners       14.1         Besteintel Conditioners       14.1       14.1       14.1		ENERG Btu savir	SY STAR Mo ngs per uni ENERGY ST	ist Efficient t for clothes AR Clothes '	washers ar Washers	-0.0300 er0.784	+0 0.1	.003 -0 083 0. <b>NG</b> 0.10	.006 154 LF 0.	-0.01 0.253	0 - 3 0 <b>Oil</b> 0.04	0.011 1.294					
Where:       AW       =       Gross customer connected load KW savings for the measure         AWh       =       Gross customer annual KWh savings for the measure         AWh       =       Gross customer annual KWh savings for the measure         HOURS       =       Average hours of use per year; see table below. Except where otherwise noted, see standalone measure references.         Windex       =       Bound Bars       8,760         Tablevisions       1,808 <sup>11</sup> Freezers       8,477         Befrigerators       8,477         Befrigerators       8,477         Bothers Washers       3,222         Dothes Washers       3,232         Wifteger       =       Baseline KWh consumption per year         KWhere       =       Energy efficient KWh consumption per year         Loss Cashers       Baseline KWh consumption per year       Kitter Television         Bit Brieder Television Air Colamerer       Bon Air Colamer Per Air Air	Water Savings	ENERG Btu savii	SY STAR Mo ngs per uni ENERGY ST.	ast Efficient t for clothes AR Clothes ' AR Most Effi	washers an Washers cient Clothe	-0.0300 er 0.784 re: <sup>(9)</sup>	-0	.003 -0 083 0. <b>NG</b> 0.10	.006 154 LF 0.	-0.01 0.253	0 - 3 0 <b>Oil</b> 0.04	0.011 1.294	-				
AW <ul> <li>Gross customer connected load kW savings for the measure</li> <li>Average hours of use per year; see table below. Except where otherwise noted, see standalone measure references.</li> <li>Product</li> <li>Product</li></ul>	<b>Water Savings</b> The prescriptive annual Wal	ENERG Btu savin E	EY STAR Me ngs per uni ENERGY ST. ENERGY ST.	ast Efficient t for clothes AR Clothes ' AR Most Effi	washers an Washers cient Clothe	-0.0300 er 0.784 re: <sup>(9)</sup>	-0	.003 -0 083 0. <b>NG</b> 0.10	.006 154 LF 0.	-0.01 0.253	0 - 3 0 <b>Oil</b> 0.04	0.011 1.294	-				
AW <ul> <li>Gross customer connected load kW savings for the measure</li> <li>Average hours of use per year; see table below. Except where otherwise noted, see standalone measure references.</li> <li>Product</li> <li>Product</li></ul>	<b>Water Savings</b> The prescriptive annual Wal ENERGY STAR Clothes Was <sup>1</sup>	ENERG Btu savii E E ter savir hers - 2.	ay STAR Mo ngs per uni ENERGY ST. ENERGY ST. ngs per unit .4 CCF	ast Efficient t for clothes AR Clothes AR Most Effi for clothes	washers an Washers cient Clothe	-0.0300 er 0.784 re: <sup>(9)</sup>	-0	.003 -0 083 0. <b>NG</b> 0.10	.006 154 LF 0.	-0.01 0.253	0 - 3 0 <b>Oil</b> 0.04	0.011 1.294					
AW <ul> <li>Gross customer connected kad kW swings for the measure</li> <li>MVh</li> <li>Gross customer annual KWh swings for the measure</li> </ul> MVh <ul> <li>Gross customer annual KWh swings for the measure</li> <li>HORES</li> <li>Average hours of use per year; see table below. Except where otherwise noted, see standalone measure references.</li> </ul> MVRE <ul> <li>Moduct</li> <li>MORES</li> <li>References.</li> </ul> MVRes <ul> <li>Average hours of use per year; see table below. Except where otherwise noted, see standalone measure references.</li> <li>Moduct</li> <li>References.</li> </ul> MVRes <ul> <li>References</li> <li>R477</li> <li>Below Boyes</li> <li>Below Boyes</li> <li>Below Boyes</li> <li>Below Boyes</li> <li>Below Boyes</li> <li>Below Boyes</li> <li>Below Air Conditioners</li> <li>Reference Boyes</li> <li>Below Air Conditioners</li> <li>Below Boyes</li> <li>Below Boyes</li></ul>	<b>Vater Savings</b> The prescriptive annual Wal INERGY STAR Clothes Wash	ENERG Btu savii E E ter savir hers - 2.	ay STAR Mo ngs per uni ENERGY ST. ENERGY ST. ngs per unit .4 CCF	ast Efficient t for clothes AR Clothes AR Most Effi for clothes	washers an Washers cient Clothe	-0.0300 er 0.784 re: <sup>(9)</sup>	-0	.003 -0 083 0. <b>NG</b> 0.10	.006 154 LF 0.	-0.01 0.253	0 - 3 0 <b>Oil</b> 0.04	0.011 1.294	_				
AW <ul> <li>Gross customer connected kad kW swings for the measure</li> <li>MVh</li> <li>Gross customer annual KWh swings for the measure</li> </ul> MVh <ul> <li>Gross customer annual KWh swings for the measure</li> <li>HORES</li> <li>Average hours of use per year; see table below. Except where otherwise noted, see standalone measure references.</li> </ul> MVRE <ul> <li>Moduct</li> <li>MORES</li> <li>References.</li> </ul> MVRes <ul> <li>Average hours of use per year; see table below. Except where otherwise noted, see standalone measure references.</li> <li>Moduct</li> <li>References.</li> </ul> MVRes <ul> <li>References</li> <li>R477</li> <li>Below Boyes</li> <li>Below Boyes</li> <li>Below Boyes</li> <li>Below Boyes</li> <li>Below Boyes</li> <li>Below Boyes</li> <li>Below Air Conditioners</li> <li>Reference Boyes</li> <li>Below Air Conditioners</li> <li>Below Boyes</li> <li>Below Boyes</li></ul>	<b>Vater Savings</b> The prescriptive annual Wal INERGY STAR Clothes Wash	ENERG Btu savii E E ter savir hers - 2.	ay STAR Mo ngs per uni ENERGY ST. ENERGY ST. ngs per unit .4 CCF	ast Efficient t for clothes AR Clothes AR Most Effi for clothes	washers an Washers cient Clothe	-0.0300 er 0.784 re: <sup>(9)</sup>	-0	.003 -0 083 0. <b>NG</b> 0.10	.006 154 LF 0.	-0.01 0.253	0 - 3 0 <b>Oil</b> 0.04	0.011 1.294					
AWh       =       Goos customer annual WM savings for the measure         HDURS       =       Average hours of use per year; see table below. Except where otherwise noted, see standalone measure references.         Product       =       Nerrage hours of use per year; see table below. Except where otherwise noted, see standalone measure references.         Product       =       Norrage hours of use per year; see table below. Except where otherwise noted, see standalone measure references.         Product       =       Norrage hours of use per year; see table below. Except where otherwise noted, see standalone measure references.         Product       =       Norrage hours of use per year; see table below. Except where otherwise noted, see standalone measure references.         Product       =       Norrage hours of use per year; see table below. Except where otherwise noted, see standalone measure references.         Wthese       =       Baseline KWh consumption per year         KWhe       =       Energy efficient KWh consumption per year         KMthese       =       Energy efficient KWh consumption per year </td <td><b>Water Savings</b> The prescriptive annual Wat NERGY STAR Clothes Wash NERGY STAR Most Efficient</td> <td>ENERG Btu savii E E ter savir hers - 2.</td> <td>ay STAR Mo ngs per uni ENERGY ST. ENERGY ST. ngs per unit .4 CCF</td> <td>st Efficient t for clothes AR Clothes AR Most Effi for clothes</td> <td>washers an Washers cient Clothe</td> <td>-0.0300 er 0.784 re:<sup>(9)</sup></td> <td>-0</td> <td>.003 -0 083 0. <b>NG</b> 0.10</td> <td>.006 154 LF 0.</td> <td>-0.01 0.253</td> <td>0 - 3 0 <b>Oil</b> 0.04</td> <td>0.011 1.294</td> <td></td>	<b>Water Savings</b> The prescriptive annual Wat NERGY STAR Clothes Wash NERGY STAR Most Efficient	ENERG Btu savii E E ter savir hers - 2.	ay STAR Mo ngs per uni ENERGY ST. ENERGY ST. ngs per unit .4 CCF	st Efficient t for clothes AR Clothes AR Most Effi for clothes	washers an Washers cient Clothe	-0.0300 er 0.784 re: <sup>(9)</sup>	-0	.003 -0 083 0. <b>NG</b> 0.10	.006 154 LF 0.	-0.01 0.253	0 - 3 0 <b>Oil</b> 0.04	0.011 1.294					
HURS <ul> <li>Average hours of use per year; see table below. Except where otherwise noted, see standalone measure references.</li> <li> <ul> <li></li></ul></li></ul>	Water Savings The prescriptive annual Wal NRERY STAR Clothes Wash NRERY STAR Most Efficient Vhere:	ENERG Blu savi E E ter savir ners - 2.	ay STAR Mc ngs per uni ENERGY ST ENERGY ST ngs per unit .4 CCF s Washers	st Efficient t for clothes AR Clothes AR Most Effi for clothes • 3.5 CCF	washers at Washers cient Clothe washers ar	-0.0300 -0.0300 er 0.784 re:(9) s Washers e:	-0 0.	003 0. 083 0. 0.10 0.22	.006 154 LF 0.	-0.01 0.253	0 - 3 0 <b>Oil</b> 0.04	0.011 1.294					
Implementation       Product	Mater Savings The presorphice annual Wall ENERGY STAR Clockes Wall ENERGY STAR Most Efficient Where: <u>A</u> WW	ENERG Blu savin E E E E E E E E E E E E E E E E E E E	SY STAR Me ngs per uni ENERGY ST ENERGY ST ENERGY ST .4 CCF s Washers Gross custo	st Efficient t for clothes AR Clothes AR Most Effi for clothes - 3.5 CCF	washers an Washers cient Clothe washers an	-0.0300 -0.0300 er 0.784 	-0.0.	003 0. 083 0. 0.10 0.22	.006 154 LF 0.	-0.01 0.253	0 - 3 0 <b>Oil</b> 0.04	0.011 1.294					
Product         Product <t< td=""><td>Mater Savings The prescriptive annual Wala ENERGY STAR Most Efficient SNERGY STAR Most Efficient Where: <u>AMW</u> <u>AWW</u></td><td>ENERG Blu savin E E E E E E E E E E E E E E E E E E E</td><td>SY STAR Mo ngs per uni ENERGY ST. ENERGY ST. Ings per unit .4 CCF s Washers Gross custo Gross custo</td><td>ast Efficient t for clothes AR Clothes AR Most Effi for clothes - 3.5 CCF mer connec mer annual</td><td>washers and Washers cient Clothe washers and ted load kW kWh saving</td><td>e: s vashers s for the n</td><td>or the me</td><td>003 0.003 0.000 0.</td><td>.006 154 0. 0.</td><td>•0.01 0.253 12 25</td><td>0 - 0 3 0 0.04 0.13</td><td>0.011 .294</td><td></td></t<>	Mater Savings The prescriptive annual Wala ENERGY STAR Most Efficient SNERGY STAR Most Efficient Where: <u>AMW</u> <u>AWW</u>	ENERG Blu savin E E E E E E E E E E E E E E E E E E E	SY STAR Mo ngs per uni ENERGY ST. ENERGY ST. Ings per unit .4 CCF s Washers Gross custo Gross custo	ast Efficient t for clothes AR Clothes AR Most Effi for clothes - 3.5 CCF mer connec mer annual	washers and Washers cient Clothe washers and ted load kW kWh saving	e: s vashers s for the n	or the me	003 0.003 0.000 0.	.006 154 0. 0.	•0.01 0.253 12 25	0 - 0 3 0 0.04 0.13	0.011 .294					
None         Sound Bars         8,760           1,808         1,808         1,808           1,808         1,777         1           1,808         1,777         1           1,808         1,777         1           1,808         1,777         1           1,808         1,777         1           1,809         1,227         1           1,000         1,227         1           1,000         Air Conditioner         1,41           1,000         Air Conditioner         1,01	Mater Savings The prescriptive annual Wala ENERGY STAR Most Efficient SNERGY STAR Most Efficient Where: <u>AMW</u> <u>AWW</u>	ENERGE Blu savin E E E E E E E E E E E E E E E E E E E	SY STAR Mo ngs per uni ENERGY ST. ENERGY ST. ngs per unit .4 CCF s Washers Gross custo Gross custo Average ho	ast Efficient t for clothes AR Clothes AR Most Effi for clothes - 3.5 CCF mer connec mer annual	washers and Washers cient Clothe washers and ted load kW kWh saving	e: s vashers s for the n	or the me	003 0.003 0.000 0.	.006 154 0. 0.	•0.01 0.253 12 25	0 - 0 3 0 0.04 0.13	0.011 .294	ndalone measu				
Indevisions       1,898/3         Freezers       8,477         Dothes Dropes       22         Dothes Dropes       22         Dothes Dropes       22         Dothes Dropes       1,632	Mater Savings The prescriptive annual Wala ENERGY STAR Most Efficient SNERGY STAR Most Efficient Where: <u>AMW</u> <u>AWW</u>	ENERG Blu savir E E E E E E E E E E E E E	SY STAR Mo ngs per unit ENERGY ST ENERGY ST ENERGY ST Ags per unit 4 CCF s Washers Gross custo Gross custo Average ho references.	st Efficient t for clothes AR Clothes AR Most Effi for clothes - 3.5 CCF mer connec mer annual	washers an Washers cient Clothe washers ar ted load kW kWh saving er year; se	e: s vashers s for the n	or the me	003 0.003 0.000 0.	.006 154 0. 0.	•0.01 0.253 12 25	0 - 0 3 0 0.04 0.13	0.011 .294	ndalone measu				
Image: Processor in the second seco	Mater Savings The prescriptive annual Wala ENERGY STAR Most Efficient SNERGY STAR Most Efficient Where: <u>AMW</u> <u>AWW</u>	ENERG Blu savir E E E E E E E E E E E E E	SY STAR Me mgs per uni ENERGY ST ENERGY ST Ings per unil mgs per unit mgs per unil mgs per unit mgs per unit	st Efficient t for clothes AR Clothes AR Most Eff for clothes - 3.5 CCF mer connec emer annual	washers ar Washers cient Clothe washers ar ted load kW kWh saving er year; see HOURS	e: s vashers s for the n	or the me	003 0.003 0.000 0.	.006 154 0. 0.	•0.01 0.253 12 25	0 - 0 3 0 0.04 0.13	0.011 .294	ndalone measu				
Interface     Interface     Interface     Interface	Nater Savings The presorphe annual Wall RERGY STAR Clocks Wall RERGY STAR Most Efficient Where: <u>AWW</u> <u>AWW</u>	ENERG Btu savir E E E E E E E E E E E E E	SY STAR M Ings per uni ENERGY ST INERGY ST INFO INTERGY ST INFO INTERGY ST INFO INTERGY ST INTERGY ST INTE	st Efficient t for clothes AR Clothes AR Most Eff for clothes - 3.5 CCF mer connec mer annual urs of use p	washers an Washers cient Clothe washers ar ted load KM KWh saving er year; see HOURS 8,760	e: s vashers s for the n	or the me	003 0.003 0.000 0.	.006 154 0. 0.	-0.01 0.253 12 25	0 - 0 3 0 0.04 0.13	0.011 .294	ndalone measu				
Bothes Washers     322 toom Air Coaners     8,840 <sup>41</sup> Room Air Conditioners     14.1       Dehumidflers     1,632       Whease     =     Beseline Wrh consumption per year       Whease     =     Energy efficient Wrh consumption per year       Whease     =     Energy efficient Wrh consumption per year       Robidential Refrigerator     =     Energy efficient Wrh consumption per year       Number     Residential Cothes Washer     Summer Keiner State       18 Room Air Condenoring     Number     Number     Number       Number     Name     State     Nimter Of Navio     Summer Keiner State       4     Residential Cothes Washer     20.49     28.8%     16.9%     12.3%     4.4%     3.3%	Nater Savings The presorphe annual Wall RERGY STAR Clocks Wall RERGY STAR Most Efficient Where: <u>AWW</u> <u>AWW</u>	ENERG Btu savin Etu savin Eter savin erers - 2. t Clothes	sy STAR Mc ngs per uni ENERGY ST ENERGY ST ENERGY ST Gross custo Gross custo Gross custo Gross custo Average nos. Froduct Sound Bars Sound Bars	st Efficient t for clothes AR Clothes AR Most Eff for clothes - 3.5 CCF mer connec mer annual urs of use p	washers an Washers cient Clother washers ar ted load KM KWh saving er year; see HOURS 8,760	e: s vashers s for the n	or the me	003 0.003 0.0000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0	.006 154 0. 0.	-0.01 0.253 12 25	0 - 0 3 0 0.04 0.13	0.011 .294	ndalone measu				
Number     Name     Status     Winter     Status       4     Residential Refrigerators Residential Colontes vasher     Active     20.9%     Cfr Mark     Summer     Miner       13.8     Residential Refrigerators Residential Colontes vasher     Active     20.9%     Cfr Mark     Summer     Miner     Summer       14.1     Dehumidifiers     1.632     Dehumidifiers     1.632     Dehumidifiers     Dehumidifiers       150     Residential Colontes Vasher     =     Breery efficient KMb consumption per year     Energy efficient KMb consumption per year	Mater Savings The prescriptive annual Wala ENERGY STAR Most Efficient SNERGY STAR Most Efficient Where: <u>AMW</u> <u>AWW</u>	ENERG Btu saviri E E E E E E E E E E E E E E E E E E E	SY STAR MC Ings per unit ENERGY ST INGS per unit INGS per unit INGS CUSE Gross Custe Gross Custe Gross Custe Gross Custe Counce Frederences. Sound Bars Televisions Freezers	st Efficient t for clothes AR Clothes AR Most Eff for clothes - 3.5 CCF mer connec mer annual	washers ar Washers cient Clothe washers ar ted load KM KWh saving er year; see HOURS 8,760 (1,598 <sup>-1)</sup> 8,477	e: s vashers s for the n	or the me	003 0.003 0.0000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0	.006 154 0. 0.	-0.01 0.253 12 25	0 - 0 3 0 0.04 0.13	0.011 .294	ndalone measu				
Rommer     Residential Refrigerator       Normer     Name       Normer     Name       Residential Refrigerator	Mater Savings The prescriptive annual Wala ENERGY STAR Most Efficient SNERGY STAR Most Efficient Where: <u>AMW</u> <u>AWW</u>	ENERG Blu savin E E E E E E E E E E E E E E E E E E E	ay STAR Me Ings per uni ENERGY ST ENERGY ST Ings per unial A CCF Gross custo Gross custo Gross custo Gross custo Foduct Televisions Televisions Refrigerato	st Efficient for clothes AR Clothes AR Clothes for clothes for clothes for clothes mer connec mer annual urs of use p	washers an Washers cient Clothe washers ar ted load KM KWh saving er year; see kHOURS 8,760 [,1998] <sup>3]</sup> 8,477	e: s vashers s for the n	or the me	003 0.003 0.0000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0	.006 154 0. 0.	-0.01 0.253 12 25	0 - 0 3 0 0.04 0.13	0.011 .294	ndalone measu				
behumidifiers     1,632       WMtuse     =     Baseline KWh consumption per year       KWhez     =     Energy efficient KWh consumption per year       Kood Shapes     =     Energy efficient KWh consumption per year       Bresidential Refrigerator Is Residential Refrigerator Bresidential Cohnes Washer Als Efficient Television 138 Room Alr Conditioning     Status     Winter Officient View Original Status     Summer Summer Status       Number     Name     Status     Original Officient View Original Offic	Nater Savings The presorphe annual Wall RERGY STAR Clocks Wall RERGY STAR Most Efficient Where: <u>AWW</u> <u>AWW</u>	ENERG Blu savin E E E E E E E E E E E E E E E E E E E	SY STAR M Ings per uni ENERGY ST INGS PERGY ST INGS PERGY ST INGS PERGY ST INGS PERGY ST INGS IN INGS IN IN IN IN IN IN IN IN IN IN	st Efficient for clothes AR Clothes AR Clothes AR Most Eff for clothes are connec mer annual urs of use p	washers at Washers cient Clothet washers ar ted load KM KWh saving ted load KM KWh saving 8,767 8,477 8,477 322	e: s vashers s for the n	or the me	003 0.003 0.0000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0	.006 154 0. 0.	-0.01 0.253 12 25	0 - 0 3 0 0.04 0.13	0.011 .294	ndalone measu				
Whese       Baseline W/h consumption per year         Whese       = Energy efficient W/h consumption per year         MHEE       = Energy efficient W/h consumption per year         Social Shapes       Energy efficient W/h consumption per year         Breisdential Refrigerator       Breisdential Cothes Wather         Breisdential Cothes Wather       Breisdential Cothes Wather         BR Room Air Cleaner       Bo Room Air Conditioning         Number       Name       Statue       Writer Winter Ori NaWh Off Math       Summer Mather Mather         4       Residential Refrigerator       Active 30.8% 33.0%       17.1% 19.1% 7.0% 10.0% 10.0%       10.0% 5.3%         9       Residential Cothes Washer Active 42.0% 28.8% 16.9% 12.3% 4.4% 3.3%       33.0%       17.1% 19.1% 7.3% 4.4% 3.3%	Vater Savings The presorigite annual Wala RERGY STAR Clockes Wala NERGY STAR Most Efficient Vhere: <u>Addw</u>	ENERG Blu savin Et savin ers - 2. t Clothes	ay STAR MA Ings per uni ENERGY STT INSERGY ST INSERGY S	st Efficient 4 for clothes 4 for clothes 4 for clothes 5 for clothes 5 dottes 6 dottes 7 dott	washers at Gent Clothe washers ar ted load KM KWh saving k, saving	e: s vashers s for the n	or the me	003 0.003 0.000 0.	.006 154 0. 0.	-0.01 0.253 12 25	0 - 0 3 0 0.04 0.13	0.011 .294	ndalone measu				
Withes     =     Energy efficient kWh consumption per year       Ood Shapes Ib Residential Refrigerator Residential Cethes Washer As Desidential Cethes Washer Residential Cethes Washer Active     State     Summer for North Of North On KWh     Summer Summer     Winter     Summer North Of North On KWh     Summer Summer     Winter     Summer North Of North On KWh     Summer Summer     Winter     Summer     Winter     Summer     Winter     Summer       4     Residential Refrigerator     Active     30.6%     33.0%     17.1%     19.1%     7.6%     Summer       9     Residential Cethes Washer Active     42.0%     28.8%     16.9%     12.3%     4.4%     3.3%	Nater Savings The presorphe annual Wall RERGY STAR Clocks Wall RERGY STAR Most Efficient Where: <u>AWW</u> <u>AWW</u>	ENERGE Blu savin E E E E E E E E E E E E E E E E E E E	SY STAR MA INSERTING STAR MA INSERTING STAR INSERTING STAR INSERTI	st Efficient at Cortobes at Cortobes at Cortobes are Coothes for clothes for clothes are connec mer connec mer connec mer annual sus of use p sus of	washers ar Washers cient Clothe washers ar ted load KM KWth saving er year; sei s, 560 1, 498-13 8, 877 8, 877 222 222 5, 840(4) 141	e: s vashers s for the n	or the me	003 0.003 0.000 0.	.006 154 0. 0.	-0.01 0.253 12 25	0 - 0 3 0 0.04 0.13	0.011 .294	ndalone measu				
None     Name     Nam     Name     Name <td>Nater Savings The presorphe annual Wall RERGY STAR Clocks Wall RERGY STAR Most Efficient Where: <u>AWW</u> <u>AWW</u></td> <td>ENERGE Blu savin E E E E E E E E E E E E E E E E E E E</td> <td>SY STAR MA INSERTING STAR MA INSERTING STAR INSERTING STAR INSERTI</td> <td>st Efficient at Cortobes at Cortobes at Cortobes are Coothes for clothes for clothes are connec mer connec mer connec mer annual sus of use p sus of</td> <td>washers ar Washers cient Clothe washers ar ted load KM KWth saving er year; sei s, 560 1, 498-13 8, 877 8, 877 222 222 5, 840(4) 141</td> <td>e: s vashers s for the n</td> <td>or the me</td> <td>003 0.003 0.000 0.</td> <td>.006 154 0. 0.</td> <td>-0.01 0.253 12 25</td> <td>0 - 0 3 0 0.04 0.13</td> <td>0.011 .294</td> <td>ndalone measu</td>	Nater Savings The presorphe annual Wall RERGY STAR Clocks Wall RERGY STAR Most Efficient Where: <u>AWW</u> <u>AWW</u>	ENERGE Blu savin E E E E E E E E E E E E E E E E E E E	SY STAR MA INSERTING STAR MA INSERTING STAR INSERTING STAR INSERTI	st Efficient at Cortobes at Cortobes at Cortobes are Coothes for clothes for clothes are connec mer connec mer connec mer annual sus of use p sus of	washers ar Washers cient Clothe washers ar ted load KM KWth saving er year; sei s, 560 1, 498-13 8, 877 8, 877 222 222 5, 840(4) 141	e: s vashers s for the n	or the me	003 0.003 0.000 0.	.006 154 0. 0.	-0.01 0.253 12 25	0 - 0 3 0 0.04 0.13	0.011 .294	ndalone measu				
None     Name     Nam     Name     Name <td>Water Savings The prescriptive annual Wat NERGY STAR Codhes Wast NERGY STAR Most Efficient Vihere: AKW AWW HOURS</td> <td>ENERG Blu savin ter savin ners - 2. t Clothes = 0 = 0 = 0 t</td> <td>SY STAR MA INTERNATIONALI INTERNATIONAL INTERNATIONAL INTERNATIONAL INTERNATIONAL INTERNATIONALI IN</td> <td>st Efficient ar Clothes ar Clothes ar Clothes for clothes for clothes - 3.5 CCF mer connec mer annual urs of use p sers sers shers leaners rs</td> <td>washers ar Washers ciert Clothe washers ar ted load kM kWh saving 8,760 (1,989.1) 8,477 322 5,940.4) 5,404.41 1,652</td> <td>0.0300 e10.784 re:(1) s Washers e: s Vashers t savings fe s for the n t table belo</td> <td>or the me</td> <td>003 0.003 0.0000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0</td> <td>.006 154 0. 0.</td> <td>-0.01 0.253 12 25</td> <td>0 - 0 3 0 0.04 0.13</td> <td>0.011 .294</td> <td>ndalone measu</td>	Water Savings The prescriptive annual Wat NERGY STAR Codhes Wast NERGY STAR Most Efficient Vihere: AKW AWW HOURS	ENERG Blu savin ter savin ners - 2. t Clothes = 0 = 0 = 0 t	SY STAR MA INTERNATIONALI INTERNATIONAL INTERNATIONAL INTERNATIONAL INTERNATIONAL INTERNATIONALI IN	st Efficient ar Clothes ar Clothes ar Clothes for clothes for clothes - 3.5 CCF mer connec mer annual urs of use p sers sers shers leaners rs	washers ar Washers ciert Clothe washers ar ted load kM kWh saving 8,760 (1,989.1) 8,477 322 5,940.4) 5,404.41 1,652	0.0300 e10.784 re:(1) s Washers e: s Vashers t savings fe s for the n t table belo	or the me	003 0.003 0.0000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0	.006 154 0. 0.	-0.01 0.253 12 25	0 - 0 3 0 0.04 0.13	0.011 .294	ndalone measu				
Load Shapes       Bit Residential Refrigerator Isa Residential Cothes Washer       Sa Residential Cothes Washer       Winter       Name       Residential Refrigerator       Active Continuing       9     Residential Cothes Washer       Active 20.496       20.496       Sammer       Sammer <td <="" colspan="4" td=""><td>Mater Savings The prescriptive annual Wat NERKY STAR Clothes Wast SRERGY STAR Most Efficient Where: <u>ARW</u> ARW HOURS</td><td>ENERG Blu savin ter savin ners - 2. t Clothes = 0 = 0 = 0 t</td><td>SY STAR MA INTERNATIONALI INTERNATIONAL INTERNATIONAL INTERNATIONAL INTERNATIONAL INTERNATIONALI IN</td><td>st Efficient ar Clothes ar Clothes ar Clothes for clothes for clothes - 3.5 CCF mer connec mer annual urs of use p sers sers shers leaners rs</td><td>washers ar Washers ciert Clothe washers ar ted load kM kWh saving 8,760 (1,989.1) 8,477 322 5,940.4) 5,404.41 1,632</td><td>0.0300 e10.784 re:(1) s Washers e: s Vashers t savings fe s for the n t table belo</td><td>or the me</td><td>003 0.003 0.0000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0</td><td>.006 154 0. 0.</td><td>-0.01 0.253 12 25</td><td>0 - 0 3 0 0.04 0.13</td><td>0.011 .294</td><td>ndalone measu</td></td>	<td>Mater Savings The prescriptive annual Wat NERKY STAR Clothes Wast SRERGY STAR Most Efficient Where: <u>ARW</u> ARW HOURS</td> <td>ENERG Blu savin ter savin ners - 2. t Clothes = 0 = 0 = 0 t</td> <td>SY STAR MA INTERNATIONALI INTERNATIONAL INTERNATIONAL INTERNATIONAL INTERNATIONAL INTERNATIONALI IN</td> <td>st Efficient ar Clothes ar Clothes ar Clothes for clothes for clothes - 3.5 CCF mer connec mer annual urs of use p sers sers shers leaners rs</td> <td>washers ar Washers ciert Clothe washers ar ted load kM kWh saving 8,760 (1,989.1) 8,477 322 5,940.4) 5,404.41 1,632</td> <td>0.0300 e10.784 re:(1) s Washers e: s Vashers t savings fe s for the n t table belo</td> <td>or the me</td> <td>003 0.003 0.0000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0</td> <td>.006 154 0. 0.</td> <td>-0.01 0.253 12 25</td> <td>0 - 0 3 0 0.04 0.13</td> <td>0.011 .294</td> <td>ndalone measu</td>				Mater Savings The prescriptive annual Wat NERKY STAR Clothes Wast SRERGY STAR Most Efficient Where: <u>ARW</u> ARW HOURS	ENERG Blu savin ter savin ners - 2. t Clothes = 0 = 0 = 0 t	SY STAR MA INTERNATIONALI INTERNATIONAL INTERNATIONAL INTERNATIONAL INTERNATIONAL INTERNATIONALI IN	st Efficient ar Clothes ar Clothes ar Clothes for clothes for clothes - 3.5 CCF mer connec mer annual urs of use p sers sers shers leaners rs	washers ar Washers ciert Clothe washers ar ted load kM kWh saving 8,760 (1,989.1) 8,477 322 5,940.4) 5,404.41 1,632	0.0300 e10.784 re:(1) s Washers e: s Vashers t savings fe s for the n t table belo	or the me	003 0.003 0.0000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0	.006 154 0. 0.	-0.01 0.253 12 25	0 - 0 3 0 0.04 0.13	0.011 .294	ndalone measu
<ul> <li>Bis Bisdinertial Refrigerator</li> <li>Bis Residential Clothes Washer</li> <li>Sa Residential Clothes Washer</li> <li>Sa Residential Clothes Washer</li> <li>Sa Residential Clothes Washer</li> <li>Saturg</li> <li>Mumber</li> <li>Namber</li> <li>Namber</li> <li>Residential Refrigerator</li> <li>Active</li> <li>Saturg</li> <li< td=""><td>Mater Savings The preoripilve annual Water RERGY STAR Clothes Wast ENERGY STAR Most Efficient AWW AWW HOURS KWheese</td><td>ENERG Blu savin E ter savir e clothes = 0 = 0 = 0 = 0 = 0 = 0 = 0 = 0 = 0 = 0</td><td>SY STAR MK INERGY ST INERGY ST INERGY ST INS A S</td><td>est Efficient ar Clothes ar Clothes ar Clothes for clothes for clothes are connec mer connec mer connec mer annual are connec mer annual are clothes es schere scheres conditioners are scheres and the consump</td><td>Washers ar Washers cient Clothe washers ar ted load KM KWh saving 8,760 8,777 322 32,804(4) 141 1,632 300 per yea</td><td>0.0300 0.0300 s 0.784 s Washers e: r s for the re table belo</td><td>or the me</td><td>003 0.003 0.0000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0</td><td>.006 154 0. 0.</td><td>-0.01 0.253 12 25</td><td>0 - 0 3 0 0.04 0.13</td><td>0.011 .294</td><td>ndalone measu</td></li<></ul>	Mater Savings The preoripilve annual Water RERGY STAR Clothes Wast ENERGY STAR Most Efficient AWW AWW HOURS KWheese	ENERG Blu savin E ter savir e clothes = 0 = 0 = 0 = 0 = 0 = 0 = 0 = 0 = 0 = 0	SY STAR MK INERGY ST INERGY ST INERGY ST INS A S	est Efficient ar Clothes ar Clothes ar Clothes for clothes for clothes are connec mer connec mer connec mer annual are connec mer annual are clothes es schere scheres conditioners are scheres and the consump	Washers ar Washers cient Clothe washers ar ted load KM KWh saving 8,760 8,777 322 32,804(4) 141 1,632 300 per yea	0.0300 0.0300 s 0.784 s Washers e: r s for the re table belo	or the me	003 0.003 0.0000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0	.006 154 0. 0.	-0.01 0.253 12 25	0 - 0 3 0 0.04 0.13	0.011 .294	ndalone measu				
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Name Status     Winter Summer Sum Summer Sum Summer Summe	Water Savings       The prescriptive annual Water       NNERRY STAR Clobes Wast       Where:       AdWn       AdWn       AdWn       HOURS       AWN       KWhese       Where:	ENERG Blu savin E ter savir e clothes = 0 = 0 = 0 = 0 = 0 = 0 = 0 = 0 = 0 = 0	SY STAR MK INERGY ST INERGY ST INERGY ST INS A S	est Efficient ar Clothes ar Clothes ar Clothes for clothes for clothes are connec mer connec mer connec mer annual are connec mer annual are clothes es schere scheres conditioners are scheres and the consump	Washers ar Washers cient Clothe washers ar ted load KM KWh saving 8,760 8,777 322 32,804(4) 141 1,632 300 per yea	0.0300 0.0300 s 0.784 s Washers e: r s for the re table belo	or the measure	003 0.003 0.0000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0	.006 154 0. 0.	-0.01 0.253 12 25	0 - 0 3 0 0.04 0.13	0.011 .294	ndalone measu				
Number         Name         Statu         Winter         Nume         Summer         Summer         Number         Number         Number         Number         Number         Number         Number         Number         Statu         Winter         Summer         Summer         Winter         Kum         Summer         Kum         Kum         Summer         Kum         Kum <td>Mater Savings The prescriptive annual Wal ENERGY STAR Most Efficient Where:</td> <td>ENERG Blu savin E ter savir e clothes = 0 = 0 = 0 = 0 = 0 = 0 = 0 = 0 = 0 = 0</td> <td>SY STAR MK INERGY ST INERGY ST INERGY ST INS A S</td> <td>est Efficient ar Clothes ar Clothes ar Clothes for clothes for clothes are connec mer connec mer connec mer annual are connec mer annual are clothes es schere scheres conditioners are scheres and the consump</td> <td>Washers ar Washers cient Clothe washers ar ted load KM KWh saving 8,760 8,777 322 32,804(4) 141 1,632 300 per yea</td> <td>0.0300 0.0300 s 0.784 s Washers e: r s for the re table belo</td> <td>or the measure</td> <td>003 0.003 0.0000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0</td> <td>.006 154 0. 0.</td> <td>-0.01 0.253 12 25</td> <td>0 - 0 3 0 0.04 0.13</td> <td>0.011 .294</td> <td>ndalone measu</td>	Mater Savings The prescriptive annual Wal ENERGY STAR Most Efficient Where:	ENERG Blu savin E ter savir e clothes = 0 = 0 = 0 = 0 = 0 = 0 = 0 = 0 = 0 = 0	SY STAR MK INERGY ST INERGY ST INERGY ST INS A S	est Efficient ar Clothes ar Clothes ar Clothes for clothes for clothes are connec mer connec mer connec mer annual are connec mer annual are clothes es schere scheres conditioners are scheres and the consump	Washers ar Washers cient Clothe washers ar ted load KM KWh saving 8,760 8,777 322 32,804(4) 141 1,632 300 per yea	0.0300 0.0300 s 0.784 s Washers e: r s for the re table belo	or the measure	003 0.003 0.0000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0	.006 154 0. 0.	-0.01 0.253 12 25	0 - 0 3 0 0.04 0.13	0.011 .294	ndalone measu				
Number         Name         Statue         Winter         Number         Summer         Winter         Summer         Summer         Winter         Kum         Summer         Winter         Kum         Kum         Summer         Winter         Kum	Mater Savings The prescriptive annual Wall RERGY STAR Most Efficient Where: AWW AWW AWW HOURS Where Where Build Safety	ENERGE Blu saviu Eter savir ners - 2. t Clothes	SY STAR MK INERGY ST INERGY ST INERGY ST INS A S	est Efficient ar Clothes ar Clothes ar Clothes for clothes for clothes are connec mer connec mer connec mer annual are connec mer annual are clothes es schere scheres conditioners are scheres and the consump	Washers ar Washers cient Clothe washers ar ted load KM KWh saving 8,760 8,777 322 32,804(4) 141 1,632 300 per yea	0.0300 0.0300 s 0.784 s Washers e: r s for the re table belo	or the measure	003 0.003 0.000 0.	.006 154 0. 0.	-0.01 0.253 12 25	0 - 0 3 0 0.04 0.13	0.011 .294	ndalone measu				
Number         Name         Status On kWh         Winter On kWh         Winter Of kWh         Summer NetWh         Summer KWh         Summer	Mater Savings The prescriptive annual Wat Represcriptive annual Wat Represcriptive annual Wat Representation	ENERGE Blu saviu Eter savir ners - 2. t Clothes	SY STAR MK INERGY ST INERGY ST INERGY ST INS A S	est Efficient ar Clothes ar Clothes ar Clothes for clothes for clothes are connec mer connec mer connec mer annual are connec mer annual are clothes es schere scheres conditioners are scheres and the consump	Washers ar Washers cient Clothe washers ar ted load KM KWh saving 8,760 8,777 322 32,804(4) 141 1,632 300 per yea	0.0300 0.0300 s 0.784 s Washers e: r s for the re table belo	or the measure	003 0.003 0.000 0.	.006 154 0. 0.	-0.01 0.253 12 25	0 - 0 3 0 0.04 0.13	0.011 .294	ndalone measu				
Number         Number         Number         Off kWh         On kWh         Off kWh         On kWh         Off kWh         KW         kW           4         Residential Refrigerator         Active         30.8%         33.0%         17.1%         19.1%         79.6%         100.0%           9         Residential Clothes Washer         Active         42.8%         16.9%         12.3%         4.4%         3.3%	Mater Savings The prescriptive annual Wale RERGY STAR Most Efficient Where:  Maker Multiple M	ENERGE Blu saviu Eter savir ners - 2. t Clothes	SY STAR MK INERGY ST INERGY ST INERGY ST INS A S	est Efficient ar Clothes ar Clothes ar Clothes for clothes for clothes are connec mer connec mer connec mer annual are connec mer annual are clothes es schere scheres conditioners are scheres and the consump	Washers ar Washers cient Clothe washers ar ted load KM KWh saving 8,760 8,777 322 32,804(4) 141 1,632 300 per yea	0.0300 0.0300 s 0.784 s Washers e: r s for the re table belo	or the measure	003 0.003 0.000 0.	.006 154 0. 0.	-0.01 0.253 12 25	0 - 0 3 0 0.04 0.13	0.011 .294	ndatone measu				
4 Residential Refrigerator Active 30.8% 33.0% 17.1% 19.1% 79.6% 100.0% 9 Residential Clothes Washer Active 42.0% 28.8% 16.9% 12.3% 4.4% 3.3%	Mater Savings The preoripite annual Wal INERGY STAR Clobes Wash ENERGY STAR Most Efficient Marene Marene MWhere WWhere MWhere	ENERGE Blu savi E ter savir hers - 2. t Clothes = 0 = 0 = 0 = 0 = 0 = 0 = 0 = 0 = 0 = 0	SY STAR MK ENERGY ST ENERGY ST ENERGY ST ENERGY ST ENERGY ST ENERGY ST Gross custo & Washers Gross custo Gross custo Gross custo Gross custo Gross custo Gross custo Saster Frederice Clothes Dy Clothes Wa Room Air C Energy effici Energy effic	st Efficient AR Clothes AR Clothes AR Most Eff for clothes 3.3 CCF mer connec mer annual a.3.5 CCF mer connec mer annual so clothes rs rs rs rs rs rs rs rs rs hors so clothes rs rs rs rs rs rs rs rs rs rs rs rs rs	Washers ar Washers Clothe washers ar ted load KM KWh saving 8,760 8,777 122 22,2840(4) 1,632 22,2840(4) 141 1,632 23,2840(4) 141 1,632	0.0300 0.784 s Washers e: e: r r per year	v the me reasure	Image: constraint of the second se	.006 154	0.01 0.252 9 12 25		0.011 .294	ndalone measu				
	Mitter Savvings The prescriptive annual Wall ENERGY STAR Most Efficient Where:	ENERGE Blu savi E ter savir hers - 2. t Clothes = 0 = 0 = 0 = 0 = 0 = 0 = 0 = 0 = 0 = 0	SY STAR MA Ings per uni ENERGY ST ENERGY ST ENERGY ST INGS PER UNI SAVERAGE ST INGS CUSTO Gross CUSTO	st Efficient t for clothes AR Clothes AR Clothes AR Most Eff for clothes a.3.5 CCF mer connec mer annual urs of use p the server of the server	Washers ar Washers Clothe washers ar ted load KM KWh saving 8,760 8,777 322 32,840(4) 141 1,632 32,989(1) 141 1,632 32,989(4) 141 1,632 32,989(4) 141 1,632 32,989(4) 141 1,632 32,989(4) 141 1,632 32,989 1,999 1,99 1,909 1,909 1,909 1,909 1,909 1,909 1,909 1,909 1,909 1,909 1,909 1,909 1,909 1,909 1,909 1,909 1,900 1,	0.0300 s 0.784 s Washers e: f savings fc s for the r t table belo f r per year Summer On WWh	or the me easure w. Exce	r Winth	oof 154 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0.	P 225		0.011 .294	ndalone measu				
73 Residential - Dehumidifier Active 15.9% 17.5% 31.7% 34.9% 0.0% 35.3%	Water Savings       The presority annual Wala       The presority annual Wala       DERROY STAR Most Efficient       Where:       AMW       AMW       HOURS       MWhene:       Where:       The presority annual Wala       MWhene:       The presority annual Wala       MWhene:       The Residential Refrigerator       The Residential Chelse wala       Refrigerator       The Residential Refrigerator       The Residential Refrigerator       The Refrigerator	ENERGE Blu savi Et savir E E E E E E E E E E E E E E E E E E E	SY STAR MA Ings per uni ENERGY ST ENERGY ST ENERGY ST INGS PER UNI ST Gross custo Average ho Average ho Average ho Average ho Average ho St Statu Average ho Average ho St St St St St St St St St St St St St	st Efficient t for clothes AR Clothes AR Clothes AR Clothes AR Most Eff for clothes for clothes a.3.5 CCF mer connec mer annual rs of use p mer connec mer annual rs frs ers shers leaners int h consump ient kWh cc on kWh cc a.3.8%	washers ar washers ar ted load KM kWh saving er year; se HOURS 8,477 1,632 222 222 5,840 <sup>(4)</sup> 1,632 1,632 1,632 232 232 232 232 232 232 232	0.0300 complete set of the set of	summe off kw 19.1%	r Wint: r W	.006 154 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0.	0.00 0.252 7 12 12 25 wise r		0.011 .294	ndalone measu				
	Nater Savings The prescriptive annual Wat NERGY STAR Codews NERGY STAR Most Efficient AW ARERGY STAR Most Efficient AW HOURS AW HOURS AW AW Besidential Arthrights A HOURS A H	ENERG Blu savi ter savin er clothes e clothes	SY STAR MA Ings per uni INREQY ST ENREGY ST ENREGY ST ENREGY ST ENREGY ST ENREGY ST ENREGY ST SWASHERS Gross custo Gross custo Gross custo Gross custo Gross custo Average ho Average ho Average ho Sound Bars Televisions Refirements Clothes Dy Clothes Wa Room Air C Clothes Wa Energy effic Energy effic Energy effic Energy effic	st Efficient at for clothes are clothes a	washers ar Washers ciert Clothe washers ar ted load KM KWh saving r year; see k0URS 8,477 1,698(3) 8,477 122 222 5,540(4) 141 1,632 con pr yea nsumption pr winter Orf KM 28,896	closed	Summer	ws         s           0.22         0.22           0.22         0.22	.006 154 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.	0.00		0.011 .294	ndalone measu				

94	Efficient Television		Active	48.0%	19.0%	24.0%	9.0%	22.0%	17.0%
118	Room Air Cleaner		Active	31.7%	34.9%	15.9%	17.5%	66.6%	66.6%
99	Room Air Condition	ing .	Active	0.7%	2.8%	53.3%	43.2%	0.0%	11.9%
Net Sa	vings Factors	s							
Measures									
RFRESFZF	Energy star freez	ter							
CKLESWR	P Energy Star Cloth	nes Washe	er.						
RFRESRR	P Energy star refrig	gerator							
ACEESARI	P Energy Star room	n AC							
ACEDEHU	M Energy Star Dehu	umidifier							
EQPTLVS	N Efficient Televisio	ons							
RFRESRT	2 Tier 2 refrigerato	or							
CKLC2WR	P Energy Star cloth	ies washe	r CEE Ti	er 2					
CKLESDRY	( Energy Star Cloth	nes Dryer							
CKLESETA	Energy Star Most	Efficient	Clothes	Dryer					
EQPTVSB	R ENERGY STAR So	ound Bars							
ACEESRA	C ENERGY STAR RO	oom Air Cl	eaner						
ACEDHUM	E ENERGY STAR Re	esidential I	Dehumio	lifier Most	Efficient tie	r			
	Base Track]								
6032EPEP	[is base track] Effi	cient Prod	ucts - R	esidential					
п	rack Name	Track Nr	. Measu	ire Code	Free Rider	Spill Ove	r		
Efficient Pr	roducts - Residential	6032EPEF	RFRES	FZP	0.67	1.33			
Efficient Pr	roducts - Residential	6032EPEF	CKLES	WRP	0.50	1.00			
Efficient Pr	roducts - Residential	6032EPEF	RFRES	RRP	0.50	1.00			
Efficient Pr	roducts - Residential	6032EPEF	ACEES	ARP	0.67	1.33			
Efficient Pr	roducts - Residential	6032EPEF	ACEDE	HUM	0.77	1.00			

Efficient Products - Residentia	10032EPEP	ACEESARP	0.67	1.33
Efficient Products - Residentia	6032EPEP	ACEDEHUM	0.77	1.00
Efficient Products - Residentia	6032EPEP	EQPTLVSN	0.90	1.10
Efficient Products - Residentia	6032EPEP	RFRESRT2	0.90	1.00
Efficient Products - Residentia	6032EPEP	CKLC2WRP	0.50	1.00
Efficient Products - Residentia	6032EPEP	CKLESDRY	0.90	1.10
Efficient Products - Residentia	6032EPEP	CKLESETA	1.00	1.20
Efficient Products - Residentia	6032EPEP	EQPTVSBR	0.90	1.10
Efficient Products - Residentia	6032EPEP	ACEESRAC	0.95	1.05
Efficient Products - Residentia	6032EPEP	ACEDHUME	0.95	1.05

Lifetimes
The measure lifetime for each product is provided in the table below. Analysis period is the s
standalone measure for references. e as the life me. Except where othe

Product	Measure Life
Sound Bars	4.4 years <sup>[10]</sup>
Televisions	6 years
Freezers	17 years
Refrigerators	17 years
Clothes Dryers	12 years
Clothes Washers	14 years
Room Air Cleaners	9 years <sup>[11]</sup>
Room Air Conditioners	10.5 years
Dehumidifiers	12 years

Persistence The persistence factor is assumed to be one.

Measure Cost
The per-unit incremental cost for each product is provided in the table below. Except where oth ted, see sta

Product	Incremental Cost
ENERGY STAR Sound Bars [12]	\$0
ENERGY STAR Televisions	\$0
Freezers (Basic)	\$9
Freezers (Advanced)	\$40
Refrigerators (Basic)	\$12
Refrigerators (Advanced)	\$21
Clothes Dryers (Basic)	\$61
Clothes Dryers (Advanced)	\$412
Clothes Washers (Basic)	\$124
Clothes Washers (Advanced)	\$170
ENERGY STAR Room Air Cleaners <sup>[13]</sup>	\$56
Room Air Conditioners (Basic)	\$50
Room Air Conditioners (Advanced)	\$139
Dehumidifiers (Basic)	\$10
Dehumidifiers (Advanced)	\$75

tnotes
Baseline electric energy consumption based on information from a 2014 Fraunhofer Center for Sustainable Energy System study titled "Energy Consumption of Consume Electronics in US Households." See file EPA RPA Analysis, EVT_2017.45x for baseline efficiency calculation. Due to the high market penetration of DENGY TAR certified soundhars, a weighted avarage of the unit energy consumption of both non-ENERGY STAR (20% of market) and ENERGY STAR (80% of market) models was calculated to accurately provide savings estimates for the market.
This measure assumes a more stringent requirement than ENERGY STAR Version 3.0. The more stringent requirement was developed by decreasing the power requirements and increasing the efficiency requirement by 50%. See file EPA RPP Analysis_EVT_2017.xlsx for assumptions included in high efficiency requirement.
Based on 5.2 hours per day on mode. See "Efficient Televisions" measure for details.
Based on 16 hours of use per day, 365 days per year
See file EPA RPP Analysis_EVT_2017.tex for kWh consumption and savings values for sound bars, freezers, room air cleaners, and ENERGY STAR room air conditioners. For Clothes Dyer, Clothes Washers, Refrigerators, Dehumidiffers and Most Efficient Room AC see downstream measures under Efficient Rootacks program for savings algorithms and assumptions. Clothes Dyer, Clothes Washers, Refrigerators, Dehumidiffers and Most Efficient Room AC have seperate analysis workbooks attached.
See '2021 ESRPP Freezers.xls'
See '2021 ESRPP Refrigerators.xlsx'
See '2019 Clothes Dryer RPP Calculations.xlsx' for fossil fuel savings analysis.
See '2019 Clothes Washer RPP Calculations.xlsx' for fossil fuel savings analysis.
Sound bar lifetime is lifetime for video and compact audio products from file 'EPA RPP Analysis_EVT_2017.xlsx'.
Room air cleaner lifetime from file 'EPA RPP Analysis_EVT_2017.xlsx'.
Incremental cost assumption provided in file 'EPA RPP Analysis_EVT_2017.xlsx'.

## **Home Energy Kit**

Measure Number: RS-MLT-KIT e Portfolio: Status: Active Effective Date: 2021/1/1 \_\_\_1/1/1 [ None ] Exiet End Date: Program: Existing Homes Multiple End Uses End Use:

### Update Summary e 2021 Update Su

Included three new kit options as Energy Savings Kits for VPPSA customers (Jacksonville, Barton and Ludlow utilities only) as part of the Tailored Communities effort.

Corrected the electric DHW % to 25%

## **Referenced Documents**

- Kereferenced Documents RUW FCM Demail Impacts Standards Development EREUT-EREUT-ERL-table-update, 2014-02-05.ksc FMR Group, Inc., Twohtsek Researchenk Lighting Nours-of-Like Study," prepared for CT Energy Efficiency Boarc Energy Efficiency Advisory Council, National Grid MA, National Grid RI, NYSERDA, Northeast Utilities, May 5, 2 UMPChapter2:-readental-lighting-evaluation-protocol Lockeed Martin Energy Solutions meanda, powersting, report Cadma, Janeem Missault E Prangera. R Process Rolaution, Nay 2016 Schultz, Energy National Water Future Measurements, 2008 Cadma, Janeem Standard Theorem Schulter Forgarm Year 5, Jaiv 2014 2021-2023 EFT, Lamp Analysis ENT, Home Energy RKL Analys, Feb 2021 EVT\_Home Energy RL Analys, Feb 2021

## Description

Description This measure applies to Home Energy Kits, which consist of a number of residential products designed to save energy. The kits are pre through the following avenues:

Bulk orders to foodbanks to be dis
Bulk mail order to customers who ed and handed out to in

Bulk mail order to customers who participate in programs such as Home Energy Visits and Energy Choices and express interest in a home energy kit. Kits will also be distributed to past program participants, such as those who visited the Home Ownership Center.

Event giveaways
 Online ordering or customers who contact customer service and expressed interest in a kit.

This measure is characterized for 9 didirct types of kits, labeled: Whole Home Energy Kit 1 & 2; Audit Kit 1 & 2; 2021 Kit 1 & 2; and kits provide VPSA customers through the tailored communities effor, Whole Home Efficiency Kit, Water Efficiency Kit, and Smart Connected Lighting Kit. EVT communicate with the potential kit receiptents to find which kit best suits their needs and use their discretion accordingly when choosing which of to send to the customer.

We due to the dualities. We consist of a combination of the following products: 5.5W, 9W, 11W, and 15W, CEE Tier 1 omnidirectional LED bulks; 9W, CEE Tier 1 directional LED bulk; Tier 1 advanced power strips; faucet aerators with a flow rate of 1.0 and 1.5 gallons per minute (gpm); low-flow showerheads with a flow rate o 1.5 gpm with an integrated thermostatically-initiated shower restriction valve; and pipe wrap insulation for an uninsulated 3/4F (pipe - There are addition Die-Hvourself (UV) weatherization products included in rate (R1 i), however, energy savings are not being claimed for these measures. The DIP products are; foam board insulation, weatherstripping, arcylic cault, and spray foam insulation. Additionally, technologies included in the kits provided to VPSA customers; lie LED nightlights, WFI controlled smart cutlets, and motion occupancy sensors do not have associated energy savings claims. See savings tables for product mixes of the six kit options for more detail. ovided to

## Program Type Calculation Type: Market Opportunity: Time of Sale

Program Delivery/Implementation Type: Efficiency Kits

Baseline Efficiencies Far CEE Tier L LED bulks, the baseline is an weighted average market baseline, comprised of a mix of CFLs, LED, and ESA-compliant incandescent and halogen bulks. Federal legislation stemming from the Emergy Independence and Security Act of 2007 began the phasing out of ormindirectional incandescent bulks. From 2012, 1000 incandescents could not longer be manufactured, followed by restrictions on 70% in 2013 and 60W/40W in 2014. Additionally, an ESA backstop provision was included that would require replacement baseline lamps to meet an efficacy requirement of 45 lumens/wat or higher bergining on 1/1/2020. However, in December 2019, Dole Susual fand determination for General Service banadescent Lamps (CSILs), finding that this more stringert standard was not economically justified. The natural growth f LED market share however, has and will continue grow over the liftmer of the LED massauris installed. There was and will continue the obselence growth of LED baseline developed, based und obselence that any south of LED has been developed. The stringer stringer and will continue that there were a single that divers are average to the basisting growth of LED baseline developed, based und instanced grow over the liftmer of the LED massauris installed. There were any, and also used to estimate how replacement lamps would damage over the lifterim of the LED massing environment lamps would damage over the lifterim of the LED massing environment lamps would damage over the lifter of the LED massing environment lamps would and prove the lifter of the LED masseline that replacement lamps would for the advectory and standard standard and the replacement lamps would for the advectory that the standard stand

For Tier 1 advanced power strips, the baseline is a standard power strip that does not control any of the cor

Eor low-flow faucet aerators, the baseline is a standard faucet aerator with a flow rate of 2.2 gpm. Savings assumptions include a 0.83 thro factor<sup>[1]</sup> for baseline faucets to account for the fact that faucets are not always operated at full flow, reducing the flow rate to 1.83 gpm. For low-flow showerheads, the baseline is a standard showerhead with a flow rate of 2.5 gpm, with no restriction valve in place

For pipe wrap insulation, the baseline is an uninsulated domestic hot water pipe.

### Efficient Equipment

Efficient Equipment
The efficient equipment is a home henry Rk consisting of a combination of the following products: 5.5W, CEE Tier 1 omnidirectional LED bubs; 9W, CEE Tier 1 omnidirectional LED bubs; 9W, CEE Tier 1 omnidirectional LED bubs; 9W, CEE Tier 1 directional direction directional directions; and 3W direction directional directions; and 3W direction directional directions; and 3W directional direction; and directional directions; and and and directional directions; and and and directional directions; and and and directional directional direction; and directional directional direction; and directional direction; anator dire

### **Baseline Adjustment**

Descention of VID Scincer The natural growth of LED market share, has and will continue to grow over the lifetime of the LED measures installed. Therefore a forecast of the baseline growth of LED largets has been developed, based upon historical growth rates provided via CREED LightTracker data for no-program state review of projections provided by the beaptimetry of Energy.

This forecast is used to estimate how baseline replacement lamps would change over the lifetime of the LED future. A single mid-life adjust calculated that results in an equivalent net present value of lifetime savings as the forecast decline in annual savings. The appropriate adjust percentage of the base years averings for each future type are provided in the table below.

The following table shows the calculated adjustments for the five LED bulb products included in the various kit options; a 40-w omnidirectional, 5.5-watt LED bulb; a 60-watt equivalent, omnidirectional, 9-watt LED bulb; a 75-watt equivalent, omnidirection 100-watt equivalent, omnidirection; 11-watt LED bulb; and 65-watt equivalent, directional, 9-watt LED bulb; a nal, 11-watt LED bulb; a

	LED	Bulb Wattages Assumed	Bulb Wattages Assumed in Calculation						
Lamp Type	(Watts)	Base 2021 (Watts)	Base 2022 (Watts)	Base 2023 (Watts)					
	5.5	14.7	14.0	13.2					
Omnidirectional	9.0	24.1	22.9	21.6					
	11.0	29.4	27.9	26.4					
	15.0	40.5	38.4	36.3					
Directional	9.0	16.7	16.2	15.7					

∆kW <sub>LED</sub>	avings								
	= SaveDemand <sub>LED</sub> x ISR <sub>LED</sub> x Num <sub>LE</sub>	•							
ΔkW <sub>APS</sub>	$= \Delta kWh_{APS} / HOURS_{APS}$								
∆kW <sub>Aerator</sub>	$= \Delta kWh_{A erator} / HOURS_{DHW\_Conserve}$								
$\Delta kW_{Showerhead}$	$= \Delta kWh_{Showerhead} / HOURS_{DHW_Cons}$	erve							
∆kW <sub>Pipe Wrap</sub>	= ΔkWh <sub>Pipe Wrap</sub> / 8,760								
Symbol Table									
ectric Energy Sa	vinas								
ectric Energy and D									
/hole Home Kit 1									
roduct				2021		2022		2023	
roduct				ΔkW	∆kWh	ΔkW	∆kWh	∆kW	∆kWh
	ectional 9W LED Bulb (total for 2 bulbs)			0.02710		0.02490		0.02261	
	ectional 15W LED Bulb (total for 2 bulbs)			0.04580		0.04209		0.03822	
ier 1 Advanced Pov .0 GPM Faucet Aer				0.00416	33.5	0.00416	33.5	0.00416	
	ad w/ Thermostatically-Initiated Shower	Restriction	Value	0.00380		0.00560		0.00580	
Whole Home Kit 1 T		Resolicuol	I VOIVE			0.01554			
/hole Home Kit 2									
				2021		2022		2023	
roduct				ΔkW	∆kWł	ΔkW	∆kWł		ΔkWh
	ectional 9W LED Bulb (total for 3 bulbs)			0.04065		0.03735			1 33.4
	ectional 15W LED Bulb (total for 3 bulbs)			0.06870		0.06313		0.0573	
ier 1 Advanced Pov				0.00416		0.00416		0.0041	
	al 9W LED Bulb (total for 2 bulbs)			0.01379		0.01292		0.0120	
Vhole Home Kit 2 T	otai			0.12729	154.8	0.11755	145.2	2 0.1074	3   135.2
udit Kit 1									
				2021		2022		2023	
roduct				ΔkW	ΔkWł	h ΔkW	ΔkW		ΔkWi
EE Tier 1, Omnidin	ectional 9W LED Bulb (total for 4 bulbs)			0.05420	53.4	0.04980	49.1	0.0452	22 44.6
oam Insulation				N/A	N/A	N/A	N/A	N/A	N/A
ipe Wrap Insulation	1 (3/4")			0.00081	7.1	0.00081	7.1	0.0008	31 7.1
/eatherstripping				N/A	N/A	N/A	N/A	N/A	N/A
crylic Caulk				N/A N/A	N/A N/A	N/A N/A	N/A N/A	N/A N/A	N/A N/A
pray Foam Insulati .0 GPM Faucet Aer				0.00560		0.00560			50 19.2
udit Kit 1 Total	301			0.06061		0.05621			53 70.9
Audit Kit 2									
				2021		2022		2023	
roduct				ΔkW	∆kWh		∆kWh		∆kWh
EE Tier 1, Omnidin	ectional 9W LED Bulb (total for 4 bulbs)			0.05420	53.4	0.04980	49.1	0.04522	44.6
.5 GPM Faucet Aer	ator			0.00128	4.4	0.00128	4.4	0.00128	4.4
.0 GPM Faucet Aer					19.2	0.00560		0.00560	
ow-Flow Showerhe	ad w/ Thermostatically-Initiated Shower	Restriction	n Valve	0.01954	67.0	0.01954	67.0	0.01954	67.0
	ad w/ mermostatically-initiated Shower								
udit Kit 2 Total	ad wy Thermostadicany-initiated Shower				143.9	0.07622	139.6	0.07163	135.1
	au wy mermosaddany andateu Shower				143.9	0.07622	139.6	0.07163	135.1
	au wy miennosaocany snoaceu snower			0.08062	143.9		139.6	0.07163	135.1
2021 Kit 1	au wy Trie mosadocary sinoado shower	2021 ΔkW	ΔkWh	0.08062		2023	139.6 ΔkWh	0.07163	135.1
2021 Kit 1 Product	ectional 9W LED Bulb (total for 5 bulbs)	2021		0.08062	ΔkWh	2023 ΔkW		0.07163	135.1
2021 Kit 1 Product CEE Tier 1, Omnidin		2021 ΔkW 0.06775	66.8	0.08062 2022 ΔkW	ΔkWh 61.4	2023 ΔkW	∆kWh 55.7	0.07163	135.1
2021 Kit 1 Product ZEE Tier 1, Omnidir ZEE Tier 1, Omnidir ZEE Tier 1, Omnidir	sctional 9W LED Bulb (total for 5 bulbs)	2021 ΔkW 0.06775 0.02484 0.03312	66.8 24.5 32.6	0.08062 2022 ΔkW 0.06225 0.02283 0.03043	ΔkWh 61.4 22.5 30.0	2023 ∆kW 0.05652 0.02073 0.02763	ΔkWh 55.7 20.4 27.2	0.07163	135.1
021 Kit 1 troduct IEE Tier 1, Omnidir IEE Tier 1, Omnidir IEE Tier 1, Omnidir	ectional 9W LED Bulb (total for 5 bulbs)	2021 ΔkW 0.06775 0.02484	66.8 24.5 32.6	0.08062 2022 ΔkW 0.06225 0.02283 0.03043	ΔkWh 61.4 22.5	2023 ΔkW 0.05652 0.02073 0.02763	ΔkWh 55.7 20.4 27.2	0.07163	135.1
021 Kit 1 roduct EE Tier 1, Omnidir EE Tier 1, Omnidir EE Tier 1, Omnidir 021 Kit 1 Total	ectional 9W LED Bulb (total for 5 bulbs)	2021 ΔkW 0.06775 0.02484 0.03312	66.8 24.5 32.6	0.08062 2022 ΔkW 0.06225 0.02283 0.03043	ΔkWh 61.4 22.5 30.0	2023 ∆kW 0.05652 0.02073 0.02763	ΔkWh 55.7 20.4 27.2	0.07163	135.1
021 Kit 1 roduct EE Tier 1, Omnidir EE Tier 1, Omnidir EE Tier 1, Omnidir 021 Kit 1 Total	ectional 9W LED Bulb (total for 5 bulbs)	2021 ΔkW 0.06775 0.02484 0.03312	66.8 24.5 32.6	0.08062 2022 ΔkW 0.06225 0.02283 0.03043 0.11551	ΔkWh 61.4 22.5 30.0	2023 ΔkW 0.05652 0.02073 0.02763 0.10488	ΔkWh 55.7 20.4 27.2		135.1
021 Kit 1 roduct EE Tier 1, Omnidir EE Tier 1, Omnidir EE Tier 1, Omnidir 021 Kit 1 Total 021 Kit 2	ectional 9W LED Bulb (total for 5 bulbs)	2021 ΔkW 0.06775 0.02484 0.03312	66.8 24.5 32.6	0.08062 2022 ΔkW 0.06225 0.02283 0.03043 0.11551 2021	ΔkWh 61.4 22.5 30.0 113.8	2023 ΔkW 0.05652 0.02073 0.02763 0.10488 2022	ΔkWh 55.7 20.4 27.2 103.4	2023	
021 Kit 1 troduct EE Tier 1, Omnidir EE Tier 1, Omnidir EE Tier 1, Omnidir 021 Kit 1 Total 021 Kit 2 troduct	ectional 9W LED Bulb (total for 5 bulbs)	2021 ΔkW 0.06775 0.02484 0.03312	66.8 24.5 32.6	0.08062 2022 ΔkW 0.06225 0.02283 0.03043 0.11551 2021 ΔkW	ΔkWh 61.4 22.5 30.0 113.8 ΔkWh	2023 ΔkW 0.05652 0.02073 0.10488 2022 ΔkW	ΔkWh 55.7 20.4 27.2 103.4		ΔkWh
021 Kit 1 roduct EE Tier 1, Omnidin EE Tier 1, Omnidin EE Tier 1, Omnidin 021 Kit 1 Total 021 Kit 2 roduct EE Tier 1, Omnidin	sctional 9W LED Bulb (total for 5 bulbs) sctional 5.5W LED Bulb (total for 3 bulbs) sctional 11W LED Bulb (total for 2 bulbs)	2021 ΔkW 0.06775 0.02484 0.03312 0.12571	66.8 24.5 32.6	0.08062 2022 ΔkW 0.06225 0.02283 0.03043 0.11551 2021 ΔkW 0.06775	ΔkWh 61.4 22.5 30.0 113.8 ΔkWh 66.8	2023 ΔkW 0.05652 0.02073 0.02763 0.10488 2022 ΔkW 0.06225	ΔkWh 55.7 20.4 27.2 103.4 ΔkWh 61.4	2023 ДkW 0.05652	ΔkWh 55.7
021 Kit 1 roduct EE Tier 1, Omnidin EE Tier 1, Omnidin EE Tier 1, Omnidin 021 Kit 1 Total 021 Kit 2 roduct EE Tier 1, Omnidin EE Tier 1, Omnidin	ectional 9W LED Bulb (total for 5 bulbs) cetional 5.5W LED Bulb (total for 3 bulbs) ectional 11W LED Bulb (total for 2 bulbs) cetional 9W LED Bulb (total for 5 bulbs)	2021 ΔkW 0.06775 0.02484 0.03312 0.12571	66.8 24.5 32.6	0.08062 2022 ΔkW 0.06225 0.02283 0.03043 0.11551 2021 ΔkW	ΔkWh 61.4 22.5 30.0 113.8 ΔkWh 66.8 24.5	2023 ΔkW 0.05652 0.02073 0.10488 2022 ΔkW	ΔkWh 55.7 20.4 27.2 103.4 ΔkWh 61.4 22.5	2023 ДкW	ΔkWh 55.7 20.4
2021 Kit 1 Product EEE Tier 1, Omnidin EEE Tier 1, Omnidin EEE Tier 1, Omnidin 2021 Kit 1 Total 2021 Kit 2 Product EEE Tier 1, Omnidin EEE Tier 1, Omnidin	ectional 9W LED Bulb (total for 5 bulbs) cetional 5.5W LED Bulb (total for 2 bulbs) cetional 11W LED Bulb (total for 2 bulbs) ectional 9W LED Bulb (total for 5 bulbs) cetional 5.5W LED Bulb (total for 3 bulbs) cetional 11W LED Bulb (total for 2 bulbs)	2021 ΔkW 0.06775 0.02484 0.03312 0.12571	66.8 24.5 32.6	0.08062 2022 AkW 0.06225 0.02283 0.3043 0.11551 2021 AkW 0.06775 0.02484 0.03312 0.00128	ΔkWh 61.4 22.5 30.0 1113.8 ΔkWh 66.8 24.5 32.6 4.4	2023 AkW 0.05652 0.02073 0.02763 0.10488 2022 AkW 0.06225 0.02283 0.03043 0.03043	ΔkWh 55.7 20.4 27.2 103.4 103.4 ΔkWh 61.4 22.5 30.0 4.4	2023 ΔkW 0.05652 0.02073 0.02763 0.00128	ΔkWh 55.7 20.4 27.2 4.4
1021 Kit 1 Yroduct ZEE Tier J, Omnidin ZEE Tier J, Omnidin ZET Tier J, Omnidin 2021 Kit 1 Total 1021 Kit 2 Toduct ZEE Tier J, Omnidin ZEE Tier J, Omnidin ZEE Tier J, Omnidin ZEE Tier J, Omnidin ZET Tier J, Omnidin	ectional 9W LED Bulb (total for 5 bulbs) tectional 5.SW LED Bulb (total for 3 bulbs) ectional 11W LED Bulb (total for 2 bulbs) ectional 9W LED Bulb (total for 5 bulbs) ectional 5.SW LED Bulb (total for 3 bulbs) totor	2021 ΔkW 0.06775 0.02484 0.03312 0.12571	66.8 24.5 32.6 123.9	0.08062 2022 AkW 0.06225 0.02283 0.03043 0.11551 2021 AkW 0.06775 0.02484 0.03122 0.00128 0.00128	ΔkWh 61.4 22.5 30.0 113.8 ΔkWh 66.8 24.5 32.6 4.4 19.2	2023 AkW 0.05652 0.02073 0.02763 0.10488 2022 AkW 0.06225 0.02283 0.03043 0.03043 0.00128 0.00560	ΔkWh 55.7 20.4 27.2 103.4 61.4 22.5 30.0 4.4 19.2	2023 ΔkW 0.05652 0.02073 0.02763 0.00128 0.00560	ΔkWh 55.7 20.4 27.2 4.4 19.2
021 Kit 1 troduct EE Tier 1, Omnidin EE Tier 1, Omnidin EE Tier 1, Omnidin 021 Kit 2 Toduct EE Tier 1, Omnidin EE Tier 1, Omnidin	ectional 9W LED Bulb (total for 5 bulbs) cetional 5.5W LED Bulb (total for 3 bulbs) ectional 11W LED Bulb (total for 2 bulbs) ectional 9W LED Bulb (total for 5 bulbs) ectional 9W LED Bulb (total for 3 bulbs) ectional 11W LED Bulb (total for 2 bulbs) for	2021 ΔkW 0.06775 0.02484 0.03312 0.12571	66.8 24.5 32.6 123.9	0.08062 2022 AkW 0.06225 0.02283 0.03043 0.11551 2021 AkW 0.0675 0.02484 0.03122 0.03122 0.00158	ΔkWh 61.4 22.5 30.0 113.8 ΔkWh 66.8 24.5 32.6 4.4 19.2 67.0	2023 ΔkW 0.05652 0.02073 0.10488 2022 ΔkW 0.06225 0.02283 0.02283 0.02283 0.02283 0.03043 0.03043 0.00128 0.00156	ΔkWh 55.7 20.4 27.2 103.4 ΔkWh 61.4 22.5 30.0 4.4 19.2 67.0	2023 ΔkW 0.05652 0.02073 0.02763 0.00128 0.00560 0.01954	ΔkWh 55.7 20.4 27.2 4.4 19.2 67.0
221 KR 1 coduct EE Tier 1, Omnidin EE Tier 1, Omnidin EE Tier 1, Omnidin 221 KR 2 coduct EE Tier 1, Omnidin EE Tier 1, Omnidin EE Tier 1, Omnidin EE Tier 1, Omnidin EE Tier 1, Omnidin	ectional 9W LED Bulb (total for 5 bulbs) tectional 5.SW LED Bulb (total for 3 bulbs) ectional 11W LED Bulb (total for 2 bulbs) ectional 9W LED Bulb (total for 5 bulbs) ectional 5.SW LED Bulb (total for 3 bulbs) totor	2021 ΔkW 0.06775 0.02484 0.03312 0.12571	66.8 24.5 32.6 123.9	0.08062 2022 AkW 0.06225 0.02283 0.03043 0.11551 2021 AkW 0.0675 0.02484 0.03122 0.03122 0.00158	ΔkWh 61.4 22.5 30.0 113.8 ΔkWh 66.8 24.5 32.6 4.4 19.2 67.0	2023 AkW 0.05652 0.02073 0.02763 0.10488 2022 AkW 0.06225 0.02283 0.03043 0.03043 0.00128 0.00560	ΔkWh 55.7 20.4 27.2 103.4 ΔkWh 61.4 22.5 30.0 4.4 19.2 67.0	2023 ΔkW 0.05652 0.02073 0.02763 0.00128 0.00560 0.01954	ΔkWh 55.7 20.4 27.2 4.4 19.2
021 Kit 1 Torduct EE Tier 1, Omnidin EE Tier 1, Omnidin EE Tier 1, Omnidin 021 Kit 1 Total 021 Kit 2 Toduct EE Tier 1, Omnidin EE Tier 1, Omnidin EE Tier 1, Omnidin EE Tier 1, Omnidin Co PM Fauctet Aren 0 GPM Fauc	ectional SW LED Bulb (total for 5 bulbs) cetional S.SW LED Bulb (total for 3 bulbs) ectional 11W LED Bulb (total for 2 bulbs) ectional SW LED Bulb (total for 5 bulbs) ectional SW LED Bulb (total for 3 bulbs) ectional 11W LED Bulb (total for 2 bulbs) totor ator ator	2021 ΔkW 0.06775 0.02484 0.03312 0.12571	66.8 24.5 32.6 123.9	0.08062 2022 AkW 0.06225 0.02283 0.03043 0.11551 2021 AkW 0.0675 0.02484 0.03122 0.03122 0.00158	ΔkWh 61.4 22.5 30.0 113.8 ΔkWh 66.8 24.5 32.6 4.4 19.2 67.0	2023 ΔkW 0.05652 0.02073 0.10488 2022 ΔkW 0.06225 0.02283 0.02283 0.02283 0.02283 0.03043 0.03043 0.00128 0.00156	ΔkWh 55.7 20.4 27.2 103.4 ΔkWh 61.4 22.5 30.0 4.4 19.2 67.0	2023 ΔkW 0.05652 0.02073 0.02763 0.00128 0.00560 0.01954	ΔkWh 55.7 20.4 27.2 4.4 19.2 67.0
221 Kit 1 troduct EE Tier 1, Omnidin EE Tier 1, Omnidin EE Tier 1, Omnidin 221 Kit 1 Total 221 Kit 2 troduct EE Tier 1, Omnidin EE Tier 1, Omnidin EE Tier 1, Omnidin EE Tier 1, Omnidin EE Tier 1, Omnidin Co Tier 1	ectional 9W LED Bulb (total for 5 bulbs) tectional 5.SW LED Bulb (total for 3 bulbs) ectional 11W LED Bulb (total for 2 bulbs) ectional 9W LED Bulb (total for 5 bulbs) ectional 5.SW LED Bulb (total for 3 bulbs) totor	2021 ΔkW 0.06775 0.02484 0.03312 0.12571 Restriction	66.8 24.5 32.6 123.9	0.08062 2022 AKW 0.06225 0.02283 0.03043 0.11551 2021 2021 2021 2021 2021 2021 2021	ΔkWh 61.4 22.5 30.0 113.8 ΔkWh 66.8 24.5 32.6 4.4 19.2 67.0	2023 ΔxW 0.05652 0.02073 0.0273 0.02763 0.02763 0.02763 0.0283 0.03255 0.0225 0.0225 0.0225 0.0225 0.0225 0.0225 0.0225 0.0225 0.05225 0.05225 0.05225 0.05225 0.05225 0.05225 0.05225 0.0525 0.0525 0.0525 0.0525 0.0577 0.0525 0.0555	ΔkWh 55.7 20.4 27.2 103.4 ΔkWh 61.4 22.5 30.0 4.4 19.2 67.0	2023 ΔkW 0.05652 0.02073 0.02763 0.00128 0.00560 0.01954	ΔkWh 55.7 20.4 27.2 4.4 19.2 67.0
021 Kit 1 croduct EE Tier 1, Omnidie EE Tier 1, Omnidie EE Tier 1, Omnidie 201 Kit 1 Total 021 Kit 1 Total 021 Kit 2 croduct EE Tier 1, Omnidie EE Tier 1, Omnidie EE Tier 1, Omnidie EE Tier 1, Omnidie Colf Figure 4 5 GPM Faucte 4 0 GPM Fau	ectional SW LED Bulb (total for 5 bulbs) cetional S.SW LED Bulb (total for 3 bulbs) ectional 11W LED Bulb (total for 2 bulbs) ectional SW LED Bulb (total for 5 bulbs) ectional SW LED Bulb (total for 3 bulbs) ectional 11W LED Bulb (total for 2 bulbs) totor ator ator	2021 Δ&W 0.06775 0.02484 0.03312 0.12571 Restriction	66.8 24.5 32.6 123.9	0.08062 2022 AW 0.06225 0.0228 0.0238 0.0304 0.11551 AW 0.03075 0.06775 0.06775 0.06775 0.06775 0.06775 0.01521 2022	ΔkWh 61.4 22.5 30.0 113.8 ΔkWh 66.8 24.5 32.6 4.4 19.2 67.0	2023 Δ&W 0.05652 0.02073 0.02763 0.02763 0.02763 0.02763 0.02763 0.02763 0.02763 0.0283 0.00283 0.00184 0.00560 0.01954 0.014193	ΔkWh 55.7 20.4 27.2 103.4 ΔkWh 61.4 22.5 30.0 4.4 19.2 67.0	2023 ΔkW 0.05652 0.02073 0.02763 0.00128 0.00560 0.01954	ΔkWh 55.7 20.4 27.2 4.4 19.2 67.0
221 Kit 1 troduct EE Tier 1, Omnidin EE Tier 1, Omnidin EE Tier 1, Omnidin 221 Kit 1 Total 221 Kit 2 troduct EE Tier 1, Omnidin EE Tier 1	ectional SW LED Bulb (total for 5 bulbs) cetional S.SW LED Bulb (total for 3 bulbs) ectional 11W LED Bulb (total for 2 bulbs) ectional SW LED Bulb (total for 5 bulbs) ectional SW LED Bulb (total for 3 bulbs) ectional 11W LED Bulb (total for 2 bulbs) totor ator ator	2021 Δ&W 0.06775 0.02484 0.03312 0.12571 Restriction	66.8 24.5 32.6 123.9	0.08062 2022 AW 0.06225 0.0228 0.0238 0.0304 0.11551 AW 0.06775 0.06775 0.06775 0.06775 0.06775 0.01521 2022	ΔkWh 61.4 22.5 30.0 113.8 ΔkWh 66.8 24.5 32.6 4.4 19.2 67.0 214.5	2023 Δ&W 0.05652 0.02073 0.02763 0.02763 0.02763 0.02763 0.02763 0.02763 0.02763 0.0283 0.00283 0.00184 0.00560 0.01954 0.014193	ΔkWh 55.7 20.4 27.2 103.4 61.4 22.5 30.0 4.4 19.2 67.0 194.8	2023 ΔkW 0.05652 0.02073 0.02763 0.00128 0.00560 0.01954	ΔkWh 55.7 20.4 27.2 4.4 19.2 67.0
021 Kit 1 Todukt EE Tier 1, Omridin EE Tier 1, Omridin EE Tier 1, Omridin 221 Kit 1 Total 221 Kit 1 Total 221 Kit 2	ectional SW LED Bub (total for 5 bubs) cetional S.SW LED Bub (total for 3 bubs) ectional 11W LED Bub (total for 2 bubs) ectional SW LED Bub (total for 5 bubs) ectional SW LED Bub (total for 3 bubs) ectional 11W LED Bub (total for 3 bubs) totor ator ator ator ator / Thermostatically-Initiated Shower scy Kit - VPPSA Customers	2021 AKW 0.06775 0.02484 0.03312 0.12571 2.021 AKW 0.02710	66.8 24.5 32.6 123.9 N Valve	0.08062 2022 AkW 0.06225 0.02283 0.03043 0.11551 2021 AkW 0.06775 0.02484 0.03128 0.00128 0.00128 0.00128 0.00128 0.00128 0.00128	ΔkWh 61.4 22.5 30.0 113.8 ΔkWh 66.8 24.5 32.6 4.4 19.2 67.0 214.5 214.5	2023 ΔkW 0.05652 0.0273 0.02763 0.10488 2022 ΔkW 0.05255 0.02281 0.03043 0.01493 0.01493 0.01493 2022 ΔkW 0.05261 0.02562 0.02262 0.02263 0.02264	ΔkWh 55.7 20.4 27.2 103.4 61.4 22.5 30.0 4.4 19.2 67.0 194.8 2.3 37.7	2023 AkW 0.05652 0.02073 0.02763 0.00128 0.00560 0.01954	ΔkWh 55.7 20.4 27.2 4.4 19.2 67.0
021 Kit 1 croduct EE Tier 1, Omnidin EE Tier 1, Omnidin EE Tier 1, Omnidin 201 Kit 1 Total 021 Kit 2 Total 021 Kit 2 Total 021 Kit 2 Total EE Tier 1, Omnidin EE Tier 1, Omnidin 201 Kit 2 Total Arbei Home Efficier roduct EE Tier 1, Omnidin EE Tier 1, Omnidin EE Tier 1, Omnidin EE Tier 1, Omnidin	ectional 9W LED Bub (total for 5 bulbs) cctional 5.5W LED Bub (total for 2 bulbs) cctional 11W LED Bub (total for 2 bulbs) cctional 9W LED Bub (total for 2 bulbs) cctional 9W LED Bub (total for 2 bulbs) tor tor ad w/ Thermostatically-initiated Shower scy KR - VPPSA Customers cctional 9W LED Bub (total for 2 bulbs) tor and the formation of the formation of the formation scy KR - VPPSA Customers cctional 15W LED Bub (total for 2 bulbs) tectional 15W LED Bub (total for 2 bulbs) er Strip	2021 AKW 0.06775 0.02484 0.03312 0.12571 2.021 2.0221 AKW 0.02210 AKW 0.02710 0.04580 0.04580	66.8 24.5 32.6 123.9 123.9 ΔkWh 26.7 45.1 33.5	0.08062 2022 A&W 0.06225 0.02283 0.03043 0.11551 2021 AW 0.01551 0.02484 0.03122 0.00128 0.00128 0.01551 0.02484 0.03512 0.01551 0.0015510000000000	ΔkWh 61.4 22.5 30.0 1113.8 ΔkWh 66.8 24.5 32.6 4.4 19.2 67.0 214.5 214.5 214.5 33.5	2023 404W 0.05652 0.02073 0.02763 0.02763 0.0284 0.06225 0.02283 0.03824 0.01954 0.01954 0.01954 0.01954 0.04954 0.04954 0.04954 0.04954 0.04954 0.04954 0.04954 0.049555 0.049555 0.049555 0.049555 0.049555 0.049555 0.04955 0.04955 0.04955 0.04955 0.04	ΔkWh 55.7 20.4 27.2 103.4 61.4 22.5 30.0 4.4 19.2 67.0 194.8 ΔkWh 22.3 37.7 33.5	2023 AkW 0.05652 0.02073 0.02763 0.00128 0.00560 0.01954	ΔkWh 55.7 20.4 27.2 4.4 19.2 67.0
021 Kit 1 Todukt EE Tier 1, Omnidin EE Tier 1, Omnidin EE Tier 1, Omnidin 221 Kit 1 Total 221 Kit 2 221 Ki	ectional 9W LED Bub (total for 5 bulbs) cctional 5.5W LED Bub (total for 2 bulbs) cctional 11W LED Bub (total for 2 bulbs) cctional 9W LED Bub (total for 2 bulbs) cctional 9W LED Bub (total for 2 bulbs) tor tor ad w/ Thermostatically-initiated Shower scy KR - VPPSA Customers cctional 9W LED Bub (total for 2 bulbs) tor and the formation of the formation of the formation scy KR - VPPSA Customers cctional 15W LED Bub (total for 2 bulbs) tectional 15W LED Bub (total for 2 bulbs) er Strip	2021 ΔKW 0.06775 0.02485 0.03312 0.13571 0.12571 2021 ΔKW 0.02710 0.04580 0.00416 0.00456	66.8 24.5 32.6 123.9 Ν Valve ΔkWh 26.7 45.1 33.5 19.2	0.08062 2022 Δ&W 0.06225 0.0228 0.0283 0.1551 2021 Δ&W 0.06755 0.0284 0.03312 0.01321 0.01321 0.01521 2022 Δ&W 0.02490 0.04269 0.04269 0.04269	ΔkWh 61.4 22.5 30.0 113.8 4.4 24.5 32.6 4.4 19.2 67.0 214.5 214.5 4.1 52.5 4.1 52.5 4.1 52.5 53.5 19.2	2023 0.05652 0.02073 0.02763 0.02763 0.02763 0.0284 0.06225 0.05225 0.05225 0.05256 0.05256 0.05256 0.05560 0.01046 0.00416 0.00416 0.00416	ΔkWh 55.7 20.4 27.2 103.4 61.4 22.5 30.0 4.4 19.2 67.0 194.8 7.0 194.8 3.7 7.0 3.7 3.7 3.5 19.2	2023 AkW 0.05652 0.02073 0.02763 0.00128 0.00560 0.01954	ΔkWh 55.7 20.4 27.2 4.4 19.2 67.0
021 Kit 1 roduct EE Tier I 1, Omnidin EE Tier I 1, Omnidin EE Tier I 1, Omnidin EE Tier I 1, Omnidin C21 Kit 1 Total 021 Kit 2 roduct EE Tier 1, Omnidin 5 GPM Faucet Are 0. GPM Faucet Are 0. GPM Faucet Are 10 Kit 2 Kit 2 Total roduct EE Tier 1, Omnidin EE Tier 1, Omnidin	ectional SW LED Bulb (total for 5 bulbs) ectional 5.SW LED Bulb (total for 2 bulbs) ectional 11W LED Bulb (total for 2 bulbs) ectional SW LED Bulb (total for 2 bulbs) ectional SW LED Bulb (total for 2 bulbs) stor etcore and the state of the state of the state of the state ectional IW LED Bulb (total for 2 bulbs) ectional SW LED Bulb (total for 2 bulbs)	2021 AKW 0.05775 0.02484 0.03312 0.12571 2021 AKW 0.02710 0.04580 0.00416 0.00560 0.00560	66.8 24.5 32.6 123.9 Акичн 26.7 45.1 33.5 19.2 0.0	0.08062 2022 AKW 0.06225 0.02283 0.03043 0.03043 0.01551 AKW 0.01551 0.02484 0.03122 0.02480 0.0128 0.00128 0.00128 0.00128 0.00280 0.01281 0.02490 0.02490 0.02490 0.02490 0.02490 0.02490 0.02490 0.02490 0.02490 0.00416 0.004600 0.004	ΔkWh 61.4 22.5 30.0 113.8 24.5 32.6 4.4 19.2 67.0 214.5 24.5 41.5 33.5 19.2 0.0	2023 A&W 0.05652 0.02073 0.02763 0.02763 0.0284 0.0282 0.0284 0.00128 0.00128 0.00128 0.00128 0.00128 0.00128 0.00261 0.02261 0.00261 0.00261 0.00261 0.00261 0.00261 0.00261 0.00261 0.00261 0.00261 0.00261 0.00261 0.00261 0.00261 0.00261 0.00261 0.00261 0.00050 0.00	ΔkWh 55.7 20.4 27.2 103.4 61.4 22.5 30.0 4.4 19.2 67.0 194.8 7 4.4 19.2 67.0 194.8 3.7 19.2 3.7 19.2 3.7 19.2 3.5 19.2 0.0	2023 AkW 0.05652 0.02073 0.02763 0.00128 0.00560 0.01954	ΔkWh 55.7 20.4 27.2 4.4 19.2 67.0
021 Kit 1 roduct EE Tier I 1, Omnidin EE Tier I 1, Omnidin EE Tier I 1, Omnidin EE Tier I 1, Omnidin C21 Kit 1 Total 021 Kit 2 roduct EE Tier 1, Omnidin 5 GPM Faucet Are 0. GPM Faucet Are 0. GPM Faucet Are 10 Kit 2 Kit 2 Total roduct EE Tier 1, Omnidin EE Tier 1, Omnidin	ectional SW LED Bulb (total for 5 bulbs) ectional 5.SW LED Bulb (total for 2 bulbs) ectional 11W LED Bulb (total for 2 bulbs) ectional SW LED Bulb (total for 2 bulbs) ectional SW LED Bulb (total for 2 bulbs) stor etcore and the state of the state of the state of the state ectional IW LED Bulb (total for 2 bulbs) ectional SW LED Bulb (total for 2 bulbs)	2021 AKW 0.05775 0.02484 0.03312 0.12571 2021 AKW 0.02710 0.04580 0.00416 0.00560 0.00560	66.8 24.5 32.6 123.9 Акичн 26.7 45.1 33.5 19.2 0.0	0.08062 2022 AKW 0.06225 0.02283 0.03043 0.03043 0.01551 AKW 0.01551 0.02484 0.03122 0.02480 0.0128 0.00128 0.00128 0.00128 0.00240 0.04290 0.04240 0.04240 0.04240 0.04240 0.04240 0.04405 0.0455 0.0455 0.0455 0.0455 0.0455 0.0455 0.0455 0.0455 0.0455 0.0455 0.0455 0.0455 0.0455 0.0455 0.0455 0.0455 0.0455 0.0455 0.04555 0.04555 0.04555 0.04555 0.04555 0.0455	ΔkWh 61.4 22.5 30.0 113.8 24.5 32.6 4.4 19.2 67.0 214.5 24.5 41.5 33.5 19.2 0.0	2023 Adw 0.05652 0.02073 0.02763 0.02763 0.02763 0.02283 0.03282 0.03282 0.03282 0.0329 0.0329 0.0329 0.03292 0.03	ΔkWh 55.7 20.4 27.2 103.4 61.4 22.5 30.0 4.4 19.2 67.0 194.8 7 4.4 19.2 67.0 194.8 3.7 19.2 3.7 19.2 3.7 19.2 3.5 19.2 0.0	2023 AkW 0.05652 0.02073 0.02763 0.00128 0.00560 0.01954	ΔkWh 55.7 20.4 27.2 4.4 19.2 67.0
221 Kit 1 todukt EE Tier 1, Omnidin EE Tier 1, Omnidin EE Tier 1, Omnidin 221 Kit 2 todukt EE Tier 1, Omnidin EE Tier 1, Omnidin	ectional 9W LED Bulb (total for 5 bulbs) ectional 5.5W LED Bulb (total for 2 bulbs) ectional 11W LED Bulb (total for 2 bulbs) ectional 9W LED Bulb (total for 2 bulbs) ectional 5.5W LED Bulb (total for 2 bulbs) ectional 11W LED Bulb (total for 2 bulbs) tor ad w/ Thermostatically-Initiated Shower ectional 9W LED Bulb (total for 2 bulbs) ectional 9W LED Bulb (total for 2 bulbs)	2021 AKW 0.05775 0.02484 0.03312 0.12571 2021 AKW 0.02710 0.04580 0.00416 0.00560 0.00560	66.8 24.5 32.6 123.9 Акичн 26.7 45.1 33.5 19.2 0.0	0.08062 2022 AKW 0.06225 0.02283 0.03043 0.03043 0.01551 AKW 0.01551 0.02484 0.03122 0.02480 0.0128 0.00128 0.00128 0.00128 0.00240 0.04290 0.04240 0.04240 0.04240 0.04240 0.04240 0.04405 0.0455 0.0455 0.0455 0.0455 0.0455 0.0455 0.0455 0.0455 0.0455 0.0455 0.0455 0.0455 0.0455 0.0455 0.0455 0.0455 0.0455 0.0455 0.04555 0.04555 0.04555 0.04555 0.04555 0.0455	ΔkWh 61.4 22.5 30.0 113.8 24.5 32.6 4.4 19.2 67.0 214.5 24.5 41.5 33.5 19.2 0.0	2023 A&W 0.05652 0.02073 0.02763 0.02763 0.0284 0.0282 0.0284 0.00128 0.00128 0.00128 0.00128 0.00128 0.00128 0.00261 0.02261 0.00261 0.00261 0.00261 0.00261 0.00261 0.00261 0.00261 0.00261 0.00261 0.00261 0.00261 0.00261 0.00261 0.00261 0.00261 0.00261 0.00261 0.00050 0.00	ΔkWh 55.7 20.4 27.2 103.4 61.4 22.5 30.0 4.4 19.2 67.0 194.8 7 4.4 19.2 67.0 194.8 3.7 19.2 3.7 19.2 3.7 19.2 3.5 19.2 0.0	2023 AkW 0.05652 0.02073 0.02763 0.00128 0.00560 0.01954	ΔkWh 55.7 20.4 27.2 4.4 19.2 67.0
221 Kit 1 todukt EE Tier 1, Omnidin EE Tier 1, Omnidin EE Tier 1, Omnidin 221 Kit 2 todukt EE Tier 1, Omnidin EE Tier 1, Omnidin	ectional 9W LED Bulb (total for 5 bulbs) ectional 5.5W LED Bulb (total for 2 bulbs) ectional 11W LED Bulb (total for 2 bulbs) ectional 9W LED Bulb (total for 2 bulbs) ectional 5.5W LED Bulb (total for 2 bulbs) ectional 11W LED Bulb (total for 2 bulbs) tor ad w/ Thermostatically-Initiated Shower ectional 9W LED Bulb (total for 2 bulbs) ectional 9W LED Bulb (total for 2 bulbs)	2021 AKW 0.05775 0.02484 0.03312 0.12571 2021 AKW 0.02710 0.04580 0.00416 0.00560 0.00560	66.8 24.5 32.6 123.9 Акичн 26.7 45.1 33.5 19.2 0.0	0.08062 2022 AkW 0.06223 0.02283 0.0283 0.0283 0.01551 2021 2021 2021 2021 2022 2022 202 202	ΔkWh 61.4 22.5 30.0 113.8 24.5 32.6 4.4 19.2 67.0 214.5 24.5 41.5 33.5 19.2 0.0	2023 AKW 0.05652 0.02073 0.02763 0.02783 0.02783 0.0228 0.0225 0.02283 0.02284 0.02284 0.04560 0.04560 0.03580 0.03261 0.0275 0.0225 0.0225 0.0225 0.0225 0.0225 0.0255 0.00560 0.0256 0.00560 0.0056	ΔkWh 55.7 20.4 27.2 103.4 61.4 22.5 30.0 4.4 19.2 67.0 194.8 7 4.4 19.2 67.0 194.8 3.7 19.2 3.7 19.2 3.7 19.2 3.5 19.2 0.0	2023 A&W 0.05652 0.02073 0.00128 0.00560 0.01954 0.1313	ΔkWh 55.7 20.4 27.2 4.4 19.2 67.0
1021 Kit 1 Yodukt EE Tier 1, Omnidin EE Tier 1, Omnidin EE Tier 1, Omnidin 1021 Kit 1 Total 1021 Kit 1 Total 1021 Kit 2 Total 1021	ectional 9W LED Bulb (total for 5 bulbs) ectional 5.5W LED Bulb (total for 2 bulbs) ectional 11W LED Bulb (total for 2 bulbs) ectional 9W LED Bulb (total for 2 bulbs) ectional 5.5W LED Bulb (total for 2 bulbs) ectional 11W LED Bulb (total for 2 bulbs) tor ad w/ Thermostatically-Initiated Shower ectional 9W LED Bulb (total for 2 bulbs) ectional 9W LED Bulb (total for 2 bulbs)	2021 AKW 0.05775 0.02484 0.03312 0.12571 2021 AKW 0.02710 0.04580 0.00416 0.00560 0.00560	66.8 24.5 32.6 123.9 Акичн 26.7 45.1 33.5 19.2 0.0	0.08062 2022 2024 2024 2024 2024 2024 2024 2	ΔkWh 61.4 22.5 30.0 113.8 24.5 32.6 4.4 19.2 214.5 214.5 214.5 3.5 19.2 0.0 118.6	2023 AKW 0.05652 0.02073 0.02763 0.02763 0.02783 0.02783 0.02283 0.03043 0.00288 0.00280 0.01594 0.01594 0.01594 0.01594 0.01594 0.01594 0.01594 0.0250 0.01594 0.0250 0.0154 0.0250 0.0250 0.0154 0.0250 0.0550 0.0550 0.0550 0.0250 0.0550 0	ΔkWh 55.7 20.4 27.2 103.4 4.4 19.2 67.0 194.8 4.4 19.2 67.0 194.8 37.7 33.5 19.2 0.0 112.6	2023 Δ&W 0.05652 0.02763 0.02763 0.02763 0.02763 0.01954 0.1313	ΔkWh 25.7 20.4 27.2 4.4 19.2 67.0 184.3
1021 Kit 1 Yodukt EE Tier 1, Omnidin EE Tier 1, Omnidin EE Tier 1, Omnidin 1021 Kit 1 Total 1021 Kit 1 Total 1021 Kit 2 Total 1027	etional 9W LED Bulb (total for 5 bulbs) etional 5.5W LED Bulb (total for 2 bulbs) etional 11W LED Bulb (total for 2 bulbs) etional 9W LED Bulb (total for 2 bulbs) etional 5.5W LED Bulb (total for 2 bulbs) etional 11W LED Bulb (total for 2 bulbs) tor ad w/ Thermostatically-Initiated Shower etional 9W LED Bulb (total for 2 bulbs) etional 9W LED Bulb (total	2021 AKW 0.05775 0.02484 0.03312 0.12571 2021 AKW 0.02710 0.04580 0.00416 0.00560 0.00560	66.8 24.5 32.6 123.9 Акичн 26.7 45.1 33.5 19.2 0.0	0.08062 2022 Δ&W 0.06225 0.02283 0.03043 0.11551 2021 ΔW 0.0312 0.06775 0.02484 0.03128 0.00576 0.0128 0.00128 0.00128 0.00128 0.02494 0.04209 0.0420 0.044 0.0420 0.044 0.0420 0.044 0.0420 0.044 0.0420 0.044	ΔkWh 61.4 22.5 30.0 1113.8 24.5 32.6 4.4 19.2 67.0 214.5 32.6 4.4 4.1 5 33.5 19.2 0.0 118.6	2023 AKW 0.05652 0.02073 0.02763 0.02763 0.02783 0.02783 0.02283 0.03043 0.00288 0.00280 0.01594 0.01594 0.01594 0.01594 0.01594 0.01594 0.01594 0.0250 0.01594 0.0250 0.0154 0.0250 0.0250 0.0154 0.0250 0.0550 0.0550 0.0550 0.0250 0.0550 0	ΔkWh 55.7 20.4 27.2 103.4 61.4 22.5 30.0 4.4 19.2 67.0 194.8 ΔkWh 22.3 33.5 19.2 0.0 112.6	2023 ΔKW 0.05652 0.02073 0.02073 0.02073 0.02073 0.03540 0.03550 0.03500 0.03550 0.035000 0.035000 0.035000 0.035000 0.035000 0.035000 0.035000 0.035000 0.035000 0.035000 0.035000 0.035000 0.035000 0.035000 0.035000 0.0350000 0.0350000 0.0350000 0.0350000000000000000000000000000000000	ДАММ 55.7 20.4 27.2 67.0 184.3 184.3
2021 KR 1 Product EE Tier 1, Omnidin EE Tier 1, Omnidin EE Tier 1, Omnidin EE Tier 1, Omnidin EE Tier 1, Omnidin 2021 KR 1 Total 2021 KR 2 Product EE Tier 1, Omnidin ES GPH Faucet Are 2047 Faucet Are EE Tier 1, Omnidin EE Tier 1, Omnidin ET Fichency KR Product 2021 KR 2 Product 2021 KR 2 Product 2021 KR 2 Product 2021 KR 2 2021 KR	ectional 9W LED Bulb (total for 5 bulbs) lectional 5.SW LED Bulb (total for 2 bulbs) ectional 11W LED Bulb (total for 2 bulbs) ectional 11W LED Bulb (total for 5 bulbs) lectional 5.SW LED Bulb (total for 5 bulbs) ectional 11W LED Bulb (total for 5 bulbs) tor ator ator ator ator ator VPESA Customers ectional 9W LED Bulb (total for 2 bulbs) ectional 15W LED Bulb (total for 2 bulbs) extor ectional 15W LED Bulb (total for 2 bulbs) er Strip ectional 15W LED Bulb (total for 2 bulbs) er Strip ectional 15W LED Bulb (total for 2 bulbs) extored 15W LED Bulb (total for 4 bulbs)	2021 AKW 0.05775 0.02484 0.03312 0.12571 2021 AKW 0.02710 0.04580 0.00416 0.00560 0.00560	66.8 24.5 32.6 123.9 Акичн 26.7 45.1 33.5 19.2 0.0	0.08062 2022 2024 2024 2024 2024 2024 2024 2	ΔkWh 61.4 22.5 30.0 1113.8 24.5 24.5 32.6 4.9 24.5 214.5 214.5 214.5 214.5 33.5 41.5 24.5 19.2 0.0 118.6	2023 ΔkW 0.05652 0.0273 0.10488 2022 ΔkW 0.0525 0.0228 0.03243 0.03048 0.03048 0.03048 0.0128 0.0128 0.0128 0.0128 0.0128 0.0225 ΔkW 0.02261 0.0380 0.03950 0.005000 0.00500 0.00500 0.0	ΔkWh 55.7 20.4 27.2 103.4 27.2 103.4 4.4 22.5 30.0 4.4 19.2 67.0 194.8 ΔkWh 22.3 3.7 194.8 0.0 112.6	2023 ΔKW 0.05652 0.02073 0.02073 0.02073 0.02073 0.03540 0.03550 0.03500 0.03550 0.035000 0.035000 0.035000 0.035000 0.035000 0.035000 0.035000 0.035000 0.035000 0.035000 0.035000 0.035000 0.035000 0.035000 0.035000 0.0350000 0.0350000 0.0350000 0.0350000000000000000000000000000000000	ΔkWh 55.7 20.4 19.2 67.0 184.3 84.3
EE Tier I, Omnidin EE Tier I, Omnidin 2021 Kit I Total 2021 Kit I Omnidin 2021	ectional 9W LED Bub (total for 5 bulbs) cctional 5.5W LED Bub (total for 2 bulbs) cctional 11W LED Bub (total for 2 bulbs) cctional 9W LED Bub (total for 2 bulbs) cctional 9W LED Bub (total for 2 bulbs) tor ad w/ Thermostatically-Initiated Shower cctional 9W LED Bub (total for 2 bulbs) tor cctional 9W LED Bub (total for 2 bulbs) tor w Strip cctional 9W LED Bub (total for 2 bulbs) tor w Strip cctional 9W LED Bub (total for 4 bulbs) tor	2021 AKW 0.05775 0.02484 0.03312 0.12571 2021 AKW 0.02710 0.04580 0.00416 0.00560 0.00560	66.8 24.5 32.6 123.9 Акичн 26.7 45.1 33.5 19.2 0.0	0.08062 2022 AXW 0.06225 0.0293 0.03031 2021 AWW 0.06775 0.02494 0.03312 0.01351 0.01540 0.04010 0.04029 0.0416 0.04040 0.0404 0.040 0.04	ΔkWh 61.4 22.5 30.0 113.8 ΔkWh 66.8 24.5 32.6 4.4 19.2 67.0 214.5 33.5 19.2 0.0 118.6 ΔkWh 53.4 4.4	2023 Δ&W 0.05652 0.10488 2022 Δ&W 0.0525 0.0283 0.00540 0.03943 0.01954 0.03943 0.01954 0.03943 0.01954 0.03943 0.01954 0.03943 0.01954 0.03943 0.01954 0.03950 0.02261 0.03952 0.02261 0.03952 0.02261 0.03952 0.01954 0.03952 0.02261 0.03952 0.02261 0.03952 0.02261 0.03952 0.02261 0.03952 0.02261 0.03952 0.00500 0.00500 0.00500 0.00550 0	ΔkWh 25.7 20.4 27.2 103.4 61.4 22.5 30.0 194.8 67.0 194.8 37.7 33.5 19.2 33.7 19.2 33.7 19.2 3.3 5 19.2 3.3 19.2 4.4 112.6	2023 Δ&W 0.05652 0.0273 0.0273 0.0273 0.00560 0.03562 0.03552 0.05	ΔkWh 55.7 20.4 19.2 67.0 184.3 ΔkWh 44.6 4.4
1921 Kit 1 todukt EE Tier 1, Omnidin EE Tier 1, Omnidin 5 GPM Faucet Aerr 0. GPM	ectional 9W LED Bub (total for 5 bulbs) cctional 5.5W LED Bub (total for 2 bulbs) cctional 11W LED Bub (total for 2 bulbs) cctional 9W LED Bub (total for 2 bulbs) cctional 9W LED Bub (total for 2 bulbs) tor ad w/ Thermostatically-Initiated Shower cctional 9W LED Bub (total for 2 bulbs) tor cctional 9W LED Bub (total for 2 bulbs) tor w Strip cctional 9W LED Bub (total for 2 bulbs) tor w Strip cctional 9W LED Bub (total for 4 bulbs) tor	2021 AKW 0.06775 0.02484 0.03312 0.12571 2021 2021 AKW 0.02710 0.04580 0.00016 0.000560 0.000560	66.8 24.5 32.6 123.9 α Valve ΔkWh 26.7 45.1 33.5 19.2 0.0 124.5	0.08062 2022 AkW 0.06225 0.0283 0.0303 0.11551 2022 2021 AkW 0.06775 0.02484 0.0312 0.0154 0.00156 0.00154 0.01543 0.01544 0.00416 0.00416 0.00416 0.00406 0.00406 0.00406 0.00406 0.00406 0.00406 0.00406 0.00406 0.004 0.0046 0.	ΔkWh 61.4 22.5 30.0 1113.8 ΔkWh 66.8 24.5 4.4 19.2 67.0 214.5 32.6 4.4 19.2 67.0 214.5 33.5 19.2 0.0 118.6 3.3 5 19.2 0.0 118.6	2023 Δ&W 0.05652 0.0273 0.10488 2022 ΔW 0.0525 0.0225 0.0225 0.0304 0.0304 0.0304 0.0304 0.0304 0.0304 0.0304 0.000000 0.000000 0.00000 0.000000 0.00000000	ΔkWh 55.7 20.4 27.2 103.4 61.4 22.5 30.0 4.4 19.2 67.0 194.8 7 30.0 194.8 23 33.5 19.2 3.5 19.2 0.0 112.6	2023 Δ&W 0.06552 0.02763 0.02763 0.02763 0.02763 0.0128 0.0128 2023 Δ&W 2023 Δ&W	АКWh 55.7 20.4 19.2 67.0 184.3 184.3 АкWh 44.6 19.2
221 Kit 1 Croduct EE Tier 1, Omnidin S GM Faucet Are Nor Down Prov Showenhe ET fice 1, Omnidin EE Tier 1, Omnidin Omnid EE Tier 1, Omnidin Omnid EE Tier 1, Omnidin E	etional 9W LED Bulb (total for 5 bulbs) etional 5.5W LED Bulb (total for 2 bulbs) etional 11W LED Bulb (total for 2 bulbs) etional 9W LED Bulb (total for 5 bulbs) etional 5.5W LED Bulb (total for 3 bulbs) etional 5.5W LED Bulb (total for 2 bulbs) tor ad w/ Thermostatically-initiated Shower etional 9W LED Bulb (total for 2 bulbs) etion etional 9W LED Bulb (total for 2 bulbs) etion	2021 AKW 0.06775 0.02484 0.03312 0.12571 2021 2021 AKW 0.02710 0.04580 0.00016 0.000560 0.000560	66.8 24.5 32.6 123.9 α Valve ΔkWh 26.7 45.1 33.5 19.2 0.0 124.5	0.08062 2022 4XW 0.06225 0.0283 0.0303 2 2021 2 202 2 2 2 2 2 2 2 2 2 2 2 2 2	ΔkWh 61.4 22.5 30.0 113.8 24.5 32.6 4.4 19.2 214.5 21	2023 Δ4W 0.05652 0.10488 2022 2022 2022 2022 0.0284 0.06525 0.0284 0.03043 0.03043 0.03043 0.03043 0.03043 0.03044 0.03044 0.03045 0.02261 0.03046 0.03046 0.00508	كلالله الله الله الله الله الله الله	2023 AkW 0.05652 0.02073 0.02763 0.0128 0.01954 0.1313 2023 AkW 0.04522 0.04522 0.01288 0.04522	АкWh 25.7 20.4 27.2 4.4 19.2 67.0 184.3 184.3 АкWh 44.6 4.4 4 19.2 67.0
221 KR 1 oduct EE Tier 1, Omnidin EE Tier 1, Omnidin EE Tier 1, Omnidin EE Tier 1, Omnidin EE Tier 1, Omnidin 221 KR 2 oduct EE Tier 1, Omnidin 5 GMF Faucet Are 0 GMF Faucet Are	etional 9W LED Bulb (total for 5 bulbs) etional 5.5W LED Bulb (total for 2 bulbs) etional 11W LED Bulb (total for 2 bulbs) etional 9W LED Bulb (total for 5 bulbs) etional 5.5W LED Bulb (total for 3 bulbs) etional 5.5W LED Bulb (total for 2 bulbs) tor ad w/ Thermostatically-initiated Shower etional 9W LED Bulb (total for 2 bulbs) etion etional 9W LED Bulb (total for 2 bulbs) etion	2021 AKW 0.06775 0.02484 0.03312 0.12571 2021 2021 AKW 0.02710 0.04580 0.00016 0.000560 0.000560	66.8 24.5 32.6 123.9 α Valve ΔkWh 26.7 45.1 33.5 19.2 0.0 124.5	0.08062 2022 4XW 0.06225 0.0283 0.0303 2 2021 2 202 2 2 2 2 2 2 2 2 2 2 2 2 2	ΔkWh 61.4 22.5 30.0 113.8 24.5 32.6 4.4 19.2 214.5 21	2023 Δ&W 0.05652 0.10488 2022 Δ&W 0.02763 0.02763 0.02763 0.02763 0.02763 0.02763 0.02763 0.02763 0.03242 0.01954 0.01954 0.01954 0.01954 0.00000 0.07058 2022 2022 2022 2025	كلالله الله الله الله الله الله الله	2023 AkW 0.05652 0.02073 0.02763 0.0128 0.01954 0.1313 2023 AkW 0.04522 0.04522 0.01288 0.04522	АкWh 25.7 20.4 27.2 4.4 19.2 67.0 184.3 184.3 АкWh 44.6 4.4 4 19.2 67.0
221 KR 1 coduct EE Tier 1, Omnidin EE Tier 1, Omnidin S GPM Faucet Aer Tier 1, Omnidin S GPM Faucet Aer Part 1, Omnidin EE Tier 1, Omnidin	etional 9W LED Bulb (total for 5 bulbs) etional 5.5W LED Bulb (total for 2 bulbs) etional 11W LED Bulb (total for 2 bulbs) etional 9W LED Bulb (total for 5 bulbs) etional 5.5W LED Bulb (total for 3 bulbs) etional 5.5W LED Bulb (total for 2 bulbs) tor ad w/ Thermostatically-initiated Shower etional 9W LED Bulb (total for 2 bulbs) etion etional 9W LED Bulb (total for 2 bulbs) etion	2021 AKW 0.06775 0.02484 0.03312 0.12571 2021 2021 AKW 0.02710 0.04580 0.00016 0.000560 0.000560	66.8 24.5 32.6 123.9 α Valve ΔkWh 26.7 45.1 33.5 19.2 0.0 124.5	0.08062 2022 4XW 0.06225 0.0283 0.0303 2 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4	ΔkWh 61.4 22.5 30.0 113.8 24.5 32.6 4.4 19.2 214.5 21	2023 Δ&W 0.05652 0.10488 2022 Δ&W 0.02763 0.02763 0.02763 0.02763 0.02763 0.02763 0.02763 0.02763 0.03242 0.01954 0.01954 0.01954 0.01954 0.00000 0.07058 2022 2022 2022 2025	كلالله الله الله الله الله الله الله	2023 AkW 0.05652 0.02073 0.02763 0.0128 0.01954 0.1313 2023 AkW 0.04522 0.04522 0.01288 0.04522	АкWh 25.7 20.4 27.2 4.4 19.2 67.0 184.3 184.3 АкWh 44.6 4.4 4 19.2 67.0
021 Ki 1 roduct EE Ter 1, Omridin EE Tier 1, Omridin C 10 FM Faucet Aer Out A 2 Total Whole Home Efficien roduct EE Tier 1, Omridin EE Tier 1, Omr	ectional 9W LED Park (total for 5 bulks) ectional 5.5W LED Bark (total for 3 bulks) ectional 11W LED Bark (total for 2 bulks) ectional 9W LED Bark (total for 5 bulks) ectional 5.5W LED Bark (total for 5 bulks) ectional 5.5W LED Bark (total for 5 bulks) tor ator ator ator ator ator ator ator ator exp Kit - VPFSA Customers ectional 9W LED Bark (total for 2 bulks) wer Strip ectional 9W LED Bark (total for 2 bulks) tor ator	2021 AKW 0.06775 0.02494 0.03312 0.12571 2021 AKW 0.0210 AKW 0.0456 0.00416 0.00416 0.00416 0.00416 0.00416 0.00416 0.00416 0.00416 0.00416 0.00416 0.00416 0.00416 0.00416 0.00416 0.00416 0.00416 0.0040 0.0040 0.0040 0.0040 0.00775 0.0040 0.00775 0.0040 0.0075 0.007	66.8 24.5 32.6 123.9 Α Valve	0.08062 2022 AXW 0.06225 0.02283 0.03043 0.05070 2021 AXW 0.03702 0.02484 0.03122 0.02484 0.03122 0.02484 0.03122 0.02484 0.03122 0.02484 0.03122 0.02484 0.0312 0.02484 0.0312 0.02484 0.0312 0.02484 0.0312 0.0248 0.0406 0.0000 0.000 0.	ΔkWh 61.4 22.5 30.0 1113.8 24.5 22.6 7.0 214.5 27.0 214.5 41.5 33.5 41.5 33.5 19.2 0.0 118.6 33.5 19.2 0.0 118.6	2023 Δ&W 0.05652 0.0273 0.0273 0.0273 0.0273 0.0273 0.0275 0.0228 0.0228 0.0324 0.0525 0.0324 0.0354 0.0354 0.0555 0.0354 0.0555 0.0354 0.0354 0.0354 0.0354 0.0354 0.0354 0.0354 0.0354 0.0354 0.0354 0.0354 0.0354 0.0354 0.0354 0.0354 0.0354 0.0354 0.0354 0.0355 0.	كلالله الله الله الله الله الله الله	2023 AkW 0.05652 0.02073 0.02763 0.0128 0.01954 0.1313 2023 AkW 0.04522 0.04522 0.01288 0.04522	АкWh 25.7 20.4 27.2 4.4 19.2 67.0 184.3 184.3 АкWh 44.6 4.4 4 19.2 67.0

WiFi Controlled Smar	t Outlet	0.00000		0.00000		0.00000		
Smart Motion Occupa		0.00000		0.00000		0.00000		
smart Connected Ligr			26.7	0.02490	24.5	0.02261	22.3	
ΔkWh <sub>LED</sub>	= SaveEleq.eD $\times$ ISR <sub>LED</sub> $\times$ NumLe	D						
ΔkWh <sub>APS</sub>	$= SaveElec_{APS} \times ISR_{APS}$							
∆kWh <sub>Aerator</sub>	= SaveElec <sub>Aerator</sub> $\times$ ISR <sub>Aerator</sub> $\times$ I							
∆kWh <sub>Showerhead</sub>	= (SaveElec <sub>Showerhead</sub> + SaveElec	Shower Valve	) × 15Rs	ihowerhead	× %Ele	ctric_DHW		
∆kWh <sub>Pipe Wrap</sub>	= SaveElecPipe Wrap X ISRPipe Wrap	x %Electric	_DHW					
and at Table								
symbol Table								
ssil Fuel Savings								
Vhole Home Kit 1		AMME	tu (fue		MMBtu	AMM	Btu	AMMBtu
roduct		oil)		ga	atural 1s)		pane)	(total)
0 GPM Faucet Aera	tor ad w/ Thermostatically-Initiated	0.084			039	0.100		0.223
hower Restriction V	alve	0.299		0.	138	0.356	•	0.793
hole Home Kit 1	fotal							1.015
udit Kit 1								
oduct		ΔMME oil)	ltu (fue	91 (n	MMBtu atural	ΔMM (proj	Btu pane)	ΔMMBtu (total)
oam Insulation		0.000		-	15) 000	0.000		0.000
ipe Wrap Insulation	(3/4")	0.000			032	0.033		0.089
/eatherstripping		0.000		0.	000	0.000	1	0.000
crylic Caulk		0.000			000	0.000		0.000
pray Foam Insulatio		0.000			000	0.000		0.000
udit Kit 1 Total								0.312
udit Kit 2								
oduct		ΔMME oil)	ltu (fue		MMBtu atural	ΔMM (prop		∆MMBtu (total)
5 GPM Faucet Aera		0.020			1 <b>5)</b>	0.023	ane)	0.052
GPM Faucet Aera		0.020			039	0.100		0.032
	ad w/ Thermostatically-Initiated	0.299		0.	138	0.356		0.793
nower Restriction V	alve							1.067
								1007
021 Kit 2								
oduct		∆MME oil)	tu (fue	el (n	MMBtu atural	ΔMM (prop		∆MMBtu (total)
5 GPM Faucet Aera	tor	0.020			1 <b>5)</b>	0.023		0.052
) GPM Faucet Aera		0.084			039	0.100		0.1223
w-Flow Showerhea	ad w/ Thermostatically-Initiated	0.299		0.	138	0.356		0.793
21 Kit 2 Total	aive							1.067
hole Home Efficie	ncy Kit - VPPSA Customers				MMP-			1
roduct		∆MME oil)	ltu (fue	el (n	MMBtu atural is)	ΔMM (prop		∆MMBtu (total)
0 GPM Faucet Aera		0.084		0.	039	0.100		0.223
hole Home Efficie	ncy Kit 2 Total							0.223
ater Efficiency Ki	t - VPPSA Customers		-					
roduct		∆MME oil)	ltu (fue	91 (n	MMBtu atural is)	ΔMM (prop		ΔMMBtu (total)
.5 GPM Faucet Aera	tor	0.020		5	009	0.023		0.052
0 GPM Faucet Aera		0.084		0.	039	0.100		0.223
w-Flow Showerhea nower Restriction V	nd w/ Thermostatically-Initiated alve	0.299	_	0.	138	0.356	_	0.793
ater Efficieny Kit	2 Total		_					1.067
ΔMMBtu <sub>Aerator</sub>	$= SaveFuel_{Acrobor} \times ISR_{Acrobor} \times I$ $= (SaveFuel_{Showerhead} + SaveFuel_{Showerhead} + SaveFue$				ı x %Fue	₂l_DHW		
AMMBtupipe Wrap	= SaveFuelpipe Wrap X ISRpipe Wrap	, x %Fuel_D	HW					
Symbol Table								
ater Savings ater Savings								
Whole Home Kit 1				-				

1.0 GPM Faucet Aerator			ACCF		
	There	nostatically-Initiated Shower	1.14		
Restriction Valve	mem	iostatically-initiated Shower	2.93		
Whole Home Kit 1 Total			4.07		
Audit Kit 1	_				
Audit Kit 1 Product			ΔCCF		
1.0 GPM Faucet Aerator			1.14		
Audit Kit 1 Total			1.14		
			1		
Audit Kit 2					
Product 1.5 GPM Faucet Aerator			0.26		
1.0 GPM Faucet Aerator			1.14		
	Thern	nostatically-Initiated Shower	2.93		
Restriction Valve			4.34		
			-1.54		
2021 Kit 2					
Product			ΔCCF		
1.5 GPM Faucet Aerator			0.26		
1.0 GPM Faucet Aerator			0.57		
Low-Flow Showerhead w/ 1 Restriction Valve	I hern	nostatically-Initiated Shower	2.93		
2021 Kit 2 Total			3.77		
Whole Home Efficiency K	ät - V	PPSA Customers			
Product 1.0 GPM Faucet Aerator			ACCF		
1.0 GPM Faucet Aerator Whole Home Efficiency K	it Tot	tal	1.14 1.14		
LINCE LINCENCY N	10				
Water Efficiency Kit - VP	PSA	Customers			
Product			ΔCCF		
1.5 GPM Faucet Aerator			0.26		
1.0 GPM Faucet Aerator			1.14		
Low-Flow Showerhead w/ 1 Restriction Valve	Thern	nostatically-Initiated Shower	2.93		
Water Efficiency Kit Tota	al		4.34		
ACCFAerator		later <sub>Aerdor</sub> × ISR <sub>Aerdor</sub> × NumAerd			
ΔCCFShowerhe = (!					
ΔCCFShowerhe = (!					
ΔCCFshowerhe ad	Savel		er Valve) × ISRShowerhe		
ΔCCFshowerhe ad	=	Natersnownhead + SaveWatersnow Proportion of water heating supp	er Valve) × ISRShowerhe lifed by electricity		
ACCFstowerte ad PACEFstowerte ad PACEFstowerte PACEFstowerte ACCFstowerte ad PACEFstowerte ACCFstowert	=	Vatersnownhead + SaveWatersnow Proportion of water heating supp = 25%?? Proportion of water heating supp	er Valve) × ISRshowerhe slied by electricity slied by fuel oil, natura		
ACCFstowerte ad PACEFstowerte ad PACEFstowerte PACEFstowerte ACCFstowerte ad PACEFstowerte ACCFstowert	=	Vatershownhaid + SavetWatershow Proportion of water heating supp = 25% <sup>27</sup> Proportion of water heating supp Fuel OII Patural Gas Pro-	er valve) × ISRShowenhe lifed by electricity lifed by fuel oil, natura <b>spane</b>		
ACCFstowerhe ad here: 9KFuel_DHW	=	VaterShownhad + SaveWaterShow Proportion of water heating supp = 25% <sup>2</sup> 7 Proportion of water heating supp Fuel OII Cases Pro- 26% 12% 310	er valve) × ISRShowenhe lifed by electricity died by fuel oil, natura spane	gas, or propane <sup>[7]</sup>	
ACCFstowerte ad ACCFstowerte ad Phere:	= =	Vatershownhad + SaveWatershow Proportion of water heating supp = 25% <sup>27</sup> Proportion of water heating supp Fuel OII Extrured Case Proc 26% 12% 312 Gross customer annual water sa	er valve) × ISRShowenhe lifed by electricity died by fuel oil, natura spane 16 16	gas, or propane <sup>[7]</sup> t aerators (see table "Wat	
ACCFshowerhe al ACCFshowerhe al PAElectric_DHW SkFuel_DHW ACCFshowerhead	= = =	Vatershownhad + SaveWatershow Proportion of water heating supp = 25% <sup>27</sup> Proportion of water heating supp = 25% <sup>27</sup> = 25%	er vaive) × ISRshowenhe died by electricity died by fuel oil, natura pane % wings for low-flow fau	gas, or propane <sup>(7)</sup> t aerators (see table "Wate erheads (see table "Wate	r Savings")
ACCFstowerte ad ACCFstowerte ad Phere:	= = =	Vatershownhad + SaveWatershow Proportion of water heating supp = 25% <sup>27</sup> Proportion of water heating supp = 25% <sup>27</sup> Fuel ON Extended the support = 25% <sup>27</sup> Proportion of water heating supp = 25% <sup>27</sup> = 25% <sup>27</sup> Proportion of water heating supp = 25% <sup>27</sup> = 25% <sup>27</sup>	er vaive) × ISRshowenhe slied by electricity slied by fuel oil, natura spane % wings for low-flow fau wings for low-flow sho gs for low-flow faucet	gas, or propane <sup>(7)</sup> t aerators (see table "Wate erators (see table "Wate erators (see table "Bectri	r Savings") c Energy and Demand Saving
ACCFshowerhe al ACCFshowerhe al PAElectric_DHW SkFuel_DHW ACCFshowerhead	= = =	Vatershownhad + SaveWatershow Proportion of water heating supp = 25% <sup>27</sup> Proportion of water heating supp = 25% <sup>27</sup> = 25%	er vaive) × ISRshowenhe slied by electricity slied by fuel oil, natura spane % wings for low-flow fau wings for low-flow sho gs for low-flow faucet	gas, or propane <sup>(7)</sup> t aerators (see table "Wate erators (see table "Wate erators (see table "Bectri	r Savings") c Energy and Demand Saving
ACCFshowhe at SiElectric_DHW SiElectric_DHW ACCFshowhead ACCFshowhead AWArater	Savel = = = =	Valet's sowethead + SaveWalet's sow Proportion of water heating supp = 25% 7 Fuel COL Gas Pre 26% 12% 311 Gross customer annual water sa Gross customer annual Walety savin Gross customer annual Walety savin	er value) × ISRshowenhe slied by electricity slied by fuel oil, natura spane % wings for low-flow faucet gs for Tier 1 advanced	gas, or propane <sup>[7]</sup> t aerators (see table "Wate enheads (see table "Wate erators (see table "Electri power strips (see table "E	r Savings") c Energy and Demand Savin lectric Energy and Demand
ACCFstowerhe at ACCFstowerhe at ACCFstowerhe GeElectric_DHW GeElectric_DHW GeElectric_DHW ACCFstowerhead AKWArster AKWArster AKWArst	Savel = = = =	Vatershownhead + SaveWatershow Proportion of water heating supp = 25%7 Fuel Cit Case provided the set of the save 26% 12% 311 Gross customer annual water sa Gross customer annual water sa Gross customer annual Wi savin Savings") Gross customer annual Wi savin	er vaive) × ISRShowenhe ilied by electricity ilied by fuel oil, natura wings for low-flow fau wings for low-flow faucet gs for low-flow faucet gs for Tier 1 advanced gs for CEE Tier 1 omn	as, or propane <sup>(7)</sup> t aerators (see table "Wate erheads (see table "Wate erators (see table "Electri sower strips (see table "Electri inectional LED bulbs (see t	r Savings") c Energy and Demand Saving lectric Energy and Demand lable "Electric Energy and De
ACCFSnowhere ad ACCFSnowhere ad ACCFSnowhere Stellectric_DHW St&Fuel_DHW ACCFSnowhere ACCFSNO	Savel = = = =	Vatershownhead + SaveWatershow Proportion of water heating supp = 25%/7 Proportion of water heating supp = 25%/7 Proportion of water heating supp = 25%/7 Erest support = 25%/7 Goss customer annual water sa Gross customer annual with savin Gross customer annual kW savin Gross customer annual kW savin Savings")	er vaive) × ISRShowerhe ilied by electricity ilied by fuel oil, natura pane % infos for low-flow faue wings for low-flow faue to for low-flow faue gs for Tier 1 advanced gs for CEE Tier 1 omn gs for pipe wrap insult	as, or propane <sup>(7)</sup> t aerators (see table "Wate entends (see table "Wate erators (see table "Electri sover strips (see table "Electri irectional LED bulbs (see t inectional LED bulbs (see t ion (see table "Electric En	r Savings") c Energy and Demand Saving lectric Energy and Demand table "Electric Energy and De ergy and Demand Savings")
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ACCFshowerhe ad ACCFshowerhe ad ACCFshowerhe Stiffuel_DHW ACCFshowerhead AKWArster AKWArster AKWArster AKWArster	Savel	Vatersnownhowl + SaveWatersnow Proportion of water heating supp = 25% 7 Fuel Oil Gase Percent 26% 12% 314 Gross customer annual KW savin Gross customer annual KW savin	er valve) × ISRshowerhe slied by electricity slied by fuel oil, natura spane % wings for low-flow fauet gs for Tier 1 advance gs for CEE Tier 1 omn gs for pipe wrap insul gs for pipe wrap insul gs for low-flow showe ngs for low-flow fauet gs for Ice Tier 1 advance	gas, or propane <sup>[7]</sup> t aerators (see table "Wat erheads (see table "Wate arators (see table "Electri inctional LED bults (see inctional LED bults (see inctional LED bults (see inctional LED bults (see table "Electric aerators (see table "Electric power strips (see table "Electric	r Savings") c Energy and Demand Saving lectric Energy and Demand able "Electric Energy and De ergy and Demand Savings") Energy and Demand Savings ic Energy and Demand Savin Electric Energy and Demand
ACCFShowethe at ACCFShowethe at ACCFShowethe BERCHIC_DHW 96Electric_DHW 96Electric_DHW ACCFShowethead AKWArstare AKWARStare AKWARStare AKWARSTARE AKWARTARE AKWARSTARE AKWART	Savek = = = = = = = = = = = = = = = = = = =	Vaterstowenhead + SaveWaterstowenhead + Save	er vaive) × ISRShowerhe died by electricity died by fuel oil, natura ypane % wings for low-flow faue wings for low-flow faue gs for low-flow faue gs for low-flow faue gs for Der Tier 1 advance gs for pipe wrap insul gs for low-flow faue to reflew faue for low-flow faue for low-flow faue for low-flow faue faue for low-flow faue faue faue for low-flow faue faue for low-flow faue faue for low-flow faue faue for low-flow faue faue for low-flow faue faue for low-flow faue faue for low-flow faue faue faue for low-flow faue faue faue for low-flow faue faue faue faue for low-flow faue faue for low-flow faue faue for low-flow faue	as, or propane <sup>(7)</sup> t aerators (see table "Wate enheads (see table "Wate erators (see table "Electri inctional LED bulbs (see table "Electric En- neads (see table "Electric aerators (see table "Electric power strips (see table "Electri power strips (see table "Electri to (see table "Electric)	r Savings") c Energy and Demand Saving lectric Energy and Demand lable "Electric Energy and De ergy and Demand Savings") Energy and Demand Savings ric Energy and Demand Savi Electric Energy and Demand table "Electric Energy and D
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ISR <sub>Aerator</sub>		In service rate or the percentage of	funit	s rehated t	hat actually get	used for fai	icet aerators		
DRAerator		= 0.57 <sup>(8)</sup>	i unic	is rebated t	nat actually get	useu, ioi iai	JUEL DEI DIUTS		
ISRAPS	-	In service rate or the percentage of $= 0.63^{(9)}$	f unit	s rebated t	hat actually get	used, for Ti	er 1 advance	d power strip	s
ISR <sub>LED</sub>	-	0.90 <sup>(5)</sup>							
ISR <sub>Pipe Wrap</sub>	-	0.45 <sup>[10]</sup>							
ISR <sub>Showerhead</sub>	-	In service rate or the percentage of $= 0.56^{[11]}$	f unit	is rebated t	hat actually get	used, for sh	owerheads		
Num <sub>Aerator</sub>	-	Number of faucet aerators included = 2 of the 1.0 GPM faucet aerators = 1 of the 1.0 GPM fuacet aerators = 1 of the 1.5 GPM faucet aerators	in W in 20	/hole Home		I, and Audit	Kit 2		
Numien		Number of LED bulbs included in or	ne Ho	ime Enerav	Kit				
NUMLED			Wh	ole	Whole Home	Audit	Audit Kit	2021 Kit	20
		Lamp Option CEE Tier 1, Omnidirectional	Hor	me Kit 1	Kit 2	Kit 1	2	1	2
		5.5W LED Bulb CEE Tier 1, Omnidirectional 9W	0		0	0	0	3	3
		LED Bulb	2		3	4	4	5	5
		CEE Tier 1, Omnidirectional 11W LED Bulb	0		0	0	0	2	2
		CEE Tier 1, Omnidirectional 15W LED Bulb	2		3	0	0	0	
		CEE Tier 1, Directional 9W LED						0	0
		Bulb	0		2	0	0	0	0
SaveDemandLED	-	Annual electric demand savings (ki	N) fo	r a CEE Tie Demand		Demand s		Demand s	avin
				(kW) for	year 2021	(kW) for	year 2022	(kW) for y	
		CEE Tier 1, Omnidirectional 5.5W LED Bulb		0.00828		0.00761		0.00691	
		CEE Tier 1, Omnidirectional 9W LI Bulb	ED	0.01355		0.01245		0.01130	
		CEE Tier 1, Omnidirectional 11W	LED	0.01656		0.01522		0.01382	
		Bulb CEE Tier 1, Omnidirectional 15W	LED	0.02290		0.02104		0.01911	
		Bulb CEE Tier 1, Directional 9W LED Bu	ılb	0.00689		0.00646			
SaveElecAerator	_	Annual electric energy savings (kW			. faunak anvakar			0.00602	
		= 67.3 kWh for 1.0 GPM faucet aer = 30.8 kWh for 1.5 GPM faucet aer	ator						
SaveElec <sub>APS</sub>	-	Annual electric energy savings (kW = 53.1 kWb <sup>[13]</sup>	'h) fo	r a Tier 1 a	dvanced power	strip			
SaveElecLED		Annual electric energy savings (kW	h) fo	r a CFF Tie	r 1 omnidirectio	nal I FD bulb	(6)		
SURCEACTED		Lamp Option	11) 10	Energy s		Energy s (kWh) fo 2022	avings	Energy sa (kWh) for 2023	
		CEE Tier 1, Omnidirectional 5.5W		8.2		7.5		6.8	
		LED Bulb CEE Tier 1, Omnidirectional 9W L	ED	13.4		12.3		11.1	
		Bulb CEE Tier 1, Omnidirectional 11W		16.3		15.0		13.6	
		Bulb		22.6				18.8	
		CEE Tier 1, Omnidirectional 15W Bulb	LED	22.0		20.7		10.0	
		CEE Tier 1, Directional 9W LED Bu	ılb	6.8		6.4		5.9	
SaveElec <sub>Pipe Wrap</sub>	-	Annual electric energy savings (kW = 63.4 <sup>[14]</sup>	'h) fo	r pipe wrap	insulation				
SaveElecshower Valve	-	Annual electric energy savings (kW	'h) fo	r a shower	restriction valve				
		= 105.2 kWh <sup>[15]</sup>							
SaveElec <sub>Showerhead</sub>	-	Annual electric energy savings (kW = 373.1 kWh <sup>[16]</sup>	'h) fo	r a low-flov	v showerhead				
SaveFuelAerator	-	Annual fossil fuel savings (MMBtu)			aucet aerator <sup>[12]</sup>				
		= 0.288 MMBtu for 1.0 GPM faucet = 0.132 MMBtu for 1.5 GPM faucet							
CausEvalu	_	Annual fossil fuel savings (MMBtu)			. dation				
		= 0.272 MMBtu <sup>[14]</sup>							
SaveFuelshower Valve	-	Annual fossil fuel savings (MMBtu) = 0.451 MMBtu <sup>(15)</sup>	for a	shower re	striction valve				
SaveFuelShowerhead	-	Annual fossil fuel savings (MMBtu) = 1.600 MMBtu <sup>[16]</sup>	for a	low-flow si	howerhead				
SaveWatershowerhead	-	Annual water savings (CCF) for a le = $4.09 \text{ CCF}^{[16]}$	ow-fl	ow shower	head				
		Annual (1997) (1997) (1997)	ow-fi	ow faucet a					
SaveWaterAerator	-	Annual water savings (CCF) for a lo			ierator[12]				
SaveWater <sub>Aerator</sub>	-	<ul> <li>annual water savings (CCF) for a log</li> <li>annual water savings (CCF) for a</li></ul>			erator(12)				
		= 1.00 CCF for 1.0 GPM faucet aero	ator	er restrictio					

For pipe wrap insulation:

For LED bu	<u>llbs:</u>							
Residentia	I: Loadshape #1: Residential Indoor Ligh	ting						
	ntial DHW insulation							
96a Stand	by Losses - Entertainment Center	Status	Winter	Winter	Summer	Summer	Winter	Summer
		Status			Summer On kWh		Winter kW	Summer kW
96a Stand	by Losses - Entertainment Center	<b>Status</b> Active						kW
96a Stand Number	by Losses - Entertainment Center	Active	On kWh	<b>Off kWh</b> 35.0%	On kWh	Off kWh	kW	<b>kW</b> 8.2%
96a Stand Number	by Losses - Entertainment Center Name Residential Indoor Lighting	Active	On kWh 36.9%	<b>Off kWh</b> 35.0%	On kWh 13.0%	Off kWh 15.1%	<b>kW</b> 29.8% 100.0%	<b>kW</b> 8.2%

## Net Savings Factors

Measures ZZZEEKIT Home Energy Efficiency Kit

## Tracks [Base Track] 6034LISF [is base track] LISF Retrofit

6036RETR [is base track] Res Retrofit 6032LIEP [6032EPEP] Efficient Products - Low Income

Lifetimes See the table below for the measure lifetime for each product included in a Home Energy Kit.

Product	Lifetime (years)
CEE Tier 1 Omnidirectional LED Bulbs	15 <sup>[17]</sup>
Tier 1 Advanced Power Strips	5 <sup>[18]</sup>
Low-Flow Faucet Aerators	10 <sup>[19]</sup>
Low-Flow Showerheads w/ Thermostatically-Initiated Shower Restriction Valves	10(19)
Pipe Wrap Insulation	12 <sup>(20)</sup>

Measure Cost The measure cost is the actual cost of the kit incurred by the program, as detailed in the following table: 

Incremental Cost	
Whole Home Kit 1	\$65.00
Whole Home Kit 2	\$52.50
Audit Kit 1	\$50.50
Audit Kit 2	\$49.00
2021 Kit 1	\$22.40
2021 Kit 2	\$34.15
Whole Home Efficiency Kit - VPPSA Customers	\$39.50
Water Efficiency Kit - VPPSA Customers	\$43.50
Smart Connected Lighting Kit - VPPSA Customers	\$57.00

O&M Cost Adjustments To account for the shift in baseline due to replacement lamps, the levelized baseline replacement cost over the lifetime of the LED lamps is calc based on the following assumptions.<sup>[21]</sup>

Lamp Type	Omnidirectional	Directional	Assumed Lifetime (hours)
LED	\$5.00	\$10.00	
CFL	\$2.50	\$4.50	10,000
Halogen	\$1.25	\$3.50	1,000
Incandescent	\$0.50	\$3.50	1,000

The calculation results in the following equivalent annual baseline replacement cost

Measure	Annual baseline C	0&M assumption for	r bulbs installed in
Medsure	2021	2022	2023
CEE Tier 1, Omnidirectional 9W LED Bulb (60W equivalent)	\$0.39	\$0.37	\$0.35
CEE Tier 1, Omnidirectional 15W LED Bulb (100W equivalent)	\$0.39	\$0.37	\$0.35
CEE Tier 1, Directional 9W LED Bulb (65W equivalent)	\$1.08	\$1.02	\$0.96
Ominidirectional 5.5W LED Bulb (40W equivalent)	\$0.39	\$0.37	\$0.35
Ominidirectional 11W LED Bulb (75W equivalent)	\$0.39	\$0.37	\$0.35

## **Reference Tables**

Measure	Item Code
Whole Home Kit 1	RES-EEKIT-WHK1
Whole Home Kit 2	RES-EEKIT-WHK2
Audit Kit 1	RES-EEKIT-AK1
Audit Kit 2	RES-EEKIT-AK2
2021 Kit 1	RES-EEKIT-211
2021 Kit 2	RES-EEKIT-212
Whole Home Efficiency Kit	RES-EEKIT-VPPSA1
Water Efficiency Kit	RES-EEKIT-VPPSA2
Smart Connected Lighting Kit	RES-EEKIT-VPPSA3

## Footnotes

Schultdt, Marc, and Debra Tachibana, "Energy Related Water Fixture Measurements: Securing the Baseline for Northwest Single Family Homes. 2008 ACEEE Summer Study on Energy Efficiency in Buildings," 2008, page 1-265.

- [2] For additional details on the baseline adjustment calculation see reference file, "EVT, Home Energy Kit, Analysis, Feb 2021.xisx". And for the derivation of the market forecast and accompanying bulb waitage estimates, see reference file, "2021-2023 EVT Lamp Analysis.xisx".
- [3] Full load hours from Loadshape #8a (Residential DHW Conserve) and #54a (Controlled DHW Conservation).
- [4] Derived from CalPlug Tier 2 APS Evaluation Study Retrieved from: http://embertec.com/assets/pdf/CalPlug\_Tier2\_APS\_Evaluation.pdf. Advanced power strips are assumed to be plugged in at all times. Annual hours when the equipment is turned off ar 2, 40. The equipment is estimated to be in standar mode 1.04 hours/day or 708 hours/year. Savings are achieved during periods when equipment is off or in standar mode. Thus, the hours of operation used to determine demand savings are 7,340 + 708 = 8,048. No savings are achieved during the remaining 712 hours per year when equipment is in use.

[5] Lifetime ISR for LED bulbs based on methodology from Chapter 21: Residential Lighting Evaluation Protocol of the Uniform Methods Project. Using a

1st Year ISR of 70% (1st year ISR value for both CFL and LED bulks in efficiency kits is 59% in the Illinois Technical Reference Manual for Energy Efficiency, Version 6.0 ("Free bulks provided without request, with little or no education. Based on "Impact and Process Evaluation of 2013 (PY6) Ameren Illinois Company Residential CFL Distribution Program, Report Table 11 and Appendix B."). Efficiency Vermont assumes the ISR for free LED bulks is higher than for free CFL bulks. and a discourt tate of 3.00% based on the Vermont societal cost test, the lifetime ISR after three years is 90%. See file EVT\_Home Energy Re\_Analysis\_Feb 2021.dss for calculaton details.

- [6] Annual KW and KWh values for LED bulbs assume an LED bulb wattage of 5.5W, 9W, 11W, and 15W for the omnidirectional products and 9W for the directional product, which is the actual wattage of LED lamps provided in kome Energy KBs. Baseline wattage values are based on a 40W-equivalent bulb, 60W-equivalent bulb, 75W-equivalent bulb, 100W-equivalent bulb, and a 55W-equivalent bulb, respectively. For additional details on the energy and demand savings acluaditone ser derence file, "701\_kmon Energy KB, Analysis, Junz 2021.visc". And for the derivation of the market forecast and accompanying bulb wattage estimates, see reference file, "2021-2023 EVT Lamp Analysis.vdsc".
- [7] DHW fuel percentages sourced from "Vermont Single-Family Existing Homes On-Site Report", NMR, July 2018; Table 59: Water Heating System Fuel (pg. 52)
- [8] Average of kits aerator in service rate (average of 61.5%) from Navigant, "energy/SMART Energy Savings Kits, GPY 4 Evaluation Report (FINAL)," April 29, 2016, p. 20, and kits aerator in service rate for single family homes (52%) from Cadmus, "Ameren Missouri Efficient Products Impact and Process Evaluation: PY 2015," May 13, 2016, p. 23.
- (9) Advanced power strip ISR is average of ISRs from Cadmus, "Process Evaluation Report, PPL Electric EE&C Plan, Program Year Five," November 13, 2014, p. 147.
- [10] In the absence of evaluation studies supporting an ISR for free pipe wrap insulation, EVT leveraged the ISR assumptions of a stand-alone free shower restriction valve, which was used in the previous iteration of this measure. The shower restriction valve was assigned an ISR of 45% under the logic that contomers would be less familiar with these products. Using the same product familiarly principal established with shower restriction valves, EVT assigned a similar 45% ISR for pipe wrap insulation, assuming customers would react in a similar manner.
- [11] Average of showerhead in service rate for kits including one showerhead (65%) from Navigant, "energy/SMART Energy Savings Kits, GPY 4 Evaluation Report (FIN4L)," April 29, 2016, p. 20, and kits showerhead in service rate for single family homes (47%) from Cadmus, "Ameren Missouri Efficient Products Impact and Process Evaluation: PV 2015," May 13, 2016, p. 23.
- [13] Annual KWh savings value for Tier 1 advanced power strips is from the "Controlled Power Strip" measure (effective 01/01/2018) under the Efficient Products program within the EVT TRM. Values for entertainment centers (75.1 kWh) and home offices (31 kWh) were averaged.
- [14] Annual KWh and MMBLU values for pipe wrap insulation for 3/4" pipes from the "Pipe Wrap" measure (effective 01/01/2017) under the Existing Homes program within the EVT TRM.
- [15] Annual WM, MMBu, and CCF values for shower restriction valves are from the "Thermostatically Initiated Shower Restriction Valve" measure (effective 01/01/2018) under the Efficient Products program within the EVT TRM.
- [16] Annual KWh, MMBtu, and CCF values for low-flow showerheads are from the "Low Flow Showerhead" measure (effective 01/01/2017) under the Existing Homes program within the EVT TRM.
- [17] The lifetime for LED bubs is the actual rated life of the product provided in kits (25,000 hours) divided by annual hours of use (986 hours). All lighting lifetimes are capped at 15 years (although their rated life)hours is higher).
- [18] 10-year estimate: Lockeed Narin, Inc., Ency Solutions, Advanced Power Strip Research Report Final Report, Prepared for the New York State Energy Research and Development Authority (MSERDA), 2011. As persistence has not been studied for this measure, 5 years is being used as a conservable estimate.
- [19] Both low flow showerheads and thermostatically-initiated shower restriction valves have a measure life of 10 years. As the offered product is a low flow showerhead with an integrated thermostatic restriction valve, the 10 year measure life was deemed appropriate. The low flow showerhead measure is sourced from California DEEX; see file DER2014-EU-Lable-update\_2014-02-05.xlsx. And the thermostatically-initiated shower restriction valve measure life is sourced from California DEEX see file DER2014-EU-Lable-update\_2014-02-05.xlsx. And the thermostatically-initiated shower restriction valve measure life is sourced from California DEEX see file DER2014-EU-Lable-update\_2014-02-05.xlsx.
- [20] Measure lifetime from California DEER. Average of values for electric DHW (13 years) and gas DHW (11 years); see file DEER2014-EUL-tableupdate\_2014-02-05.xlsx.
- [21] For additional details on O&M cost adjustments see reference file, "EVT\_Home Energy Kit\_Analysis\_Jun 2021.xlsx"

ENERG	Y STAR Ceiling Fan
Measure Number:	
Status:	EVT TRM Portfolio 2018-12 Active
Effective Date: 2 End Date: 1	
Program: E	[None ] Efficient Products Program
End Use: 1	Multiple End Uses
Update Sumn New measure	aary
ENERGY STAR C     U.S. DOE Code c     ENERGY STAR Li	Documents AR LED Lang, Analysis, Dec 2017 elling Tam Product: Specification Version 4 Frederal Register (CPR), Federal Baseline, 2017 gift Findure_Ceiling Fan Calculator Ceiling Fan Analysis
Description This measure is the i specifications.	installation of a residential ceiling fan with and without lighting fixtures that meets the minimum ENERGY STAR efficiency
Baseline Effic The baseline equipm ight bulbs.	clencies ent is assumed to be a residential ceiling fan meeting federal equipment standards <sup>(1)</sup> with EISA qualified incandescent or halogen
Efficient Equi	prment ent is a residential ceiling fan meeting the minimum ENERGY STAR specifications. <sup>[2]</sup>
Algorithms	
Electric Demand S	Javings
ΔkW	$= \Delta kW_{Fun} + \Delta kW_{Light}$
ΔkWFan	= (Watts High <sub>Base</sub> - Watts High <sub>EE</sub> ) / 1000
∆kWLight	$= ((Watts_{Base} - Watts_{EE}) / 1000) \times WHF_d$
Symbol Table	
Electric Energy Sa	
	$= \Delta k W h_{Fan} + \Delta k W h_{Light}$
$\Delta kWh_{Fan}$	$= (Days \times Hours \times ((\% LowEsse × Watts LowEsse) + (\% MedEsse × Watts MedEsse) + (\% HgHEsse × Watts HgHEsse))(1000) - (Day s × Hours × ((\% LowEs × Watts LowE) + (% HedE × Watts MedE) + (% HgHE × Watts HgHE))(1000)$
$\Delta kWh_{Light}$	= ((Watts_{Bose} - Watts_{EE}) / 1000) $\times$ Hours $\times$ Days $\times$ WHF $_{e}$
Symbol Table	
Fossil Fuel Saving	S
Where:	
% High <sub>Base</sub>	= Percent of time baseline equipment is run on high speed 20%
% High <sub>EE</sub>	<ul> <li>Percent of time efficient equipment is run on high speed</li> <li>20%<sup>(4)</sup></li> </ul>
% Low <sub>Base</sub>	= Percent of time baseline equipment is run on low speed apply 9
% Lowee	۹۵۶۶۶۶۶ = Percent of time efficient equipment is run on low speed
	40%(5)
% Med <sub>Base</sub>	= Percent of time baseline equipment is run on medium speed 40여년 위
% Med <sub>EE</sub>	<ul> <li>Percent of time efficient equipment is run on medium speed 40%<sup>(3)</sup></li> </ul>
$\Delta kW_{\text{Fan}}$	= Gross customer connected load kW savings associated with the ceiling fan
$\Delta kW_{Light}$	<ul> <li>Gross customer connected load kW savings associated with the lights</li> </ul>
ΔkW	<ul> <li>Gross customer connected load kW savings for the measure</li> </ul>
$\Delta kWh_{Fan}$	<ul> <li>Gross customer annual KWh savings associated with the ceiling fan</li> </ul>
$\Delta kWh_{Light}$	<ul> <li>Gross customer annual kWh savings associated with the lights</li> </ul>
ΔkWh	<ul> <li>Gross customer annual kWh savings for the measure</li> </ul>
Days	<ul> <li>Number of days per year equipment is in use</li> <li>365 days</li> </ul>
Hours	<ul> <li>Average number of hours per day equipment is in use</li> <li>3 hours/day<sup>[5]</sup></li> </ul>
Watts High <sub>Ba</sub>	x = Baseline fan wattage at high speed 67 watts <sup>(6)</sup>
Watts High <sub>EE</sub>	21 watte[7]
Watts High <sub>EE</sub> Watts Low <sub>Bat</sub>	31 watts <sup>(7)</sup> = Baseline fan wattage at low speed
	e = Baseline fan wattage at low speed 15 watts <sup>(6)</sup>

Watts Med <sub>Base</sub>	<ul> <li>Baseline fan wattage at medium speed</li> <li>34 watts<sup>(6)</sup></li> </ul>
Watts $Med_EE$	<ul> <li>Efficient fan wattage at medium speed</li> <li>13 watts<sup>(7)</sup></li> </ul>
Watts <sub>Base</sub>	<ul> <li>Total input wattage of the baseline lamps. Please see the reference table section for more detail, as the baseline lamp wattage varies depending on the replacement scenario.<sup>[3]</sup></li> </ul>
Watts <sub>EE</sub>	<ul> <li>Total input wattage of the efficient lamps</li> </ul>
	16.4 watts <sup>(8)</sup>
WHFd	Waste heat factor for demand to account for cooling savings from efficient lighting. The cooling savings are only added to the summer peak savings. The value for residential lighting is assumed to be 1.0.
WHFe	Waste heat factor for energy to account for cooling savings from efficient lighting. The value for residential lighting is assumed to be 1.0.

## Baseline Wattage

Replacement Scenario	2019-2020 Watts <sub>Base</sub>	2021 Watts <sub>Base</sub>
Conventional <sup>[3]</sup>	73.3	29.4
Residential New Construction (RNC) <sup>[4]</sup>	37.7	26.7

### Deemed Energy and Demand Savings

Measure Description	Item Code		20 (Annual ings)	2021 (/ Savi	
		ΔkW	ΔkWh	ΔkW	ΔkWh
Ceiling Fan Only	CEILFAN	0.0360	22	0.0360	22
Lights Only		0.0569	62	0.0130	14
RNC Lights Only		0.0213	23	0.0103	11
Ceiling Fan w/ Light Kit	CEILFANL	0.0929	84	0.0490	36
RNC Ceiling Fan w/ Light Kit	CEILFANLRNC	0.0573	45	0.0463	33

Load Shapes 1a Residential Indoor Lighting 10a Residential Ventilation

1         Residential Indoor Lighting Active         36.9%         35.0%         13.0%         15.1%         29.8%         8.2%           10         Residential Ventilation         Active         31.7%         34.9%         15.9%         17.5%         32.2%         32.2%	Number	Name	Status	Winter On kWh	Winter Off kWh	Summer On kWh	Summer Off kWh	Winter kW	Summer kW
10 Decidential Ventilation Active 21 79/ 24 09/ 15 09/ 17 59/ 27 79/ 27 79/	1	Residential Indoor Lighting	Active	36.9%	35.0%	13.0%	15.1%	29.8%	8.2%
10 Residential Vehilladon Active 51.776 54.576 15.576 17.576 52.276 52.276	10	Residential Ventilation	Active	31.7%	34.9%	15.9%	17.5%	32.2%	32.2%

## Net Savings Factors

Measures VNTCLFAN Ceiling fan

Tracks [Base Track]	
6032EPEP [is base track]	
6038VESH [is base track]	RNC VESH
6041LINC [6038VESH]	Low Income Single Family New Construction

	Track Name	Track Nr.	Measure Code	Free Rider	Spill Over
Efficient	t Products - Residential	6032EPEP	VNTCLFAN	1.00	1.00
RNC VE	SH	6038VESH	VNTCLFAN	0.95	1.10

Lifetimes Measure life is estimated to be 15 years<sup>[9]</sup>

## Measure Cost

Measure Description	Item Code	Incremental Cost <sup>[10]</sup>
Ceiling Fan Only	CEILFAN	\$33.45
Ceiling Fan w/ Light Kit	CEILFANL	\$46.00
RNC Ceiling Fan w/ Light Kit	CEILFANLRNC	\$45.19

Lamp Type	Annual baseline 0	0&M assumptions 1	for bulbs installed
Lamp Type	2019	2020	2021
Ceiling Fan w/ Light Kit	\$0.43	\$0.32	\$0.21
RNC Ceiling Fan w/ Light Kit	\$0.26	\$0.23	\$0.21

## Footnotes

U.S. DOE Code of Federal Register, Rules and Regulations Docket Number EERE-2012-BT-STD-0045, Energy Conservation Program: Energy Conservation Standards for Ceiling Fans (10 CFR Part 430), January 19, 2017

- [2] ENERGY STAR Program Requirements, Product Specification for Residential Ceiling Fans and Ceiling Fan Light Kits, Version 4.0, effective June 15, 2018
- [3] The baseline lamp wattages are assumed to be EISA impacted incandescent or halogen light bulks. The regulations stipulate that by January 1, 2020, all lamps must meet the efficiency orbit of at least 45 lumms per watt. Due to the expected delay in clearing retail invertory and to account for the operating life of an incandescent and halogen lamps, the shift is operating retain orbit and the sense interval or the sense of th
- [4] The RNC baseline lamp watage uses similar assumptions as the market opportunity baseline with EISA impacted incandescent or halogen light bulbs. Additionally, Vermont residential code stipulating 75% of permanently installed fixtures meet high efficacy requirements was factored into the baseline lamps and weighted accordingly.
- [5] The percent of time the ceiling fan is operated at the varying speeds (low/medium/high) and the run hours per day is sourced from the ENERGY STAR Calculator.
- [6] The baseline wattages at the varying speeds (low/medium/high) is sourced from the ENERGY STAR Calculator
- [7] The efficient watages at the low and high speed settings are sourced from the average of available products on the ENERGY STAR Qualified Products List (QPL), as pulled on 10/11/2018. The efficient wattage at the medium speed is interpolated based on the varying speed wattages from the ENERGY STAR version 30, as sourced from the ENERGY STAR Calculator. For more information on the QPL data set, please see "EVT Residential Ceiling Fan Analysis.xist"
- [8] The efficient wattage is based on the average ceiling fan light kit wattage, as sourced from the ENERGY STAR QPL, as pulled on 10/11/2018. For reference, the QPL had 6 ceiling fan light kits that had CPL lamps, averaging 2.2 bults per kit, and 43 ceiling fan light kits that had LED lamps, averaging 1.2 bults per kit.

[9] Measure life is sourced from the ENERGY STAR Calculator and accounts for a blended liftime of the applicable ceiling fan light kit lamp types

[10] The incremental cost for the ceiling fan with light kit is sourced from the ENERGY STAR Calculator. The incremental cost for just the ceiling fan was back-tracked by subtracting the weighted average incremental cost of the light kits by leveraging lamp cost information from the "EVT ENERGY STAR LED Lamp Analysis".

compre	ehensive Shell Measure Savings
Measure Number:	
	81a Artive
	2014/1/1
	[None]
	Residential New Construction
End Use: 1	Multiple End Uses
	Documents me2011_pmpLota_MEDIAN-FINAL_121613.visx me2011_REVN413_MEDIAN-FINAL_121613.visr
	Update, Memo to PSD_FINAL bm.docx
VESH Requireme	ints
Estimated Me	asure Impacts
Estimated Me Algorithms Demand Savings	asure Impacts
Algorithms	= Demand <sub>Adute</sub> - Demand <sub>40044</sub>
Algorithms Demand Savings	· .
Algorithms Demand Savings Demand Savings	· .
Algorithms Demand Savings Demand Savings Symbol Table	· .
Algorithms Demand Savings Demand Savings Symbol Table Energy Savings	= Demand <sub>Andhulk</sub> - Demand <sub>4D0H</sub>
Algorithms Demand Savings Demand Savings Symbol Table Energy Savings Energy Savings	= Demand <sub>Addusk</sub> - Demand <sub>4DBH</sub> = Energy <sub>Adusk</sub> - Energy <sub>10DBH</sub>
Algorithms Demand Savings Demand Savings Symbol Table Energy Savings Energy Savings Where:	= Demand <sub>Adutt</sub> - Demand <sub>4004</sub> = Energy <sub>Adutt</sub> - Energy <sub>LDet</sub> = REM/Rate modeled demand (KW) of the AsBuilt home
Algorithms Demand Savings Demand Savings Symbol Table Energy Savings Energy Savings Where: Demand <sub>activit</sub>	= Demand <sub>Adduit</sub> - Demand <sub>4/DBH</sub> = Energy <sub>Aduit</sub> - Energy <sub>LDBH</sub> t = REM/Rate modeled demand (KW) of the AsBuilt home

Energy and demand savings will be calculated using the User Defined Reference Home (UDRH) feature in REM(Rate<sup>™</sup>. All Residential New Construction Projects will be modeled in REM(Rate<sup>™</sup> to estimate annual energy consumption and demand for heating, cooling and hot water. Each project will be modeled a second time to a baseline<sup>®</sup> specification. The difference in modeled energy consumption and demand between the AsBuilt project and UDRH baseline models will be the savings for that project.

Baseline Efficiencies The following table provides an overview of the UDRH baseline specification<sup>13</sup>. The efficiencies listed below for the Energy Code Plus and ENERGY STAR program tiers are a mixture of prescriptive program guidelines and mandatory prescriptive nequirements. Mandatory nequirements are noted with an asteristic. Each program home will be unique and may fall above or below the efficiency guidelines listed below. All homes must meet a minimum performance (HERS) target<sup>4</sup>.

			Above-Baseline Efficiency			
		UDRH	Energy Code Plus	ENERGY STAR		
Heating	Boiler, gas/prop	94.1 AFUE	85 AFUE*			
	Boiler, oil/kero	86.9AFUE				
	Furnace, gas/prop	87.0 AFUE	95 AFUE*			
	Furnace, oil/kero	83.0 AFUE	85 AFUE*			
Cooling	CAC	13 SEER	14.5 SEER*			
Heat Pump	ASHP	7.7 HSPF / 13 SEER	ENERGY STAR	qualified* <sup>[5]</sup>		
	GSHP	3.1 COP / 11.24 EER				
Domestic Hot Water	Tank, gas/prop	0.62 EF	0.59 EF			
	Tank, oil/kero	0.49 EF	0.51 EF			
	Instant, gas/prop	0.82 EF	0.82 EF			
	Indirect, gas/prop	0.87 EF				
	Indirect, oil/kero	0.80 EF	N/A			
Air Leakage	Infiltration	3.4 ACH50	4 ACH50*	3 ACH50*		
Thermal Shell	Insulation Grade <sup>[6]</sup>	2	2	1		
	Ceiling	R-38	R-49			
	Above-grade walls	R-19	R-20			
	Foundation Wall	R-10	R-15			
	Slab-on-Grade	R-10	R-15			
	Frame floors	R-24	R-30			
	Windows	U - 0.34	U - 0.32*			

	Fficiency r Baseline Efficiency above.							
Juora	ting Hours							
pera	ang nours							
7a Reside 5b Reside	Shapes ntial DHW insulation ntial Space heat lential A/C							
Number	Name	Status	Winter On kWh	Winter Off kWh	Summer On kWh	Summer Off kWh	Winter kW	Summer kW
7	Residential DHW insulation	Active	31.7%	34.9%	15.9%	17.5%	100.0%	100.0%
5	Residential Space heat						25.0%	
11	Residential A/C	Active	6.6%	3.8%	51.1%	38.6%	0.0%	16.0%
Not S	avings Factors							
Measure	us -							
	PH Comprehensive Therma							
	PC Comprehensive Therma							
HWECOM	IP1 Comprehensive Therma	I Measure	REMRate	Calculated	DHW			
	Base Track] H [is base track] RNC VESH							
Track Na	me Track Nr. Measure Co	de Free R	ider Spill	Over				
	H 6038VESHTSHCOMPH	0.95	1.10					
	H 6038VESHTSHCOMPC		1.10					
RNC VESI	H 6038VESHHWECOMP1	0.95	1.10					
Persis	tence stence factor is assumed to b	ie one.						
Lifetin 25 years.	nes							
	eriod is the same as the lifet	ime.						
	we Cost							
\$3,627 <sup>[118</sup>	Ire Cost							
0&M 0	Cost Adjustments							
Fossil	Fuel Description							
ootnot	tes							
	omprehensive measure char , Central Air Conditioner, Spa							on measures: Heating Savings, Efficient Furnace Fan el Water Heater
[2] Baseline specifications are derived from the Vermont Residential New Construction Baseline Study Analysis of On-Site Audits Final Report, February 13, 2013. A new UDRH baseline will be submitted to DPS for review within three months of final updates to a new Vermont RNC baseline study.								
	eference document VT UDRH							
Efficia	ncy Vermont Residential New	/ Construc	tion Requi	rements a	nd			
	fications http://www.efficiend			Har much	and long be	CH Dec		a df

[5] http://www.energystar.gov/index.cfm?c=products.pr\_find\_es\_products

[6] Insulation grade refers to the quality of insulation installation. Research has shown insulation is typically installed poorly and not to manufacturer's specifications. This has a significant impact on energy performance of the insulation. Grade 1 (per manufacturer instructions) is required by ENERGY STAR Homes.

## **Door Heater Controls**

Measure Number: (CF.RFG-DHC e Portfolio: Status: Active Effective Date: 2021/1/1 End Date: [None] Program: Commercial & Industrial End Use: Refrigeration

## Update Summary March 2021 Update Summary:

- Volution of the advance of the match new template (new measure number, added sections, item codes, etc.)
   Updated bonus factor to maintain consistency with other refrigeration measures
   Updated measure lifetime Previous life time estimate appeared to be based on general commercial refrigeration equipment (10 years). Revised
   measure lifetime is consistent with our refrigeration case measures (add doors to open display cases) and industry estimates.
   Added an unknown cooler type option

## Referenced Documents

- Referenced Documents United States Degriment of Energy 10 CFR Part 431, Docket No. EERE-2010-0T-STD-0003, 2010 Ardi-Sweat Door Heater Controls NEEP IESA Final June 23 2015 The Cadmus Group, Commercial Refrigeration Loadshape Project Final Report, Northeast Energy E Measurement, and Verification Forum, Leinington, MA 2015. Door Heater Control Study 2016 V2:X8 SWCR001-01 And Sweat Heater Controls, May 2019 EVT\_Door Heate Control\_Analys, Mar 2021

Description Lescription Another option to zero-energy doors – that is also effective on existing reach-in cooler or freezer doors – is "on-off" control of the operation of the door heaters. Because relative humidity levels differ greatly across the United Status; a door heater in Vermont needs to operate for a much shorter season than a door heater in Florida. By installing a control device to turn off door heaters when there is little or no risk of condensation, one can realize energy and cost savings.

There are two strategies for this control, based on either (1) the relative humidity of the air in the store or (2) the "conductivity" of the door (which drops when condensation appears). In the first strategy, the system activates your door heaters when the relative humidity in your store rises above a specific septoint, and turns them of whon the relative humidity liabelow that steption. It has escond strategy, the sensor activates the door heaters when the door conductivity falls below a certain setpoint, and turns them off when the conductivity rises above that setpoint.

## Program Type

Calculation Type: F Implementation Type: Downstr

## **Baseline Efficiencies**

The baseline condition is a cooler or freezer glass door that is continuously heated to prevent condensation

### Efficient Equipment ler or freezer glass door with a humidity-based door-heater control. High efficiency is a

	orithms		
	ric Demand Sa		
ΔkV	v	$= kW_{door} \times N_{door} \times ES \times BF$	
Sym	bol Table		
Elect	ric Energy Sav	gs	
∆kV	Vh	= ΔKW × 8760	
Sym	bol Table		
Fossi	l Fuel Savings		
Where	2:		
	ΔkWh	<ul> <li>Gross customer annual kWh savings for the measure (kWh)</li> </ul>	
	ΔkW	<ul> <li>Gross customer connected load kW savings for the measure (kW)</li> </ul>	
	8760	= Hours / Year	
	BF	<ul> <li>Bonus factor for reduced cooling load from eliminating heat generated by the door heater from entering the cooler freezer<sup>[1]</sup></li> </ul>	r
		= 1.4 for coolers	
		= 1.8 for freezers	
		= 1.4 for unknown	
	ES	= Perceit annual energy savings from off-time of heating elements $= 45.196^{(1)}$	
	kWdoor	<ul> <li>Connected load kW of a typical reach-in cooler or freezer door and frame with a heater<sup>(3)</sup></li> </ul>	
		= 0.066 kW for coolers	
		= 0.230 kW for freezers	
		= 0.130 kW for unknown	
	N <sub>door</sub>	<ul> <li>Number of doors controlled by sensor</li> </ul>	

## Load Shapes

For Loadshape details, see reference: EVT\_Door Heater Control\_Analysis\_Mar 2021.xls 69b Door Heater Control

Number	Name	Status	Winter On kWh	Winter Off kWh	Summer On kWh	Summer Off kWh	Winter kW	Summer kW
69	Door Heater Control	Active	29.0%	38.0%	15.0%	18.0%	90.9%	96.5%

## **Net Savings Factors**

Measures RFRDRCON Refrigeration door heater controls

6013PRES [is base track]	Pres Equip Rpl
6014PRES [is base track]	6014PRE5
Lifetimes	
12 years <sup>[4]</sup>	
Manager Coat	
	n door heater control unit is \$971. When evaluated on a per door basis costs are estimated at \$121 per cooler door and \$214
	Lifetimes 12 years <sup>(4)</sup> Measure Cost

## O&M Cost Adjustments

There are no standard operation and maintenance cost adjustments used for this measure.

## Reference Tables

Reference Tables					
Measure Application (Case Type)	Units	Item Code	ΔkW	∆kWh	Incremental Cost
Cooler	per door	CEO-RFR-DHC-H / CEO-RFR-DHC-M	0.04167	365	\$121
Freezer	per door	CEO-RFR-DHC-L	0.18671	1,636	\$214
Unknown	per door	CEO-RFR-DHC-U	0.08208	719	\$145

## Footnotes

[1] Bruis factors as derived in the NEEP Refrigeration Loadshape Report. The Cadmus Group, Commercial Refrigeration Loadshape Project Final Report, Northeast Energy Efficiency Partnerships, Regional Evaluation, Measurement, and Verification Forum, Lexington, MA 2015. (Page 78, Figure 54). The 1.4 unknown case type bonus factor represents a weighted average of low, medium, and high temperature refrigeration types.

- [2] Difference in effective runtime of an uncontrolled heater and all control style heater controls. Anti-sweat door heater control reduced run time. The Cadmus Group, Commercial Refrigeration Laadshape Project Final Report, Northeast Energy Efficiency Partnerships, Regional Evaluation, Measurement, and Verification Forum, Lexington, MA 2015. Page 69, Section 4.1.4, Table 37.
- [3] Wattages per door derived from NEEP Refrigeration Loadshape Report. The Cadmus Group, Commercial Refrigeration Loadshape Project Final Report, Northeast Energy Efficiency Partnerships, Regional Baalaution, Neasurement, and Verification Forum, Lexington, NA 2015 (pg. 57), For more detail, see reference file: ICVT\_Dort Netler Control (Jna)se, Nar 2021. 48
- [4] Commercial Refrigeration Anti-Sweat Heater Controls, California Technical Forum, Workpaper SWCR001-01, May 2019
- [5] Heater control unit costs were determined from the NEEP Incremental Cost Study Part 4 spreadsheet as listed for the New England region on a per controller and per door cost basis. See reference "Anti-Sweat Door Heater Controls NEEP ICS4 Final June 23 2015.vds/", "Summary of Results" tab. The cost for the unknown case types is weighted using sample data from: NEEP Refrigeration Loadshape Report. The Codimus Group, Commercial Refrigeration Loadshape Project Final Report, Northeast Energy Efficiency Partnerships, Regional Evaluation, Measurement, and Verification Forum, Lexington, MA 2015

## Add Doors to Open Display Cases

Measure Number:	CI-RFG-DOOR b
Portfolio:	EVT TRM Portfolio 2020-0
Status:	Active
Effective Date:	2020/1/1
End Date:	[ None ]
Program:	Commercial & Industrial
End Use:	Refrigeration

Update Summary Corrected a math error in the calculation of the cooling interactive effects. Revisions were made to the  $\Delta kWh_{A/C}$  algorithm and to the deemed saw values and table.

## Referenced Documents

- Lighting Telliform; Waste Heat Adjustment Methodology
  EVT Refrigeration Analysis Tool Vob
  2016 Vermoth Bainess Sector Market Characterization and Assessment Study
  PKBE, Yadd Doors to Open, Medium-Temperature Cases", Work Paper RESIPREF116, April 2014
  New York Standards Approach for Estimating Energy Savings\_V6\_January 2019
  EVT\_Add Doors\_Analysis, Apr 2020

Description
One display cases are typically found in grocery and convenience stores, and have been a preference of store owners because they allow customers a clear view and easy access to refrigerated products. This measure is retoriting existing, open, refrigerated display cases by adding and intailing doors. The baseline equipment is an open vertical or horizontal display cases with a doors or covering. The efficient equipment is the installation of solid doors on the existing display case. Replacement of open display cases with allows in the owned under this measure is the installation of solid doors on the existing display case. Replacement of open display cases with doors is not covered under this measure display characterization. High, medium, and low temperature cases are eligible, however, the measure assumptions delated in this characterization are based on medium temperature display cases, with the installation of zero energy doors, as it was deemed the most likely candidate for participation in this measure. Additionally, this measure is only applicable for site less that 10,000 sith houlding space. Sites over this threshold and other larger grocery stores are not eligible for this measure and their participation will be conducted on a custom basis.

Energy savings are based on air infiltration reduction from the addition of doors to the open display cases. The air infiltration reductions assume a reduced heat gain and subsequent reduced load on the refrigeration compressors. Both radiant and conduction heat losses were factored into the analysis as well. Energy savings are based on a per linear foot of display case.

Interactive HAC energy savings were also included in the measure savings analysis. The HAC Interactive effects calculation assesses the measure's impact on the heating and cooling equipment. With adding a door to an open refrigerated display case, excess cold air leaking into the conditioned space no longer has to be treated by the heating system, resulting in additive savings. Similarly, the reduction in cold air from the open refrigerated display case no longer subjements the efforts of the space cooling equipment, which results in an overall increase in its consumption.

## Program Type Retrofit

## **Baseline Efficiencies**

line condition is an open, refrigerated, display case without any covering.

## Efficient Equipment

ofitting an existing open, refrigerated, display case by adding doors. The efficient of

## Algorithms

	rithms ric Demand Sa	vings	
ΔkW	/ <sub>Case</sub>	$= \Delta kWh_{c}$	<sub>æ</sub> / 8760
ΔkW	I <sub>A/C</sub>	$= \Delta kWh_{\mu}$	c / Hours <sub>Cooling</sub>
ΔkW	I	$= \Delta k W_{Ca}$	$_{+} + \Delta k W_{A/C}$
Symb	ool Table		
Electr	ric Energy Sav	ings	
∆kW	/h <sub>Case</sub>	= ((ΔHG	CL) / (EER x 1000)) x 8760
ΔkW	/h <sub>A/C</sub>	= MMBtu	VAC Cool X CL X (1 / SEER) X 1000
ΔkW	/h	= ∆kWho	see + AkWhu/C
Symb	ool Table		
Fossil	Fuel Savings		
ΔΜΝ	1Btu	= MMBtu	VAC Heat X CL X (1 / AFUE)
Symb	ol Table		
Wate N/A	r Savings		
Where	:		
	ΔHG	-	Heat Gain; the decreased load or the reduced heat gain on the open refrigerated display case with the installation o a door (Btu/hr-linear foot)
			= 1,148 Btu/h-ft <sup>[3]</sup>
	$\Delta kW_{A/C}$	-	Gross connected load kW increase associated with the space cooling equipment
	$\Delta kW_{\text{Case}}$	-	Gross connected load kW savings associated with the open refrigerated display case
	ΔkW	-	Gross customer connected load kW savings
	$\Delta kWh_{A/C}$	-	Gross annual kWh energy increase associated with the space cooling HVAC equipment
	$\Delta kWh_{Case}$	-	Gross annual kWh energy savings associated with the open refrigerated display case
	ΔkWh	-	Gross customer annual KWh energy savings
	ΔMMBtu	-	Gross customer annual MMBtu fossil fuel savings
	1000	-	Conversion from watts to kilowatts (W / kW)
	8760	-	Annual operating hours of the refrigerated display case
	AFUE	-	Annual Fuel Utilization Efficiency; HVAC heating equipment operating efficiency
			= 86.8%(8)

CL	<ul> <li>Case Length; refrigerated case length in feet</li> <li>= 1<sup>(4)</sup></li> </ul>
EER	<ul> <li>Energy Efficiency (Ratio; display case compressor efficiency (Btu/hr-watt)</li> <li>= 11.36<sup>[5]</sup></li> </ul>
HoursCooling	= Total combined hours the site is providing cooling $= 2,420 \ \text{hours}^{(2)}$
MMBtu <sub>HVAC Cool</sub>	<ul> <li>Total cooling load increase on the HVAC equipment per linear foot of display case</li> <li>= -2.084 MMEtu<sup>(4)</sup></li> </ul>
MMBtu <sub>HVAC Heat</sub>	= Total heating load decrease on the HVAC equipment per linear foot of display case = $6.289$ MMBLI <sup>(9)</sup>
SEER	<ul> <li>Seasonal Energy Efficiency Ratio; HVAC equipment operating efficiency (Bu/hr-watt)</li> <li>= 11.7<sup>(7)</sup></li> </ul>

### Deemed Energy and Demand Savings

Measure	Item Code	Demand Savings	Annual Energy Savings (ΔkWh / linear foot)	Fossil Fuel MMBtu Savings (ΔMMBtu / linear foot) <sup>[1]</sup>		
		(DKW / IIIedi TOOL)	(AKWIT/ IIIIeal TOOL)	Oil	Natural Gas	Propane
Adding Doors to Open Display Cases		0.1011	885.6	0	0	0
HVAC Interactive Effects		-0.0736	-178.1	1.398	2.595	2.296
Overall Measure Savings	CEO-RFR-DOOR	0.0275	707.5	1.398	2.595	2.296

## Mid-Life Savings Adjustment

### Load Shapes

Load Snapes							
14a Commercial Refrigeration							
15c Commercial A/C							

IDC COMM	Se commercial Aye								
Number	Name	Status	Winter On kWh	Winter Off kWh	Summer On kWh	Summer Off kWh	Winter kW	Summer kW	
14	Commercial Refrigeration	Active	33.0%	32.6%	17.0%	17.4%	69.0%	77.2%	
15	Commercial A/C	Active	18.0%	10.0%	46.0%	26.0%	0.0%	34.2%	

### Net Savings Factors

Measures RFRDOORS Add Doors to Open Refrigerated Cases

Tracks [Base Track] 6013PRES [is base track] Pres Equip Rpl

Lifetimes The measure life is 12 years<sup>[10]</sup>

## Measure Cost

The incremental cost, which includes both material and labor, is \$521.55 per linear foot.<sup>[11]</sup>

### **O&M Cost Adjustments**

## Reference Tables

# Footnotes

- Through the split in fossil fuel MMBu heating savings is sourced from the "2016 VT Business Sector Market Characterization and Assessment Study", Cadmas, April 30, 2017. The oil and natural gas equipment distribution is sourced from page 65. However, propane equipment was not included in this breakdown, so in order to include propane equipment distribution, leveraged data from the overall heating system fuel type from page 63 and shifted the % breakdown of propanes in procentage points to match the oil and natural gas furnace breakdown. For more information, please see "EVT\_Add Doors\_Analysis\_Apr 2020.xts/" [1]
- [2] The total combined hours in which the site is providing cooling is based on an outdoor air temperature bin analysis, where the site is conditioning cold air at outdoor temperatures of 60PF and above. For more information on the derivation of these hours, please see 'HVAC IE' tab in the "EVT\_Add Doors\_Analysis\_Apr 2020.xtsx"
- [3] The change in heat gain is sourced as the typical value for a medium temperature display case adding doors from the PG&E Workpaper, "Add Doors to Open Medium Temperature Cases RCESPRCF116', April 2014. The workpaper assumes a net reduction in heat gain with the installation of doors on open refrigerated display cases. The primary benefits account for the decrease in excess heat entering the display case for an infiltration. Radiation and conduction heat gains were also include in the deviation of this value. Additionally, the net heat gain must be installation of the display case for any many benefits account of this value. Additionally, the net heat gain must be in assumptions on how often the refrigerated case doors will be used and the display case accessed by customers and site associates, reducing some of the ari infiltration. benefits of the new door.
- [4] Energy savings are based on a unit basis of "per linear foot" of open display case. As a result, for practical purposes involving the energy savings algorithm, the deemed value for the case length is 1 foot.
- [5] The ERR is sourced as the average compressor efficiency for medium temperature cases (11.36 EER; case temperature 10<sup>op</sup>F to 40<sup>op</sup>F). This value was calculated as the average of standard reciprocating and discus compressor efficiencies, using a typical condensing temperature of 90<sup>op</sup>F and a saturated suction temperature (ST) of 20<sup>op</sup>F for medium temperature applications. These ERR values were developed in "EVT Refrigeration Analysis" To 40<sup>op</sup>F und 10<sup>op</sup> Using data from Emerson Climate Technology software; last updated November 2013. It was assumed that the typical display case is a medium temperature application.
- (6) The MMRU increase on the MARC cooling equipment is based on an outdoor air temperature bin analysis, the total hours of operation of the cooling system, and the building's overall loss of additional cooling as a result of the installation of the doors on the open enforcented display case. The analysis assumes a certain amount of conditioned air has to be treated to replace the air previously cooled by the display case. The analysis assumes an increased load on the cooling system, at outdoor temperatures above 60°F. A 25% disabiling factor was also applied to account for some of the coil at pouring out of the display case and subcooling the site's conditioned space, which will not trigger a thermostatic response from the HAC equipment. For more information on the analysis device to device the load increase on the HAC cooling equipment per linear foot of display case, please see the 'HAAC IE' tab in the "EVIT\_Add Doors\_Analysis\_Apr 2020.xis."
- [7] The SEER value is based on the average commercial cooling efficiency for existing buildings and is sourced from "2016 VT Business Sector Market Characterization and Assessment Study", April 30 2017 (Table 16: Cooling Efficiency of Single-Zone Unitary HVAC Systems <5.5 tons)</p>
- Average AFLE of the HVAC heating equipment is based on the weighted average of existing commercial heating systems, as sourced from the "2016 VT Business Sector Market Characterization and Assessment Study", Cadmus, April 2017 (page 65). For more information on its derivation, please see 'Heating AFUE' tab in the "EVT\_Add Doors\_Analysis\_Apr 2020.xlsx' [8]
- The MMBtu decrease on the HAAC heating equipment is based on an outdoor air temperature bin analysis, the total hours of operation in which the site is providing heat, and the building's overall reduced heating load as a result of the installation of the doors on the open refrigerated display case. The analysis assumes a certain reduction of conditioned air that had to be treated to make up for the air previously cooled by the display case. The reduced heat gain on the refrigerated display case equals the reduced heat loss by the site and a heating load that no longer has to be provided by [9] The MMBtu derre

the MAC system. Furthermore, the analysis assumes a decrease load on the heating system, at outdoor temperatures below 60°F. A 25% disabiling factor was also applied to account for some of the cold air pouring out of the display case and subcooling the site's conditioned space, which will not trigger a thermstatic response from the HAC equipment. For more information on the analysis used to derive the bad decrease on the HAAC heating equipment per linear foot of display case, please see the 'HAAC IE' tab in the "EVT\_Add Doors\_Analysis\_Apr 2020.dist'

[10] The measure life is sourced from the PG&E Workpaper, "Add Doors to Open Medium Temperature Cases - PGE3PREF116", April 2014.

[11] The incremental cost is sourced from the PG&E Workpaper, "Add Doors to Open Medium Temperature Cases - PGE3PREF116", April 2014

Portfolio:	CI-RFG-EVPMC e									
Status:	Active									
	Date: 2021/1/1 : [None]									
End Use:	Refrigeration									
Ipdate Sum	x -									
<ul> <li>Updated fan m</li> </ul>	terization with new TRM template otor kW to maintain consistency with other C&I evaporator measures\									
	known cooler temperature type bin nnce for the measure life									
Referenced	Documents									
	roup, Commercial Refrigeration Loadshape Project Final Report, Northeast Energy Efficiency Partnerships, Regional Evaluation, and Verification Forum, Lexington, MA 2015.									
Oak Ridge Nati	onal Laboratory, "Q-Sync Motors in Commercial Refrigeration: Preliminary Test Results and Projected benefits", 2015.									
	n Controls_NEEP_ICS4 Final June 23 2015.xlsx Business Sector Market Characterization and Assessment Study									
Evaporator Mo	tors Reference 2017_v4									
<ul> <li>DEER EUL Tabl</li> <li>EVT_Analysis_</li> </ul>	e_2014-02-05 Evaporator Fan Motor Control_Mar 2021									
Description										
Valk-in cooler eva	porator fans typically run all the time; 24 hrs/day, 365 days/yr. The continuous operation is due to the need to provide cooling when									
	running, and to provide air circulation when the compressor is not running. Evaporator fans controls can be added to reduce fan run nding on the call for cooling and air circulation, while maintaing circulation requirements.									
Program Ty	10									
Calculation Type: F	tetrofit									
npiementation Ty										
Baseline Eff	iciencies tion is a refrigeration system without an evaporator fan control.									
Efficient Equ	ipment refrigeration system with an evaporator fan control and a smaller wattage circulating fan.									
ign enidency is a	renge daan specin men ar exportion fen one er und e aname maage er calaeing fan									
Algorithms lectric Demand	Faultan									
AkW	= kW <sub>Pan</sub> × n <sub>Fans</sub> × LRF × BF									
77KAA	= KWFan × IIFans × LKF × DF									
Symbol Table										
	Savings = ΔkW × 8760									
Electric Energy										
Symbol Table	= DMV × 8760									
Electric Energy ΔkWh Symbol Table	= DMV × 8760									
Electric Energy ΔkWh Symbol Table	_ ΔΔW × 8760									
Electric Energy : ΔkWh Symbol Table Fossil Fuel Savin Vhere: ΔkW	gs = Gross customer connected load kW savings for the measure (KW)									
Electric Energy : AkWh Symbol Table Symbol Table Cossil Fuel Savin Vhere: AkW AkWh	gs = Gross customer connected load kW savings for the measure (kW) = Gross customer annual kWh savings for the measure (kWh)									
Electric Energy : ΔkWh Symbol Table Fossil Fuel Savin Vhere: ΔkW	gs = Gross customer connected load kW savings for the measure (KW)									
Electric Energy : AkWh Symbol Table Symbol Table Cossil Fuel Savin Vhere: AkW AkWh	gs g Gross customer connected load kW savings for the measure (kW) Gross customer annual kWh savings for the measure (kWh) Gross customer annual kWh savings for the measure (kWh) Hours / Year Boous factor for reduced cooling load from eliminating heat generated by the evaporator fan inside the cooler or									
Electric Energy : ΔkWh Symbol Table Fossil Fuel Savin Vhere: ΔkW ΔkWh 8760	gs									
Electric Energy : ΔkWh Symbol Table Fossil Fuel Savin Vhere: ΔkW ΔkWh 8760	gs g Gross customer connected load KW savings for the measure (KW) Gross customer annual KWh savings for the measure (KWh) Gross customer annual KWh savings for the measure (KWh) Hours / Year Hours / Year Boous factor for excluded cooling load from eliminating heat generated by the evaporator fan inside the cooler or fracted in a second									
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Electric Energy :: ΔkWh Symbol Table Foossil Fuel Savin Vhere: ΔkW ΔkWh ΔkWh BF	gs g									
Electric Energy : ΔkWh Symbol Table Fossil Fuel Savin Vhere: ΔkW ΔkWh 8760	gs g g g g g g g g g g g g g g g g g g									
Electric Energy :: ΔkWh Symbol Table Foossil Fuel Savin Vhere: ΔkW ΔkWh ΔkWh BF	gs g g g g g g g g g g g g g g g g g g									
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lectric Energy 1: ΔkWh Symbol Table Coossil Fuel Savin Vhere: ΔkW ΔkWh ΔkWh BF	gs         gs         = Gross customer connected load KW savings for the measure (KW)         = Gross customer annual KWh savings for the measure (KWh)         = Gross customer annual KWh savings for the measure (KWh)         = Hours / Year         = Bonus factor for reduced cooling load from eliminating heat generated by the evaporator fan inside the cooler or freezers:         = 1.4 for coolers         = 1.4 for secons         = 1.5 for freezers         = 1.6 for secons         = 1.7 for type         Moter Type         Wd         Shaded Arbic (SP)         0.135									
lectric Energy 1: ΔkWh Symbol Table Coossil Fuel Savin Vhere: ΔkW ΔkWh ΔkWh BF	gs									
Electric Energy :: ΔkWh Symbol Table Foossil Fuel Savin Vhere: ΔkW ΔkWh ΔkWh BF	gs g									
lectric Energy 1 ΔkWh Symbol Table Sosal Fuel Savin Vhere: ΔkWv ΔkWh 8760 BF kWr <sub>son</sub>	gs         gs         =       Gross customer connected load kW savings for the measure (kWr)         =       Gross customer annual kWh savings for the measure (kWr)         =       Gross customer annual kWh savings for the measure (kWr)         =       Hours / Year         =       Boxus factor for reduced cooling load from eliminating heat generated by the evaporator fan inside the cooler or freezers!         =       1.4 for coolers         =       1.6 or freezers         =       1.6 or freezers         =       1.05									
Idetric Energy 1:	gs         gs         =       Gross customer connected load kW savings for the measure (6W)         =       Gross customer annual kWh savings for the measure (6W)         =       Gross customer annual kWh savings for the measure (6W)         =       Hours / Year         =       Boxus factor for reduced cooling load from eliminating heat generated by the evaporator fan inside the cooler or freezer(1)         =       1.4 for coolers         =       1.5 or freezers         =       1.4 for coolers         =       1.6 or freezers         =       1.6 or freezers         =       1.6 or freezers         =       1.15         EcoM       0.064         Synchronoue       0.058         Unition       0.105									
ilectric Energy 1 ΔKWh Symbol Table Symbol Table Cossil Fuel Savin AKWr S760 BF KWr S760	gs         gs         a Gross customer connected load kW savings for the measure (kWr)         a Gross customer annual kWrh savings for the measure (kWrh)         b Hours / Year         b Rouss factor for reduced cooling load from eliminating heat generated by the eveporator fan inside the cooler or freezers1         a 1.4 for coolers         a 1.4 for coolers         a 1.4 for coolers         a 1.4 for coolers         b Connected load kW of each eveporator fan motor, based on existing motor type in eveporator fan unit[2]         Mator Type         Store Connected load for (SC)         c Connected load KW of each eveporator fan motor, based on existing motor type in eveporator fan unit[2]         Batter Type         Linktoorn 0.058         Linktoorn 0.105         a Load Reduction Factor for motor controlled units (31.3%) <sup>[3]</sup> a Number of eveporator fans driven by the controls									
ilectric Energy : ΔKWh Symbol Table Symbol Table Symbol Table ΔKWr 5760 BF KWr,an BF KWr,an REF REAS REF Could Shapped dot	gs         gs         a       Gross customer connected load kW savings for the measure (6W)         a       Gross customer annual kWh savings for the measure (6W)         a       Gross customer annual kWh savings for the measure (6W)         a       Gross customer annual kWh savings for the measure (6Wh)         a       Hours / Year         a       Boxus factor for reduced cooling load from eliminating heat generated by the evaporator fan inside the cooler or freezer(1)         a       1.4 for coolers         b       1.5 for freezers         a       1.4 for coolers         b       1.5 for freezers         b       1.3 for freezers         b       1.3 for freezers         b       1.0 for         connected load kW of each evaporator fan motor, based on existing motor type in evaporator fan unit*?         Mator Type       W         Synchronou       0.058         Unisoown       0.105         a       Number of evaporator fans driven by the controls         a       Number of evaporator fans driven by the controls         a									
Idectric Energy 1:	gs									
lectric Energy :	gs									
lectric Energy :	gs         gs         a       Gross customer connected load kW savings for the measure (kW)         a       Gross customer annual kWh savings for the measure (kWh)         a       Gross customer annual kWh savings for the measure (kWh)         a       Hours / Year         b       Borus factor for reduced cooling load from eliminating heat generated by the exeporator fan inside the cooler or freezers <sup>1</sup> a       1.4 for coolers         a       1.4 for freezers <sup>1</sup> a       1.4 for freezers <sup>1</sup> a       1.4 for coolers         a       1.4 for unknown         a       Connected load kW of each evaporator fan motor, based on existing motor type in evaporator fan unit <sup>12</sup> Modor Type       Windown         0.064       Synchronous         0.058       Unknown         a       Luade Reduction Factor for motor controlled units (31.3%) <sup>13</sup> a       Number of evaporator fans driven by the controls         state, see reference:: "EVT_Analysis_Ekaporator Fan Motor Control_Mar 2021.xtsx*         Control       Numer         States       Winter Winter Summer Winter Summer									
Idectric Energy 1: AWW Symbol Table Symbol Table Symbol Table AWW AWW AWW AWW BF AWW BF AWW AWW AWW AWW AWW BF AWW BF AWW AWW AWW AWW AWW AWW AWW AW	gs         gs         a       Gross customer connected load KW savings for the measure (KW)         a       Gross customer annual KWh savings for the measure (KWh)         a       Gross customer annual KWh savings for the measure (KWh)         a       Hours / Year         a       Bonus factor for reduced cooling load from eliminating heat generated by the eveporator fan inside the cooler or freezers <sup>1</sup> a       1.4 for coolers         a       1.4 for unknown         Connected load KW of each eveporator fan motor, based on existing motor type in eveporator fan unit?         Word Type       WY         Staded Prie (SP)       0.135         e       Load Reduction Factor for motor controlled units (31.3%) <sup>[3]</sup> e       Number of eveporator fane driven by the controls         s       see reference: "EVT_Analysis_Exeporator Fane Motor Control_Mar 2021.s/sc*"         control       Status       Winter       Summer         Rene       Status       Winter       Summer       Summer         see reference: "EVT_Analysis_Exeporator Fan Motor Control_Mar									
Electric Energy 1: AKWh Symbol Table Symbol Table Tosall Fuel Savin Vierre: AKWr BF KWran ERF Remain	series and reduction Factor for motor controlled units (31.3%) <sup>[3]</sup> to control.      to control.									
Idectric Energy ::	gs         gs         a       Gross customer connected load kW savings for the measure (kW)         a       Gross customer annual kWh savings for the measure (kWh)         a       Gross customer annual kWh savings for the measure (kWh)         a       Hours / Year         a       Borus factor for reduced cooling load from eliminating heat generated by the exeporator fan inside the cooler or freezers <sup>1</sup> a       1.4 for coolers         b       1.0 of freezers         a       1.4 for coolers         b       0.044         Synchronou       0.058         Unicom       0.058									
lectric Energy : AWW Symbol Table AWW Symbol Table AWW Symbol Table E Symbol	gs         gs         a       Gross customer connected load kW savings for the measure (kW)         a       Gross customer annual kWh savings for the measure (kWh)         a       Gross customer annual kWh savings for the measure (kWh)         a       Hours / Year         a       Borus factor for reduced cooling load from eliminating heat generated by the exeporator fan inside the cooler or freezers <sup>1</sup> a       1.4 for coolers         b       1.0 of freezers         a       1.4 for coolers         b       0.044         Synchronou       0.058         Unicom       0.058									

Lifetimes 15 years<sup>[4]</sup>

## Measure Cost

ator fan motor controller including labor is \$91 per fan.<sup>[5]</sup> The cost for an e

# O&M Cost Adjustments There are no standard operation and maintenance cost adjustments used for this measure.

# Reference Tables

Energy Savings for Evaporator Fan Motor Controls									
Temperature Range	:	Savings by M	4otor Type (Δk	Wh)					
remperature kange	SP	ECM	Synchronous	Unknown					
Low (<25F)	666	316	286	518					
Medium / High (25-40F / 41-65F)	518	246	223	403					
Unknown	518	246	223	403					

Demand Savings for Evaporator Fan Motor Controls										
Temperature Range	Savings by Motor Type (ΔkW)									
Temperature Kange	SP	ECM	Synchronous	Unknown						
Low (<25F)	0.076	0.036	0.033	0.059						
Medium / High (25-40F / 41-65F)	0.059	0.028	0.025	0.046						
Unknown	0.059	0.028	0.025	0.046						
avings is on a per fan	basis, not p	er controller.	. A single control	unit can control						

Measure Description	Item Code
Evaporator Fan Motor Controls (ECM) - Low Temp	BES-EFAN-CC1
Evaporator Fan Motor Controls (ECM) - Med/High Temp	BES-EFAN-CC2
Evaporator Fan Motor Controls (ECM) - Unknown	BES-EFAN-CCEU
Evaporator Fan Motor Controls (Sync) - Low Temp	BES-EFAN-CC3
Evaporator Fan Motor Controls (Sync) - Med/High Temp	BES-EFAN-CC4
Evaporator Fan Motor Controls (Sync) - Unknown	BES-EFAN-CCSU
Evaporator Fan Motor Controls (Unknown) - Low Temp	BES-EFAN-CC5
Evaporator Fan Motor Controls (Unknown) - Med/High Temp	BES-EFAN-CC6
Evaporator Fan Motor Controls (Unknown) - Unknown	BES-EFAN-CCUU

### Footnotes

- [1] Borus factors as derived in the NEEP Refrigention Loadshape Report. The Cadmus Group, Commercial Refrigeration Loadshape Project Final Report, Northeast Energy Efficiency Partnerships, Regional Evaluation, Measurement, and Verification Forum, Lexington, MA 2015. Page 78, Figure 54. The 1.4 unknown case type bonus factor represents a weighted average of low, medium, and high temperature refrigeration types.
- [2] The evaporator fan motor waitage is based on motor type efficiencies and output ratings as calculated from power consumption values for walk-in motors from the following analysis file "Exaporator Motors Reference 2012, v4.six/, "Surings Table" tab. The original source material is the Northasst. Energy Efficiency Partnership (NEEP) Refrigeration Loadshape Rejort "Commercial Refrigeration Loadshape Rejort Erical Report", Cadmus, Regional Evaluation, Measurement, and Verification Forum, 2015 (page 87) section 5.1.4). Efficiency values for ECM and Q-Sync evaporator fan motor, as sourced from "Q-Sync Motors in Commercial Refrigeration: Preliminary Test Results and Projected Benefits", Oak Kidge National Laboratory, 2015 (page 17) section 1). The unknown motor type is based on a 31% or SPNCEVISP gait as raporated in the 2015 Vermont Basiness Sector Market Characterization and Assessment Study, Figure 89, pg. 112.. For the Unknown motor type, the 31% split in motor types uses the average of the two high efficiency motor types. Despirator for Vermont Basiness Sector Market 2021.stor".
- [3] Load reduction factor as reported in NEEP Loadshape Report for evaporator fan motor control units. This is the difference in effective runtime of unctrolled motors and the effective runtime of all control styles for motor controls. The Cadmus Group, Commercial Refrigeration Loadshape Projec Final Report, Northeast Energy Efficiency Partnerships, Regional Evaluation, Measurement, and Verification Forum, Lexington, MA 2015. Page 67, Table 34. oject
- [4] The 15 year measure life for evaporator fan motor controls is sourced from DEER 2014 effective useful life (EUL) estimates; California DEER 2014 Effective Useful Life Table Update, DEER2014-EUL-table-update, 2014-02-05 x/sx.
- [5] Evaporator fan control unit cost of \$520 is referenced from the NEEP Incremental Cost Study Part 4 spreadsheet as listed for the New England region on a per controller cost basis. See reference "Evaporator Fan Controls, NEEP\_ICS4 Final June 22 2015.xdsr," Summary of Result' tab. Per fan cost is estimated to be \$91 per fan based an average of \$57 finas per controller deviced from 2016 EVT Evaporator Fan Motor Control installation data. See reference file "EVT\_Analysis\_Exaporator Fan Motor Control\_Mar 2021.xdsr".
- [6] For detailed savings calculations see reference file "Evaporator Fan Motor Control 2017 Update v2.xlsx".

# **Refrigerant Leak Repair**

Measure Number	CI-RFG-LKRPR b
Portfolio:	
Status:	Active
Effective Date:	2021/1/1
End Date:	[ None ]
Program:	Commercial & Industrial
End Use:	Refrigeration

Update Summary Added non-energy GHG savings and updated the assumed baseline and efficient leakage rates.

- ent Study
- Referenced Documents 2016 Vermont Business Sector Market Characterization and Assessme VT SF Bicking homes Onsite Report DRAFT 122117 U.S. DOE Commercial Refrigeration Savings Potential\_Navigant\_2009 Refrigeration Analysis Tod VGT\_INM Test. EPA Green Chill Findial Impact Calculator ARE[3018: Train Report

- PAA Green Chill Financial Impact Calculator
   AARI, 2018, Final, Report
   ARB Refrigerant Data
   Green Chill, Progress Report 2011\_09062012
   VIT\_Refrigerant Loak Repair\_Analysis\_May 2021
   IPCC\_Chapter08\_FINAL

### Description

This measure is for the detection and repair of refrigerant leaks in commercial refrigeration systems. Refrigerant leaks can cause refrigeration work harder in order to compensate for the lost refrigerant. This can lead to lower performing equipment and reduced operating efficiencies.

In addition to energy savings, there are a number of non-energy therefits associated with regarding refrigerant lasks during the product of the source of th

Refrigerant leaks also have adverse effects on the environment, with refrigerants being a significant contributor to greenhouse gas e Neingen it was also have autores effects on the environment, will reingenatis being a significat cultification to grean tobe give anisators. EPA regulations under Section 606 of the Clean Air Act regimes commercial tests with refrigeration systems to maintain certain leak mitigation standars however, small businesses and other commercial operations outside of large grocery stores and supermarkets, not only do not adhere to these EPA standards, but are rarely, if ever, largeted for inspections, resulting in a large portion of commercial refigreation systems keiking refigreant and not being properly maintained. This measure, and its affiliated program, is designed to larget small commercial businesses such as independent grocery stores and markets, dairy farms, craft breweries, and other small businesses utilizing refigreation systems to detect refigreant leaks and repari them. This measure is only applicable for sites with 100 horsepower or less in total refrigeration compressor capacity, with no individual compressor exceeding

# Program Type Calculation Type: Retrofit

15 horsepower.

Implementation Type: Midstream

**Baseline Efficiencies** The baseline is a refrigeration system with an estimated 25% leak rate.<sup>[1]</sup>

## Efficient Equipment

ipment to is a refrigeration system with detected and repaired leaks, with a conservatively estimated 13% leak rate.<sup>[2]</sup> The efficient sce

### Algorithms Electric Demand Savings $= \Delta kWh / Hours$ ΔkW Symbol Table

Non-Energy GHG Savings

ΔGHG = Charge x ΔLeak x GWP

# Symbol Table

Electric Energy Savings ΔkWh = (Capacity / 1000) x DC\_{Comp} x (1 / EER\_{Pre} - 1 / EER\_{Post}) x Hours = EER<sub>Post</sub> x (1 - % EER Improvement) EERpre

### Symbol Table

Fossil Fuel Savings

### N/A

Where:			
	% EER Improvement	1	Percent improvement of compressor operating efficiency due to repaired leak $= 7.5\%^{[6]}$
	ΔGHG	-	Gross customer annual non-energy GHG savings (lbs. CO2e)
	ΔkW	-	Gross customer connected load kW savings
	ΔkWh	-	Gross customer annual KWh energy savings
	ΔLeak	-	Percentage of total charge that leaks from the system on an annual basis. The difference between the baseline and efficient leakage rate.
			= 12%(4)
	Capacity	1	Operating capacity of the compressor in Btu/h See Reference Table for deemed assumptions
	Charge	-	Charge of the refrigeration system, in units of mass (lbs) See Reference Table for deemed assumptions
	DC <sub>Comp</sub>	1	Duty cycle of the compressor = 45% <sup>2</sup> /1
	EERPost	-	Energy Efficiency Ratio of the compressor post leak repair See Reference Table for deemed assumptions
	EER <sub>Pre</sub>	-	Energy Efficiency Ratio of the compressor prior to leak repair

	Se	e Referer	nce Table	for deemed	d results					
GWP		Robal warming potential of refrigerant (lbs CO2e / lb refrigerant)								
Hours	= To									
<b>Load Shape</b> 4a Commercial F										
Number	Name	Status	Winter On kWh		Summer On kWh		Winter kW	Summer kW		
14 Comm	ercial Refrigeration	Active	33.0%	32.6%	17.0%	17.4%	69.0%	77.2%		
Net Saving	s Factors									
Measures										

Tracks [Base Track] 6013UPST [is base track] Upstream - Commercial

Lifetimes The measure life is estimated to be 3 years.

Measure Cost A copy of contractor invoices that detail the work performed to repair the refrigerant leak, as well as additional labor and parts to in refrigeration system performance will be used for the incremental cost for this measure.

O&M Cost Adjustments Refrigeration systems operating at low refrigerant levels work harder and result in excessive wear and tear on the mechanical components like the compressor, which can experience burnout if not properly maintained. OBM cost savings are based on an annual fulfillment of the system's leaked refrigerant. Refrigerant technican labor rates and the material cost of the leaked refrigerant are included in the annual savings estimate.<sup>[4]</sup>

As routine operation and maintenance is not typically performed by the target participant for this measure, and occurs only when absolutely necessary, typically when the system or certain components are no longer functioning, an additional 15% adder is included in the GMH calculator. This was include in an attempt to capture wear and learn on the refingeration system due to unmitigated leaks. The 15% added accurstle for early burnuct of compressors due to increased cycling, and other adverse deterioration of components in the refrigeration system that will require maintenance and early replacement due to increased cycling. ssor Hp O&M Cost Savings Cor

compressor rip	Oduli Cost Savings
1	\$36
1.5	\$58
2	\$72
2.5	\$86
3	\$107
3.5	\$121
4	\$135
4.5	\$149
5	\$163
5.5	\$176
6	\$190
7	\$274
7.5	\$287
8	\$301
9	\$329
10	\$357
15	\$496

## Reference Tables

Compressor Hp	Capacity (Btu/h)	EER Pre	EER Post <sup>(9)</sup>
1	7,033	8.70	9.41
1.5	10,551	8.70	9.41
2	14,067	8.73	9.44
2.5	17,584	9.68	10.46
3	21,100	9.69	10.48
3.5	24,618	10.05	10.86
4	28,134	10.06	10.88
4.5	31,651	10.13	10.95
5	35,167	10.17	10.99
5.5	38,685	10.55	11.40
6	42,201	10.55	11.40
7	49,234	10.49	11.34
7.5	52,752	11.08	11.98
8	56,268	11.03	11.92
9	63,301	10.95	11.84
10	70,335	10.24	11.07
15	105,502	10.10	10.92

### Deemed Energy and Demand Savings

Compressor Hp	Item Code	Deemed Demand Savings (ΔkW)	Deemed Energy Savings (AkWh)
1	RFRLEAKRPR1	0.0274	231
1.5	RFRLEAKRPR15	0.0412	347
2	RFRLEAKRPR2	0.0545	459
2.5	RFRLEAKRPR25	0.0609	513
3	RFRLEAKRPR3	0.0739	622
3.5	RFRLEAKRPR35	0.0822	692
4	RFRLEAKRPR4	0.0948	798
4.5	RFRLEAKRPR45	0.1053	886
5	RFRLEAKRPR5	0.1161	977
5.5	RFRLEAKRPR55	0.1231	1,036
6	RFRLEAKRPR6	0.1343	1,130
7	RFRLEAKRPR7	0.1583	1,332
7.5	RFRLEAKRPR7.5	0.1610	1,355
8	RFRLEAKRPR8	0.1714	1,443
9	RFRLEAKRPR9	0.1956	1,646

10	RFRLEAKRPR10	0.2318	1,951
15	RFRLEAKRPR15	0.3530	2,971
Deemend Non-E	Energy GHG Savi	ngs	
Compressor Hp	Item Code	Charge Size (lbs of refrigerant) <sup>[10]</sup>	GHG Savings (Ibs of CO2e)
1	RFRLEAKRPR1	7	2,146
1.5	RFRLEAKRPR15	14	4,292
2	RFRLEAKRPR2	14	4,292
2.5	RFRLEAKRPR25	14	4,292
3	RFRLEAKRPR3	20	6,132
3.5	RFRLEAKRPR35	20	6,132
4	RFRLEAKRPR4	20	6,132
4.5	RFRLEAKRPR45	20	6,132
5	RFRLEAKRPR5	20	6,132
5.5	RFRLEAKRPR55	20	6,132
6	RFRLEAKRPR6	20	6,132
7	RFRLEAKRPR7	67	20,542
7.5	RFRLEAKRPR7.5	67	20,542
8	RFRLEAKRPR8	67	20,542
9	RFRLEAKRPR9	67	20,542
10	RFRLEAKRPR10	67	20,542
15	RFRLEAKRPR15	67	20,542

## Footnotes

- U.S. EPA Green Chill Program, "Profile of an Average U.S. Supermarket's Greenhouse Gas Impacts from Refrigeration Leaks Compared to Electricity Consumption", June 2011
- [2] U.S. EPA Green Chill Program, "Progress Report Green Chill a Partnership at Work", 2011 (pg. 6). To further substantiate the efficient condition leakage rate, supplemental data was pulled from the AHRI report, "AHRI Project 8018 Final Report, Review of Refrigerant Management Programs", Navigant, January 2016. This report includes data suggesting the California AH Resourced Board (CARB) Refrigerant Management Program has beer able to reduce leakage rates to between 9% and 17%. These two sources, therefore, suggest that an average leakage rate of 13% is a reasonable assumption for post-correction "efficient" conditions.
- [3] The compressor operating hours are based on a weighted average of walk-in cold storage applications and sites utilizing economizers. If a site leverages a refrigeration economizer, the compressor will not operate at outdoor air temperatures 4% below the cold storage set temperatures. The weighting for sites with economizers is sourced from the '2016 Vermont Basiness Sector Market Daracterization and Assessment Study', Cadmus, April 2017 (page 109). The weighting for the cold storage applications and associated average refrigeration set temperature is sourced from the '2016 Vermont Basiness Sector Market Daracterization and Assessment Study', Cadmus, April 2017 (page 109). The weighting for the cold storage applications and associated average refrigeration set temperature is sourced from 'Energy Savings Potential and R&D Opportunities for Commercial Refrigeration', U.S. DOE, Navigant, 2009 (page 66). For more information on how the compressor operating hours were limed across the different outdoor air temperatures, please see "EVT\_Refrigerant Leak Repair\_Analysis\_May 2021.sdx'.
- [4] The leakage rate improvement, or change in leakage rate, is calculated as the difference between the baseline leakage rate, 25%, and the improved, or efficient, leakage rate of 13%.
- [5] The global warming potential of refrigerant represents an average of the most common refrigerants seen in commercial systems in Vermont. This weighting is based on engineering judgement and the refrigerants averaged are; R407C, R407A, R134a, R404a, and R507. GWP100 values were used to calculate the average, which was sourced from the "Intergovernmental Panel on Climate Change (IPCC), Climate Change 2013; The Physical Science, Chapter 8: Anthrogenetic and Natural Radiative Efficience, Radiative Efficiencies, and Metrix Values" (pp. 731 738). For more detail on the refrigerant weighting, please see the Notes' tab in the file: "EVT\_Refrigerant Lak Repair\_Analysis\_May 2021.x5x."
- (6) Compressor EER kingrovement, as a result of repairing a refrigerant leak, is based on a binned weather analysis of an average refrigeration system. The compressor EER kines depending on the outdoor air and condensing temperature. For the pusposes of this characterization, the energy savings associated with the leak repair were summed across different temperature bin and realized in a % improvement of the compressor's operating condition. The EER kinetityles at the varying bins, which were used to determine the reduced effects of the compressor's operating condition. The EER kinetityles at the varying bins, which were used to determine the reduced effects of the compressor is higher outdoor air and condensing temperatures, were taken as a straight average from the EVT's custom refrigeration analysis tool, "Refrigeration analysis tool, "Refrigeration on oper-analysis resis" is in the condensing set poirt. While bulkeresge a statuated suction temperature of 20°F, the saturated condensing temperature is preputally 5°F higher in the pre-retroft scomario as compared to the post-retroft scomario. This assumption is based on the fact that a loss of refrigerant will cause reductors in both the discharge and suction pressure. As a result, this leads to a lower eveporator temperature causing the compressor to work more and more inefficiently in order to increase the temperature of the refrigerant in order to dissapate healt in the condenser. For pradical purposes for this measure, a 5°F increase was assumed for the pre-retroft suction condensing temperature.
- [7] The average compressor duly cycle is 45% based on a compressor full load operation of 3,910 hours. This value is sourced from EVT's custom refrigeration analysis tool, "Refrigeration Analysis Tool\_v5f\_TRM Test.xism".
- [8] The cost per pound of refrigerant (\$6.83)(b) is sourced from the EPA Green Chill Program Financial Calculator for Supermarkets (https://www.epa.gov/greenchil/greenchil/greenchil-resources-and-reports). The labor cost associated with adding refrigerant to a depleted system is based on an hourly refigrant technican ned or 5165 per know, as quoted by Turner Piping and Refrigeration, a refrigeration service contractor based in Rutland, VT. It was estimated that this service would require 15 minutes per system ton.
- (9) The post-retrofit EER is based on the actual rated compressor EER, assuming post leak repair the system resumes its rated operating performance. The value is sourced from leveraging default baseline EER values from the Refrigeration Analysis Tool (see "Refrigeration Analysis" tool (see "Refrigeration") too (see "Refrige
- [10] Refrigerant system charge is sourced from Heatcraft compressor cut sheets. For more information please see: "EVT\_Refrigerant Leak Repair\_Analysis\_May 2021.xtsx."

# **Plate Coolers for Dairy Farms**

Measure Number:	CI-RFG-PLATE c
Portfolio:	EVT TRM Portfolio 2020-
Status:	Active
Effective Date:	2020/1/1
End Date:	2023/12/31
Program:	Commercial & Industrial
End Use:	Refrigeration

- Update Summary Reactivated this measure and provided the following updates
- Networked us in measure and provided use intring spontance.
  Developed new algorithms to calculate savings based on the quantity of milk production. The measure was previously based on a deemed tiered system developed from analysis of 51 custom projects from 2003 through 2012. The tiered system had two bins and was based on the number of milking cows on the farm. As the energy savings are dependent on the amount of milk yield, the measure was re-developed to increase accuracy and miligate risks.
   Made subsequent updates to the measure description, measure life, and footnotes.
   Opted to leverge the existing incremental costs as they are a good representation of the dairy equipment market in Vermont, which has stayed relatively consistent over time.

### **Referenced Documents**

- ard DHW Schedules May 2014 U.S. DOE Bu
- U.S. DOE\_Building America Standaro Univ Vermont Agriculture Census\_2017
   Energy Efficiency for Dairy Enterprises
   EVT\_Plate Cooler\_Analysis\_May 2020\_v3

### Description

Description A mik plate coder is used in dairy applications to pre-cool milk prior to it entering the primary bulk tank refrigeration system. A plate coder is a heat exchanger used to transfer head from the milk stream to a stream of ambient temperature water. Eactric savings are achieved by reducing the downstream cooling load of the associated refrigerant based system. Generally, there is no opportunity to reclaim heat from the water used in the heat exchange process and it is therefore assumed that this energy is lost. However, Efficiency Vermon tencourages famers to use the plate coder's warm water to feed cows. Cows prefer to drink warm water and the more water they drink the more milk output they provide, Drinking warm water is stressful metabolically for cows and an indirect benefit of this measure is this platential for increased milk production. Nowever, it is recommended that the dairy farm, prior to measure implementation, determine if an adequate supply of water is available for the function of the plate coder.

On larger driving farms, plate coolers are generally used in conjunction with a variable speed milk transfer pump to manage flow rate of the milk to enso optimal heat exchange and reduce refrigeration use even further. For conservative purposes, the energy savings for this measure were developed assuming a variable-speed milk transfer pump is not prevent on state. Costs of plate coders vary graftly based on cooler plate size, therefore the rebat is a tiered rebate, with tiers based on the number of coxes as proxy for the volume of milk requiring cooling:

This measure restricts participation for dairy farms with 74 cows or less, as it is not cost-effective for farms with lower milk yields

# Program Type Calculation Type: Retrofit

Implementation Type: Downst

### **Baseline Efficiencies**

where milk is not pre-cooled with a plate cooler, but goes directly into a refrigerated coo The ba ine state is a ling sys

High Efficiency The high efficiency case is installation and use of a plate cooler to pre-cool milk using ambient temperature water prior to refrigerated cooling

## Algorithms

∆kW	″h	$= (\Delta T_{MB})$	x Lbs of I	4ilk x C <sub>p,m</sub> x E	ays) / (EER	< 1000)					
hank	ol Table										
ΔkW	ic Demand S										
ДКМ		= ∆kWh	/ Hours								
/here	:										
	ΔkW	-	Gross cu	stomer conne	cted load kW	demand sa	avings				
	ΔkWh	-	Gross cu	stomer annua	l kWh energy	savings					
	$\Delta T_{\rm Milk}$	-	Change i	n milk temper	ature attribu	table to the	plate cool	er			
			= 30°F[2								
	1000	-	Conversi	on factor from	watts to kilo	watts					
	C <sub>p,m</sub>	-	Specific I	neat of milk							
			= 0.93 B	u/lbºF							
	Days	-	Number	of milking day	s per year						
			= 365 da	ys							
	EER	-	Efficiency	of the existin	g bulk tank r	efrigeratior	n compress	or[3]			
			= 9.9 EE	R for reciproc	ating compre	ssors					
			= 11.1 E	ER for scroll c	ompressor						
			= 10.5 u	nknown/other	compressor						
	Hours	-		perating hour	5						
			= 2,679	nours <sup>[4]</sup>							
	Lbs of Milk	-	Quantity	of milk produc	ed per day t	hat needs t	to be coole	d. See Refe	erence Ta	bles for de	emed values.
	<b>i Shapes</b> arm Plate Coole	er / Heat Re	covery Uni	t							
Numb	er	Name		State	Winter	Winter Off kWh		Summer	Winter kW	Summer kW	
					On KWN	OII KWN	OII KWN	OII KWN	N.VV	K.VV	

## Net Savings Factors

Measures RFRPLATE Plate cooler

Tracks [Base Track] 6013CUST [is base track] Cust Equip Rpl 6013PRES [is base track] Pres Equip Rpl

## Lifetimes

The expected measure life of a plate cooler is 15 years.<sup>[5]</sup>

# Measure Cost

The default incremental meas	ure costs are detailed	in the table below:
Savings Bin (Ibs of milk/day)	Incremental Cost <sup>(6)</sup>	
< 5,100	\$2,875	
5,101 to 6,800	\$2,875	
6,801 to 13,600	\$6,530	
13,601 to 34,000	\$6,530	
> 34,001	\$6,530	

## O&M Cost Adjustments

nance cost adjustments used for this me l opera

# Reference Tables Deemed Energy and Demand Savings

Compressor Type	Savings Bin (Lbs of Milk/Day)	Average Lbs of Milk/Day	Energy Savings (ΔkWh)	Demand Savings (ΔkW)	Item Code
	< 5,100	4,500	4,629	1.728	RFRPLATEREC1
	5,101 to 6,800	5,951	6,121	2.285	RFRPLATEREC2
Reciprocating	6,801 to 13,600	10,201	10,493	3.917	RFRPLATEREC3
	13,601 to 34,000	23,801	24,483	9.139	RFRPLATEREC4
	> 34,001	34,001	34,975	13.055	RFRPLATEREC5
	< 5,100	4,500	4,128	1.541	RFRPLATESCR1
	5,101 to 6,800	5,951	5,460	2.038	RFRPLATESCR2
Scroll	6,801 to 13,600	10,201	9,359	3.493	RFRPLATESCR3
	13,601 to 34,000	23,801	21,836	8.151	RFRPLATESCR4
	> 34,001	34,001	31,194	11.644	RFRPLATESCR5
	< 5,100	4,500	4,364	1.629	RFRPLATEUNK1
	5,101 to 6,800	5,951	5,772	2.155	RFRPLATEUNK2
Unknown/Other	6,801 to 13,600	10,201	9,894	3.693	RFRPLATEUNK3
	13,601 to 34,000	23,801	23,084	8.617	RFRPLATEUNK4
	> 34,001	34,001	32,976	12.309	RFRPLATEUNKS

## Footnotes

(1) While a plate cooler unit would be baseline for a new construction project, farmers typically re-use old equipment when extensively rerowating old facilities. New construction for dairy farms in the state of Vermont is rare, and anecdotally, EVT staff has only heard of one case (between 2006 and 2012) where a new construction project resulted in purchase of new equipment.

[2] The efficacy of a mik plate cooler is sourced from; Sarford, Scott (University of Wisconsin-Madison), "Energy Efficiency for Dairy Enterprises", Presentation to Agricultural and Life Sciences Program staff, December 2014. It was assumed that there is a 25% difference in mik temperature for a single pass plate cooler and a 35% temperature difference for a double/multi-pass plate cooler. For the purposes of this measure characterization, a straight average of 30% temperature difference for a double/multi-pass plate cooler. For the purposes of this measure characterization, a straight average of 30% temperature difference for a double/multi-pass plate cooler. For the purposes of the overall load on the refrigeration compressors, and the temperature differential of the mik represents that reduced load.

The 30°F milk temperature differential is also corroborated by the rule of thumb that a plate cooler can reduce the temperature of the milk to within 12°F of the water used in the heat exchanger. The temperature of water being 52°F (Average ground water temperature for Burlington, Montpelier, Rutland, and Springfield, UT from U.S. DOE Standard Building America DHW Schedules, May 2014), the temperature of the milk exiting the plate cooler being 64°F, and the temperature of the milk entering the plate cooler being 94°F, resulting in a milk temperature differential across the plate cooler being 64°F.

- [3] Compressor performance data obtained from "Emerson Climate Technologies Product Selection Software Version 1.0.25; Database Date: December 22, 2010." Current CHP or replacement model compressors with capacities from 12,000 Btu/h to 10,0000 Btu/h included in anjme EER averages. For assumed operating conditions and more detail on the compressor performance data, see: "VPL 7.Pate Code", Anajes, May 220, 22". Additionally, the unknown/other compressor replacement model as straight average in the performance data between reciprocating and scroll compressors.
- [4] The annual operating hours are based on the EVT Loadshape for Dairy Farm Combined End Uses.
- [5] The measure life is sourced from 2014 Database for Energy-Efficiency Resources (DEER), Version 2014.2.04, "Effective/Remaining Useful Life Values", California Public Ubilities Commission, February 4, 2014
- [6] The incremental costs are sourced from 51 custom EVT projects spanning 2003 through 2012. For more information on is derivation, please see: "EVT\_Plate Cooler\_Analysis\_May 2020\_v2.vbs".

# **Commercial Reach-In Refrigerators and Freezers**

Measure Numbe	r: CI-RFG-RIREFR h
Portfolio:	
Status:	Active
Effective Date:	2021/1/1
End Date:	[ None ]
Program:	Commercial & Industri

l & Industrial End Use: Refrigeration

Update Summary This update adds Non-Energy Greenhouse Gas savings quantification to the measure characterization.

- Referenced Documents

  Units: Enrory Savings (UES) Measures and Supporting Documentation, ConRefrigeratorFreezer\_v3\_2.x4sm
  2008 Database for Energy-Efficiency Resources (DEER), Version 2008.2.05, "Effective/Remaining Useful Life V
  4. Q. CLES, COMM, DATA Max.
  Toro Incr., "California Commercial-Victore equipment-caliculator-Fridge-Freezer
  ENERGY STAR commercial-Victore equipment-caliculator-Fridge-Freezer
  e.ek-commercial-victor-enforgerator-and/freezer-analysis-June-2020
  A ANB Refrigrenzer blab

- ARB Refrigerant Data
   EVT PIP 124 Refrigerant Management FINAL

Description
The masure described here is a high-efficiency packaged commercial reach-in cooler (refrigerator or freezer) with solid or glass doors, typically used by foodservice establishments, using only natural refrigerants (R-290 and R-600a). This includes one, two and three door reach-in, rol-in/trough and pass-through commercial coolers. Bevergen merchandses a - special type of reach-in refrigerants will be also door - and included in this characterization. To align with the Vermont commercial kitchen equipment market, the baseline for this measure uses the previous Federal Standard.

Program Type Calculation Type: Market Opportunity: Time of Sale Program Delivery/Implementation Type: Downstream

Baseline Efficiencies The baseline equipment is assumed to be a refrigerator or freezer meeting the minimum federal manufacturing standards as specified by Federal Standards effective January 2010.<sup>11</sup> This baseline is not the current Federal Standard, but is used by the DREKOY STAR kitchen Appliance Calculator that represents the market baseline found in Vermont today. See the average baseline energy use in the savings table in the Reference Tables section.

A high efficiency reach-in refigerator or freezer is one that meets the requirements of the ENERGY STAR 4.0 specifications (those meeting the ENERGY STAR specifications as of March 2017). Refer to the Reference Tables section for the detailed specifications. This refrigerator or freezer will have natural refrigerants used in its components.

4kW	$= \Delta kWh / Hours$
mbol Table	
n-Energy GH	G Savings
lGHG	= Charge x Leak x ΔGWP
mbol Table	
ctric Energy S	Savings
.kWh	= kWh <sub>Base</sub> - kWh <sub>Eff</sub>
mbol Table	
sil Fuel Savin	gs
ere:	
ΔkW	<ul> <li>Gross customer connected load kW savings for the measure (kW)</li> </ul>
ΔGHG	<ul> <li>Gross customer annual non-energy GHG savings (lbs. CO<sub>2</sub>e)</li> </ul>
ΔGWP	= 100-year time horizon global warming potential difference between baseline and efficient refrigerants. Units in It
	Carbon Dioxide Equivalent per lb refrigerant.
	= 1,295.5 <sup>[3]</sup>
ΔkWh	<ul> <li>Gross customer annual kWh savings for the measure (kWh)</li> </ul>
Charge	<ul> <li>Charge of the refrigerant within the system, in units of mass (lbs)</li> </ul>
	= 1.02 lbs <sup>[4]</sup>
Hours	<ul> <li>Annual operating hours (8760 hours)<sup>[2]</sup></li> </ul>
kWh <sub>Base</sub>	= Electric energy consumption of a Federal Standard Reach-In Refrigerator or Freezer
	= Refer to Specifications for Refrigerators and Freezers table below for Baseline Algorithm
kWh <sub>Eff</sub>	= Electric energy consumption of a natural refrigerant ENERGY STAR Reach-In Refrigerator or Freezer
	= Refer to Specifications for Refrigerators and Freezers table below for Efficient Algorithm
Leak	= Leak rate, expressed as percentage of total refrigerant charge, of the system on an annual basis
	=2%[5]

# **Operating Hours**

Load Shapes Commercial Reach-In Refrigerator & Freezer load shape is developed using the California Commercial End-Use Survey.<sup>[6]</sup> 119a Commercial Reach-In Refrigerator & Freezer

Not Cr	ings Fe	hore						
	ings Fac	tors						
Measures	Commercial	freener Nek	uni Dofrigo					
	Commercial							
RERCEIREN	Commerciai	rerrigerator -	Naturai ke	rrigerant				
Tracks [Ba	se Track]							
	[is base track]	Pres Equip	Rpl					
6014PRES [	[is base track]	6014PRES						
	ne Track Nr.				r			
	Rpl 6013PRES 6014PRES			1.00				
	Rpl 6013PRES			1.00				
6014PRES	6014PRES	RFRCMRFN	0.95	1.05				
	ence factor is a	issumed to be	e one.					
Lifetime 12 years.[7]	:5							
Measure Based on ex		st prices and	nrice studie	s performed b	hy others th	ne determ	ined incremental costs a	e tabulated below
		se prices and	price statut	is performed t	oy outers, a	ie determ		
					(0)			
	ncremental (	LOST TOP REF	rigerators	and Freezer	-(-)			
Incrementa								
Door Type	Volume 0 < V < 15	Refrigerator						
	15 < V < 30							
Solid Door	15 ≤ V < 50 30 ≤ V < 50							
	50 ≦ V < 50	\$ 1,540	.92 \$ 1,9	85.74				
	0 < V < 15							
Glass Door	$15 \leq V < 30$							
	$30 \le V < 50$	\$ 1,023	.15 \$ 1,4	31.97				
Note: V = in	50 ≤ V ternal volume	\$ 1,594 in cubic feet	.27 \$ 2,04	15.00				
1400C. V = 111	cernar volume	III CODIC TEEL						
08.M Co	et Adjuct	monto						
	es in O&M cos		nt betweer	the standard	and efficien	nt refriger;	ators.	
Referen	ce Table	s						
			s for Refri	gerators and	l Freezers	[9]		
		Refrigerator		Freezer				
Door Type	Volume			ΔkWh	ΔkW			
	0 < V < 15	728.3	0.083	733.7	0.084			
Solid Door	$15 \leq V < 30$	978.9	0.112	1,980.8				
	30 ≤ V < 50	1,395.1	0.159	4,035.8				
	50 ≤ V			6,015.4				
	0 < V < 15 15 ≤ V < 30			1,949.0				
Glass Door	15 ≤ V < 50 30 ≤ V < 50	1,962.4	0.100	9,222.0	0.563			
	50 ≦ V < 50			13,758.1				
				.,				
		Non	-Energy G	HG Savings				
1.02 lb x 2.0	1% x 1,295.5 Ⅱ							
	value is the s				re reaardk	acc of vo	lumo	
noce, chis i	value is the s	ame for rer	ngerators	anu neezei	s, regarak	255 07 70	iume.	
		Specificat	ions for R	efrigerators	and Freez	ers		
(10)(11)								
Descript	ion	MDEC	`c (Mavim	um Daily Ener	ray Consur	nntion k	Wh/day)	1
and Volu		HIDEK	2 (1-122811)	in baily cher	gy consum	npelony k	,	
(cu. ft.	.)	Refr	igerator			Fr	eezer	
		laseline	ENERG	Y STAR 4.0	Base	line	ENERGY STAR 4.0	-
Solid Do		osenne	ENERG	. 51/10 1.0	0050		Energy Strate no	
0 ≤ V <			0.02	2V+0.97			0.21V+0.90	
15 ≤ V <		LOV+2.04	0.06	5V+0.31	0.40V-	+1 79	0.12V+2.248	
30 ≤ V <		101 12:01	0.04	V+1.09	0.407	+1.50	0.285V-2.703	
50 ≤ V	/		0.02	4V+1.89			0.142V+4.445	
Glass Do	or							
0 ≤ V <			0.000	SV+0.445				-
15 ≤ V <								
	JU	L2V+3.34		W+1.12	0.75V	+4.1	0.232V+2.36	
	0.1		0.07	6V+0.34				
30 ≤ V <	50		-					
30 ≤ V < 50 ≤ V	0.1		0.105	5V-1.111				
30 ≤ V < 50 ≤ V	50	in cubic feet.	0.10	5V-1.111				
30 ≤ V < 50 ≤ V	0.1	in cubic feet.	0.105	5V-1.111				
30 ≤ V < 50 ≤ V Note: V = in	ternal volume	in cubic feet.	0.10	5V-1.111				
30 ≤ V < 50 ≤ V Note: V = in <b>ootnote</b>	ternal volume				ray Corres	ation Ch-	rdards for Commercial I	efrigeration Fouriement <sup>4</sup> Desument last
30 ≤ V < 50 ≤ V Note: V = in <b>ootnote</b> 1] United :		ment of Energ	IV, 10 CFR I	Part 431, <i>"Ene</i>				efrigeration Equipment* Document last to comply with these standards.
30 ≤ V < 50 ≤ V Note: V = in <b>cootnote</b> 1] United : updated	0.1     0.1     1	ment of Energ 20. January 1,	gy, 10 CFR I , 2010 and I	Part 431, <i>"Ene</i> before March 2	27, 2017 is i	the manu	acturer applicability date	to comply with these standards.
30 ≤ V < 50 ≤ V Note: V = in <b>ootnote</b> 1] United : updated	0.1     0.1     1	ment of Energ 20. January 1,	gy, 10 CFR I , 2010 and I	Part 431, <i>"Ene</i> before March 2	27, 2017 is i	the manu	acturer applicability date	
30 ≤ V < 50 ≤ V Note: V = in <b>cootnote</b> 1] United : updates 2] The ref 3] The glc	s     s     s     S	ment of Energ 20. January 1, sumed to alw potential of ba	y, 10 CFR I , 2010 and I vays be plug aseline unit	Part 431, <i>"Ene</i> before March ; gged in and op refrigerant as	27, 2017 is 1 perating 876 sumes R-13	the manul i0 hours p 14a, which	acturer applicability date er year. This provides ar is considered the most	to comply with these standards. annual average KW demand savings. common refrigerant seen in self-contained
30 ≤ V < 50 ≤ V Note: V = in <b>cootnote</b> 1] United : update: 2] The ref 3] The glc comme		ment of Energ 20. January 1, sumed to alw potential of ba tos and freez	y, 10 CFR I , 2010 and I vays be plug aseline unit ers. The GV	Part 431, <i>"Ene</i> before March : gged in and op refrigerant as VP100 value fo	27, 2017 is the erating 876 sumes R-13 or R-134a is	the manul i0 hours p Ma, which assumed	acturer applicability date er year. This provides ar is considered the most 1,300, as described by I	to comply with these standards. annual average kW demand savings. common refrigerant seen in self-contained IP 124. Efficient unit refrigerant is assumed
30 ≤ V < 50 ≤ V Note: V = in Octnote 1 United : update 2 The ref 3 The glc comme to be e (CARB)	0.1     0	ment of Energ 20. January 1, sumed to alw potential of be tos and freez ropane) or R- lanagement F	y, 10 CFR I 2010 and i rays be plug aseline unit ers. The GV 600a (Isob trogram, wl	Part 431, "Ene before March : gged in and op refrigerant as VP100 value fo utane), which nose assumpti	27, 2017 is the erating 876 sumes R-13 or R-134a is have GWP11 ons can be the	the manul i0 hours p 14a, which assumed 00 values found in ti	acturer applicability date er year. This provides ar is considered the most of 1,300, as described by I of 4 and 5 respectively, he attached file: "ARB Re	to comply with these standards. annual average KW demand savings. common refrigerant seen in self-contained
30 ≤ V < 50 ≤ V Note: V = in Footnote [1] United: update: [2] The ref [3] The glo comme to be e (CARB)	0.1     0	ment of Energ 20. January 1, sumed to alw potential of be tos and freez ropane) or R- lanagement F	y, 10 CFR I 2010 and i rays be plug aseline unit ers. The GV 600a (Isob trogram, wl	Part 431, "Ene before March : gged in and op refrigerant as VP100 value fo utane), which nose assumpti	27, 2017 is the erating 876 sumes R-13 or R-134a is have GWP11 ons can be the	the manul i0 hours p 14a, which assumed 00 values found in ti	acturer applicability date er year. This provides ar is considered the most of 1,300, as described by I of 4 and 5 respectively, he attached file: "ARB Re	to comply with these standards. annual average KW demand savings. common refrigerant seen in self-contained MP 124. Efficient unit refrigerant is assumed ber the California Air Resource Board

[4] The average refrigerant charge of "Stand alone (self-contained) refrig units," sourced from the California Air Resource Board (CARB) Refrigerant Management Program, whose sasumptions can be found in the attached file: "ARB Refrigerant Data.xlsx". See cell DI6 of worksheet "Refrigerant Leakage." Value used to three significant figures.

[5] Per Program Implementation Plan (PIP) No, 124

- (6) Loadshape derived from data in the California Commercial End-Lke Survey, Itron Inc., "California Commercial End-Lke Survey," prepared for California Energy Commission, March 2006. See reference file 'CA, CELS, COMM, DATA.xis/. "The California Commercial End-Lke Survey (CEUS) is a comprehense study of commercial building sector end-use energy use. Itron performed the survey under contract to the California Energy Commission (CEC), and with the support of Pacific Cas & Betric, San Dego Gas and Electric, Southern California Edison, Southern California Edison, Southern California Edison, Southern California Gas Company and the Sarcametor Munical Utility District. A stratified, and sum support 20 and Commercial facilities was targeted and a sample of 2,790 were actually completed. Commercial premises are weighted and aggregated to building segment results.
- [7] 2008 Database for Energy-Efficiency Resources (DEER), Version 2008.2.05, "Effective/Remaining Useful Life Values", California Public Utilities Commission, December 16, 2008. See reference file "Effective Useful Life EUL\_Summary\_10-1-08.xls".
- [8] Northwest Regional Technical Forum, ENERY STAR Version 4.0 Analysis. Refer to CostData&Analysis tab in ComRefrigeratorFreezer\_v4\_2.xdsm. These costs include the average cubic foot size from this analysis and applies to the Northwest RTF's average cost per cubic foot. Analysis can be found on Costs tab in EVT Commercial Reach In Refrigerator and Freezer Analysis June 2020.xdsx.
- [9] Calculated savings from baseline. See reference: EVT Commercial Reach In Refrigerator and Freezer Analysis June 2020.xlsx.
- [10] United States Department of Energy, 10 CFR Part 431, "Energy Conservation Standards for Commercial Refrigeration Equipment", January 1, 2010 and before March 27, 2017
- [11] ENERGY STAR, "ENERGY STAR Program Requirements for Commercial Refrigerators and Freezers", v4.0, Effective January 1, 2017.

# **Floating Head Pressure Control**

Measure Number: [F=12.6] Portfolio: 96 Status: Active Effective Date: 2017/1/1 End Date: [ None ] Program: Commercial & Industrial End Use: Refrigeration

Update Summary
- Measure is updated to replace savings deemed by manufacturer compressor listings with recent studies and savings for Floating Head Pressure Control

Referenced Documents
The main analysis file used as the basis for this measure, RTF, "Commercial: Grocery - Floating Head Pressure Controls for Single Compressor Systems
workbook.ComGroceryHPECIngleCompressor\_J\_1\_S.vkm, 2016 was developed for the Regional Technical Forum (RTF), a technical advisory committee
to the Northwest Hower and Conservation Council established in 1999 to develop standards to verify and evaluate energy efficiency savings by Portland
Energy Conservation, Inc. (PECI).

# The work was performed in support of a unitary condensing unit FHP measure developed by PECI for the RTF in 2010. In attempt to contact PECI for further details about the work it was learned that the original authors no longer work in the same capacity, and furthermore, PECI is no longer responsible for the management of the refrigeration programs for which the workbook originally served.

DEE2014-BLL-table-update, 2014-02-05.4sr.
 RTF, "Commercial: Grocery - Roating Head Pressure Controls for Single Compressor Sys Cond'CoveryPHC SingleCompressor yL\_5.4tem, 2016
 PP Savings Extrapolation.xtex

Description Description Installers conventionally design a refrigeration system to condense at a set pressure-temperature setpoint, typically 90 degrees. By installing a "floating head pressure control" condenser system, the refrigeration system can change condensing temperatures in response to different outdoor temperatures. This means that as the outdoor temperature drops, the compressor will not have to work as hard to reject heat from the cooler or freezer. This measure is for the application of floating head pressure controls for compressors s 10HP and a condensing temperature set to 70Hr. This measure is strictly limited to single compressor systems.

Baseline Efficiencies The baseline is a refrigeration system without floating head pressure control.

Efficient Equipment
High efficiency is a refrigeration system with floating head pressure control.

Algorithms Electric Demand Savings = ΔkWh / HOURS ΔkW

Symbol Table

Electric Energy Savings

ΔkWh = kWhee × HP

Floating Head Pressure Control kWh Savings per Horsepower (kWh/HP)<sup>[2]</sup>

	Temperature Range						
Unit Type	Low Temperature (Freezer)	Medium Temperature (Refrigerator)	Unknown Temperature <sup>[3]</sup>				
Self-Contained Unit (SCU)	793	703	732				
Remote Condensing Unit (RCU)	636	439	502				
Unknown Type <sup>[4]</sup>	715	571	617				

Symbol Table Fossil Fuel Savings

re:	
ΔkW	= Gross customer connected load kW savings for the measure (kW)
ΔkWh	<ul> <li>Gross customer annual kWh savings for the measure (kWh)</li> </ul>
HOURS	<ul> <li>Full load hours (7713 hours)<sup>[1]</sup></li> </ul>
HP	<ul> <li>Actual compressor horsepower.</li> </ul>
kWh <sub>HP</sub>	<ul> <li>kWh per horsepower (value from savings table in Reference Tables section)</li> </ul>

## **Operating Hours**

Operating hours that produce savings from a floating head pressure control system will correlate with outside air temperature. When temperatures are below the condensing setpoint, the controls will operate. For a set point of 70°F, the operating hours are 7713.<sup>[1]</sup>

### Load Shapes

70011000								
Number	Name	Status	Winter On kWh	Winter Off kWh	Summer On kWh	Summer Off kWh	Winter kW	Summer kW
70	Floating Head Pressure Control	Active	33.3%	37.1%	12.9%	16.8%	100.0%	0.0%

## Net Savings Factors

Measures RFRFHCON Refrigeration floating head pressure controls

### Tracks [Base Track] 6012CNIR [is base track] C&I Retro

6013CUST [is base track] Cust Equip Rpl

 Track Name
 Track Nr.
 Measure Code Free Rider Spill Over

 C&I Retro
 6012CNIR
 RFRHCON
 0.94
 1.00

 Cust Equip Rpl 6013CUST RFRFHCON
 0.94
 1.00

Persistence The persistence factor is assumed to be one.

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Lifetimes 15 years.<sup>[5]</sup>

## Measure Cost Roating Head Pressure Control Costs per Horsepower (\$/HP)<sup>[6]</sup>

		Temperature Range	1	
Unit Type	Low Temperature (Freezer)	Medium Temperature (Refrigerator)	Unknown Temperature <sup>[3]</sup>	
Self-Contained Unit (SCU)	\$296	\$390	\$360	
Remote Condensing Unit (RCU)	\$157	\$207	\$191	
Unknown Type <sup>[4]</sup>	\$227	\$299	\$275	

## Water Descriptions

There are no water algorithms or default values for this measure.

## Reference Tables

## Footnotes

- [1] Annual average of hours for Vermont that temperature is below 70°F. This is the condensing temperature that is set for the floating head pressure control as required by EVT. Hours are deemed from TMY3 weather data for Vermont. See "FHP Savings Extrapolation.xisx" for further details.
- [2] Derived from RTF saving estimates for the NW climate zone and extrapolated to Vermont climate zone by using cooling degree-days. RTF, "Commercial: Grocery - Floating Head Pressure Controls for Single Compressor Systems", workbook ComGroceryFPPCSingleCompressor\_v1\_5.xtsm, 2016.
- [3] Unknown values based on weighted average; 2010 ASHRAE Refrigeration Handbook, page 15.1 "Medium- and low-temperature display refrigerator line-ups account for roughly 68% and 32%, respectively, of a typical supermarket's total display refrigerators."
- [4] For unit type unknown, it is assumed 50/50 split of self-contained and remote condensing units.
- [5] California DEER 2014 Effective Useful Life (EUL) table. See Reference file "DEER2014 EUL Table Update.xlsx".
- [6] Costs are based on number of additional valves per condenser motor for different HP ratings and includes installation labor costs. Costs are averaged and shown on a per HP basis. See reference file RTF, "Commercial: Grocery - Floating Head Pressure Controls for Single Compressor Systems", workbook. Com/Grocery/FASSingle:Compressor, U\_Skim, 2016.

# **High Efficiency Condensing Units**

Measure Numbe	er: I-E-14 d
Portfolio:	
Status:	Active
Effective Date:	2021/1/1
End Date:	[ None ]
Program:	Commercial & Industrial
End Lico:	Pofrigoration

Update Summary For 2021, adding fractional compressor horsepower options (0.5 and 0.75 HP), as well as 5.5 and 6.0 HP options to the program. Original TRM supporting work had already established savings and inputs for the larger capacities, but the offering was limited to 5 HP and lower units. Thus, this update is simply equanding the inpact summary tables to now show 5.5 and 6.0 HP units. Fractional horsepower options also rely on previous workd and are extrapolations.

### Referenced Documents

ool v5d\_Modified for HECU TRM : contains the template of the analysis tool used to establish savings for this meas Trenton Data & Heatcraft Data: product data sheets from which capacities were derived for analysis

HECU Capacity Inputs and Savings Outputs 2021: outlines the methodology to determine average capacities from product data and summ analysis outputs from the analysis tool

HECU Connected kW Load Savings 2021: shows the derivation of connect load savings for this measure

HECU Compressor Fan Loadshape F: shows the derivation of the custom loadshape developed for HECU compressor fan energy and demand say HECU Incremental Costs 2021: outlines the methodology used to establish incremental costs

Trenton Data
 Heatcraft Data
 Refrigeration Analysis Tool V5d\_Modified for HECU TRM
 HECU Compressor Fan Loadshape F
 HECU Incremental Costs 2021

- HECU Connected kW Load Savings 2021
   HECU Capacity Inputs and Savings Outputs 2021

# Description

Description
This characterization captures the savings attributed to an upstream commercial refrigeration condensing unit initiative capitalizing on market
opportunities to drive the installation of efficient condensing units instead of standard baseline units. Applicable to condensing units serving Low (0°F) and
Medium (22°F) conditioned environments, an efficient consering unit is instead of units incorporating three requisite attributes: an efficient consering unit is instead of units incorporating three requisite attributes: an efficient consering unit is devined by units incorporating three requisite attributes: an efficient consering unit is devined value attributes and efficient scroll compressor, floating head pressure controls, and modulating compressor fan speed capital structures assumed, however some units are capital with a variable geed drives that valued realize additional saving). The collisities effect of these three features realits in the renfigeration load requirements being met while using less power as compared to a baseline unit. Units with compressor horsepower
ratings in the range of 1-6hg are eligible to participate in the upstream initiative. Eligibility is imited to outdoor units. Savings claimed assume the efficient
unit replaces abaseline outdoor unit, however it's worth noting that a customer replacing an indoor unit with an outdoor unit would likely realize
additional savings.

As illustrated in the following sections, prescriptive deemed savings will be claimed based on a unit's temperature application, power phase requirer and compressor horsepower rating. Of note is that for the purposes of the TRM, horsepower ratings are specific in 1/2 horsepower increments. It it believed that most eligible units will may nearly to an established horsepower category, however in the event a qualifying unit fails somewhere in the middle of an established category, it will be assigned to the closest category with the most conservative total kWh savings.

### **Baseline Efficiencies**

Descente Enforcements A baseline condensing unit is one with a standard compressor efficiency rating (as defined and established by EVT's Refrigeration Analysis Tool), no floating head pressure controls, and single speed compressor fan motors.

### Efficient Equipment

ing Units must have scroll compressor technology, incorporate floating head pressure controls, and have the ability to modulate High Efficiency Conden compressor fan speed.

### Algorithms

AUGOTIONIS Electric Demand Savings A full deviation of demand savings is shown in reference file "HECU Connected WU Load Savings." The tabulated energy saving values for each of the three components (scoil compressor, compressor fans, floating head pressure contols) was divided by their respective annual full load operating hours, as described in the following table. Note that final tabulated savings outcomes for Medium temperature units are a blend to account for installations assumed to occur in systems that have pre-oxisting economizers installated. The 2016 Vermome Business Sector Market Characterization and Assessment Study (cadmus, 2017) reports that about 22% of walk-in coolers in EVT territory have economizers Accounting for the fact that HECUs have many additional applications, including builts thats and closed cases for example, where economizer use is not possible, EVT will assume that 10% of installations through the program occur on systems equipped with economizers.

Component	Annual Full Load Operating Hours	Source
Scroll Compressor	2913.35171232877 (w/Economizer), 3910 (w/o Economizer)	EVT Refrigeration Analysis Tool (CATInput worksheet)
Compressor Fan(s)	6087	As derived in HECU Compressor Fan Loadshape F
Eloating Head Pressure Controls	7221	EVT Refrigeration Analysis Tool (CATInnut worksheet)

Temp	Phase	HP	Scroll Compressor	Condenser Fan(s)	<b>Floating Head Pressure Controls</b>	Total
		0.5	0.11762	0.03342	0.05259	0.20363
		0.75	0.17643	0.05013	0.07888	0.30542
		1	0.21997	0.07605	0.12982	0.42584
		1.5	0.16477	0.08149	0.15421	0.40046
		2	0.19216	0.09504	0.17984	0.46703
		2.5	0.22508	0.11132	0.21065	0.54705
	1	3	0.21755	0.14153	0.28241	0.64149
		3.5	0.30964	0.16165	0.30956	0.78085
		4	0.34246	0.17879	0.34237	0.86361
		4.5	0.34856	0.18197	0.34847	0.87899
		5	0.25508	0.18916	0.38505	0.82928
		5.5	0.27098	0.20095	0.40906	0.88098
Medium		6	0.29003	0.24856	0.51558	1.05417
Medium		0.5	0.08264	0.03017	0.04916	0.16198
		0.75	0.12397	0.04525	0.07375	0.24294
		1	0.15623	0.06806	0.11695	0.34124
		1.5	0.13245	0.07799	0.14330	0.35374
		2	0.15447	0.09095	0.16712	0.41254
		2.5	0.18093	0.10654	0.19576	0.48322
	3	3	0.18620	0.13028	0.24637	0.56283
		3.5	0.27717	0.14907	0.26912	0.69534
		4	0.30654	0.16487	0.29764	0.76904
		4.5	0.31200	0.16780	0.30294	0.78274
		5	0.27084	0.18512	0.34883	0.80477
		5.5	0.28773	0.19666	0.37058	0.85496
		6	0.30695	0.22553	0.42958	0.96205
		0.5	0.02888	0.02241	0.04157	0.09286
		0.75	0.04332	0.03362	0.06236	0.13930
		1	0.05776	0.04482	0.08315	0.18574

		1.5	0.08895	0.06433	0.11805	0.27134
		2	0.12604	0.09116	0.16728	0.38449
		2.5	0.11317	0.10645	0.20257	0.42219
	1	3	0.12627	0.11877	0.22601	0.47105
		3.5	0.15284	0.14376	0.27357	0.57016
		4	0.14442	0.14687	0.28200	0.57329
		4.5	0.15564	0.15828	0.30390	0.61783
		5	0.17356	0.17651	0.33889	0.68896
		5.5	0.23952	0.19129	0.35632	0.78712
w	6	0.28600	0.22841	0.42547	0.93988	
		0.5	0.02388	0.02036	0.03782	0.08206
		0.75	0.03582	0.03054	0.05673	0.12310
		1	0.04776	0.04073	0.07564	0.16413
		1.5	0.06397	0.05854	0.10972	0.23224
		2	0.09065	0.08296	0.15547	0.32908
		2.5	0.09374	0.09918	0.18896	0.38187
	3	3	0.10458	0.11065	0.21082	0.42606
		3.5	0.12659	0.13394	0.25518	0.51571
		4	0.15581	0.14292	0.26794	0.56668
		4.5	0.16792	0.15403	0.28875	0.61070
		5	0.18725	0.17176	0.32200	0.68101
		5.5	0.24354	0.18914	0.34672	0.77940
		6	0.29081	0.22584	0.41401	0.93066

 6
 0.23961
 0.22584
 0.41401
 0.33066

 Electric Energy Swings
 Electric Energy Swings
 Electric Energy Swings
 Electric Energy Swings

 As described in full detail in the reference file "Refrigeration Analysis Tool vicit Orderators for High Efficiency Condensing Units were established by running treatorism Intry Tsefforsation Analysis Tool, with condentations for differences in refrigeration temperature environment, capacity, single or three-phase power requirements, and the existence of an economizer. For the pruposes of screening and, the savings for each component will be treated separatively against its respective loadshape, as described in the Load Shapes section below. The following table outlines the energy savings (WhN) associated with each specified unit:

Гетр	Phase	HP	Scroll Compressor	Condenser Fan(s)	<b>Floating Head Pressure Controls</b>	Total
		0.5	448.2	203.4	379.7	1031.3
		0.75	672.2	305.1	569.6	1547.0
		1	838.1	462.9	937.5	2238.5
		1.5	627.8	496.0	1113.5	2237.4
		2	732.2	578.5	1298.6	2609.3
		2.5	857.6	677.6	1521.1	3056.3
	1	3	828.9	861.5	2039.3	3729.7
		3.5	1179.8	984.0	2235.4	4399.1
		4	1304.9	1088.3	2472.3	4865.4
		4.5	1328.1	1107.7	2516.3	4952.1
		5	971.9	1151.4	2780.5	4903.8
		5.5	1032.5	1223.2	2953.8	5209.5
		6	1105.1	1513.0	3723.0	6341.1
ledium		0.5	314.9	183.6	355.0	853.5
			472.3	275.4	532.5	1280.3
		1	595.3	414.3	844.5	1854.1
		1.5	504.7	474.7	1034.8	2014.2
		2	588.6	553.6	1206.8	2349.0
		2.5	689.4	648.5	1413.6	2751.4
	3	3	709.4	793.0	1779.0	3281.5
	5	3.5	1056.0	907.4	1943.3	3906.7
		4	1168.0	1003.5	2149.3	4320.8
		4.5	1188.8	1021.4	2187.6	4397.8
		4.5 5	1032.0	1021.4	2518.9	4677.6
		5.5	1096.3			4969.3
				1197.1	2675.9	
		6	1169.5	1372.8	3102.0	5644.4
		0.5	119.5	136.4 204.6	300.2	556.2 834.3
			179.3			
		1	239.1	272.8	600.4	1112.3
		1.5	368.1	391.6	852.5	1612.2
		2	521.7	554.9	1208.0	2284.5
		2.5	468.4	648.0	1462.8	2579.2
	1	3	522.6	722.9	1632.0	2877.6
		3.5	632.6	875.1	1975.4	3483.1
		4	597.8	894.0	2036.3	3528.1
		4.5	644.2	963.5	2194.5	3802.2
		5	718.4	1074.4	2447.1	4239.9
		5.5	991.4	1164.4	2573.0	4728.7
		6	1183.7	1390.3	3072.3	5646.4
		0.5	98.8	123.9	273.1	495.9
		0.75	148.3	185.9	409.7	743.8
		1	197.7	247.9	546.2	991.8
		1.5	264.8	356.4	792.3	1413.4
		2	375.2	505.0	1122.7	2002.8
		2.5	388.0	603.7	1364.5	2356.1
	3	3	432.9	673.5	1522.3	2628.7
		3.5	523.9	815.3	1842.7	3181.9
		4	644.9	870.0	1934.8	3449.7
		4.5	695.0	937.6	2085.1	3717.7
		5	775.0	1045.5	2325.1	4145.7
						4553.0
		5.5	1008.0	1151.3	2503.7	4663.0

Not applicable.

Load Shapes Loadshape 14a will be used to capture the coincident peak energy and demand savings attributed to the energy savings associated with the scroll compressor.

Loadshape 70a will be used to capture the coincident peak energy and demand savings attributed to the energy savings associated with floating head pressure controls.

The custom loadshape described below will be used to capture the coincident peak energy and demand savings attributed to low speed compres operation. A full derivation of this loadshape is available in the reference file \*IECU Compressor Fan Loadshape F\*.

			Energy		Dema	and	
Winte	er Peak	Winter Off-Peak	Summer Peak	Summer Off-Peak	Winter	Summer	
Oct-M 11pm	lay, 7am- , M-F	Oct-May, Weekends all day and 11pm-7am, M-F	Jun-Sept, 7am- 11pm, M-F	Jun-Sept, Weekends all day and 11pm-7am, M- F	Dec-Jan, 5pm-7pm, M-F, non-holiday	Jun-Aug, 1pm-5pm, M-F, non-holiday	FLH
40.09	196	47.99%	4.09%	7.84%	100.00%	1.15%	6087.00

# 14a Commercial Refrigeration 70b Floating Head Pressure Control

	Name	Status	On kWh		On kWh	Summer Off kWh	kW	kW
14 Co	nmercial Refrigeration	Active	33.0%	32.6%	17.0%	17.4%	69.0%	77.2%
70 Flo	ating Head Pressure Contro	ol Active	33.3%	37.1%	12.9%	16.8%	100.0%	0.0%
Net Savi	ngs Factors							
leasures								
	Outdoor High Efficiency Con	densing Un	it					
racks [Bas	-							
6013UPST [is	base track] Upstream - C	ommercial						
<b>ifetimes</b> The expected	neasure life is 13 years, co	onsistent w	ith EVT's c	ustom refr	igeration a	nalysis assu	umptions	for a scroll
	neasure life is 13 years, co	onsistent w	ith EVT's c	ustom refr	igeration a	nalysis assu	umptions	for a scroll
he expected		onsistent w	ith EVT's c	ustom refr	igeration a	nalysis assu	umptions	for a scroll
The expected	Cost				-			
The expected Measure Incremental co	Cost sts are established based				-			
Measure noremental co	Cost sts are established based Incremental Cost				-			
Measure noremental co Horsepower 0.5	Cost sts are established based Incremental Cost \$52.10				-			
Measure noremental co Horsepower 0.5 0.75	Cost sts are established based Incremental Cost \$52.10 \$126.30				-			
Measure noremental co Horsepower 0.5	Cost           sts are established based           Incremental Cost           \$52.10           \$126.30           \$200.50				-			
Measure Incremental co Horsepower 0.5 0.75 1.0	Cost sts are established based Incremental Cost \$52.10 \$126.30				-			
Measure neremental co Horsepower 0.5 0.75 1.0 1.5	Cost           ats are established based           Incremental Cost           \$52.10           \$126.30           \$200.50           \$348.90				-			
Measure noremental or Horsepower 0.5 0.75 1.0 1.5 2.0	Cost           sts are established based           Incremental Cost           \$52.10           \$126.30           \$200.50           \$348.90           \$600.00				-			
he expected <b>Veasure</b> noremental or <b>Horsepower</b> 0.5 0.75 1.0 1.5 2.0 2.5	Cost           sts are established based           hcremental Cost           \$52.10           \$126.30           \$200.50           \$348.90           \$600.00           \$586.50				-			
The expected <b>Veasure</b> Incremental co <b>Horsepower</b> 0.5 0.75 1.0 1.5 2.0 2.5 3.0	Cost es are established based fsz.10 \$126.30 \$200.50 \$348.90 \$600.00 \$586.50 \$573.00				-			
The expected <b>Measure</b> Incremental co <b>Horsepower</b> 0.5 0.75 1.0 1.5 2.0 2.5 3.0 3.5	Incremental Cost           \$22.10           \$126.30           \$200.50           \$348.90           \$500.60           \$573.00           \$899.00				-			
Ne expected Veasure noremental or Horsepower 0.5 0.75 1.0 1.5 2.0 2.5 3.0 3.5 4.0	Cost as are established based \$52.10 \$200.50 \$248.30 \$586.50 \$585.50 \$573.00 \$999.00 \$1225.00				-			
he expected Veasure noremental or Horsepower 0.5 0.75 1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5	Cost bs are established based \$52.10 \$126.30 \$348.90 \$600.00 \$573.00 \$973.00 \$999.00 \$1225.00 \$1228.50				-			

Footnotes
[1] On August 21, 2017 several Efficiency Vermont staff members met with FW Webb representatives in Rutland, VT. Representing FW Webb were 2
General Managers (Darrell Read and Brian Bradley) as well as the Director of Refrigeration (Rich Boynton) and Business Development Manager (Chuck
Fiorino). During this meeting, cost information comparing standard (non-controlled, hermetic compressor) condenses and premium efficiency
condenses (floating head pressure controls and scroll compressory) was shared for compressory rated at 2,3,4 and 5 horsepower. The costs for
other capacities were extrapolated per the methods outlined in the referenced document "HECU Incremental Costs.visx".

# **Refrigerated Case Covers** Measure Number: I-E-2 c

Portfolio:	93
Status:	Active
Effective Date:	2017/1/1
End Date:	[ None ]
Program:	Commercial & Industrial
End Use:	Refrigeration

Update Summary

• Measure updated to utilize the U.S. Department of Energy, Energy Conservation Standards for Commercial Refrigeration Equipment Engine
Spreadsheet
• Measure updated to utilize more recent Measure Cost and case cover efficiencies

### Referenced Documents

- Referenced Documents
  Northwest Regional Technical Forum, Commercial Grocery Strip Curtain analysis, 2016. "ComGroceryStripCurtain, v1\_6.vtsm".
  PG8E, "NigH Covers for Open Vertical and Horizontal Display Cases (Low and Medium Temperature Cases)", Work Paper PGECOREF101, July 2014.
  PG8E, "Strip Curtains for Doorways to Refingerated Storage", Work Paper PGECOREF103, May 2012.
  EVT Refingeration Analysis Tool V5D
  Refingerated Case Covers Study 2016 v2.vlsx:

Description
By covering refrigerated cases, the heat gain due to the spilling of refrigerated air and convective mixing with room air is reduced at the case opening.
Strip curtains can be deployed continuously and allow the customer to reach through the curtain to select the product. Continuous curtains can be pulled
down overright while the store is closed. Strip curtains are not used for low temperature, multi-deck applications. Gass door retrofits are a better
choice for these applications.

# Algorithms

	rithms ic Demand Sav	lings
∆kW		= (HG $\times$ EF $\times$ CL $\times$ DF) / (EER $\times$ 1000)
Symbo	ol Table	
Electri	c Energy Savi	ngs
∆kW	h	= $\Delta kW \times Usage \times 365$
Symbo	ol Table	
Fossil	Fuel Savings	
Where:		
	ΔkW	= Gross customer connected load kW savings for the measure (kW)
	ΔkWh	<ul> <li>Gross customer annual kWh savings for the measure (kWh)</li> </ul>
	1000	<ul> <li>Conversion from watts to kW (W/kW)</li> </ul>
	365	= Days / Year
	CL	<ul> <li>Refrigerated case length in feet (ft). Case length is the open length of the refrigerated box. If the unit is two sided use the open length of both sides.</li> </ul>
	DF	= Disabling Factor to account for the portion of the time that the strip curtain is intentionally disabled, as well as time to access the product. The Disabling factor is assumed to be 80% for strip curtains and 100% for continuous case covers. <sup>[1]</sup>
	EER	= Compressor efficiency (Btu/hr-watt). The average compressor efficiency (EER) is 11.36 for medium temperature applications (case temperature 10°F to 40°F) and 17.7 for high temperature applications (case temperature 45°F to 65°F). <sup>[2]</sup>
	EF	= Efficiency Factor: Fraction of heat gain prevented by case cover. The Efficiency Factor for strip curtains is $0.82^{[1]}$ The Efficiency Factor for continuous covers is $0.50.[4]$
	HG	<ul> <li>Loss of cold air or heat gain for refrigerated cases with no cover (Btu/hr-ft opening). The heat gain is 734 for open cooler applications.<sup>[5]</sup></li> </ul>
	Usage	<ul> <li>Average hours per day that case cover is in place (hrs/day). Assume 24 hrs/day for strip curtains. Assume 8 hours per day for continuous covers.</li> </ul>

Baseline Efficiencies The baseline condition is a refrigerated case without a cover.

Efficient Equipment High efficiency is a refrigerated case with a strip curtain or night cover High effici

Load Shapes Source: Strip curtain uses the same energy distribution as the previously-developed commercial refrigeration loadshape in Vermont State Cost-Effectivenes: Screening Tool. Coincident factors for strip curtains are set at 100% since the calculated kW savings is an average for every hour. The night case covers loadshape is based on the savings occurring from 11 PM to 7 AM.

# 67a Strip Curtain 77a Refrigeration Night Covers

Number	Name	Status				Summer Off kWh		Summer kW
67	Strip Curtain	Active	33.0%	32.6%	17.0%	17.4%	100.0%	100.0%
77	Refrigeration Night Covers	Active	6.0%	60.6%	3.0%	30.4%	0.0%	0.0%

Net Savings F	actors
Measures	

Measures RFRCOVER Refrigerator covers

Tracks [Base Track] 6013PRES [is base track] Pres Equip Rpl

6014PRES [is base track] 6014PRES

 Track Name
 Track Nr.
 Measure Code
 Free Rider Spill Over

 Pres Equip Rpl 6013PRES RFRCOVER
 0.95
 1.00

6014PRES 6014PRES RFRCOVER 0.95 1.05

Persistence The persistence factor is assumed to be one.

Lifetimes Strip curtains: 4 years

Continuous covers: 5 years

# Measure Cost

Typically costs are approximately \$42/ft for continuous curtains<sup>[4]</sup> and \$40/ft for strip curtains.<sup>[6]</sup>

O&M Cost Adjustments Strip curtains require regular cleaning -- \$4.33/yr-ft (1 minute/foot every two weeks at \$10/hr). Continuous curtains require that they are pulled down nightly – \$2.53/yr-ft (5 sec. per 4-foot section, twice per day, at \$10/hr)

Fossil Fuel Descriptions There are no fossil fuel algorithms or default values for this measure.

# Water Descriptions There are no water algorithms or default values for this measure.

# Reference Tables Demand and Energy Savings for Strip and Continuous Refrigeration Covo

	Scrip and conclinuous Reingeration Covers.							
		Refrigerated Space Temperature						
Cover Type	Medium Temp	(10°Fto 40°F)	High Temp (45°F to 65°F)					
	Demand Savings (ΔkW/ft)	Annual Energy Savings (ΔkWh/ft)	Demand Savings (ΔkW/ft)	Annual Energy Savings (ΔkWh/ft)				
Strip Curtains	0.041	363	0.027	238				
Continuous (Night Cover)	0.032	92	0.021	61				

Footnotes

ment established January 2006. Reviewed June 2016. [1] TAG agreer

[2] Average EER values were calculated as the average of standard reciprocating and discus compressor efficiencies, using a typical condensing temperature of SOPE and saturated suction temperatures (SST) of 20PE for medium temperature applications and 4SPE for high temperature applications. ERIs is developed in DTP Temperatoria Analysis Tool VXPE, as seen on the "Overall EERs" summary tab. Values are developed using data from Emerson Climate Technology software. Last updated November 2013.

[3] Calculated from the average effectiveness against infiltration or reduction of heat infiltration pre and post strip curtain installation. Derived in Northwest Regional Technical Forum, Commercial Grocery Strip Curtain analysis, 2016. See reference file "ComGroceryStrip\_v1\_6.stsm", Values on tab "Cooling Lack Culc".

[4] PG&E, "NgHt Covers for Open Vertical and Horizontal Display Cases (Low and Medium Temperature Cases)", Work Paper PGECOREF101, July 2014. Page 7, Section 4.3.

[5] Calculated from the average baseline (no cover) infiltration of commercial coolers. Derived in Northwest Regional Technical Forum, Commercial Grocery Strip Curtain analysis, 2016. See reference file "ComGroceryStrip\_v1\_6.xism". Value on tab "Cooling Load Calc".

[6] Cost per linear foot derived with the assumption that a typical display case merchandise cooler has an internal height of 4 feet and costs per square foot is \$10 as listed in the following reference. FG8E, "Strip Curtains for Doorways to Refrigerated Storage", Work Paper RECOREF103, Hey 2012. Page 31, Section 4.3.

[7] Labor rate of \$10/hour is effective in the state of Vermont as of January 1, 2017. Rate is based on Vermont Department of Labor, "Establishment of Minimum Wage", Section 384, Chapter 5, Title 21, Subsection (a).

[8] For detailed calculation of demand and energy savings see reference file "Refrigerated Case Covers Study 2016 v2.xlsx"

# **ENERGY STAR Commercial Ice Makers**

Portfolio:	DUT TOM DO	rtfolio 2018-09	
Status:	EVI TRM Po Active	0.010 2018-03	
Status: Effective Date:			
	[ None ]		
Program:	Commercial	9. Inductrial	
End Use:	Refrigeration		
Ipdate Sum		the federal standard	effective in January 2018, to the efficient criteria to reflect the ENERGY STAR 3.0 specification, a
the incremental			· · · · · · · · · · · · · · · · · · ·
eferenced	Docume	nts	
			Use of Commercial Ice-Cube Machines and Quantify
			(DEER), Version 2008.2.05, "Effective/Remaining Use
		upment Calculator_ ice-makers-analysis	
<ul> <li>everenergy-su</li> </ul>	il -commercial-	ice-makers-analysis	100-2013
escription			
			RGY STAR-qualified commercial continous ice machine. This measure applies to air-cooled, cube-
			ned, and remote-condensing units and excludes flake and nugget type ice machines. This measure
ould relate to the cludes batch typ		n existing unit at the	end of its useful life, or the installation of a new system in a new or existing building. This measu
his measure was nould be verified.		be applicable to the	following program types: TOS and NC. If applied to other program types, the measure savings
iouid de venned.			
lgorithms	Cardona		
lectric Deman			
		(())00000000000000000000000000000000000	
ΔkW		n / ( HOURS × DC)	
ΔkW Symbol Table		n / ( HOURS × DC)	
	= ΔkWł	n / ( HOURS × DC)	
Symbol Table	= ΔkWł Savings	h / ( HOURS × DC)	× (DC × H) × 365
Symbol Table	= ΔkWł Savings		× (DC × H) × 365
Symbol Table	= ΔkWł Savings		$\times$ (DC $\times$ H) $\times$ 365
Symbol Table	= ΔkWł Savings		× (DC × H) × 365
Symbol Table lectric Energy ΔkWh	= ΔkWł Savings	h <sub>base</sub> - kWh <sub>ee</sub> )/ 100)	$\times$ (DC $\times$ H) $\times$ 365 onnected load XW savings for the measure (XW)
Symbol Table lectric Energy	= ΔkWł Savings	h <sub>oaze</sub> - kWh <sub>es</sub> )/ 100) Gross customer c Gross customer a	onnected load KW savings for the measure (KW) nnual KWh savings for the measure (KWh)
Symbol Table lectric Energy ΔkWh /here: ΔkW ΔkWh 100	= ΔkWł Savings	h <sub>ease</sub> - kWh <sub>eo</sub> )/ 100) Gross customer c Gross customer a Factor to convert	onnected load KW savings for the measure (KW)
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Symbol Table lectric Energy ΔkWh /here: ΔkW ΔkWh 100	= ΔkWł Savings	h <sub>ease</sub> - kWh <sub>eo</sub> )/ 100) Gross customer c Gross customer a Factor to convert	onnected load KW savings for the measure (KW) nnual KWh savings for the measure (KWh) KWhbase and KWhee into maximum KWh consumption per pound of ice
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Symbol Table lectric Energy ΔkWh /here: ΔkWw ΔkWh ΔkWh ΔkWh ΔkWh ΔkWh ΔkWh ΔkWh ΔkWh ΔkWh	= ΔkWł Savings	h <sub>base</sub> - kWh <sub>ba</sub> )/ 100) Gross customer c Gross customer a Factor to convert Days per year Duty cycle of the t 0.57	onnected load KW savings for the measure (KW) nnual KWh savings for the measure (KWh) KWhbase and KWhee into maximum KWh consumption per pound of ice ce maching <sup>(1)</sup>
Symbol Table lectric Energy ΔkWh /here: ΔkW ΔkW ΔkW ΔkW ΔkW ΔkW ΔkW ΔkW	= ΔkWł Savings	Gross customer c Gross customer a Factor to convert Days per year Duty cycle of the 1 0.57 Harvest Rate (poc	onnected load KW savings for the measure (KW) nnual KWh savings for the measure (KWh) KWhbase and KWhee into maximum KWh consumption per pound of ice ce machine <sup>(1)</sup> unds of ice made per day)
Symbol Table lectric Energy ΔkWh /here: ΔkWw ΔkWh ΔkWh ΔkWh ΔkWh ΔkWh ΔkWh ΔkWh ΔkWh ΔkWh	= ΔkWł Savings	Gross customer c Gross customer a Factor to convert Days per year Duty cycle of the 1 0.57 Harvest Rate (poc	onnected load KW savings for the measure (KW) nnual KWh savings for the measure (KWh) KWhbase and KWhee into maximum KWh consumption per pound of ice ce maching <sup>(1)</sup>
Symbol Table lectric Energy ΔkWh /here: ΔkWw ΔkWh ΔkWh ΔkWh ΔkWh ΔkWh ΔkWh ΔkWh ΔkWh ΔkWh	= ΔkWł Savings	Gross customer c Gross customer a Factor to convert Days per year Duty cycle of the 1 0.57 Harvest Rate (poc	onnected load KW savings for the measure (KW) nnual KWh savings for the measure (KWh) KWhbase and KWhee into maximum KWh consumption per pound of ice ce machine <sup>(1)</sup> ands of ice made per day) est rates use to calculate KW and KWh savings, see reference table #2 below
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Symbol Table lectric Energy AWW AWW AWW AWW AWW 100 365 DC H	= ΔkWł Savings	Gross customer c Gross customer a Factor to convert Days per year Duty cycle of the 1 0.57 Hanvest Rate (poc For assumed harm	onnected load KW savings for the measure (KW) nnual KWh savings for the measure (KWh) KWhbase and KWhee into maximum KWh consumption per pound of ice ce machine <sup>(1)</sup> ands of ice made per day) est rates use to calculate KW and KWh savings, see reference table #2 below
Symbol Table lectric Energy AWW AWW AWW AWW AWW 100 365 DC H	= ΔkWł Savings	Gross customer o Gross customer o Factor to convert Daty cycle of the I 0.57 Harvest Rate (poo For assumed han Annual operating 8760	onnected load KW savings for the measure (KW) nnual KWh savings for the measure (KWh) KWhbase and KWhee into maximum KWh consumption per pound of ice ce machine <sup>(1)</sup> ands of ice made per day) est rates use to calculate KW and KWh savings, see reference table #2 below
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Symbol Table lectric Energy AWW here: AWW AWW 100 265 0 2 0 H HOURS	= ΔkWł Savings	Gross customer c Gross customer a Factor to convert Days per year Duty cycle of the 1 0.57 Harvest Rate (po. For assumed han Annual operating 8760 Maximum KWh cc Calculated using 1	onnected load kW savings for the measure (kW) nnual kWh savings for the measure (kWh) WHbase and kWhee into maximum kWh consumption per pound of ice ce machine <sup>(1)</sup> ands of ice made per day) vest rates use to calculate kW and kWh savings, see reference table #2 below hours <sup>(2)</sup>
Symbol Table lectric Energy AWW here: AWW AWW 100 265 0 2 0 H HOURS	= ΔkWł Savings	Gross customer o Gross customer a Factor to convert Days per year Duty cycle of the 10.57 Harvest Rate (poo For assumed han Annual operating 8760 Maximum kWh co Calculated using 1 equipment. See	onnected load KW savings for the measure (KW) nnual KWh savings for the measure (KWh) KWhbase and KWhee into maximum KWh consumption per pound of ice ce machine <sup>[1]</sup> ands of ice made per day) est rates use to calculate KW and kWh savings, see reference table #2 below hours <sup>[2]</sup> rsumption per 100 pounds of ice for the baseline equipment the algorithms in reference table #1 below and the assumed harvest rate (if) of the efficient reference table #2 for calculated KWh <sub>base</sub> values.
Symbol Table loctric Energy AWW AWW AWW 100 365 DC DC H H HOURS KWhbase	= ΔkWł Savings	Gross customer o Gross customer o Gross customer a Factor to convert Days per year Duty cycle of the I 0.57 Harvest Rate (poo For assumed han Annual operating 8760 Maximum NV/h cc Calculated using Calculated using	onnected load KW savings for the measure (KW) nnual KWh savings for the measure (KW) KWhbase and KWhee into maximum KWh consumption per pound of ice ce machine <sup>(1)</sup> ands of ice made per day) vest rates use to calculate KW and KWh savings, see reference table #2 below hours <sup>(2)</sup> nsumption per 100 pounds of ice for the baseline equipment the algorithms in reference table #1 below and the assumed harvest rate (H) of the efficient reference table #2 for calculated KWh <sub>base</sub> values. nsumption per 100 pounds of ice for the efficient equipment
Symbol Table loctric Energy AWW AWW AWW 100 365 DC DC H H HOURS KWhbase	= ΔkWł Savings	Gross customer o Gross customer o Gross customer a Factor to convert Daty cycle of the 0.57 Harvest Rate (pox For assumd harvest Annual operating 8760 Maximum NWh cc Calculated using 1 equipment. See Maximum NWh cc	onnected load XW savings for the measure (XW) nnual XVh savings for the measure (XVh) XVhbase and XVhee into maximum XVh consumption per pound of ice ce machine <sup>[1]</sup> inds of ice made per day) west rates use to calculate XV and XVh savings, see reference table #2 below hours <sup>[2]</sup> rsumption per 100 pounds of ice for the baseline equipment he algorithms in reference table #1 below and the assumed harvest rate (H) of the efficient reference table #2 for calculated XVh <sub>base</sub> values. nsamption per 100 pounds of ice for the deficient equipment he algorithms in reference table #2 below and the assumed harvest rate (H) of the efficient efficience table #2 below and the assumed harvest rate (H) of the efficient
Symbol Table loctric Energy AWW AWW AWW 100 365 DC DC H H HOURS KWhbase	= ΔkWł Savings	Gross customer o Gross customer o Gross customer a Factor to convert Daty cycle of the 0.57 Harvest Rate (pox For assumd harvest Annual operating 8760 Maximum NWh cc Calculated using 1 equipment. See Maximum NWh cc	onnected load KW savings for the measure (KW) nnual KWh savings for the measure (KW) KWhbase and KWhee into maximum KWh consumption per pound of ice ce machine <sup>(1)</sup> ands of ice made per day) vest rates use to calculate KW and KWh savings, see reference table #2 below hours <sup>(2)</sup> nsumption per 100 pounds of ice for the baseline equipment the algorithms in reference table #1 below and the assumed harvest rate (H) of the efficient reference table #2 for calculated KWh <sub>base</sub> values. nsumption per 100 pounds of ice for the efficient equipment

The baseline equipment is as rds effective on January 28, 2018. al ice

High Efficiency The efficient equipment is assumed to be a new co ina the mir num ENERGY STAR Version 3.0 efficiency leve cial co us ice m

Number	Name		Status			Summer On kWh		Winter kW	Summer kW
14	Commercial Re	frigeration	Active	33.0%	32.6%	17.0%	17.4%	69.0%	77.2%
Net S	avings Fact	ors							
Measure									
RFRCOM	IM Commercial	cemaker							
Tracks [	Base Track]								
6012CNI	R [is base track]	C&I Retro							
6013CU5	T [is base track]	Cust Equi	p Rpl						
6013PRE	S [is base track]	Pres Equi	p Rpl						
Persis									
The persi	stence factor is a	ssumed to	be one.						
Lifetin	nes								
	3]								

Measure Cost The incremental capital cost for this measure is \$222.<sup>(4)</sup>

O&M Cost Adjustments
No differences in O&M costs are apparent between standard d costs are apparent between standard and efficient ice makers.

Fossil Fuel Description

Water Descriptions While the EMEKGY STAR labeling criteria require that certified commercial ice machines meet certain "maximum potable water use per 100 pounds of ice made" requirements, such requirements are intended to prevent equipment manufactures from gaining energy efficiency at the cost of water consumptions. A review of the AME certification Directory)<sup>10</sup> Pradicates that approximately 81% of air-coled, cube-type machines meet the EMERGY STAR potable water use requirement. Therefore, there are no assumed water impacts for this measure.

## Reference Tables

Reference Table #1

# Algorithms for Calculating kWh<sub>base</sub> and kWh<sub>ee</sub><sup>[6]</sup>

Equipment Type	Harvest Rate Ib ice/24 hours	Algorithm for kWh <sub>base</sub> (kWh/100 lb ice)	Algorithm for kWh <sub>ee</sub> (kWh/100 lbs ice)
Ice-Making Head	<310	9.19+0.00629H	7.90+0.005409H
Ice-Making Head	>=310 and <820	8.23-0.0032H	7.08-0.002752H
Ice-Making Head	>=820 and <4000	5.61	4.82
Remote Condensing (but not remote compressor)	<800	9.7-0.0058H	7.76-0.00464H
Remote Condensing (but not remote compressor)	>=800 and <4000	5.06	4.05
Self-Contained	<200	14.22+0.03H	12.37-0.0261H
Self-Contained	>=200 and <700	9.47-0.00624H	8.24+0.005429H
Self-Contained	>=700 and <4000	5.1	4.44

### Reference Table #2

Annual Electric Energy and Demand Savings per Ice Machine [7]

Equipment Type	Harvest Rate Ib ice/24 hours	Assumed Harvest Rate	kWhbase	kWhee	ΔkWh	ΔkW
Ice-Making Head	>=310 and <820	581	6.37	5.48	1076.5	0.22
Ice-Making Head	>=820 and <4000	899	5.61	4.82	1478.1	0.30
Remote Condensing (but not remote compressor)	<800	572	6.38	5.11	1512.4	0.30
Remote Condensing (but not remote compressor)	>=800 and <4000	2012	5.06	4.05	4230.7	0.85
Self-Contained	<200	152	9.65	8.39	399.6	0.08
Self-Contained	>=200 and <700	319	7.48	6.51	644.2	0.13

Duty ordev varies considerably from one installation to the next. A field study of eight ice machines in California indicated an average duty cycle of 57% ("A Field Study to Characterize Water and Energy Use of Commercial Ice-Cube Machines and Quantify Saving Potential", Food Service Technology Center, December 2007).

[2] Unit is assumed to be connected to power 24 hours per day, 365 days per year.

[3] 2008 Database for Energy-Efficiency Resources (DEER), Version 2008.2.05, "Effective/Remaining Useful Life Values," California Public Utilities Commission, December 16, 2008.

[4] Incremental cost for continuos-type machines from ENERGY STAR Commercial Kitchen Equipment Savings Calculator. Calculator cites EPA research using AutoQuotes, 2016.

[5] AHRI Certification Directory. Accessed on 7/7/10.

[6] Algorithms from federal equipment standards and ENERGY STAR specifications for commercial ice makers.

[7] Refer to analysis document EVT\_Commercial Ice Maker\_Analysis\_Sept 2018.xlsx. Average assumed ice harvest rate based on average of bins in ENERGY STAR commercial kitchen equipment calculator.

# **Evaporator Fan Motors**

 Measure Number:
 EES ©

 Portfolio:
 EVT TRM Portfolio 2017-11

 Status:
 Adive

 Effective Date:
 2018/1/1

 End Date:
 [None]

 Program:
 Commercial & Industrial

 End Use:
 Refrigeration

- Update Summary

   Measure updated to aggregate characterizations across temperature range and baseline motor for Brushelss DC Motors in both Case Coole
  Walk-h applications.
   Incorporcepted participation data through 2016 which made very minor revisions to the Synchronus motor prescriptive savings due to cha
  the weighted averages.
   Updated the revised workdook, "exaporator-motors-reference-2017-v4.xtsc" replacing the older version, "exaporator-motors-referencev3.xtsc", Updated the references throughout the characterization as well.
   Made subsequent edits to the Description section, which discuss the reason for the characterization aggregation (adding measure to m
  program) and how the characterization was performed. e-2016

### Referenced Documents

- Referenced Documents
   The Cadrus Group, Commercial Refrigeration Loadshape Project Final Report, Northeast Energy Efficiency Partnerships, Regional Evaluation
  Measurement, and Verification Forum, Loxington, MA 2015.
   Navigant, "Energy Savings Potential and Opportunities for Hgh-Efficiency Electric Motors in Residential and Commercial Equipment", 2013.
   Oak Ridge Hatona Llaboratory, "Osyme Notors in Commercial Refrigeration: Preliminary Testesults and Projected Benefics", 2015.
   Oak Ridge Hatona Llaboratory, "Osyme Notors in Commercial Refrigeration: Preliminary Testesults and Projected Benefics", 2015.
   AESC, Inc., "Energy Savings of Permanent Magnet Synchronous Fan Motor Assembly Refrigerated Case Exoporators", 2016.
   DEEP2014-EUL-table-update, 2014-02-05.xlsx
   Esoporator Motors Reference 2017\_v4

### Description

Description Refigerator and Freezer walk-in unit evaporator fans typically contain two to twelve evaporator fans that run nearly 24 hours each day, 365 days each year. Not only do these fans use electricity, but the heat that each fan generates must also be removed by the refrigeration system to keep the product cold, adding more to the annual electricity costs. If the coder or freezer has single-phase power, the electricity usage can be reduced by choosing brushless DC (RO) motors or permanent magnet syndromous motors (Sync), instead of conventional staded-pole (CP) and permanent split capacitor (PSC) motors. Brushless DC motors are also known by the copyrighted trade name ECM (Electronically Commutated Motor).

In 2016, synchronous motors have been added to Efficiency Vermont's Lystream Refrigeration Program. Synchronous motors are not tracked through a typical Commercial Refrigeration Rebate Form. Prescriptive savings for synchronous motors have been estimated using historical Efficiency Vermont data. See reference tables below.

In 2017, brushless permanent magnet motors (also known as ECM) have been added to Efficiency Vermont's EEPM Midstream Program. Similar to sychronous motors, prescriptive savings for BPM motors have been estimated using historical Efficiency Vermont data and aggregated across temperature ranges and replacement/baseline motor.

# Algorithms

Elect	ric Demand S	avings			
∆kV	v	$= (KW_{Base} - KW_{Eff}) \times DC_{Evap} \times BF$			
kW	lase	$= W_{Bose,Out} \times (1/\eta_{Bose}) / 1000$			
kW	iff	$= W_{\rm EFL_Out} \times (1/\eta_{\rm EH}) \ / \ 1000$			
Sym	ool Table				
Elect	ric Energy Sa	vings			
∆kV	Vh	$= \Delta kW \times 8760$			
Sym	ool Table				
Fossi	l Fuel Savings				
Where	2:				
	ΔkW	= Gross customer connected load kW savings for the measure (kW)			
	$\Delta kWh$ = Gross customer annual kWh savings for the measure (kWh)				
n <sub>Base</sub> = Baseline motor efficiency, 0.26 for SP/0.40 for PSC <sup>[1]</sup>					
	WBase_Out	<ul> <li>Rated watt output of baseline motor, 12 watts for cases/42 watts for walk-in applications<sup>[2]</sup></li> </ul>			
	η <sub>Eff</sub>	<ul> <li>New motor efficiency, 0.66 for BDC/0.73 for Sync<sup>[1]</sup></li> </ul>			
	1000	<ul> <li>Convert watts to kilowatts (W/kW)</li> </ul>			
	8760	= Hours / Year			
	BF	Bonus factor for reduced cooling load from eliminating heat generated by the evaporator fan inside the cooler or freezer (1.4 for coolers, 1.8 for freezers) <sup>[4]</sup>			
	DC <sub>Evap</sub>	<ul> <li>Duty cycle of the evaporator fan, 97.8%<sup>[5]</sup></li> </ul>			
	kW <sub>Base</sub>	<ul> <li>Electrical demand of the baseline motor</li> </ul>			
	kW <sub>Eff</sub>	<ul> <li>Electrical demand of the efficient motor</li> </ul>			
	kW <sub>Eff</sub>				
	W <sub>Eff_Out</sub>	<ul> <li>Rated watt output of efficient motor, 12 watts for cases/42 watts for walk-in applications</li> </ul>			

## **Baseline Efficiencies**

The baseline condition is shaded pole or permanent split capacitor evaporator fan motor

### Efficient Equipment

shless DC or synchronous evaporator fan motor

Operating Hours A cooler evaporator fan runs all the time or 8760 hours per year. A freezer evaporator fan runs 8550 hours per year due to defroit cycles.<sup>[2]</sup> The smaller number of hours for freezer fan run time is captured in the duty cycle factor in the AXW calculation, so that 100% coincidence factors may be applied to both applications.

Load Shapes Eveporator fan loadshape was reassessed using results and data from the Cadmus NEEP Loadshape report. For evaluation details see the reference file "Eveporator Motors Reference 2017 v4.4sx", 'Cadmus Loadshape 2015' tab. 25a Flat (8760 hours)

Number Name Status Winter Winter Summer Summer Winter Summer Flat (8760 hours) Active 31.7% 34.9% 15.9% 17.5% 100.0% 100.0% 25

## Net Savings Factors

Measures RFRBLFAN Efficient blower fan RFRSYFAN Synchronous Motor Evaporator Fan

### Tracks [Base Track]

RES l'is base tra ack1 Pres Equip Rol 6013P 6013UPST [is base track] Upstream - Commercial 6014PRES [is base track] 6014PRES

# Persistence

The persistence factor is assumed to be one.

Lifetimes 15 years[6

### Measure Cost

Retrofit cost are shown below for brushless DC and synchronous motors applied in both case and walk-in applications.<sup>(7)</sup>

## Evaporator Fan Retrofit Costs

Application	Motor	Туре			
	Brushless DC	Synchronous			
Case	\$114	\$120			
Walk-In	\$143	\$145			
Toct of retrafit includes installation					

### O&M Cost Adjustments

There are no standard operation and maintenance cost adjustments used for this measure.

### Reference Tables

	Motor Savings for Evaporator Fans						
			Case	Cooler	Walk-In	Coolers	Footnotes
Measure	Temperature Range	Baseline Motor	Demand Savings kW/motor	Energy Savings kWh/year	Demand Savings kW/motor	Energy Savings kWh/year	
Brushless Permanent Magnet Motor	Low/Medium/High	SP/PSC	0.04	308	0.10	899	
Synchronous Motor	Low/Medium/High*	SP/PSC*	0.04	322	0.10	904	

[1] Efficiencies were determined using an average of baseline motor efficiencies from the following reports. Navigant, "Energy Savings Potential and Opportunities for High-Efficiency Electric Motors in Residential and Commercial Equipment", 2013. Page 5, Table 2.1. Oak Ridge National Laboratory, "Q-Sync Motors in Commercial Refrigeration: Preliminary Test Results and Projected benefits", 2015. Page 1, Section 1.

[2] Motor wattage derived using motor type efficiencies and output ratings. Calculated power consumption comparable to NEEP loadshape neported value for baseline walk-in motors. For calculation details see reference file "Exaporator Motors Reference 2012 VA.skx", "Savings Table" tab. NEEP values for reference from The Cadmac Group, Commercial Refineration Landshape Project Final Report Northeast Energy Efficiency Partnerships, Regional Evaluation, Measurement, and Verification Forum, Lesington, MA 2015. Page 87, Section 5.1.4.

- [3] Oak Ridge National Laboratory, "Q-Sync Motors in Commercial Refrige ation: Preliminary Test Results and Projected benefits", 2015. Page 1, Section
- [4] Bonus factors as derived in the NEEP Refrigeration Loadshape Report. The Cadmus Group, Commercial Refrigeration Loadshape Project Final Northeast Energy Efficiency Partnerships, Regional Evaluation, Measurement, and Verification Forum, Lexington, MA 2015. Page 78, Figure 54. ject Final Report,
- [5] An evaporator fan runs on average 8567 hours per year, 97,8% of the full 8760 hours per year, due to defrost cycles. The Cadmus Group, Commercial Retrigeration Laadshape Project Final Report, Northeast Energy Efficiency Partnerships, Regional Evaluation, Measurement, and Verification Forum, Lexington, Wa 2015, Dege 67, Jable 34.
- [6] DEER 2014 effective useful life (EUL) estimates. California DEER 2014 Effective Useful Life Table Update, DEER2014-EUL-table ental Cost
- [7] Costs are determined from manufacturer quotes and listings. See reference files Evaporator Motors Reference 2017 V4.xisx, NEEP Incremental Study Emerging Technology, Q-SyncMotors.xisx, 2016, AESC Inc., "Energy Savings of Permanent Alagnet Synchronous Fan Motor Assembly Reference and Case Evaporators", 2016, Reg. 26.

# **Refrigerator/Freezer Early Retirement**

	erator/Freezer Early Retirement
Status: Effective Date: End Date: Program:	EVT TRM Portfolio 2017-10 Active 2018/1/1 [ None ] Ellient Products Program
End Use:	Refrigeration
updated IL regressi This measure comb EP: Freezer Early EH: Refrigerator Ea LI: Refrigerator Ea	retirement of refrigerators and freezers has been recalculated using the last year of data from the EVT program (2015) and using an on model. ines the following characterizations in to one measure:
Applicable m Efficient Products Multi Family Existing Homes Low Income Single	
FinalResidentia     Refrig Freezer	
up program or whe from units removed	rement measure for the removal of an existing inefficient secondary refrigerator or freezer from service either through a curbside pict a suitable unit is removed during a house visit. The program will target refrigerators with an age greater than 10 years, though data through the program suggests the average age of refired units is over 25 years. Savings are calculated for the estimated energy the assumed remaining life of the unit.
Baseline Effi The existing refrige	ciencies rator baseline consumption is based upon data collected by Jaco from units retired in the last EVT program 2015.
High Efficien	icy
Algorithms Electric Demand ΔkW Symbol Table Electric Energy S ΔkWh	= LNMI/Hours
Where:	
ΔkW AkWb	gross customer connected load kW savings for the measure
ΔkWh	gross customer annual kWh savings for the measure     Household Factor, to adjust savings based on the household type from which unit is removed.     = 84% for low income <sup>12</sup> , 72% for multi family <sup>(3)</sup> , 1.0 for all others
Hours	= Equivalent Full Load Hours $= 8477^{[1]}$
PartUse	Part use adjustment factor to account for average use of appliance through the year <sup>[4]</sup> Unit Type PartUse     Refrigerator 99.6%     Freezer 99.8%
UEC	Unit Energy Consumption of the retired unit <sup>(1)</sup> Unit Type UEC (WMN)     Refrigerator 746     Freezer 825
Load Shapes 4b Residential Refri	gerator
	Name Statu Winter Winter Summer Summer Winter Summer Winter Summer Kingerator Active 30.8% 33.0% 17.1% 19.1% 79.6% 100.0%
Net Savings	Factors
Measures RFRRERPS Refrigo	erator early retirement program, secondary
Tracks [Base Tra 6032EPEP [is base	cky   track] Efficient Products - Residential
	Page 226

Persistence The persistence factor is assumed to be one.

### Lifetimes 8 years

Analysis period is the same as the lifetime.

Measure Cost

The cost of the administrative, pickup and recycling of the refrigerator is \$110 based upon cost provided by Jaco during previous program

O&M Cost Adjustments There are no operation and maintenance cost adjustments for this measure.

Reference Tables

Unit Type	Reporting Category	Algorithm	kWh savings	kW savings
	Low Income	746 * 0.996 * 0.84	624	0.074
	Multi family	746 * 0.996 * 0.72	535	0.063
	All other (Efficient Products and Existing Homes)	746 * 0.996 * 1.0	743	0.088
	Low Income	825 * 0.998 * 0.84	692	0.082
Freezer	Multi family	825 * 0.998 * 0.72	593	0.070
	All other (Efficient Products and Existing Homes)	825 * 0.998 * 1.0	823	0.097

Footnotes

- Consistent with other Residential Refrigerator measures and based on the ratio of UEC to kW, calculated using an algorithm for the kW during any hour (or group of hours) from the Californias study; Cadmus Group; "Residential Retrofit High Impact Measure Evaluation Report", Feb 8, 2010. For the calculations are "Refrigerator two Calculations.sk";
- [2] Size Factor is calculated by comparing the average Low Income retrofitted energy savings per unit (592/wh for ENERGY STAR and 620 for CEE T2) to the average single family residential retrofitted energy savings (709/Wh for ENERGY STAR and 737 for CEE T2) indicating a 84% savings factor.
- [3] Size Factor is calculated by comparing the average MF retrofitted energy savings per unit (S25kwh) to the average single family residential retrofitted energy savings (726kWh) indicating a 72% savings factor.
- [4] Based on analysis of Jaco data for program year 2015. Participants were asked how much the refrigerator was run through the year and the average result divided by 12 months.
- [5] Unit Energy Consumption is based upon review of the data collected by Jaco from units retired during the last year of the program 2015. To estimate the consumption of the retired units EVT applied results from this program data in a regression equation performed in a recert Cadmus Illinois evaluation (equation coefficients provided in a July 30 memo from Cadmus: "Appliance Recycling Update no single door"). See "Refrig Freezer Retirement Analysis, 2018.vdsc".

[6] KEMA "Residential refrigerator recycling ninth year retention study", 2004, page 3-1.

## **Freezer Early Replacement**

Measure Number:	R-RFG-FRER e
Portfolio:	EVT TRM Portfolio 2020-0
Status:	Active
Effective Date:	2020/1/1
End Date:	[ None ]
Program:	Low Income Single Family
End Use:	Refrigeration

### Update Summary

Update Summary Induded deemed every saving estimates for the low income single-family voucher program. As part of this revision, changed some verblage for the measure description, baseline equipment, and reference notes. To account for the low income single-family voucher program and how the age of the freezer is no longer a restriction to participation, (meaning any age freezer is eligible for replacement as part of the program), created an additional input for KMN\_Exit variable that is specified areaged of baseline unit electricity consumption based on the age of the freezer from data sourced from the VT SF Existing Homes On-Site Market Assessment Report.

### Applicable Markets



# Referenced Documents

- Refrigerator kW Calculations
   2003 D&R Int. Freezer Fact Sheet
   2020 VT Appliance Data\_TRMCostAnalysis
   EVT\_Freezer ER\_Analysis\_Mar 2020\_2020

Description An ENERGY STAR qualifying residential freezer is installed replacing an existing unit. Units must be pre-1993 in order to be eligible for early replacement if age is unknown, the units can be metered to determine consumption. If metering indicates an annual consumption of 2:990 kWh or a savings of 2:565kWh, the measure is eligible. Eligible can also be beaded unon a value interpection, where the unit appears to be in poor condition such as leaking seals or warped doors. In this instance a reduced savings (based on 1993-2001 units) should be claimed.

However, for the low income single-family oucher program, the age and condition of the equipment does not preclude customers from participation, allowing for any eligible freezer, regardless of age or condition to be replaced. The baseline in this instance is a weighted average of freezers in Verme single-family homes based on equipment age. After the first three years, which accounts for the remaining life of the replaced unit, the baseline shifts to a new freezer meeting the minimum federal efficiency standard for freezers effective September 15<sup>th</sup>, 2014.

# Program Type Calculation Type: Early Replacement

Program Delivery / Implementation Type: Downstream and Free Product (Low Income Single-Family Voucher Program)

Baseline Efficiencies <u>Domstream</u>, Buseline efficiency for the first three years is an existing pre-1993 freezer meeting the minimum federal standard effective in 1990 (except for units eligible valual inspection only, where a 1993-2001 freezer is assumed based on federal standard effective in 1993). After that the baseline is a new refrigerator meeting the minimum federal efficiency standard effective September 15<sup>th</sup>, 2014.

Low Income Single-Family Voucher Program: Baseline efficiency for the voucher program for the first three years is an existing freezer where the age and condition of the freezer is unknown. The baseline efficiency is a veriphted average of freezers based on equipment age and meeting the minimum foderal standards at the dato of manufacturing! If Atter Inters three years, which accounts for the remaining life of the replaced unit, the baseline shifts to a new freezer meeting the minimum federal efficiency standard for freezers effective September 15<sup>th</sup>, 2014.

### High Efficiency

The High Efficiency level is a freezer meeting ENERGY STAR specifications for efficiency established September 15, 2014 (at least 10% more.efficient than federal standard units).

# Algorithms

ectric Demand Savings	
ΔkW	= ΔkWh/Hours
$\Delta kW_{PTe-1993}$ units for remaining life of existing unit (3 years)	= 512.4/8477 = 0.0604 kW
$\Delta kW_{PTe}$ 1993 units for remaining measure life	= 59.8/8477 = <b>0.0071 kW</b>
$\Delta kW$ 1993 - 2001 units for remaining life of existing unit (3 years)	= 259.8/8477 = 0.0306 kW
$\Delta kW$ 1993-2001 units for remaining measure life	= 59.8/8477 = <b>0.0071 kW</b>
$\Delta kW$ voucher units for remaining life of existing units (3 years)	= 274.5/8477 = <b>0.0324 kW</b>
ΔkW Voucher unit for remaining measure life	= 59.8/8477 = <b>0.0071 kW</b>
ymbol Table	
ectric Energy Savings	
ΔkWh	= $kWh_{EXIST} - kWh_{ESTAR}$ (for remaining life of existing unit (1st 6 years)
	= kWh_{base} \cdot kWh_{ESTAR} (for remaining measure life)
$\Delta kWh$ $p_{re}$ 1993 units for remaining life of existing unit (1st 3 years)	= 1010.3 - 497.9 = 512.4 kWh
$\Delta kWh$ pre-1993 units for remaining measure life	= 497.9 - 438.1 = 59.8 kWh
$\Delta$ kWh 1993- 2001 units for remaining life of existing unit (1st 3 years)	= 757.7 - 497.9 = 259.8 kWh
ΔkWh 1993-2001 for remaining measure life	= 497.9 - 438.1 = 59.8 kWh
$\Delta kWh$ Voucher units for remaining life of existing unit (1st 3 years)	= 772.4 - 497.9 = 274.5 kWh
AkWh Voucher units for remaining measure life	= 497.9 - 438.1 = 59.8 kWh

### Deemed Energy and Demand Savings

	ΔkWh Remaining Life of Existing Unit	ΔkWh Remaining Measure Life	ΔkW Remaining Life of Existing Unit	ΔkW Remaining Measure Life	Mid life Adjustment	ItemCode
Pre -1993	512.4	59.8	0.0604	0.0071	11.7%	LIFRZERP
1993-2001	259.8	59.8	0.0306	0.0071	23.0%	LIFRZERP1
Voucher (age unknown)	274.5	59.8	0.0324	0.0071	21.8%	EHFRZERVOU

### Mid Life Savings Adjustment

For early replacement measures a mid life adjustmet of 59.8/512.4 = 11.7% will be applied after 3 years for pre-1993 units; 59.8/259.8 = 23.0% for 1993-2001 units; and 59.8/274.5 = 21.8% for voucher program units.

## Load Shapes

Number	Name	Status	Winter On kWh	Winter Off kWh	Summer On kWh	Summer Off kWh	Winter kW	Summer kW
4	Residential Refrigerator	Active	30.8%	33.0%	17.1%	19.1%	79.6%	100.0%

### **Net Savings Factors**

Measures RFRESFZR Energy star freezer, early replacement

Tracks [Base Track] 6034LISF [is base track] LISF Retrofit 6036RETR [is base track] Res Retrofit 6017PRES [is base track] 6017PRES 6020PRES [is base track] 6020PRES

# Lifetimes

For early replacement measures, the remaining useful life of the existing unit is assumed to be 3 years. For market opportunity measures lifetime is assumed to be 16 Years.<sup>[7]</sup> Analysis period is the same as the lifetime.

Measure Cost The full cost for an ENERGY STAR unit is \$620. The cost of a baseline replacement freezer is \$580.<sup>[6]</sup>

### **O&M Cost Adjustments**

n and maint nance cost adjustments for this measure

# Footnotes

- FOUNDERS
  [1] Average equivalent 1990, 1993, 2001, and 2014 Federal Standard consumption for all units on ENERCY STAR qualified list, accessed 05/2015. See "EVT\_Freezer ER\_Analysis, Mar 2020\_2020.uks", (The Code of Federal Regulations (10 CFR 430.32(a)) has appliance energy standards statutes for refrigrantors and freezers that was used to create age categories, specific for the voucher program; (1) pre-1993; (2) 1993-2001; (3) 2001-2014; and the current federal standards which became effective on Signetime 15, 2014, (4) once to define a single baseline unit consumption for the voucher program in which age is not being collected and is unknown, the annual electricity use, based on age, was weighted, using residential market assessment data for the ager fertificantors in Vermont, sourced from; VMRV, Vermont Single-Family Existing Homes On-Site Report, Draft\*, Dec 2017 (Section 8.3 Separate Freezer; Table 76 Separate Freezers Year of Manufacture).
- [2] The Summer and Winter Coincident KW are calculated using an algorithm for the KW during any hour (or group of hours) from the California study; Cadmus Group; "Residential Retrofit Hgh Impact Measure Evaluation Report", Feb 8, 2010. To calculate an Equivalent Full Load Hours the UEC (\* PartUse) is divided by the summer coincident KW (956 \* .779)(0.088 = #477 hours. The summer coincidence factor is therefore assumed to be 1.0 and a winter coincidence factor calculated as the relative winter to summer KW result from the algorithm. For the calculation see "Refrigerator KW Calculations.uls".
- [3] Average equivalent current Federal Standard consumption value for all units on ENERGY STAR qualified list accessed 05/2019. See "EVT\_Freezer ER\_Analysis\_Mar 2020\_2020.vls".
- [4] Average of units on ENERGY STAR qualified list accessed 05/2019. See "EVT\_Freezer ER\_Analysis\_Mar 2020\_2020.xls".
- [5] Average equivalent 1990 Federal Standard consumption for all units on ENERGY STAR qualified list, accessed 05/2019. See "EVT\_Freezer ER\_Analysis\_Mar 2020\_2020.xls".
- [6] Average equivalent 1993 Federal Standard consumption for all units on ENERGY STAR qualified list, accessed 05/2019. See "EVT\_Freezer ER\_Analysis\_Mar 2020\_2020.xls".
- [7] Source: 2003 D&R Int. Freezer Fact Sheet
- [8] Based on review of data from the Northeast Regional ENERGY STAR Consumer Products Initiative; "2009 ENERGY STAR Appliances Practices Report," submitted by Lodheed Martin, December 2009. This value has been inflated assuming 2% inflation to estimate costs in 2020. See 2020 VT Appliance Data, "TRACostAvalysis.ids/or data.

# Energy Efficient Refrigerators

Measure Number: RS-RFG-EERFG n Portfolio: Status: Active Effective Date: 2021/1/1 End Date: [None ] Program: Efficient Products Program End Use: Refrigeration

Update Summary Added non-energy GHG savings and a natural refrigerant refrigerator option

Applicable Markets

Multifamily

Efficient Products

Low Income Single Family

Residential New Construction

Existing Homes

### **Referenced Documents**

- refrig\_Tanklue\_tsd
   2016 Vermort Business Sector Market Characterization
   VIT SF Estding Homes Onsile Report DRAFT 122117
   LBAL\_savings-Inferime presistence-brief
   LL and MF-size Ratorit
   Refrigerators Retroft Savings\_V2
   Refrigerator Rotat
   Retroft Retroft Retroft Savings\_V2
   Retroft Retro

### Description

A refrigerator is installed instead of a new unit of baseline efficiency. The measure applies to market opportunity and early replacement programs. This measure includes a natural refrigerant option (R-290 and R-600a) meeting ENERGY STAR specifications and listed on their Qualified Products List

Program Type Calculation: Time of Sale (Market Opportunity) and Early Replacement Program Delivery / Implementation Type: Downstream and Free Product (Low Income Single-Family Voucher Program)

### **Baseline Efficiencies** Baseline Efficiencies - New

Baseline efficiency is a new refrigerator meeting the minimum federal efficiency standard for refrigerators effective September 15th, 2014.

Note a different baseline is provided for each efficient level. This is to account for the fact that the average capacity of the most efficient units is significantly lower than that of the standard ENERGY STAR.

For Shift Model approach the actual rated consumption of the baseline unit will be known and used.

### Baseline Efficiencies – Retrofit

Baseline efficiency for the first six years is the existing refrigerator. To be eligible, units must either be older than 1993 or be pre-2001 and deemed to be in significantly poor condition via a visual inspection (pre-1993 or unit in poor condition). However, for the low income single-family voucher program, the age and condition of the equipment does not predude customers from participation, allowing for any eligible refrigerator, regardless of age or condition to be replaced. The baseline in this instance is a weighted average of refrigerators in Vermont single-family home based on equipment age. After the first six years the baseline is a new refrigerator meeting the minimum federal efficiency standard for refrigerators effective September 15<sup>th</sup>, 2014.

### High Efficiency

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The High Efficiency level is a refrigerator meeting Energy Star specifications for efficiency effective September 15th, 2014 (10% above federal standard)<sup>(1)</sup>, a refrigerator meeting ENERGY STAR Most Efficient, or meeting CEE Tier 3 specifications (20% above federal standards). For the ENERGY STAR Natural Refrigerant option, it is a refrigerator meeting ENERGY STAR specifications and listed on the ENERGY STAR qualified products list with a R-600a or R-290 refrigerant. For Shift Model approach the actual rated consumption of the efficient unit will be known and used.

	rithms ric Demand S	avings			
ΔkV	V	= ∆kWh ,	Hours		
Sym	ool Table				
Non-	Energy GHG	Savings			
ΔGł	łG	= Charge	x ΔLeak x ΔGW	p.	
Sym	ool Table				
Elect	ric Energy Sa	vings			
ΔkV	Vh (Market Opp	ortunity and I	Market Shift)	= (kWh <sub>base</sub> – kWh <sub>eff</sub> ) × HF	
ΔkV	Vh (Early Repla	cement - 1st	three years)	= (kWh_{baseOLD} - kWh_{eff}) $\times$ HF	
ΔkV	Vh (Early Repla	cement - Ren	naining Life)	= (kWh <sub>base</sub> - kWh <sub>eff</sub> ) × HF	
Where	2:				
	ΔGHG	-	Gross customer	annual non-energy GHG savings (	lbs. CO2e)
	ΔGWP		Difference in glo refrigerant) = 1,295.5 <sup>[2]</sup>	bal warming potential between th	e baseline refrigerant and efficient refrigerant (lbs CO2e / lb

	ΔkW	-	Gross customer	r connected load l	kW savings	for the	measure				
	ΔkWh (Early Replacement - 1st three years)	-	Gross customer	r annual kWh savi	ings for Ear	ly Repla	cement, ren	naining life (	of existing u	nit (1st three ye	ears)
	ΔkWh (Early Replacement - Remaining Life)	-	Gross customer	r annual kWh savi	ings for Ear	ly Repla	cement, ren	naining mea	sure life		
	ΔkWh (Market Opportunity and Market Shift)	-	Gross customer	r annual kWh savi	ings for Mai	rket Opp	ortunity and	d Market Shi	ft approach		
	ΔLeak	-	Percentage of t = 2% <sup>[3]</sup>	otal charge that l	eaks from t	the syste	m on an an	nual basis			
	Charge	-	Charge of the r = 0.342 lb <sup>(4)</sup>	efrigeration syste	m, in units	of mass	(lbs)				
	HF		is removed.	income <sup>(5)</sup> , 60% fo						ousehold type fr	rom which unit
	Hours		Equivalent Full 8477	Load Hours							
	kWh <sub>base</sub>			nsumption of base pacity of available					te different	value for each	category since
			Efficiency Leve	el of Unit Installed		kWh <sub>ba</sub>	e				
			ENERGY STAR			693					
			ENERGY STAR	Natural Refrigera	ant	552					
			ENERGY STAR			460					
			CEE Tier 3			455					
	kWh <sub>baseOLD</sub>			Approach only k				aront up has	far and an	ones along Mag	
	KWII baseO LD			ilable product in e				erenic value i	IOF Eduli Cau	egory since the	average
				el of Unit Installed	F	poor condition Uni		Age Unknown			
			ENERGY STAR		1	L454 <mark>[10]</mark>		817[11]			
			ENERGY STAR	ant 1	158		651				
			ENERGY STAR	Most Efficient	965			542			
			CEE Tier 3		9	955		537			
	kWh <sub>eff</sub>			nsumption of effic			different valu	ue for each	category sin	ice the average	capacity of
			available produ	ct in each catego	ry varies <sup>[12]</sup>						
			Efficiency Leve			kWh					
			ENERGY STAR			632					
			ENERGY STAR	Natural Refrigera	ant	494					
			ENERGY STAR	Most Efficient		409					
			CEE Tier 3			349					
			For Shift Mode	el Approach only k	Wh <sub>eff</sub> = Act	tual Rate	ed kWh <sup>(13)</sup>				
	Life Savings Ad			le provides the ap	propriate n	nidlife a	ljustment to	be applied:			
			gle Family		Low Incom		-	Multi			
Efficier	icy Level of Unit Installe	Δk۱	Wh Early	∆kWh remaining	∆kWh Earl	y .	∆kWh rema	ining ΔkWh	Early	∆kWh remaini	
	Y STAR	Rep 822	placement, 1	life of ER 61	Replaceme 674	ent, 1	life of ER 50	Repla 493	cement, 1	life of ER 36	Adjustment 7.4%
	Y STAR Y STAR Natural	-				_	-				
Refrige	rant Refrigerator	664		58	664		58	664		58	8.7%
ENERG	Y STAR Most Efficient	556		51	556		51	556		51	9.1%
CEE Ti	er 3	606	5	107	606	_	107	606		107	17.6%

	Low Income Single-Family \		
Efficiency Level of Unit Installed	∆kWh Early Replacement, 1	∆kWh remaining life of ER	Midlife Adjustment
ENERGY STAR	151	50	32.9%
ENERGY STAR Most Efficient	133	51	38.1%
CEE Tier 3	188	107	56.7%

# Load Shapes

Number	Name	Status	Winter On kWh	Winter Off kWh	Summer On kWh	Summer Off kWh	Winter kW	Summer kW
4	Residential Refrigerator	Active	30.8%	33.0%	17.1%	19.1%	79.6%	100.0%

# Net Savings Factors

6020PRES [is base track] 6020PRES

Measures		
RFRESRRP	Energy star re	efrigerator
RFRESRER	Energy star re	efrigerator, early replacement
RFRESRT3	Tier 3 refrige	rator
RFRESRT2	Tier 2 refrige	rator
RFRT2RER	CEE Tier 2 Re	frigerator, Early Replacement
RFRT3RER	CEE Tier 3 Re	frigerator, Early Replacement
RFRESMSH	Market Shift B	ENERGY STAR Refrigerator
Tracks [Ba	se Track]	
6032EPEP [i	s base track]	Efficient Products - Residential
6034LISF [is	base track]	LISF Retrofit
6038VESH [	is base track]	RNC VESH
6017PRES [i	s base track]	6017PRES
6017CUST [	is base track]	6017CUST

6013EPEP [6032EPEP] Efficient Products - Commercial

Persistence The persistence factor is assumed to be one.

### Lifetimes 17 years<sup>[14]</sup>

For early replacement, the remaining useful life of the existing unit is assumed to be 3 years Analysis period is the same as the lifetime.

### Measure Cost

The incremental cost to the ENERGY STAR level is \$12, to ENERGY STAR Most Efficient level is \$21, to ENERGY STAR Natural Refrigerant is \$21, and to CEE Tier 3 is \$64 <sup>[15]</sup>.

For early replacement measures the full cost of a baseline unit is assumed to be \$802.The full cost of the installed ENERGY STAR efficient unit is assume to be \$814 for ENERGY STAR, \$823 for ENERGY STAR Most Efficient, \$823 for ENERGY STAR Natural Refrigerant, and \$866 for CEE Tier 3.

### **O&M Cost Adjustments**

N/A

### Prescriptive Savings Tables

For Market Opportunity, deemed savings are a	s follo	WS:	
Efficiency Level of Unit Installed	∆kWh	∆kW	Item Code
ENERGY STAR	61	0.0072	EPP-RFR-T1
ENERGY STAR Natural Refrigerant Refrigerator			EPP-RFR-T1G
ENERGY STAR Most Efficient			EPP-RFR-T2
CEE Tier 3	107	0.0126	EPP-RFR-T3

For Market Opportunity Multifamily, deemed savings for ENERGY STAR are as follows (other efficiency levels provided above)

Efficiency Level of Unit Installed AkWhAkW Item Code ENERGY STAR 37 0.0043 MFFRIGES

### For Early Replacement, deemed AkW savings:

	Single F	amily		Low Inc	ome		Multi Fa	mily		Low Income S Prorgram	ingle-Family V	oucher
Efficiency Level of Unit	1st three	∆kW remaining life		1st three	∆kW remaining life	Item Code			Item Code	∆kW 1st three years	∆kW remaining life	Item Code
ENERGY STAR	0.0969	0.0072	EHFRIGERP	0.0795	0.0059	LIFRIGERP	0.0582	0.0043	MFFRIGERP	0.0178	0.0059	LIFRIGERPVOU
ENERGY STAR Natural Refrigerant Refrigerator	0.0783	0.0068	EHFRIGERPG	0.0783	0.0068	LIFRIGERPG	0.0783	0.0068	MFFRIGERPG	N/A	N/A	N/A
ENERGY STAR Most Efficient	0.0655	0.0060	EHFRIGERP1	0.0655	0.0060	LIFRIGERP1	0.0655	0.0060	MFFRIGERP1	0.0156	0.0060	LIFRIGERPVOU1
CEE Tier 3	0.0715	0.0126	EHFRIGERP2	0.0715	N/A	LIFRIGERP2	0.0715	0.0126	MFFRIGERP2	0.0222	0.0126	LIFRIGERPVOU2

Early Replacement deemed AkWh savings

	Single Far	nily		Low Incon	ne		Multi Fam	ily	Low Income Single-Family Vouc Program			Family Voucher
Efficiency Level of Unit Installed	∆kWh 1st three years		Item Code			Item Code			Item Code			Item Code
ENERGY STAR	822	61	EHFRIGERP	674	50	LIFRIGERP	493	36	MFFRIGERP	151	50	LIFRIGERPVOU
ENERGY STAR Natural Refrigerant Refrigerator	664	58	EHFRIGERPG	664	58	LIFRIGERPG	664	58	MFFRIGERPG	N/A	N/A	N/A
ENERGY STAR Most Efficient	556	51	EHFRIGERP1	556	51	LIFRIGERP1	556	51	MFFRIGERP1	133	51	LIFRIGERPVOU1
CEE Tier 3	606	107	EHFRIGERP2	606	107	LIFRIGERP2	606	107	MFFRIGERP2	188	107	LIFRIGERPVOU2

## Deemed Non-Energy GHG Savings

 Item Code
 GHG Savings (lbs of CO2e)

 EPP-RFR-T1G
 8.86122

 EHFRIGERPG
 8.86122

LIFRIGERPG	
MFFRIGERPG	8.86122

### Footnotes

[1] ENERGY STAR Program Requirements Product Specifications for Residential Refrigerators and Freezers, version 5.0, effective September 9, 2014

- [2] The 100-year time horizon glonal warming potential difference between baseline and efficient refrigerant. Units are in lbs of carbon dioxide equivalent per lb refrigerant. The global warming potential of baseline unit refrigerant assumes R-134a, which is considered the most common refrigerant seen in household refrigerants. The GWP100 value for R-134a is assumed to be 1,300 lbs CO2e / lb refrigerant, assumes baseline unit refrigerant assumes and to be 1,900 lbs CO2e / lb refrigerant, assumed to be either R-290 (Popane or R-600a (bsobtane), which have GWP100 values of 4 and 5 respectively, per the California Air Resource Bard (CARB) Refrigerant Management, EVT, the average of GWP100 values for the efficient scenario is 4.5 lbs CO2e / lb refrigerant as assumed to be either R-290 (Popane or R-600a (bsobtane), which have GWP100 values of 4 and 5 respectively, per the California Air Resource Bard (CARB) Refrigerant Management, EVT, the average of GWP100 values for the efficient scenario is 4.5 lbs CO2e / lb refrigerant and is assumed to derive the difference in refrigerant GMP100 values (1,300 4.5 = 1,295.5)
- Is 5 to Cu2e / to reinge and all is assimilted to berive the dimeterized in reinge and curved values (-1,300 \*+3 \* 1,25-3).
  [3] For self-contained systems, reports from both EPA (U.S. EPA, "Revised Draft Analysis of U.S. Commercial Supermarket Refrigerantion Systems", November 2003) and California Air Resource Board (CARR, "California's High Gaba) Warming Potential Gases Emission Inventory Methodology and Technical Support Document", April 2016, Suggest an average 1% annual leakage rate which likely represents a mixture of slow leakage and clastrophic failures. For this equipment tops, the end-of-life (EQL) emissions are at 77% or greater, importance to that of the operational leakage, but the magnitude of this issue is varied in the literature. Some sources claim EOL emissions are at 77% or greater (\*APRI Project BOIS) Final Report, Review of Refrigerant Management Program", Nivagint, January 2016), while delives downplay this factor, it is likely that EOL erfligerant recovery has improved in recert years with more attention on this topic. However, it is also clear that all enforces near a leakage rate at 9% based on the estimated 1% average annual leakage rate, plus another 1% to represent some portion of the refrigerant tat is not properly recovered at end of life.
- [4] The average refrigerant charge of a residential refrigerator is sourced from the California Air Resource Board (CARB) Refrigerant Management Program, whose assumptions can be found in the attached file: "ARB Refrigerant Data.xis.".
- [5] Size Factor is calculated by comparing the average Low Income retrofitted energy savings per unit (709.1kWh) to the average single family residential retrofitted energy savings (868.5kWh) indicating a 82% savings factor. See "L1 and MF size Factor.xks".
- [6] Size Factor is calculated by comparing the average MF retrofitted energy savings per unit (525kwh) to the average single family residential retrofitted energy savings (869kWh) indicating a 60% savings factor. See "LI and MF size Factor.x/s".
- [7] The average consumption value for each Federal Standard equivalent to the ENERGY STAR and ENERGY STAR Most Efficient units purchased through the Efficiency Vermont program in 2017 and 2018. Since there was only one CEE Tier 3 unit purchased, the CEE Tier 3 assumption is based upon the average of the Federal Standard for CEE 13 qualified units from the ENERGY STAR Qualified Products List. See YEVT\_Analysis\_Refrigerator Savings\_June 2021.xlsr/; tab "Savings".

The average consumption value for the baseline unit for ENERGY STAR Natural Refrigerants, which meets the federal standard established on Setpember 15th, 2014, is sourced from the ENERGY STAR QPL which reports on the equivalent federal baseline, taking into account product data and capacity, For more detal, please set: "Natural Refrigerance, ENERGY STAR Centified Refrigerants, 2021.size". The lice contains the ENERGY STAR QPL as accessed on February 3, 2021.

- [8] Note that the baseline model may be different in different locations as the highest selling low efficiency unit will be selected.
- [9] The existing unit assumption for when a Most Efficient, Natural Refrigerator, or CEE Tier 3 is installed is adjusted downwards to account for the significantly lower capacity of the more efficient units. See 'EVT\_Analysis\_Refrigerator Savings\_June 2021.xisx'; tab 'Savings'.
- [10] Based on custom data using model numbers collected by Efficiency Vermont in 2008-2009 before measure became prescriptive and when only pre 1993 units were eligible. See "Refrigerator Retroft Savings.v2:x6". These values (based on rated efficiency) are inflated by 10% to account for degradation of performance based on a LBNL estimate in "Energy Savings Lifetimes and Persistence".
- Note for a post-1993 unit which is deemed eligible for replacement via a visual inspection by a EVT program representative will be in particularly poor condition and is therefore assumed to have a similar consumption to a pre-1993 unit.
- [11] Based on custom data using model numbers collected by Efficiency Vermont in 2008-2009 before measure became prescriptive. Leverages average annual electricity use of refrigerators and freezers from the Association of Nome Applance Narufactures (AHAM), which captures the electricity use of refrigerators over times addreds became addreds became addreds. The Cado e forderal Regulators (10 GFR 4403 24(a)) has appliance mergy standards statutes for refrigerators and freezers that was used to create age categories for this measure; (1) pre-1993; (2) 1993-2001; (3) 2001-2014; and the current federal standards which became effective on September 15, 2014; (4) post-2014). The annual electricity use was then weighted, using residential market assessment data for the age of refrigerators is thermos, sourced from, MRA, Vermont Single-Family Existing Homes On-Site Report, Draft\*, Dec 2017 (Section 82. Refrigerators; Table 73 Refrigerator Year of Manufacture). The unit electric consumption was further influed (based on rated efficiency) by Urbo saccount for degredation of performance based on a LBNL estimate in "Energy Savings Lifetimes and Persistence". For more detail, please see: "Refrigerator Refroft Savings\_V2/de".
- [12] The average consumption value for each ENERGY STAR and ENERGY STAR Most Efficient unit purchased through the Efficiency Vermont program in 2013 and 2018. Since there was only one CEE Tier 3 unit purchased, the CEE Tier 3 assumption is based upon the average of the T3 qualified units from the ENERGY STAR Qualified Products List. See "EVT\_Analysis, Refrigerator Savings\_Apr 2021.kts", tab "Savings". The average consumption value for ENERGY STAR Natural Refrigerants is sourced from the ENERGY STAR QPL as accessed on February 3, 2021. For more detail, please see: "Natural Refrigerants, ENERGY STAR Certified Refrigerators." Saving Star 2014.kts"
- more detail, please see: "Natural Refrigerants\_DNERGY STAR Certified Refrigerantors\_2021.xlsx" [13] Note that the efficient model may be different in different locations as a efficient model will be selected that is from the same manufacturer as the
- baseline model.
- [14] Based on 2011 DOE Rulemaking Technical Support Document. See page 8-30 of 'refrig\_finalrule\_tsd.pdf'.
- [15] Based on inflating to \$2018 the \$2009 costs provided in Tables 8.1.1 and 8.2.2 DOE 2011-08-26 Technical Support Document for Energy Conservation Standards for Residential Refrigerators, Refrigerator-Freezers and Freezers. See 'EVT\_Analysis\_Refrigerator Savings\_June 2021.45x'; tab "Costs".

# **High Efficiency Evaporators**

 
 Measure Number:
 VIII-D-16 a

 Portfolio:
 EVT TRM Portfolio 2019-07

 Status:
 Active

 Effective Date:
 2019/1/1

 End Date:
 [None ]
 [ None ] Commercial & Industrial Refrigeration Program: End Use:

### Update Summary

## Referenced Documents

- Referenced Documents
   The Cadmus Group, Commercial Refrigeration Loadshape Project Final Report, Northeast Energy Efficiency Partnerships, Regional Evaluation
   Measurement, and Verification Forum, Learington, MA 2015.
   Newgant, "Energy Savings Potential and Opportunities for Hgh-Efficiency Electric Motors in Residential and Commercial Equipment", 2013.
   Nakagant, "Energy Savings Orburnatial and Opportunities for Hgh-Efficiency Electric Motors in Residential and Commercial Equipment", 2013.
   Nakagant, "Energy Savings of Parmanert Magnet Synchronous Fam Motor Assembly Refrigerated Case Evaporators", 2016.
   Supporter Norton Korts Reference 2015.
   Naka Kitake Mators Reference 2015.
   Supporter Motors Reference 2017. v4
   USL SOE Commercial Refrigeration Savings Potential, Navigant, 2009
   Bohn Low Profile Unit Coders Spectre
   Hortinsk, Meno, Hwatcraft, Smart Defrost KR. Savings Validation, 2007
   Hardingturer Savings Claims, Market Fill, Maestir Controller, Savings Map
   Ele Savings and Barefills, Nater Controller, Savings Map
   Interlink, Refers, Savings Claidator
   Herdingtures Taure Biol. Energy Savings Calculator
   Herdingtures Smart Defrost KR. Energy Savings Calculator
   Herdingtures Smart Defrost KR. Energy Savings Calculator
   Herdingtures Taure Biol. Energy Savings Calculator
   Herdingtures Smart Defrost KR. Energy Savings Calculator
   Herdingtures Smart Defrost KR.
   Engengtures Smart Defrost KR.
   Engengtures Smart Defrost KR.
   Engengtures Smart Defrost KR.

## Description

Description This measure characterizes the savings attributed to an upstream commercial refrigeration high efficiency exaporator unit. This initiative is designed to capitalize on market opportunities to drive the installation of efficient evaporator units instead of standard baseline options. This measure is applicable to evaporator units installed in walk-in cold storage applications, serving Low (0°F) and Medium (32°F) conditioned environments.

eraptication and a resonance in making tool said age applications, seeining target (or gradienting care try clausioning care motioned a minimum care motion in the transmission of the sing definition of the attributes incorporated into the unit. The 1 requisite attributes are programmable bruckless permanent magnet (QRM) or permanent magnet (QRM) concerns for the attributes incorporated into the unit. The 1 requisite attributes are programmable bruckless permanent magnet (QRM) or permanent magnet (QRM) concerns for the attributes incorporated into the unit. There 1 and requirements are programmable bruckless permanent magnet (QRM) or permanent magnet synchronous (Sync) motors for the executation of samet defined controls and an electronic expansion valve (EEV). The collective effect of these features results in the refrigeration load requirements being met while using less power, as compared to a sealine unit. Every and demand savings are appreciated for each tier through a measure by measure step incremental improvement approach.

Ther 1: Busiless permanent magnet motors (sometimes referred to as ECM, ICM, or brushless DC motors) and permanent magnet synchronous motors (sometimes referred to as synchronous, Sync, or Q-Sync, motors) offer efficiency gains for exaporator frans over baseline options such as shaded pole (SP) or permanent split capacitor (PSC) motors. Esaporator fan motor controls reduce fan run time or speed depending on the required refrigeration load. Exaporator fans typically run continuously and the application of fan motor controls modulate the fan speed or run time with the refrigeration compressor to operate when the system is delivering a refrigeration load. Additionally, energy savings are realized through the reduced load on the refrigeration compressor caused by a reduction in excess heat given off by the evaporator fans when in operation. Energy savings are realized at the evaporator unit.

evaporator unit. Tier 2: Enaporator coil smart defrost controls uses temperature and pressure sensors to monitor system processes and skip the electric defrost cycle if it is not needed. For an evaporator unit in a walk-in cold storage application, the defrost cycle operates periodically throughout the day. Smart defrost controls leverage statistical modeling to learn the operations and requirements of the system, reducing defrost cycles if unnecessary. Electronic expansion wakes (EBV) offer deficiency gains over baseline thermostatic expansion walves regulate the temperature and pressure of the refrigerant in the refrigerant regulation precision, which can optimize overheating in the evaporator and improve overall compressor performance. Energy avaings are based on an overall increase in the system's suction temperature, which result in a reduction in the suction pressure and reduced load on the compressor.

# Program Type Market Opportunity: Time of Sale

### Program Delivery / Implementation Type

## **Baseline Efficiencies**

A baseline unit is an evaporator with shaded pole (SP) or permanent-split capacitor (PSC) fan motors, no evapo and a thermostatic expansion valve.

## Efficient Equipment

ent unit is a high efficiency evaporator with two tiers of measure attributes: Tier 1: An evaporator unit with BLPM or Sync fan motors and fan motor controls.

Tier 2: An evaporator unit with Tier 1 attributes combined with evaporator coil smart defrost controls and an electronic expansion valve

Algorithms Electric Demand Sa	ivings
$\Delta kW_{Fans}$	$= ((W_{Fan \; Out} \times (1 \; / \; \eta_{Base})) \cdot (W_{Fan \; Out} \times (1 \; / \; \eta_{EE}))) \times N_{Fan} \times DC_{Evap} \times BF \; / \; 10$
AkWFan Controls	= (WFan $_{Out}$ x (1 / $\eta_{EE})$ / 1000) x $N_{Fan}$ x LRF x BF
AkWDefrost Controls	$= kW_{DE} \times N_{Fan} \times SVG_{DE} \times BF$
ΔkW <sub>EEV</sub>	= $\Sigma$ ((Capacity / 1000) × (DC <sub>Comp</sub> × SVG <sub>EEV</sub> ) / EER)
ΔkW <sub>Tier 1</sub>	$= \Delta k W_{Fans} + \Delta k W_{Fan} \ Controls$
ΔkW <sub>Tier 2</sub>	$= \Delta KW_{Fans} + \Delta KW_{Fan} \ Controls + \Delta KW_{Defrost} \ Controls + \Delta KW_{EEV}$
Symbol Table	
Vater Savings VA Electric Energy Sav	vings
$\Delta kWh_{Fans}$	$= \Delta kW_{Fans} \times 8760$
ΔkWh <sub>Fan Controls</sub>	$= \Delta k W_{Fan \ Controls} \times 8760$
AkWhDefrost Controls	$= \Delta kW_{Defrost \ Controls \ X} \ FLH$
<b>AkWheev</b>	= AkWrey x Hours

$\Delta kWh_{Tier\;1}$		= ∆kWł	h <sub>≓ans</sub> + ∆kWł	¶Fan Contro	ols					
$\Delta kWh_{Tier\;2}$		= ∆kWi	n <sub>⊭ans</sub> + ∆kWi	¶≓an Contro	ols + ΔkWh	Defrost Contr	<sub>ols</sub> + ∆kWh <sub>l</sub>	EEV		
Symbol Tabl	e									
Fossil Fuel S	Savings									
∆kW <sub>D</sub>	efrost Controls	-	Gross conn	ected loa	d kW savii	ngs associa	ted with sn	nart defros	t controls	š.
∆kW <sub>EE</sub>	EV	-	Gross conn	ected loa	d kW savii	ngs associa	ted with th	e electonic	expansio	on valve.
ΔkWe	an Controls		Gross conn	ected loa	d kW savii	nos associa	ted with ev	aporator f	an motor	controls.
∆kW <sub>Fz</sub>	ans	-	Gross conn	ected loa	d kW savi	ngs associa	ted with hi	gh efficieni	cy fan mo	itors.
∆kW <sub>Ti</sub>	er 1	-	Gross conn	ected loa	d kW saviı	ngs associa	ted with Ti	ier 1		
ΔkW <sub>Tb</sub>	er 2	-	Gross conn	ected loa	d kW savii	ngs associa	ted with Ti	ier 2		
		_							t control	
	Defrost Contro	k =	Gross annu							
∆kWh	EEV	-	Gross annu	al kWh e	nergy savi	ngs associa	ated with th	ne electroni	ic expansi	ion valve.
ΔkWh	Fan Controls	-	Gross annu	al kWh e	nergy savi	ngs associa	ated with e	vaporator f	an motor	controls.
ΔkWh	East		Gross annu	ial kWh e	nerav savi	nas associa	ated with hi	iah efficien	cv fan mo	btors.
ΔkWh			Gross annu							
ΔkWh	Tier 2	-	Gross annu	al kWh e	nergy savi	ngs associa	ated with T	ier 2		
η <sub>Base</sub>		-	Efficiency of	of the bas	eline fan r	notor				
			= 0.31[1]							
NEE		-	Efficiency of	of the high	efficiency	/ fan motor				
			= 0.66 <sup>[2]</sup>							
8760			Annual ope	rating ho	urs per ve	ar of the e	vanorator f	ans		
BF		-	Bonus facto in cold stor = 1.4 <sup>[3]</sup>			ng load fro	m eliminati	ng excess l	heat gene	erated by the evaporator fans inside the walk-
Capac	ity	-	Operating ( = 39,600 E		of the com	pressor in I	3tu/h			
DC <sub>Corr</sub>	1p	-	Duty cycle = 45% <sup>[5]</sup>	of the cor	npressor					
DC <sub>Eva</sub>	p	-	Duty cycle = 97.8% <sup>[6]</sup>		aporator fa	n				
EER		-	Energy Effi	ciency Ra	tio of the	compressor	(7)			
FLH		-	Average fu	ll load de	frost hour:	5				
			= 487 hour							
Hours		-	Total sumr = 8,417 ho	urs <sup>(15)</sup>						
kW <sub>DE</sub>		-	Connected		) of the de	efrost elem	ent per eva	porator fai	n	
LRF		-	Load Redu = 31.3% <sup>[9]</sup>		or for the	evaporator	fan motor	controlled	units	
N <sub>Fan</sub>		-	Number of			med assum	ptions <sup>[10]</sup>			
SVGDE		-	Energy sav = 30% <sup>[11]</sup>	iings fact	or for the	smart defro	ost controls	; % of defi	rost cycle	s saved by controls
SVG <sub>EE</sub>				ings facto	r for the	ectronic o	mansion	alve: % of	compress	or cycle saved by EEV
	-		=4.5% <sup>[12]</sup>					,		
WFan 0	Dut	-	Rated watt = 42 watts		ut of the e	vaporator f	an motor			
Mid-Life	Savings	s Adju	stment							
···										
Load Sha 132a High Effi 133a High Effi	ciency Evap									
Number		Name		Status	Winter On kWh	Winter Off kWh	Summer On kWh	Summer Off kWh	Winter kW	Summer kW
132 Hig	gh Efficiency	/ Evapora	tor - Tier 1							
			tor - Tier 2							
Net Savi	ngs Fac	tors								
Measures RFRHEET1 H	tiah efficien	cv evan	rator, tier 1							
RFRHEET2 H										
I		, 21000								

Tracks [Base Track] 6013UPST [is base track] Upstream - Commercial

 Track Name
 Track Nr.
 Measure Code
 Free Rider Spill Over

 Upstream - Commercial 6013UPST RFRHEET1
 1.00
 1.00

Upstream - Commercial 6013UPST RFRHEET2 1.00 1.00

Lifetimes The measure life is assumed to be 15 years<sup>[16]</sup>

# Measure Cost

ricasure cost						
Measures	Unit	Incremental Cost				
Evaporator Fan Motors	per fan	\$143[17]				
Evaporator Fan Motor Controls	per evaporator	\$520 <sup>[18]</sup>				
Smart Defrost Controls	per evaporator	\$500 <sup>[19]</sup>				
Electronic Expansion Valve (EEV)	per evaporator	\$40[20]				

### O&M Cost Adjustments

### IVA

### Reference Tables Deemed Energy and Demand Savings

Deemed Measure	Tier 1			Tier 2		
Deemeu measure	ΔkW	ΔkWh	Incremental Cost	ΔkW	∆kWh	Incremental Cost
1 Fan Evaporator	0.1263	1,106	\$663	0.5802	1,929	\$1,203
2 Fan Evaporator	0.2526	2,212	\$806	1.0845	3,219	\$1,346
3 Fan Evaporator	0.3789	3,318	\$949	1.5888	4,509	\$1,489
4 Fan Evaporator	0.5052	4,424	\$1,092	2.0931	5,799	\$1,632
5 Fan Evaporator	0.6315	5,530	\$1,235	2.5974	7,089	\$1,775
6 Fan Evaporator	0.7578	6,636	\$1,378	3.1017	8,379	\$1,918

### Reference Table: Item Codes

Deemed Measure	Item Code
1 Fan Evaporator, Tier 1	HEEVAP1F1T
2 Fan Evaporator, Tier 1	HEEVAP2F1T
3 Fan Evaporator, Tier 1	HEEVAP3F1T
4 Fan Evaporator, Tier 1	HEEVAP4F1T
5 Fan Evaporator, Tier 1	HEEVAP5F1T
6 Fan Evaporator, Tier 1	HEEVAP6F1T
1 Fan Evaporator, Tier 2	HEEVAP1F2T
2 Fan Evaporator, Tier 2	HEEVAP2F2T
3 Fan Evaporator, Tier 2	HEEVAP3F2T
4 Fan Evaporator, Tier 2	HEEVAP4F2T
5 Fan Evaporator, Tier 2	HEEVAP5F2T
6 Fan Evaporator, Tier 2	HEEVAP6F2T

### Footnotes

- UILTICACES 1] Efficiencies for the baseline shaded pole (SP) and permanent split capacitor (PSC) fan motors were determined using an average of baseline motor efficiencies, as sourced from the; "Energy Savings Potential and Opportunities for Hgh-Efficiency Detric Motors in Residential and Commercial Engigenerit", Wayant, 2013 (page 5; table 21) and "CS yene Motors in Commercial Befrigeneous Preliminary Test Results and Projected Bereflet", Oak Ridge National Laboratory, 2015 (page 1; exciton 1). The baseline fan motor efficiency of 31% regresents a weighted average efficiency of SP and PSC fan motors, which was derived from past participation results for the EVT Exeporator. Fan Motor measure for replaced baseline motors in walk-in coders. For more detail on this weighting, Jelaes see "EVT\_JEE Exeporators, Analys, May 2019, et al.".
- [2] Efficiency of a BLPM evaporator fan motor, as sourced from "Q-Sync Motors in Commercial Refrigeration: Preliminary Test Results and Projected Benefits", Oak Ridge National Laboratory, 2015 (page 1; section 1)
- [3] The average borus factor is derived from the Northeast Energy Efficiency Partnership (NEEP) Refrigeration Loadshape Report "Commercial Refrigeration Loadshape Project Final Report", Cadmus, Regional Evaluation, Measurement, and Verification Forum, 2015 (page 78; figure 54). The 1.4 borus factor represents a weighted average of low, medium, and high temperature refrigeration types for walk-in coders/freezers.
- [4] Average compressor capacity, as sourced from "Energy Savings Potential and R&D Opportunities for Commercial Refrigeration", U.S. DOE, Navigant, 2009 (page 69, results based on a 5 hp semi-hermetic compressor for the waik-in cooler and a 1.5 hp semi-hermetic compressor for the freezer. Weighting for waik-in they was based on past VT participation for Exposure Familtonia.
- [5] The average compressor duty cycle is 45%, based on a compressor full load operation of 3,910 hours. This value is sourced from EVT's custom refrigeration analysis tool, "Refrigeration Analysis Tool, v5f\_TRM Test.xlsm".
- [6] An evaporator fan runs on average 8,567 hours per year; 97.8% of the full 8,760 hours in a year. This value is sourced from the Northeast Energy Efficiency Partnership (NEEP) Refingeration Loadshape Report - "Commercial Refingeration Loadshape Project Final Report", Cadmus, Regional Evaluation, Measurement, and Verification Forum, 2015 (page 67; hibe 34).
- [7] The compressor EER varies depending on the outdoor air and condensing set temperatures. For the purposes of this characterization, the energy savings associated with the EEV were summed across different temperature bins. The average compressor EER of 10.6 (at a hybical condensing set point of 90°F and a saturated suction temperature of 20°F) is sourced from the "Energy Savings Netential and R&D Opportunities for Commercial Befrigreation", U.S. DOB, Nelway, 2005 (page 60), sensitive sets compressor for the valience of the frequence of the reduced effects of the compressor of the valience of and a 1.5 hp semi-hermetic compressor for the valience of the reduced effects of the compressor of the valience of the frequence of the reduced effects of the compressor at the valience of the reduced of defects the reduced effects of the compressor at the valience of the valience of the valience of the reduced effects of the compressor at the valience of the reduced effects of the compressor at the valience of the reduced effects of the compressor at the valience of the value of the v
- [8] The electric defrost element KW is proportional to the number of evaporator fans blowing over the evaporator coll. The average wattage of the defrost element per fan is based on manufacturer specifications for evaporators from Bohn and Larkin (see: "Bohn Low Profile Unit Coolers Spec Sheet.pdf").
- (9) The load reduction factor (IRF) is sourced from Northeast Energy Efficiency Partnership (NEEP) Refrigeration Loadshape Report "Commercial Refrigeration Loadshape Project Final Report," Cadmas, Regional Evaluation, Neasurement, and Verification Forum, 2015 (page 67, table 34). The LPF is the difference in effective runtime of uncontrolled motions and the effective runtime of all control styles for execution controls.
- [10] Energy savings are based on the number of fans per evaporator unit. Reference tables are provided to detail deemed savings depending on the number of evaporator fans. For prescriptive implementation purposes, the number of fans will be collected for each rebated unit.
- [11] Exportator coil smart defrost controls typically claim between 30 and 40% in savings. For added reference, 43.6% in energy savings was verified by third-party testing conducted by Intertexi Testing Services on Heatcraft InterLink Smart Defrost Kit (see "Intertexi Memo, Heatcraft Amart Defrost Kit Savings Validation, 2007, edf). Additionally, a manufacturer of smart defrost cortroly. Savings Validations Demand Defrost, claims 21% in savings for northeast applications (see "Manufacturer Savings Claim, Master Bit, Meater controller, Savings Map, pdf). For purposes of this measure characterization, an average energy savings factor saxungtion of 30% was used. This value is also corroborated by custom assumptions used in EVT's analysis for refrigeration projects, "Refrigeration Analysis Tool\_v5\_TMM Test.kism".
- [12] Compressor consumption reduction for the EEV measure is based on an overall increase in the suction temperature, which results in a reduction in the suction pressure. The EVT Refrigeration Analysis tool ("Refingeration Analysis Tool, G/G/Jsm") used for custom refrigeration projects, assumes a 1.5% reduction in compressor consumption per degree increase in the suction temperature; a factor based on engineering judgement. For practical purposes for this measure, a 3% change in the suction temperature is assumed.
- [13] The evaporator fan motor wattage is based on motor type efficiencies and output ratings as calculated from power consumption values for baseline walk-n motors from the following analysis file: "Exaporator Motors Reference 2017, v4.sdc," "Savings Table" tab. The original source material is the Nertheast Energy Efficiency Patrimetry (NEEP) Referenciation Loadshape Report - "Commercial Refiguration Loadshape Project Final Report", Cadmus, Regional Evaluation, Measurement, and Verification Forum, 2015 (page 87; section 5.1.4)
- [14] The average annual full load hours of the defrost cycle is based on 4 defrost cycles per day, lasting in duration for 20 minutes per cycle. This value is sourced from EVT's custom refrigeration analysis tool, "Refrigeration Analysis Tool\_v6f\_TRM Test.vlsm".
- [15] The compressor operating hours is a based on a weighted average of walk-in cold storage applications and sites utilizing economizers. If a site leverages a refrigeration economizer, the compressor will not operate at outdoor air temperatures 4P below the cold storage set temperatures. The weighting for sites with economizers is sourced from the "2016 Vermone Basiness Sector Warket Characterization and Assessment Study", Cadmus, April 2017 (page 109). The weighting for the cold storage applications and associated average refrigeration set temperature is sourced from "Energy"

Savings Potential and R&D Opportunities for Commercial Refrigeration?, U.S. DOE, Navigant, 2009 (page 68). For more information on how the compressor operating hours were binned across the different outdoor air temperatures, please see "EVT\_HE Evaporators, Analysis, May 2019, vd.skr."

- [16] The 15 war measure life for evaporator fan motors is sourced from DEER 2014 effective useful life (EJJ, estimates; California DEER 2014 Effective Useful Life Table Update, DEER2014 = FL4-table-update, 2014 effective Useful Life Table Update, DEER2014 = FL4-table-update, 2014 effective Useful Life Table Update, DEER2014 = FL4-table-update, 2014 effective Useful Life Table Update, DEER2014 = FL4-table-update, 2014 effective Useful Life Table Update, DEER2014 = FL4-table-update, 2014 effective Useful Life Table Update, DEER2014 = FL4-table-update, 2014 effective Useful Life Table-Update, 2014 effective, 2014 effective
- [17] Incremental costs for evaporator fan motors are determined from manufacturer quotes and listings for walk-in application. See reference files from the "Evaporator Motors Reference 2017\_v4.xisx" and "Energy Savings of Permanent Magnet Synchronous Fan Motor Assembly Refrigerated Case Evaporators", 2016 (page 26).
- [18] Evaporator fan control unit cost of \$520 is referenced from the NEEP Incremental Cost Study Part 4; spreadsheet as listed for the New England region on a per controller cost basis. See reference "Evaporator Fan Controls\_NEEP\_JCS4 Final June 23 2015.xlsx", "Summary of Results" tab.

[19] The evaporator coil smart defrost control is based on a typical Smart Defrost Rk cost of \$400-\$600 per system, as by a Heatcraft Interlink Parts Smart Defrost calculator (see "Interlink Parts Smart Defrost Rk".\_\_Energy Savings Calculator html"). The MasterBilt Master Controller and Beacon II systems are more complex control and data logging systems that do more than just defrost, and are therefore more costly. This measure characterization and the measure cost is only for the defrost control profinor of the systems. This value is also used for custom project refrigeration costs, as sourced from the EVT Refrigeration Analysis Tool ("Refrigeration Analysis Tool used". TRet Test.stem").

[20] Results of a recent training attended by Sheryl Graves on new High Efficiency Evaporators

## **Insulation and Airsealing**

Measure Number: VII-K-2 a				
Portfolio:				
Status:	Active			
Effective Date:	2019/1/1			
End Date:	2020/12/31			

Program: Existing Homes End Use: Thermal Shell

Update Summary This is a new Efficiency Vermont offering and version one of the characterization

## Referenced Documents

- NEST VEIC Data Share 9Jun2017
   VT SF Existing Homes Onsite Report DRAFT 122117
   DIY Support Workbook FINAL\_new RR

### Description

Description This characterization is support of Efficiency Vermont's Existing Homes Insulation and Airsealing Program. Participants can elect to weatherize (airseali and insulate) either their flat, open attic CR heir basement/crawkpace (im joists and walks. With the exception of selecting treatment ands, ster-sording organization and flut bytes, savings for this measure and fully desend values. Although this characterization is broken out by airsealing and insulation savings components, the find savings claim for the appropriate treatment area will be the sum of these two components. This is a refront measure, savings encore yith processing the thermal resistance of building assemblies and reducing air infiltration that would subsequently need to be heated by the heating system(s). The expectation is that the work will be completed by a qualified professional.

Additional program materials are linked in the Referenced Documents section and include the program rebate form and quality standards n

# Program Type

## **Baseline Efficiencies**

Baseline existing home attic and basement conditions are in large part defined by the information and data published in the Vermost Single-Family Existing Homes On-Site Report, Decomber 21, 2017. Baseline is therefore loosely defined as the typical, single-family existing home attic or basement that fails within EVT market territory. Descriptions, footnotes and references in the remaining characterization context clearly specify and describe the baseline treatment and characteristics.

## Efficient Equipment

ETRICHENT Equipment The efficient condition upgrades the insulation properties of the attic structural assembly to an overall weighted value of R-49 or the basement structural assembly to R-15. Additionally, comprehensive air sealing must have occurred, preferably through the application of polycrethane foam.

## Algorithms

Electric Demand Savings Demand savings are exclusive to the heating season and the winter peak demand period. The total electric savings for each source (e.g., heat pump) resulting from insulating and airsealing are divided by the expected full load heating hours to establish the demand reduction. The load/shape is subsequently used in conjunction with this value to establish winter peak demand savings.

kW <sub>save</sub>	-
Symbol Table	

# Energy Savings: Airsealing

kWh<sub>save</sub>  $= \%_{Load} \times \beta_{CFM50} \times \psi \times SF_n \times HDH_n \times 60 \times c_p \times \rho \ / \ (\eta_{source} \times N_{heat} \times \omega)$ MMBtuswe =  $%_{Load} \times \beta_{CFM50} \times \psi \times SF_n \times HDH_n \times 60 \times c_p \times p / (\eta_{source} \times N_{heat} \times \omega)$ Symbol Table

kWh<sub>source</sub> / EFLH<sub>eheat</sub>

Energy Saviyas: Insulation This characterization limits the savings claim to the primary heating system only, although it is common for homes to have multiple heating sources. Both insulation and airsaining savings components are claimed and savings are limited to space heating savings. The savings calculations must be performed for the primary heating source, i.e., we system that contributes the largest proportion of heating load on a annual basis. An example at the end of this section illustrates how this characterization is used to daim savings.

Btu <sub>save</sub>	= %Load	× (1/R <sub>pre</sub> -	$(1/R_{pre} \cdot 1/R_{post}) \times SF_n \times HDH_n \times \psi / (r_{pource} \times \omega)$				
:							
%Load	<ul> <li>Portion of annual heating load supplied by the primary heating source.<sup>[2]</sup></li> <li>= 92.0%</li> </ul>						
<b>ВСЕМ50</b>	-		improvement factor (CFN (CFM <sub>50</sub> /ft <sup>2</sup> )	1 <sub>50</sub> /ft <sup>2</sup> ) <sup>[3]</sup>			
η <sub>source</sub>	-	Operating	efficiency of the heating s	ource <sup>[4]</sup> , dep	endent of fuel and system type:		
		S	/stem/Fuel Type	Efficiency			
			Oil	0.85			
		Boiler	Nat. Gas	0.873			
			Propane	0.874			
			Oil	0.814			
		Furnace	Nat. Gas	0.921			
			Propane	0.90			
			Pellet stove	0.70			
			Newer EPA woodstove	0.60			
			Cataylitic woodstove	0.50			
			Non-catalytic woodstove	0.40			
		Other	Outdoor wood boiler	0.25			
			Open hearth fireplace	0.10			
			Gas/Propane stove	0.65			
			Heat Pump	2.93			
			Electric Resistance	1.00			

Ψ	<ul> <li>Adjustment factor to bring savings estimates given by this simplified algorithm to evaluation bill anaylisis results.<sup>[5]</sup></li> <li>= 0.55 (dimensionless)</li> </ul>
ρ	= Density of air at prevalent conditions during the heating season (b)/ft <sup>3</sup> ) = 0.0749 (b)/ft <sup>2</sup> )
60	= Converts volumitric air flow per minute to hour = 60 (minutes/hour)
Cp	<ul> <li>Specific heat of air at prevalent conditions during the heating season (8tu/lb F)</li> <li>= 0.24 (8tu/lb F)</li> </ul>
EFLH <sub>eheat</sub>	<ul> <li>Effective Full Load Hours for electric heating source (hours)</li> <li>= 1,354.8 (hours)<sup>(1)</sup></li> </ul>
HDH <sub>n</sub>	<ul> <li>Heating Degree Hours<sup>[6]</sup>, dependent on space being treated (F hr):</li> <li>= 127,691.3 (F hr) for flat, open attic OR 99,194.6 (F hr) for basement/crawlspace rim joists and walls</li> </ul>
kWsave	= Electric demand savings (kW)
kWh <sub>source</sub>	<ul> <li>Total electric energy savings from the primary, secondary, or tertiary source for insulation and airsealing improvements, as calculated in the Energy Savings: Insulation and Energy Savings: Airsealing sections (kWh)</li> </ul>
kWh <sub>source</sub> kWh <sub>save</sub>	
	improvements, as calculated in the Energy Savings: Insulation and Energy Savings: Airsealing sections (kWh)
kWh <sub>save</sub>	improvements, as calculated in the Energy Savings: Insulation and Energy Savings: Airsealing sections (kWh) Annual electic energy savings (kWh)
kWh <sub>save</sub> MMBtu <sub>save</sub>	improvements, as calculated in the Energy Savings: Insulation and Energy Savings: Airsealing sections (W/h) Annual electic energy savings (W/h) Annual fuel savings (M/BLu) Conversion factor from volumetric air flow at 50 Pascal pressure to natural conditions <sup>(7)</sup>
KWh <sub>save</sub> MMBtU <sub>save</sub> N <sub>heat</sub>	Improvements, as calculated in the Energy Savings: Insulation and Energy Savings: Alirsealing sections (kWh)     Annual electic energy savings (kWh)     Annual fuel savings (MMBu)     Conversion factor from volumetric air flow at 50 Pascal pressure to natural conditions <sup>(7)</sup> Zo (dimensionless)     Thermal resistance of the improved (post-treatment) assemblies separating conditioned space to the ambient     environment <sup>(9)</sup> , dependent on space being treated (hr F ft <sup>2</sup> /Bu):

The following table summarizes the savings outcomes for each treatment area, treatment activity, heating system type, and fuel type. To exemplify how savings shall be claimed, let's assume a project has weatherized an open attic. The site has a primary natural gas furnace. Natural gas savings: savings from insulating are established as 0.842 MMBtu and savings from airsealing are established as 2.807 MMBtu for total natural gas savings of 3.649 MMBtu.

# Summarized Savings Outcomes

			Con land	Flat, Open Attic		Basement/Crawlspace Rim J	
System/F	Fuel Type	Treatment	Savings Units	Primary Heat Souce, 92% heating load	Itemcode	Primary Heat Souce, 92% heating load	Itemcode
		Insulation		0.912		1.210	
	Oil	Airsealing		3.041		2.680	
		Total		3.954	PRO-A-BOIL-OIL	3.891	PRO-B-BOIL-OI
		Insulation		0.888		1.178	
		Airsealing		2.961		2.610	
Boiler	Nat. Gas	Total		3.850	PRO-A-BOIL- NGAS	3.788	PRO-B-BOIL- NGAS
		Insulation		0.887		1.177	
		Airsealing		2.958		2.607	
	Propane	Total		3.845	PRO-A-BOIL- PROP	3.784	PRO-B-BOIL- PROP
		Insulation		0.953	1100	1.264	11001
				3.176		2.799	
	Oil	Airsealing		3.1/6	PRO-A-FURN-	2.799	PRO-B-FURN-
		Total		4.129	OIL	4.063	OIL
		Insulation		0.842		1.117	
urnace	Nat. Gas	Airsealing		2.807		2.474	
		Total		3.649	PRO-A-FURN- NGAS	3.591	PRO-B-FURN- NGAS
		Insulation		0.862		1.143	
	Propane	Airsealing		2.872		2.532	
	Propane	Total		3.734	PRO-A-FURN- PROP	3.674	PRO-B-FURN- PROP
		Insulation		1.108		1.469	
		Airsealing		3.693		3.255	
	Pellet stove	Total		4.801	PRO-A-PLLT- WOOD	4.724	PRO-B-PLLT- WOOD
		Insulation	MMBtu	1.293		1.714	
	Newer FPA	Airsealing		4.309		3,797	
	woodstove	Total		5.601	PRO-A-EPAW- WOOD	5.512	PRO-B-EPAW- WOOD
		Insulation		1.551		2.057	
	Cataylitic	Airsealing		5.170		4.557	
	woodstove	Ansealing		5.170	PRO-A-CATW-	4.557	PRO-B-CATW-
		Total		6.722	WOOD	6.614	WOOD
		Insulation		1.939		2.571	
	Non-catalytic	Airsealing		6.463		5.696	
	woodstove	Total		8.402	PRO-A-NCAT- WOOD	8.267	PRO-B-NCAT- WOOD
		Insulation		3.102		4.114	
	Outdoor wood	Airsealing		10.341		9.114	
Other	boiler	Total		13.443	PRO-A-ODWB- WOOD	13.228	PRO-B-ODWB- WOOD
		Insulation		7.756		10.285	
	Open hearth	Airsealing		25.852		22.784	
	fireplace	Total		33.608	PRO-A-OHFP- WOOD	33.069	PRO-B-OHFP- WOOD
		Insulation		1.193		1.582	
	Gas stove	Airsealing		3.977		3.505	
	Gas stove	Total		5.170	PRO-A-STVE- NGAS	5.088	PRO-B-STVE- NGAS
		Insulation		1.193		1.582	
	C	Airsealing		3.977		3.505	
	Gas stove	_		5.170	PRO-A-STVE-	5.088	PRO-B-STVE-
		Total			PROP		PROP
		Total		77.6 (0.05725)	PROP	102.9 (0.07592)	PROP

		Total		336.1 (0.			FINO-74-11	- I-IF -	330.7 (0.24409)	FRO-D-TIFTEFF
		Insulation	kWh (kW)				ELEC			ELEC
		Airsealing	(KVV)	227.3 (0. 757.7 (0.					301.4 (0.22249) 667.7 (0.49287)	
	Electric Resistance						PRO-A-E	RES-		PRO-B-ERES-
		Total		985 (0.72	2702)		ELEC		969.2 (0.71536)	ELEC
	Shapes									
5b Reside	ential Space heat					-				
Number	Name	Status			Summer On kWh		Winter kW	Summ kW	er	
	Residential Space h	heat Active	42.9%	57.1%	0.0%	0.0%	25.0%	0.0%		
Measure TSHNAIR Fracks [	avings Factor as IS Insulate and airse (Base Track] R [is base track] Re	eal								
ifetin	nes									
	for both airsealing ar	nd insulating	component	s are 25 ye	ars.[11]					
	asure costs are comp	rised of the	rost of sizes	aling and	nculative 4	he treatmo	nt arca[12			
	and costs are comp	seu or ure (			isulation 8					
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outo	omes of EM&V/DPS r	negotiations,	the 0.55 ad	justment f	actor is inte	ended to be			2018 program impact eva ings estimated by HERO a	
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assu syste visual reference referenc	ems in the off season al inspection of TMV3 titioned and unconditis the HDH assumes a ba ground coupled, and L_newRR for a comp gacy negotiated value gacy negotiated value gacy negotiated value average area in the Vermor s, eight foot wall height dation type and previous L_newRR. d on program requin- ires (R-15) due to thi heid number is a con Vermont Single-Famil ort Workbook FINAL, sine R-values sources med for attics (Table	revealed tha cournert "NES" vithin a defini. The heating data, this per to see temperatu are usually or lete derivatic e carried over y this algorith en attics is de and "Airseall alence in the mant's and "Airseall and "Airsea	t a base the dheating and the dheating and the dheating as season w. The VEIC Data dheating as season w. The dheating as the dheating and the dheating and the thermal rd and thermal rd and the the the the thermal rd and the the thermal rd and	mperature a Share 9: 3 share 9: 5 stablished by the Vet grees F bù toric EVT H thit evaluat thit evaluat thit evaluat the stablishes " toric EVT H the valuat the stablishes b stablishes b	of 58 degr of 58 degr un2017. <sup>11</sup> lidd be included as the time as 5 eptemin mont. Single and the included end on the Perfore ded impacts of <4,400 p Foundation home Perfore ded impacts of <4,400 p and the included for a full c Poundation to the Perfore ded impacts Site Repo- to twall heig For a full c Poecember ; Existing Hol assumed for it basemer in basemer	rees F and eses is appr an atterm ded in the period with ren family to period with premise the Blend" and manual to the model of the mo	n closely a uses Clim opriate to to make total, ass total assert May 6th. disting Hol - C me perforivation. B er 21, 201 me perforivation. B er 21, 201 mer	ate Non capture e a cons ming the ratures Heating mess On- fitioned limate 1 Star pro- mance assement 7 (Tabl 5 Star pro- mance assement 7 (Tabl 7 (Ta	mails data for Burlington 1 the heating terdencies: eventive estimate of heat at homeowners would di 'consistently' full below Degree Hours for lasem 'sonis ternetly' full below basements are allowed t knormats' in the DIY Suppe ogram performance evalu- projects. See worksheets treatment area (voll ar t 2.2) as a basis and assu- t 2.3 as a basis and assu- t 2.5 as a basis and assu- t 2.5 as a basis and assu- t 2.5 and the set of the second the set a weighted, compt "Foundation Blend" in th ars higher than what the for in basements that are ment (crawlapsec) that 1	ment factor is adopted. Internation Airport. A f a bytical Vermon A f a bytical Vermon A f a bytical Vermon B S8 degrees. Based on or ent assumes a blend or ent assumes a blend or saking in temperature, rt Workbook alation finding intended to alation finding intended to alation finding intended to base somedian reporter site number based on DP Support Workbook program and REES below grade. The final was been sourced from indication Blend' in the DD re conservative) value he fact that median is own.

[12] Costs based on EVT Engineering estimates, to be refined with actual program cost data as it becomes available and statistically significant.

# **HPwES 2.0 Airsealing**

Measure Numbe	er: VII-K-2 e
Portfolio:	
Status:	Active
Effective Date:	2020/1/1
End Date:	[ None ]
Program:	Existing Homes
End Use:	Thermal Shell

Update Summary
This is a new Efficiency Vermont offering for the Home Performance with Energy Star program and version one of the characteri

### Referenced Documents

- NEST VEIC Data Share 9Jun2017
   VT SF Existing Homes Onsite Report DRAFT 122117
   hpwes-2-0-support-workbook-final-FY2020

### Description

Description This characterization in support of Efficiency Vermont's Home Performance with Energy Star Program. This characterization captures the impact associated with airsealing activities in a residence. This is a retroft measure, saving energy by reducing air infiltration that would subsequently need to be heated by the primary heating system. Heating system characteristics, as well as actual pre and post work blower door results will be used to establish project level impacts. Bower door results will be mapped to no of three catagories for three assignment of humant to enable prescriptive implementation of this measure. These categories are represented by a distinct CHMS0 designation indicating improvement (reduction) in infiltration; 400, 100, and 2000 CFMS0. These values were chooks lased on historic averages of HMAES project OMMS0 and 50% infiltration improvements of past program participants. Qualification for incertives requires a minimum of 10% reduction in infiltration.

Baseline Efficiencies Home airtightness, as indicated by blower door testing(CFM50), prior to implementation of airsealing measures

Efficient Equipment
Home airtightness, as indicated by blower door testing(CFM50), following implementation of airsealing measures.

Algorithms Electric Demand Savings Demand savings are exclusive to the heating season and the winter peak demand period. The total electric savings for each source (e.g., heat pump) resulting from airsaeling are divided by the expected full load heating hours to establish the demand reduction. The loadheape is subsequently used in conjunction with this value to establish winter peak demand savings.

= kWhsave / EFLHeheat kW<sub>save</sub> Symbol Table

Energy Savings: Airsealing This characterization limits the savings claim to the primary heating system only. Additionally, savings are limited to space heating savings. The savi calculations must be performed for the primary heating source, i.e., the system that contributes the largest proportion of heating load on a annual basis. An example at the end of this section illustrates how this characterization is used to claim savings.

MMBtu <sub>save</sub>	$= \beta_{CFMS0} \times \psi \times SEAL_{20} \times HDH_n \times 60 \times c_p \times \rho \ / \ (\eta_{source} \times N_{heat} \times \omega)$
kWh <sub>save</sub>	$= \beta_{CEMS0} \times \psi \times SEAL_{20} \times HDH_n \times 60 \times c_n \times \rho / (n_{source} \times N_{heat} \times \omega)$

**ВСЕМ50** 

η<sub>source</sub>

Infiltration improvement (CFMs\_0), as confirmed by blower door testing. The difference between pre and post readings will be used to map to one of three deemed values that will form the basis of savings, as outlined in the following table:

Blower Door Pre/Post Difference (CFM50)	Deemed Improvement for Impact Claim (CFM50)
>0 and <800	400
800 to <1600	1200
>1600	2000

Operating efficiency of the heating source<sup>[2][3]</sup>, dependent of fuel and system type:

	1	System/Fuel Type	Efficiency	
	Boiler	Oil	0.85	
	Boller	Propane	0.874	
	Furnace	Oil	0.814	
	Furnace	Propane	0.90	
		Pellet stove	0.70	
		Newer EPA woodstove	0.60	
		Cataylitic woodstove	0.50	
		Non-catalytic woodstove	0.40	
	Other	Outdoor wood boiler	0.25	
		Open hearth fireplace	0.10	
		Propane stove	0.65	
		Heat Pump	2.93	
		Electric Resistance	1.00	
Ψ		000 (Btu/MMBtu) or 3,412.1		n by this simplified algorithm to evaluation bill anaylsis results
¥	-	dimensionless)	Sumates grie	
ρ	= Density of	of air at prevalent conditions	during the h	eating season (lb/ft <sup>3</sup> )
	= 0.0749	(lb/ft <sup>3</sup> )		
60	= Converts	) (lb/ft <sup>3</sup> ) volumitric air flow per min nutes/hour)	ute to hour	
	= Converts = 60 (mi	volumitric air flow per min nutes/hour) heat of air at prevalent con		the heating season (Btu/lb F)
60 Cp EFLHeheat	<ul> <li>Converts</li> <li>= 60 (mi</li> <li>Specific I</li> <li>= 0.24 (I</li> <li>= Effective</li> </ul>	volumitric air flow per min nutes/hour) heat of air at prevalent con	ditions during	

	= 113,443.0 (F hr)
kW <sub>save</sub>	= Electric demand savings (KW)
kWh <sub>save</sub>	<ul> <li>Annual elecric energy savings (kWh)</li> </ul>
MMBtu <sub>save</sub>	= Annual fuel savings (MMBtu)
N <sub>heat</sub>	<ul> <li>Conversion factor from volumetric air flow at 50 Pascal pressure to natural conditions<sup>(6)</sup></li> <li>= 20 (dimensionless)</li> </ul>
SEAL <sub>20</sub>	<ul> <li>Realization Rate from 2020 sampling of projects<sup>(7)</sup></li> <li>= 1.06925303531848</li> </ul>

The following table summarizes the savings outcomes for all prescriptive savings possibilities. To exemplify how savings shall be claimed, let's assume a project has achieved 1350 CFM50 infiltration improvement, as shown by blower door testing. The site has a primary propane furnace. 1350 CFM50 blower door pre/post difference maps to a deemed value of 1200 CFM50 improvement, itemcode HPSEAL12BOILPROP, which has 4.940 MMRtu savings associated with it.

### Summarized Savings Outcomes

System/Fu	el Type	CFM50 Improvement	MMBtu Savings	kWh Savings	kW Savings	Itemcode
		>0 and <800	1.693			HPSEAL4BOILOIL
	Oil	800 to <1600	5.079			HPSEAL12BOILOIL
Boiler		>1600	8.465			HPSEAL20BOILOIL
Duilei		>0 and <800	1.647			HPSEAL4BOILPROP
	Propane	800 to <1600	4.940			HPSEAL12BOILPROP
		>1600	8.233			HPSEAL20BOILPROP
		>0 and <800	1.768			HPSEAL4FURNOIL
	Oil	800 to <1600	5.304			HPSEAL12FURNOIL
Furnace		>1600	8.840			HPSEAL20FURNOIL
Furnace		>0 and <800	1.599			HPSEAL4FURNPROP
	Propane	800 to <1600	4.797			HPSEAL12FURNPROP
		>1600	7.995			HPSEAL20FURNPROP
		>0 and <800	2.056			HPSEAL4PLLTWOOD
	Pellet stove	800 to <1600	6.168			HPSEAL12PLLTWOOD
		>1600	10.279			HPSEAL20PLLTWOOD
		>0 and <800	2.399			HPSEAL4EPAWWOOD
	Newer EPA	800 to <1600	7.196			HPSEAL12EPAWWOOD
	woodstove	>1600	11.993			HPSEAL20EPAWWOOD
		>0 and <800	2.878			HPSEAL4CATWWOOD
	Cataylitic woodstove	800 to <1600	8.635			HPSEAL12CATWWOOD
	woodstove	>1600	14.391			HPSEAL20CATWWOOD
		>0 and <800	3.598			HPSEAL4NCATWOOD
	Non-catalytic woodstove	800 to <1600	10.793			HPSEAL12NCATWOOD
	woodstove	>1600	17.989			HPSEAL20NCATWOOD
		>0 and <800	5.756			HPSEAL4ODWBWOOD
Other	Outdoor wood boiler	800 to <1600	17.269			HPSEAL12ODWBWOOD
	Dollel	>1600	28.782			HPSEAL200DWBWOOD
		>0 and <800	14.391			HPSEAL4OHFPWOOD
	Open hearth fireplace	800 to <1600	43.173			HPSEAL12OHFPWOOD
	IIIepiace	>1600	71.956		•	HPSEAL200HFPWOOD
		>0 and <800	2.214			HPSEAL4STVEPROP
	Propane stove	800 to <1600	6.642			HPSEAL12STVEPROP
		>1600	11.070			HPSEAL20STVEPROP
		>0 and <800		143.9	0.10405	HPSEAL4HPMPELEC
	Heat Pump	800 to <1600		431.7	0.31215	HPSEAL12HPMPELEC
		>1600		719.6	0.52032	HPSEAL20HPMPELEC
		>0 and <800		421.8	0.30499	HPSEAL4ERESELEC
	Electric Resistance	800 to <1600		1265.3	0.9149	HPSEAL12ERESELEC
	resistance	>1600		2108.8	1.5248	HPSEAL20ERESELEC

### Load Shapes 5b Residential Space heat

Number	Name	Status	Winter On kWh	Winter Off kWh	Summer On kWh	Summer Off kWh	Winter kW	Summer kW
5	Residential Space heat	Active	42.9%	57.1%	0.0%	0.0%	25.0%	0.0%

## Net Savings Factors

Measures TSHAIRSL Airsealing

Tracks [Base Track] 6036HPES [6036RETR] HPWES EVT

Lifetimes Lifetime for airsealing measures is 20 years.<sup>[8]</sup>

### Measure Cost

Predabilite CUSK Total measure costs of \$3,000 are used <u>as a placeholder value</u>, to be trued up at year-end closeout with actual invoiced project cost averages for arisealing work.<sup>10</sup>:

# Footnotes

Footnotes
[1] EFU-finest is taken to be the established full load hours for a heat pump under the premise that the majority of any eletric heat sources are likely to be heat pumps. Further, as this value is higher than the default EFU for the loadshape applicable to this measure, the demand savings err on the conservative side. This value is calculated in an analysis of heat pump metered data. The partial load of each heat pump is summed up through the heating season, and there are an average across all units metered. See TRM measure Variable Speed Mini-Spitt Heat Pumps (Market Opportunity) for additional background and reference documents.

[2] Boiler and furnace efficiencies are the median values reported by the Vermont Single-Family Existing Homes On-Site Report, December 21, 2017 in Tables 46 and 47. Heat pump efficiency conservatively taken to be the minimum qualifying efficiency requirement for EVT's programs, HSPF = 10.0, converted to COP by dividing by 3.41214.

Pellet stove: The FD Clertified Wood Heater Database, which only lists EPA compliant models, indicates that the average modern pellet stove – year 2017 and never – on average operates at about 73% efficiency. To accommodate older models and non-compliant models it is reasonable to assume 70% efficiency for the pellet stove category.

"Never EPA Woodstow" refers to units sold after July 1, 1992 when Phase 2 particulate emissions standards became effective (4.1 g/hr for catalytic stoves and 7.5 g/hr for non-catalytic stoves). These units characteristically have better officiencies than older or non-compliant units. The EPA Certification Wood Heater Dtablase, which only its efficiencies for qualifying models dated back to 2015, indicates that the model move performs at a date 73% efficiency. Green that performance has increased since the 1992 standard and considering stove maintenance realities – per DOE, even one-tenth of an inch of soot buildup on stove intensis can drop heat transfer afficiency of the metal by 50% – it is fully reasonable to assume the general "Newer EPA Woodstove" category operates with 60% efficiency.

Catalytic & Non-catalytic woodstoves: According to the EPA, certified stoves can be 50% more efficient than non-certified units. Additionally, since non certified units produce more particulate emissions, it follows that sook buildup likely plays a stronger influence on efficiency. Telen together, it is reasonable to assume the worst performing category of woodstoves, non-catalytic, operates at 40% efficiency. Per the EPA certified Vood Heater Database, modern catalytic woodstoves have about a 6% efficiency advantage on average, compared to non-catalytic models. It is therefore reasonable to assume that the catalytic woodstove category operates at 50% efficiency, sequency between newer EPA woodstoves and non-catalytic woodstoves.

Autoor wood boller: The EPA Certified Wood Heater Database lists average efficiency ratings for cord wood fired hydronic central heaters at 67%, however this does not account for heat hydronic heat transfer efficiencies, or the fact that outdoor bollers are often fueled with green/with freword, which can have heat the heating value of properly assessment wood. Soch bulking is also a common size in outdoor wood bollers, which further inhibits heat transfer and reduces efficiency. System design, such as pipe lengths, are also critical to consider, but impossible to generalize. The calmination of these factors leads to a reasonable assumption of 25% efficiency for a bytical central wood boller, although in practice efficiencies could be much higher or lower.

\*\*See continuation below in reference 8199

[3] Open hearth freplace: values of up to 10% are commonly referenced. DOE and the EPA do not cite specific numbers, but do caution "Generally, a wood-burning freplace: is a very inefficient way to heat your home. Freplace drafts can pull the warm air up the chinney, causing other rooms to be coder. If you use cretrah heat while burning in a freplace, your heater will work harder to maintain constant temperatures throughout the house" and "Traditional freplaces draw in as much as 300 cubic feet per minute of heated room air for combuston, then send it straights when the house" and "Attitudional mentional seaks the safes these issues with didenticated air supplice, ages doors, and heat recovery systems, most traditional freplaces are still energy losers." When used as primary heat source, a 10% efficiency is a reasonable assumption.

Propane stove: Modern vented gas stoves can achieve efficiencies close to non-condensing furnaces, however to account for aged equipment as well as products such as fireplace inserts, an efficiency of 65% is deemed appropriate.

[4] This adjustment factor mirrors that which is applied to HERO-based HPWES projects. Based on the 2018 program impact evaluation and subsequent outcomes of BNA/UFS repotations, the 0.55 adjustment factor is intended to better align the savings estimated by HERO algorithms to those established by evaluation, time the agorithms used by this characterization closely align with FEO, the same adjustment factor is adopted.

(5) Heating Degree Hours for attic assumes a base temperature of 58 degrees F and uses Climate Normals data for Burlington Internation Airport. A recent Next Study by EVT revealed that a base temperature of 58 degrees is appropriate to capture the heating tendencise of a byckal Vermont home. See referenced document \*NEX\* UPC Lota Share Shar0127.<sup>1</sup> In an attempt to make a consentive estimate of theating degree hours, it was assumed that only days within a defined heating gespension would be included in the total, assuming that homeowners would diable or set back heating systems in the off season. The heating season would be included in the total, assuming that homeowners would diable or set back heating systems in the off season would be assess the time period where temperatures "constent/ fail blocks' 58 degrees. Based on visual inspection of TMV3 data, this period was established as the time period where temperatures "constent/ fail blocks' 58 degrees. Based on visual conditioned ages are arroad by the Vermont Single-Family Ebsing homes: On-Sine Report, December 21, 2012, Unconditioned space FDH assumes a base tomperature of 48 degrees F based on the premise that unconditioned basements are allowed to swing in temperature, are gound coupled, and are usually cool. See worksheets "Foundation Blend" and "HCH - Climate Normals" in the HPWES 2.0 Support Workbook FIPAL for a complete derivation.

[6] A legacy negotiated value carried over from a historic EVT Home Performance With Energy Star program performance evaluation finding intended to bring savings predicted by this algorithm in line with evaluated impacts.

[7] BVT performed a sampling of 35 FV2020 projects. Contractors were interviewed and desk reviews of projects were completed to evaluate measure realization rates. Ansealing realization rate established by using TRN-based algorithms and actual reported (and/or verified) pre/post blower door numbers.

[8] Lifetime consistent with Tracker assumptions.

[9] Due to highly variable scopes and approaches to airsealing, EVT will use actual cost data collected for a particular performance year to perform a year-end adjustment to deemed costs to align with actual average costs.

# **HPwES 2.0 Insulation: Exterior Walls**

Measure Numbe	r: VII-K-3 b
Portfolio:	
Status:	Active
Effective Date:	2019/1/1
End Date:	[ None ]
Program:	Existing Homes
End Use:	Thermal Shell

Update Summary
This is a new Efficiency Vermont offering for the Home Performance with Energy Star program and version one of the characterization

### Referenced Documents

- NEST VEIC Data Share 9Jun2017
   VT SF Existing Homes Onsite Report DRAFT 122117
   R-values common building materials
   hpwes-2-0-support-workbook-final-FY2020

Description Description This characterization is in support of Efficiency Vermont's Home Performance with Energy Star Program. This characterization captures the impact associated with blown-in wall insulation activities in a residence. This is a retroft measure, savings energy by increasing the thread resistance of structural decire wall assembles. Reating system characteristics, as well as precessing the unmain resistance propries will be used to estabilish project level impacts. Precediting insulation (relating Insulation (relating Insulation (relating the wall assemble is completely void of thermal insulation material) or "Selfing Insulation" (relating Insulation (relating the wall assemble is completely void of thermal insulation material) or "Selfing Insulation" (relating the wall assemble contains any amount of thremal insulation material) to enable prescriptive implementation of this measure. Post insulation levels assume maximum potential nominal insulation performance is achieved - nominal R13 in 2-4 wall construction and R19 in %6 construction<sup>11</sup>. *Note: this characterization captures the impacts associated with 100 SQPT of wall insulation work, exclusive of glazing. Projects will claim multiple quantities of measures, depending on how much wall insulation work is done.* 

### **Baseline Efficiencies**

Descrince E-ITICLENCIES Baseline conditions are defined by the thermal resistance properties of the existing wall assembly. Two baseline wall assemblies are considered within this characterization: a wall assembly with zero non-structural insulation material and a wall assembly with any amount of non-structural insulation material.

Efficient Equipment Efficient Equipment Efficient Equipment are defined by the improved thermal resistance properties of a wall assembly after blown-insulation work has been performed. It is assumed that normal insulation ratings are achieved. Because insulation work is limited to non-destructive methods, wall cavity thickness dicates improvement limits. Assuming cellulose, fiberglass, or rock wool insulation is used, this limits the theoretical nominal R value ratings to approximately R1 for 2A stud construction and R19 for 2A6 construction. Ultimately, a single blended value for an improved wall condition is assumed within this discussion of the stud construction. .es nately R13

Algorithms Electric Demand Savings Demand savings are exclusive to the heating season and the winter peak demand period. The total electric savings for each source (e.g., heat pump) resulting from insulating are divided by the expected full load heating hours to establish the demand reduction. The loadhehape is subsequently used in conjunction with this value to establish winter peak demand savings.

kW <sub>save</sub>	= kWh <sub>save</sub> / EFLH <sub>eheat</sub>

Energy Savings: Insulation This characterization limits the savings claim to the primary heating system only. Additionally, savings are limited to space heating savings. The savings calculations must be performed for the primary heating source, i.e., the system that contributes the largest proportion of heating load on a annual basis. An example at the end of this section illustrates how this characterization is used to claim savings.

MMBtu <sub>save</sub>	= (1/R_{pre} - 1/R_{post}) × SF_n × HDH_n × $\psi$ × WALL <sub>20</sub> / ( $\eta_{source}$ × $\omega$ )	
kWh <sub>save</sub>	= (1/R_{pre} - 1/R_{post}) \times SF_n \times HDH_n \times \psi \times WALL_{20} / (\eta_{source} \times \omega)	

		S	ystem/ Fuel Type	Efficiency	
		Boiler	Oil	0.85	
			Propane	0.874	
		Furnace	Oil	0.814	
			Propane	0.90	
			Pellet stove	0.70	
			Newer EPA woodstove	0.60	
			Cataylitic woodstove	0.50	
			Non-catalytic woodstove	0.40	
		Other	Outdoor wood boiler	0.25	
			Open hearth fireplace	0.10	
			Propane stove	0.65	
			Heat Pump	2.93	
			Electric Resistance	1.00	
ω	-		n factor from Btu to MMBtu 00 (Btu/MMBtu) or 3,412.1		appropriate
Ψ	-		nt factor to bring savings e mensionless)	stimates give	en by this simplified algorithm to evaluation bill anaylsis
EFLH <sub>eheat</sub>	-	Effective F = 1,383 (I	full Load Hours for electric	heating sour	ce (hours)
HDH <sub>n</sub>	-	Heating D = 127,691	egree Hours <sup>[6]</sup> , (F hr): 1.3 (F hr)		
kW <sub>save</sub>	-	Electric de	emand savings (kW)		
kWh <sub>save</sub>	-	Annual ele	ecric energy savings (kWh)	)	
MMBtu <sub>save</sub>	-	Annual fu	el savings (MMBtu)		
R <sub>post</sub>		environme	esistance of the improved ent (hr F ft <sup>2</sup> /Btu) <sup>(7)</sup> : 17 (hr F ft <sup>2</sup> /Btu)	(post-treatm	ent) wall assemblies separating conditioned space to t
R <sub>pre</sub>	-	Thermal r	esistance of the existing (	ore-treatmen	<li>t) exterior wall assembly separating conditioned space</li>

		ambient environmen	t (hr F ft <sup>2</sup> /Btu). Based	on the presence of insula
		Walls		
		Evaluated Existing Insulation Condition	Deemed Wall Asembly R- Value for Impact Claim	
		No Insulation	2.58593	
		Existing Insulation	10.55070	
SFn	-	Area of treatment wi = 100 (ft <sup>2</sup> )	ith improved insulation	properties
WALL <sub>20</sub>	-	Realization Rate from	n 2020 sampling of pro	jects, dependent on clai
		Evaluated Existin	g Insulation Conditio	n WALL <sub>20</sub>
		No Insulation		0.659243635788118
		Existing Insulation		1.0

The following table summarizes the savings outcomes for each heating system type, and fuel type. To exemplify how savings shall be claimed, let's assume a project has insulated 100 R<sup>2</sup> of wall area and had no existing insulation. The site has a primary programe fumace. Remode HPVINEOFURPROP indicates this project would have 1.556 MMBtu savings associated with wall insulation work. Alternatively, if that same project has insulated 200 R<sup>2</sup> of and area, a quantity of three measures would be claimed for a tatial of 3 x 1.556 – 4.666 MMBtu propane savings.

## Summarized Savings Outcomes

System/I	Fuel Type	Pre R-Value	MMBtu Savings	kWh Savings	kW Savings	Itemcode
	Oil	No Insulation	1.647			HPWINSOBOILOIL
Boiler	01	Existing Insulation	0.086			HPWINSG2BOILOIL
JOIIGI	Propane	No Insulation	1.602			HPWINSOBOILPROP
	Propane	Existing Insulation	0.084			HPWINSG2BOILPROP
	Oil	No Insulation	1.720			HPWINSOFURNOIL
urnace	01	Existing Insulation	0.090			HPWINSG2FURNOIL
unace	Propane	No Insulation	1.556			HPWINSOFURNPROP
	Propane	Existing Insulation	0.082			HPWINSG2FURNPROP
	Pellet strive	No Insulation	2.000			HPWINSOPLLTWOOD
	Penet Stove	Existing Insulation	0.105			HPWINSG2PLLTWOOD
	Newer EPA woodstove	No Insulation	2.333			HPWINS0EPAWWOOD
	Newer EPA Woodstove	Existing Insulation	0.122			HPWINSG2EPAWWOOD
	Catavlitic woodstove	No Insulation	2.800			HPWINS0CATWWOOD
	Cataylitic woodstove	Existing Insulation	0.147			HPWINSG2CATWWOOD
		No Insulation	3.500			HPWINSONCATWOOD
	Non-catalytic woodstove	Existing Insulation	0.183			HPWINSG2NCATWOOD
ther	Outdoor wood boiler	No Insulation	5.600			HPWINS00DWBW00D
Iner	Outdoor wood boller	Existing Insulation	0.294			HPWINSG20DWBW00D
	Open hearth fireplace	No Insulation	14.000			HPWINS00HFPW00D
	Opennearun irrepiace	Existing Insulation	0.734			HPWINSG20HFPW00D
	Propane stove	No Insulation	2.154			HPWINSOSTVEPROP
	Propane stove	Existing Insulation	0.113			HPWINSG2STVEPROP
	Line Dama	No Insulation		140	0.10123	HPWINSOHPMPELEC
	Heat Pump	Existing Insulation		7.3	0.00528	HPWINSG2HPMPELEC
	Electric Resistance	No Insulation		410.3	0.29667	HPWINS0ERESELEC
	Electric Resistance	Existing Insulation		21.5	0.01555	HPWINSG2ERESELEC

## Load Shapes

Number	Name	Status	Winter On kWh	Winter Off kWh	Summer On kWh	Summer Off kWh	Winter kW	Summer kW
5	Residential Space heat	Active	42.9%	57.1%	0.0%	0.0%	25.0%	0.0%

### Net Savings Factors

Measures TSHNACWL Attic/ceiling/wall insulation

Tracks [Base Track] 6036HPES [6036RETR] HPWES EVT

Lifetimes Lifetime for wall insulation is 30 years.[10]

Measure Cost Measure costs of \$200 are used <u>as a placeholder value</u> for 100 ft<sup>2</sup> wall insulation. All costs will be trued up at year-end closeout with actual invoiced project cost averages for insulation work.[11]:

### Footnotes

- (1) Per the 2017 Existing Homes Onsite Report, these two construction types represent 86% of homes in EVT territory. Given that an additional 7% of homes use 24" center construction, this characterization assumes that 15° center construction conservatively represents at lease 35% of homes. Therefore these two will hopes are used to determine an acceptable demend assumption representing any wall hope participating in the program.
- [2] EFU4<sub>brack</sub> is taken to be the established full load hours for a heat pump under the premise that the majority of any eletric heat sources are likely to be heat pumps. Further, as this value is higher than the default EFLH for the loadshape applicable to this measure, the demand savings err on the conservative side. This value is calculated in an analysis of heat pump metered data. The partial load of each heat pump is summed up through the heating search, and taken as an average across all units metered. See TRM measure Variable Speed Mini-Split Heat Pumps (Market Opportunity) for additional background and reference documents.
- [3] Boiler and furnace efficiencies are the median values reported by the Vermont Single-Family Existing Homes On-Site Report, December 21, 2017 in Tables 46 and 47. Heat pump efficiency conservatively taken to be the minimum qualifying efficiency requirement for EVT's programs, HSPF = 10.0, converted to COP by dividing by 341214.

Pellet stove: The EPA Certified Wood Heater Database, which only lists EPA compliant models, indicates that the average modern pellet stove – year 2017 and never – on average operates at about 73% efficiency. To accommodate older models and non-compliant models it is reasonable to assume 70% efficiency for the pellet shove category.

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general neveral cPA WOOSDXWE category operates with 04% efficiency. Catalytic & Non-catalytic woodstowes: According to the EPA, certified stoves can be 50% more efficient than non-certified units. Additionally, since non-certified units produce more particulate emissions; it follows that soot buildup likely plays a stronger influence on efficiency. Taken together, it is reasonable to assume the worst performing category of woodstoves, non-catalytic, operates at 40% efficiency. For the EPA certified Wood Heater Database, modern catalytic woodstoves have about a 6% efficiency advantage on average, compared to non-catalytic models. It is therefore reasonable to assume that the catalytic woodstove category operates at 50% efficiency, squarely between never EPA woodstoves and non-catalytic woodstoves.

Autoor wood boller: The EPA Certified Wood Heater Database lists average efficiency ratings for cord wood fired hydronic central heaters at 67 however this does not account for heat hydronic heat transfer efficiencies, or the fact that outdoor bollers are often fuelded with green/wet frewor which can have have that the heating value of properly assessment wood. Soot bullous is also a common size in outdoor wood ballers, which further inhibits heat transfer and rotuces efficiency. System design, such as pipe lengths, are also critical to consider, but impossible to generalize. The culmination of these factors leads to a reasonable assumption of 25% efficiency for a typical central wood boller, although in practice efficiencies could be much higher or lower. aters at 67%

\*\*See continuation below in reference 8201

[4] Open hearth fireplace: values of up to 10% are commonly referenced. DDE and the EPA do not cite specific numbers, but do caution "Generally, a wood-burning fireplace: is a very inefficient way to heat your home. Fireplace drafts can pull the warm air up the chimney, causing other rooms to to cooler. If you use central heat well burning in a fireplace, your heater will work harder to maintain constant temperatures throughout the house" and "Traditional fireplaces drafts can go the second of the

Propane stove: Modern vented gas stoves can achieve efficiencies close to non-condensing furnaces, however to account for aged equipment as well as products such as fireplace inserts, an efficiency of 65% is deemed appropriate.

- This adjustment factor mirrors that which is applied to HERO-based HPwES projects. Based on the 2018 program impact evaluation and subsequen outcomes of EM&V/DPS negotiations, the 0.55 adjustment factor is intended to better align the savings estimated by HERO algorithms to those established by evaluation. Since the algorithms used by this characterization closely align with HERO, the same adjustment factor is adopted. [5] This adj
- (6) Heating Degree Hours for attic assumes a base temperature of 58 degrees F and uses Climate Normals data for Burlington Internation Airport. A recent Nest study by EVT revealed that a base temperature of 58 degrees is appropriate to capture the heating tendencies of a typical Vermont home. See referenced document "NEST VEIC Data Share \$9,An2017." In an attempt to make a consensative estimate of heating tendencies of a typical Vermont home. See referenced document "NEST VEIC Data Share \$9,An2017." In an attempt to make a consensative estimate of heating tendencies of a typical Vermont home. See referenced document "NEST VEIC Data Share \$9,An2017." In an attempt to make a consensative estimate of heating tendencies of a typical Vermont share and one of the other temperature of Sources would be included in the total, assuming that homeovers would disable or set back heating systems in the off season. The heating season would be included in the total, assuming that homeovers would disable or set back heating systems in the off season. The heating season would be included in the total, assumes a bierd of conditioned and unconditioned space as reported by the Vermont Single-Family Existing Heating Degree Hours for basement assumes a bierd of conditioned and unconditioned space as reported by the Vermont Single-Family Existing Heating Degree Hours for basement assumes a bierd of a degrees F based on the premise that unconditioned basements are allowed to swing in temperature, are ground coupled, and are usally cool. See worksheets "Foundation Blend" and "HDH Climate Normals" in the HPWES 2.0 Support Workbook FIN4L\_walls for a complete derivation.
- [7] This value is a weighted blend of near perfect (Grade I) insulated wall assemblies using 2v4 and 2x6 studs 16° on center construction. Per the existing home report, this construction represents 86% of homes in EVT territory. Given that an additional 7% of homes use 24° center construction, this characterization assumes that 16° center construction conservatively represents at least 93% of homes. Its therefore taken to be an acceptable deemed assumption for any wall by pe arricipating in the program. For a full derivation, see the workshet "Walls" in reference document HPWES 2.0 Support Workbook FIN4L, walls. Note that this number reflects the r-value of insulation as well as all other assembly materials.

[8] Existing Insulation deemed value is a weighted blend of Grade III and Grade III (as defined by the 2017 Existing Homes Onsite Report) insulated wall assemblies using 2v4 and 2x6 studs 16° on center construction. Per the report, Grade II and Grade III ratings represent 100% of existing values as its VT territory, Grade III insulation assumes 3% of insulation area is comprised of gaps and Grade III ratings represent 100% of existing values as its comprised of gaps and Grade III assumes 3.5%. For a full deviation of "No Insulatio" and "Distinging insulation" assembly assumes values of the insulation as well as all other assembly smatterials and air gaps.

[9] EVT performed a sampling of 35 FY2020 projects. Contractors were interviewed and desk reviews of projects were completed to evaluate measure realization rates. Wall insulation realization rate established by using TRM-based algorithms with verified variable inputs.

[10] Lifetimes consistent with Tracker assumptions.

[11] Due to highly variable scopes and approaches to insulating, EVT will use actual cost data collected for a particular performance year to perform a year-end adjustment to deemed costs to align with actual average costs.

# HPwES 2.0 Insulation: Attic and/or Basement

 Measure Number:
 VII-K-2 g

 Portfolio:
 Status:

 Status:
 Active

 Effective Date:
 2021/1/1

 End Date:
 [ None ]

 Program:
 Existing Homes

 End Use:
 Thermal Shell

# **Update Summary**

Updated Attic insulation RR for 2021 to reflect improved efforts to collect more documentation.

# **Referenced Documents**

- NEST VEIC Data Share 9Jun2017
- VT SF Existing Homes Onsite Report DRAFT 122117
- hpwes-2-0-support-workbook-final-FY2020

# Description

This characterization is in support of Efficiency Vermont's Home Performance with Energy Star Program. This characterization captures the impact associated with open attic and/or basement/crawlspace rim joist and wall insulation activities in a residence. This is a retrofit measure, saving energy by savings energy by increasing the thermal resistance of structural assemblies. Heating system characteristics, as well as actual pre and post thermal resistance properties will be used to establish project level impacts. Pre-existing insulation levels (post assumes current RBES code minimum requirements are met) will be mapped to one of three categories for the assignment of impact to enable prescriptive implementation of this measure. In order for insulation work to be incentivized, existing basement insulation must have a nominal rating of R10 or lower, and attic insulation R30 or lower.

# **Baseline Efficiencies**

Baseline conditions are defined by the overall weighted nominal insulation R-value of existing insulation.

# **Efficient Equipment**

Current Vermont Residential Building Energy Standards minimum requrements define the efficient conditions for both insulation measures.

For open attics, the efficient condition upgrades the insulation properties of the attic assembly by achieving an overall weighted nominal insulation R-value of R-49.

For basements, an overall weighted nominal insulation R-value of R-15 defines the efficient condition.

# Algorithms

## **Electric Demand Savings**

Demand savings are exclusive to the heating season and the winter peak demand period. The total electric savings for each source (e.g., heat pump) resulting from insulating are divided by the expected full load heating hours to establish the demand reduction. The loadhshape is subsequently used in conjunction with this value to establish winter peak demand savings.

kW<sub>save</sub>

=  $kWh_{save}$  /  $EFLH_{eheat}$ 

Symbol Table

### **Energy Savings: Insulation**

This characterization limits the savings claim to the primary heating system only. Additionally, savings are limited to space heating savings. The savings calculations must be performed for the primary heating source, i.e., the system that contributes the largest proportion of heating load on a annual basis. An example at the end of this section illustrates how this characterization is used to claim savings.

MMBtu <sub>save</sub>	= (1/R <sub>pre</sub> - 1/R <sub>post</sub> ) × SF <sub>n</sub> × HDH <sub>n</sub> × $\psi$ × RR <sub>20</sub> / (η <sub>source</sub> × $\omega$ )
kWh <sub>save</sub>	= (1/R <sub>pre</sub> - 1/R <sub>post</sub> ) × SF <sub>n</sub> × HDH <sub>n</sub> × $\psi$ × RR <sub>20</sub> / (η <sub>source</sub> × $\omega$ )

# TRM Characterization: HPwES 2.0 Insulation: Attic and/or Basement

Nsource	= Operating	g efficiency o	f the heating source	<sup>[2][3]</sup> , dependent of fuel	and system type:					
	S	ystem/Fue	l Type Effic	ciency						
		Oil	0.85							
	Boiler	Propane	0.87	'4						
		Oil	0.81	.4						
	Furnace	Propane	0.90	)						
		Pellet stove	e 0.70	)						
		Newer EPA	woodstove 0.60	)						
		Cataylitic v	voodstove 0.50	)						
		Non-cataly	tic woodstove 0.40	)						
	Other	Outdoor w	ood boiler 0.25	;						
		Open hear	th fireplace 0.10	)						
		Propane st	ove 0.65	;						
		Heat Pump	2.93	3						
		Electric Re	sistance 1.00	)						
ω		Conversion factor from Btu to MMBtu or kWh, as appropriate = 1,000,000 (Btu/MMBtu) or 3,412.14 (Btu/kWh)								
ĥ	-	ent factor to b limensionless		tes given by this simplifi	ed algorithm to evalua	tion bill anaylsis result				
EFLH <sub>eheat</sub>	= Effective = 1,383 (		urs for electric heati	ng source (hours)						
HDH <sub>n</sub>	= Heating D	Degree Hours	<sup>[5]</sup> , dependent on s	pace being treated (F hr	):					
	= 127,69	1.3 (F hr) foi	flat, open attic OR	99,194.6 (F hr) for base	ement/crawlspace rim	joists and walls				
kW <sub>save</sub>	= Electric d	emand savin	gs (kW)							
kWh <sub>save</sub>	= Annual el	ecric energy	savings (kWh)							
MMBtu <sub>save</sub>	= Annual fu	iel savings (N	1MBtu)							
R <sub>post</sub>	environm	ent <sup>[6]</sup> , deper	ndent on space bein	-treatment) assemblies g treated (hr F ft <sup>2</sup> /Btu):						
	= 49.0 (h	ır F ft²/Btu) fi	or flat, open attic Ol	R 22.4 (hr F ft <sup>2</sup> /Btu) for l	basement/crawlspace	rim joists and walls				
R <sub>pre</sub>	ambient e	environment <sup>[</sup>	<sup>7]</sup> , dependent on sp	existing (pre-treatment ace being treated (hr F savings, as outlined in t	ft <sup>2</sup> /Btu). Reported ratin					
	Attic			Basement						
	Evaluat Existing	ed J R-Value	Deemed R-Value for Impact Claim		Deemed R-Value for Impact Claim**					
	Below 1	0	5	Below 3	8.5					
	10 to 20		15	3 to 7	12.2					
	Above 2	0	25	Above 7	15.8					

# TRM Characterization: HPwES 2.0 Insulation: Attic and/or Basement

		insulation only are 1.5, 5 and 8.	5 (hr F	ft <sup>2</sup> /Btu) respectively.		
RR <sub>20</sub>	=	Realization Rate from 2020 sam	pling of	projects, dependent on space typ	e and claimed existing	insulation leve
		Attic		Basement		
		Evaluated Existing R-Value	RR <sub>20</sub>	Evaluated Existing R-Value*	RR <sub>20</sub>	
		Below 10	0.40	Below 3	0.303456151518978	
		10 to 20	1.0	3 to 7	1.0	
		Above 20	1.0	Above 7	1.0	
SFn	=	Area of treatment with improved	d insula	tion properties <sup>[9]</sup>		
		- 852 87 (ft <sup>2</sup> ) for flat open attic		7.59 (ft <sup>2</sup> ) for basement/crawlspac	o rim joists and walls	

The following table summarizes the savings outcomes for each treatment area, treatment activity, heating system type, and fuel type. To exemplify how savings shall be claimed, let's assume a project has insulated an open attic and had existing R-25 nominally rated insulation. The site has a primary propane furnace. R-28 existing insulation maps to a deemed value of R-25, itemcode HPAINS15FURNOIL which has **3.079 MMBtu** savings associated with it.

# **Summarized Savings Outcomes**

# Attic

System/I	Fuel Type	Pre R-Value	MMBtu Savings	kWh Savings	kW Savings	Itemcode
		<10	5.062			HPAINS5BOILOIL
	Oil	10 to 20	3.260			HPAINS15BOILOIL
Boiler		>20	1.381			HPAINS25BOILOIL
DOIIGI		<10	4.923			HPAINS5BOILPROP
	Propane	10 to 20	3.170			HPAINS15BOILPROP
		>20	1.343			HPAINS25BOILPROP
		<10	5.286			HPAINS5FURNOIL
	Oil	10 to 20	3.404			HPAINS15FURNOIL
Furnace		>20	1.442			HPAINS25FURNOIL
runace		<10	4.781			HPAINS5FURNPROP
	Propane	10 to 20	3.079			HPAINS15FURNPROP
		>20	1.304			HPAINS25FURNPROP
		<10	6.147			HPAINS5PLLTWOOD
	Pellet stove	10 to 20	3.958			HPAINS15PLLTWOOD
		>20	1.676			HPAINS25PLLTWOOD
		<10	7.171			HPAINS5EPAWWOOD
	Newer EPA woodstove	10 to 20	4.618			HPAINS15EPAWWOOI
		>20	1.956			HPAINS25EPAWWOOI
		<10	8.606			HPAINS5CATWWOOD
	Cataylitic woodstove	10 to 20	5.542			HPAINS15CATWWOO
		>20	2.347			HPAINS25CATWWOO
		<10	10.757			HPAINS5NCATWOOD
	Non-catalytic woodstove	10 to 20	6.927			HPAINS15NCATWOOD
		>20	2.934			HPAINS25NCATWOOD
		<10	17.211			HPAINS50DWBW00D
Other	Outdoor wood boiler	10 to 20	11.083			HPAINS150DWBW00
		>20	4.694			HPAINS250DWBW00
		<10	43.028			HPAINS50HFPWOOD
	Open hearth fireplace	10 to 20	27.708			HPAINS150HFPWOOD
		>20	11.735			HPAINS250HFPWOOD
		<10	6.620			HPAINS5STVEPROP

	Propane stove	10 to 20	4.263			HPAINS15STVEPROP
		>20	1.805			HPAINS25STVEPROP
		<10		430.1	0.31102	HPAINS5HPMPELEC
	Heat Pump	10 to 20		277.1	0.20036	HPAINS15HPMPELEC
		>20		117.4	0.08489	HPAINS25HPMPELEC
		<10		1261.0	0.91179	HPAINS5ERESELEC
	Electric Resistance	10 to 20		812.0	0.58713	HPAINS15ERESELEC
		>20		343.9	0.24866	HPAINS25ERESELEC
Basemen	. <b>8</b> -					
	Fuel Type	Pre R-Value	MMBtu Savings	kWh Savings	kW Savings	Itemcode
Systempt	uei rype	<3	1.380	KWII Savings	KW Savings	HPBINS8BOILOIL
	Oil		2.313			
	OII	3 to 7				HPBINS12BOILOIL
Boiler		>7	1.156			HPBINS16BOILOIL
	5	<3	1.342			HPBINS8BOILPROP
	Propane	3 to 7	2.249			HPBINS12BOILPROP
		>7	1.124			HPBINS16BOILPROP
		<3	1.441			HPBINS8FURNOIL
	Oil	3 to 7	2.415			HPBINS12FURNOIL
Furnace		>7	1.207			HPBINS16FURNOIL
		<3	1.303			HPBINS8FURNPROP
	Propane	3 to 7	2.184			HPBINS12FURNPROP
		>7	1.092			HPBINS16FURNPROP
		<3	1.676			HPBINS8PLLTWOOD
	Pellet stove	3 to 7	2.808			HPBINS12PLLTWOOD
		>7	1.404			HPBINS16PLLTWOOD
		<3	1.955			HPBINS8EPAWWOOD
	Newer EPA woodstove	3 to 7	3.276			HPBINS12EPAWWOO
		>7	1.637			HPBINS16EPAWWOO
		<3	2.346			HPBINS8CATWWOOD
	Cataylitic woodstove	3 to 7	3.931			HPBINS12CATWWOO
		>7	1.965			HPBINS16CATWWOO
		<3	2.932			HPBINS8NCATWOOD
	Non-catalytic woodstove	3 to 7	4.914			HPBINS12NCATWOO
		>7	2.456			HPBINS16NCATWOO
		<3	4.692			HPBINS80DWBW00E
Other	Outdoor wood boiler	3 to 7	7.863			HPBINS120DWBWOC
		>7	3.930			HPBINS160DWBWOC
		<3	11.729			HPBINS80HFPWOOD
	Open hearth fireplace	3 to 7	19.657			HPBINS120HFPWOOI
		>7	9.825			HPBINS160HFPWOOI
		<3	1.804			HPBINS8STVEPROP
	Propane stove	3 to 7	3.024			HPBINS12STVEPROP
		>7	1.512			HPBINS16STVEPROP
		<3		117.3	0.08482	HPBINS8HPMPELEC
	Heat Pump	3 to 7		196.6	0.14215	HPBINS12HPMPELEC
		>7		98.2	0.07101	HPBINS16HPMPELEC
		<3		343.7	0.24852	HPBINS8ERESELEC
	Electric Resistance	3 to 7		576.1	0.41656	HPBINS12ERESELEC
		>7		287.9	0.20817	HPBINS16ERESELEC

**Load Shapes** 

5b Residential Space heat

5 Residential Space heat Active 42.9% 57.1% 0.0% 0.0% 25.0% 0.0%	Number	Name	Status	Winter On kWh	Winter Off kWh	Summer On kWh	Summer Off kWh	Winter kW	Summer kW
	5	Residential Space heat	Active	42.9%	57.1%	0.0%	0.0%	25.0%	0.0%

# **Net Savings Factors**

## Measures

TSHNACWL Attic/ceiling/wall insulation

TSHNFNDN Foundation insulation, interior

# Tracks [Base Track]

6036HPES [6036RETR] HPWES EVT

# Lifetimes

Lifetime for attic insulation is 30 years.<sup>[10]</sup>

Lifetime for basement insulation is 15 years.

# **Measure Cost**

Measure costs of \$3,000 are used *as a placeholder value* for attic insulation.

Measure costs of \$3,000 are used *as a placeholder value* for basement insulation.

All costs will be trued up at year-end closeout with actual invoiced project cost averages for airsealing work.[11]:

# Footnotes

[1] EFLH<sub>eheat</sub> is taken to be the established full load hours for a heat pump under the premise that the majority of any eletric heat sources are likely to be heat pumps. Further, as this value is higher than the default EFLH for the loadshape applicable to this measure, the demand savings err on the conservative side. This value is calculated in an analysis of heat pump metered data. The partial load of each heat pump is summed up through the heating season, and taken as an average across all units metered. See TRM measure Variable Speed Mini-Split Heat Pumps (Market Opportunity) for additional background and reference documents.

[2] Boiler and furnace efficiencies are the median values reported by the Vermont Single-Family Existing Homes On-Site Report, December 21, 2017 in Tables 46 and 47. Heat pump efficiency conservatively taken to be the minimum qualifying efficiency requirement for EVT's programs, HSPF = 10.0, converted to COP by dividing by 3.41214.

Pellet stove: The EPA Certified Wood Heater Database, which only lists EPA compliant models, indicates that the average modern pellet stove – year 2017 and newer – on average operates at about 73% efficiency. To accommodate older models and non-compliant models it is reasonable to assume 70% efficiency for the pellet stove category.

"Newer EPA Woodstove" refers to units sold after July 1, 1992 when Phase 2 particulate emissions standards became effective (4.1 g/hr for catalytic stoves and 7.5 g/hr for non-catalytic stoves). These units characteristically have better efficiencies than older or non-compliant units. The EPA Certified Wood Heater Database, which only lists efficiencies for qualifying models dated back to 2015, indicates that the modern woodstove performs at about 73% efficiency. Given that performance has increased since the 1992 standard and considering stove maintenance realities – per DOE, even one-tenth of an inch of soot buildup on stove internals can drop heat transfer efficiency of the metal by 50% – it is fully reasonable to assume the general "Newer EPA Woodstove" category operates with 60% efficiency.

Catalytic & Non-catalytic woodstoves: According to the EPA, certified stoves can be 50% more efficient than non-certified units. Additionally, since non-certified units produce more particulate emissions, it follows that soot buildup likely plays a stronger influence on efficiency. Taken together, it is reasonable to assume the worst performing category of woodstoves, non-catalytic, operates at 40% efficiency. Per the EPA Certified Wood Heater Database, modern catalytic woodstoves have about a 6% efficiency advantage on average, compared to non-catalytic models. It is therefore reasonable to assume that the catalytic woodstove category operates at 50% efficiency, squarely between newer EPA woodstoves and non-catalytic woodstoves.

Outdoor wood boiler: The EPA Certified Wood Heater Database lists average efficiency ratings for cord wood fired hydronic central heaters at 67%, however this does not account for heat hydronic heat transfer efficiencies, or the fact that outdoor boilers are often fueled with green/wet firewood, which can have half the heating value of properly seasoned wood. Soot buildup is also a common issue in outdoor wood boilers, which further inhibits heat transfer and reduces efficiency. System design, such as pipe lengths, are also critical to consider, but impossible to generalize. The culmination of these factors leads to a reasonable assumption of 25% efficiency for a typical central wood boiler, although in practice efficiencies

could be much higher or lower.

\*\*See continuation below in reference 8200

[3] Open hearth fireplace: values of up to 10% are commonly referenced. DOE and the EPA do not cite specific numbers, but do caution "Generally, a wood-burning fireplace is a very inefficient way to heat your home. Fireplace drafts can pull the warm air up the chimney, causing other rooms to be cooler. If you use central heat while burning in a fireplace, your heater will work harder to maintain constant temperatures throughout the house" and "Traditional fireplaces draw in as much as 300 cubic feet per minute of heated room air for combustion, then send it straight up the chimney... Although some fireplace designs seek to address these issues with dedicated air supplies, glass doors, and heat recovery systems, most traditional fireplaces are still energy losers." When used as primary heat source, a 10% efficiency is a reasonable assumption.

Propane stove: Modern vented gas stoves can achieve efficiencies close to non-condensing furnaces, however to account for aged equipment as well as products such as fireplace inserts, an efficiency of 65% is deemed appropriate.

[4] This adjustment factor mirrors that which is applied to HERO-based HPwES projects. Based on the 2018 program impact evaluation and subsequent outcomes of EM&V/DPS negotiations, the 0.55 adjustment factor is intended to better align the savings estimated by HERO algorithms to those established by evaluation. Since the algorithms used by this characterization closely align with HERO, the same adjustment factor is adopted.

[5] Heating Degree Hours for attic assumes a base temperature of 58 degrees F and uses Climate Normals data for Burlington Internation Airport. A recent Nest study by EVT revealed that a base temperature of 58 degrees is appropriate to capture the heating tendencies of a typical Vermont home. See referenced document "NEST VEIC Data Share 9Jun2017." In an attempt to make a conservative estimate of heating degree hours, it was assumed that only days within a defined heating season would be included in the total, assuming that homeowners would disable or set back heating systems in the off season. The heating season was defined as the time period where temperatures "consistently" fall below 58 degrees. Based on visual inspection of TMY3 data, this period was established as September 19th to May 6th. Heating Degree Hours for basement assumes a blend of conditioned and unconditioned space as reported by the Vermont Single-Family Existing Homes On-Site Report, December 21, 2017. Unconditioned space HDH assumes a base temperature of 48 degrees F based on the premise that unconditioned basements are allowed to swing in temperature, are ground coupled, and are usually cool. See worksheets "Foundation Blend" and "HDH - Climate Normals" in the HPwES 2.0 Support Workbook FINAL for a complete derivation.

- [6] Based on program requirements, which align with Vermont RBES. The R-value for basements appears higher than what the program and RBES requires (R-15) due to the fact that the thermal resistance properties of soil have been accounted for in basements that are below grade. The final weighted number is a composite value based on statistics of homes with below, mixed and no basement (crawlspace) that have been sourced from the Vermont Single-Family Existing Homes On-Site Report, December 21, 2017. For a full derivation, see the worksheet "Foundation Blend" in the HPWES 2.0 Support Workbook FINAL.
- [7] The final value for basements is a weighted, composite value based on statistics of homes with below, mixed and no basement (crawlspace). Additionally, it accounts for the thermal resistance properties of soil. For a full derivation, see the worksheet "Foundation Blend" in the HPwES 2.0 Support Workbook FINAL.
- [8] EVT performed a sampling of 35 FY2020 projects. Contractors were interviewed and desk reviews of projects were completed to evaluate measure realization rates. Basement and attic insulation realization rate established by using TRM-based algorithms with verified variable inputs. For 2021, the attic realization rate is increased to 40% to reflect on-going improvements in documentation of projects. EVT will be actively working to update the shell TRMs for 2022.
- [9] The average area for open attics is derived from a dataset of ~4,400 past EVT home performance projects. See worksheets "Additional Assumptions" and "Airsealing Improvement Factor" for a complete derivation. Basement treatment area (wall area) uses median reported floor areas in the Vermont Single-Family Existing Homes On-Site Report, December 21, 2017 (Table 12) as a basis and assumes completely square areas, eight foot wall heights for full basements and four foot wall heights for crawlspaces. Final value is a weighted, composite number based on foundation type and prevalence in the EVT market territory. For a full derivation, see the worksheet "Foundation Blend" in the HPwES 2.0 Support Workbook FINAL.

[10] Lifetimes consistent with Tracker assumptions.

[11] Due to highly variable scopes and approaches to insulating, EVT will use actual cost data collected for a particular performance year to perform a year-end adjustment to deemed costs to align with actual average costs.