VERMONT DEPARTMENT OF PUBLIC SERVICE

Vermont Energy Efficiency Market Potential Study

prepared for

Vermont Department of Public Service

FINAL REPORT

November 2019

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1 Executive Summary

1.1 BACKGROUND & STUDY SCOPE

Every three years, the Vermont Public Utility Commission conducts a Demand Resources Plan (DRP) proceeding to identify short- and long-term energy efficiency budgets and savings goals, as well as other compensation matters related to the delivery of energy efficiency services by Vermont's Energy Efficiency Utilities (EEUs).[1] As part of the DRP, the Vermont Department of Public Service ("DPS" or "Department") commissioned the GDS/Cadmus team to conduct a joint assessment of electric and natural gas energy efficiency potential to help inform and establish future energy efficiency savings goals.

The scope of this study includes assessing the energy efficiency potential associated with the State's three designated EEUs. This study assesses both electric and natural gas energy efficiency potential throughout Vermont for a period of 20 years (2021-2040).

The main objectives of the study include:

- Evaluating the electric and natural gas energy efficiency technical and economic potential savings throughout Vermont, and more specifically within the service areas of the three Vermont EEUs;
- Evaluating the achievable potential savings for each EEU per two defined scenarios;
- Calculating the Vermont Societal Cost Test (VT SCT) benefit-cost ratio for the achievable potential savings scenarios and determining the associated EEU budgets;
- Providing an analysis of the rate and bill impacts associated with the estimates of achievable potential;
- Providing the results of the potential analysis in a format useful for supporting the development of individual EEU DRP modeling

The 2019 Vermont Market Potential Study (MPS) does not include a discussion or analysis of demand response either through direct load control or rates. This study does not specifically examine potential peak load reduction and energy reductions from demand response programs but does estimate demand savings and peak load reductions associated with different types of energy efficiency potential. In addition, it does not include modeling assumptions related to EEU Thermal Energy and Process Fuel programs.

1.2 TYPES OF POTENTIAL ESTIMATED

The scope of this study distinguishes three types of energy efficiency potential: (1) technical, (2) economic, and (3) achievable.

- ***Technical Potential*** is the theoretical maximum amount of energy use that could be displaced by efficiency, disregarding all non-engineering constraints such as cost-effectiveness (including measure costs and program delivery costs) and the willingness of end users to adopt the efficiency measures. Technical potential is constrained only by factors such as technical feasibility and applicability of measures. Under technical potential, GDS assumed that 100% of new construction and market opportunity measures are adopted as those opportunities become available (e.g., as new buildings are constructed they immediately adopt efficiency measures, or as existing measures reach the end of their useful life). For retrofit measures, implementation was assumed to be resource constrained and that it was not possible to install all retrofit measures all at once. Rather, retrofit opportunities were assumed to be replaced incrementally until 100% of stock were converted to the efficient measure over a period of no more than 20 years.

[1] Efficiency Vermont (EVT) delivers EEU services throughout most of the state. The City of Burlington Electric Department ("BED") delivers EEU services in its service territory. Vermont Gas Systems (VGS) delivers natural gas EEU services in its service territory.

- ***Economic Potential*** refers to the subset of the technical potential that is economically cost-effective as compared to conventional supply-side energy resources. Economic potential follows the same adoption rates as technical potential. Like technical potential, the economic scenario ignores market barriers to ensuring actual implementation of efficiency. Finally, economic potential only considers the costs of efficiency measures themselves, ignoring any programmatic costs (e.g., marketing, analysis, administration) that would be necessary to capture them.[2]
- ***Achievable Potential*** considers real-world barriers to encouraging end users to adopt efficiency measures, the non-measure costs of delivering programs (for administration, marketing, tracking systems, and monitoring and evaluation), and the capability of programs and administrators to boost program activity over time.[3] This analysis provides two scenarios of achievable potential: maximum achievable, and program achievable potential.
  - ***Maximum Achievable (MA) Potential*** is the amount of energy use that efficiency can realistically be expected to displace, assuming the most aggressive program scenario possible (e.g., providing end users with incentive payments for the entire incremental cost of more efficient equipment).
  - ***Program Achievable (PA) Potential*** estimates achievable potential on EEUs paying incentive levels (as a percent of incremental or total measure costs) that are calibrated to historical levels. Program achievable potential also seeks to align initial year savings with recent historical achievements, to reflect likely barriers with accelerating (or decreasing) program activity too rapidly, allowing program activity to expand (or contract) more gradually over time. Last, common to program modeling for EEUs, sector equity constraints are applied for the residential, commercial and industrial, low-income, and small business sectors. These equity targets are in place to ensure that program spending levels are proportionally similar to EE&C charge collections.

1.3 APPROACH SUMMARY

The GDS/Cadmus team used a bottom-up approach to estimate energy efficiency potential in the residential and commercial sectors. Bottom-up approaches begin with characterizing the eligible equipment stock, estimating savings and screening for cost-effectiveness first at the measure level, then summing savings at the end-use and service area levels. Due to additional complexities in the industrial sectors, GDS utilized the bottom-up modeling approach to first estimate measure-level savings and costs as well as cost-effectiveness, and then applied cost-effective measure savings to all applicable shares of energy load.

1.4 STUDY LIMITATIONS/CAVEATS

As with any assessment of energy efficiency potential, this study necessarily builds on various assumptions and data sources, including the following:

- Energy efficiency measure lives, savings, and costs
- Projected penetration rates for energy efficiency measures
- Projections of electric and natural gas avoided costs[4]
- Future known changes to codes and standards
- EEU load forecasts and assumptions on their disaggregation by sector, segment, and end use
- End-use saturations and fuel shares
- Equity targets for program spending

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[2] National Action Plan for Energy Efficiency, “Guide for Conducting Energy Efficiency Potential Studies” (November 2007), page 2-4.

[3] Ibid.

[4] The avoided costs used in the 2019 analysis were approved in Commission Order EEU 2015-04 on December 20, 2017. A sensitivity analysis was also performed with different avoided costs and is discussed in further detail below (tables 4-4,5-4, and 6-4).

While the GDS/Cadmus team has sought to use the best and most current available data, there are often reasonable alternative assumptions which would yield slightly different results. For instance, the analysis assumes that nearly all existing measures, regardless of their current efficiency levels, can be eligible for future installation and savings opportunities. Other studies may select a narrower viewpoint, limiting the amount of potential from equipment that is already considered to be energy efficient. Additionally, the models used in this analysis must make several assumptions regarding program delivery and the timing of equipment replacement that may ultimately occur more rapidly (or more slowly) than currently forecasted.

Furthermore, while the lists of energy efficiency measures examined in this study analysis represent technologies available on the market today and characterized in the Vermont Technical Reference Manual (TRM), as well as a limited amount of emerging technologies not characterized in the TRM but available to the contractors from other jurisdictions, these measure lists are not exhaustive. GDS/Cadmus acknowledge that new efficient technologies may become available over the course of the 20-year study timeframe that could produce efficiency gains and costs at different levels than those currently assumed.

Where possible, GDS/Cadmus and the Department frequently collaborated with the EEUs to ensure consistency, where possible, with assumptions and methodological considerations that are expected to be employed by the EEUs during the program planning process.

1.5 ENERGY EFFICIENCY POTENTIAL

1.5.1 Efficiency Vermont (EVT)

Figure 1-1 provides the cumulative annual technical, economic, MA and PA results for the 3-yr, 10-yr, and 20-yr timeframes for EVT. The 3-yr technical potential is 9.3% of forecasted sales, and the economic potential is 8.7% of forecasted sales, indicating that most technical potential is cost-effective. The 3-yr MA is 7.1% and the PA is 4.4%.

FIGURE 1-1 EVT ELECTRIC ENERGY (MWH) INCREMENTAL ANNUAL POTENTIAL (AS A % OF SALES)

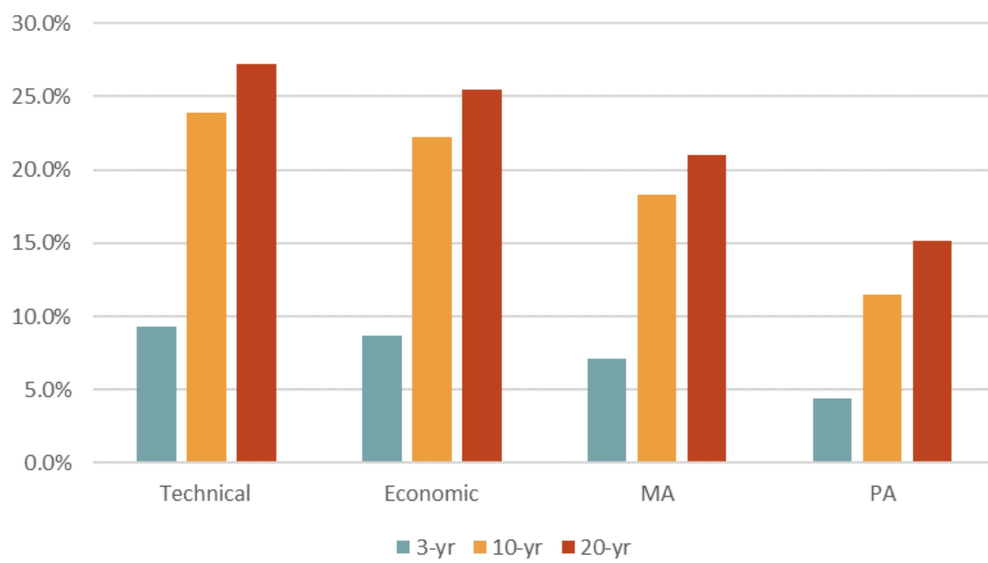
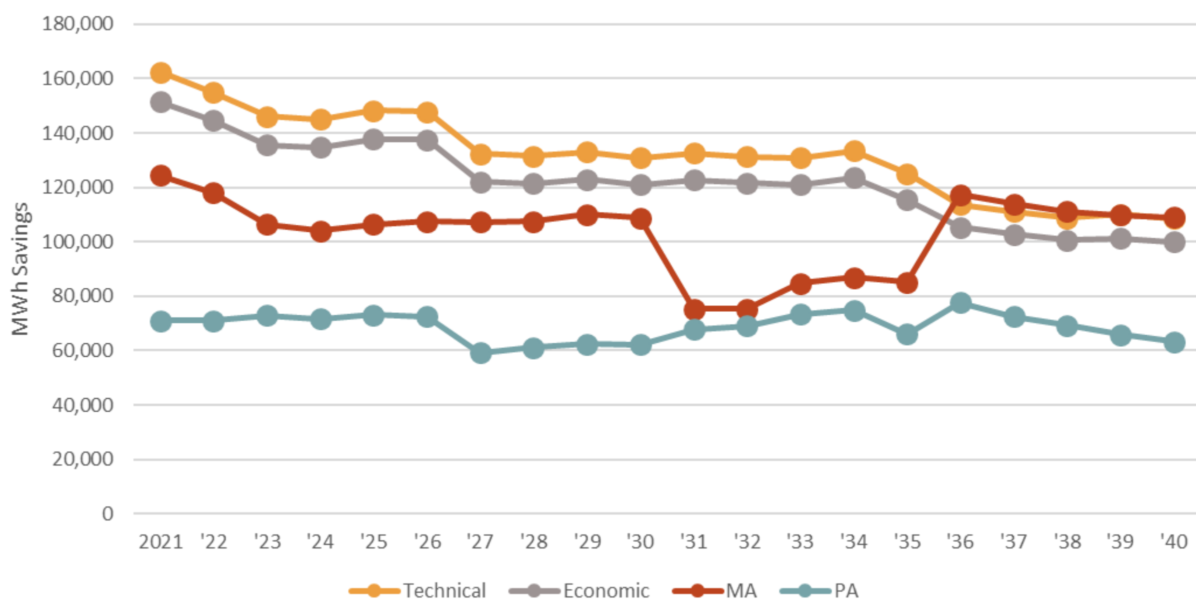


Figure 1-2 illustrates the technical potential, economic potential, MA and PA incremental annual MWh energy efficiency savings estimates in the EVT territory for all sectors combined. The PA savings in 2021 are 71,000 MWh/yr and range from 59,000 MWh/yr to nearly 78,000 MWh/yr.

FIGURE 1-2 SUMMARY OF EVT POTENTIAL (INCREMENTAL ANNUAL MWH)



On an annual basis, the technical and economic potential decline over time. This decline over the analysis timeframe is driven by the nonresidential sector, where the analysis assumes (based on historical savings levels)[5] that EVT's programs successfully encourage customers to replace inefficient equipment, particularly within the lighting end-use, prior to their natural replace on burnout cycle. Absent a new, more efficient, technology that could again be offered as retrofit option, the potential savings is expected to decline over time until the measures installed at the beginning of the analysis are eligible for replacement again. This trend is even more evident in the maximum achievable scenario, where the timing of savings was again shifted to the first decade of the analysis to ensure initial projections were aligned with historical achievements. This creates a multi-year dip in savings where limited new installation opportunities are available. The savings then spike again near the end of the analysis as measures installed at the beginning of the analysis are assumed to be replaced and reinstalled.

In the residential sector, for technical, economic, and maximum achievable potential the incremental annual potential remains slightly more stable. With the exception of a decrease in savings in 2023 as screw-based LED bulbs are expected to become the baseline (see Section 2.3.5), the level of potential is gradually increasing over time. This is driven by an increase in the annual adoption rates of cold-climate heat pumps in residential dwellings to help meet Vermont's policy objectives including but not limited to Tier III Renewable Energy Standard (Section 2.3.2) and, the generally shorter lifetime of residential measures that allow for installation opportunities earlier in the analysis timeframe and more frequently.

Overall, EVT's Program Achievable Potential remains stable over the analysis timeframe, though slightly below recent historical levels. In the nonresidential sector, the Program Achievable strikes a balance between moving forward the natural replacement cycle and a more consistent stream of savings and costs, resulting in a steadier savings projection. Residential Program Achievable potential, then, also remains stable over the analysis timeframe as a direct byproduct of the nonresidential sector potential

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[5] In 2018, EVT achieved more than 66,000 MWh of nonresidential lighting savings, or more than 8% of all estimated C&I lighting load. Sustained savings at this level would eliminate all C&I lighting load in just over 12 years. It is not reasonable to expect efficient lighting measures to eliminate all lighting load, thus all reasonable lighting potential would be exhausted considerably sooner assuming the same level of annual savings. Given that the typical efficient lighting fixture has an assumed effective useful life of 15 years, it seems plausible and accurate to assume EVT has established a successful retrofit market for C&I lighting.

and the associated targeted equity split in sector program budgets noted above and in Section 2.4.4.[6] Additional detail at the sector level is provided in Section 4.

1.5.2 Burlington Electric Department (BED)

Figure 1-3 provides the cumulative annual technical, economic, MA and PA results for the 3-yr, 10-yr, and 20-yr timeframes for BED. The 3-yr technical potential is 7.0% of forecasted sales, and the economic potential is 6.4% of forecasted sales, indicating that most technical potential is cost-effective. The 3-yr MA is 5.1% and the PA is 3.6%.

FIGURE 1-3 BED ELECTRIC ENERGY (MWH) INCREMENTAL ANNUAL POTENTIAL (AS A % OF SALES)

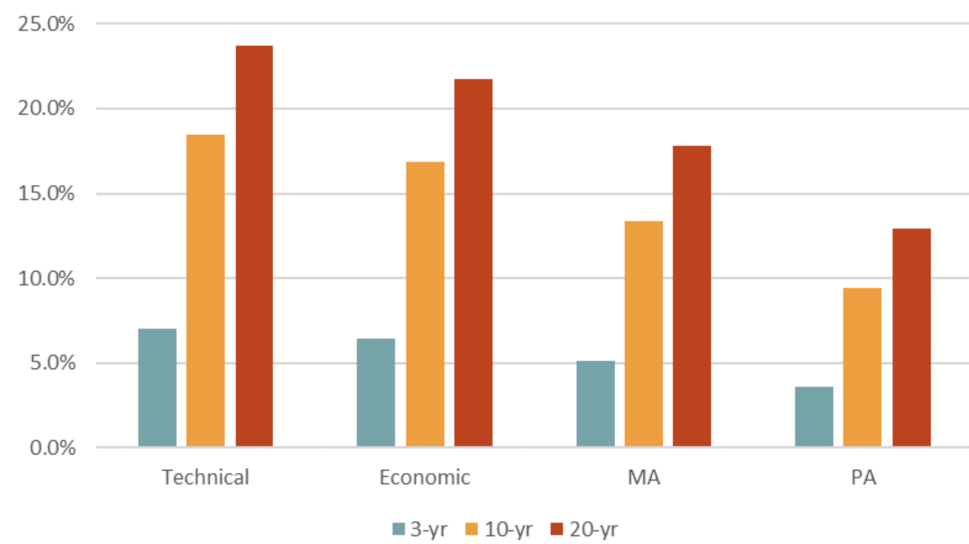
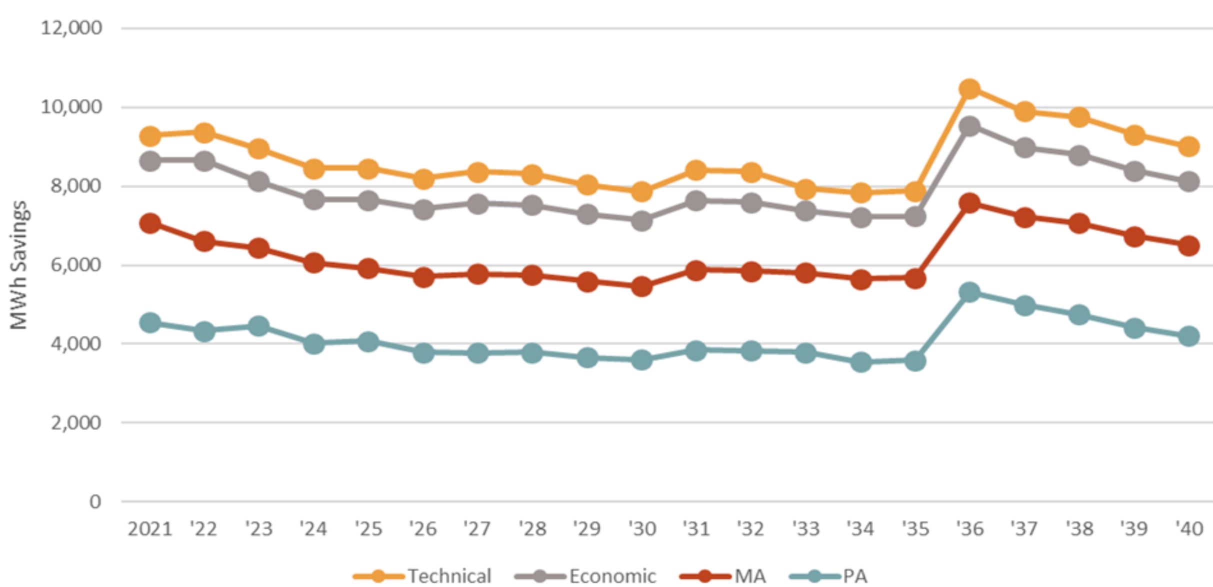


Figure 1-4 illustrates the technical potential, economic potential, MA and PA incremental annual MWh energy efficiency savings estimates in the BED territory. The PA savings in 2021 are roughly 4,500 MWh/yr and range from 3,561 MWh/yr to 5,327 MWh/yr. over the 20-year timeframe.

FIGURE 1-4 SUMMARY OF BED POTENTIAL (INCREMENTAL ANNUAL MWH)



[6] The analysis determined that the nonresidential sector is the limiting factor in addressing the equity considerations, in that there is not enough potential in that sector to maintain equity relative to the remaining potential in the residential sector. Instead, the residential sector potential was scaled down to address the equity constraints.

In the BED service area, potential experience a gradual decrease in time, followed by an increase in 2037 as measures installed early in the analysis are re-installed in later years. Like EVT, this decline over the analysis timeframe is driven by the nonresidential sector, where the analysis assumes that BED's C&I offerings will encourage equipment retrofits (at a more modest rate than EVT) prior to their natural replace-on-burnout cycle. As a result, fewer installation opportunities exist over time until the measures installed at the beginning of the analysis are eligible for replacement again.

Consistent with EVT's residential potential, the BED technical, economic, and maximum achievable potential the incremental annual potential increases slightly over time, though not enough to offset the decrease in the nonresidential sector. The increase in residential sector potential is again driven by the forecasted annual adoption of cold-climate heat pumps[7] in residential dwellings to meet Vermont's policy objectives including but limited to Tier III and the generally shorter lifetime of residential measures that allow for installation opportunities earlier in the analysis timeframe and more frequently.

BED's Program Achievable Potential is a subset of the Maximum Achievable potential. In the nonresidential sector, the Program Achievable achieves a similar pattern of savings relative to the Maximum Achievable potential. As with EVT, residential Program Achievable potential is derived to ensure that equity targets for program spending across sectors are maintained. Additional detail at the sector level is provided in Section 5.

1.5.3 Vermont Gas Systems (VGS)

Figure 1-5 provides the cumulative annual technical, economic, MA and PA results for the 3-yr, 10-yr, and 20-yr timeframes for VGS. The 3-yr technical potential is 9.1% of forecasted sales, and the economic potential is 7.7% of forecasted sales, indicating that most technical potential is cost-effective. The 3-yr MA is 5.9% and the PA is 2.6%.

FIGURE 1-5 VGS NATURAL GAS ENERGY (MCF) INCREMENTAL ANNUAL POTENTIAL (AS A % OF SALES)

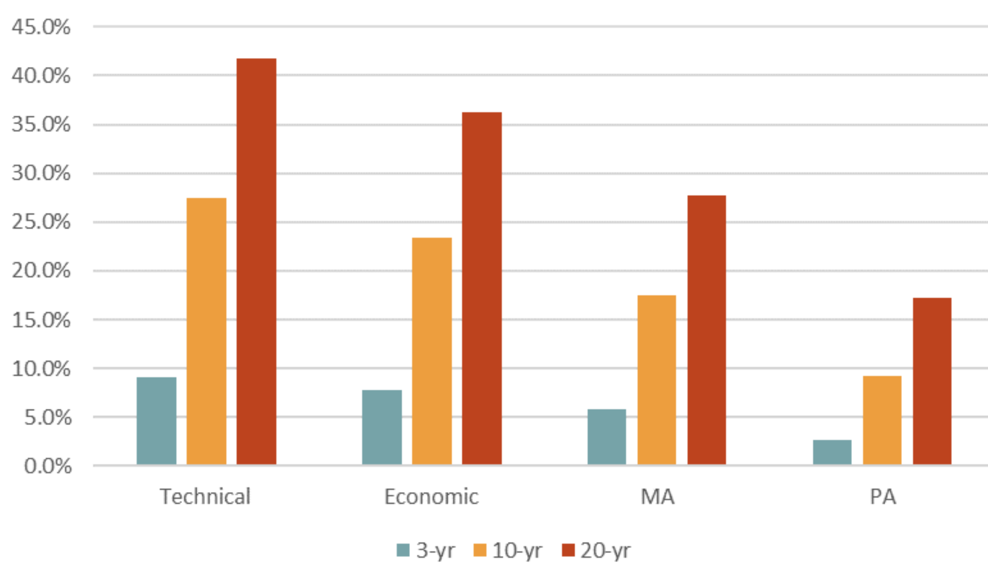
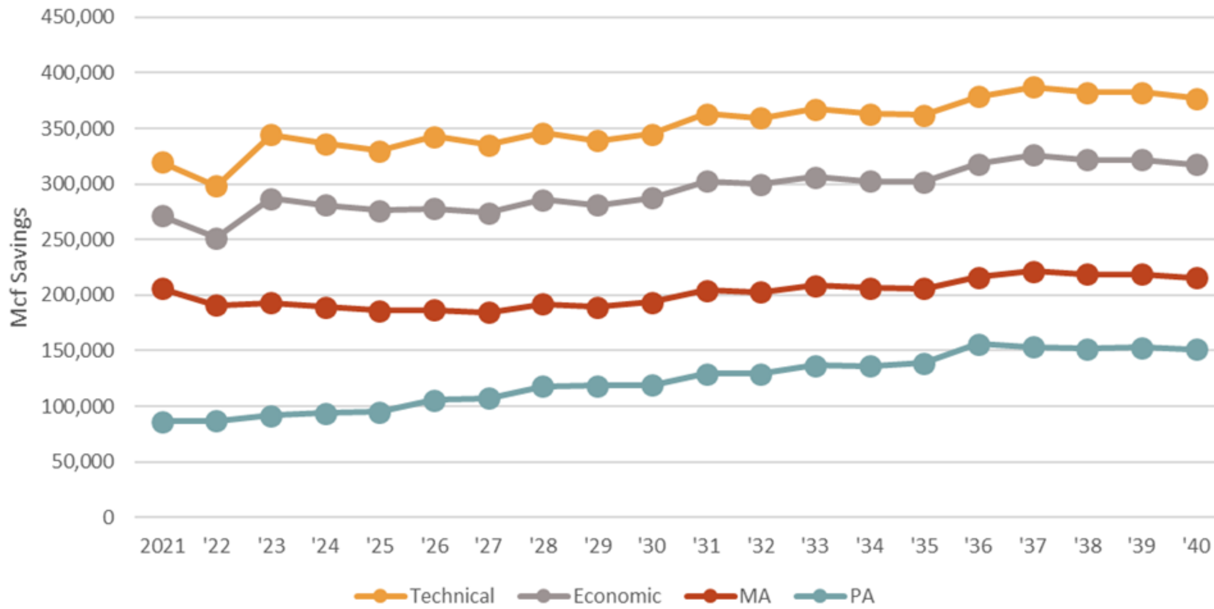


Figure 1-6 illustrates the technical potential, economic potential, MA and PA incremental annual Mcf energy efficiency savings estimates in the VGS territory. The PA savings range from 87,000 Mcf/yr to 156,000 Mcf/yr.

[7] BED's Net Zero Energy goal by 2030, and the number of cold-climate heat pumps to get there, was a consideration in the development of the potential analysis. However, the annual number of cold-climate heat pumps assumed in the potential study analysis is significantly less than what is in BED's Net Zero Energy plan.

FIGURE 1-6 SUMMARY OF POTENTIAL (INCREMENTAL ANNUAL MCF)



Overall, Technical, Economic, Maximum Achievable, and Program Achievable potential increases over the analysis timeframe. VGS has offered award winning energy efficiency programs for many years prior to being appointed an EEU in 2016. Since 2016, VGS' EEU budgets and goals have been established through a Public Utility Commission process aimed at achieving all reasonably achievable cost-effective energy efficiency, as required by state stature. The electric EEUs in Vermont have offered electric energy efficiency programs for decades within the same legislative mandate. Due to the relative nascence of its EEU regulated energy efficiency program as well as VGS' recent expansion into Addison County, natural gas energy efficiency offers increasing potential and savings opportunities.

The increasing potential is more prevalent in the nonresidential sector. In the residential sector, annual increases in Technical, Economic, and Maximum Achievable potential are mitigated by rates of natural gas expansion, and the increased prevalence of cold-climate heat pumps in the VGS service area.

As with EVT and BED, Program Achievable potential is a subset of maximum achievable potential and consideration to achieve targeted equity in program spending across sectors plays a role in determining the total Program Achievable potential.

1.6 SAVINGS SUMMARY

Table 1-1 provides the incremental annual savings from 2021-2023 as well as the cumulative annual savings over a 3-, 10-, and 20-yr period by type of potential and by EEU. The PA ranges from 3% to 4% across the three EEUs by 2023 and between 9% and 12% by 2030.

TABLE 1-1 ELECTRIC AND NATURAL GAS ENERGY EFFICIENCY POTENTIAL SUMMARY

	2021 Inc. Ann.	2022 Inc. Ann.	2023 Inc. Ann.	3-YR Cum. Ann.	10-YR Cum. Ann.	20-YR Cum. Ann.
EVT (MWh)						
Technical	162,532	155,033	146,111	438,932	1,275,953	1,655,330
Economic	151,467	144,553	135,621	407,902	1,192,233	1,509,474
MA	124,503	118,010	106,533	334,583	983,406	1,244,001
PA	71,098	70,970	72,902	208,073	617,161	897,637

	2021 Inc. Ann.	2022 Inc. Ann.	2023 Inc. Ann.	3-YR Cum. Ann.	10-YR Cum. Ann.	20-YR Cum. Ann.
EVT (% of forecasted sales)						
Technical	4%	3%	3%	9%	24%	28%
Economic	3%	3%	3%	9%	22%	25%
MA	3%	3%	2%	7%	18%	21%
PA	2%	2%	2%	4%	12%	15%
BED (MWh)						
Technical	8,721	8,802	8,486	25,306	71,096	98,812
Economic	8,079	8,090	7,665	23,222	64,978	90,543
MA	6,613	6,148	6,065	18,431	51,540	74,319
PA	4,522	4,316	4,436	13,033	36,357	53,853
BED (% of forecasted sales)						
Technical	3%	2%	2%	7%	18%	24%
Economic	2%	2%	2%	6%	17%	22%
MA	2%	2%	2%	5%	13%	18%
PA	1%	1%	1%	4%	9%	13%
VGS (Mcf)						
Technical	319,608	298,200	344,414	914,476	2,850,932	4,522,953
Economic	271,402	251,849	287,030	775,031	2,421,296	3,918,779
MA	206,025	191,037	193,133	588,342	1,814,892	3,002,313
PA	86,524	87,187	91,865	264,429	962,447	1,858,162
VGS (% of forecasted sales)						
Technical	3%	3%	3%	9%	28%	42%
Economic	3%	3%	3%	8%	23%	36%
MA	2%	2%	2%	6%	18%	28%
PA	1%	1%	1%	3%	9%	17%

1.7 ACHIEVABLE POTENTIAL PORTFOLIO BUDGETS & COST-EFFECTIVENESS

Table 1-2 provides annual resource acquisition budgets by EEU for the MA and PA scenarios. The resource acquisition budgets, below, include both incentive and non-incentive costs for programs but exclude any additional Development and Support Services (DSS) budgets, Department evaluation costs, and any EEU performance awards. The MA budget ranges from $125 million to $176 million over the study timeframe. The PA budget ranges from $40 million to $57 million over the study timeframe.

As a point of reference, the Public Utility Commission's 2020 Resource Acquisition budgets for EVT, BED and VGS are $44M, $2.5M, and $3.0M respectively. An additional review of historical savings and budgets by EEU is provided in Section 3.4.

TABLE 1-2 MA AND PA POTENTIAL BUDGETS BY EEU AND STATEWIDE TOTALS ($, IN MILLIONS)

	MA				PA			
	Total	EVT	BED	VGS	Total	EVT	BED	VGS
2021	$138	$110	$5.8	$22	$46	$38	$2.3	$5.6
2022	$136	$109	$5.5	$21	$45	$37	$2.2	$5.5
2023	$127	$100	$5.3	$21	$46	$38	$2.2	$5.8
2024	$125	$99	$5.1	$21	$46	$38	$2.0	$5.8
2025	$128	$102	$4.9	$21	$47	$39	$2.0	$5.9
2026	$130	$104	$4.6	$21	$47	$38	$1.8	$6.5
2027	$131	$106	$4.6	$21	$40	$31	$1.8	$6.6
2028	$133	$107	$4.6	$21	$42	$33	$1.8	$7.1
2029	$134	$109	$4.4	$21	$42	$33	$1.7	$7.1

	MA				PA			
	Total	EVT	BED	VGS	Total	EVT	BED	VGS
2030	$133	$107	$4.3	$21	$42	$33	$1.7	$7.2
2031	$125	$99	$4.6	$22	$45	$35	$1.8	$7.7
2032	$125	$98	$4.5	$22	$45	$36	$1.8	$7.7
2033	$131	$105	$4.3	$23	$48	$38	$1.7	$8.1
2034	$136	$109	$4.3	$22	$49	$39	$1.6	$8.1
2035	$143	$116	$4.5	$22	$44	$35	$1.7	$8.2
2036	$166	$136	$6.1	$24	$57	$45	$2.7	$9.5
2037	$166	$136	$6.0	$24	$54	$42	$2.6	$9.4
2038	$171	$141	$5.9	$24	$51	$40	$2.4	$9.3
2039	$176	$146	$5.7	$24	$50	$38	$2.3	$9.4
2040	$175	$146	$5.5	$24	$49	$37	$2.2	$9.3

Figure 1-7 provides the sector-level budgets for the PA potential scenario for all three EEUs combined for each year of the 2021-2040 timeframe. In the residential sector PA budgets range from $18 million to $28 million. In the nonresidential sector PA budgets range from $22 million to $29 million.

FIGURE 1-7 ANNUAL STATEWIDE BUDGETS FOR PA POTENTIAL

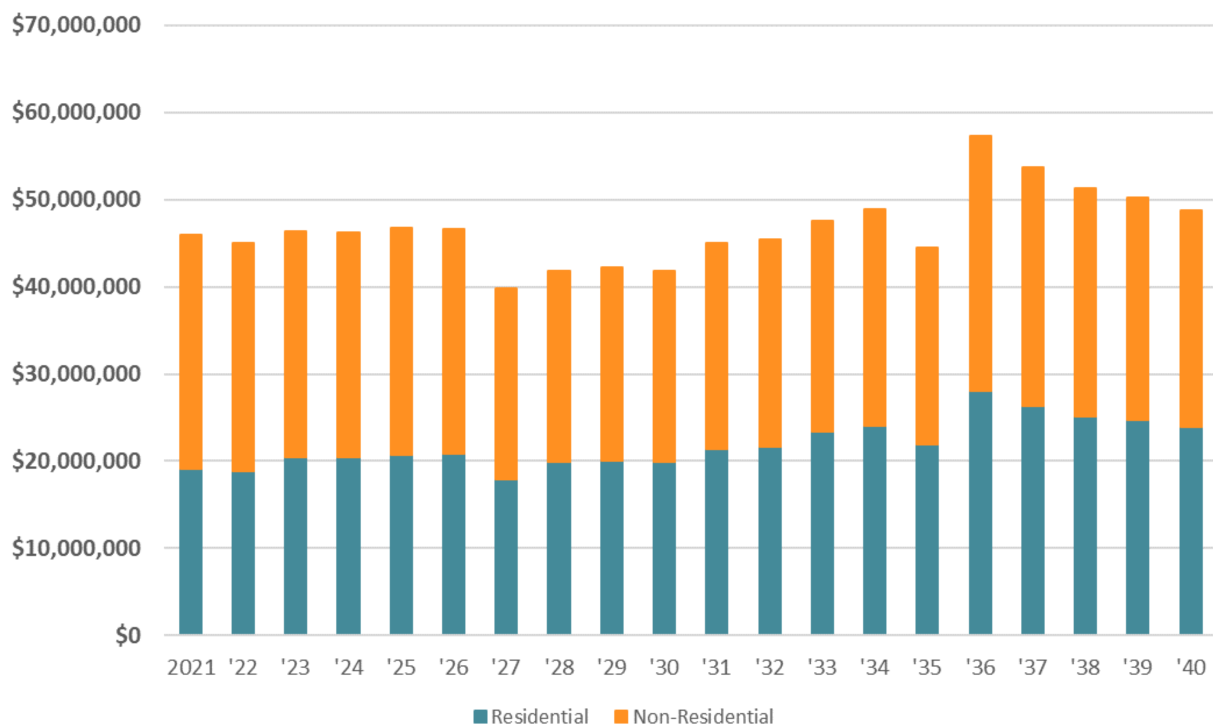


Table 1-3 provides the summary benefit/cost data for each achievable potential scenario. The results are shown for each EEU, all sectors combined, and is also aggregated at the statewide level. The benefit-cost ratio, based on currently approved avoided costs, is nearly 3.2 in the MA scenario and exceeds 4.2 in the PA scenario. The improved benefit-cost ratio in the PA scenario is due to a more equitable split between residential and nonresidential program activity than resulted in the MA scenario, as well as a limited emphasis on low cost of energy saved measures like lighting fixtures and/or cold-climate heat pumps to align with expected policy goals. Overall, the PA scenario is estimated to yield more than $3.7 billion in NPV savings over 20 years.

TABLE 1-3 SOCIETAL COST TEST NPV BENEFITS, COSTS, NET SAVINGS, AND RATIOS FOR STATEWIDE PA ($ IN MILLIONS)

All Sectors	NPV Lifetime Benefits	NPV Program Costs	NPV Savings (Benefits - Costs)	Societal Cost Test Ratio
MA Potential				
EVT	$5,281	$1,790	$3,492	3.0
BED	$308	$76	$232	4.1
VGS	$1,387	$318	$1,069	4.4
Total	$6,976	$2,183	$4,793	3.2
PA Potential				
EVT	$3,826	$938	$2,887	4.1
BED	$235	$47	$187	5.0
VGS	$880	$188	$692	4.7
Total	$4,940	$1,174	$3,767	4.2

1.8 RATE & BILL IMPACTS

The GDS/Cadmus team assesses the projected impact of EEU investments in energy efficiency on projected rates and customers' bills. Implementation of energy efficiency programs affects both the utility's revenue requirement and units of energy sold. Rate impacts vary over time; in the long run, depending upon the composition and trend in the utility's fixed and variable avoided costs, the impacts may be small or even negative.

Energy efficiency programs affect customers in particular rate classes differently, depending upon whether they participate in an energy efficiency program. Program nonparticipant bills may be higher or lower than they would have been absent energy efficiency programs, depending on the trend in rates after program implementation. Participants, on the other hand, will experience a change in their bills from the lower consumption caused by the adoption of energy-efficiency measures offered through programs. Participants bills will almost always be lower even in circumstances where energy efficiency programs lead to an increase in the average rate.

Table 1-4 shows the rate and bill impacts combined across customer classes averaged over the study period. Results are shown for each utility and compare the program achievable and maximum achievable savings scenarios. The rate and bill impact analysis include resource acquisition budgets in addition to estimates based on historic development and support services, performance awards, and DPS evaluation costs. The Rate and Bill Impact Analysis and Methodology section of this report describes the methodology employed by the GDS/Cadmus team to calculate rate and bill impacts in more detail.

TABLE 1-4 AVERAGE RATE AND BILL DIFFERENCES RELATIVE TO BASELINE WITHOUT FUTURE EFFICIENCY

	Program Achievable Potential Scenario		Maximum Achievable Potential Scenario	
All Customers	Rates (2021-2040)	Average Bill Impacts	Rates (2021-2040)	Average Bill Impacts
EVT	3.0%	-7.3%	14.2%	-3.7%
BED	3.3%	-5.3%	9.5%	-3.2%
VGS	2.6%	-6.7%	16.6%	-2.3%

1.9 ORGANIZATION OF REPORT

The remainder of this report is organized in seven sections as follows:

Section 2 Analysis Approach details the methodology used to develop the estimates of technical, economic, and achievable for electric and natural gas energy efficiency savings.

Section 3 Characterization of Vermont EEU Service Areas provides an overview of the Vermont EEU service areas and a brief discussion of the forecasted energy sales by sector.

Section 4 EVT Market Potential Assessment provides a breakdown of the technical, economic, and achievable potential in the EVT service area. Also discussed are estimated portfolio budgets, cost-effectiveness, and rate and bill impacts.

Section 5 BED Market Potential Assessment provides a breakdown of the technical, economic, and achievable potential in the BED service area. Also discussed are estimated portfolio budgets, cost-effectiveness, and rate and bill impacts.

Section 6 VGS Market Potential Assessment provides a breakdown of the technical, economic, and achievable potential in the VGS service area. Also discussed are estimated portfolio budgets, cost-effectiveness, and rate and bill impacts.

Appendices presents additional detailed information on measure assumptions and sources, annual savings and costs, and other global assumptions that were summarized in the report.

- Appendix A – provides a glossary of terms
- Appendix B – provides additional detail on the calculation of the low-income equity target
- Appendix C – provides additional EVT measure data and savings summary tables
- Appendix D – provides additional BED measure data and savings summary tables
- Appendix E – provides additional VGS measure data and savings summary tables
- Appendix F – provides additional Rate and Bill Impact detail

2 Analysis Approach

The majority of this section focuses on the assumptions and methodology directly related to the 2019 VT Market Potential Study (MPS) being developed by the PSD as part of the three-year Demand Resource Plan (DRP) proceeding, but additional sections add additional context regarding the development of EEU Program implementation models and the calculation of Rate and Bill Impacts associated with the long-term estimates of energy efficiency potential.

The 2019 VT MPS does not include a discussion or analysis of demand response either through direct load control or rates. In addition, it does not include modeling assumptions related to EEU Thermal Energy and Process Fuel programs. These assumptions will be developed at a later date and are beyond the scope of the 2019 VT MPS.

The main objectives of this energy efficiency potential study are to estimate the technical, economic, maximum achievable potential (MA) and program achievable potential (PA) for energy efficiency for Efficiency Vermont (EVT), Burlington Electric Department (BED) and Vermont Gas Systems (VGS) from 2021-2040; and to provide potential MWh, MW, and/or Mcf savings estimates for each level of energy efficiency potential. This study does not specifically examine potential peak load reduction and energy reductions from demand response programs but does estimate demand savings and peak load reductions[8] associated with different types of energy efficiency potential.

2.1 OVERVIEW OF APPROACH

The GDS/Cadmus team used a bottom-up approach to estimate energy efficiency potential in the residential and commercial sectors. Bottom-up approaches begin with characterizing the eligible equipment stock, estimating savings and screening for cost-effectiveness first at the measure level, then summing savings at the end-use and service area levels. Due to additional complexities in the industrial sectors, GDS utilized the bottom-up modeling approach to first estimate measure-level savings and costs as well as cost-effectiveness, and then applied cost-effective measure savings to all applicable shares of energy load. Further details of the market research and modeling techniques utilized in this assessment are provided in the following sections.

2.2 MARKET CHARACTERIZATION

The initial step in the analysis is to gather a clear understanding of the current market segments and EEU service areas in Vermont. The GDS/Cadmus Team coordinated with the VT PSD and EEUs to gather utility sales and customer data and existing market research to define appropriate market sectors, market segments, vintages, saturation data and end uses for each EEU service territory. This information serves as the basis for completing a forecast disaggregation of both the residential and nonresidential sectors.

2.2.1 Load Forecast Development

The electric load forecast that is used for the Potential Study is based on the 2018 VELCO Long Range Transmission Plan. PSD and Efficiency Vermont (EVT) utilized this base forecast and apply territory specific adjustments. For IRP purposes and the Demand Resource Plan proceeding, BED uses a separate long term forecast of energy load and peak demand out to 2040 in Burlington (Itron does this load forecast for BED

[8] Estimated peak load reductions are estimated, to the extent practicable, in a manner consistent with the coincident summer and winter peak periods as defined in the 2019 Vermont TRM. Several of the connect/smart measures (including advanced thermostats, smart water heater controls, connective lighting and other controls) are expected to be DR-enabled devices that could further contribute to future flexible load management. Other devices, including efficient refrigeration and laundry equipment are also likely candidates to include DR-enabled features, included as part of their efficient designation, over the analysis timeframe.

but it is separate and distinct from the ITRON forecast for VELCO). Embedded in the base forecasts for EVT and BED are the impacts of past and future energy efficiency (both naturally occurring energy efficiency from advancements in codes and standards as well as budgeted electric energy efficiency programs delivered by EVT and BED). The EVT and BED forecasts do not include any adjustment for the decay of energy efficiency savings in the forecast because the programs are assumed to produce lasting market transformation effects.

Also included in the EVT and BED forecasts are the effects of renewable energy programs, cold-climate heat pumps (CCHPs), and electric vehicle loads. The Distribution Utilities Renewable Energy Standard Tier III electrification efforts are assumed to be included in the forecast, but actual Tier III implementation achievements and subsequent planning updates are not precisely accounted for in the 2018 VELCO Long Range Transmission Plan.[9] For the assessment of energy efficiency potential, only the associated load impacts of cold-climate heat pump adoption are explicitly accounted for in the current analysis ; solar and electric vehicle adoption are not expected to produce additional efficiency opportunities in the 2019 VT MPS. For the rate and bill impact analysis, solar and EV loads were included to enable a full accounting of load on electricity sales and rates.

The gas load forecast is suppled directly by VGS and includes an estimate of natural gas customers and sales by rate type. The natural gas sales forecast used for modeling purposes excluded interruptible sales that are exempt from the EEU activities, VGS company use, and net unbilled usage.

For the purposes of the Potential Study a forecast with no forward going energy efficiency from EVT, BED and VGS programs is needed. This "no efficiency" forecast starting in 2021 is used as a baseline for quantifying future energy efficiency potential. To produce a "no efficiency" forecast the effects of past efficiency investments are maintained and the cumulative "gross" energy savings projected starting in 2021 is added back to the load forecast.

Finally, since the Potential assessment does not include Vermont's Self-Managed Energy Efficiency Program (SMEEP) participants, the load for SMEEP program participants is removed from EVT and VGS's load forecasts. The potential assessment includes the loads of Act 150 Energy Savings Account (ESA) pilot participants because these customers will still pay the energy efficiency charge (potential is a function of load). However, the ESA pilot energy savings may be associated with either regulated or unregulated fuels. Therefore, potential will not be specifically assessed for the ESA pilot.

An additional discussion of the EEU load forecasts used in the 2019 VT MPS analysis is included in Section 3.2

2.2.2 Forecast Disaggregation

In the residential sector, GDS calibrated each EEU forecast through a bottom aggregated of end-use level load calculations. This process first required the development of end-use level estimates of consumption of primary and secondary electric heating, cooling, water heating and other base load end-uses. These estimates were derived primarily through TRM measure assumptions and calculations leveraging TRM algorithms. These end use estimates were then multiplied by the estimated proportion of customers that applied to each end use, to calculate an estimated service territory total consumption for each end use. For example, when completing this process for the electric EEUs, the estimated primary electric heating consumption for homes with electric furnaces or heat pumps was multiplied by the proportion of homes which have primary electric heating, to calculate the total primary electric heating load in the respective EVT and BED service territories.

[9] For example, cold-climate heat pump penetrations have been recently updated to be greater than originally assumed. Therefore, as it pertains to this assumption the load may be slightly understated.

In the commercial and industrial sectors, disaggregated forecast data provides the foundation for the development of energy efficiency potential estimates. The GDS/Cadmus team disaggregated the nonresidential sector for each EEU into building or industry types using each EEU's nonresidential customer data. This disaggregation involved two steps. First, rate codes determine whether the customer is captured in either the EEU's commercial or industrial load forecast. Next, the appropriate industry (for industrial customers) or building type (for commercial customers) is assigned. The GDS/Cadmus team uses the following information, when available in the EEUs' customer data, to determine the appropriate building or industry type:

- **Building description or Standard Industrial Classification (SIC) Description.** This is the EEU's description of the building or industry type for an individual customer.
- **SIC Code.** A standardized four-digit code used to classify industries. The GDS/Cadmus team mapped SIC codes to the building and industry types considered in this study.
- **Square footage (when available).** The GDS/Cadmus team used square footage to determine whether a building belonged in a "small" or "large" category (e.g. small or large retail).

Using these fields, The GDS/Cadmus team assigned each customer in the EEUs' nonresidential data sets to one of the commercial or industrial segments listed in Table 2-1. Also to be considered are: wastewater treatment plants, breweries, and specific sub-categories of University facilities (sports facilities, cafeterias, main chiller plants, etc.).

TABLE 2-1 NONRESIDENTIAL SEGMENTS

Commercial	Industrial	
Assembly	Apparel	Plastics Rubber Products
Grocery	Beverage and Tobacco Products	Primary Metal Manufacturing
Health Care Other	Chemical Manufacturing	Printing Related Support
Hospital	Electrical Equip. Manufacturing	Textile Mills
Large Office	Fabricated Metal Products	Textile Product Mills
Large Retail	Food Manufacturing	Transportation Equip. Manufacturing
Lodging	Furniture Manufacturing	Wood Product Manufacturing
Miscellaneous	Industrial Machinery	
Restaurant	Instruments	
School K-12	Leather and Allied Products	
Small Office	Miscellaneous Manufacturing	
Small Retail	Nonmetallic Mineral Products	
University	Paper Manufacturing	
Warehouse	Petroleum and Coal Products	

The GDS/Cadmus team further disaggregated sales for each of the segments into end uses. For commercial segments, The GDS/Cadmus team primarily used EIA's 2012 Commercial Building Energy Consumption Survey (CBECS) for the Northeast Census region to determine energy use intensities, expressed in kWh or MMBtu per square foot, for each end use within each segment.[10] The GDS/Cadmus team next used data compiled from metering studies, EM&V, and engineering algorithms to further disaggregate energy intensities into more granular end uses and technologies. For the industrial sector, the analysis relied on the EIA's Manufacturing Energy Consumption survey to disaggregate industry-specific estimates of electric and natural gas consumption into end uses.[11]

[10]U.S. Energy Information Agency. *Commercial Buildings Energy Consumption Survey (CBECS)*. May 20, 2016. https://www.eia.gov/consumption/commercial/. The GDS team used EIA CBECS to derive energy use intensities for broad end use categories, such as space heating, cooling, water heating, cooking, and refrigeration. We will rely on EM&V reports, metering studies, and technical reference manuals to further disaggregate energy intensities into specific technologies.

[11] U.S. EIA. *Manufacturing Energy Consumption Survey (MECS) 2010.* March 2013. https://www.eia.gov/consumption/manufacturing/data/2010/.

Table 2-2 and Table 2-3 lists the potential electric end-uses and natural gas end-uses, respectively, that were reflected in the forecast disaggregation and subsequent potential assessment.

TABLE 2-2 ELECTRIC END USES

Residential	Commercial	Industrial
Space Heating	Space Heating	Space Heating
Water Heating	Water Heating	Water Heating
Space Cooling	Space Cooling	Space Cooling
Lighting	Interior Lighting	Interior Lighting
Building Shell	Exterior Lighting	Exterior Lighting
Plug Loads/Other Misc.	Building Shell	Building Shell
Appliances	Ventilation	Ventilation
Cooking	Plug Loads/Other Misc.	Miscellaneous
	Refrigeration	Refrigeration
	Cooking	Air Compression
	Office Equipment	Fuel Generation
	Air Compression	Process Heating/Cooling
	Motors	Machine Drive
		Motors

TABLE 2-3 NATURAL GAS END-USES

Residential	Commercial	Industrial
Space Heating	Space Heating	HVAC
Water Heating	Water Heating	Indirect Boiler
Building Shell	Room Heat – Gas	Motors
Clothes Washer/Dryer	Pool Heat	Process Heat
Cooking	Dryer	Process Other
	Cooking	Other
	Other	

2.2.3 Building Stock/Equipment Saturation

To assess the potential electric energy efficiency savings available, estimates of the current saturation of baseline equipment and energy efficiency measures are necessary. For purposes of our analysis, baseline equipment saturation estimates refer to the percent of homes or business that are currently equipped with a particular technology or building characteristic (i.e. the fraction of buildings with air conditioning, or the fraction with natural gas furnaces). Energy efficient saturation estimates refer to the percent of equipment that is already energy efficient. These estimates, paired with the market forecast data, allow the GDS/Cadmus Team to analyze the total number of eligible homes and business that can convert their existing equipment or building characteristics to the more efficient alternative throughout the study timeframe.

2.2.3.1 Residential Sector

For the residential sector (which includes both single and multi-family), the GDS/Cadmus team relied on several recent primary research efforts conducted in Vermont. The measure analysis for EVT, BED, and VGS was largely be informed by the draft 2019 Vermont Single-Family Existing Homes Report, the 2019 Vermont Residential New Construction Report, 2017 Vermont Single-Family Existing Homes On-site Report, 2017 VT Residential New Construction Baseline Study Analysis of On-Site Audit Report, and the 2013 VT Multifamily Onsite Report, all completed by NMR. Assumptions embedded in the EEU forecasts will also be considered in the development of baseline equipment saturations to ensure consistency, where possible, between the long-range forecasts and the market potential study.

EIA Residential Energy Consumption Survey (RECS) data from 2015 will help fill in data gaps that cannot directly be informed by Vermont primary research. Other data sources included ENERGY STAR unit shipment data, recent Vermont evaluation reports, and baseline studies from other states. The ENERGY STAR unit shipment data was used to fill data gaps related to the increased saturation of energy efficient equipment across the U.S. in the last decade.

2.2.3.2 Nonresidential Sector

In the nonresidential sector, the GDS/Cadmus team relied on primary market research conducted for the 2016 Vermont Business Sector Market Characterization and Assessment study. This study documents current baseline data for existing facilities and new construction throughout Vermont's business sector, in commercial and industrial facilities. The market characterization and assessment provide a milestone for progress made and serves as a roadmap for the remaining opportunities in energy efficiency, code compliance, and building operation. The study focused on business sector energy efficiency characteristics including envelope, lighting, HVAC, refrigeration, motors, and compressed air.

In addition, the GDS/Cadmus team also relied on the latest EIA Commercial Building Energy Consumption Survey (CBECS) and Manufacturing Energy Consumption Survey (MECS) to supplement the existing VT-specific market research with additional regional data. Data from recent PSD evaluations and program tracking data was also utilized to develop regarding baseline and/or efficient building and equipment characteristics.

2.2.4 Remaining Factor/Market Refill

The remaining factor is the proportion of a given market segment that is not yet efficient and can still be converted to an efficient alternative. It is, by definition, the inverse of the saturation of an energy efficient measure. For this study, the GDS/Cadmus Team, in discussions with the PSD and EEUs, have made several assumptions regarding the future potential of equipment that is already efficient, or will become efficient, over the analysis timeframe.

For measures that are not yet efficient, the GDS/Cadmus Team estimated savings that reflect the initial measure assumptions developed as part of the MPS, are consistent with the latest VT TRM, and discussed in Section 2.3.4, below. The question, then, is whether there is any additional future potential to be quantified from homes/businesses that already possess the efficient measure. Following discussions with the PSD and EEUs, the GDS/Cadmus team developed our models to allow these existing measures to be refilled, during their natural replacement cycle, by assuming that advances in the efficiency of equipment will enable new technologies, tiers, or improved standards to replace the current measure and allow for continued savings opportunities. Since the precise level of savings and measure characterizations for these future measures is not presently known, the methodology adopted assumes that subsequent equipment replacement that occurs over the course of the 20-year study timeframe, and at the end of the initial equipment's useful life, will continue to achieve similar levels of energy savings, relative to improved baselines, at similar incremental costs.[12]

There are, of course, exceptions to this logic. Select measures were considered one-time efficiency opportunities and are not be eligible to be replaced/refilled in the analysis once it has been initially converted to efficient status. Examples of these measures include: variable frequency drives, motor controls, comprehensive residential retrofits, and most shell measures (insulation, air sealing, door

[12] Given that the existing load forecasts do not include any adjustment for the decay of energy efficiency savings forecast because the programs are assumed to produce lasting market transformation effects, this coordinated assumption aggressively presumes that future technology improvements will demonstrate continuous and consistent improvement. A more conservative modeling approach might restrict the eligible pool of future opportunities (i.e. assume a certain percentage of efficient technologies do not become eligible in the future), limiting future refill across all technologies. In lieu of this approach, the GDS/Cadmus model makes limited exceptions to the refill logic, as discussed above.

improvements). Other exceptions in the 2019 VT MPS include: measures that are known to be impacted by codes or standards or are considered to have reached the limit of technological advancements in efficiency (ex. Screw-based LED Lighting, where future efficiency improvements are expected to be minimal compared to historic baselines) and miscellaneous residential electronics with high market penetration.

An additional adjustment was made to nonresidential lighting to reflect the rapid replacement of inefficient lighting with LED technologies by EVT and BED in recent years. The nonresidential lighting potential was modeled as a market opportunity with baseline lighting technologies (T-12, standard T-8, and high-performance T-8s) being replaced with LEDs at the rate of 1 divided by the baseline technology's measure life. Following discussions with the PSD and EEUs, the Cadmus/GDS team halved the measure lives for these inefficient technologies so that LED replacements would be introduced into the technical potential earlier than would have otherwise happened.

Last, we have also assumed that measures that are converted during early years of the analysis but reach the end of their useful life over the 20-year analysis timeframe, are also eligible for future installations assuming the same adjustment for future efficiency and/or costs and the same stated exceptions.

2.3 MEASURE/PROGRAM CHARACTERIZATION

2.3.1 Initial Measure Lists & Emerging Technologies

Energy efficiency measures considered in the 2019 VT MPS will include all savings measures in the 2019 Vermont Technical Reference Manual (TRM), as well as other energy efficiency measures based on the GDS/Cadmus team's knowledge of current databases of electric end-use technologies and energy efficiency measures in other jurisdictions. The 2019 VT MPS models for EVT, BED, and VGS included measures and practices that are currently commercially available, including select emerging technologies, and of the most immediate interest to energy efficiency program planners in Vermont.

In the residential sector, electric emerging technologies included, smart water heater (WH) tank controls, smart window coverings, smart ceiling fans, drain water heat recovery, variable frequency room air conditioners, heat pump dryers, home automation/home energy monitors and management systems, LEDs in agricultural applications, and smart/connected bulbs. Emerging technologies considered in the gas analysis include GFX drain water heat recovery systems.

In the nonresidential sector, specific emerging technologies that were considered as part of the analysis included air to water and centrally ducted heat pumps, high efficiency evaporators, lab ventilation, networked lighting controls, oxygen concentrators, smart/connected bulbs and fixtures, HVAC control optimization, strategic energy management and other continuous energy improvement processes, and drain water heat recovery. Emerging gas technologies in the nonresidential sector include advanced thermostats strategic energy management. While this is likely not an exhaustive list of possible emerging technologies over the next twenty years it does consider many of the known technologies that are available today but may not yet have widespread market acceptance and/or product availability.

Aside from select emerging technologies where savings and costs can reasonably be estimates, the analysis does not make explicit assumptions for including measures and practices that are not commercially available today. These assumptions are difficult to quantify and could give the appearance of an inflated potential forecast. The team recognizes that over the course of the 20-year study timeframe, new technologies may come to the market that can produce savings at significantly greater levels, but this study does not attempt to characterize measures that may represent future advancements in energy efficient technology. Similarly, the same is true in that the study does not make adjustment to future changes in baselines from which savings can be quantified beyond those that are already included in current legislation (as noted in Section 2.3.4).

2.3.2 RES Tier III & Electrification Measures

In 2015, the Vermont legislature, under Act 56, directed the Public Utility Commission to implement the Renewable Energy Standard (RES) program, to take effect on January 1, 2017. The Act requires Vermont electric Distribution Utilities (DUs) to acquire specified amounts of renewable energy and to achieve fossil fuel savings from energy transformation projects. The structure of the RES is divided into three tiers, with Tier III requiring DUs to either procure renewable energy from distributed generation resources (in excess of Tier II requirements) or acquire fossil fuel savings from energy transformation projects.

Many of the strategies that the DUs are expected to pursue to meet the RES Tier III requirements and to help customers reduce fossil fuel consumption such as conversion to electric passenger and/or fleet vehicles, are not directly applicable to the 2019 MPS. However, in select cases, there may be opportunities for increased electrification efficiency for specific measures that would fall under the purview of EVT and BED and the MPS, which are also being incentivized and counted towards DUs Tier III requirements as fuel-switching electrification measures. Electrification can be defined as any program, project, or measure that encourages replacement of direct non-electric fuel use (e.g., propane, heating oil, propane, gasoline, etc.) with an electric measure. Examples include installing an electric cold-climate heat pump to displace an oil boiler. Electrification Efficiency can be defined as any program, project, or measure that is designed to ensure that an installed electrification measure will also be the most electrically-efficient measure available.

Based on discussions with EVT and BED, the 2019 VTMPS includes specific assumptions regarding the increased adoption of cold-climate heat pumps to ensure the most electrically energy efficient units are going in to offset future fossil fuel consumption (see Section 3.2). While the fuel conversion (electrification) may be included in DU's Tier III plans and under Thermal Energy and Process Fuels (TEPF) funds, the opportunity to provide additional incentives to purchase and install *high-efficiency* cold-climate heat pumps (at the time of conversion) is considered an opportunity under Energy Efficiency Charge (EEC) funding. In addition, these converted homes are also assumed to be eligible for additional weatherization opportunities under EEC funding.

Accordingly, the GDS/Cadmus team utilized the forecast of cold-climate heat pump adoption included in the 2018 VELCO long-term forecast (including any subsequent forecast adjustments provided by EVT and BED) to quantify the electrification efficiency impacts associated with RES Tier III. Conversely, an adjustment to the VGS long-term forecast was also included to account for reduced natural gas consumption and efficiency opportunities in homes installing and off-setting all or a portion of their heating load with a CCHP.

2.3.3 Assumptions and Sources

A significant amount of data is needed to estimate and model the electric and natural gas savings potential for individual energy efficiency measures or programs across the residential and nonresidential customer sectors in Vermont. GDS utilized data specific to each EEU or the State of Vermont at large when it is available and current. GDS used the 2019 Efficiency Vermont Technical Reference Manual (VT TRM) and its supporting workbooks, the draft 2019 NMR Residential Existing Homes and New Construction Studies, the 2013 VT Multifamily Onsite Report, the 2016 Vermont Business Sector Market Characterization and Assessment Study, and the most recent program evaluations as the main sources of data for measure assumptions. GDS also conduct secondary research to develop reasonable and supportable assumptions for measures not included in the VT TRM.

Measure Savings: GDS utilized the 2019 VT TRM and its supporting workbooks to inform calculations supporting estimates of annual measure savings as a percentage of base equipment usage. For custom measures and measures not included in the VT TRM, GDS estimated savings from a variety of sources, including:

- Mid-Atlantic TRM, Illinois TRM, Maine TRM, Minnesota TRM and other existing deemed savings databases
- Building energy simulation software (BEopt) and engineering analyses
- Known changes in federal codes and standards
- Secondary sources such as the American Council for an Energy-Efficient Economy (ACEEE), Department of Energy (DOE), Energy Information Administration (EIA), ENERGY STAR©, and other technical potential studies
- Program evaluations of behavioral programs conducted for Efficiency Vermont

Measure Costs: Measure costs represent either incremental or full costs. These costs typically include the incremental cost of measure installation, when appropriate based on the measure definition. For purposes of this study, nominal measure costs were held constant over time. GDS obtained measure cost estimates primarily from the 2019 VT TRM. GDS used the following data sources to supplement the VT TRM:

- TRMs in other states
- Secondary sources such as the ACEEE, ENERGY STAR, National Renewable Energy Lab (NREL),), California Database for Energy Efficient Resources (DEER) database, Northeast Energy Efficiency Partnership (NEEP) Incremental Cost Study, and other technical potential studies
- Retail store pricing (such as websites of Home Depot, Lowe's, and Grainger) and industry experts
- Program evaluation and market assessment reports completed for utilities in other states

Measure Life: Measure life represents the number of years that energy using equipment is expected to operate. GDS obtained measure life estimates from the 2019 VT TRM, and use the following data sources for measures not in the VT TRM:

- TRMs in other states
- Manufacturer data
- Savings calculators and life-cycle cost analyses
- The California DEER database
- Other consultant research or technical reports

2.3.4 Treatment of Codes & Standards

EVT, BED, and VGS potential and program modeling includes assumptions for known future federal and/or state equipment standards as of May 2019, as shown in Table 2-4. Where possible, improvements to baseline equipment standards can be met with incremental improvements to efficient equipment standards. However, in select case, such as screw-in lighting (discussed further below) and Efficient Furnace Fan motors, improvements to the baseline standard effectively are expected to eliminate the efficient technology from future consideration.

TABLE 2-4 KNOWN FUTURE EQUIPMENT STANDARD UPDATES

Equipment Type	Expected Compliance Date	Fuel Impact	Sector Impacted	Adjusted Baseline Standard
Federal Standards				
Dehumidifiers	2019	Electric	Residential	50+ pints per day: >2.8 L/kWh
Clothes Washers	2018	Electric/Gas	Res./ C&I	IMEF=1.57 for top load (update already in TRM)
Furnace Fans	2019	Electric	Residential	Baseline shift from PSC to ECM
Pool Pumps	2021	Electric	Residential	Baseline shift from single-speed to variable speed
Automatic Ice Makers	2018	Electric	C&I	10-25% improvement over 2010

Equipment Type	Expected Compliance Date	Fuel Impact	Sector Impacted	Adjusted Baseline Standard
Comm. CAC & ASHP	2018	Electric	C&I	10% more efficient than pre-2018 standards, 25-30% more efficient in 2023
Residential CAC & ASHP	2023	Electric	Residential	ASHP: 15 SEER ; CAC: 14 SEER
Pre-Rinse Spray Valves	2019	Electric/Gas	C&I	1.0-1.28 gpm
Vending Machines	2019	Electric	C&I	5-55% more efficient than 2012
Boilers	2021	Gas	Residential	84% AFUE gas/ 86 AFUE oil
Furnaces	2023	Gas	C&I	82% AFUE gas/oil
State Standards				
Dishwashers	2020	Electric/Gas	C&I	ES Spec 2.0
Fryers	2020	Electric/Gas	C&I	ES Spec 2.0
Steam Cookers	2020	Electric/Gas	C&I	ES Spec 1.2
Compressors	2020	Electric	C&I	*See DOE Final Rule (2016)
Computer/Comp. Systems	2020	Electric	Res./ C&I	*See 20 California Code of Regulations
Faucets	2020	Electric/Gas	Residential	1.5 gpm (Bath); 1.8 gpm (Kitchen)
High-CRI Linear Fluor.	2020	Electric	Res./ C&I	
Hot Food Holding Cabinet	2020	Electric	C&I	40 watts per cubic foot (int. vol)
Ventilating Fans	2020	Electric	Residential	ES Spec v3.2
Showerheads	2020	Electric/Gas	Residential	2.0 gpm
Water Dispensers	2020	Electric	Res./ C&I	.18 kWh per day for on-demand hot/cold water cooler

In addition to accounting for future known equipment standards, GDS coordinated with the PSD and EEUs to properly reflect future improvements to residential and nonresidential building codes. While the analysis to does explicitly adjust for unknown equipment standards, the analysis is expected to assess the impact of increasing building codes over the study horizon. It is assumed that the residential and commercial building energy codes are updated on the following schedule with the associated impact of reduced savings.

TABLE 2-5 PROPOSED VERMONT CODE UPDATE SCHEDULE

International Energy Code	VT Residential Building Energy Standard	VT Commercial Building Energy Standard	Effective Date in VT	Impact on Savings in Model (RBES/CBES)
2018 IECC	2019 RBES	2019 CBES	1/1/2020	-10% / -20%
2021 IECC	2022 RBES	2022 CBES	1/1/2023	-7% / -7%
2024 IECC	2025 RBES	2025 CBES	1/1/2026	-7% / -7%
2027 IECC	2028 RBES	2028 CBES	1/1/2029	-7% / -7%
2030 IECC	2031 RBES	2031 CBES	1/1/2032	-7% / -7%

International Energy Code	VT Residential Building Energy Standard	VT Commercial Building Energy Standard	Effective Date in VT	Impact on Savings in Model (RBES/CBES)
2033 IECC	2034 RBES	2034 CBES	1/1/2035	-7% / -7%
2036 IECC	2037 RBES	2037 CBES	1/1/2038	-7% / -7%
2039 IECC	2040 RBES	2040 CBES	1/1/2041	-7% / -7%

Vermont Residential and Commercial Building Energy Codes (RBES and CBES) anticipated to go into effect on January 1, 2020 have quantifiable impacts and future iterations of the building energy codes are estimated. The upcoming RBES base code is expected to reduce available savings compared to the current 2015 code by 7% and the stretch is 13% better. So, the blended 2019 RBES base and stretch code impact is estimated to be about 10% reduction in available savings. For the 2019 CBES the impact on savings is blended by building type and is estimated to reduce savings by 20%.

The impact of increasing residential and commercial building energy codes, as well as the baseline at which savings is claimed, is expected to have a material impact on the cost-effectiveness of new construction programs (as codes advance the programs become increasingly less cost-effective).

2.3.5 Treatment of Screw-based LED Lighting

Vermont H.411 (Act 42), signed into law by Governor Scott in 2017, adopted the federal standards for general service lighting scheduled to come into effect on January 20, 2020, in order that those same standards will be in place for Vermont even if repealed at the federal level. This standard sets a minimum efficacy standard for general service lamps of 45 lumens per watt which prohibits the sale after January 20th, 2020, of any products in Vermont that do not meet or exceed this requirement. Although uncertainty remains on both the DOE definition of "general service lighting" and the veracity of the VT standard, the PSD and EEUs have agreed to follow the intent of this standard. As a direct result, by 2021 EVT and BED will no longer expect to claim savings from most general service lighting (screw-based bulbs), including omni, directional, and decorative products. Possible exceptions include potential savings from select "smart" or "connected" type bulbs or for limited direct install retrofit of LED bulbs for a small group of customers. "Smart" or "connected" bulbs are included in the list of Emerging Technologies and are expected to have measure characterizations developed as part of the model development. Direct install of LED bulbs for low income will not be included in the model beyond the first two years (2021 – 2022).

In addition to screw-based lighting, opportunities also exist for the installation of integrated LED fixtures that ensure efficient lighting throughout the life of the fixture. Although a slight departure from the model logic that screw-based lighting will effectively be transformed by 2021, the EVT and BED potential models built in remaining potential for integrated LED fixtures for a small portion of sockets to reflect opportunities that would not be directly impacted by the Energy Independence and Security Act (EISA). GDS/Cadmus assumed roughly 40% of recessed downlights and 15% of all other sockets would be eligible for integrated LED fixtures, and that the baseline for the opportunities, would remain a combination of halogen/incandescent bulbs (in lieu of the 45 lumens per watt backstop provision currently facing significant uncertainty).

2.3.6 Behavior Programs

Behavioral energy efficiency programs seek to encourage improvements in energy efficiency simply by providing users with feedback and actionable insight on their own energy usage. The most traditional behavioral program, the Home Energy Report, was previously implemented, tested, and evaluated in Vermont, and is no longer being offered by EVT.

In lieu of the previous behavioral offering, GDS/Cadmus, the Department, and EVT coordinated to review an updated behavioral program that would involve a more targeted and deeper customer engagement approach with fewer customs than the traditional high-volume approach employed by Home Energy Report programs. Rather, the intent of the EVT approach is to target high use residential customers, which in turn, produces higher savings per home. For modeling purposes, GDS/Cadmus assumed this revised behavioral offering is limited to dwellings with more than 10,000 kWh of annual consumption and is assumed to produce 225 kWh savings annually. In the EVT service area, this threshold represents approximately 19% of all residential households. In the BED service area, this represents 8% of all residences. Like the HER program, the current program assumes a single-year effective measure life. For modeling purposes, this behavioral approach was reserved for EVT and BED customers only, and a similar approach for VGS customers was not explicitly modeled.

In the nonresidential sector, the 2019 MPS assessed behavioral impacts associated with the Continuous Energy Improvement (CEI) program. This existing program leverages cohorts of similar large energy users to guide them collectively through a rigorous Strategic Energy Management (SEM) process. With a focus on enhancing the relationship and engaged partnership with these customers, critical elements of Strategic Energy Management (SEM) are deployed including customer commitment, energy management planning & implementation, and systems for monitoring, tracking & reporting performance. In CEI, behavioral savings is calculated and tracked separately from any capital investment projects. To date, this program has been evaluated by the PSD, tested positive, and continues to be implemented in Vermont.

2.3.7 Net to Gross (NTG)

All estimates of technical and economic potential, as well as measure level cost-effectiveness screening are conducted in terms of gross savings to reflect the absence of program design considerations in these phases of the analysis. The estimates of maximum and program achievable potential will, however, be presented in terms of net savings to reflect the importance of program design in overcoming market barriers to participation. Net energy savings consider free-riders (participants who would have installed the high efficiency option in the absence of the program) and spillover customers (participants who install efficiency measures due to program activities, but never receive a program incentive). Measure net-to-gross ratios were based on the evaluation findings of historical Vermont efficiency programs and mapped to individual measures in both the residential and nonresidential sectors.[13] Assumed net to gross ratios for each measure are based on reported NTG ratios in the 2019 VT TRM and are provided as an Appendix to the report.

2.4 POTENTIAL SAVINGS OVERVIEW

Potential studies often distinguish between several types of energy efficiency potential: technical, economic, achievable, and program. However, because there are often important definitional issues between studies, it is important to understand the definition and scope of each potential estimate as it applies to this analysis.

The first two types of potential, technical and economic, provide a theoretical upper bound for energy savings from energy efficiency measures. Still, even the best-designed portfolio of programs is unlikely to capture 100% of the technical or economic potential. Therefore, achievable potential attempts to estimate what savings may realistically be achieved through market interventions, when it can be

[13] Authors of this report note that most of the net to gross ratios for efficiency measures are approximately 1.0. A 2015 Synapse study found that the average NTG across 24 states over a 5-year period was 0.87. (see "State Net-to-Gross Ratios. Synapse Energy. January 2015). Given assumptions in this study and program planning models related to measure refill and savings levels that are consistent over time relative to changes in baseline, it may be important to re-examine these NTG assumptions over time to ensure all elements of changing market conditions are captured via NTG or realization rate adjustments.

captured, and how much it would cost to do so. Figure 2-1 illustrates the types of energy efficiency potential considered in this analysis.

FIGURE 2-1 TYPE OF ENERGY EFFICIENCY POTENTIAL[14]

Not Technically Feasible	TECHNICAL POTENTIAL			
Not Technically Feasible	*Not Cost Effective*	ECONOMIC POTENTIAL		
Not Technically Feasible	*Not Cost Effective*	*Market Barriers*	MAX. ACHIEVABLE POTENTIAL	
Not Technically Feasible	*Not Cost Effective*	*Market Barriers*	*Partial Incentives*	PROGRAM ACHIEVABLE POTENTIAL

2.4.1 Technical Potential

Technical potential is the theoretical maximum amount of energy use that could be displaced by efficiency, disregarding all non-engineering constraints such as cost-effectiveness and the willingness of end users to adopt the efficiency measures. Technical potential is only constrained by factors such as technical feasibility and applicability of measures. Under technical potential, GDS/Cadmus assumes that 100% of new construction and market opportunity measures are adopted as those opportunities become available (e.g., as new buildings are constructed, they immediately adopt efficiency measures, or as existing measures reach the end of their useful life). For retrofit measures, implementation will assume to be resource constrained and that it is not possible to install all retrofit measures all at once. Rather, retrofit (and early retirement) opportunities were assumed to be replaced incrementally until 100% of stock were converted to the efficient measure over a period of no more than 20 years. One hundred percent of low income, direct install measures were also assumed to be targeted over a period of 20 years.

2.4.1.1 Competing Measures and Interactive Effects Adjustments

GDS/Cadmus prevents double-counting of savings, and accounts for competing measures and interactive savings effects, through three primary adjustment factors:

Baseline Saturation Adjustment. Competing measure shares are factored into the baseline saturation estimates. For example, nearly all homes can receive insulation, but the analysis creates multiple measure permutations to account for varying impacts of different heating equipment types and have applied baseline saturations to reflect proportions of households with each heating equipment type.

Applicability Factor Adjustment. Combined measures into measure groups, where total applicability factor across measures is set to 100%. For example, homes cannot receive a programmable thermostat, connected thermostat, and smart thermostat. In general, the models will assign the measure with the most savings the greatest applicability factor in the measure group, with competing measures picking up any remaining share.

Interactive Savings Adjustment. As savings are introduced from select measures, the per-unit savings from other measures need to be adjusted (downward) to avoid over-counting. For example, the savings from install high efficiency space heating equipment in the residential sector was adjusted downward to

[14] Reproduced from "Guide to Resource Planning with Energy Efficiency." November 2007. US Environmental Protection Agency (EPA). Figure 2-1.

reflect the portion of the market making improvements to the building shell or adding smart thermostats that ultimately reduce heating use in the home.

2.4.2 Economic Potential

Economic potential refers to the subset of the technical potential that is economically cost-effective (based on screening with the Vermont Societal Cost Test) as compared to conventional supply-side energy resources. All measures that are not found to be cost-effective based on the results of the VT Societal Cost Test were excluded from further analysis. The GDS/Cadmus team then readjusted the applicability factors to the remaining measures that were cost-effective.

2.4.2.1 Vermont Societal Cost Test

The Vermont Societal Test is a modified version of the Societal Test as defined by the National Action Plan for Energy Efficiency (NAPEE) and the California Standard Practice Manual. Table 2-6 provides the components of the costs and benefits that are included in the VT Societal Cost Test.

TABLE 2-6 BENEFIT AND COST COMPONENTS OF THE VT SOCIETAL COST TEST (MEASURE-LEVEL SCREENING)

Benefits	Costs
Avoided Electric Energy Supply Cost[15]	Measure Cost (over baseline)
Avoided Electric Generation Capacity Supply Costs	Increased electric and/or fuel consumption (if any)
Avoided Electric Transmission & Distribution Costs	O&M Costs (if any)
Avoided Fuel Savings	Wholesale risk premium (10% reduction to measure cost)
Additional Resource Savings (i.e. water savings, O&M benefits)	
Externalities (i.e. compliance costs for SO_2, NO_X emissions, and the value of reduced greenhouse gas emissions)	
Non-Energy Benefits (15% adder to energy benefits)	
Low-Income Non-Energy Benefit (Additional 15% adder to energy benefits)	

In an effort to be consistent with the National Action Plan for Energy Efficiency's definition of economic potential as well as the typical practice of the Vermont EEUs for measure-level screening, GDS/Cadmus did not include marketing; analysis; administration; and evaluation, measurement, and verification (EM&V) costs for the measure cost-effectiveness screening conducted to develop the estimates of economic potential.[16] Although excluded from economic potential, these non-incentive delivery costs were included in the development of estimates of the program costs related to achievable potential savings.

[15] Savings at the meter level were adjusted for system line losses. In addition, pursuant to the most recent PUC order, DRIPE is intended to be included as a societal benefit. However, electric DRIPE benefits in the latest approved avoided costs (Commission Order EEU 2015-04) are assumed to dissipate by 2021 (the initial year of this analysis). Natural gas DRIPE does extend over the 2021-2040 timeframe and is included as a benefit in the cost-effectiveness screening.

[16] National Action Plan for Energy Efficiency: Understanding Cost-Effectiveness of Energy Efficiency Programs.

2.4.2.2 Avoided Costs

Avoided energy supply costs are used to assess the value of energy savings. This analysis used the avoided costs approved by the Vermont Public Utilities Commission in EEU-2015-04 in October 20, 2017 which were derived from the *Avoided Energy Supply Costs in New England: 2015 Update*. This forecast provided the latest available projections of marginal energy supply costs, for each New England state, that are assumed to be avoided due to reductions in the use for electricity, natural gas, and other fuels resulting from efficiency programs. The discount rate and inflation rate were provided by the EEUs. Avoided energy costs are differentiated by time and season where possible.

It is important to note than an update to the avoided costs is anticipated to be approved by the Commission by the end of 2019 in Docket 19-0397. However, the 2019 Market Potential Study was conducted before a Commission ruling on the proposed avoided costs. To illustrate the impact of the Department's proposed avoided costs on the overall societal benefits associated with potential savings, GDS/Cadmus provides estimates of Program Achievable societal benefits using both the currently approved and the Department's proposed avoided costs when discussing EEU sector and/or portfolio cost-effectiveness.[17] However, GDS/Cadmus did not develop a separate measure-level screening of economic potential using the proposed avoided costs, thus the measure mix within each sector and EEU is the same for both scenarios.

2.4.3 Achievable Potential

Achievable potential is the amount of energy that can realistically be saved given various market barriers. Achievable potential considers real-world barriers to encouraging end users to adopt efficiency measures; the non-measure costs of delivering programs (for administration, marketing, analysis, and EM&V); and the capability of programs and administrators to boost program activity over time. Barriers include financial, customer awareness and willingness to participate in programs, technical constraints, and other barriers the "program intervention" is modeled to overcome. Additional considerations include political and/or regulatory constraints. The potential study evaluated two achievable potential scenarios:

- ***Maximum Achievable Potential*** estimates achievable potential on paying incentives equal to 100% of measure incremental costs and aggressive adoption rates.
- ***Program Achievable Potential*** estimates achievable potential on EEUs paying incentive levels (as a percent of incremental or total measure costs) that are calibrated to historical levels. Program achievable potential also seeks to align initial year savings with recent historical achievements, to reflect likely barriers with accelerating (or decreasing) program activity too rapidly, allowing program activity to expand (or contract) more gradually over time. Last, common to program modeling for EEUs, sector equity constraints are applied for the residential, commercial and industrial, low-income, and small business sectors. These equity targets are in place to ensure that program spending levels are proportionally similar to EE&C charge collections.

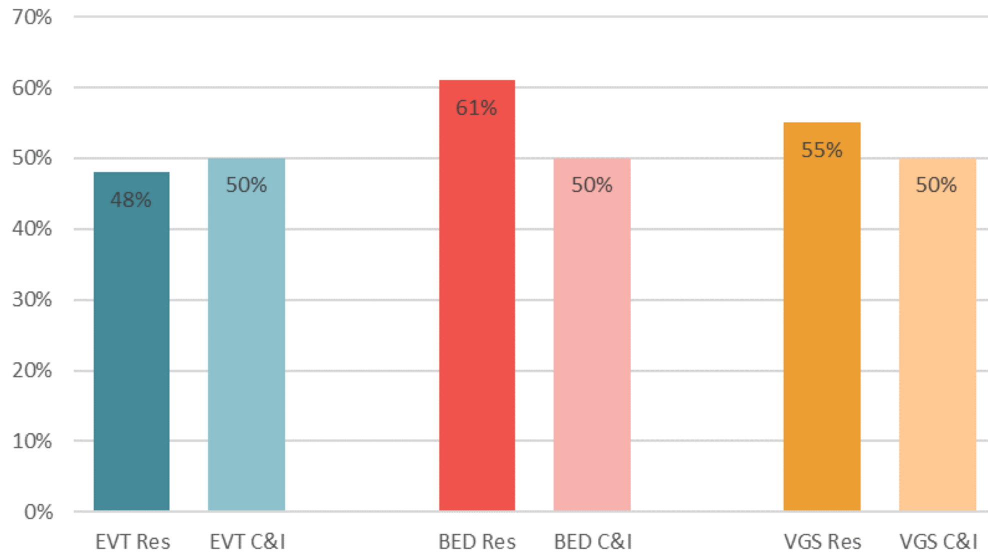
2.4.3.1 Incentive Levels and Non-Incentive Resource Acquisition Costs

While many different incentive scenarios could be modeled, the number of achievable potential scenarios was limited to the two scenarios described above. The GDS/Cadmus team analyzed the selected achievable potential scenarios with different anticipated market acceptance models based on incentive levels. In the maximum achievable scenario, the penetration curve was based on a maximum penetration assuming 100% funding of the measure incremental costs. Program achievable incentive levels were mapped to the incentive levels currently offered on energy efficiency technologies by the EEUs. In cases where GDS/Cadmus are unable to directly identify a current incentive for a specific technology, a similar

[17] In addition to a revised set of avoided costs, the Department's proposal also includes a proposed reduction to the risk premium adjustment from 10% to 5%.

technology or rebate was used as a reasonable proxy. Figure 2-2 below depicts, the sector average incentive levels that were identified for the program achievable scenario in the 2019 MPS, by EEU.

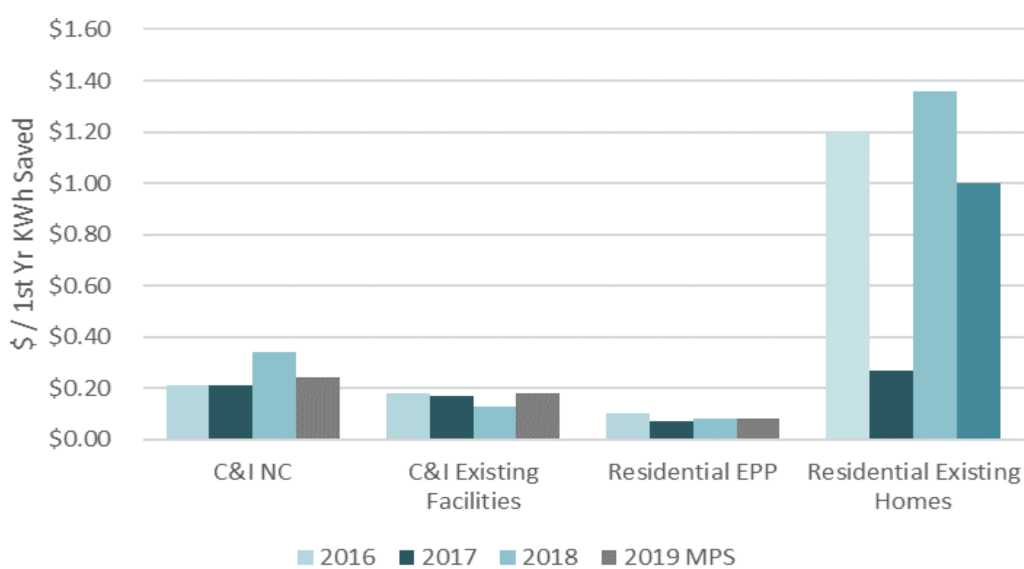
FIGURE 2-2 AVERAGE INCENTIVE LEVELS (AS A % OF INCREMENTAL MEASURE COST) ASSUMED IN THE PROGRAM ACHIEVABLE POTENTIAL SCENARIO



In addition to incentive levels, the estimates of achievable potential include an assumed non-incentive resource acquisition cost in the development of EEU budgets and sector-level cost-effectiveness. Non-incentive resource acquisition costs were developed based on historical reported program costs for EEU, and then mapped to individual measures and/or end-uses. These costs excluded additional DSS costs, Department evaluation costs, and performance awards.

Figure 2-3 through Figure 2-5 depicts a range of non-incentive acquisition costs applied in the 2019 MPS across end-uses by EEU and by sector in both the maximum and program achievable scenarios.

FIGURE 2-3 BENCHMARK OF EVT HISTORICAL NON-INCENTIVE COSTS TO 2019 MPS[18]



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[18] EVT's Residential Existing Homes program in 2017 included significant savings attributed to behavior savings, leading to non-incentive costs per 1st-YR kWh saved to be considerably lower compared to 2016 or 2018.

FIGURE 2-4 BENCHMARK OF BED HISTORICAL NON-INCENTIVE COSTS TO 2019 MPS

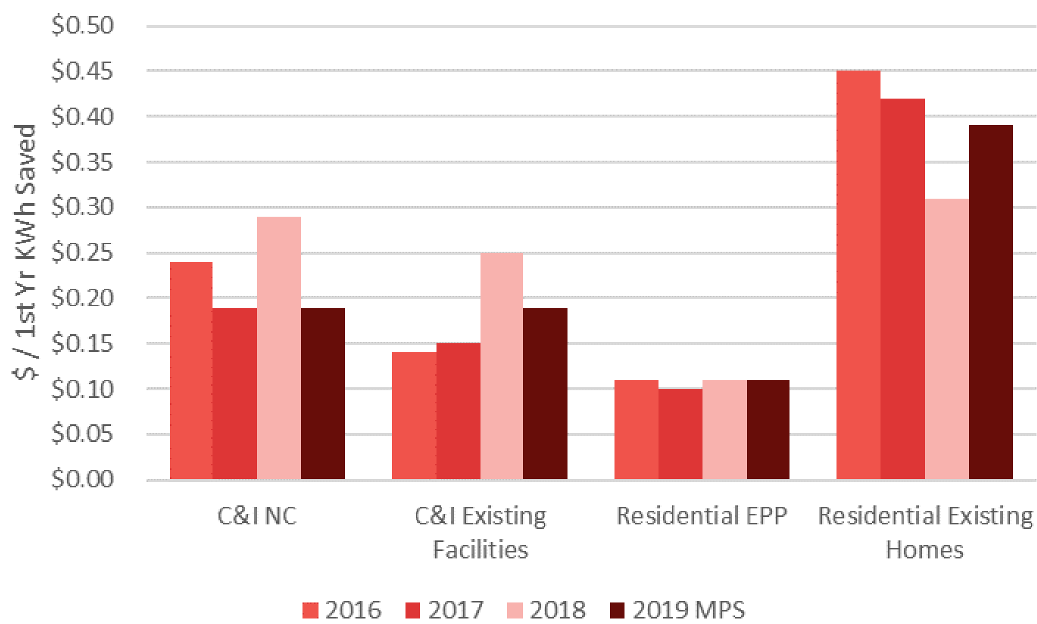
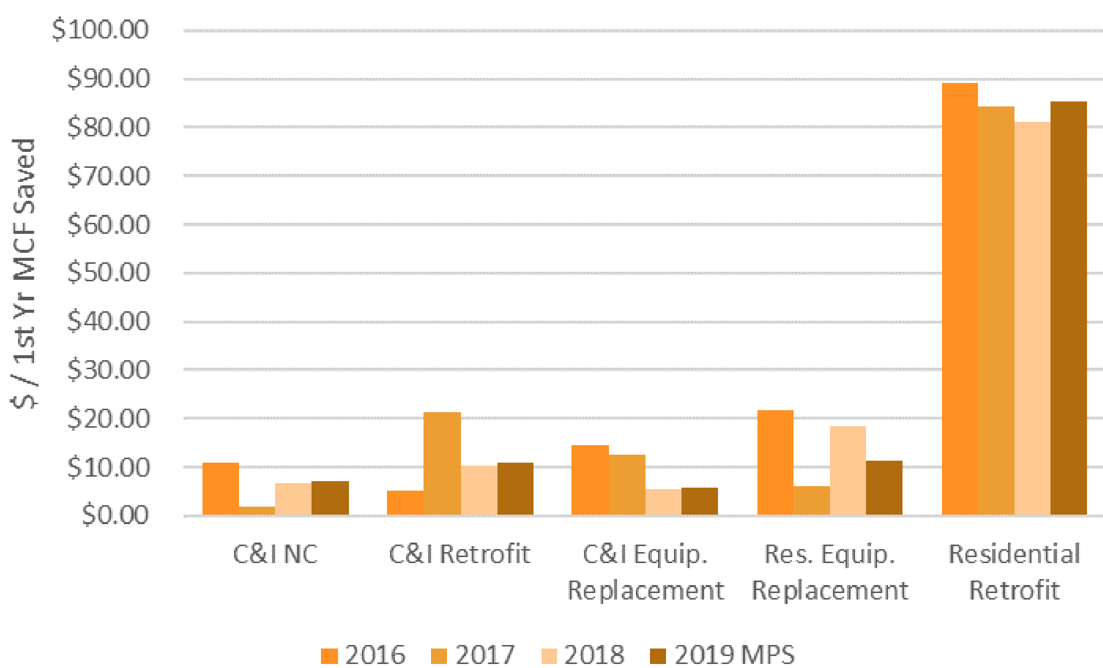


FIGURE 2-5 BENCHMARK OF VGS HISTORICAL NON-INCENTIVE COSTS TO 2019 MPS



In addition to the programs shown below, residential new construction non-incentive costs ranged from $1.05 to $1.10 per 1st YR kWh and $20 per 1st YR MCF and low-income costs were assumed to be over $1.35 per 1st YR kWh saved or $11 per 1st YR MCF saved. In both sectors, measures were ultimately mapped to existing EEU programs and assigned a specific non-incentive cost. Detailed non-incentive resource acquisition costs by measure and EEU are available in the appendices of this study.

2.4.3.2 Market Adoption Rates

GDS assessed achievable potential on a measure-by-measure basis. In addition to accounting for the natural replacement cycle of equipment in the achievable potential scenario, GDS estimated measure

specific maximum adoption rates that reflect the presence of possible market barriers and associated difficulties in achieving the 100% market adoption assumed in the technical and economic scenarios.

The initial step in the market penetration methodology is to assess the long-term market adoption potential for residential energy efficiency technologies. Due to the wide variety of measures across multiple end-uses, the GDS/Cadmus team employed varied end-use-specific ultimate adoption rates versus a singular universal market adoption curve. These long-term market adoption estimates were based on publicly available DSM research including market adoption rate surveys and other utility program benchmarking.[19] These surveys include questions to residential homeowners and nonresidential facility managers regarding their perceived willingness to purchase and install energy efficient technologies across various end uses and incentive levels. GDS/Cadmus utilized the likelihood and willingness-to-participate data to estimate the long-term market adoption potential for both the maximum and program achievable scenarios.

Table 2-7 presents the 2019 MPS long-term market adoption rates at varied incentive levels used for both the residential and nonresidential sectors. When incentives are assumed to represent 100% of the measure cost (maximum achievable), the long-term market adoption ranged by sector and end-use from 41% to 90%. For the program achievable potential scenario, the incentive levels also varied by measure resulting in measure-specific market adoption rates.[20]

TABLE 2-7 LONG-TERM MARKET ADOPTION RATES BASED ON SECONDARY WILLINGNESS-TO-PARTICIPATE SURVEY RESULTS

	Incentive Level as a % of Incremental Cost			
End-Use	**0%**	**50%**	**75%**	**100%**
Residential				
Appliances	44%	64%	73%	87%
Central AC	27%	49%	62%	79%
CFL	56%	70%	76%	81%
LED	49%	70%	78%	88%
Other	38%	55%	64%	80%
Pool Pump	9%	28%	34%	41%
Space Heating	28%	50%	63%	79%
Water Heaters	39%	54%	64%	77%
Weatherization	31%	52%	62%	78%
Nonresidential				
Appliances	34%	50%	57%	64%
Central AC	34%	58%	69%	80%
Lighting	44%	67%	77%	86%
Other	33%	57%	68%	81%
Refrigeration	53%	83%	89%	90%
Space Heating	23%	51%	62%	78%
Ventilation	33%	62%	71%	90%
Weatherization	28%	50%	65%	80%
Industrial	40%	64%	71%	80%

[19] Publicly available surveys include willingness-to-participate research conducted as part of the 2019 Indianapolis Power & Light Study, 2016 Wisconsin Potential Study, Colorado Springs Utilities 2015 DSM Potential Study, the 2015 Statewide Pennsylvania Potential Study, 2016 Dayton Power and Light Energy Efficiency Potential Study, 2013 Louisville Gas and Electric Potential Study, 2015 Oklahoma Gas and Electric and Public Service of Oklahoma Energy Efficiency Potential Study, and 2015 National Grid Nantucket Residential Energy Efficiency Potential Study.

[20] For multifamily, an additional factor was applied for each end-use to account for increased difficulty in reaching this sector. For measures where tenants are likely to purchase and install equipment, such as lighting and appliances, the study applied a 93% adjustment factor to the long-term adoption rates. For larger equipment and shell measures the adjustment factor ranged from 50%-70% of the single-family value.

One caveat to this approach is that the ultimate long-term adoption rate is generally a simple function of incentive levels and payback. There are many other possible elements that may influence a customer's willingness to purchase an energy efficiency measure. For example, increased marketing and education programs can have a critical impact on the success of energy efficiency programs. Additionally, other perceived measure benefits, such as increased comfort or safety, equipment availability, contractor knowledge, and reduced maintenance costs could also factor into a customer's decision to purchase and install energy efficiency measures. Although these additional elements are not explicitly accounted for under this incentive/payback analysis, the estimated adoption rates and penetration curves provide a concise method for estimating achievable savings potential over a specified timeframe.

Once the long-term market adoption rate is determined, initial year adoption rates were estimated by calibrating, where possible, the estimates of 2021 annual potential to recent historical levels achieved by the EEU's current DSM portfolio.[21] This calibration effort ensures that the forecasted achievable potential in 2021 is realistic and attainable. GDS/Cadmus then assumed a linear ramp rate over time from the initial year market adoption rate to the various long-term market adoption rates for each specific end-use.

As a final step in the development of program achievable potential, the GDS/Cadmus team adjusted the initial annual estimates to ensure that the associated budgets for program achievable potential met targeted equity constraints across key market segments (described in more detail in Section 2.4.4, below). To align program achievable sector budgets within the targeted constraints, GDS/Cadmus reduced the spending/savings in the misaligned sectors annually until sector equity was achieved.

2.4.4 Additional Program Achievable Potential Considerations

Program achievable potential also includes sector equity constraints for the residential, commercial and industrial, low-income, and small business sectors as follows. These equity targets on program spending can be an important limiting factor on the estimation of program achievable potential within each sector. Annual changes in estimated savings and costs in one sector manifest in similar changes in the remaining sectors in order to maintain the equity target discussed below. Ultimately, sector equity was achieved by quantifying the projected budgets associated with the achievable potential within each sector, and then scaling down the potential within each sector where the annual equity target was misaligned until the specific spending target was achieved.

2.4.4.1 Residential and Commercial and Industrial Sector Equity

Residential sector equity requirements assumed for Program Achievable Potential and EEU program models are different for EVT, BED, and VGS. The residential and commercial/industrial sector equity allocations are based on sector share of 2019 Energy Efficiency Charge (EEC) collections. The following sector equity shares are the percentages of Resource Acquisition (RA) budgets to be modeled in the residential and commercial/ industrial sectors.

***BED*.** Currently, the residential sector contributes about 25 percent of the total EEC in BED territory. Consistent with the last DRP the level of residential spending in the model is recommended to be no less than 25 percent of the BED RA budget for the forecast period 2021 through 2040. Multifamily program spending is included as residential sector spending. The level of commercial and industrial spending in the model is recommended to be the balance of the RA budget over the forecast period.

[21] This approach for initial year adoption rates was used in the estimation of program achievable potential only. For maximum achievable potential, it was assumed that the EEUs could achieve the long-term market adoption rate beginning in 2021 to acknowledge the high incentive levels and represent aggressive adoption of energy efficient technologies.

EVT. Currently, the residential sector contributes about 48 percent of the total EEC in EVT territory. Consistent with the last DRP EVT is gradually increasing the residential sector share to reach a point of full sector equity. The level of residential spending in the model is recommended to assume no less than 40 percent of the EVT RA budget for 2018 through 2022, 43 percent for 2023 through 2027, 46 percent of the RA budgets for 2028 through 2032, and 48 percent thereafter. Multifamily program spending is included as residential sector spending. The level of commercial and industrial spending in the model is recommended to be the balance of the RA budget over the forecast period.

VGS. Consistent with the historical VGS sector collections the level of residential spending in the MPS Program Achievable potential model was originally assumed to be no less than 55 percent of the VGS RA budget for the forecast period 2021 through 2040. Multifamily program spending is included as residential sector spending. However, due to additional performance targets, historical residential sector spending has been closer to 75% of the EEC spending for VGS. To more closely align performance goals with the 2016-2017 VGS Transition Period and the 2018-2020 performance period, residential spending in the 2019 MPS was set at approximately 60% of the VGS RA budget for the 2021-2040 timeframe. The level of commercial and industrial spending in the model is the balance of the RA budget over the forecast period. This is intended to find a balance between actual sector collections and a level of spending that maintains the level of energy savings reflected in historic performance goals.

2.4.4.2 Low-Income Sector Equity

Low-income sector equity requirements assumed for Program Achievable Potential and EEU program models are different for EVT, BED, and VGS. The low-income sector equity is based on the estimated number of low-income households in each service territory and an estimate of how much this population contributed to the resource acquisition budget in 2019. Associated calculations are documented further in Appendix B. The low-income equity modeling assumption for each service territory is quantified as a minimum percent of an EEUs resource acquisition budget dedicated to low-income programs as described below.

The number of low-income households in the EVT and BED service area that are at or below 80% median income has been estimated using the 2015 Vermont Housing Needs Assessment (VHNA) commissioned by the Vermont Department of Housing and Community Development22. The number of VGS low-income households that are at or below a combination of 60% and 80% at or below median income has been estimated using the number of VGS customers on the VGS residential low-income rate, low-income energy assistance plan (LIEAP) customers, and supplemental estimates from the Vermont residential baseline assessment.

BED. It is estimated that 12% of BED's residential customers are low-income and that this population will contribute approximately 3% to BED's EEC resource acquisition budget in 2019. This is based on estimates of average low-income household consumption annually in BED territory times the number of households, times the residential EEC rate for BED in 2019, times the percentage of the resource acquisition portion of EEC collections. Consistent with this calculation, the analysis assumes no less than 3% of the resource acquisition budgets be dedicated to low-income programs This includes both single-family and multifamily low-income program spending.

EVT. Per the method described above it is estimated that 31 % of EVT's residential customers are low-income and that this population will contribute approximately 11% of the resource acquisition budget for 2019. Therefore, the program achievable scenario assumes no less than 11% of the resource acquisition budgets be dedicated to low-income programs. This includes both single-family and multifamily low-income program spending.

[22]https://accd.vermont.gov/sites/accdnew/files/documents/Housing/H-Research-VTHousingNeedsAssessment.pdf.pdf

VGS. It is estimated that 9% of VGS's residential customers are low-income and that this population will contribute approximately 5% of the resource acquisition budget for 2019. Therefore, the program achievable scenario assumes no less than 5% of the resource acquisition budgets be dedicated to low-income programs. This includes both single-family and multifamily low-income program spending.

2.4.4.3 Small Business Sector Equity

The small business sector equity requirements assumed for Program Achievable Potential and EEU program models are different for EVT, BED, and VGS. The small business sector equity assumptions are is based on the current 2018-2020 performance period "equity for small business" Minimum Performance Requirements for all EEUs.

For EVT and BED this QPI is defined as serving the minimum number of participating nonresidential customers with less than 40,000 kWh annual consumption. The assumption for modeling for EVT is to serve no less than 2,000 customers each three-year performance period. For BED the assumption for modeling is to serve no less than 225 customers each three-year performance period.

For VGS this QPI is defined as serving participating nonresidential customers with less than 600 Mcf annual consumption. This applies to two out of four VGS commercial rate classes (G1 and G2). The assumption for modeling is that a minimum of 30 percent of VGS's installed commercial measures be installed in the G1 and G2 rate classes.

2.4.4.4 Optimization for Program Implementation

For select measures the VT MPS models were optimized for expected program implementation conditions. Market conditions are anticipated, and especially in the near term, to be informed by recent trends as well as professional judgment.

Specifically, in addressing the program equity constraints discussed above, rather than proportionally scaling all measures where sector equity was originally misaligned, GDS/Cadmus prioritized residential lighting (both screw-based bulbs in 2021/2022 and integrated LED fixtures throughout the analysis timeframe) as well as the expected forecast of CCHP adoption to ensure that the program achievable for these measures was not altered.

2.4.5 Rate and Bill Impact Analysis and Methodology

As a final component of the 2019 VT MPS, the GDS/Cadmus Team also assessed the rate and bill impacts associated with the maximum achievable and program achievable potential scenarios for each EEU.

Rate impacts are calculated based on changes in average revenue requirements originating from two sources: 1) directly utility expenditures on energy efficiency and 2) reduced utility energy sales due to energy savings.

Recognizing that utility revenue is a combination of variable and fixed customer charges (i.e. those that vary with consumption and those that don't), base year (year 0, calendar year 2020 for this study)[23] revenues are split into these two categories.

The rate revenue data provided included customer charge revenue by EEU for:

- Residential customers
- Commercial demand and non-demand customers

[23] Cadmus used rate revenue data from 2017, which was the most recent year available, to calculate the base average revenue requirement.

- Industrial demand and non-demand customers

For residential and non-demand C&I customers the revenue data presented combined energy and capacity revenues. For demand customers the data included separate billed capacity revenue for on-peak and off-peak kW.

Charges are expressed in average cost per kWh consumed for customer class *i*. That is:

$$Revenue_{i0} = FixedCharges_{i0} + VariableChargePerkWh_{i0} \times kWhSales_{i0}$$

where:

$$VariableChargePerkWh_{i0} = \frac{VariableCharges_{i0}}{kWhSales_{i0}}$$

Variable charges include combined energy and capacity revenues for each customer class. Customer classes were defined as:

- Residential customers
- Non-demand C&I customers
- C&I demand customers[24]

Cadmus estimated the number of C&I customers with demand charges for EVT from a list of commercial customers in 2018 with the peak kW usage and annual kWh values for each customer. Cadmus did not have a similar file for BED. All customers with peak kW usage were flagged as demand customers. The customer forecasts for EVT did not distinguish between demand and nondemand customers in the nonresidential customer counts. Cadmus used the proportion of demand customers flagged in the 2018 usage data to allocate the nonresidential customers to demand and nondemand customer counts.

Cadmus forecasted fixed and variable charges over the 20-year study period to estimate retail rates in the absence of future energy efficiency programs. The forecasted charges (fixed or variable) in any year *y* were held constant in real terms:

$$Revenue_y = FixedCharges_y + \ (VariableChargesPerkWh_y \times \ kWhSales_y)$$

where: $kWhSales_y$ represents each EEU's forecasted sales in year *y in* the absence of future DSM programs.

In addition to separating fixed customer charges from variables charges, Cadmus followed the methodology outlined in the 2014 rate and bill impact analysis by Synapse[25]. This methodology breaks the variable charge into four components that can be adjusted individually for the electric utilities.

VGS rates were based on 2019 revenue data and were broken out into an annual fixed customer and low income assistance charge, a variable gas charge ($/mcf), and a distribution charge ($/mcf).

Cadmus applied the assumptions outlined in the Synapse report for the electric utilities. EVT's variable charge is 58.1% generation, 16.7% transmission, 16.7% distribution, and 8.5% other taxes and fees. BED's variable charge is 47.7% generation, 12.7% transmission, 25.8% distribution, and 13.8% other taxes and fees. These percentages were applied to the variable charge and assumed to apply equally to each customer class.

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[24] Demand customers were only modeled separately for EVT as Cadmus was not able to obtain annual kWh usage for demand vs non-demand customers or demand vs non-demand customer counts for BED.

[25] Synapse Energy and Economics, Inc. "Rate and Bill Impacts of Vermont Energy Efficiency Programs. April 2014

Next, the baseline rates, revenue, and sales forecasts were complete for each utility and customer sector, and the impacts of energy efficiency programs were assessed. Because this is an annual analysis, yet measures are being installed over the course of the year, an assumption must be made regarding when to begin counting the energy savings. The methodology outlined below assumes energy saved through programs in year *y* take effect in year *y*. That is, it is assumed that all measures are installed on January 1st of year *y*. Thus, the effect of energy efficiency programs in any year is the sum of new installations in that year and remaining savings from previous savings, accounting for expiration of measures installed in previous years.

Sales forecasts for EVT C&I customers did not distinguish between demand and nondemand customers. Cadmus allocated the nonresidential sales forecast, as well as the forecast energy and capacity savings, using the share of kWh billing determinates in the 2017 rate revenue data.

Energy efficiency affects each rate component differently. Again, Cadmus followed the methodology outlined by Synapse.

- **Generation.** The generation rate is affected both by avoided capacity costs as well as price suppression effects. It is assumed that there are no lost revenues associated with generation costs. The post-efficiency generation rate is equal to the pre-efficiency generation costs less energy and capacity avoided costs as well as the energy and capacity DRIPE (Demand Reduction Induced Price Effect) price suppression effects divided by the post-efficiency kWh sales in year y.

- **Transmission.** Transmission rates are affected by avoided transmission costs, including New England regional network surcharge, charged to each load serving entity based on the share of the regional load.26 The post efficiency transmission rate is equal to the pre-efficiency transmission cost plus transmission lost revenue less transmission avoided costs divided by the post-efficiency kWh sales in year y.

- **Distribution**. Energy efficiency will result in lost distribution revenues as distribution costs are mostly fixed. To calculate the lost revenue charge, first we calculate the post efficiency distribution costs as the pre-efficiency costs less avoided distribution costs in year *y*. The lost revenue distribution rate is equal to:

$$\frac{Post - EE\ Distribution\ Costs_y}{Pre - EE\ kWh\ sales_y} - \frac{Post - EE\ Distribution\ Costs_y}{Post - EE\ kWh\ sales_y}$$

  Post-efficiency distribution rates are then equal to the pre-efficiency distribution costs less avoided distribution costs divided by post-efficiency kWh sales plus the lost revenue rate in year *y*.

- **Energy Efficiency Charge**. The energy efficiency rate is simply the energy efficiency budget (including resource acquisition costs and non-resource acquisition costs (i.e. DSS, performance awards, etc.)) divided by the post-efficiency kWh sales.

- **Customer charges and taxes** are assumed to be unaffected by efficiency programs and remain the same for each utility and customer class in all cases.

For VGS, Cadmus treated the gas charge as variable costs for which no lost revenues were calculated. Lost revenues were calculated for the VGS distribution charge in the same way as the electric distribution charge except avoided transmission costs were not accounted for in the distribution lost revenue calculation. All avoided costs were combined and treated as a stand-alone component.

[26] While important to note as part of the methodology, deferred T&D values have been zeroed out in the analysis.

The new rates per kWh can then be applied to an average customer's consumption to estimate the average bill impact. Cadmus calculated average bill impacts for participant and nonparticipant customers for each utility and customer class.

Participants receive direct benefits from efficiency through reduced consumption with post-efficiency bills subject to rate impacts. Nonparticipant consumption is unchanged, and bills are impacted only by the rate impacts.

Nonparticipant bill impacts are the average annual customer bill at the pre-efficiency rate less the average customer bill at the post-efficiency rate. Participant bills are the average annual consumption less average participant savings at the new rate. However, Cadmus did not have expected participant counts to determine average participant savings so instead assumed savings for PA scenarios were 10% of baseline average bills and 20% for the MA scenarios. In addition, Cadmus averaged the change in total revenue requirement between the baseline scenario and the program and maximum achievable scenarios for each customer class, which captures the combined impact of the change in rates (which affect both participants and nonparticipants) as well as the benefits of avoided consumption (which benefits only participants).

Results of the rate and bill impact analysis are discussed separately for each EEU in Section 4.5 (EVT), Section 5.5 (BED) and Section 6.5 (VGS).

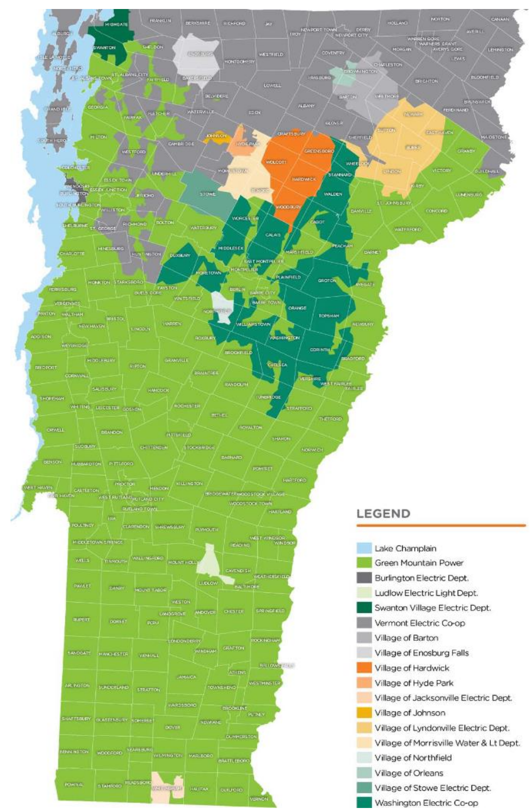
3 Characterization of Vermont EEU Service Areas

Energy efficiency potential studies and other market assessment studies are valuable sources of information for planning energy efficiency programs. To develop estimates of electricity savings potential, it is important to understand the extent to which electricity and natural gas is used by households and businesses in Vermont in the EEU service areas.[27] Data are also presented for the forecasted electric energy sales and system peak demand, and the on-going energy efficiency efforts of EVT, BED, and VGS.

3.1 EEU SERVICE AREAS

This study includes a potential of electric and natural gas potential for the three EEUs in Vermont. EVT delivers electric energy efficiency for the state, except in the BED territory where BED delivers energy efficiency services to its customers. Figure 3-1 maps the numerous electric distribution utilities in Vermont with EVT providing electric energy efficiency services to all electric utilities except BED. In 2020, EVT provided electric energy efficiency services to approximately 300,000 households and 52,300 businesses. BED provided service to an additional 17,600 households and 3,890 businesses.

FIGURE 3-1 ELECTRIC DISTRIBUTION UTILITIES IN VERMONT



VGS delivers regulated natural gas energy efficiency services in its existing service footprint (primarily Chittenden, Franklin, and Addison counties) which overlaps with both EVT and BED's service territories. In 2020, VGS projects to serve approximately 48,000 households and 6,200 nonresidential facilities. The VGS service footprint is also expected to increase by more than 11,000 homes and 1,100 nonresidential facilities over the analysis timeframe due to expansion of natural gas services in existing homes and new construction. This expansion is reflected in the current analysis.

3.2 EEU LOAD FORECASTS

This analysis of the potential for energy efficiency savings begins with utilizing the most recent and available electricity sales forecasts for each EEU for a period of 20 years beginning in 2021.

3.2.1 EVT Load Forecast

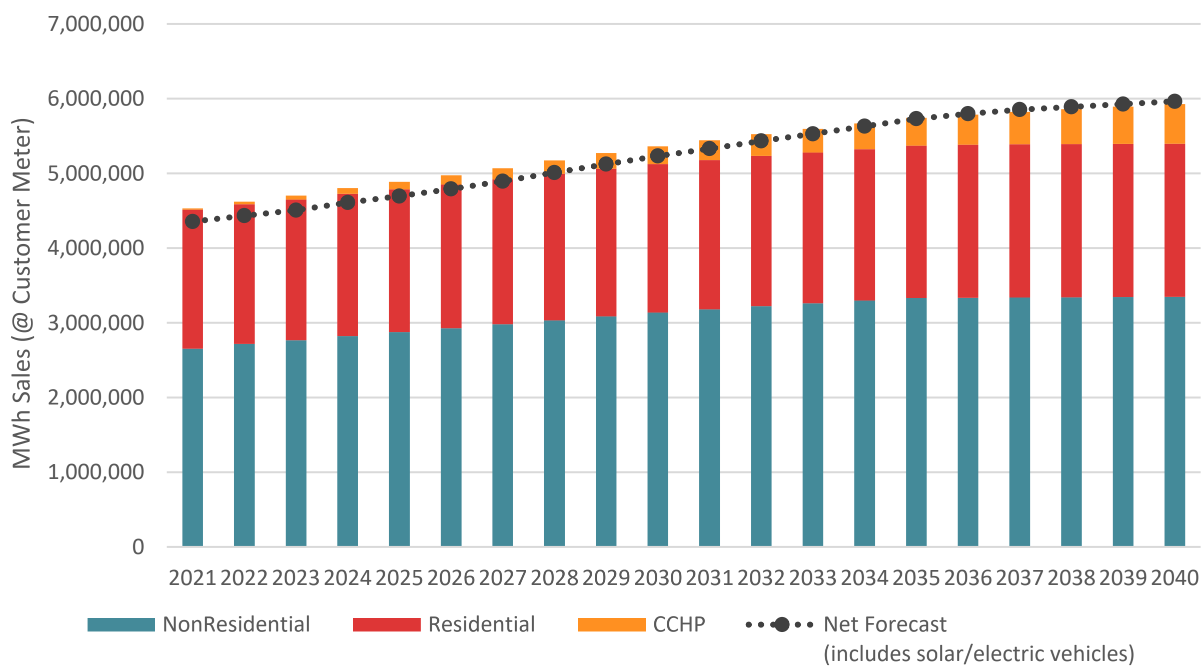
As noted in Section 2.2.1, the electric load forecast used for EVT is based on the 2018 VELCO Long Range Transmission Plan and includes several adjustments. Initial adjustments to the 2018 VELCO forecast include: 1) removing BED from the statewide forecast, 2)removing the impacts of any planned future electric and DSM activity to prevent potential double-counting of future DSM potential 3) excluding industrial opt-out load and Vermont's Self-Managed Energy Efficiency Program (SMEEP) participant and 4) converting the EVT forecast from sales at generation to sales at the meter level.

[27] The Vermont Public Utility Commission has appointed the Burlington Electric Department (BED) as the EEU for the City of Burlington, and the Commission has appointed the Vermont Energy Investment Corporation as the EEU for the remainder of the State, under the name "Efficiency Vermont" (EVT). For purposes of this report, "BED" is used to refer to the area served by the Burlington Electric Department, and "EVT" is used to refer to the area served by VEIC.

In addition, GDS/Cadmus, the Department, and EVT coordinated to produce an updated forecast of cold-climate heat pumps that are expected to be adopted and installed in EVT dwellings over the 2021-2040 period as part of Vermont's Tier III goals. This adjustment included removing the amount of CCHP sales including in the original 2018 VELCO forecast and including a new CCHP sales forecast. In total, the revised CCHP for the EVT service area assumes just over 6,000 units in 2021, more than 19,700 units from 2021-2023, and over 189,700 over the 20-year analysis timeframe.[28]

Figure 3-2 shows the electric MWh sales forecast for EVT from 2021-2040. Before adjusting for CCHPs, the total MWh sales forecast for EVT grows at a compound annual growth rate of 0.9% per year. After adjusted for expected CCHP adoption, the sales forecast is expected to grow at a compound average annual growth rate of 1.4%.

FIGURE 3-2 EVT ENERGY (MWH) SALES FORECAST FROM 2021-2040



3.2.2 BED Load Forecast

As noted in Section 2.2.1, BED uses a separate long term forecast of energy load and peak demand out to 2040 in Burlington. For the BED service area, ITRON produces an end-use forecast that includes adjustments for expected solar and electric vehicle adoption. Like adjustments made for EVT, the BED forecast has been adjusted to exclude any future planned DSM activity as well as a revised forecast of CCHP adoption in the BED service area. The revised CCHP forecast assumes nearly 350 CCHPs are installed the initial three-year analysis timeframe, and over 5,200 from 2021-2040.[29]

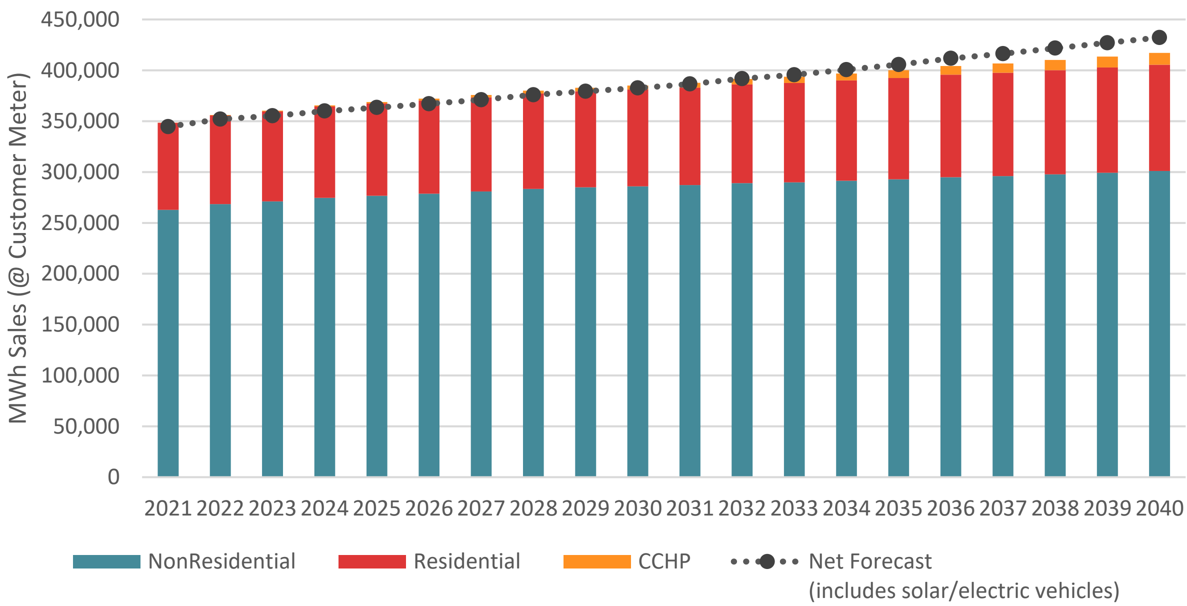
Figure 3-3 shows the MWh sales forecast for BED. A smaller share of the total system sales is attributable to the residential sector in the BED territory compared to the rest of the state. For BED, roughly 25% of sales are attributable to the residential sector and 75% are attributable to the nonresidential sector. The

[28] These CCHP counts include units that are not expected to be influenced directly by EVT programs. Following discussions with the Department, the roughly 17% of the 189,700 CCHPs installed during the 20-year analysis timeframe are considered "out of program" and not directly influenced by EVT. Additionally, EVT assumes 90% of CCHP installations will occur in the residential sector. If the Department assumes 1.2 CCHP are installed per converted homes, roughly 43% of all households will utilize CCHPs for a portion of their space heating needs by 2040. Last, the analysis assumes the average baseline CCHP would consume 2,800 kWh annually (less than the approx. 3,800 kWh assumed in the 2018 VELCO forecast).

[29] This forecast of CCHP adoption in the BED service area is a deviation from BED's Net Zero Energy by 2030 Plan, which would require more aggressive path for CCHP conversions..

total MWh sales forecast for BED grows at a compound annual growth rate of 0.9% per year (excluding CCHPs) and 1.0% per year (including CCHPs).

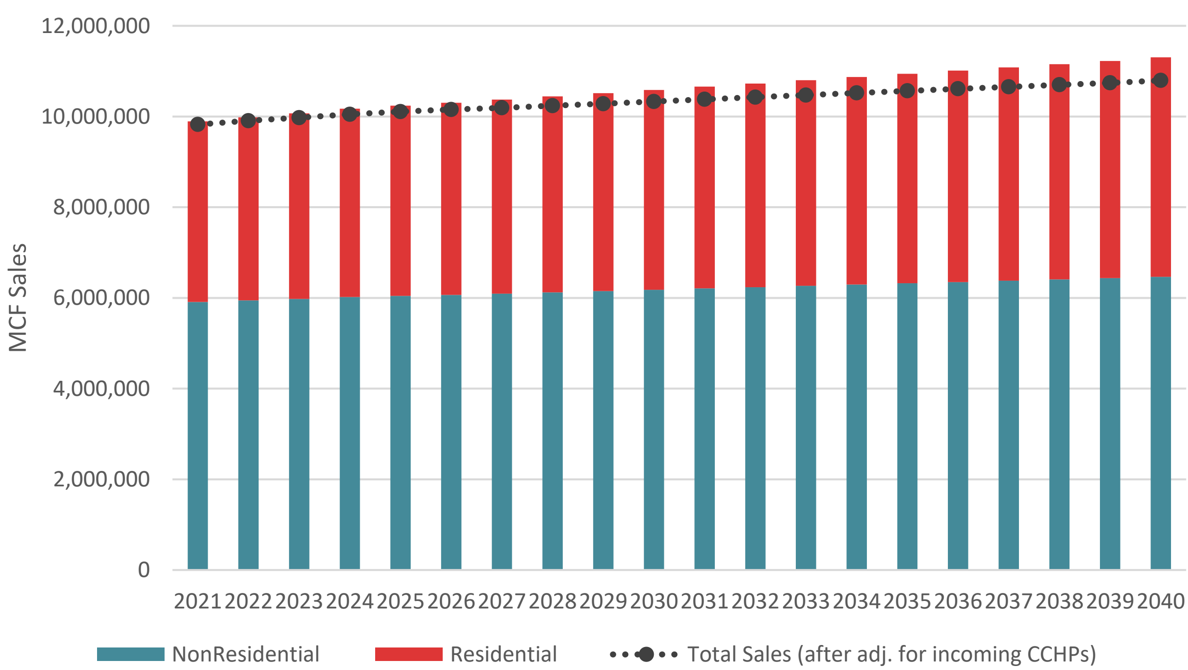
FIGURE 3-3 BED ENERGY (MWH) SALES FORECAST FROM 2018-2037



3.2.3 VGS Load Forecast

Figure 3-4 shows the natural gas MCF sales forecast for VGS from 2021-2041. VGS supplied their load forecast directly to GDS/Cadmus and excludes any industrial opt-out sales. Based on projections that 10% of the EVT CCHP unit forecast and 95% of the BED CCHP unit forecast would be installed in the VGS territory, GDS/Cadmus made an adjustment to the VGS forecast to reduce MCF sales. Over twenty years, the estimates impact of CCHP adoption is expected to reduce roughly 10% of VGS residential MCF sales. The total MCF sales forecast for VGS grows at a compound annual growth rate of 0.7% per year prior to any adjustment for CCHP adoption and slows to 0.6% after adjusting for impacts of CCHP on VGS sales.

FIGURE 3-4 VGS NATURAL GAS (MCF) SALES FORECAST FROM 2020-2040



3.3 SECTOR LOAD DETAIL

3.3.1 EVT Commercial Sector Load Detail

Figure 3-5 shows the average annual energy intensities, expressed in kWh per square foot, for each building type characterized in EVT's commercial sector. Figure 3-6, as well as Figure 3-7 shows the disaggregation of projected commercial loads for EVT in 2040 by end use. Most of the commercial consumption comes from lighting end uses (41%), followed by plug load end uses (28%), and refrigeration (13%). Lighting end uses include screw base, linear, high bay, and exterior fixtures. The plug load end use includes various appliances, office equipment, and electronics.

Figure 3-6 and Figure 3-7, show the disaggregation of EVT's commercial forecast by sector and by end use. Energy intensities range from roughly 9 kWh/sq. ft. in warehouses where lighting is the predominant end use, to nearly 55 kWh/sq. ft. in grocery stores where most electricity consumption comes from the refrigeration end use. Note that Figure 3-7 compares energy intensities, not total energy consumption, across the different commercial building types.

FIGURE 3-5. EVT ENERGY INTENSITY BY COMMERCIAL BUILDING TYPE (KWH/SQFT)

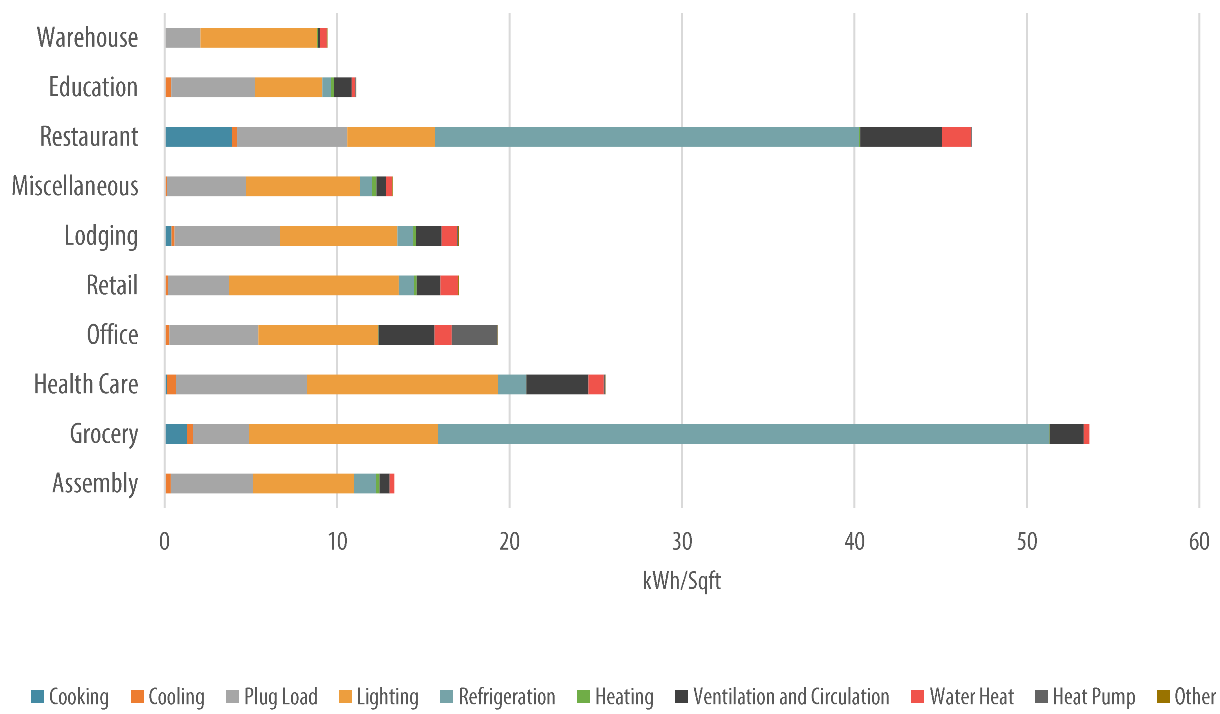


Figure 3-6 shows the EVT commercial baseline forecast in 2040, disaggregated by building type. This disaggregation reflects the mixture of building types and consumption identified in EVT's customer data set. Nearly two-thirds (31%) of projected energy consumption in 2040 comes from the "miscellaneous" building type, followed by offices (17%), retail (12%), and grocery stores (11%).[30]

Figure 3-7 shows the disaggregation of projected commercial loads for EVT in 2040 by end use. Most of the commercial consumption comes from lighting end uses (41%), followed by plug load end uses (28%), and refrigeration (13%). Lighting end uses include screw base, linear, high bay, and exterior fixtures. The plug load end use includes various appliances, office equipment, and electronics.

[30] Miscellaneous includes public order and safety buildings, religious worship, vacant building, building that are industrial/agricultural but with some retail space, and all other buildings that do not fit within another category (i.e. laboratory, data centers, telephone switching, etc.)

FIGURE 3-6. EVT BASELINE ENERGY BY COMMERCIAL BUILDING TYPE IN 2040

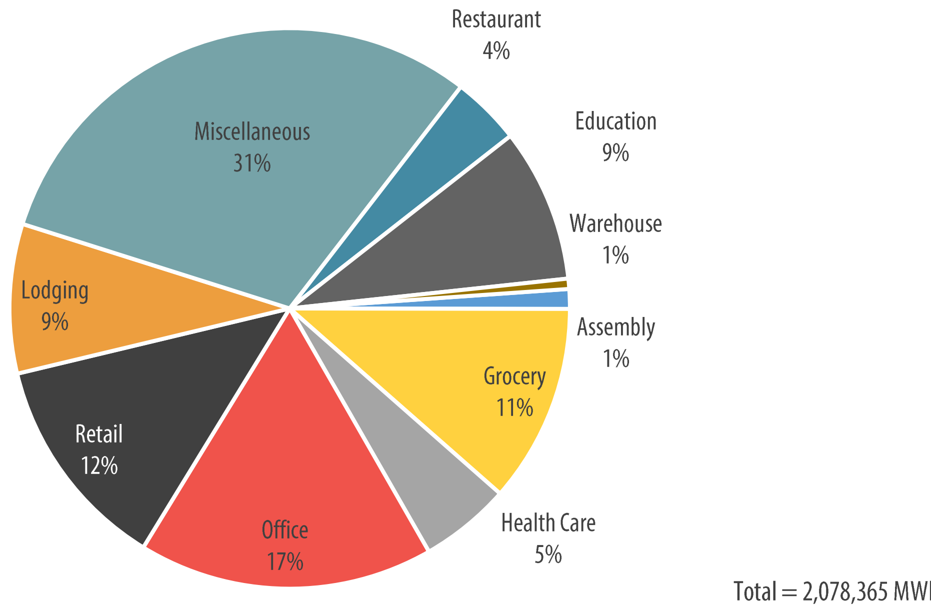
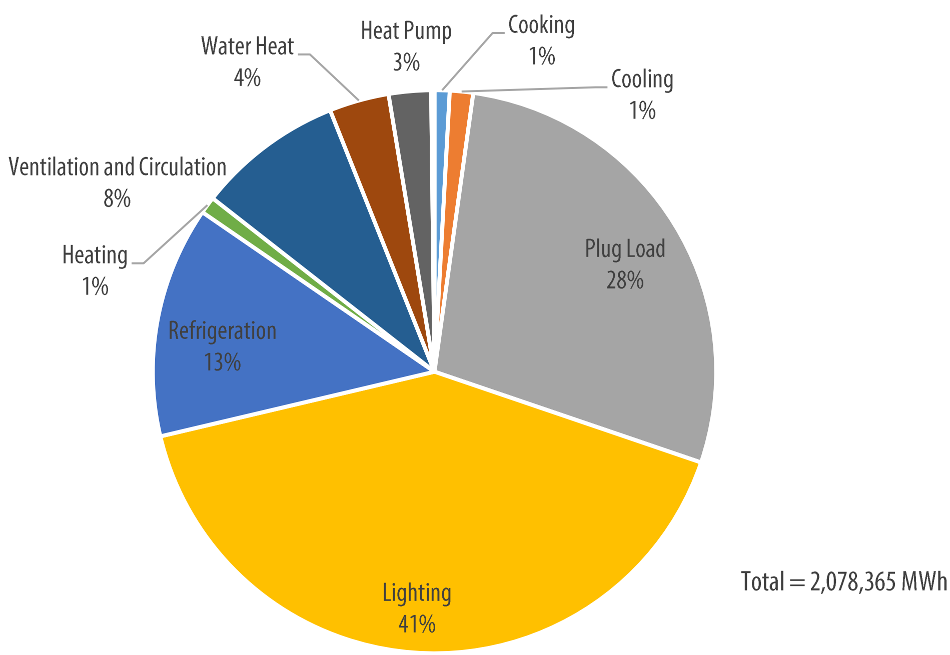


FIGURE 3-7. EVT BASELINE ENERGY BY COMMERCIAL END USE IN 2040



Using EVT's customer and forecast data, we disaggregated EVT's industrial forecast into specific industries. Figure 3-8 provides a breakout of projected 2040 industrial sales by industry. Paper manufacturing represents 30% of industrial sales, followed by nonmetallic mineral products (24%) and miscellaneous manufacturing (22%).

FIGURE 3-8. EVT BASELINE ENERGY BY INDUSTRIAL FACILITY TYPE

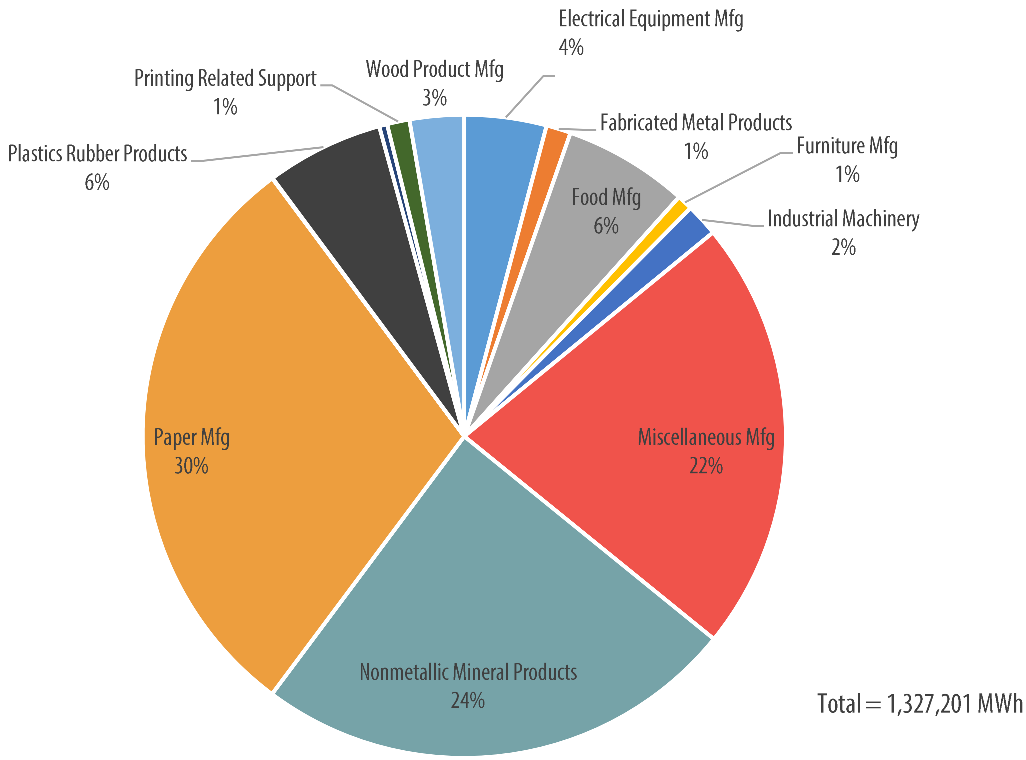
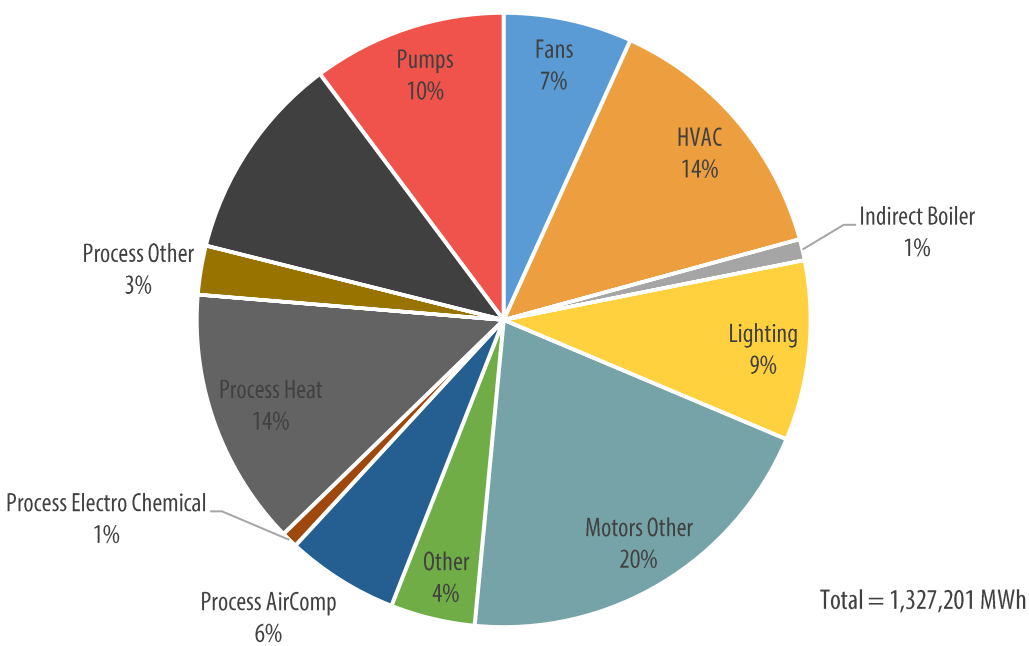


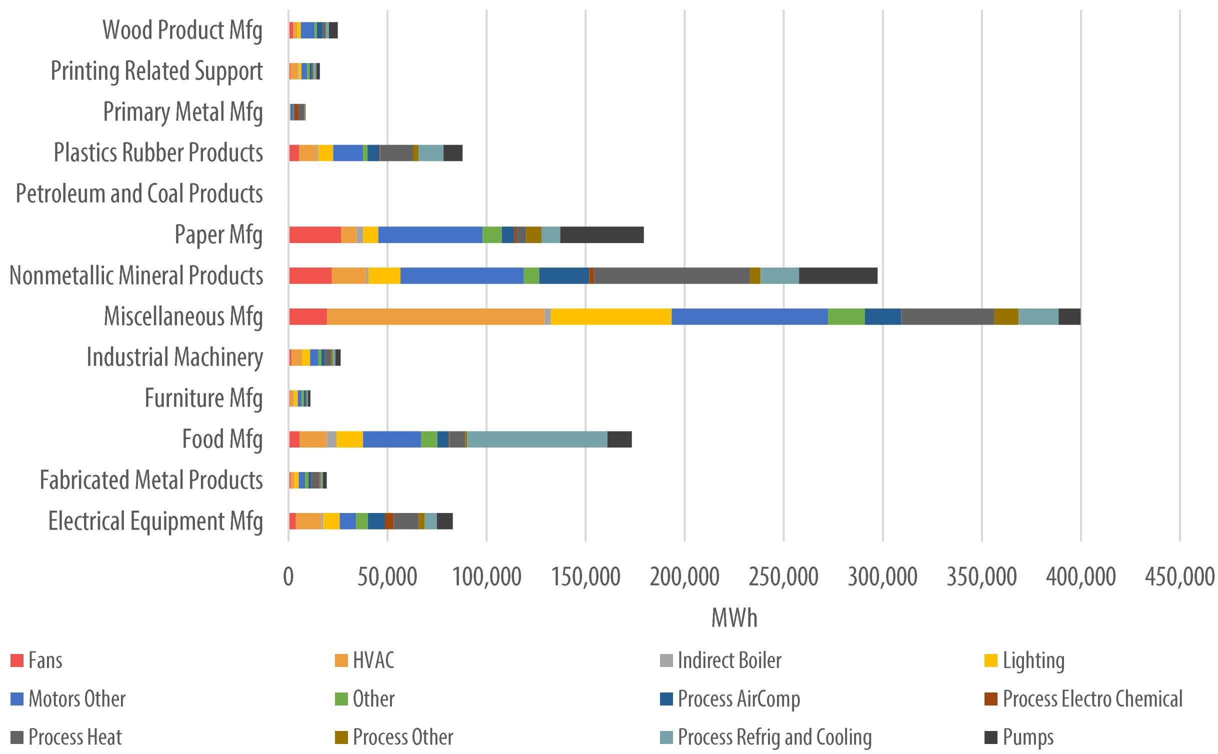
Figure 3-9 shows the distribution of forecasted industrial sales (in 2040) by end use. This distribution reflects the mixture of industries and each industry's respective end use consumption. We determined the distribution of end use consumption for each industry using data from the U.S. Energy Information Agency's (EIA) Manufacturing Energy Consumption Survey (MECS).

FIGURE 3-9. EVT BASELINE ENERGY BY INDUSTRIAL END USE



End use consumption varies across industries, as shown in Figure 3-10. For instance, the nonmetallic mineral products industry has high usage from heat processes and food manufacturing has relatively high usage in refrigeration and cooling processes.

FIGURE 3-10. EVT BASELINE ENERGY BY INDUSTRY AND END USE



3.3.2 BED Commercial Sector Load Detail

We disaggregated BED's commercial forecast into segments and end uses using the same approach as we did for EVT. However, in reviewing BED's customer data set, we did not identify industrial customers. Therefore, we only characterized the commercial sector for BED. Figure 3-11 shows commercial energy intensities for BED's commercial customers, disaggregated by segment and end use. Restaurants and grocery stores have the highest energy intensity, due to a high saturation of refrigeration equipment.

Figure 3-12 shows energy usage in BED's commercial sector, disaggregated by building type. Offices account for roughly one-third of commercial usage, followed retail (18%), miscellaneous (13%), and lodging (11%).

FIGURE 3-11. BED ENERGY INTENSITY BY COMMERCIAL BUILDING TYPE (KWH/SQFT)

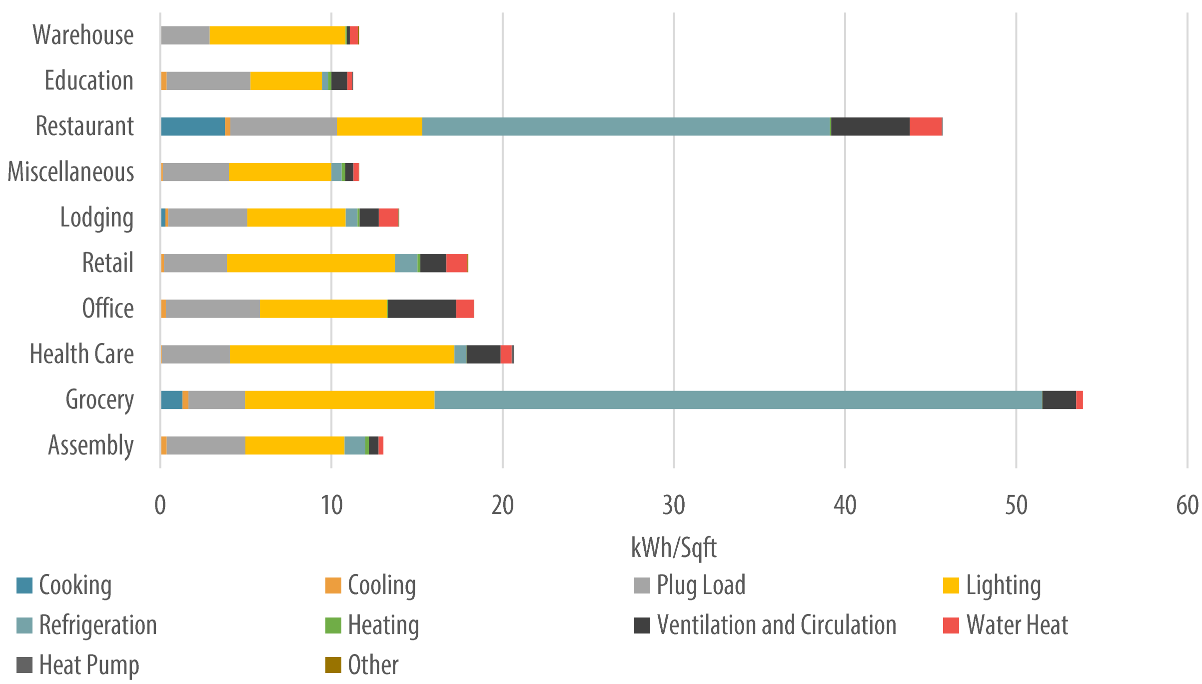
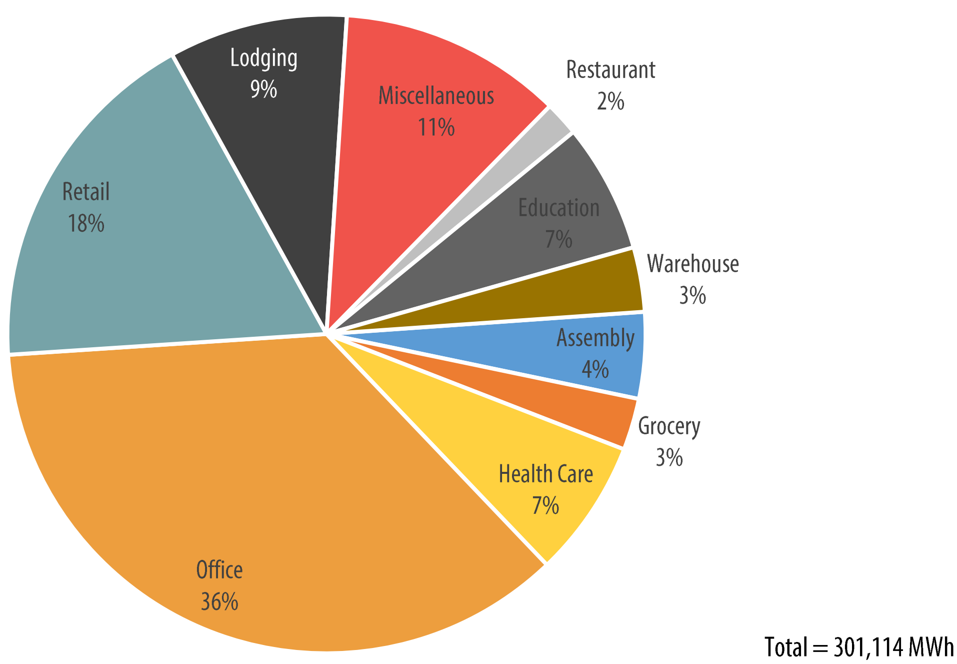
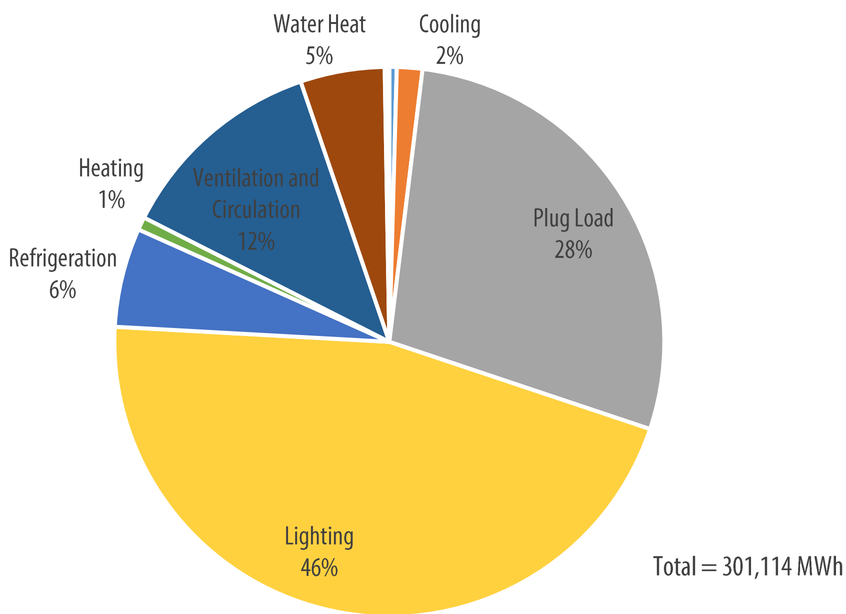


FIGURE 3-12. BED BASELINE ENERGY BY COMMERCIAL BUILDING TYPE IN 2040



Across all segments, lighting and plug load end uses account for nearly three-quarters of commercial electric consumption. Figure 3-13 breaks out projected BED usage in the commercial sector.

FIGURE 3-13. BED COMMERCIAL BASELINE ENERGY BY END USE IN 2040



3.3.3 VGS Commercial and industrial Sector Load Detail

Figure 3-14 shows energy intensities, expressed in kBtu per square foot, for commercial buildings in VGS' service territory. Energy intensities range from under 5 kBtu per square foot in warehouses, where furnaces account for most gas usage, to over 50 kBtu per square foot in restaurants where cooking accounts for most gas usage.

FIGURE 3-14. VGS ENERGY INTENSITY BY COMMERCIAL BUILDING TYPE AND END USE (KBTU/SQFT)

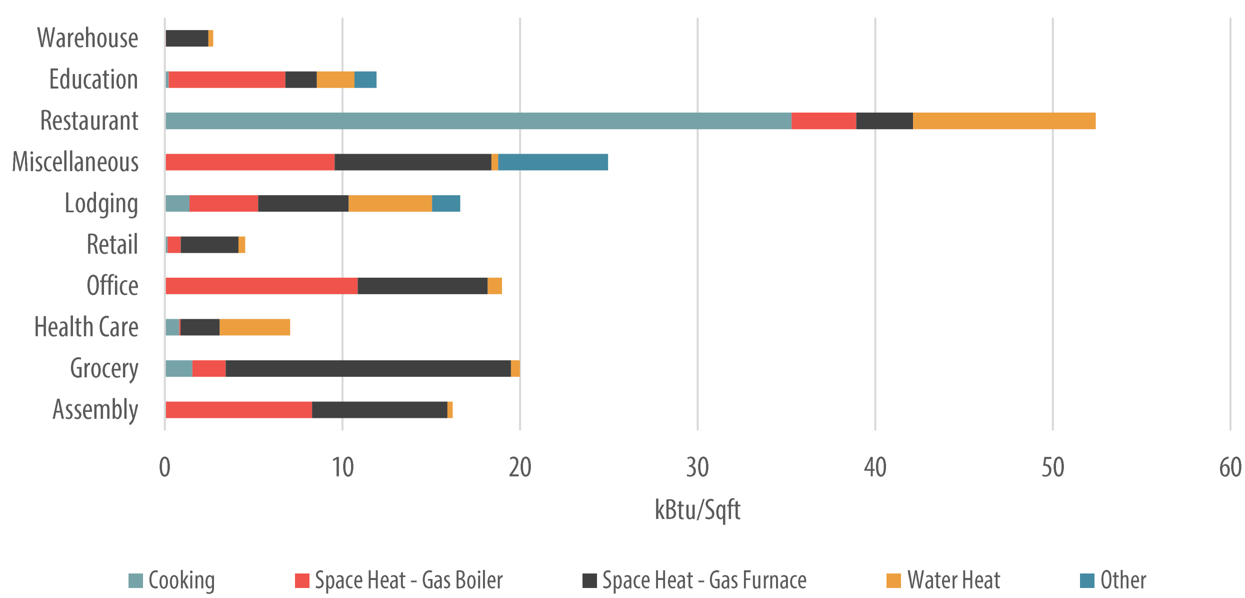


Figure 3-15 shows the distribution of commercial gas usage in VGS' service territory by building type. Nearly one-third (30%) of gas usage is in miscellaneous buildings, followed by offices (16%), retail (14%), and grocery stores (11%).[31]

FIGURE 3-15. VGS BASELINE ENERGY BY BUILDING TYPE IN 2040

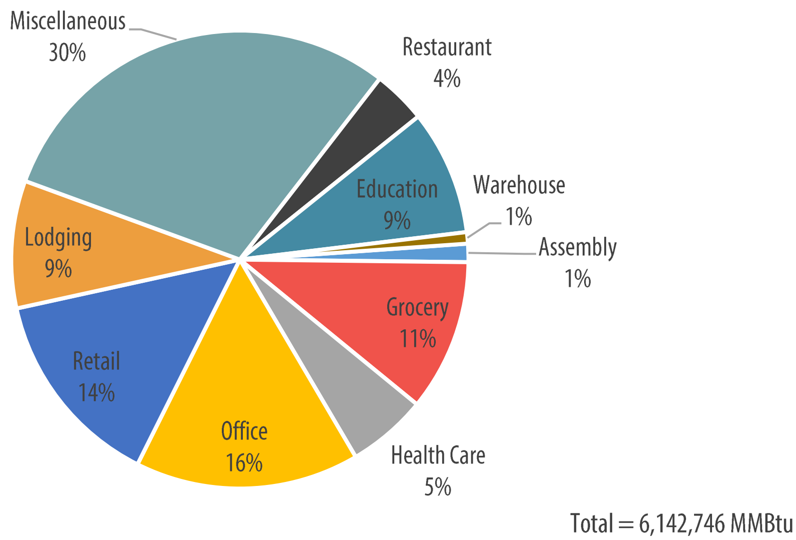
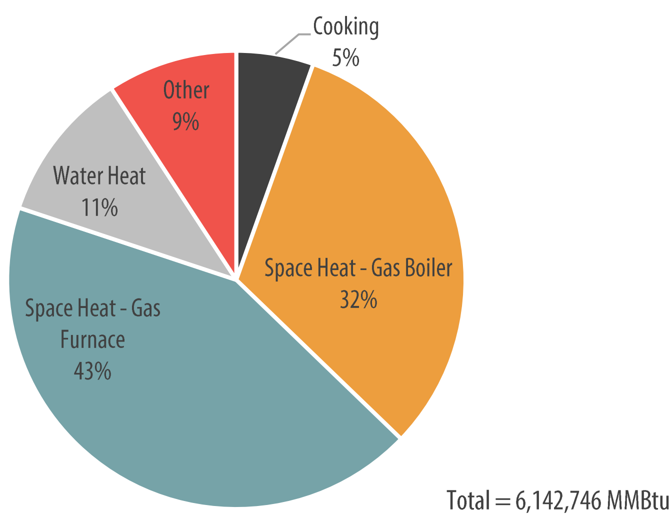


Figure 3-16 shows the distribution of commercial gas usage by end use. Across all building types, boilers and furnaces account three-fourths of total gas usage. Other end uses (i.e. pool heat, dryers, and gas room heat) account for 9%, cooking accounts for 5% of total gas usage and water heating accounts for the remaining 11%.

FIGURE 3-16. VGS BASELINE ENERGY USE BY END USE IN 2040



[31] Miscellaneous includes public order and safety buildings, religious worship, vacant building, building that are industrial/agricultural but with some retail space, and all other buildings that do not fit within another category (i.e. laboratory, data centers, telephone switching, etc.)

VGS' industrial sector consists of diverse industries, including a collection of miscellaneous industries which account for 30% of industrial gas usage. Nonmetallic mineral products, paper manufacturing, and food manufacturing account for 22%, 14%, and 13% of VGS' industrial gas usage, respectively (Figure 3-17).

FIGURE 3-17. VGS ENERGY USE BY INDUSTRY IN 2040

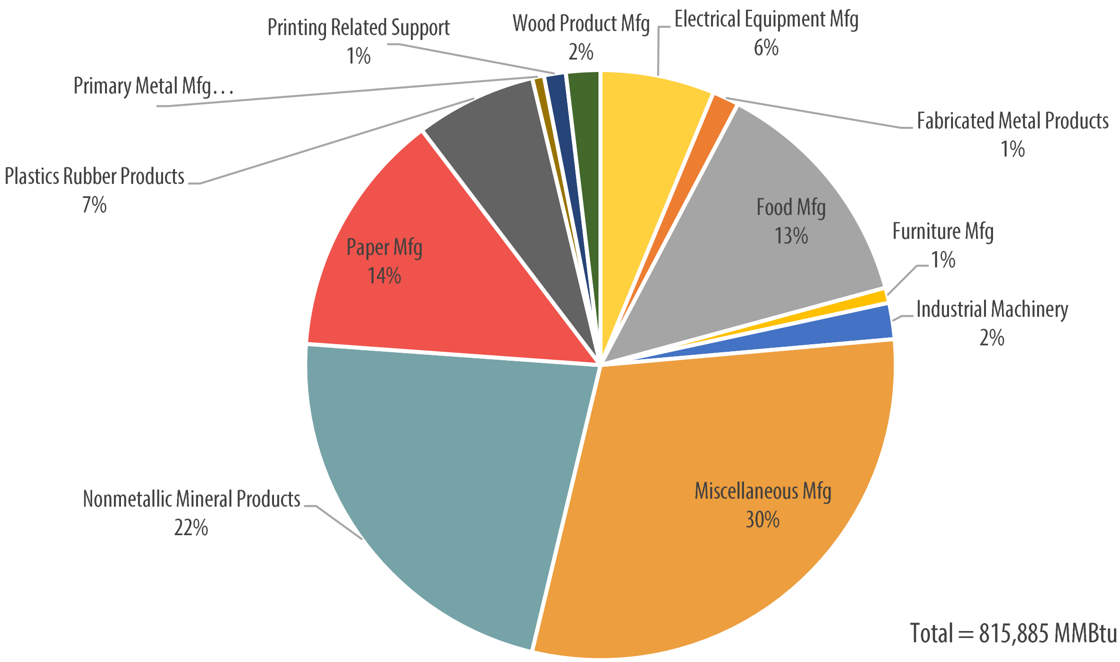


Figure 3-18 and Figure 3-19 shows the distribution of end use gas consumption in VGS' industrial sector. Process heat accounts for 45% of gas consumption, followed by Indirect Boilers (32%), and HVAC (20%). We derived the distribution of end use consumption for each industry using data from EIA's MECS.

Using these fields, The GDS/Cadmus team will assign each customer in the EEUs' nonresidential data sets to one of the commercial or industrial segments listed in Table 2-1. Also to be considered are wastewater treatment plants, breweries, and specific sub-categories of University facilities (sports facilities, cafeterias, main chiller plants, etc.).

FIGURE 3-18. VGS ENERGY USE BY END USE IN 2040

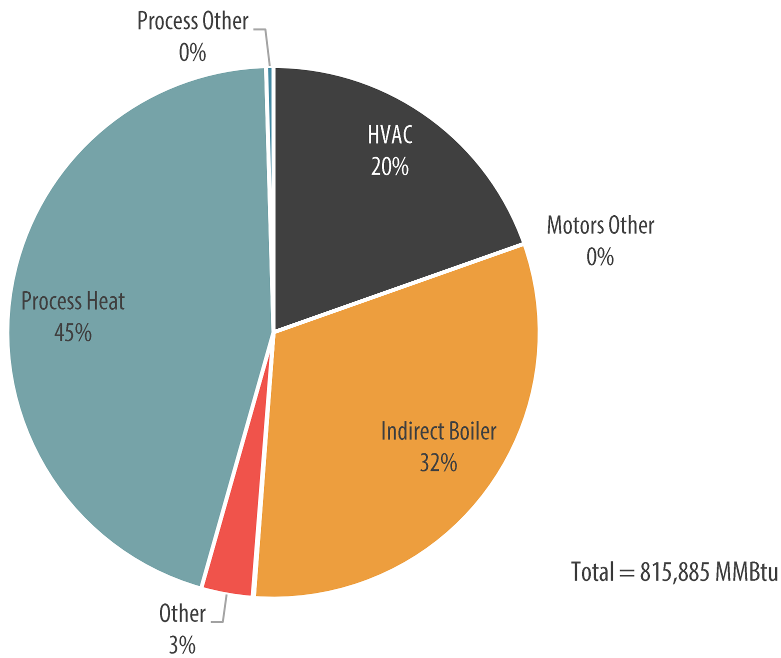
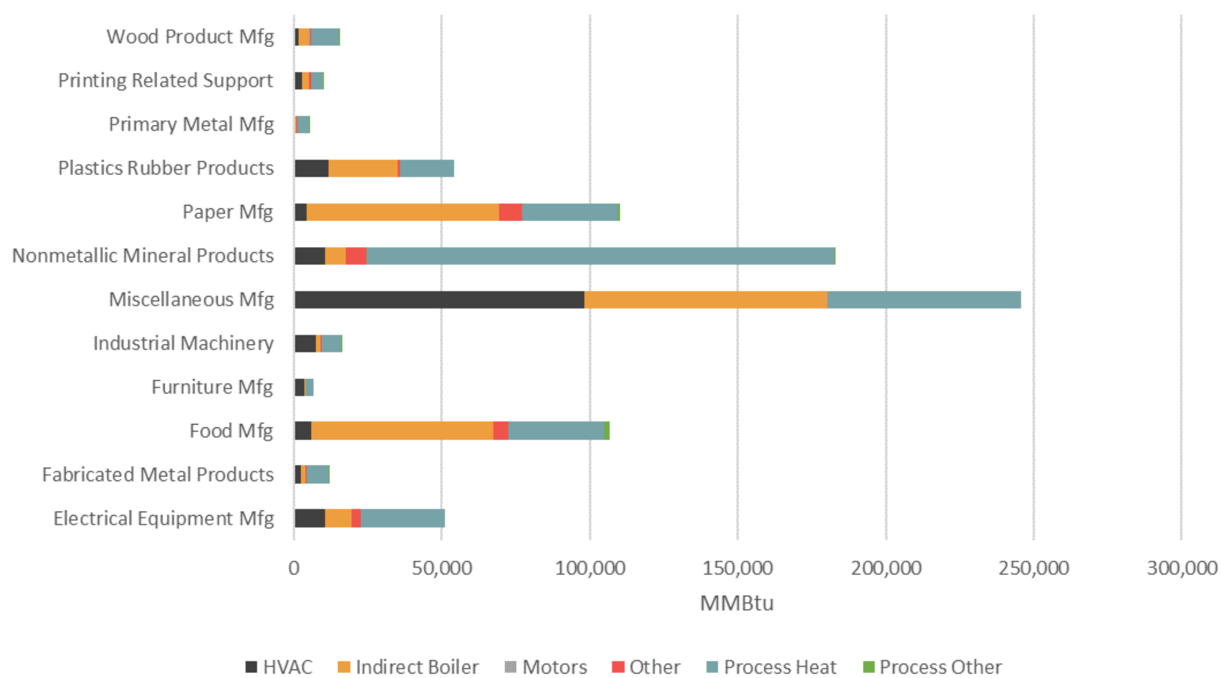


FIGURE 3-19. VGS BASELINE ENERGY BY INDUSTRY AND END USE



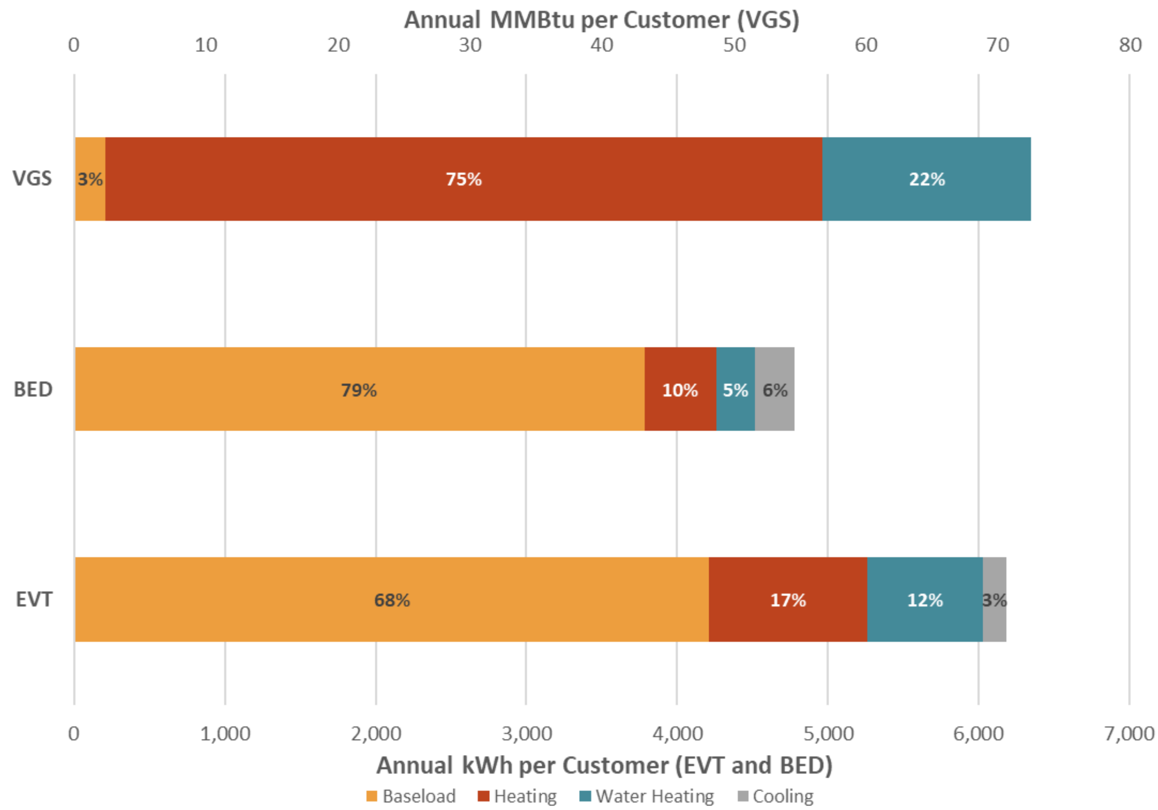
3.3.4 Residential Sector Load Detail

Figure 3-20 provides the average annual energy consumption in the residential sector by EEU and end-use based on the results of the forecast disaggregation effort discussed in Section 2.2. The average electric consumption per household in the EVT service areas was estimated to be 6,186 kWh per year. BED's residential customers, who are be characterized by a greater density of multi-family units and lower electric heating and water heating loads per customer compared to EVT, consume an average of 4,782 kWh per year per customer. For both EVT and BED, annual baseload consumption (which is comprised of

predominately of lighting, refrigeration, plug loads, cooking, and laundry) makes up much of the average annual household load. Due to the relatively small market penetration of electric space heating, water heating, and central air conditioning, the average annual contributions from these end-uses is relatively small.32

Gas consumption was estimated to be 71 Mcf per year, with most of the annual consumption attributable to space heating and water heating. Cooking and gas drying account for only 3% of the total gas consumption.

FIGURE 3-20 END-USE CONSUMPTION PER CUSTOMER – BASED ON EEU FORECAST DISAGGREGATION



3.4 2015-2017 TRIENNIAL PLAN BENCHMARKING

The GDS/Cadmus team conducted a review of the latest available information pertaining to each EEU's historical energy efficiency program performance. Various data points were collected including reported energy savings and resource acquisition costs. The purpose of this step was to understand historical program delivery and performance, and to help calibrate, where possible, our near-term estimates of achievable potential. Table 3-1 shows the 2015-2018 annual MWh/Mcf savings and annual resource acquisition costs by sector and EEU.

One caveat to the examination of historical savings and spending is that EVT exceeded their expected savings targets considerably during the 2015-2017 timeframe primarily by re-allocating nearly $19 million dollars of approved budgets to aggressively pursue the favorable market conditions created by increases in LED technology and reductions in price. In total, EVT achieved approximately 20% additional savings at a reduced cost/MWh than originally planned.[33] Although residential savings declined in 2018, lighting savings in represented 3/4th of total C&I sector savings. This is one example of how potential studies may

[32] Future residential load by end-use is expected to change based on the expected adoption levels of CCHPs, particularly in the EVT service area.

[33] Efficiency Vermont 2015-2017 Performance-to-Goals Variance Report to PUC in case number 18a-0834.

not accurately predict how programs will ultimately perform. These savings levels and cost-efficiencies are unlikely to continue throughout the 2021-2040 analysis timeframe.

TABLE 3-1 HISTORICAL ANNUAL ENERGY SAVINGS AND RESOURCE ACQUISITION COSTS BY SECTOR, BY EEU

Energy Savings	2015	2016	2017	2018
EVT (Net MWh)				
Residential	55,424	64,828	88,426	54,211
Nonresidential	49,573	62,603	69,516	88,931
Total Portfolio	104,997	127,431	157,942	143,142
BED (MWh)				
Residential	2,334	2,027	2,377	2,396
Nonresidential	3,601	4,074	4,645	2,985
Total Portfolio	5,937	6.102	7,024	5,381
VGS (MCF)				
Residential	24,756	21,001	23,576	29,652
Nonresidential	57,722	42,668	47,436	29,819
Total Portfolio	82,478	63,669	71,012	59,471
EEU $	**2015**	**2016**	**2017**	**2018**
EVT				
Residential	$20,628,830	$19,551,011	$22,237,818	$19,050,865
Nonresidential	$22,097,811	$22,589,622	$22,598,726	$24,512,890
Total Portfolio	$40,501,887	$42,140,633	$44,836,544	$43,563,755
BED				
Residential	$856,133	$797,054	$794,736	$809,121
Nonresidential	1,335,792	1,466,003	$1,603,514	$1,693,648
Total Portfolio	$2,191,925	$2,263,056	$2,398,250	$2,502,769
VGS				
Residential	$1,676,939	$2,085,220	$2,020,454	$2,062,568
Nonresidential	$599,348	$628,542	$592,565	$611,203
Total Portfolio	$2,236,287	$2,713,761	$2,613,019	$2,673,770

4 EVT Market Potential Assessment

This section provides the potential results for technical, economic, MA and PA in the EVT service territory. Results are broken down by sector as well as end use. The cost-effectiveness results for MA and PA are also provided, as are annual budgets for each of these scenarios.

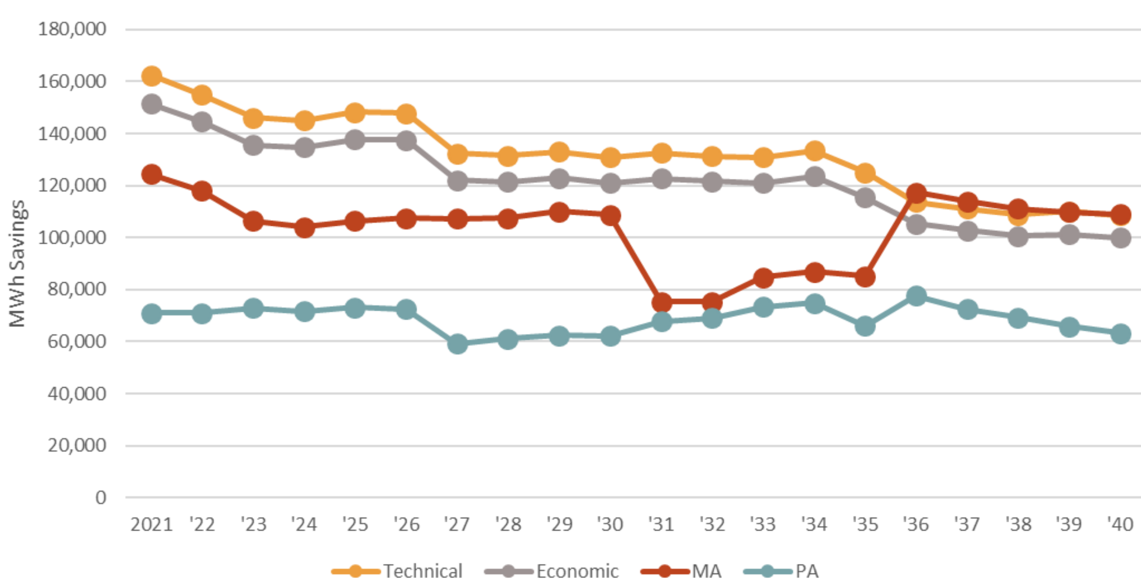
4.1 ENERGY SAVINGS POTENTIAL SUMMARY

In total, GDS analyzed 365 measure types for EVT. Many measures required multiple permutations for different applications, such as different building types, efficiency levels, and replacement options. GDS developed a total of 6,862 measure permutations for the EVT analysis and tested all measures for cost-effectiveness under the Vermont Societal Cost Test (VT SCT). A total of 82% of residential measures and 67% of nonresidential measures had a VT SCT benefit-cost ratio of 1.0 or higher.

Figure 4-1 illustrates the technical potential, economic potential, MA and PA incremental annual MWh energy efficiency savings estimates in the EVT territory for all sectors combined. The overall decrease in Technical and Economic potential over the analysis timeframe is driven by the nonresidential sector, where the analysis assumes (based on a review of historical savings) that EVT's programs successfully encourage customers to retrofit equipment prior to their natural replacement cycle.[34] As a result of the increased opportunities in the early years of the analysis, there are fewer opportunities in the later years. This result is even more evident in the Maximum Achievable potential, where additional market barriers create a more substantial decrease in opportunities until measures installed at the beginning of the study frame are once again eligible to be reinstalled.

The Program Achievable potential savings for all sectors combined is more consistent with installation opportunities more evenly distributed over the analysis timeframe. The PA savings in 2021 are 71,000 MWh/yr and range from 59,000 MWh/yr to nearly 78,000 MWh/yr.

FIGURE 4-1 SUMMARY OF POTENTIAL (INCREMENTAL ANNUAL MWH)



[34] In 2018, EVT achieved more than 66,000 MWh of nonresidential lighting savings, or more than 8% of all estimated C&I lighting load. Sustained savings at this level would eliminate all C&I lighting load in just over 12 years. It is not reasonable to expect efficient lighting measures to eliminate all lighting load, thus all reasonable lighting potential would be exhausted considerably sooner assuming the same level of annual savings. Given that the typical efficient lighting fixture has an assumed effective useful life of 15 years, it seems plausible and accurate to assume EVT has established a successful retrofit market for C&I lighting.

Figure 4-2 provides the technical, economic, MA and PA results for the 3-yr, 10-yr, and 20-yr timeframes. The 3-yr technical potential is 9.3% of forecasted sales, and the economic potential is 8.7% of forecasted sales, indicating that most technical potential is cost-effective. The 3-yr MA is 7.1% and the PA is 4.4%.

FIGURE 4-2 EVT ELECTRIC ENERGY (MWH) CUMULATIVE ANNUAL POTENTIAL (AS A % OF TOTAL SALES)

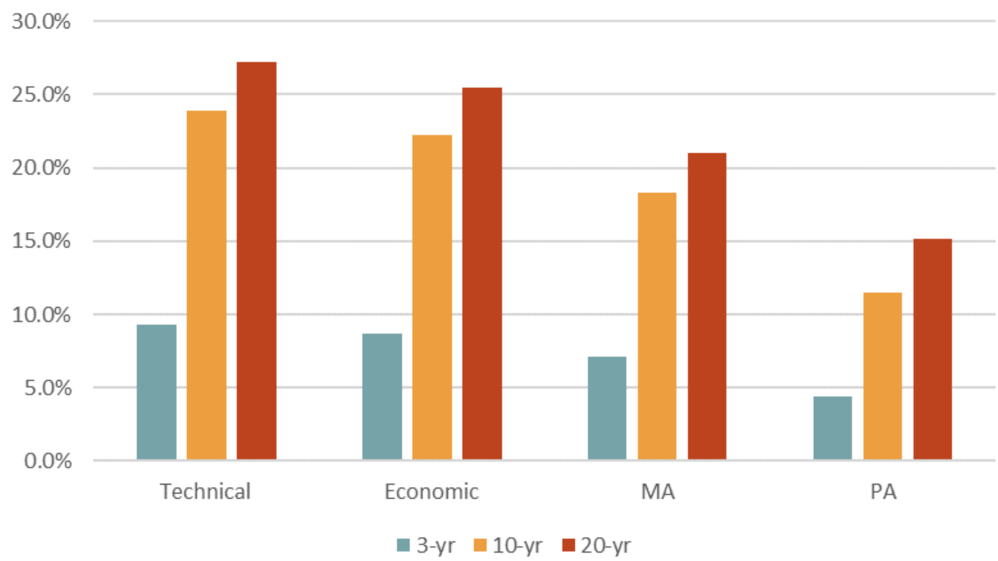


Table 4-1 provides 1-, 2-, 3-, 10-, and 20-yr cumulative annual technical, economic, MA and PA results for energy, summer peak demand, and winter peak demand. The technical potential rises to more than 1.6 million MWh by 2040, and the PA is more than half of that total, rising to nearly 900,000 MWh by 2040. Summer peak demand savings estimates exceed 100 MW and winter peak demand savings exceed 150 MW in the PA scenario.

TABLE 4-1 EVT ENERGY EFFICIENCY POTENTIAL SUMMARY

	2021	2022	2023	2030	2040
Annual Energy (MWh)					
Technical	162,532	312,203	439,246	1,281,441	1,611,891
Economic	151,467	290,698	407,902	1,192,233	1,509,474
MA	124,503	237,891	334,583	983,406	1,244,001
PA	71,098	139,648	208,073	617,161	897,637
Summer Peak Demand (MW)					
Technical	22.8	44.0	60.9	170.2	194.9
Economic	21.1	40.7	56.2	155.1	176.5
MA	16.5	31.5	44.1	124.5	142.9
PA	9.8	19.1	28.1	79.0	108.4
Winter Peak Demand (MW)					
Technical	25.9	50.9	70.7	210.0	274.2
Economic	24.2	47.5	65.8	195.4	257.4
MA	20.0	39.3	54.5	162.6	214.0
PA	11.4	22.9	33.7	101.8	150.3

4.2 RESIDENTIAL SECTOR MARKET POTENTIAL

This section of the report provides a summary of the residential energy efficiency potential in the EVT service territory. Results are provided on an annual basis for technical and economic potential, as well as MA and PA. End-use and housing type breakdowns are provided for the PA scenario. Figure 4-1 shows in the residential sector incremental annual MWh savings for each type of potential analyzed. The decrease is savings in 2023 for Technical, Economic, and Maximum Achievable potential is associated with

elimination of screw-based lighting potential, and the annual increase in potential over time is largely associated with the increased adoption of CCHPs and new construction. The Program Achievable potential maintains a slightly more consistent level of savings across the analysis timeframe but is constrained slightly by the sector equity targets on EEU spending.[35]

FIGURE 4-3 SUMMARY OF RESIDENTIAL POTENTIAL (INCREMENTAL ANNUAL MWH)- EVT

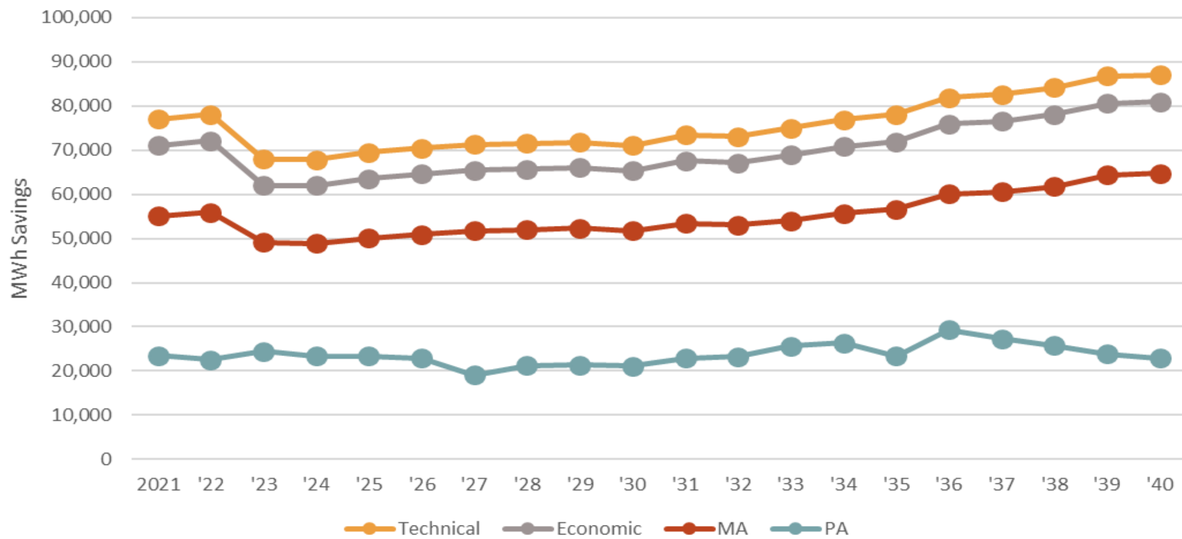
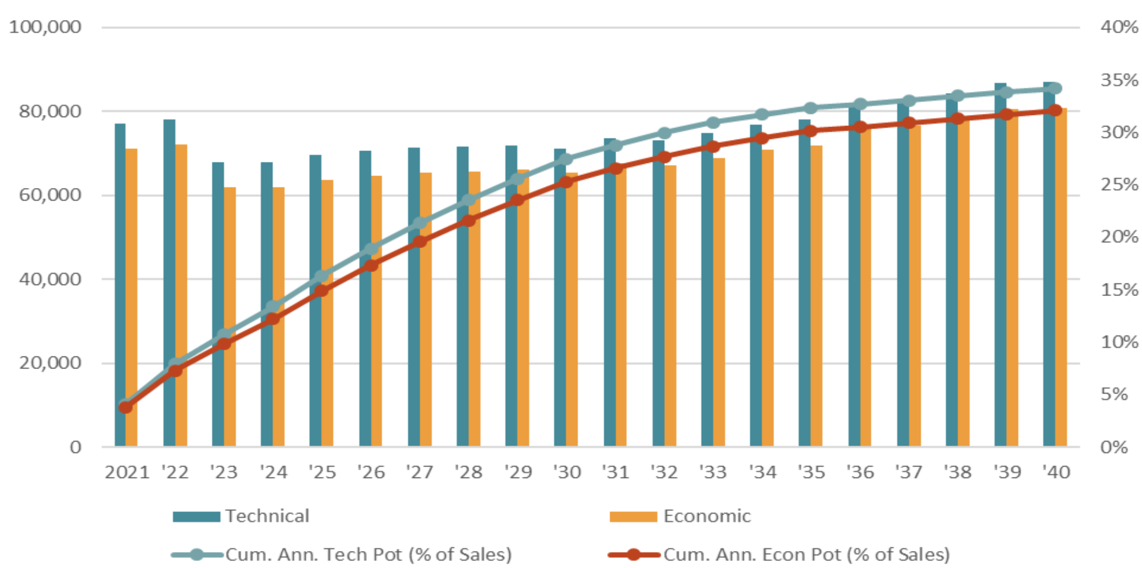


Figure 4-4 provides the 20-yr Technical and Economic Potential. The green and orange bars provide the respective incremental annual Technical and Economic Potential in MWh per year energy savings. The green and red lines provide the corresponding cumulative annual Technical and Economic Potential as a percent of forecasted annual sales. Most residential measures are cost-effective, which leads to an Economic Potential estimate of 32% that is nearly as great as the Technical Potential estimate of 34%.

FIGURE 4-4 RESIDENTIAL EVT TECHNICAL & ECONOMIC INCREMENTAL ANNUAL MWH POTENTIAL (BARS) &CUMULATIVE ANNUAL POTENTIAL AS A % OF RESIDENTIAL SALES (LINES)



[35] The analysis determined that the nonresidential sector is the limiting factor in addressing the equity considerations, in that there is not enough potential in that sector to maintain equity relative to the remaining potential in the residential sector. Instead, the residential sector potential was scaled down to address the equity constraints.

Figure 4-5 provides the MA and PA across the 20-yr timeframe of the study. The green and orange bars provide the respective incremental annual MA and PA in MWh per year energy savings. The green and red lines provide the corresponding cumulative annual MA and PA as a percent of forecasted annual sales. The MA rises to 25% by 2040 and the PA rises to 12%.

FIGURE 4-5 RESIDENTIAL EVT MA & PA INCREMENTAL ANNUAL MWH POTENTIAL (BARS) & CUMULATIVE ANNUAL POTENTIAL AS A % OF RESIDENTIAL SALES (LINES)

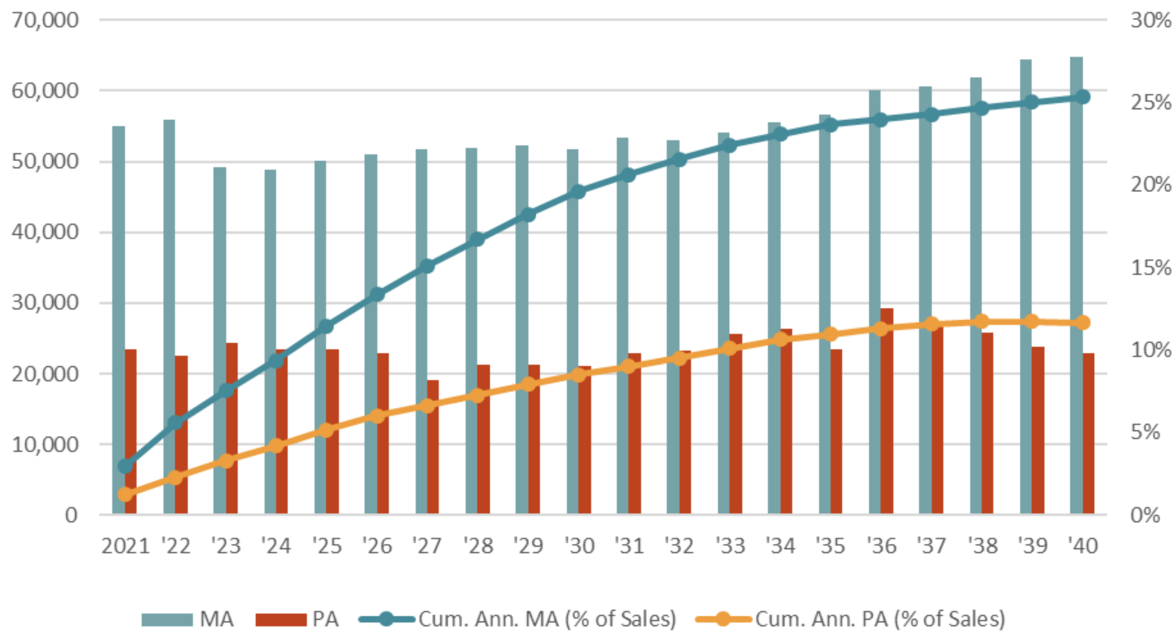


Figure 4-6 provides a breakdown of the incremental annual PA by end use. HVAC Equipment is the leading end use, with Water Heating and Appliances also accounting for large amounts of potential.

FIGURE 4-6 RESIDENTIAL PROGRAM ACHIEVABLE POTENTIAL BY END USE: INCREMENTAL ANNUAL

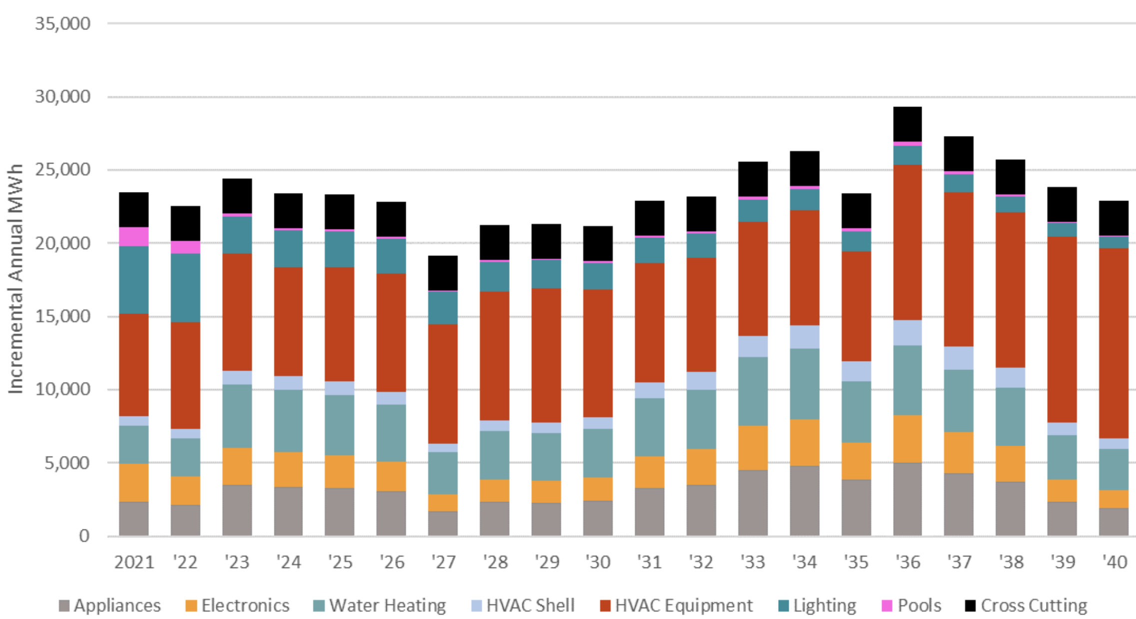
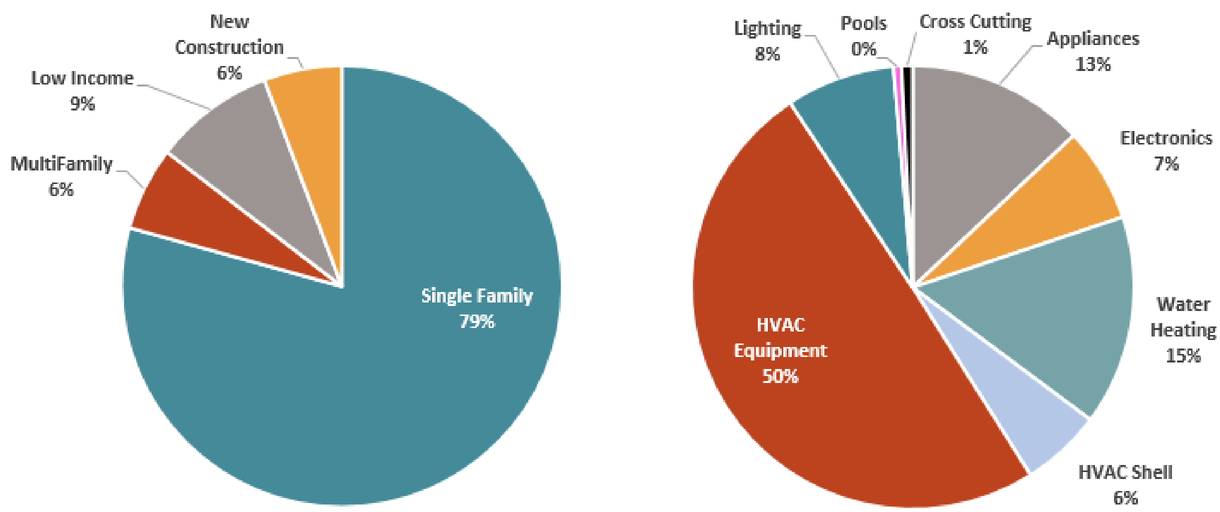


Figure 4-7 provides two illustrative views of the 20-yr cumulative annual PA. The pie chart on the left shows the breakdown of potential across housing types, income types and construction vintages. The existing single-family market segment accounts for 79% of the potential. The pie chart to the right shows this potential breakdown by end-use. Similar to the incremental annual PA breakdown shown in Figure 4-6, the cumulative annual energy savings largely come from the HVAC Equipment (primarily from increased heat pump adoption, and to a much lesser extent, smart thermostats), Water Heating, and Appliances end uses.

FIGURE 4-7 20-YEAR EVT PA SAVINGS BY MARKET SEGMENT AND END USE: RESIDENTIAL SECTOR (VALUES IN MWH)



4.3 NONRESIDENTIAL SECTOR MARKET POTENTIAL

This section of the report provides a summary of the nonresidential energy efficiency potential in the EVT service territory. Results are provided on an annual basis for technical and economic potential, as well as MA and PA. End-use and market segment breakdowns are provided for the PA scenario. Figure 4-8 shows in the nonresidential sector incremental annual MWh savings for each type of potential analyzed. Maximum Achievable potential is higher than Program Achievable potential for each year through 2030 as it was assumed that retrofit potential would be exhausted in the first ten years of the Maximum Achievable potential scenario. The increase in Maximum Achievable potential in 2036 is due to a significant increase in measure reinstallations. The Program Achievable potential maintains a slightly more consistent level of savings across the analysis timeframe but shows a slight drop off in potential in 2027 before savings slowly increase up until 2035.

FIGURE 4-8 SUMMARY OF NONRESIDENTIAL POTENTIAL (INCREMENTAL ANNUAL MWH)- EVT

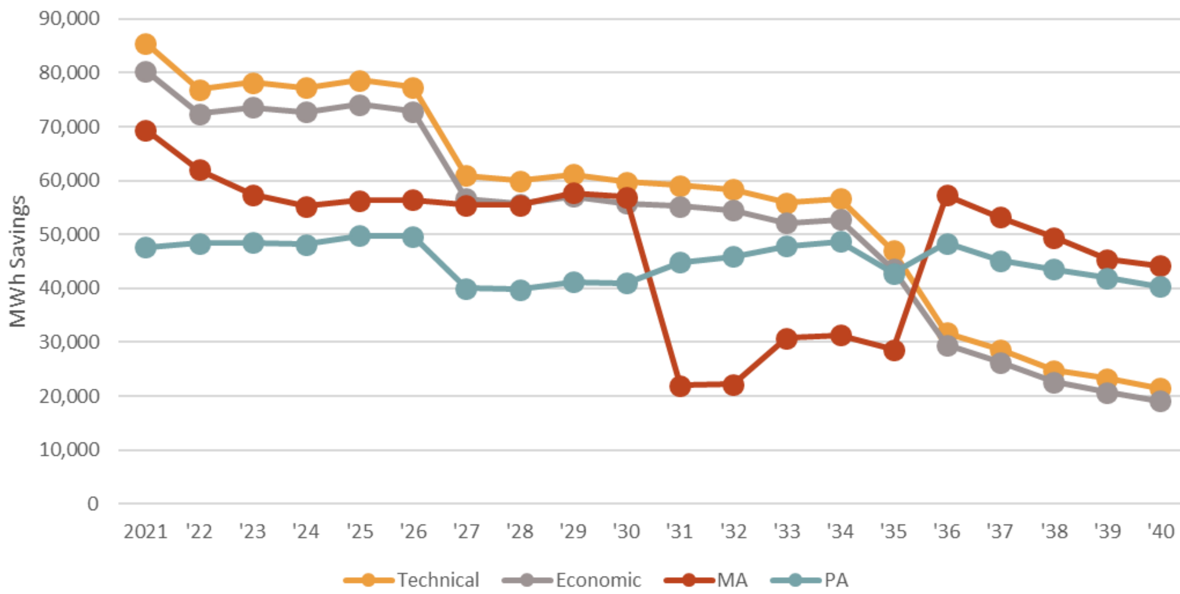


Figure 4-9 provides the 20-yr Technical and Economic Potential. The green and orange bars provide the respective incremental annual Technical and Economic Potential in MWh per year energy savings. The green and red lines provide the corresponding cumulative annual Technical and Economic Potential as a percent of forecasted annual sales. Most nonresidential measures are cost-effective, which leads to an Economic Potential estimate of 21% that is nearly as great as the Technical Potential estimate of 22%.

FIGURE 4-9 NONRESIDENTIAL EVT TECHNICAL & ECONOMIC INCREMENTAL ANNUAL MWH POTENTIAL (BARS) & CUMULATIVE ANNUAL POTENTIAL AS A % OF NONRESIDENTIAL SALES (LINES)

Figure 4-10 provides the MA and PA across the 20-yr timeframe of the study. The green and orange bars provide the respective incremental annual MA and PA in MWh per year energy savings. The green and red lines provide the corresponding cumulative annual MA and PA as a percent of forecasted annual sales. The MA rises to 18% by 2040 and the PA rises to 18%. As noted earlier in this section, the Maximum Achievable potential is higher than Program Achievable potential for each year through 2030 as it was assumed that retrofit potential would be exhausted in the first ten years of the Maximum Achievable potential scenario, with an increase in 2036 is due to a significant increase in measure reinstallations. Conversely, the Program Achievable achieves the remaining potential at a slightly steadier rate. The cumulative annual line charts show that both levels of potential achieve a similar level of total savings over the long-term.

FIGURE 4-10 NONRESIDENTIAL EVT MA & PA INCREMENTAL ANNUAL MWH POTENTIAL (BARS) AND CUMULATIVE ANNUAL POTENTIAL AS A % OF NONRESIDENTIAL SALES (LINES)

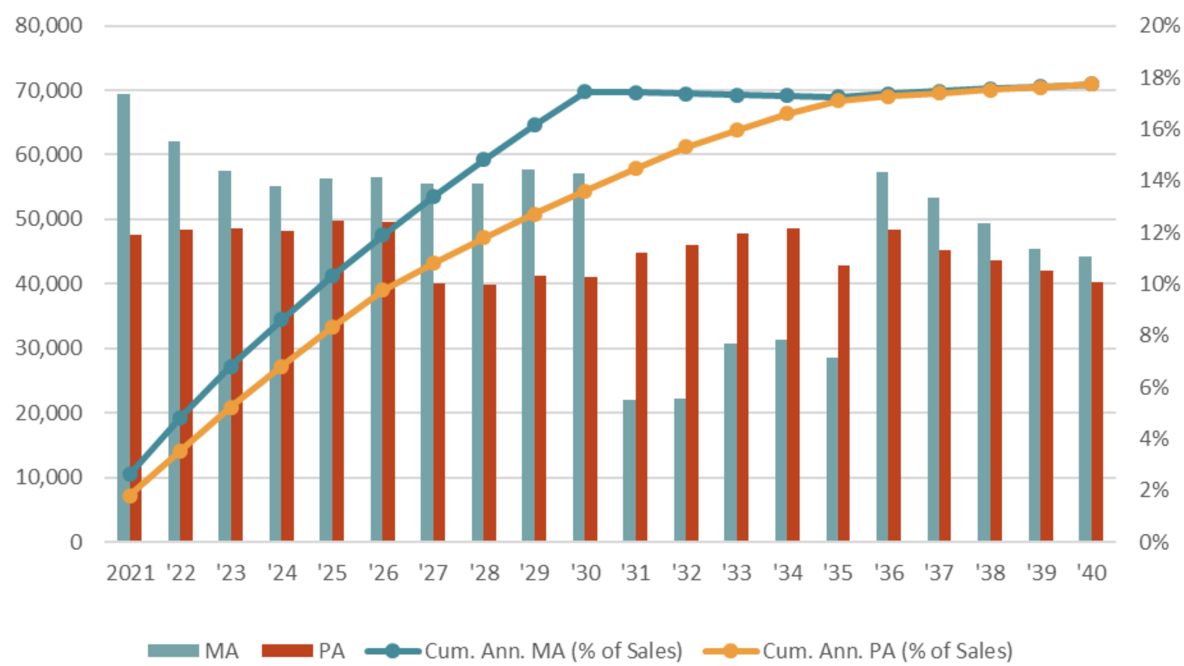


Figure 4-11 provides a breakdown of the incremental annual PA by end use. Lighting and refrigeration are the leading end uses.

FIGURE 4-11 NONRESIDENTIAL PROGRAM ACHIEVABLE POTENTIAL BY END USE: INCREMENTAL ANNUAL

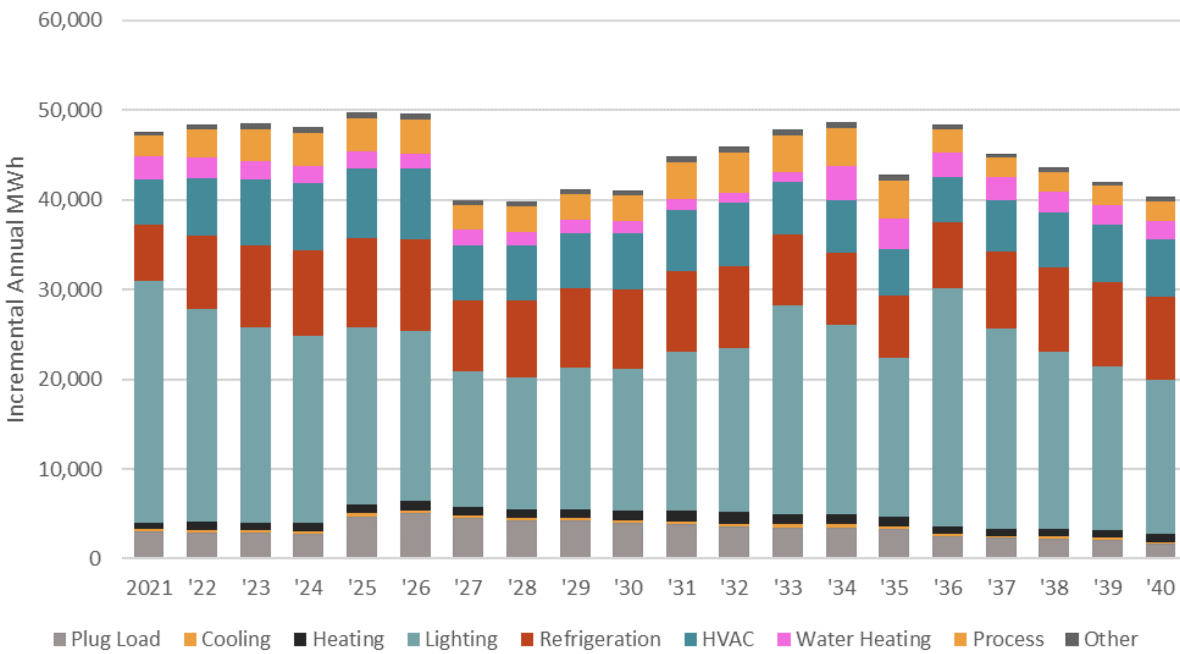
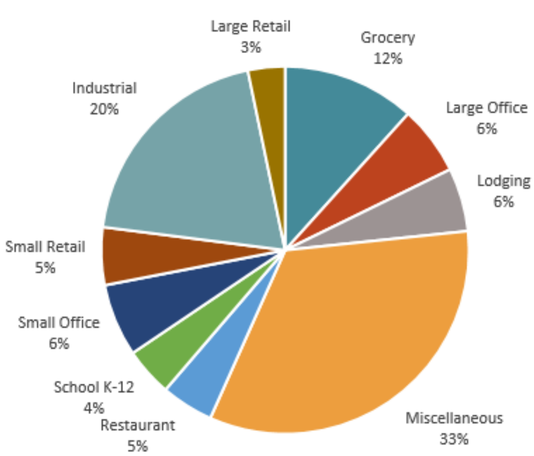
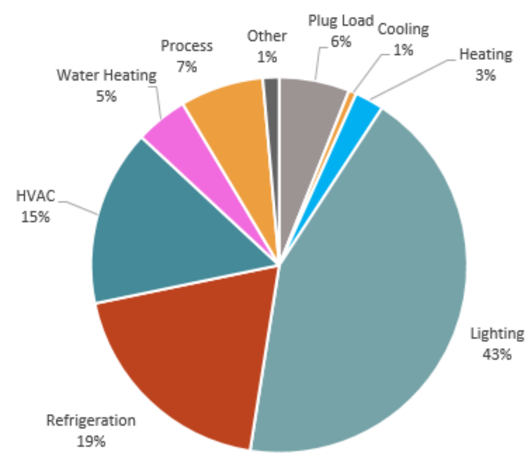


Figure 4-12 provides two illustrative views of the 20-yr cumulative annual PA. The pie chart on the left shows the breakdown of potential across market segment. The industrial sector accounts for 20% of the total nonresidential potential. The pie chart to the right shows this potential breakdown by end-use. The cumulative annual energy savings largely come from the Lighting, Refrigeration and HVAC end uses.

FIGURE 4-12 20-YEAR EVT PA SAVINGS BY MARKET SEGMENT AND END USE: NONRESIDENTIAL SECTOR (VALUES IN MWH)





4.4 EVT BUDGETS AND COST-EFFECTIVENESS

Figure 4-13 illustrates the MA and PA budgets by sector. The MA budgets range from $98 million to $146 million. The PA budgets range from $31 million to $45 million.

FIGURE 4-13 EVT MA & PA ESTIMATED RESOURCE ACQUISITION BUDGETS BY SECTOR

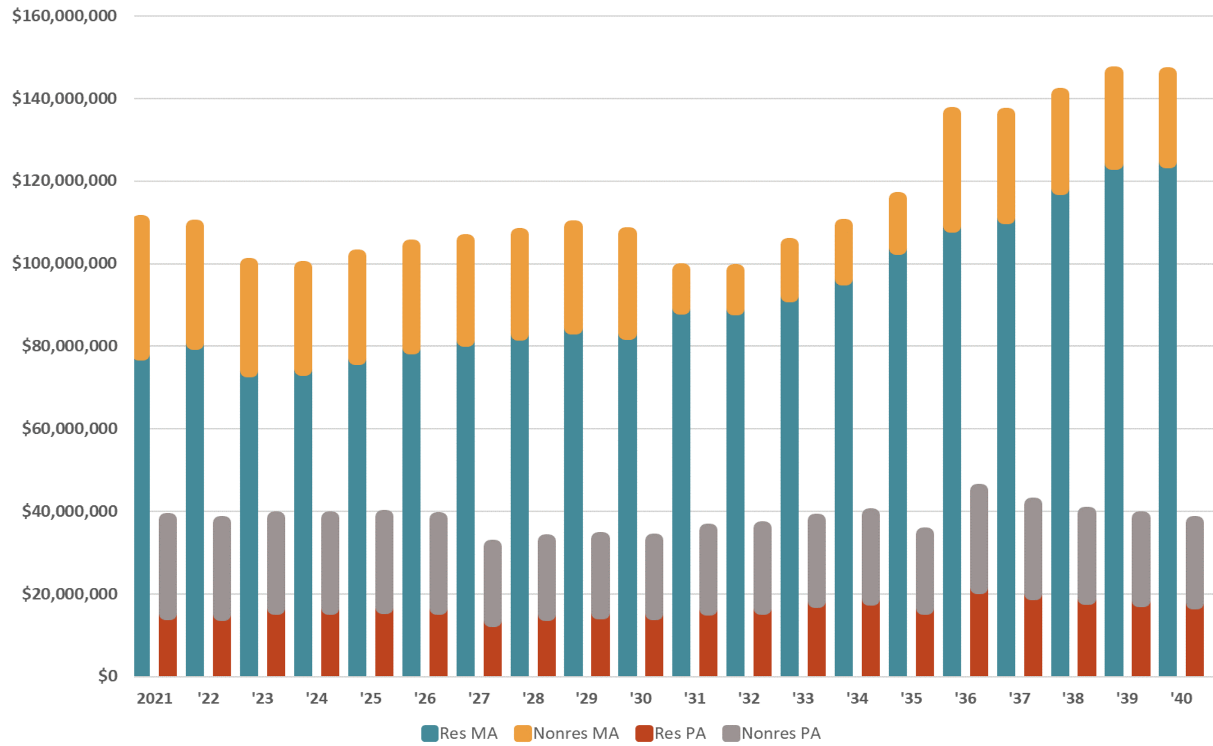


Figure 4-14 provides an incentive and admin budget breakdown for the PA scenario by sector. To align with the sector equity targets, residential budgets (including low-income) represent 40% of the budget in 2021 and increase to 48% of the total budget by 2033. Incentive budgets range from 55% to 63% of the total annual budgets.

FIGURE 4-14 EVT PROGRAM ACHIEVABLE POTENTIAL INCENTIVE AND NON-INCENTIVE COSTS BY SECTOR

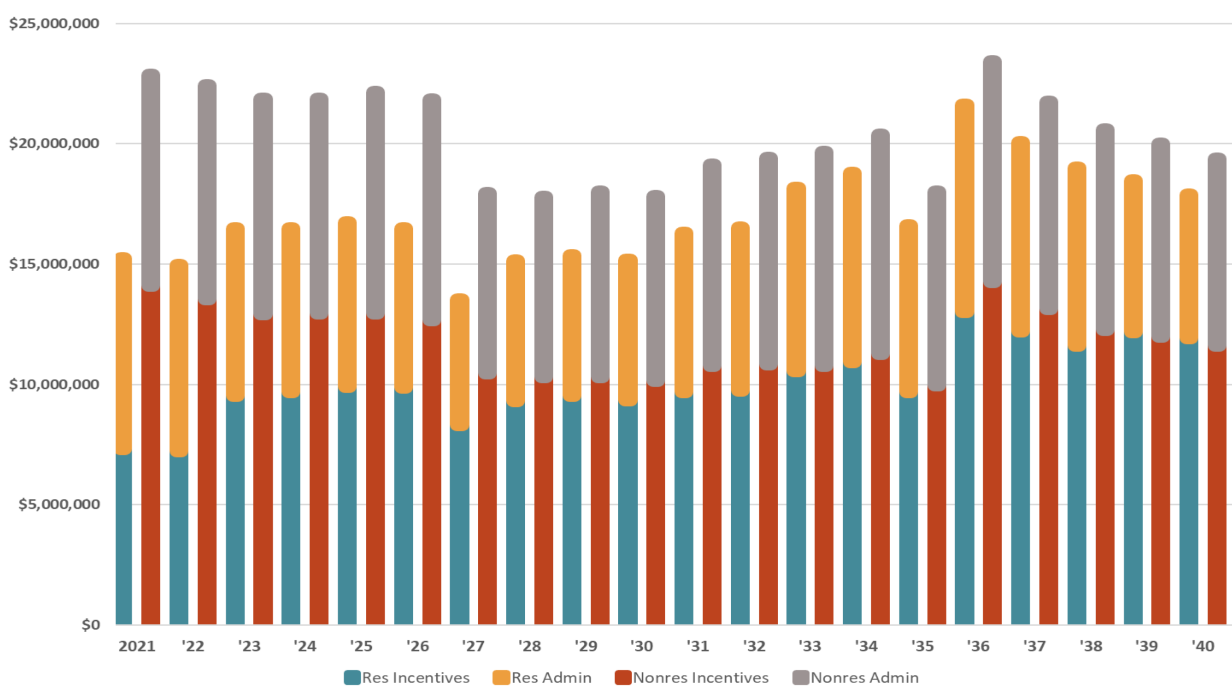


Table 4-2 and Table 4-3 show the NPV benefits and costs according to the Vermont SCT. Table 1-3 shows the MA and PA results for the residential sector. The MA scenario is estimated to provide more than $2 billion in benefits with an SCT Ratio of 1.8. The PA scenario is estimated to provide more than $800 million in benefits with an SCT Ratio of 2.1.

TABLE 4-2 EVT NPV BENEFITS & COSTS BY END USE: RESIDENTIAL MA & PA ($, IN MILLIONS)

		MA			PA	
End-Use	Benefits	Costs	SCT Ratio	Benefits	Costs	SCT Ratio
Appliances	$471.5	$418.7	1.1	$115.4	$66.8	1.7
Electronics	$186.3	$62.1	3.0	$54.2	$14.4	3.8
Water Heating	$311.1	$191.9	1.6	$119.0	$80.3	1.5
HVAC Shell	$608.3	$317.1	1.9	$149.1	$69.7	2.1
HVAC Equipment	$339.9	$167.1	2.0	$296.1	$135.6	2.2
Lighting	$172.6	$42.3	4.1	$74.4	$18.6	4.0
Pools	$27.6	$5.0	5.5	$12.3	$2.3	5.4
Cross Cutting	$9.8	$7.6	1.3	$5.1	$4.0	1.3
Total	$2,127.1	$1,211.8	1.8	$825.7	$391.6	2.1

Table 4-3 shows the MA and PA results for the nonresidential sector. The MA scenario is estimated to provide more than $3 billion in benefits with an SCT Ratio of 5.5. The PA scenario is estimated to provide more than $3 billion in benefits with an SCT Ratio of 5.5.

TABLE 4-3 EVT NPV BENEFITS & COSTS BY END USE: NONRESIDENTIAL MA & PA ($, IN MILLIONS)

		MA			PA	
End-Use	Benefits	Costs	SCT Ratio	Benefits	Costs	SCT Ratio
Plug Load	$94.0	$25.7	3.7	$93.1	$25.4	3.7
Cooling	$32.0	$38.5	0.8	$31.0	$34.8	0.9
Heating	$75.5	$31.2	2.4	$73.6	$30.2	2.4
Lighting	$1,367.7	$290.0	4.7	$1,301.3	$275.9	4.7
Refrigeration	$559.0	$75.5	7.4	$528.4	$70.5	7.5
HVAC	$505.2	$61.9	8.2	$482.5	$57.7	8.4
Water Heating	$97.4	$31.8	3.1	$95.4	$31.0	3.1
Process	$253.9	$18.6	13.6	$237.5	$16.9	14.1
Other	$169.4	$4.6	36.8	$157.1	$4.3	36.6
Total	$3,154	$578	5.5	$3,000	$547	5.5

Table 4-4 compares the combined sector NPV Benefits and Costs under the currently approved avoided costs with the proposed avoided costs noted in Section 2.4.2.2. As noted, this sensitivity only provides a high-level update to the NPV benefits and costs and does not make any further adjustment to remove measures that would no longer be considered cost-effective from the sector/portfolio measure mix.

TABLE 4-4 COMPARISON OF EVT NPV BENEFITS & COSTS UNDER APPROVED VS. PROPOSED AVOIDED COSTS ($, IN MILLIONS)

		MA			PA	
Avoided Costs	Benefits	Costs	SCT Ratio	Benefits	Costs	SCT Ratio
Approved	$5,281	$1,790	3.0	$3,826	$938	4.1
Proposed	$3,261	$1,862	1.7	$2,226	$979	2.3

4.5 EVT RATE & BILL IMPACT ANALYSIS RESULTS

Table 4-5 shows the combined rate and bill impacts across customer classes and averaged over the study period.[36] Results are shown for both the maximum achievable and program achievable savings scenarios.

[36] Rate and bill impacts beyond 2040 are not included as those savings are not realized in any year within the study period. Savings after 2040, however, are included in the cost-benefit analysis.

TABLE 4-5 AVERAGE RATE AND BILL DIFFERENCES RELATIVE TO BASELINE WITHOUT FUTURE EFFICIENCY

Customer Class	PA Potential Scenario		MA Potential Scenario	
	Rates (2021-2040)	Average Bill Impacts	Rates (2021-2040)	Average Bill Impacts
Residential	2.7%	-4.3%	28.5%	6.1%
C&I (No Demand Charge)	1.5%	-9.9%	1.5%	-11.2%
C&I (Demand Charge Customers)	3.5%	-9.6%	3.6%	-11.0%
All Customers	3.0%	-7.3%	14.2%	-3.7%

Overall, rates for EVT customers are slightly higher over the study period, with an average increase of 3.4% for the program achievable potential scenario and 14.6% for the maximum achievable scenario. This is primarily due to higher energy efficiency charges in the first five years of the study period. Rate impacts for the PA scenario by year are shown for each customer classes are shown in Figure 4-15, Figure 4-16, and Figure 4-17. Additional detail, including annual rate impacts for the MA scenario are included in Appendix E.

FIGURE 4-15 PA CHANGE IN AVERAGE RESIDENTIAL CUSTOMER AVERAGE REVENUE REQUIREMENT- EVT

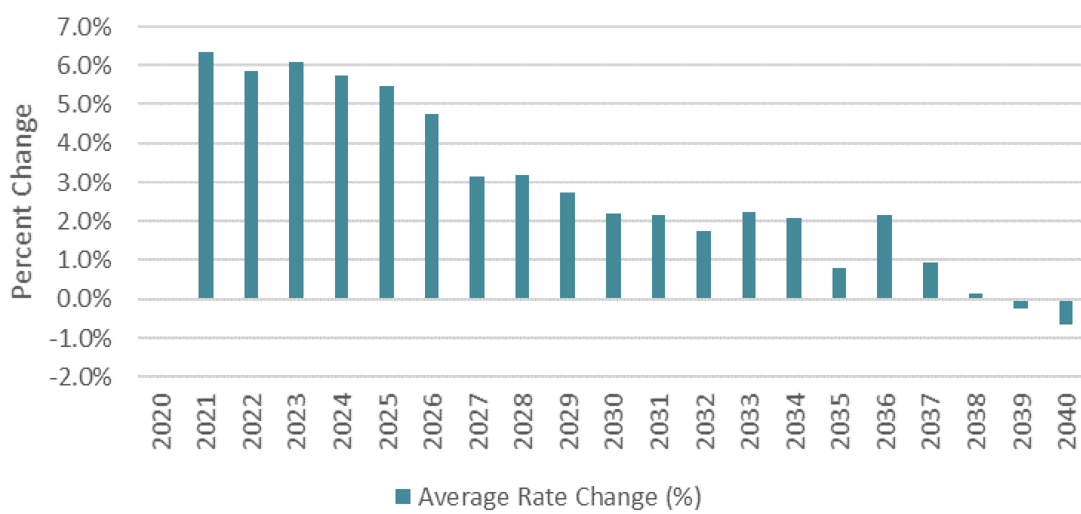


FIGURE 4-16 PA CHANGE IN AVERAGE NONDEMAND C&I CUSTOMER AVERAGE REVENUE REQUIREMENT- EVT

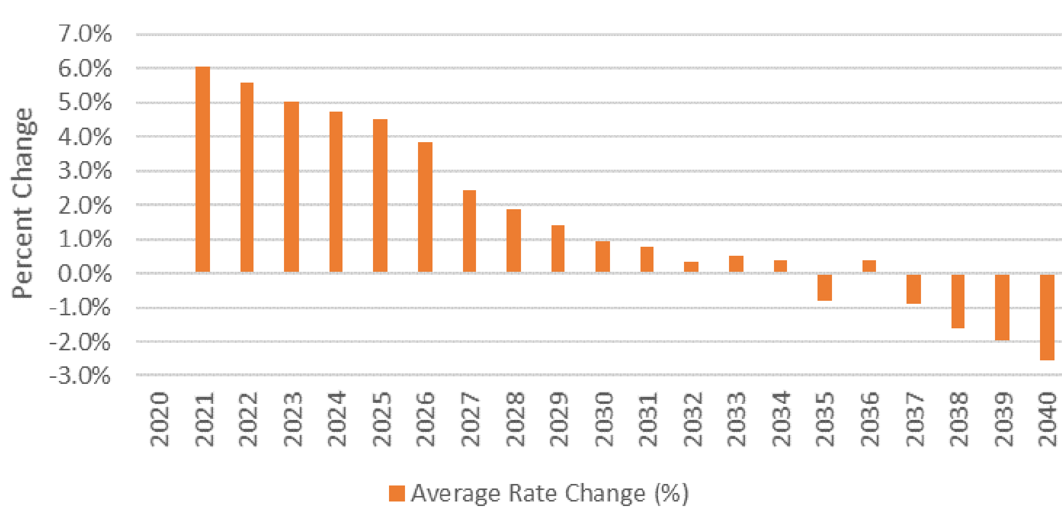
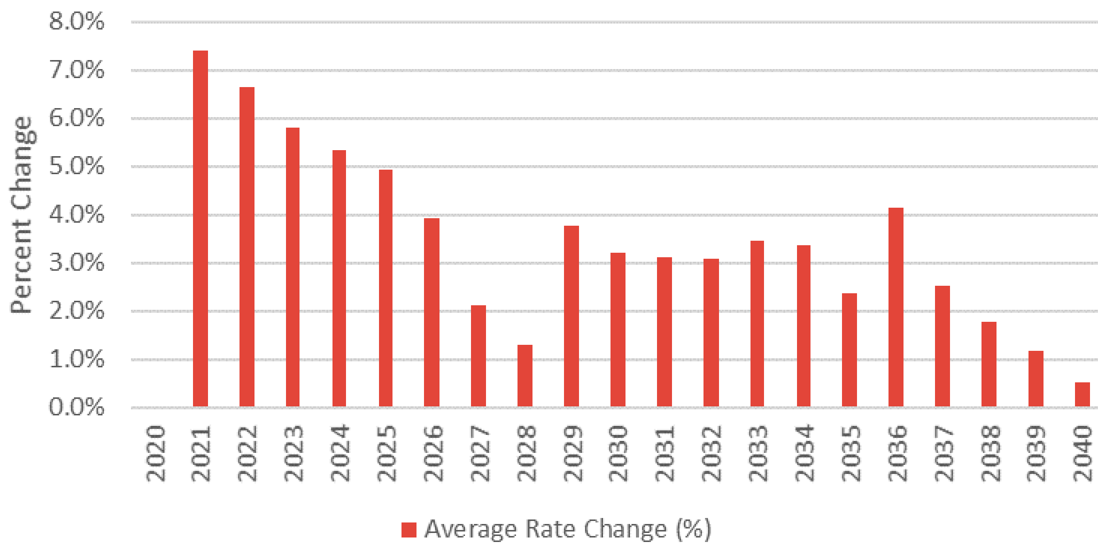


FIGURE 4-17 PA CHANGE IN AVERAGE C&I DEMAND CUSTOMER AVERAGE REVENUE REQUIREMENT- EVT



Average annual bill impacts are shown in Table 4-6 by customer class for the program achievable scenario over a three, ten, and twenty-year period. Over the 20-year analysis timeframe and across all customers (both participants and non-participants), the average annual bill is expected to decrease, with savings expected to offset any additional rate increases that result from sustained efficiency program offerings.

TABLE 4-6 AVERAGE EVT BILL IMPACTS FOR THE PROGRAM ACHIEAVABLE SCENARIO

Customer Class	PA Potential Scenario		
	Average Bill Impact (3 YR)	Average Bill Impact (10 YR)	Average Bill Impact (20 YR)
Residential	$32.79	-$11.44	-$60.13
C&I (No Demand Charge)	$22.82	-$81.58	-$178.23
C&I (Demand Charge Customers)	$516.14	-$851.32	-$1,888.48

Table 4-7 shows the average bill impacts for participants and nonparticipants by customer class. For the program achievable scenario, Cadmus assumed participant savings would be 10% of baseline consumption. Average nonparticipant bills increase slightly with the increase in rates. Participant bills decrease due to energy and demand savings, which offset the increase in rates. For C&I customers with demand charges, as stated in the rate impact methodology (Section 2.4.5) demand charges were converted to a per kWh basis, which assumes demand savings are proportional to energy savings for this analysis.

TABLE 4-7 AVERAGE EVT PARTICIPANT AND NONPARTICIPANT BILL IMPACTS FOR THE PROGRAM ACHIEVABLE SCENARIO

Customer Class	Average Rate Change (%)	Nonparticipants		Participants	
		Average New Bill	Average Bill Impact	Average New Bill	Average Bill Impact
Residential	3.6%	$1,286	$43	$1,157	-$85
C&I (No Demand Charge)	3.1%	$1,736	$51	$1,563	-$122
C&I (Demand Charge Customers)	3.5%	$20,007	$668	$18,006	-$1,333

5 BED Market Potential Assessment

This section provides the potential results for technical, economic, MA and PA in the BED service territory. Results are broken down by sector as well as end use. The cost-effectiveness results for MA and PA are also provided, as are annual budgets for each of these scenarios.

5.1 ENERGY SAVINGS POTENTIAL SUMMARY

In total, GDS analyzed 310 measure types for BED. Many measures required multiple permutations for different applications, such as different building types, efficiency levels, and replacement options. GDS developed a total of 5,795 measure permutations for the BED analysis and tested all measures for cost-effectiveness under the Vermont Societal Cost Test (VT SCT). A total of 76% of residential measures and 62% of nonresidential measures had a VT SCT benefit-cost ratio of 1.0 or higher.

Figure 5-1 illustrates the technical potential, economic potential, MA and PA incremental annual MWh energy efficiency savings estimates in the BED territory for all sectors combined. The overall decrease in Technical and Economic potential over the analysis timeframe is driven by assumptions regarding reduced lighting potential over the first decade. An increase in potential in 2036 is associated with renewed savings opportunities from measures installed early in the analysis timeframe that have reached the end of their effective useful life.

The Program Achievable potential follows a similar pattern, with a gradual decline over the first fifteen years of the study timeframe, followed by an increase due to additional measure opportunities coming back on to the market in 2036. The PA savings in 2021 are roughly 4,500 MWh/yr and range from 3,561 MWh/yr to 5,327 MWh/yr. over the 20-year timeframe.

FIGURE 5-1 SUMMARY OF POTENTIAL (INCREMENTAL ANNUAL MWH)

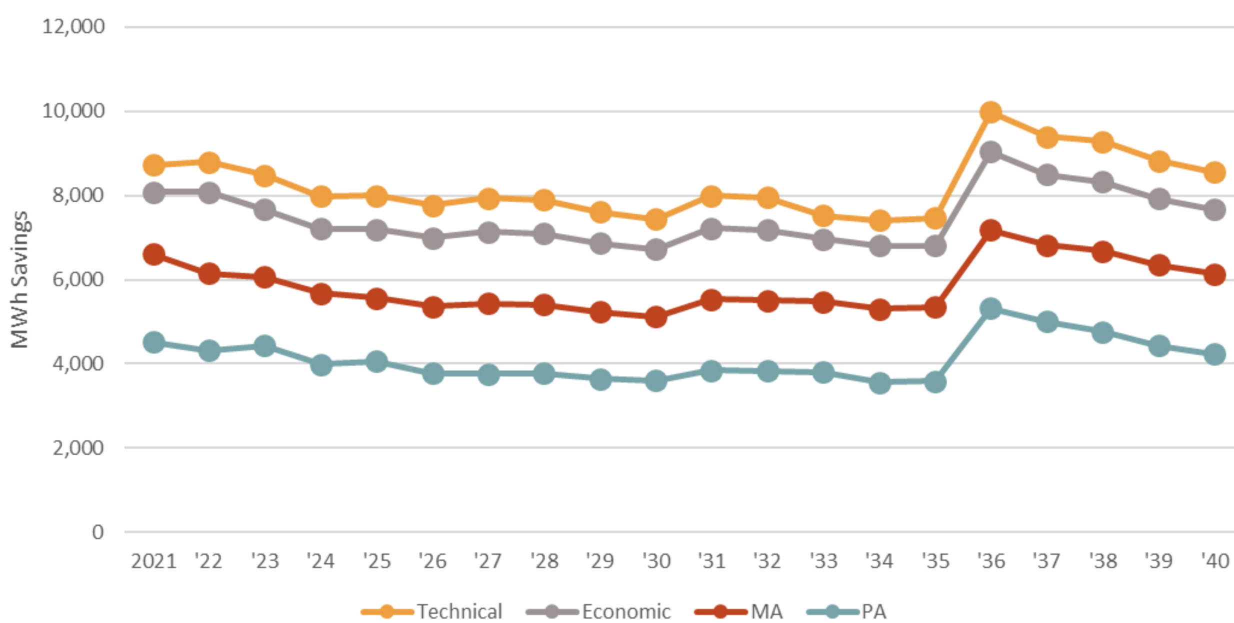


Figure 5-2 provides the technical, economic, MA and PA results for the 3-yr, 10-yr, and 20-yr timeframes. The 3-yr technical potential is 7.0% of forecasted sales, and the economic potential is 6.4% of forecasted sales, indicating that most technical potential is cost-effective. The 3-yr MA is 5.1% and the PA is 3.6%.

FIGURE 5-2 BED ELECTRIC ENERGY (MWH) CUMULATIVE ANNUAL POTENTIAL (AS A % OF TOTAL SALES)

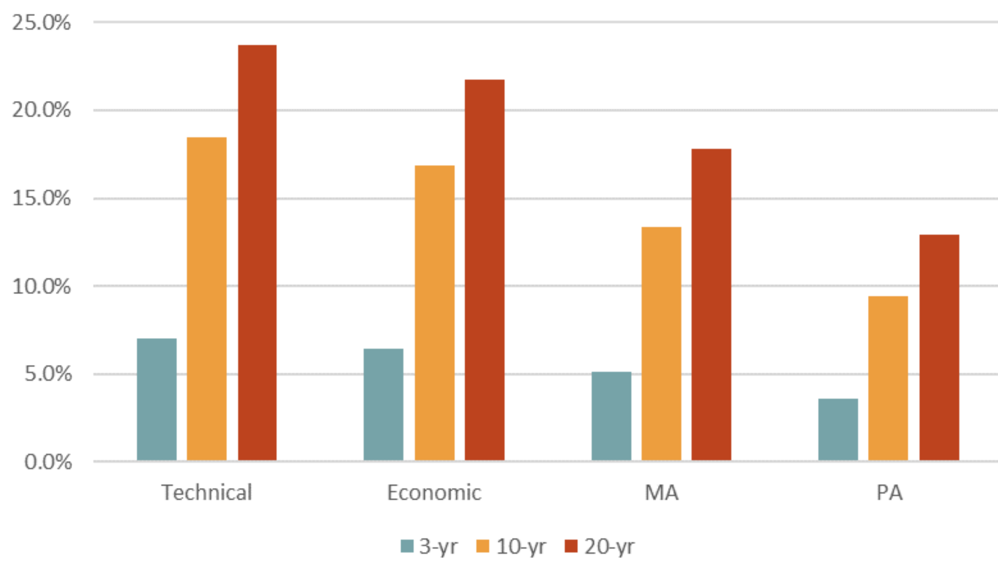


Table 5-1 provides 1-, 2-, 3-, 10-, and 20-yr cumulative annual technical, economic, MA and PA results for energy, summer peak demand, and winter peak demand. The technical potential rises to more than 98,000 MWh by 2040, and the PA is more than half of that total, rising to more than 53,000 MWh by 2040. Summer peak demand savings estimates exceed 6 MW and winter peak demand savings exceed 8 MW in the PA scenario.

TABLE 5-1 BED ENERGY EFFICIENCY POTENTIAL SUMMARY

	2021	2022	2023	2030	2040
Annual Energy (MWh)					
Technical	8,721	17,417	25,306	71,096	98,812
Economic	8,079	16,065	23,222	64,978	90,543
MA	6,613	12,659	18,431	51,540	74,319
PA	4,522	8,757	13,033	36,357	53,853
Summer Peak Demand (MW)					
Technical	1.3	2.5	3.6	9.5	12.6
Economic	1.2	2.3	3.3	8.7	11.5
MA	1.0	1.8	2.6	6.9	9.4
PA	0.6	1.2	1.7	4.5	6.6
Winter Peak Demand (MW)					
Technical	1.3	2.7	3.8	10.9	15.4
Economic	1.2	2.4	3.5	9.8	14.0
MA	1.0	1.9	2.8	7.9	11.6
PA	0.7	1.3	2.0	5.6	8.4

5.2 RESIDENTIAL SECTOR MARKET POTENTIAL

This section of the report provides a summary of the residential energy efficiency potential in the BED service territory. Results are provided on an annual basis for technical and economic potential, as well as MA and PA. End-use and housing type breakdowns are provided for the PA scenario. Figure 5-3 shows in the residential sector incremental annual MWh savings for each type of potential analyzed. The decrease is savings in 2023 for Technical, Economic, and Maximum Achievable potential is associated with elimination of screw-based lighting potential, after which potential stay relatively flat until 2036. Assumed new construction starts for BED were higher during the initial three years of the analysis, and the perceived increase in 2036 is largely attributable select new construction measures re-entering the market. The

Program Achievable potential maintains a slightly more consistent level of savings across the analysis timeframe but is constrained by the sector equity targets on EEU spending (as well as the assumption that historical incentive levels are maintained through the analysis timeframe). The increase in PA in 2036 is attributed to the associated increase in PA in the nonresidential sector and maintaining sector equity spending targets.[37]

FIGURE 5-3 SUMMARY OF RESIDENTIAL POTENTIAL (INCREMENTAL ANNUAL MWH) - BED

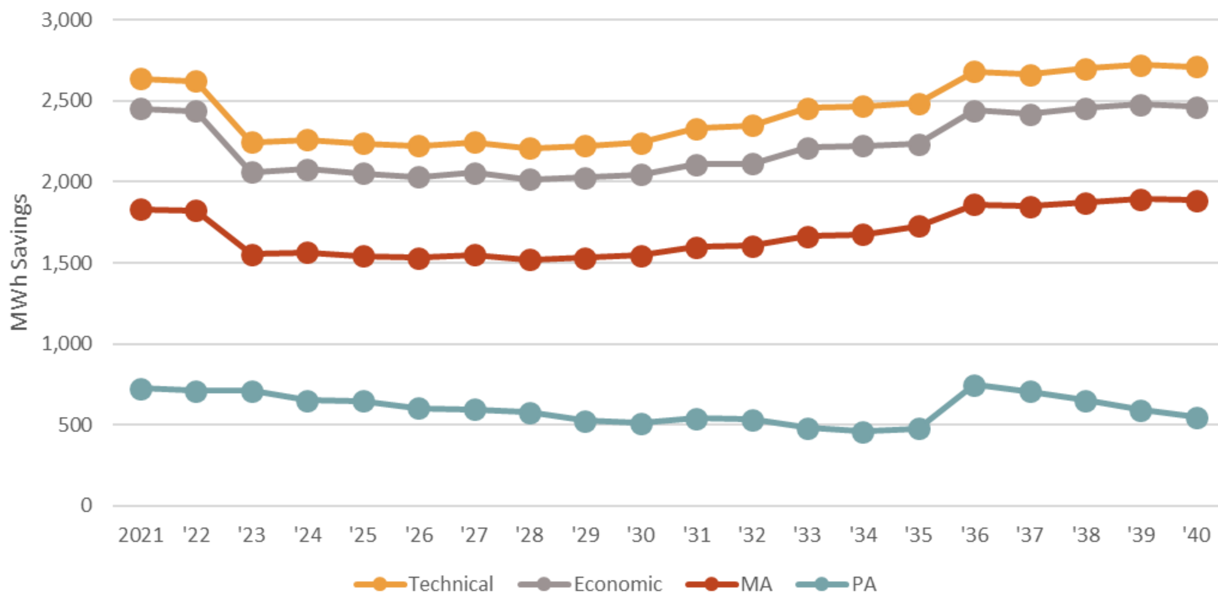


Figure 5-4 provides the 20-yr Technical and Economic Potential. The green and orange bars provide the respective incremental annual Technical and Economic Potential in MWh per year energy savings. The green and red lines provide the corresponding cumulative annual Technical and Economic Potential as a percent of forecasted annual sales. Most residential measures are cost-effective, which leads to an Economic Potential estimate of 22% that is nearly as great as the Technical Potential estimate of 23%.

[37] As was the case with EVT, the program achievable potential in the BED nonresidential sector is the limiting factor in addressing the equity considerations. Instead, the residential sector potential was scaled down to address the equity constraints.

FIGURE 5-4 RESIDENTIAL BED TECHNICAL & ECONOMIC INCREMENTAL ANNUAL MWH POTENTIAL (BARS) AND CUMULATIVE ANNUAL POTENTIAL AS A % OF RESIDENTIAL SALES (LINES)

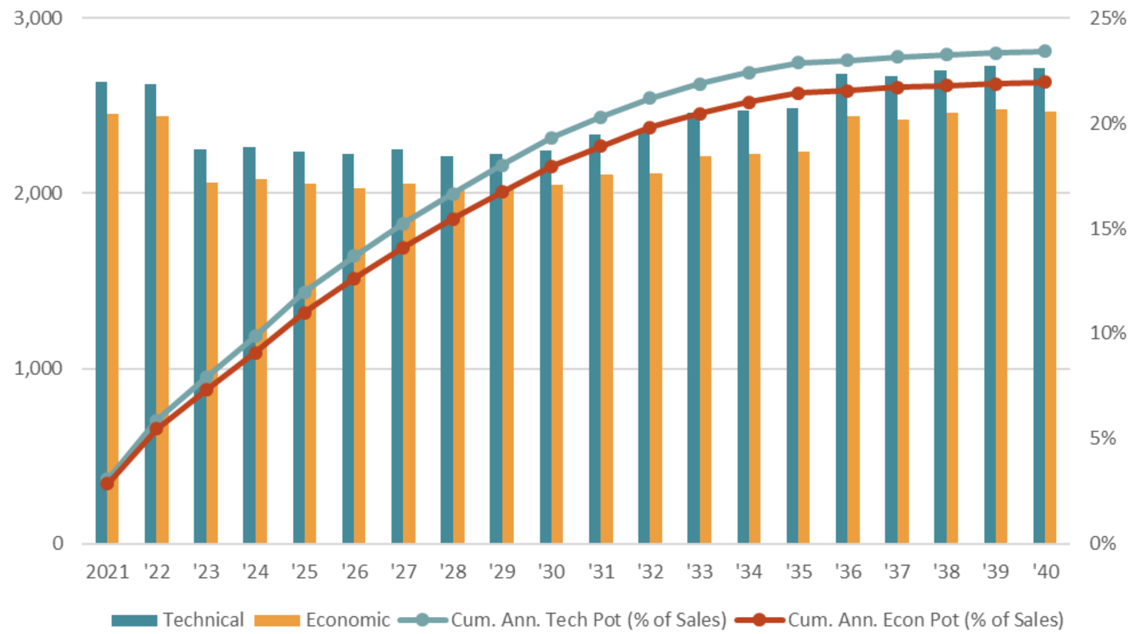


Figure 5-5 provides the MA and PA across the 20-yr timeframe of the study. The green and orange bars provide the respective incremental annual MA and PA in MWh per year energy savings. The green and red lines provide the corresponding cumulative annual MA and PA as a percent of forecasted annual sales. The MA rises to 17% by 2040 and the PA rises to 6%.

FIGURE 5-5 RESIDENTIAL BED MA & PA INCREMENTAL ANNUAL MWH POTENTIAL (BARS) AND CUMULATIVE ANNUAL POTENTIAL AS A % OF RESIDENTIAL SALES (LINES)

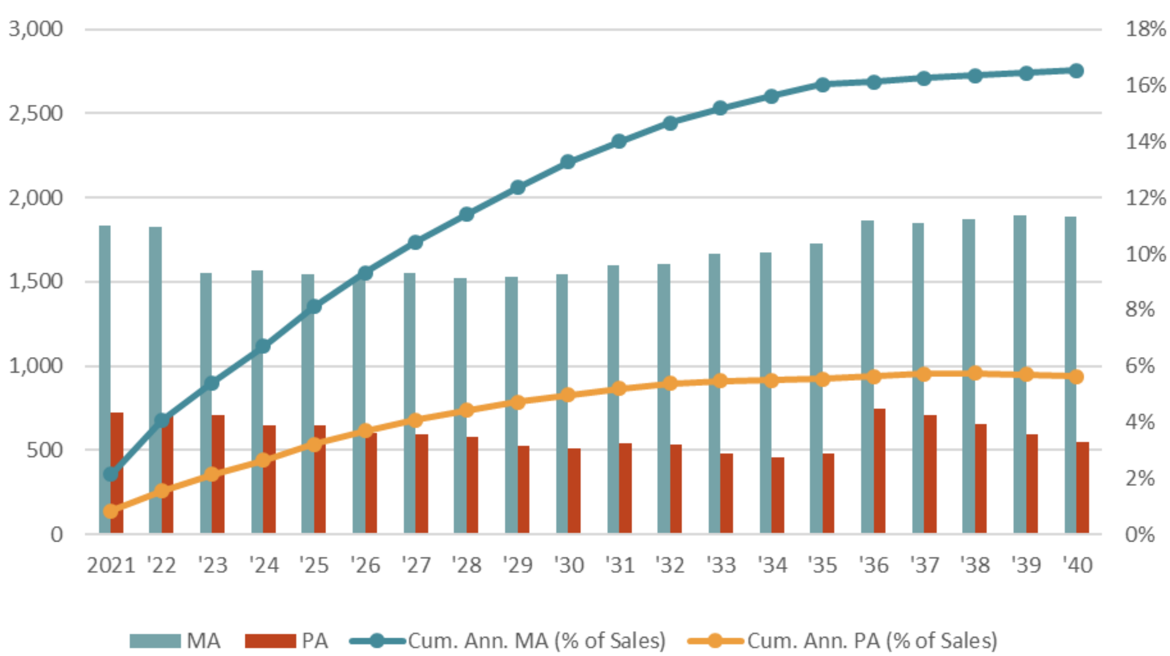


Figure 5-6 provides a breakdown of the incremental annual PA by end use. HVAC Equipment is the leading end use, with Appliances, Electronics, Lighting, and Cross-Cutting measures also accounting for large amounts of potential during various years throughout the study timeframe.

FIGURE 5-6 RESIDENTIAL PROGRAM ACHIEVABLE POTENTIAL BY END USE: INCREMENTAL ANNUAL

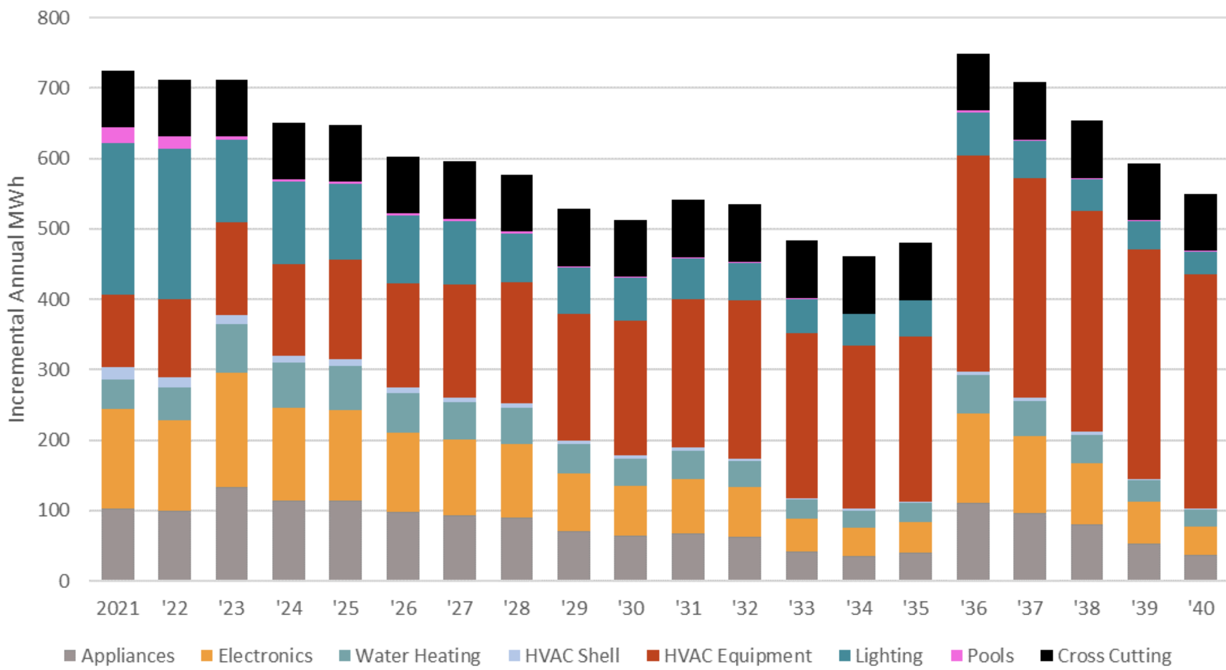
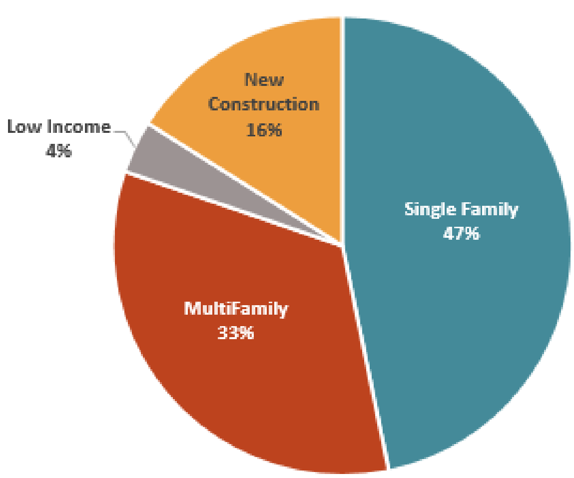
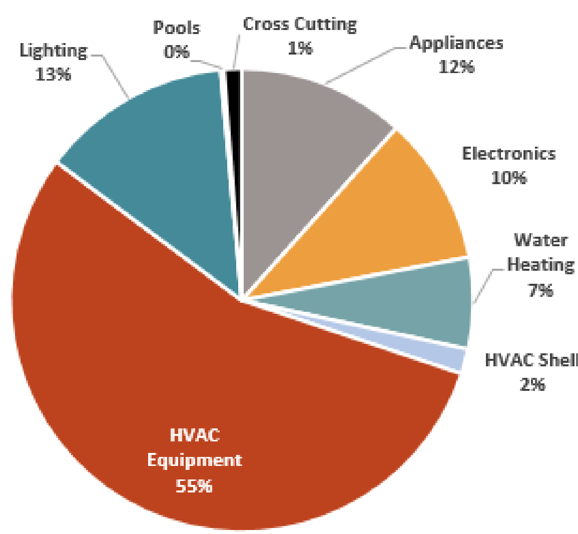


Figure 5-7 provides two illustrative views of the 20-yr cumulative annual PA. The pie chart on the left shows the breakdown of potential across housing types, income types and construction vintages. The existing single-family market segment accounts for 47% of the potential. The pie chart to the right shows this potential breakdown by end-use. Similar to the incremental annual PA breakdown shown in Figure 5-6, the cumulative annual energy savings largely come from the HVAC Equipment (primarily from increased heat pump adoption, and to a much lesser extent, smart thermostats and other HVAC equipment), Electronics, Lighting and Appliances end uses.

FIGURE 5-7 20-YEAR BED PA SAVINGS BY MARKET SEGMENT AND END USE: RESIDENTIAL SECTOR (VALUES IN MWH)





5.3 NONRESIDENTIAL SECTOR MARKET POTENTIAL

This section of the report provides a summary of the nonresidential energy efficiency potential in the BED service territory. Results are provided on an annual basis for technical and economic potential, as well as MA and PA. End-use and market segment breakdowns are provided for the PA scenario. Figure 5-8 shows in the nonresidential sector incremental annual MWh savings for each type of potential analyzed. The Technical, Economic, Maximum Achievable, and Program Achievable potential declines slightly from 2021 to 2030 as lighting potential opportunities are acquired after which potential stays relatively flat until 2036. The increase in potential in 2036 is attributed to the refill of lighting measures with a fifteen-year measure life from the first year of study, in addition to potential from measures installed for the first time in that year.

FIGURE 5-8 SUMMARY OF NONRESIDENTIAL POTENTIAL (INCREMENTAL ANNUAL MWH) - BED

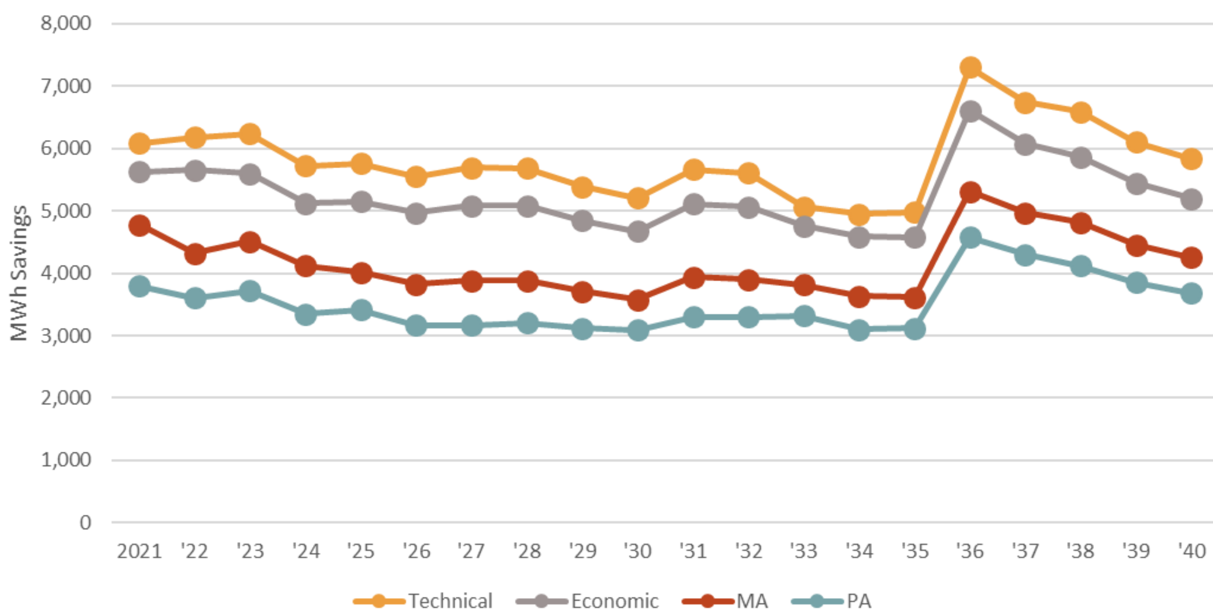


Figure 5-9 provides the 20-yr Technical and Economic Potential. The green and orange bars provide the respective incremental annual Technical and Economic Potential in MWh per year energy savings. The green and red lines provide the corresponding cumulative annual Technical and Economic Potential as a percent of forecasted annual sales. Most nonresidential measures are cost-effective, which leads to an Economic Potential estimate of 22% that is nearly as great as the Technical Potential estimate of 24%.

FIGURE 5-9 NONRESIDENTIAL BED TECHNICAL & ECONOMIC INCREMENTAL ANNUAL MWH POTENTIAL (BARS) AND CUMULATIVE ANNUAL POTENTIAL AS A % OF NONRESIDENTIAL SALES (LINES)

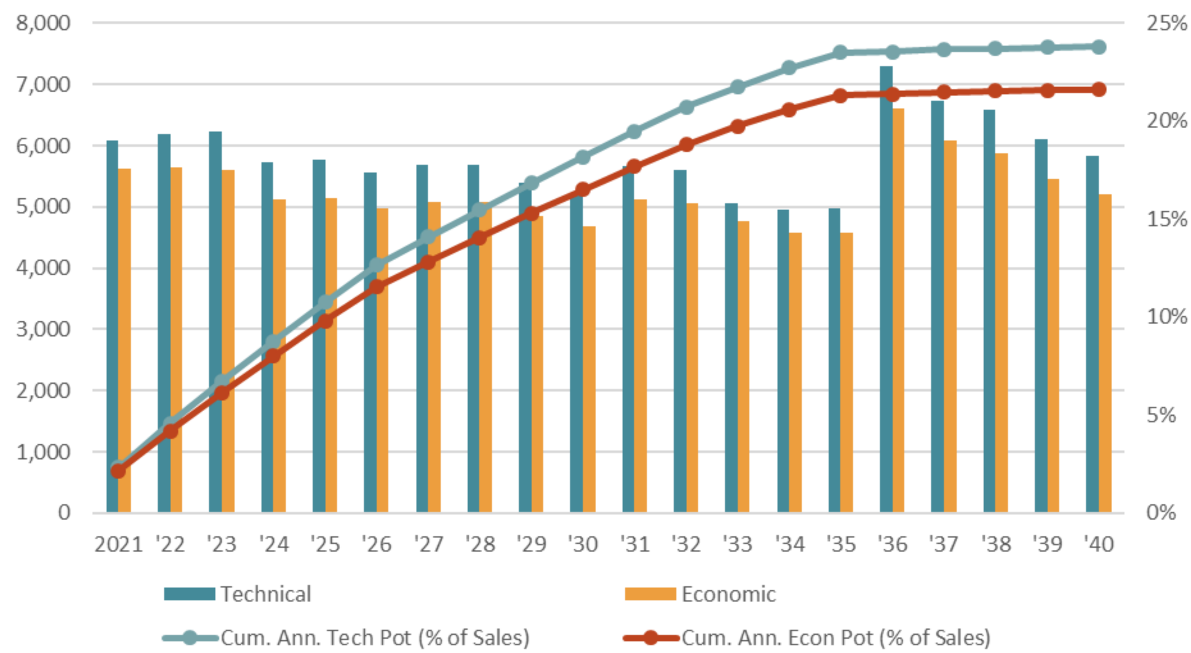


Figure 5-10 provides the MA and PA across the 20-yr timeframe of the study. The green and orange bars provide the respective incremental annual MA and PA in MWh per year energy savings. The green and red lines provide the corresponding cumulative annual MA and PA as a percent of forecasted annual sales. The MA rises to 18% by 2040 and the PA also rises to 16%.

FIGURE 5-10 NONRESIDENTIAL BED MA & PA INCREMENTAL ANNUAL MWH POTENTIAL (BARS) AND CUMULATIVE ANNUAL POTENTIAL AS A % OF NONRESIDENTIAL SALES (LINES)

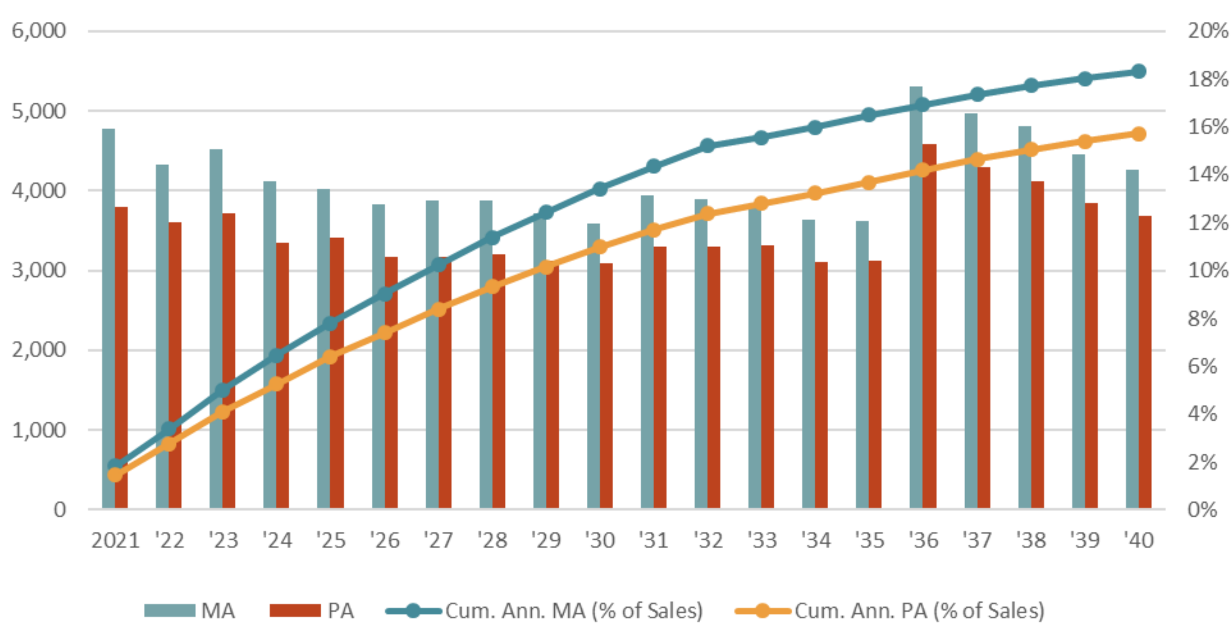


Figure 5-11 provides a breakdown of the incremental annual PA by end use. Lighting is the leading end use, with Ventilation and Circulation and Refrigeration also accounting for large amounts of potential.

FIGURE 5-11 NONRESIDENTIAL PROGRAM ACHIEVABLE POTENTIAL BY END USE: INCREMENTAL ANNUAL

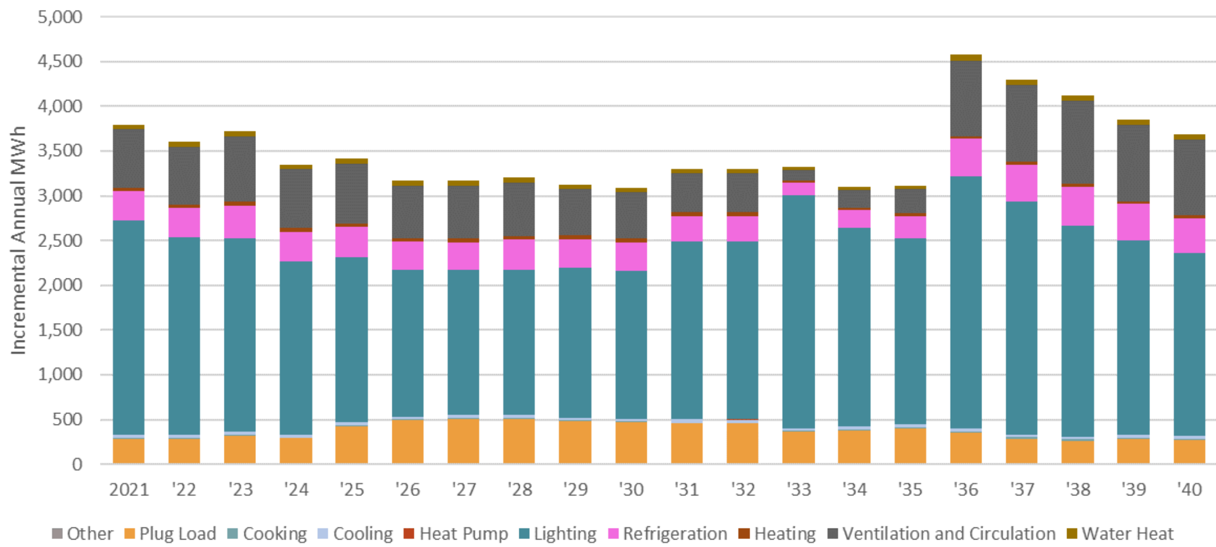
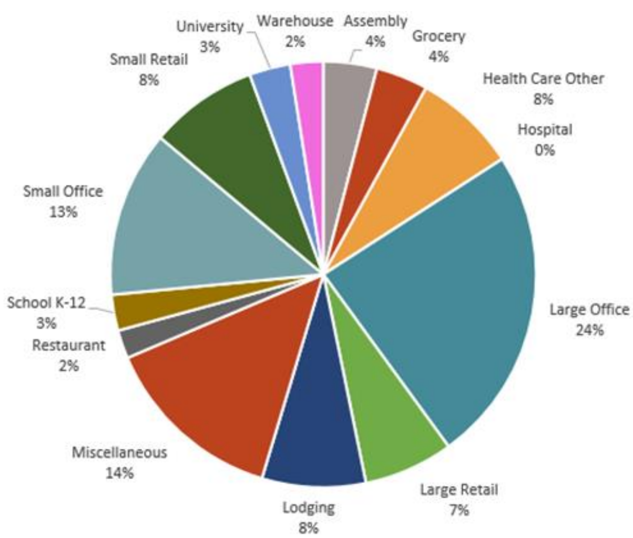
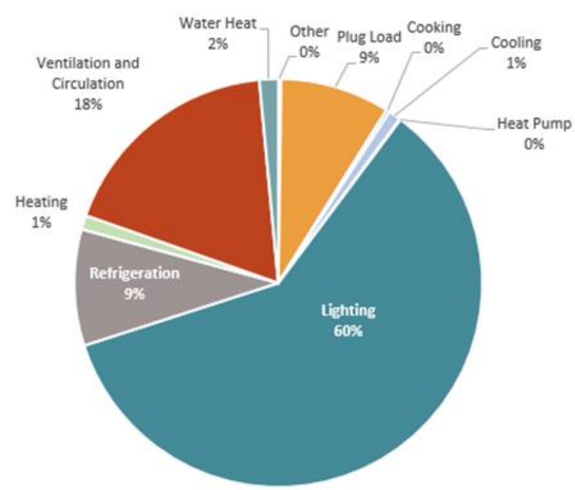


Figure 5-12 provides two illustrative views of the 20-yr cumulative annual PA. The pie chart on the left shows the breakdown of potential across market segment. Large offices and small offices combine for 37% of the potential. Large and small retail, lodging and health care combine for approximately 30% of the potential. The pie chart to the right shows this potential breakdown by end-use. Lighting is the leading end use, accounting for 60% of the potential.

FIGURE 5-12 20-YEAR BED PA SAVINGS BY MARKET SEGMENT AND END USE: NONRESIDENTIAL SECTOR (VALUES IN MWH)





5.4 BED BUDGETS AND COST-EFFECTIVENESS

Figure 5-13 illustrates the MA and PA budgets by sector. The MA budgets range from $4.8 million to $6.7 million. The PA budgets range from $1.6 million to $2.7 million.

FIGURE 5-13 BED MA & PA ESTIMATED RESOURCE ACQUISITION BUDGETS BY SECTOR

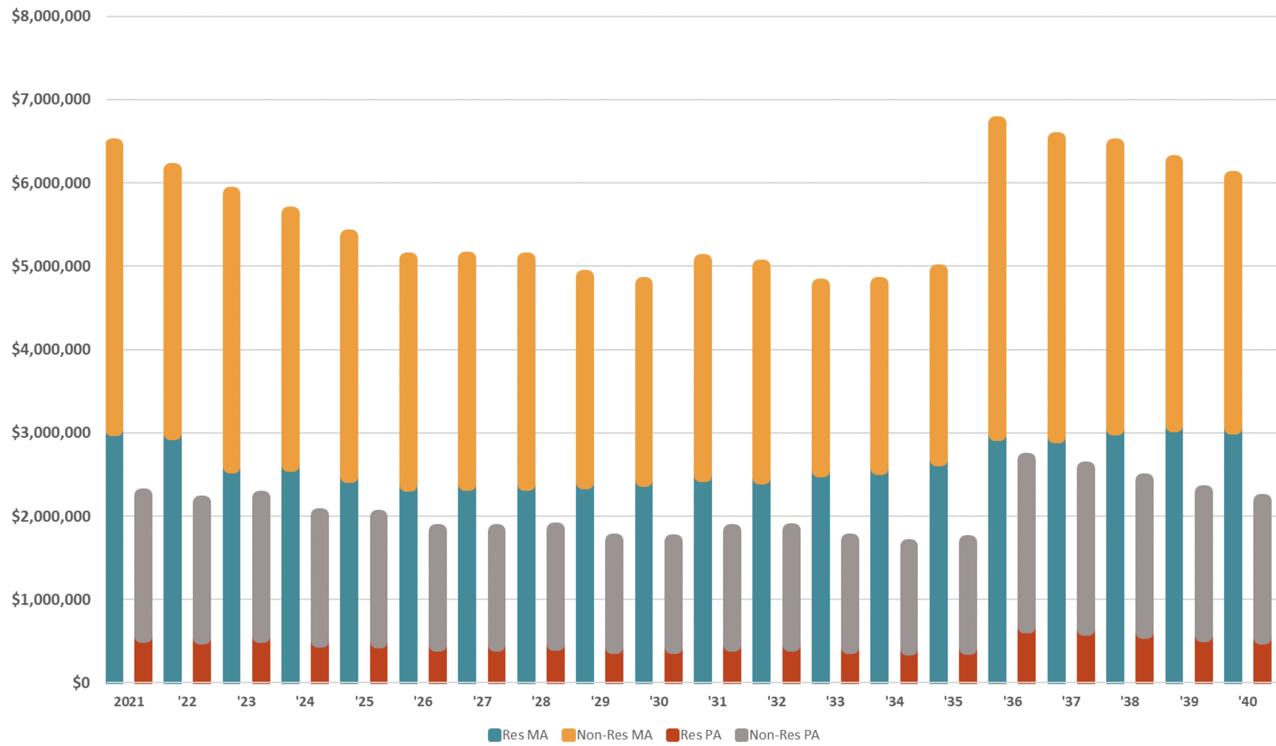


Figure 5-14 provides an incentive and admin budget breakdown for the PA scenario by sector. To align with the equity targets, residential budgets (including low-income) represent 25% of the total PA budget. Incentive budgets range from 62% to 66% of the total annual budgets.

FIGURE 5-14 BED PROGRAM ACHIEVABLE POTENTIAL INCENTIVE AND NON-INCENTIVE COSTS BY SECTOR

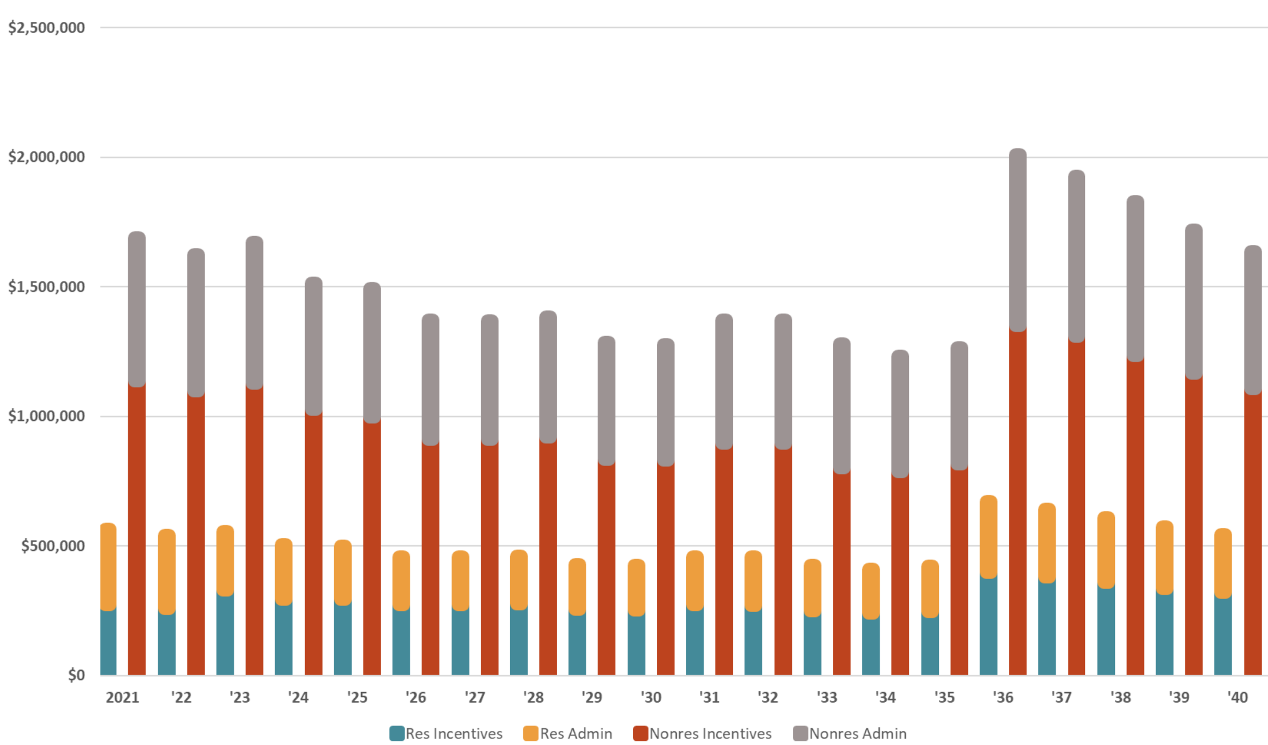


Table 5-2 and Table 5-3 show the NPV benefits and costs according to the Vermont SCT. Table 5-2 shows the MA and PA results for the residential sector. The MA scenario is estimated to provide more than $30 million in benefits with an SCT Ratio of 1.7. The PA scenario is estimated to provide more than $16 million in benefits with an SCT Ratio of 1.7.

TABLE 5-2 BED NPV BENEFITS & COSTS BY END USE: RESIDENTIAL MA & PA ($ IN MILLIONS)

	MA			PA		
End-Use	Benefits	Costs	SCT Ratio	Benefits	Costs	SCT Ratio
Appliances	$13.7	$12.1	1.1	$2.1	$1.7	1.2
Electronics	$19.6	$9.3	2.1	$2.8	$1.3	2.1
Water Heating	$5.0	$3.4	1.5	$1.0	$0.7	1.3
HVAC Shell	$3.2	$2.3	1.4	$0.9	$0.7	1.3
HVAC Equipment	$9.6	$6.2	1.6	$5.9	$3.8	1.6
Lighting	$8.4	$2.5	3.4	$3.4	$1.0	3.3
Pools	$0.4	$0.1	4.2	$0.1	$0.0	3.9
Cross Cutting	$0.2	$0.2	1.2	$0.2	$0.1	1.2
Total	$60.2	$36.1	1.7	$16.3	$9.5	1.7

Table 5-3 shows the MA and PA results for the nonresidential sector. The MA scenario is estimated to provide more than $260 million in benefits with an SCT Ratio of 5.7. The PA scenario is estimated to provide more than $218 million in benefits with an SCT Ratio of 5.8.

TABLE 5-3 BED NPV BENEFITS & COSTS BY END USE: NONRESIDENTIAL MA & PA ($ IN MILLIONS)

	MA			PA		
End-Use	Benefits	Costs	SCT Ratio	Benefits	Costs	SCT Ratio
Other	$0.49	$0.08	6.3	$0.39	$0.06	6.3
Plug Load	$12.95	$2.69	4.8	$10.58	$2.22	4.8
Cooking	$8.59	$0.11	80.1	$7.18	$0.09	80.8
Cooling	$4.53	$5.28	0.9	$3.67	$4.43	0.8
Heat Pump	$0.31	$0.07	4.4	$0.25	$0.06	4.3
Lighting	$158.24	$27.59	5.7	$129.89	$22.09	5.9
Refrigeration	$19.47	$2.69	7.2	$20.19	$2.79	7.2
Heating	$2.39	$0.40	6.0	$1.95	$0.34	5.8
Ventilation and Circulation	$50.26	$5.91	8.5	$42.14	$4.94	8.5
Water Heat	$2.78	$0.90	3.1	$2.30	$0.73	3.2
Total	$260.0	$45.7	5.7	$218.5	$37.7	5.8

Table 5-4 compares the combined sector NPV Benefits and Costs under the currently approved avoided costs with the proposed avoided costs noted in Section 2.4.2.2. As noted, this sensitivity only provides a high-level update to the NPV benefits and costs and does not make any further adjustment to remove measures that would no longer be considered cost-effective from the sector/portfolio measure mix.

TABLE 5-4 COMPARISON OF BED NPV BENEFITS & COSTS UNDER APPROVED VS. PROPOSED AVOIDED COSTS ($, IN MILLIONS)

	MA			PA		
Avoided Costs	Benefits	Costs	SCT Ratio	Benefits	Costs	SCT Ratio
Approved	$308	$76	4.1	$235	$47	5.0
Proposed	$173	$71	2.4	$132	$45	2.9

5.5 BED RATE & BILL IMPACT ANALYSIS RESULTS

Table 5-5 shows the combined rate and bill impacts for BED across customer classes and averaged over the study period. Results are shown for both the maximum achievable and program achievable savings scenarios.

TABLE 5-5 AVERAGE BED RATE AND BILL DIFFERENCES RELATIVE TO BASELINE WITHOUT FUTURE EFFICIENCY

	PA Potential Scenario		MA Potential Scenario	
Customer Class	Rates (2021-2040)	Average Bill Impacts	Rates (2021-2040)	Average Bill Impacts
Residential	3.3%	-0.7%	16.3%	3.2%
C&I	3.3%	-6.8%	7.3%	-5.2%
All Customers	3.3%	-5.3%	9.5%	-3.2%

Overall, rates for BED customers increase by 3.3% for the program achievable scenario and 9.5% for the maximum achievable scenario. Avoided cost benefits do not offset or exceed lost revenue and efficiency charges for BED nonresidential customers or residential customers in the program potential scenario. Rate impacts for the PA scenario by year are shown for each customer classes are shown in Figure 5-15 and Figure 5-16. Additional detail, including annual rate impacts for the MA scenario are included in Appendix E.

FIGURE 5-15 PA CHANGE IN AVERAGE RESIDENTIAL CUSTOMER AVERAGE REVENUE REQUIREMENT- BED

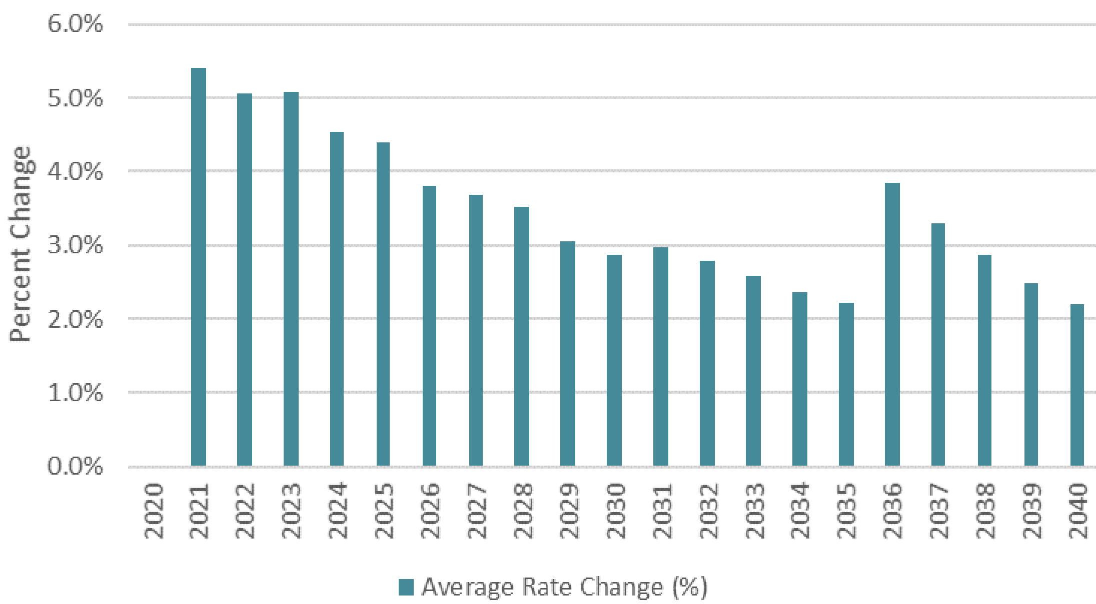
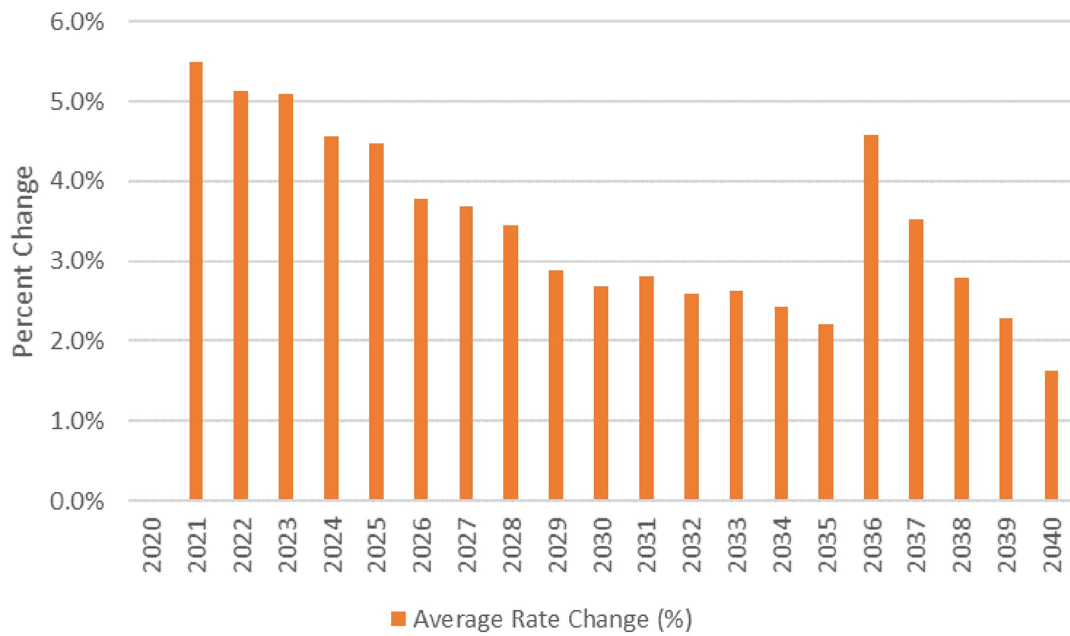


FIGURE 5-16 PA CHANGE IN AVERAGE C&I CUSTOMER AVERAGE REVENUE REQUIREMENT- BED



Average annual bill impacts are shown in Table 5-6 by customer class for the program achievable scenario over a three, ten, and twenty-year period. Over the 20-year analysis timeframe and across all customers (both participants and non-participants), the average annual bill is expected to decrease, with savings expected to offset any additional rate increases that result from sustained efficiency program offerings.

TABLE 5-6 AVERAGE BED BILL IMPACTS FOR THE PROGRAM ACHIEVABLE SCENARIO

Customer Class	PA Potential Scenario Average Bill Impact (3 YR)	Average Bill Impact (10 YR)	Average Bill Impact (20 YR)
Residential	$23.35	$4.69	-$7.97
C&I	$196.62	-$245.53	-$617.94

Table 5-7 shows the average bill impacts for participants and nonparticipants by customer class. For the program achievable scenario, Cadmus assumed participant savings would be 10% of baseline consumption. Average nonparticipant bills increase slightly with the increase in rates. Participant bills decrease due to energy and demand savings, which offset the increase in rates.

TABLE 5-7 AVERAGE BED PARTICIPANT AND NONPARTICIPANT BILL IMPACTS FOR THE PROGRAM ACHIEVABLE SCENARIO

Customer Class`	Average Rate Change (%)	Nonparticipants		Participants	
		Average New Bill	Average Bill Impact	Average New Bill	Average Bill Impact
Residential	3.3%	-0.7%	16.3%	3.2%	3.3%
C&I	3.6%	$9054	$317	$8149	-$588

6 VGS Market Potential Assessment

This section provides the potential results for technical, economic, MA and PA in the VGS service territory. Results are broken down by sector as well as end use. The cost-effectiveness results for MA and PA are also provided, as are annual budgets for each of these scenarios.

6.1 ENERGY SAVINGS POTENTIAL SUMMARY

In total, GDS analyzed 132 measure types for VGS. Many measures required multiple permutations for different applications, such as different building types, efficiency levels, and replacement options. GDS developed a total of 3,174 measure permutations for the VGS analysis and tested all measures for cost-effectiveness under the Vermont Societal Cost Test (VT SCT). A total of 81% of residential measures and 74% of nonresidential measures had a VT SCT benefit-cost ratio of 1.0 or higher.

Figure 6-1 illustrates the technical potential, economic potential, MA and PA incremental annual Mcf energy efficiency savings estimates in the VGS territory. Overall, Technical, Economic, Maximum Achievable, and Program Achievable potential increases over the analysis timeframe. Whereas the electric EEUs in Vermont have offered electric energy efficiency programs for decades, natural gas energy efficiency offers more savings opportunities due to the relative nascence of utility programs. The increasing potential is more prevalent in the nonresidential sector. The nonresidential sector potential also requires significantly more budget to obtain than historical levels. In the residential sector, annual increases in Technical, Economic, and Maximum Achievable potential are mitigated by rates of natural gas expansion, and the increased prevalence of cold-climate heat pumps in the VGS service area.

As with EVT and BED, Program Achievable potential is a subset of maximum achievable potential and consideration to achieve targeted equity in program spending across sectors plays a role in determining the total Program Achievable potential. The PA savings range from 87,000 Mcf/yr to 156,000 Mcf/yr.

FIGURE 6-1 SUMMARY OF POTENTIAL (INCREMENTAL ANNUAL MCF)

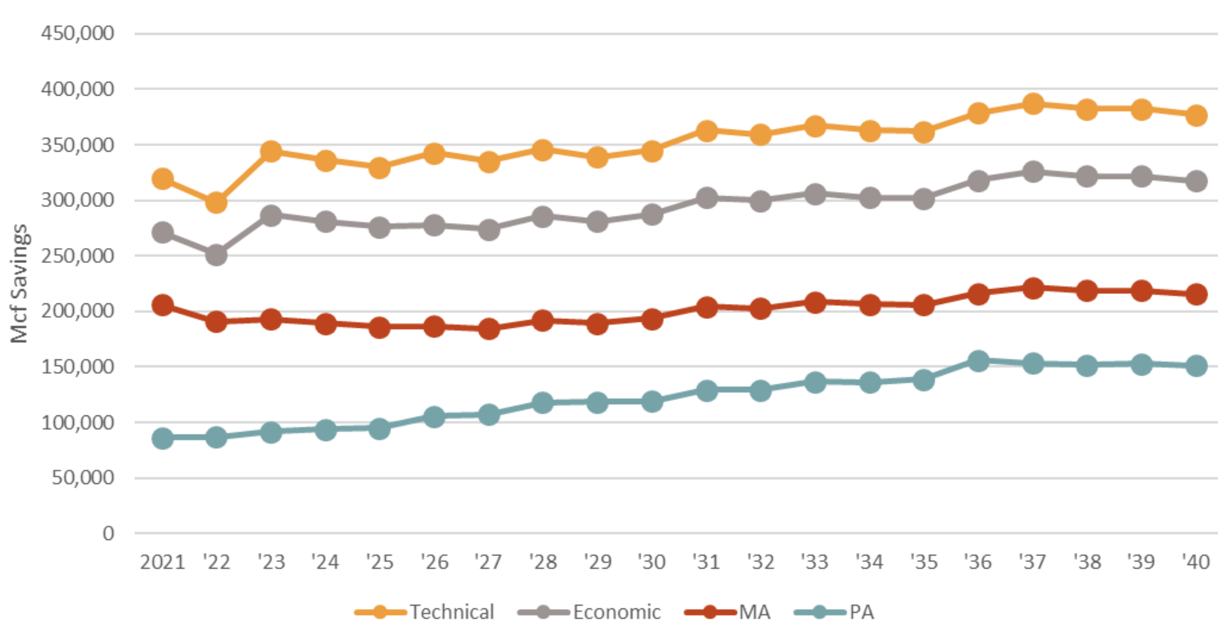


Figure 6-2 provides the technical, economic, MA and PA results for the 3-yr, 10-yr, and 20-yr timeframes. The 3-yr technical potential is 9.1% of forecasted sales, and the economic potential is 7.7% of forecasted sales, indicating that most technical potential is cost-effective. The 3-yr MA is 5.9% and the PA is 2.6%.

FIGURE 6-2 VGS ELECTRIC ENERGY (MCF) CUMULATIVE ANNUAL POTENTIAL (AS A % OF TOTAL SALES)

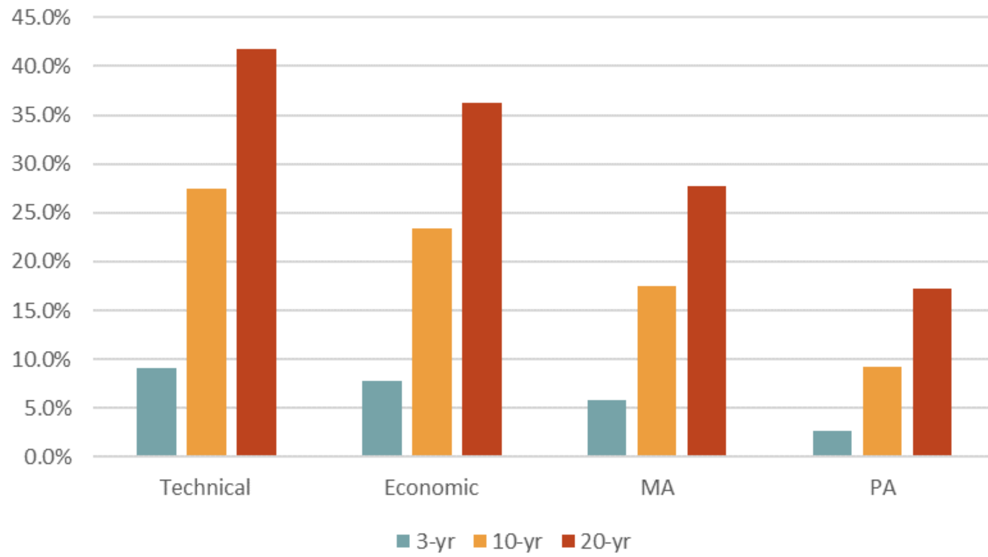


Table 6-1 provides 1-, 2-, 3-, 10-, and 20-yr cumulative annual technical, economic, MA and PA results. The technical potential rises to more than 4 million Mcf by 2040, and the PA is more than 1.6 million Mcf by 2040.

TABLE 6-1 VGS ENERGY EFFICIENCY POTENTIAL SUMMARY

	2021	2022	2023	2030	2040
Annual Energy (Mcf)					
Technical	319,608	617,555	914,476	2,850,932	4,093,761
Economic	271,402	523,099	775,031	2,421,296	3,544,837
MA	206,025	396,998	588,342	1,814,892	2,723,565
PA	86,524	173,689	264,429	962,447	1,601,426

6.2 RESIDENTIAL SECTOR MARKET POTENTIAL

This section of the report provides a summary of the residential energy efficiency potential in the VGS service territory. Results are provided on an annual basis for technical and economic potential, as well as MA and PA. End-use and housing type breakdowns are provided for the PA scenario. Figure 6-3 shows in the residential sector incremental annual MWh savings for each type of potential analyzed. Overall, Technical, Economic, and Maximum Achievable potential remains somewhat flat over the analysis timeframe. The increase in incremental annual potential over the second decade is associated with some re-upping of measures with shorter lifetimes. Like the other EEUs, the Program Achievable potential in the residential sector is constrained by the sector equity targets on EEU spending but an annual increase in nonresidential PA potential allows for a gradual increase in the residential PA potential as well. As a point of reference, the residential Program Achievable cost of energy saved for years 2021-2023 is $97/Mcf (compared to a projected $96/Mcf for the 2018-2020 period).

FIGURE 6-3 SUMMARY OF RESIDENTIAL POTENTIAL (INCREMENTAL ANNUAL MCF)- VGS

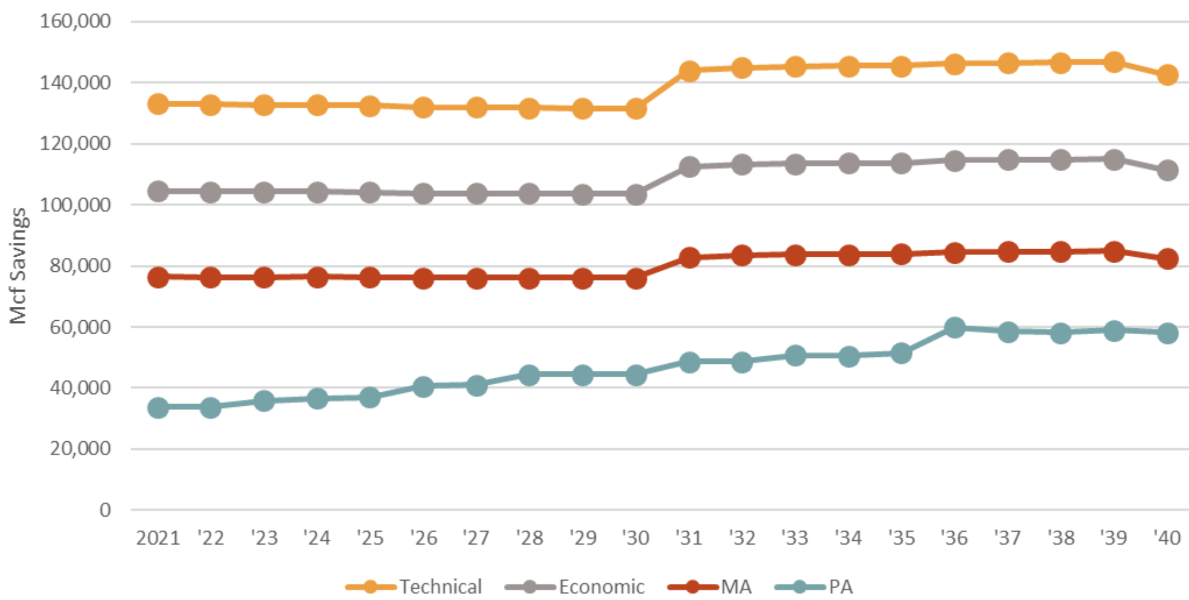


Figure 6-4 provides the 20-yr Technical and Economic Potential. The green and orange bars provide the respective incremental annual Technical and Economic Potential in Mcf per year energy savings. The green and red lines provide the corresponding cumulative annual Technical and Economic Potential as a percent of forecasted annual sales. Most residential measures are cost-effective, which leads to an Economic Potential estimate of 33% that is nearly as great as the Technical Potential estimate of 41%.

FIGURE 6-4 RESIDENTIAL VGS TECHNICAL & ECONOMIC INCREMENTAL ANNUAL MCF POTENTIAL (BARS) AND CUMULATIVE ANNUAL POTENTIAL AS A % OF RESIDENTIAL SALES (LINES)

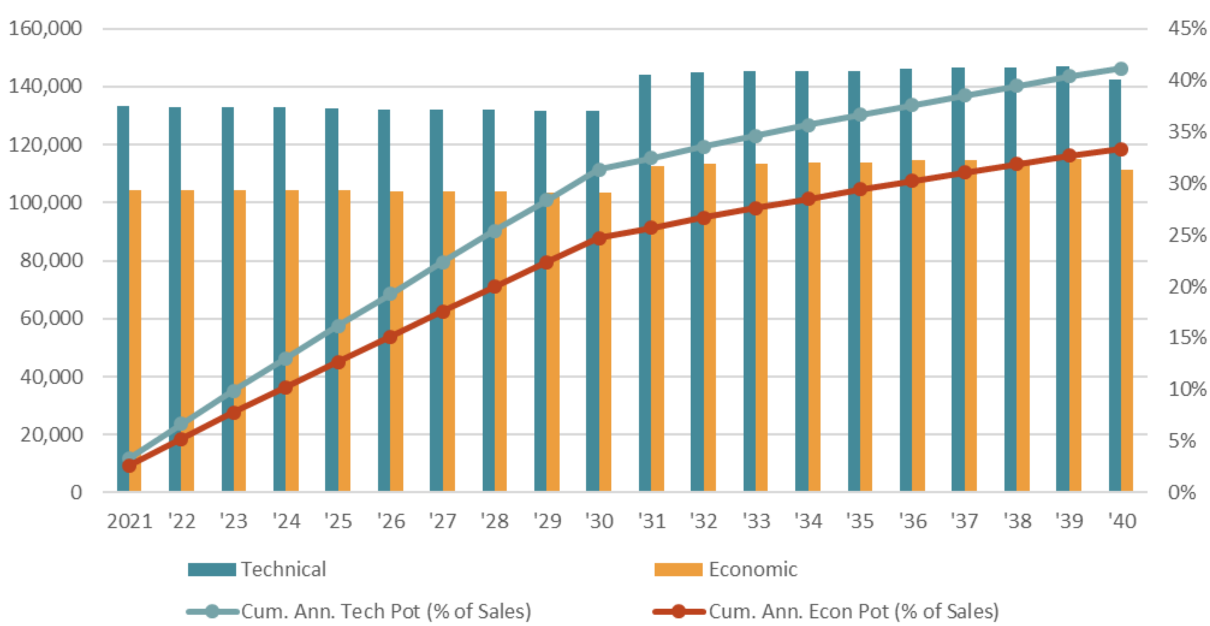


Figure 6-5 provides the MA and PA across the 20-yr timeframe of the study. The green and orange bars provide the respective incremental annual MA and PA in Mcf per year energy savings. The green and red lines provide the corresponding cumulative annual MA and PA as a percent of forecasted annual sales. The MA rises to 25% by 2040 and the PA rises to 16%.

FIGURE 6-5 RESIDENTIAL VGS MA & PA INCREMENTAL ANNUAL MCF POTENTIAL (BARS) AND CUMULATIVE ANNUAL POTENTIAL AS A % OF RESIDENTIAL SALES (LINES)

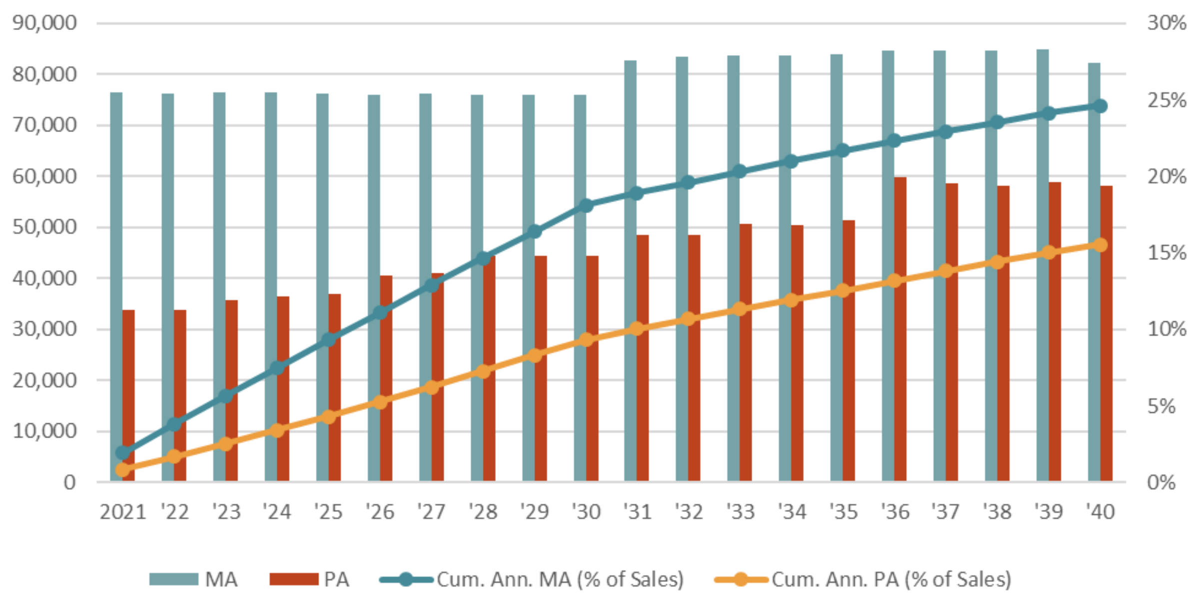


Figure 6-6 provides a breakdown of the incremental annual PA by end use. HVAC Equipment is the leading end use, with Water Heating and HVAC Shell also accounting for large amounts of potential during various years throughout the study timeframe.

FIGURE 6-6 RESIDENTIAL PROGRAM ACHIEVABLE POTENTIAL BY END USE: INCREMENTAL ANNUAL

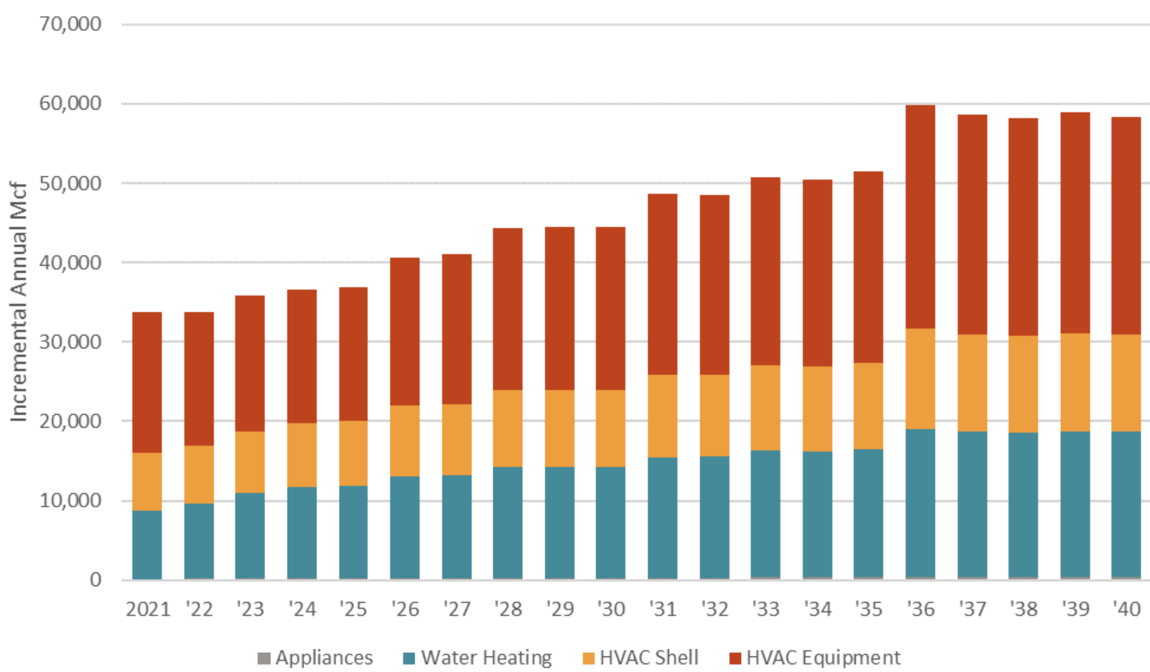
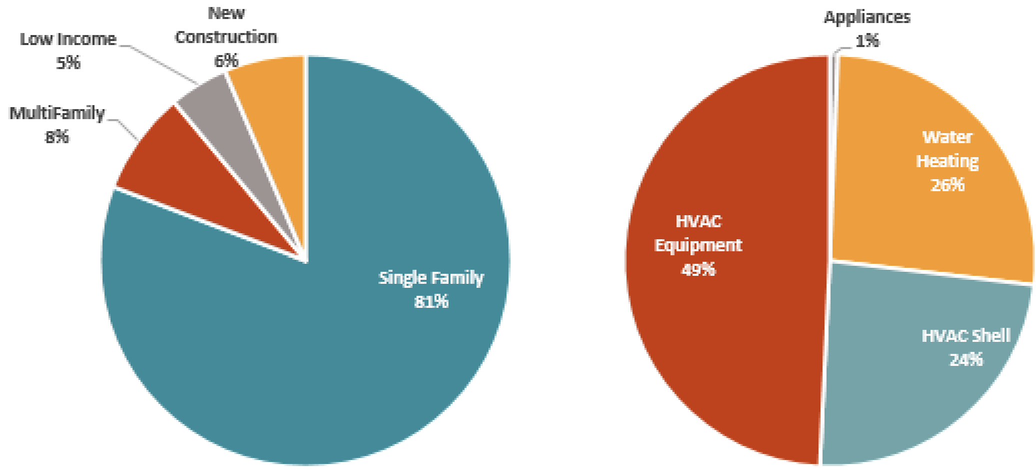


Figure 6-7 provides two illustrative views of the 20-yr cumulative annual PA. The pie chart on the left shows the breakdown of potential across housing types, income types and construction vintages. The existing single-family market segment accounts for 81% of the potential. The pie chart to the right shows this potential breakdown by end-use.

FIGURE 6-7 20-YEAR VGS PA SAVINGS BY MARKET SEGMENT AND END USE: RESIDENTIAL SECTOR (VALUES IN MCF)



6.3 NONRESIDENTIAL SECTOR MARKET POTENTIAL

This section of the report provides a summary of the nonresidential energy efficiency potential in the VGS service territory. Results are provided on an annual basis for technical and economic potential, as well as MA and PA. End-use and market segment breakdowns are provided for the PA scenario. Figure 6-8 in the nonresidential sector incremental annual Mcf savings for each type of potential analyzed. Overall, Technical, Economic, Maximum Achievable, and Program Achievable potential increases somewhat over the analysis timeframe. Whereas the electric EEUs in Vermont have offered electric energy efficiency programs for decades, natural gas energy efficiency offers more savings opportunities due to the relative nascence of utility programs. The increase in incremental annual potential over the second decade is associated with some re-upping of measures with shorter lifetimes.

As a point of reference the nonresidential Program Achievable cost of energy saved for years 2021-2023 is $41/Mcf (compared to a projected $16/Mcf for the 2018-2020 period). Historically, the nonresidential programs have encountered intermittent large projects resulting in “lumpy savings” and associated swings in the cost of energy saved. These swings have been factored into the MPS to some degree. It is possible that VGS nonresidential programs could acquire savings near historical levels if incentive and non-incentive costs were reduced. In such a scenario, the rate and bill impacts would improve from the customers perspective (see VGS nonresidential rate and bill sensitivity discussion below.

FIGURE 6-8 SUMMARY OF NONRESIDENTIAL POTENTIAL (INCREMENTAL ANNUAL MCF)- VGS

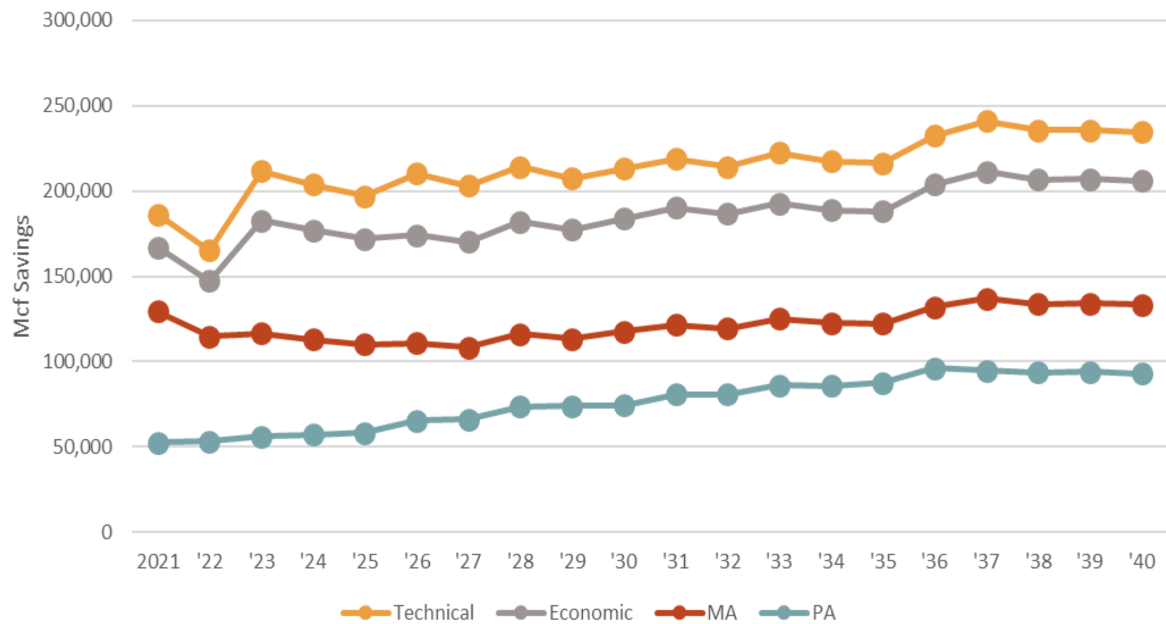


Figure 6-9 provides the 20-yr Technical and Economic Potential. The green and orange bars provide the respective incremental annual Technical and Economic Potential in Mcf per year energy savings. The green and red lines provide the corresponding cumulative annual Technical and Economic Potential as a percent of forecasted annual sales. Most nonresidential measures are cost-effective, which leads to an Economic Potential estimate of 38% that is nearly as great as the Technical Potential estimate of 42%.

FIGURE 6-9 NONRESIDENTIAL VGS TECHNICAL & ECONOMIC INCREMENTAL ANNUAL MCF POTENTIAL (BARS) AND CUMULATIVE ANNUAL POTENTIAL AS A % OF NONRESIDENTIAL SALES (LINES)

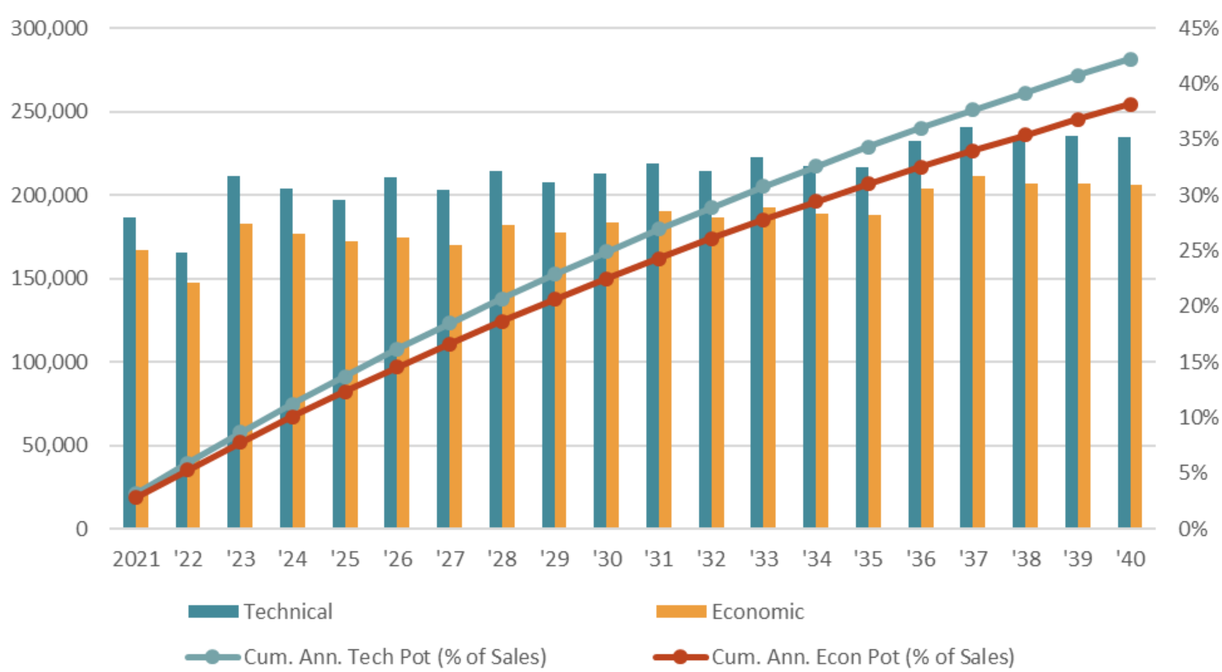


Figure 6-10 provides the MA and PA across the 20-yr timeframe of the study. The green and orange bars provide the respective incremental annual MA and PA in Mcf per year energy savings. The green and red lines provide the corresponding cumulative annual MA and PA as a percent of forecasted annual sales. The MA rises to 30% by 2040 and the PA rises to 18%.

FIGURE 6-10 NONRESIDENTIAL VGS MA & PA INCREMENTAL ANNUAL MCF POTENTIAL (BARS) AND CUMULATIVE ANNUAL POTENTIAL AS A % OF NONRESIDENTIAL SALES (LINES)

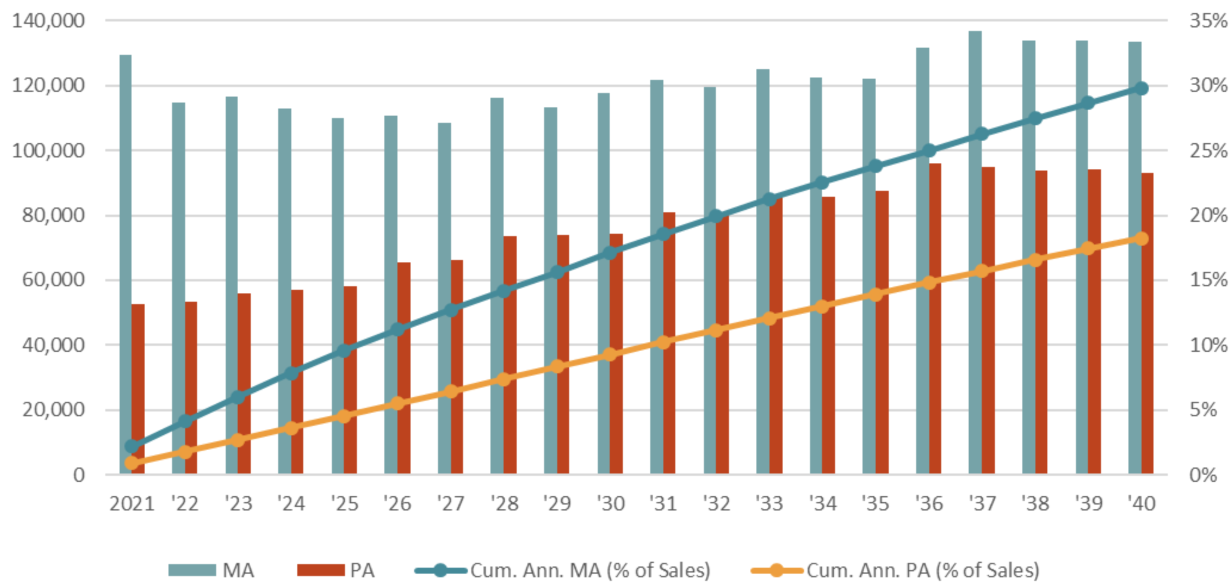


Figure 6-11 provides a breakdown of the incremental annual PA by end use. Space Heating – Gas Furnace and Space Heating – Gas Boiler are the leading end uses, followed by Cooking and Water Heating.

FIGURE 6-11 NONRESIDENTIAL PROGRAM ACHIEVABLE POTENTIAL BY END USE: INCREMENTAL ANNUAL

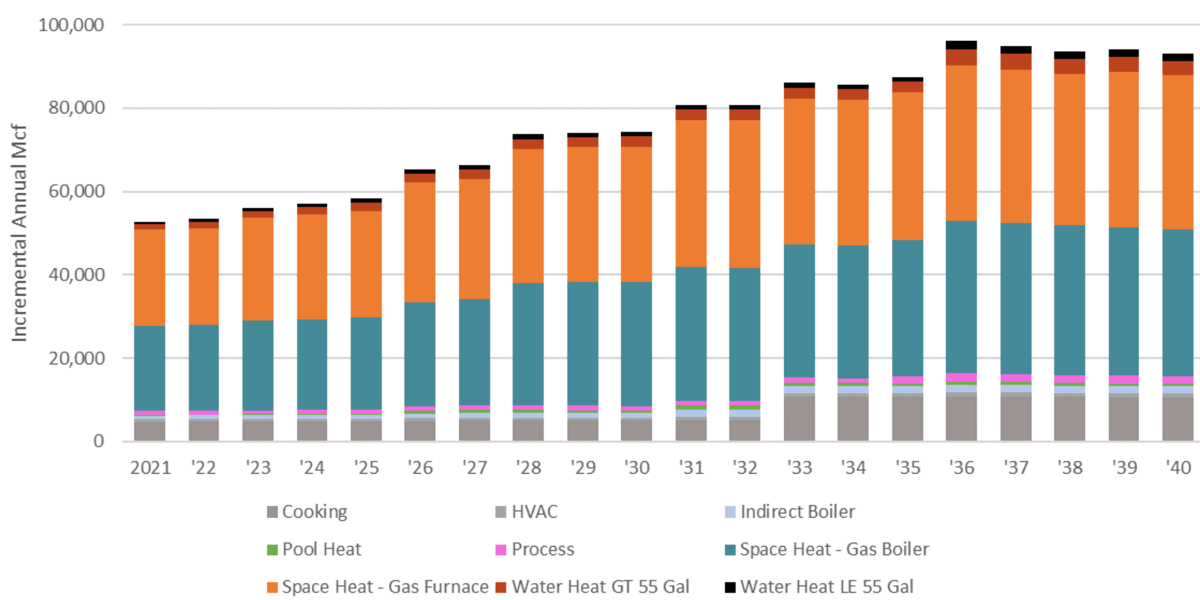
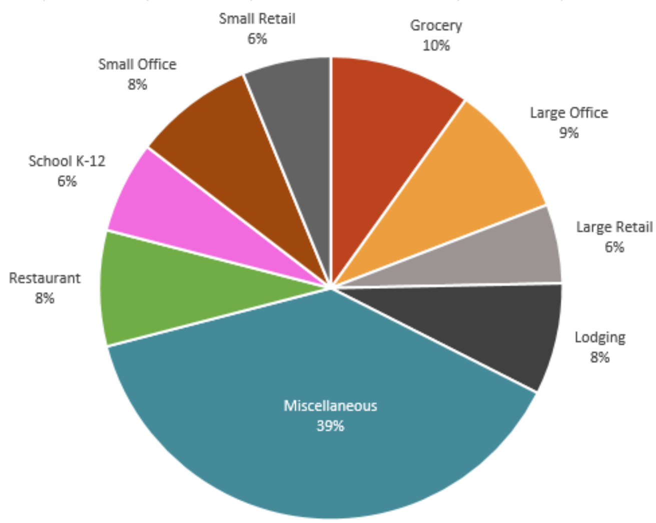
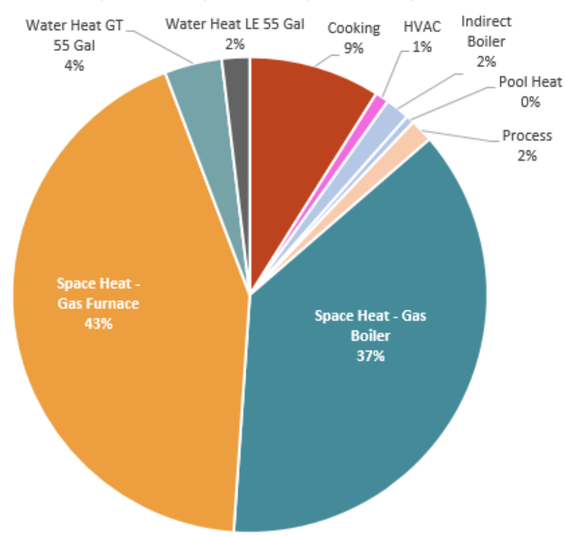


Figure 6-12 provides two illustrative views of the 20-yr cumulative annual PA. The pie chart on the left shows the breakdown of potential across market segment. Offices, restaurants, schools, retail, and lodging each account for between 6% and 10% of the potential. The pie chart to the right shows this

potential breakdown by end-use. Space heating – Gas Furnace and Space Heating – Gas Boiler are by far the leading end uses.

FIGURE 6-12 20-YEAR VGS PA SAVINGS BY MARKET SEGMENT AND END USE: NONRESIDENTIAL SECTOR (VALUES IN MCF)





6.4 VGS BUDGETS AND COST-EFFECTIVENESS

Figure 6-13 illustrates the MA and PA budgets by sector. The MA budgets range from $20.6 million to $24.2 million. The PA budgets range from $5.5 million to $9.5 million.

FIGURE 6-13 VGS MA & PA ESTIMATED RESOURCE ACQUISITION BUDGETS BY SECTOR

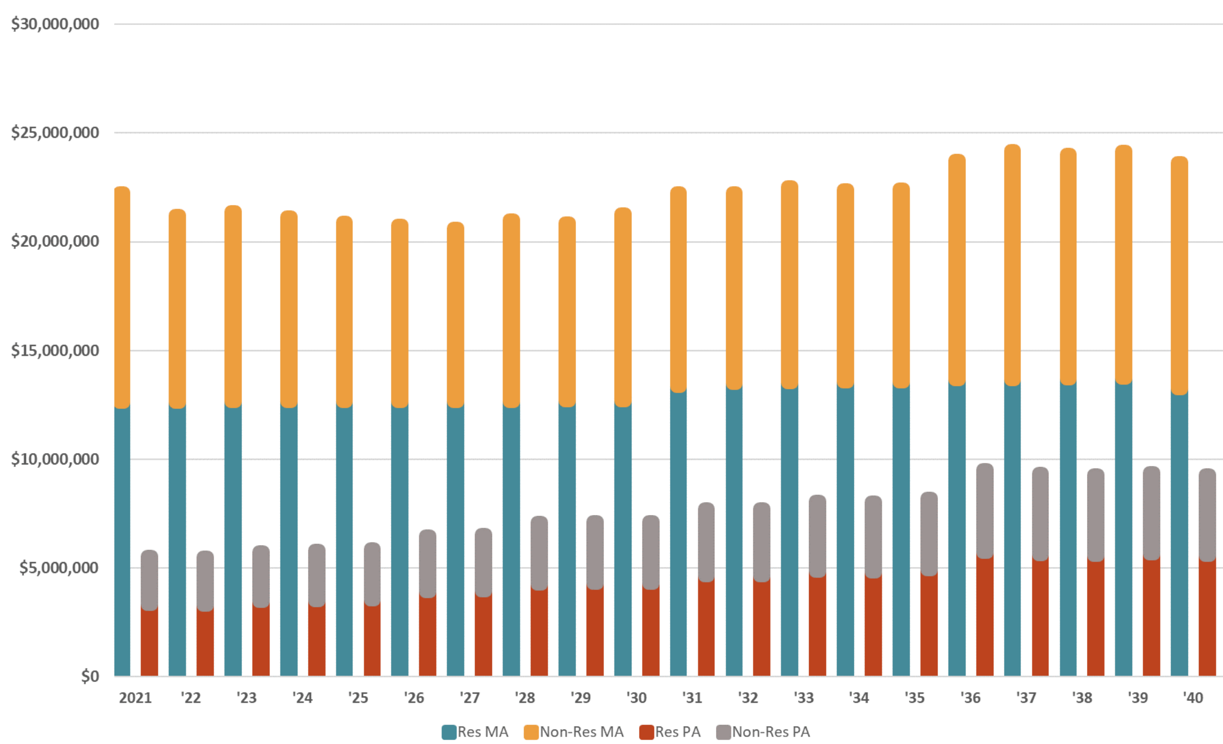


Figure 6-14 provides an incentive and admin budget breakdown for the PA scenario by sector. Incentive budgets range from 69% to 73% of the total annual budgets.

FIGURE 6-14 VGS PROGRAM ACHIEVABLE POTENTIAL INCENTIVE AND NON-INCENTIVE COSTS BY SECTOR

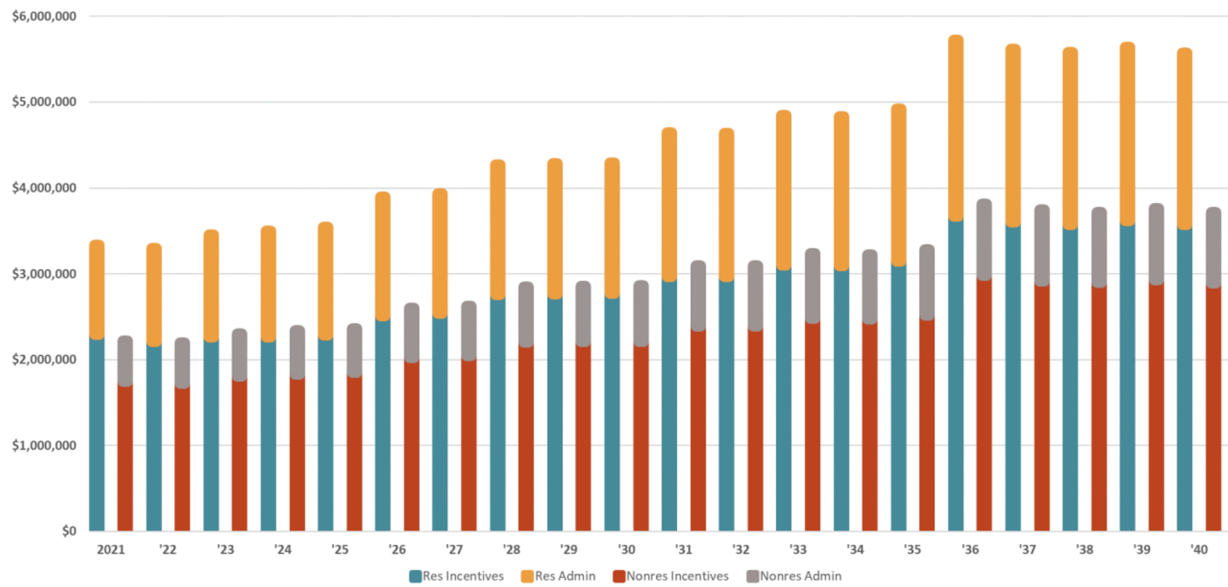


Table 6-2 and Table 6-3 show the NPV benefits and costs according to the Vermont SCT. Table 1-3 shows the MA and PA results for the residential sector. The MA scenario is estimated to provide more than $367 million in benefits with an SCT Ratio of 2.4. The PA scenario is estimated to provide $213 million in benefits with an SCT Ratio of 2.6.

TABLE 6-2 VGS NPV BENEFTIS & COSTS BY END USE: RESIDENTIAL MA & PA

	MA			PA		
End-Use	Benefits	Costs	SCT Ratio	Benefits	Costs	SCT Ratio
Appliances	$2.1	$0.7	3.0	$1.5	$0.5	3.1
Water Heating	$60.0	$23.4	2.6	$38.2	$15.0	2.5
HVAC Shell	$127.7	$87.7	1.5	$68.9	$41.8	1.6
HVAC Equipment	$178.1	$44.0	4.0	$104.3	$25.1	4.2
Total	$367.9	$155.8	2.4	$213.0	$82.4	2.6

Table 6-3 shows the MA and PA results for the nonresidential sector. The MA scenario is estimated to provide more than $1019 million in benefits with an SCT Ratio of 6.3. The PA scenario is estimated to provide more than $667 million in benefits with an SCT Ratio of 6.3.

TABLE 6-3 VGS NPV BENEFTIS & COSTS BY END USE: NONRESIDENTIAL MA & PA

	MA			PA		
End-Use	Benefits	Costs	SCT Ratio	Benefits	Costs	SCT Ratio
Cooking	$369.1	$9.7	38.0	$242.2	$6.4	37.9
HVAC	$3.5	$1.7	2.1	$2.8	$1.4	2.1
Indirect Boiler	$5.1	$2.1	2.4	$4.1	$1.7	2.4
Pool Heat	$0.7	$1.1	0.6	$0.5	$0.7	0.7
Process	$5.8	$2.0	2.8	$4.6	$1.6	2.8

End-Use	MA Benefits	MA Costs	MA SCT Ratio	PA Benefits	PA Costs	PA SCT Ratio
Space Heat - Gas Boiler	$287.4	$61.0	4.7	$187.1	$39.9	4.7
Space Heat - Gas Furnace	$334.3	$76.3	4.4	$217.4	$49.7	4.4
Water Heat GT 55 Gal	$9.0	$2.2	4.1	$5.7	$1.6	3.5
Water Heat LE 55 Gal	$4.3	$5.7	0.8	$2.7	$2.5	1.1
Total	$1,019.2	$161.8	6.3	$667.1	$105.7	6.3

Table 6-4 compares the combined sector NPV Benefits and Costs under the currently approved avoided costs with the proposed avoided costs noted in Section 2.4.2.2. As noted, this sensitivity only provides a high-level update to the NPV benefits and costs and does not make any further adjustment to remove measures that would no longer be considered cost-effective from the sector/portfolio measure mix.

TABLE 6-4 COMPARISON OF VGS NPV BENEFITS & COSTS UNDER APPROVED VS. PROPOSED AVOIDED COSTS ($, IN MILLIONS)

Avoided Costs	MA Benefits	MA Costs	MA SCT Ratio	PA Benefits	PA Costs	PA SCT Ratio
Approved	$1,387	$318	4.4	$880	$188	4.7
Proposed	$1,330	$332	4.0	$844	$196	4.3

6.5 VGS RATE & BILL IMPACT ANALYSIS RESULTS

Table 6-5 shows the combined rate and bill impacts for VGS across customer classes and averaged over the study period. Results are shown for both the maximum achievable and program achievable savings scenarios.

TABLE 6-5 AVERAGE VGS RATE AND BILL DIFFERENCES RELATIVE TO BASELINE WITHOUT FUTURE EFFICIENCY

	PA Potential Scenario		MA Potential Scenario	
Customer Class	Rates (2021-2040)	Average Bill Impacts	Rates (2021-2040)	Average Bill Impacts
Residential	6.6%	-2.9%	25.6%	5.6%
C&I	-2.7%	-11.8%	4.8%	-12.5%
All Customers	2.6%	-6.7%	16.6%	-2.3%

VGS rate impacts showed an average increase of 2.6% over the study period for the program achievable potential scenario. Avoided costs were greater than the lost revenue rate and efficiency charges starting in 2029 for nonresidential customers. Although the nonresidential acquisition cost modeled by the GDS/Cadmus team is higher than VGS' recent historical experience, this cost is quite relatively low compared with the residential acquisition cost. As a result, both bill and rate impacts are negative for nonresidential customers, whereas rate impacts increase, on average, for residential customers. On the other hand, the MA potential scenarios acquisition costs are substantially higher, leading to higher rate impacts. Rate impacts for the PA scenario by year are shown for each customer classes are shown in Figure 6-15 and Figure 6-16. Annual rate impacts for the MA scenario are included in Appendix E.

FIGURE 6-15 PA CHANGE IN AVERAGE RESIDENTIAL CUSTOMER AVERAGE REVENUE REQUIREMENT- VGS

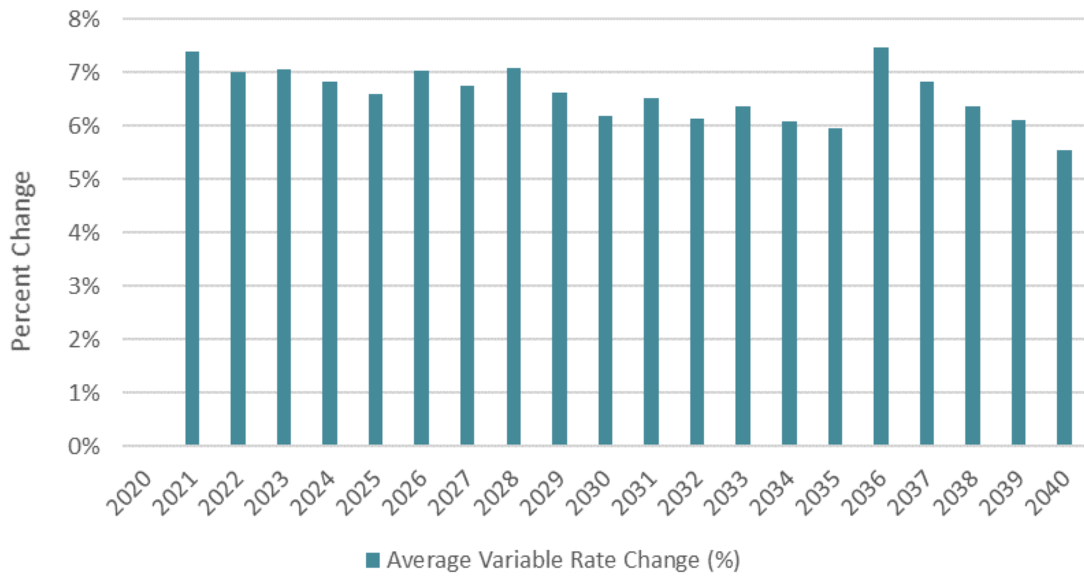
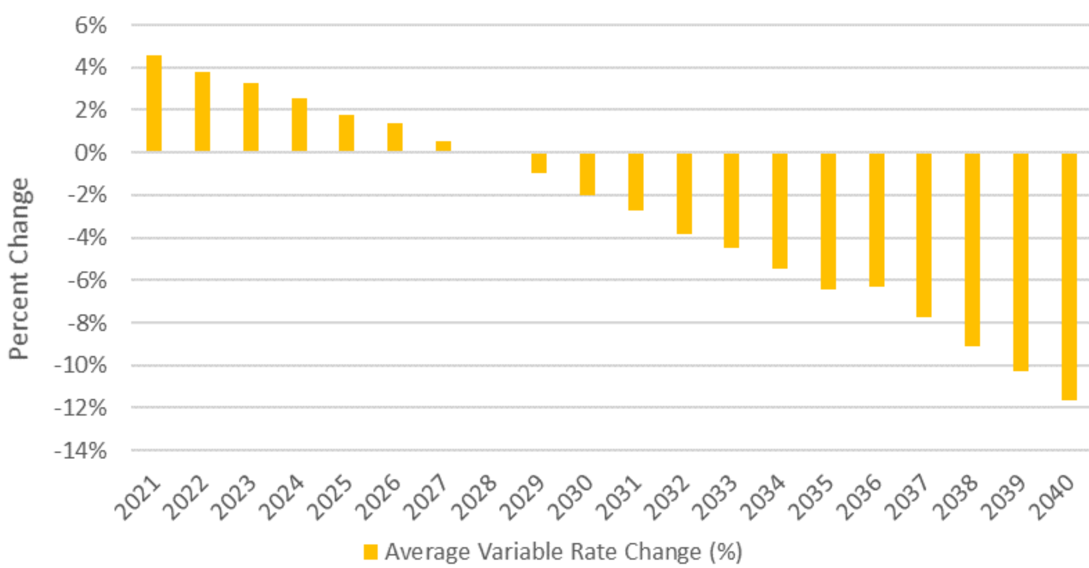


FIGURE 6-16 PA CHANGE IN AVERAGE C&I CUSTOMER AVERAGE REVENUE REQUIREMENT- VGS



Average annual bill impacts are shown in Table 6-6 by customer class for the program achievable scenario over a three, ten, and twenty-year period. Over the 20-year analysis timeframe and across all customers (both participants and non-participants), the average annual bill is expected to decrease, with savings expected to offset any additional rate increases that result from sustained efficiency program offerings. However, the average bill is expected to increase in both sectors across the shorter three-year timeframe.

TABLE 6-6 AVERAGE VGS BILL IMPACTS FOR THE PROGRAM ACHIEVABLE SCENARIO

	PA Potential Scenario		
Customer Class	Average Bill Impact (3 YR)	Average Bill Impact (10 YR)	Average Bill Impact (20 YR)
Residential	$56.50	$17.09	$27.48
C&I	$159.60	-$265.68	-$870.24

Table 6-7 shows the average bill impacts for participants and nonparticipants by customer class. For the program achievable scenario, Cadmus assumed participant savings would be 10% of baseline consumption. Average nonparticipant bills decrease slightly due to the decrease in rates. Participant bills decrease due to energy savings, in addition the decrease in rates.

TABLE 6-7 AVERAGE VGS PARTICIPANT AND NONPARTICIPANT BILL IMPACTS FOR THE PROGRAM ACHIEVABLE SCENARIO

Customer Type	Average Rate Change (%)	Nonparticipants		Participants	
		Average New Bill	Average Bill Impact	Average New Bill	Average Bill Impact
Residential	6.6%	$1,082	$67	$974	-$41
Non-Residential	-2.7%	$7,300	-$191	$6,570	-$921

APPENDIX A. Glossary of Terms

The following list defines many of the key terms used throughout report.

Achievable Potential: The November 2007 National Action Plan for Energy Efficiency "Guide for Conducting Energy Efficiency Potential Studies" defines achievable potential as the amount of energy use that energy efficiency can realistically be expected to displace assuming the most aggressive program scenario possible (*e.g.*, providing end-users with payments for the entire incremental cost of more efficient equipment). This is often referred to as maximum achievable potential. Achievable potential takes into account real-world barriers to convincing end-users to adopt efficiency measures, the non-measure costs of delivering programs (for administration, marketing, tracking systems, monitoring and evaluation, etc.), and the capability of programs and administrators to ramp up program activity over time.

Applicability Factor: The fraction of the applicable housing units or businesses that is technically feasible for conversion to the efficient technology from an engineering perspective (e.g., it may not be possible to install CFLs in all light sockets in a home because the CFLs may not fit in every socket in a home).

Avoided Costs: For purposes of this report, the electric avoided costs are defined as the generation, transmission and distribution costs that can be avoided in the future if the consumption of electricity can be reduced with energy efficiency or demand response programs.

Avoided Generation Capacity Supply Costs ($/kW-yr): These are the generation capacity costs that are avoided due to the implementation of demand response.

Avoided Transmission & Distribution ($/kW-yr): These are the transmission and distribution infrastructure costs that are avoided due to the implementation of demand response.

Base Case Equipment End-Use Intensity: The electricity used per customer per year by each base-case technology in each market segment. This is the consumption of the electric energy using equipment that the efficient technology replaces or affects. For example, if the efficient measure is a high efficiency light bulb (CFL), the base end-use intensity would be the annual kWh use per bulb per household associated with a halogen incandescent light bulb that provides equivalent lumens to the CFL.

Base Case Factor: The fraction of the market that is applicable for the efficient technology in a given market segment. For example, for the residential electric clothes washer measure, this would be the fraction of all residential customers that have an electric clothes washer in their household.

Coincidence Factor: The fraction of connected load expected to be "on" and using electricity coincident with the electric system peak period.

Coincident Peak Demand Reduction (kW): The total coincident (with the system peak) demand reduction for all program participants.

Commercial Sector: Comprised of non-manufacturing premises typically used to sell a product or provide a service, where electricity is consumed primarily for lighting, space cooling and heating, office equipment, refrigeration and other end uses. Business types are included in Section 5 – Methodology.

Cost-Effectiveness: A measure of the relevant economic effects resulting from the implementation of an energy efficiency measure or program. If the benefits are greater than the costs, the measure is said to be cost-effective.

Cumulative Annual: Refers to the overall annual savings occurring in a given year from both new participants and annual savings continuing to result from past participation with energy efficiency measures that are still in place. Cumulative annual does not always equal the sum of all prior year incremental values as some energy efficiency measures have relatively short lives and, as a result, their savings drop off over time.

Demand Response: Refers to electric demand resources involving dynamic hourly load response to market conditions, such as curtailment or load control programs.

Demand Side Management (DSM): The design, implementation, and analysis of customer-focused energy and demand use reduction programs.

Discount Rate: An interest rate applied to a stream of future costs and/or monetized benefits to convert those values to a common period, typically the current or near-term year, to reflect the time value of money. It is used in benefit-cost analysis to determine the economic merits of proceeding with the proposed project, and in cost-effectiveness analysis to compare the value of projects. The discount rate for any analysis is either a nominal discount rate or a real discount rate. A Nominal Discount Rate is used in analytic situations when the values are in then-current or nominal dollars (reflecting anticipated inflation rates).

Early Replacement: Refers to an energy efficiency measure or efficiency program that seeks to encourage the replacement of functional equipment before the end of its operating life with higher-efficiency units.

Economic Potential: The November 2007 National Action Plan for Energy Efficiency "Guide for Conducting Energy Efficiency Potential Studies" refers to the subset of the technical potential that is economically cost-effective as compared to conventional supply-side energy resources as economic potential. Both technical and economic potential ignore market barriers to ensuring actual implementation of efficiency. Finally, they only consider the costs of efficiency measures themselves, ignoring any programmatic costs (e.g., marketing, analysis, administration, evaluation) that would be necessary to capture them.

End-Use: A category of equipment or service that consumes energy (*e.g*., lighting, refrigeration, heating, process heat, cooling).

Energy Efficiency: Using less energy to provide the same or an improved level of service to the energy consumer in an economically efficient way. Sometimes "conservation" is used as a synonym, but that term is usually taken to mean using less of a resource even if this results in a lower service level (*e.g*., setting a thermostat lower or reducing lighting levels).

Energy Use Intensity (EUI): A unit of measurement that describes a building's energy use. EUI represents the energy consumed by a building relative to its size.[38]

Free Rider: Participants in an energy efficiency program who would have adopted an energy efficiency technology or improvement in the absence of a program or financial incentive.

Gross Savings: Gross energy (or demand) savings are the change in energy consumption or demand that results directly from program-promoted actions (e.g., installing energy-efficient lighting) taken by program participants regardless of the extent or nature of program influence on their actions.

Incentive Costs: A rebate or some form of payment used to encourage electricity consumers to implement a given demand-side management (DSM) technology.

Incremental: Savings or costs in a given year associated only with new installations of energy efficiency or demand response measures happening in that specific year.

Industrial Sector: Comprised of manufacturing premises typically used for producing and processing goods, where electricity is consumed primarily for operating motors, process cooling and heating, and space heating, ventilation, and air conditioning (HVAC). Applicable business types are included in section 5 – Methodology.

[38] See http://www.energystar.gov/index.cfm?fuseaction=buildingcontest.eui

Inflation: The periodic rate at which general consumer prices increase. The General Inflation Rate is normally determined as an historical trend, using the Consumer Price Index (CPI) as published by the U.S. Bureau of Labor Statistics.

Maximum Achievable: An achievable potential scenario which assumes incentives for program participants are equal to 100% of measure incremental or full costs.

Measure: Any action taken to increase energy efficiency or demand response, whether through changes in equipment, changes to a building shell, implementation of control strategies, or changes in consumer behavior. Examples are higher-efficiency central air conditioners, occupancy sensor control of lighting, and retro-commissioning. In some cases, bundles of technologies or practices may be modeled as single measures. For example, an ENERGY STAR® ™ home package may be treated as a single measure.

MMBtu: A measure of power, used in this report to refer to consumption and savings associated with natural gas consuming equipment. One British thermal unit (symbol Btu or sometimes BTU) is a traditional unit of energy equal to about 1055 joules. It is the amount of energy needed to heat one pound of water by one degree Fahrenheit. MMBtu is defined as one million BTUs.

MW: A unit of electrical output, equal to one million watts or one thousand kilowatts. It is typically used to refer to the output of a power plant.

MWh: One thousand kilowatt-hours, or one million watt-hours. One MWh is equal to the use of 1,000,000 watts of power in one hour.

Net-to-Gross Ratio: A factor representing net program savings divided by gross program savings that is applied to gross program impacts to convert them into net program load impacts.

Net Savings: Net energy or demand savings refer to the portion of gross savings that is attributable to the program. This involves separating out the impacts that are a result of other influences, such as consumer self-motivation. Given the range of influences on consumers' energy consumption, attributing changes to one cause (i.e., a particular program) or another can be quite complex.

Non-Incentive Acquisition Cost: Costs incurred by the utility that do not include incentives paid to the customer (i.e.: program administrative costs, program marketing costs, data tracking and reporting, program evaluation, etc.)

Reserve Margin: The difference between the dependable capacity of a utility's system and the anticipated peak load for a specified period.

Spillover: Additional energy efficiency actions taken by program participants as a result of program influence, but actions that go beyond those directly subsidized or required by the program.[39]

Technical Potential: The theoretical maximum amount of energy use that could be displaced by energy efficiency, disregarding all non-engineering constraints such as cost-effectiveness and the willingness of end-users to adopt the energy efficiency measures.

Useful Life (Years): The number of years that a measure is assumed to operate before needing to be replaced.

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[39] The definitions of participant and nonparticipant spillover were obtained from the National Action Plan for Energy Efficiency Report titled "Model Energy Efficiency Program Impact Evaluation Guide", November 2007, page ES-4.

APPENDIX B. Low-Income Equity Methodology

Low-income sector equity requirements assumed for Program Achievable Potential and EEU program models are different for EVT, BED, and VGS. The low-income sector equity is based on the estimated number of low-income households in each service territory and an estimate of how much this population contributed to the resource acquisition budget in 2019. Associated calculations are documented in the attached Excel spreadsheet file titled EEU Modeling Assumptions on the tabs titled EVT BED Low Income % Spending and VGS Low Income Calc. The low-income equity modeling assumption for each service territory is quantified as a minimum percent of an EEUs resource acquisition budget dedicated to low-income programs as described below.

The number of low-income households in the EVT and BED service area that are at or below 80% median income has been estimated using the 2015 Vermont Housing Needs Assessment (VHNA) commissioned by the Vermont Department of Housing and Community Development[40]. The number of VGS low-income households that are at or below a combination of 60% and 80% at or below median income has been estimated using the number of VGS customers on the VGS residential low-income rate, low-income energy assistance plan (LIEAP) customers, and supplemental estimates from the Vermont residential baseline assessment.

For EVT and BED, the total number of residential customers is approximately 296,600. BED's has approximately 17,000 residential electric meters and EVT has approximately 279,600. Therefore, BED has approximately 6% of the residential meters and EVT has approximately 94%. The VHNA estimates approximately 91,500 owner owned low-income households statewide. For EVT's service territory it is estimated that 86,000 owner owned low-income households exist (91,500 X 94% = 86,000). For EVT's service territory this approach estimates approximately 31% of the residential customers as being owner owned low-income households (86,000/279,6000 = 31%). For BED's service territory it is initially estimated that 5,490 (91,500 X 6% = 5,490) owner owned low-income households exist. However, does not square with Burlington's Community Economic Development Office (CEDO) estimate that approximately 12% of the residential sector is low-income which estimates 2,040 low-income households (17,000 X 12% = 2,040). So, the difference is attributed to a greater proportion of the low-income population in BED's service area are in rentals compared to the rest of the state. For BED's service territory this approach estimates approximately 12% of the residential customers as being owner owned low-income households (2,040/17,000 = 12%).

In VGS territory it is estimated that a total of 4,200 low-income households exist. This is a combination of approximately 2,130 customers on the VGS residential low-income rate, 300 low-income energy assistance plan (LIEAP) customers, and 1,775 supplemented from the total estimated in the Vermont residential baseline assessment (2,130 + 300 + 1,770 = 4,200). Of VGS's 46,725 residential customers approximately 9% are owner occupied (4,200/46,725 = 9%)

BED. Per the method described above it is estimated that 12% of BED's residential customers are low-income and that this population will contribute approximately $76,400 to BED's EEC resource acquisition budget in 2019. This is based on the estimate that the average low-income household uses 4,250 kWh annually in BED territory times the number of households, times the residential EEC rate for BED in 2019, times the percentage of the resource acquisition portion of EEC collections (2,040 X 4,250 X $0.0095 X 93% = $76,400).

[40] https://accd.vermont.gov/sites/accdnew/files/documents/Housing/H-Research-VTHousingNeedsAssessment.pdf.pdf

In 2019 BED's total resource acquisition budget is $2,544,500 and an estimated $76,400 was contributed by the low-income sector which is approximately 3% of the resource acquisition budget for 2019 ($76,400 / $2,544,500 = 3%).

Therefore, the models should assume no less than 3% of the resource acquisition budgets be dedicated to low-income programs ($76,400/$2,544,500 = 3%). This includes both single-family and multifamily low-income program spending.

EVT. Per the method described above it is estimated that 31 % of EVT's residential customers are low-income and that this population will contribute approximately $5,239,900 to EVT's EEC resource acquisition budget in 2019. This is based on the estimate that the average low-income household uses 6,887 kWh annually in EVT territory times the number of households, times the residential EEC rate for EVT in 2019, times the percentage of the resource acquisition portion of EEC collections (6,887 X 5,165 X $0.0128 X 88% = $5,001,689).

In 2019 EVT's total resource acquisition budget is $44,123,600and an estimated $5,001,689 was contributed by the low-income sector which is approximately 11% of the resource acquisition budget for 2019 ($5,001,689/ $44,123,600 = 11%).

Therefore, the models should assume no less than 11% of the resource acquisition budgets be dedicated to low-income programs ($5,239,900/$44,123,600 = 11%). This includes both single-family and multifamily low-income program spending.

VGS. Per the method described above it is estimated that 9% of VGS's residential customers are low-income and that this population will contribute approximately $147,500 to VGS's EEC resource acquisition budget in 2019. This is based on the estimate that the average low-income household uses 88.5 Mcf annually in VGS territory times the number of households, times the residential EEC rate for VGS in 2019, times the percentage of the resource acquisition portion of EEC collections (88.5 X 4,200 X $0.448 X 92% = $147,474).

In 2019 VGS's total resource acquisition budget is $3,014,400 and an estimated $147,474 was contributed by the low-income sector which is approximately 5% of the resource acquisition budget for 2019 ($147,474/ $3,014,400 = 5%).

Therefore, the models should assume no less than 5% of the resource acquisition budgets be dedicated to low-income programs ($147,500/$3,014,400 = 5%). This includes both single-family and multifamily low-income program spending.

APPENDIX C. EVT Measure Level Data & Savings Summary

Available Upon Request

APPENDIX D. BED Measure Level Data & Savings Summary

Available Upon Request

APPENDIX E. VGS Measure Level Data & Savings Summary

Available Upon Request

APPENDIX F. Additional Rate & Bill Analysis Detail

Available Upon Request

VERMONT DEPARTMENT OF PUBLIC SERVICE

VT Energy Efficiency Market Potential Study

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