
# Vermont Building Energy Code

## *Roadmap to Net-Zero Energy Design by 2030*

Vermont has multiple statutory requirements, state policies and energy goals regarding efficient energy use. Using the statutorily-required energy code update process to gradually transition to highly-efficient and resilient buildings that could generate as much renewable energy as they use to operate is a step to reaching our goals. This factsheet provides some background on what this might mean for energy codes in Vermont for the code cycles from 2020 to 2030. Below are some of our energy targets that net-zero energy buildings can help achieve:

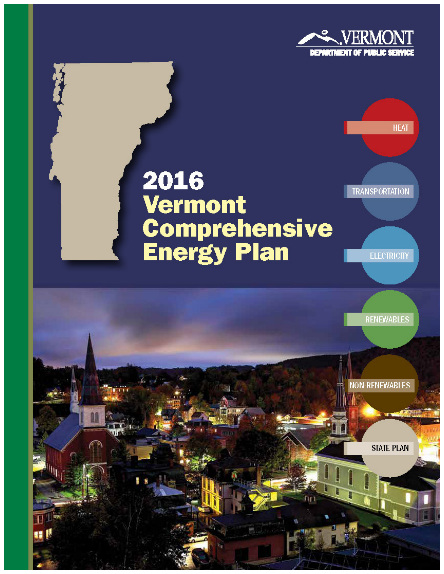
- **Comprehensive Energy Plan:** All new buildings designed to be net-zero design by 2030 and raise wood's share of building heat to 35% by 2030[1]
- **Greenhouse Gas Emissions:** Reduce greenhouse gas emissions by 50% of 1990 levels by 2028, and by 75% by 2050[2]
- **Paris Agreement:** Reduce Greenhouse Gas emissions by 26-28% below 2005 levels by 2025[3]
- **Renewable Energy Standard Tier 3:** Utilities must reduce fossil fuel consumption for their customers equal to 2% of utility sales rising to 12% in 2032[4]

Map out a path for Vermont energy code progression to achieve the goal of having all new buildings constructed to net-zero design by 2030.

*Vermont Comprehensive Energy Plan, 2016*

### Building Energy Codes and Setting the Foundation for Net-Zero Design

Energy codes are an important lever to drive efficiencies in new construction projects. Many jurisdictions are developing energy code roadmaps, to set a vision for incremental efficiency increases for intervening code cycles.




1 2016 Vermont Comprehensive Energy Plan: https://publicservice.vermont.gov/publications-resources/publications/energy_plan/2015_plan

2 10 V.S.A. § 578. Greenhouse gas reduction goals: https://legislature.vermont.gov/statutes/section/10/023/00578

3 Paris Climate Agreement. Vermont Joined 2017: https://unfccc.int/process-and-meetings/the-paris-agreement/the-paris-agreement

4 30 V.S.A. § 8002. Renewable Energy Programs: https://legislature.vermont.gov/statutes/section/30/089/08002

## What Does "Net-Zero Design" Mean?

There are a variety of definitions for "net-zero" and a variety of degrees at which the goals of net-zero are set and achieved. The Vermont Public Service Department (DPS) is committed to working with stakeholders to develop a definition of "net-zero design" for use in Vermont. Further, the DPS will continue to seek out stakeholder input and feedback through future code updates. Here are three of the most widely used definitions:

1. The U.S. Department of Energy defines **zero energy buildings (ZEB)** as an "energy-efficient building where, on a source energy basis, the actual annual delivered energy is less than or equal to the on-site renewable exported energy[5]." Likewise, in California, the State Administrative Manual (SAM) Section 1815.31 defines **zero net energy (ZNE)** as: "Energy Efficient building that produces as much clean renewable energy as it consumes over the course of a year, when accounted for at the energy generation source.[6]
2. The U.S. Department of Energy also specifically defines a **zero energy ready** home as "a high performance home which is so energy efficient, that a renewable energy system can offset all or most of its annual energy consumption[7]." This allows the home or building owner to focus their initial efforts on making the building as efficient as possible while including the capability for renewables to be added on at a later date.
3. New Buildings Institute defines **zero energy (ZE)** accordingly: ZE buildings are ultra-low energy buildings that consume only as much power as is generated onsite through renewable energy resources over the course of a year[8].

The three case studies provided in this document show a variety of approaches that could be considered.

**Energy Use Intensity (EUI)** is a metric that defines total energy use per building square foot and is the most commonly used metric for comparing and evaluating energy data. This includes energy consumption from all sources (grid-delivered and onsite-generated electricity, natural gas, district energy, and delivered fuels) in thousands of British Thermal Units (kBtu) per year and is divided by the building size in gross square feet. The metric for EUI is written as kBtu/sf/year.

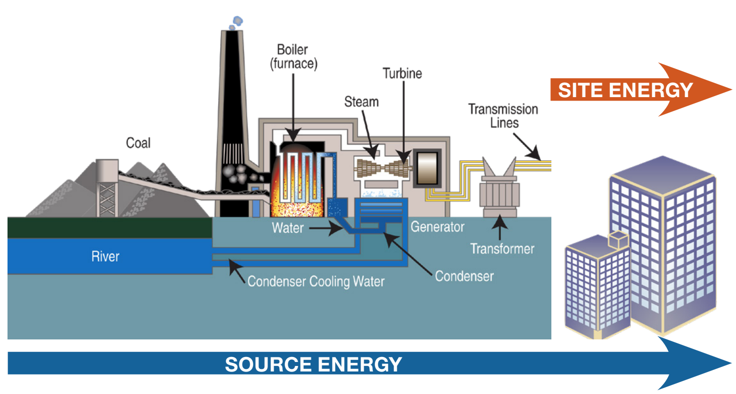
The two main types of EUI are Site EUI and Source EUI. A key consideration for net-zero definitions—one not yet decided upon in Vermont—is at what point the energy use is measured, at the "site" or the "source". This has the most impact on electricity generation which is produced by burning fossil fuel—in this case, less than one-third of the energy consumed at the power plant is delivered to the building.

## Key Terms

- **Energy =** All energy (electric, gas, steam, liquid fuel etc.) consumed on site.
- **Net =** One year or more of renewable energy production minus energy use.
- **EUI =** Energy Use Intensity in kBtu/sf/yr - metric of energy performance (see sidebar).
- **Site =** Total energy used onsite.
- **Site EUI =** is calculated with the total energy use of the building at the meter or site boundary, regardless of the source. Natural gas, electricity, and solar PV, and delivered fuels such as liquid propane, oil and wood are all converted to one unit (kBtu) and counted together.
- **Source =** Total upstream energy required.
- **Source EUI =** Takes into account the total upstream energy the building consumes, including fuel extraction transmission and delivery and production losses, which means it's always larger than or equal to the site EUI.

The exact difference between the site and source EUI is a function of the fuel mix delivered to the building, as well as the building's location.

- **Source Energy =** Represents the total amount of raw fuel that is required to operate the building. It incorporates all fuel extraction, transmission, delivery, and production losses.




5 U.S. Department of Energy. A Common Definition for Zero Energy Buildings: https://www.energy.gov/sites/prod/files/2015/09/f26/A%20Common%20Definition%20for%20Zero%20Energy%20Buildings.pdf

6 U.S. Department of Energy. Zero Energy Ready Homes: https://www.energy.gov/eere/buildings/doe-zero-energy-ready-home-partner-central

7 State Administrative Manual (SAM) Section 1815.31: https://www.dgs.ca.gov/Resources/SAM

8 New Buildings Institute Zero Energy Definition: https://newbuildings.org/hubs/zero-energy/

## Case Study #1

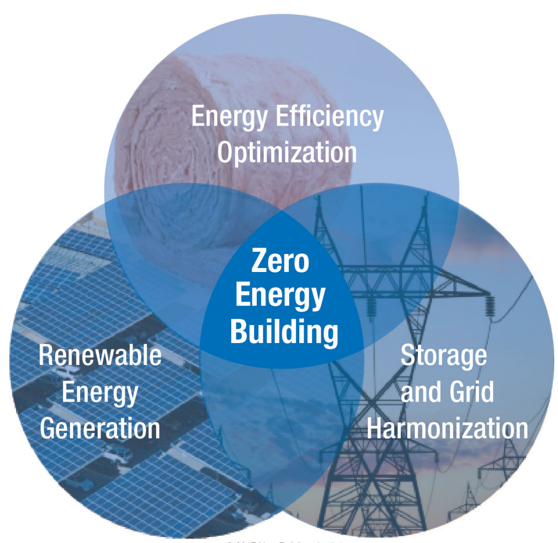
### McKnight Lane | Waltham, VT

Fourteen unit development utilizing VERMOD homes. Each unit has a 6-kW rooftop solar array and sonnen eco 6kWh AC battery for energy storage.

| | |
|---|---|
| **Construction status** | Completed in 2016 |
| **Developer/Designer Team** | Cathedral Square (developer), Addison County Community Trust (owner/manager) |
| **Heat** | 12 kBtu ductless air source heat pump in each home |
| **Hot Water** | 50 gallon heat pump water heater |
| **Ventilation** | CERV demand-controlled energy recovery ventilation system |
| **Renewables** | 6 kW roof-mounted solar PV |
| **Total Square Footage / Conditioned Floor Area** | 980 to outside of thermal envelope, 816 conditioned floor area |
| **Roof (R-value)** | R-60 |
| **Exterior Wall (R-value)** | R-43 |
| **Window U Value** | U-.210 |
| **Insulated floor assembly (R-value)** | 40 |
| **Sub Slab on Grade (R-value)** | N/A |
| **Air infiltration - CFM50/s.f. of above grade surface area** | 0.02 |

## Net-Zero Energy Buildings and Vermont's Building Grid Interactions in the Age of Net-Zero

For a century, electricity has flowed only one way: from the power plant to the building. This long-established paradigm is changing quickly as distributed renewables and NZE buildings come online. As more Vermont buildings include distributed energy generation and achieve low/zero net energy consumption levels, it is essential that reductions in grid impacts be designed into buildings and be encouraged by building codes. A "Grid-Integrated Efficient Building" is an efficient, connected and smart building with a portfolio of interoperable technologies that can adjust demand up or down and shift, store, or dispatch electric load in response to grid and building needs.



## Other State's Zero Energy Policies

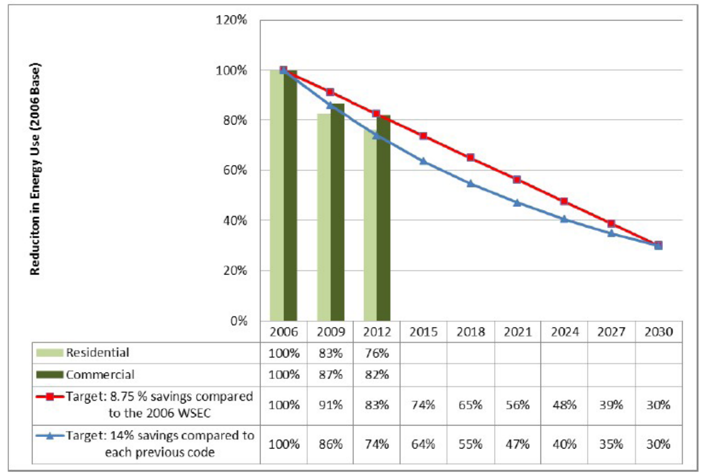
Other state's have established zero energy policies and goals that Vermont could reference and consider. Some of these are included below.

**Washington State:** Residential and Nonresidential construction permitted under the 2031 state energy code must achieve a 70 percent reduction in annual net energy consumption (compared to the 2006 state energy code).[9]

**California Title 24 – The First ZNE Roadmap**

California's Global Warming Law (AB32), the California Public Utilities Commission, and the California energy Commission have all contributed to the state's 2020 goal for a net-zero residential code and a 2030 goal for a net-zero commercial code.[10]

**Incremental Code Improvement Compared to Targets**




9 Washington State RCW 19.27A.160 Residential and nonresidential construction—Energy consumption reduction: https://app.leg.wa.gov/RCW/default.aspx?cite=19.27A.160

10 California AB 32 Global Warming Solutions Act of 2006: https://ww3.arb.ca.gov/cc/ab32/ab32.htm

## Case Study #2

### Vergennes Community Housing | Vergennes, VT

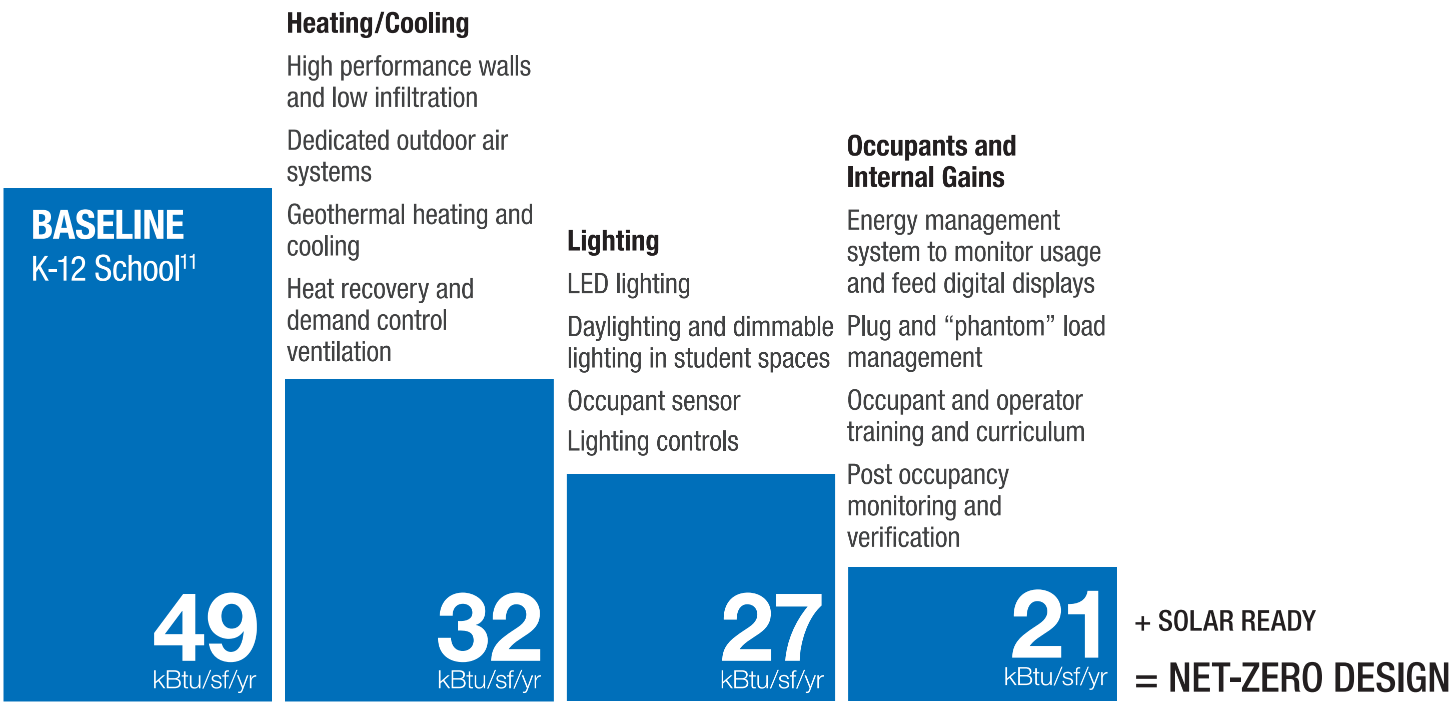
Twenty-four mixed income units with a high-performance envelope and passive house air sealing standards that will greatly reduce the energy load of the building.

| | |
|---|---|
| **Construction status** | Construction start: August 2019 |
| **Developer/Designer Team** | Housing Vermont (developer), Addison County Community Trust |
| **Heat** | Natural gas hydronic heat |
| **Hot Water** | Direct-fire condensing boiler (natural gas) |
| **Ventilation** | Whole building energy recovery ventilator with tempered air provided by DX cooling and natural gas fired heater. |
| **Renewables** | Solar is being bid separately |
| **Total Square Footage / Conditioned Floor Area** | 23,500 |
| **Roof (R-value)** | 44 |
| **Exterior Wall (R-value)** | 31.25 |
| **Window U Value** | 0.21 |
| **Slab Edge (R-value)** | 15 |
| **Sub Slab on Grade (R-value)** | 10 |
| **Air infiltration - CFM50/s.f. of above grade surface area** | 0.05 |

## Setting Performance Targets for Individual Net-Zero Energy Buildings

Each building has its own unique set of challenges and opportunities in working towards net-zero. Shown below are general guidelines and how they were applied to a net-zero design Elementary School project in the Northeast. Design considerations to achieve zero energy could include the following steps:

- Use integrated design to achieve absolute energy performance levels for each energy system instead of designing to simply "% better than code"
- Couple with other sustainability goals and policies
- Consider solar capacity on roof and/or campus
- Use the technical design and benchmarks to set appropriate energy targets and solar budgets




### NZE Targets for Vermont Schools (ASHRAE, 2018)

This Guide for K-12 Schools was developed through the collaboration of ASHRAE, the American Institute of Architects (AIA), the Illuminating Engineering Society (IES), and the U.S. Green Building Council (USGBC), with support from the U.S. Department of Energy (DOE).

The NZE energy design targets for schools in Vermont's climate zone 6A are to the right.[12]


| Site Energy | |
|---|---|
| Primary School EUI, kBtu/ft² yr | Secondary School EUI, kBtu/ft² yr |
| 21.1 | 20.6 |
| **Source Energy** | |
| Primary School EUI, kBtu/ft2 yr | Secondary School EUI, kBtu/ft2 yr |
| 62.8 | 61.2 |

11 CBECS 2012 Data: https://portfoliomanager.energystar.gov/pdf/reference/US%20National%20Median%20Table.pdf

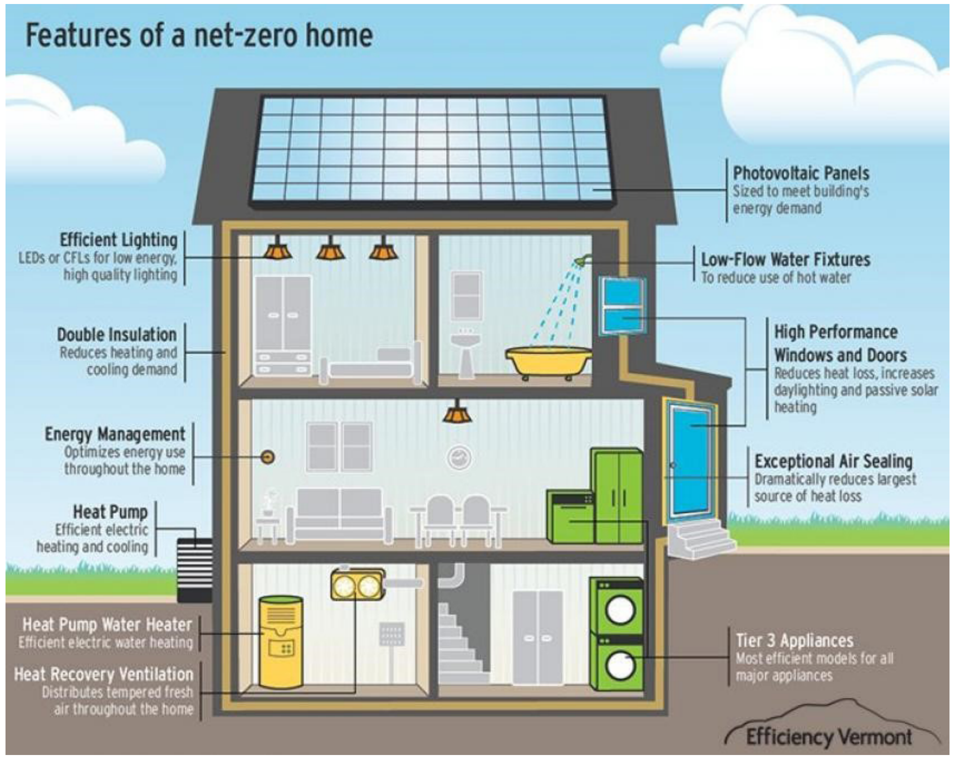
12 AEDG Guide NZE EUI Feasibility Targets for Vermont Climate Zone AEDG Targets: https://www.ashrae.org/technical-resources/aedgs/zero-energy-aedg-free-download

## What Could This Mean For Vermont Residential Building Energy Standards (RBES)?

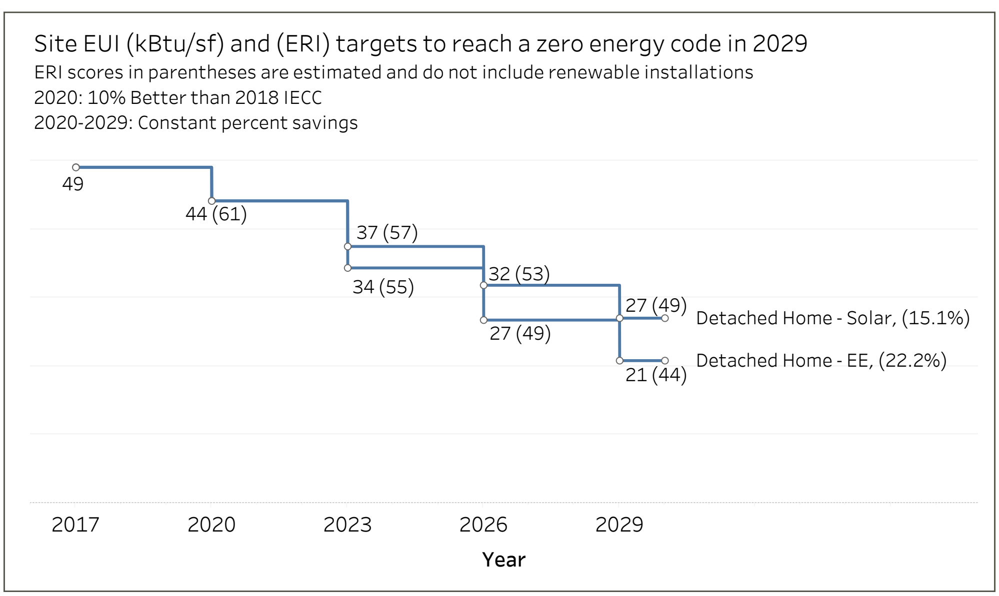
The image to the right shows the various features that commonly comprise a net-zero home. In future code updates, it is envisioned that the areas and measures that will most likely see the greatest improvements in efficiency (or, the greatest areas of increased stringency in code) include:

- Air leakage reduction
- Continuous insulation
- Distributed mechanical ventilation
- Triple glazed windows

However, with each code update, technical developments in efficiency measures and generation technologies will be assessed to find the most cost-effective, affordable transition to net-zero energy design by 2030. For example, during the 2020 code update process, triple glazed windows were not required since they are currently not cost-effective at today's window prices and fuel costs. However, it is expected that the cost of high-performance windows will decline over the next decade, so they may be a measure to assist in achieving net-zero energy design by 2030.




A potential path to net-zero-ready design residential codes is shown below for two scenarios: one with a maximum level of solar power and one with a more efficient energy performance. The former scenario would include a 15.1% increase in efficiency each cycle; the latter would see a 22.2% increase each cycle. For each code improvement cycle, related Energy Rating Index (ERI) or Home Energy Rating System (HERS) scores are shown along with the expected energy use levels. HERS is the nation's most widely used home rating system. The ERI is a standardized version of HERS used in energy codes, including the IECC.

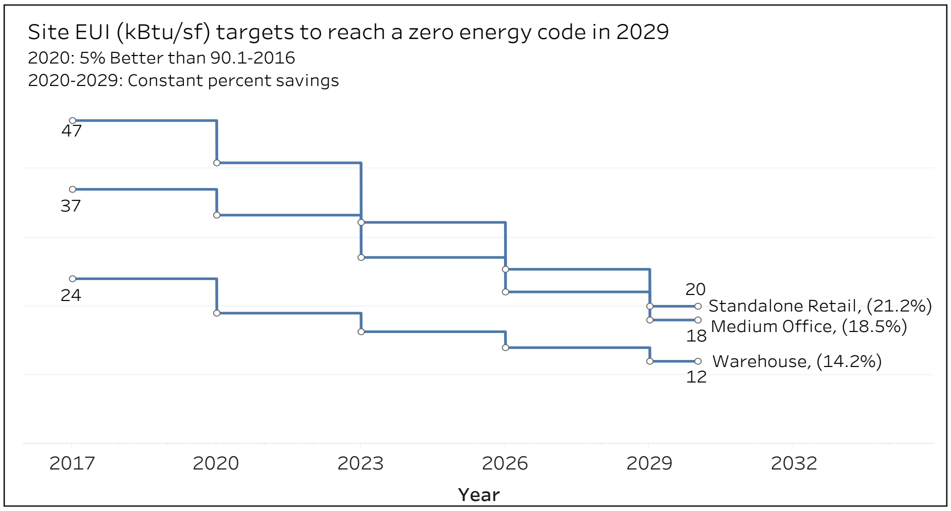


## What Could This Mean For Vermont Commercial Building Energy Standards (CBES)?

A graphical representation of code improvements for office, retail and warehouse building-types along with a table summarizing all building types is presented below.

A variety of data sources were used to set the 2029 code cycle energy use index (EUI) targets for the eight building types: retail, office, warehouse, high-rise and mid-rise residential units, and primary and secondary schools. The information was tailored around national prototype building specifications used by the US Department of Energy. The EUI target interim steps to 2030 were calculated assuming a constant percentage increase in stringency each code cycle.

### Code-level Energy Use Targets for Three Building Types (2017-2029)




### Data Sources for Vermont Targets

| Label | Source | Description |
|---|---|---|
| 90.1-2016 | PNNL Modeling Data for 90.1-2016 | Prototype modeling |
| CBECS 2012 | CBECS 2012 | Commercial building stock performance |
| Getting to Zero Tracker | NBI Getting to Zero Tracker | Existing zero energy building performance |
| Standard 100 | ASHRAE Standard 100 | ASHRAE Standard 100 energy targets |
| NREL School Feasibility | NREL - School Technical Feasibility | Maximum achievable energy performance study |
| ARUP CA Feasibility | ARUP - California Technical Feasibility | Maximum achievable energy performance study |
| Glazer Max Tech | GARD Analytics - Max Tech Potential | Maximum achievable energy performance study |
| Toronto | Toronto Zero Emissions Framework | Toronto zero energy performance targets |

### Building Type Information

| Building Type | CBECS 2012 | Building Models | Getting to Zero Tracker |
|---|---|---|---|
| Medium Office | 10k-100k sf | 53,600 sf, 3 floors | 10k-100k sf |
| Medical Office | All sizes | N/A | N/A |
| Primary School | All sizes | 73,960 sf, 1 floor | All Sizes |
| Secondary School | All sizes | 210,900 sf, 2 floors | All Sizes |
| Mid-rise Multifamily | N/A | 33,600 sf, 4 floors | All Sizes |
| High-rise Multifamily | N/A | 84,360 sf, 10 floors | N/A |
| Warehouse | All Sizes | 49,495 sf, 1 floor | N/A |
| Large Hotel | N/A | 122,132 sf, 7 floors | N/A |
| Standalone Retail | All Sizes | 25,00 sf, 1 floor | N/A |

## Case Study #3

### **Waitsfield Town Offices** | Waitsfield, VT

"Net-zero" town offices with vault, research space, meeting room and two full bathrooms. Six full-time occupants during weekdays (8-5) and community meetings two to three nights per week (10-20 people).

| | |
|---|---|
| **Construction status** | Completed in 2016 |
| **Developer/Designer Team** | Maclay Architects (architect) |
| **Heat** | Cold climate air source heat pumps |
| **Hot Water** | Two instantaneous tankless hot water heaters |
| **Ventilation** | Whole building energy recovery ventilator |
| **Renewables** | 100 kW solar array at town garage provides 17kW needed by building. |
| **Total Square Footage / Conditioned Floor Area** | 4,389 |
| **Roof (R-value)** | 60 |
| **Exterior Wall (R-value)** | 40 |
| **Window U Value** | 0.23 |
| **Slab Edge (R-value)** | 12 |
| **Sub Slab on Grade (R-value)** | 20 |
| **Air infiltration - CFM50/s.f. of above grade surface area** | 0.075 - 5 sides<br>0.057 - 6 sides |


## Where To From Here?

With each building energy code update, technical developments in efficiency measures and generation technologies will be assessed to find the most cost-effective, affordable transition to net-zero energy design by 2030. For the 2020 CBES updates the primary areas of efficiency improvement are in the lighting and envelope sections. In subsequent code updates, the focus will likely be on mechanical efficiency improvements. For RBES, the primary areas of efficiency are building envelope and air tightness verification.

Transitioning to net-zero energy design by 2030 is an evolving process in Vermont. Various issues still need to be discussed with stakeholders and decided on by the State, including:

- Which of the multiple definitions of net-zero design will be adopted in Vermont?
- Will net-zero design in Vermont be determined at the site or source level?
- What role does advanced wood heating play in Vermont's transition to net-zero energy?

Further, there are a variety of issues that are separate but integrally linked to the code update process, the roadmap to net-zero energy design by 2030 and achieving Vermont's multiple statutory requirements and policy goals.

For additional information on the Vermont Energy Code Roadmap and the Energy Code Development process, visit:
https://publicservice.vermont.gov/content/building-energy-standards