VERMONT
DEPARTMENT OF PUBLIC SERVICE

2022 Vermont Comprehensive Energy Plan

• Electricity • Thermal • Transportation

VERMONT
DEPARTMENT OF PUBLIC SERVICE

Dear Fellow Vermonters:

In January 2017, I accepted the appointment from Governor Phil Scott to serve as the Commissioner of the Department of Public Service because I welcomed the public trust and responsibility of ensuring that Vermont's energy policy is grounded on a foundation of facts and robust analysis, and to engage with Vermonters to hear how Vermont can best ensure energy needs are being met affordably, reliably, and in an environmentally sound manner. Vermont energy policy is brought to life by the Comprehensive Energy Plan.

Within this document, current energy challenges are identified, and policies, strategies, and recommendations to address those challenges are discussed in the context of statutory energy policy principles articulated in 30 V.S.A. § 202a. The plan transparently describes the tradeoffs inherent in each policy framework, including impacts to energy consumption, cost, and emissions; and, it highlights what may be needed in specific program design to ensure an equitable energy future. At a time when our national political and policy discourse is plagued by heedless partisanship, insidious assertions of "fake news," and the absurd notion of positing the prerogative of invoking "alternative facts" when attacking reason, science, and verifiable data, Vermont continues to be a place where we can sit down with our neighbors and – in a clear-eyed, respectful, and transparent manner – agree on facts and discuss the inherent tradeoffs involved when pursuing any policy. This Comprehensive Energy Plan seeks to lay the foundation for those discussions in energy policy.

Of course, it does so in a time when Vermont continues to struggle with the ongoing COVID-19 pandemic, when racial and economic justice have finally emerged as policy principles, and when energy burden remains high. I am proud that this plan places equity at the forefront of energy policy discussion, recognizing that the benefits and burdens of energy policy have not historically been equitably distributed. I am proud that in this plan the authors place equity at the forefront of energy policy discussion, where the equity considerations are intended to become a core criterion for decision-making, along with the traditional statutory principles, designed to root out and address existing inequities.

Technological advancements over the last decade have set the foundation for a just and equitable transition to a more affordable, cleaner, more efficient, and more reliable energy future for Vermont's residents and businesses. I also want to underscore the discussion in this plan of the challenges and tradeoffs inherent in evolving to a secure, resilient grid that can efficiently integrate even more renewable and distributed energy resources while remaining an affordable platform for Vermonters to electrify – and thus decarbonize – our heating and transportation needs.

I hope you find this plan informative, and that it encourages action, big or small, to ensure our energy requirements are met consistent with Vermonters' needs and with State Energy Policy.

June E. Tierney
Commissioner, Department of Public Service

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Errata and Technical Corrections

Date	Nature of Change

Executive Summary

Vermont is at a moment of great opportunity to take control of its energy future. Technology changes over the last decade have set the foundation for a just and equitable transition to a more affordable, cleaner, more efficient, and more reliable energy future for Vermont's residents and businesses. Even though significant challenges remain and the transition will take time to implement, the recent advances in technology, strategy, and application have positioned Vermont to make significant strides in the next decade and beyond — strides that will enable us to maintain and reestablish the principles of state energy policy, as set forth in 30 V.S.A. § 202a:

> *To ensure to the greatest extent practicable that Vermont can meet its energy service needs in a manner that is adequate, reliable, secure, and sustainable; that ensures affordability and encourages the State's economic vitality, the efficient use of energy resources, and cost-effective demand-side management; and that is environmentally sound.*
>
> *To identify and evaluate, on an ongoing basis, resources that will meet Vermont's energy service needs in accordance with the principles of reducing greenhouse gas emissions and least-cost integrated planning, including efficiency, conservation, and load management alternatives; wise use of renewable resources; and environmentally sound energy supply.*
>
> *To meet Vermont's energy service needs in a manner that will achieve the greenhouse gas emissions reductions requirements pursuant to 10 V.S.A § 578 and is consistent with the Vermont Climate Action Plan adopted and updated pursuant to 10 V.S.A. § 592.*

This Comprehensive Energy Plan balances the principles articulated in 30 V.S.A. § 202a of energy adequacy, reliability, security, and affordability, which are all essential for a vibrant, resilient, and robust economy and for the health and well-being of all Vermonters. It also recognizes that the current energy system is marked by systemic inequities that have a disproportionate impact on many of Vermont's communities, in terms of issues such as energy burden and access to renewable energy opportunities. When approached through the lens of equity and justice, the transition required to meet Vermont's renewable energy goals and GHG reduction requirements presents us with opportunities to root out and redress those existing inequities.

This CEP advances these guiding principles through pathways, strategies, and recommendations found throughout the plan, building on and re-establishing the high-level goals set in the 2011 and 2016 CEPs: **Meet 25% of energy needs from renewable sources by 2025, 45% by 2035, and 90% by 2050.**

This Comprehensive Energy Plan is structured to meet the greenhouse gas requirements of the Global Warming Solutions Act, and to be consistent with the Climate Action Plan required by 10 V.S.A. §592. In addition, and in support of the greenhouse gas reduction requirements and the top-level goal above, this CEP establishes — or reestablishes — the following set of goals:

The Global Warming Solutions Act requires the following reductions in greenhouse gases:

- 26% reduction from 2005 levels by 2025
- 40% reduction from 1990 levels by 2030
- 80% reduction from 1990 levels by 2050.

- In the **transportation sector**, meet 10% of energy needs from renewable energy by 2025, and 45% by 2040.
- In the **thermal sector**, meet 30% of energy needs from renewable energy by 2025, and 70% by 2042.
- In the **electric sector**, meet 100% of energy needs from carbon-free resources by 2032, with at least 75% from renewable energy.

These targets will not be easy to reach, particularly in the transportation and thermal sectors. They provide a vision, and this CEP articulates the pathways, strategies, and specific recommendations for actions aimed at meeting them. At a high level, the 2022 CEP continues building on themes from previous plans, with additional insight and knowledge from more recent experience:

- The burdens and benefits of energy policy in Vermont have not been equitably distributed across the state or its citizens. Strategies in this plan will consider both the historical distribution of impacts and those impacts that will occur with energy policy action.
- Transformational changes to the way Vermont generates, delivers, and uses electricity are upon us. The electric grid must be optimized to ensure resilience and responsiveness, and to benefit all electric consumers. This plan will provide a structure to guide the course of a highly dynamic, distributed, resilient future electric grid.
- Vermont's energy policy is interconnected with the health and economic well-being of Vermonters. Energy policy needs to consider non-energy-related objectives that can be advanced with action in the energy sphere.
- Efficiency continues to be the most cost-effective first resource, and can and should be structured to equitably distribute the benefits to the Vermonters most in need.
- Innovation in technology and policy will continue to be necessary to achieve the needed energy transition affordably, reliably, and equitably.

To keep moving toward our targets, Vermont must acknowledge that the goals articulated by the Legislature's energy policy can at times be in conflict. Those conflicts cannot be a cause for inaction; instead they must help us improve policy and prioritize the actions that should be supported. Even though all decisions will not please all people all the time, the decisions made under ever-changing circumstances cannot happen under cover. To meet the required need, some actions will have negative impacts on some stakeholders — and transparency in the decision-making process is critical to ensuring that those negative impacts are mitigated.

This plan advocates for a decision-making process that can set benchmarks for understanding when a policy is no longer cost-effective and other options can more affordably achieve the desired outcome. In other words, this plan recognizes uncertainty in Vermonters' lives and future.

Policy must be nimble in the face of change. Transparently articulating how these principles have been applied when taking action will help ensure that necessary conversation and debate on policy priorities takes place, and that estimated implications of a given action or set of actions are made on the basis of consistent data and facts.

This CEP also provides detail about current programs, and articulates the benefits and costs of programs from different perspectives — including a broad societal perspective and that of Vermonters, both those who participate in transitional programs early on and those who do not. By clearly articulating our assumptions and pursuing policies that seek to balance tradeoffs instead of ignoring them, we can move beyond partisan debate and take action that is best for Vermont residents and businesses.

Just and Equitable Energy Transition

Acknowledging that "every one of us benefits when we make society fairer and more just," as noted by Vermont's Director of Racial Equity in her 2021 report to the Legislature, the principles of building Vermont's renewable energy future through a lens of equity and just transition run throughout this 2022 CEP. As Vermont moves towards a cleaner energy future and develops the policies and programs to support those changes, it will be critical to do so through a lens of equity and justice to ensure that no Vermonter is left behind. That has historically not been the case.

The average statewide total energy burden, or energy spending as a percent of income, is about 10%, but the energy burden for some Vermonters can be much higher. There is a broad range of costs, given Vermont's rural character, old buildings, and variable weather; the average energy burden for towns across Vermont ranges from 6% to 20%, and for many individuals it can be even greater. Clean energy technologies, which can reduce costs and energy burden, see limited adoption in areas with the highest energy burden.[1]

The energy system, at its roots, was built to serve people through enabling the provision of critical services, such as warm and healthy homes on cold winter evenings and the fuel to support local business operations. Approaching the clean energy transition through an equity and justice lens will help ensure that we meet the needs of Vermont's citizens, communities, and businesses/institutions — in particular those that have historically been marginalized or underserved and will be most impacted by this transition. The energy transition opens the door, not just to meet renewable energy and climate objectives, but to do so in a way that better serves all Vermonters, uplifts those who have not had access or ability to participate previously, addresses and repairs the root causes of existing inequities, and in the process builds a more inclusive energy system for Vermont.

Leveraging the foundational work of the Just Transitions subcommittee of the Vermont Climate Council, Chapter 3 grounds this CEP in clear understanding of what is meant by *energy equity* and a *just transition*

[1] Efficiency Vermont, *Vermont Energy Burden Report*, October 2019, Sears & Lucci.

for the system. It considers what this means for Vermont moving forward and provides recommendations for steps to broadly advance a just and equitable energy transition while implementing the programmatic and policy actions outlined in the plan.

Adequate, Secure, and Reliable Energy Services

As described in this CEP, many pathways for our energy future involve significant electrification of non-fossil resources. A modern electric grid allows for the integration of distributed energy resources (DERs) — e.g., electric vehicles, heat pumps, smart appliances, storage, and generation — while maintaining and improving safety and reliability. The grid needs to continue to perform — to reliably deliver the required energy to customers, every hour of the year, to and from resources that are exponentially more distributed, diverse, and variable, under increasing pressure from severe weather events and cyberattacks, while weaning off fossil resources and staying affordable. Where we don't electrify, ensuring that biofuels (solid, gas or liquid) remain available and affordable is critical.

This CEP sets the goal of a secure and affordable electric grid that can efficiently integrate, use, and optimize high penetrations of distributed energy resources to enhance the state's resilience and reduce greenhouse gas emissions. It also recognizes the role that broadband services play in delivering transformative technologies to all Vermonters, together with the capability of managing those technologies to reduce costs. This CEP does not create a stepwise plan for a modern grid, because such a plan would be outdated upon publication. Instead, Chapter 4 illustrates the tradeoffs associated with achieving a modern grid that must be explored.

Adequacy, *security*, and *reliability* do not just pertain to our electric grid; they are principles that apply to all of Vermont's energy end uses. Energy demand management through efficiency — providing the same service while using less energy — remains paramount to our future. Whether it is tightening our buildings through comprehensive weatherization retrofits or reducing our vehicle miles traveled, energy efficiency can improve the health, well-being, and pocketbook of Vermonters and Vermont businesses while ensuring reliable energy service by lowering overall demand.

For sectors where electrification options are limited, biofuels remain a viable alternative. Even where electrification eventually needs to occur, biofuels can be made available to provide a great many Vermonters with a transition fuel, often with low upfront costs.

Since the Last CEP

The 2011 CEP established a goal of meeting 90% of the state's energy needs through renewable sources by 2050, proposing steps to minimize our dependence on fossil fuels. The 2016 CEP maintained that trajectory, and proposed additional actions to get us on the path toward achieving both the 90-by-2050 target and the GHG requirements. The CEP prompted many positive steps toward these targets and requirements; and many successes have been achieved, including these:

- Implementation of the Renewable Energy Standard, including "Tier III," which requires electric utilities to reduce fossil fuel consumption from its customers;

- Authorization of innovative electric utility pilots that allow utilities to take steps toward climate action through modernizing systems and programs with long-term benefits to ratepayers;
- Authorization of a doubling of investment in natural gas efficiency programs, and in research on and development of renewable natural gas to meet the needs of hard-to-electrify sectors;
- Development of a broad array of electric vehicle customer and dealer incentives and charging rates, to reduce upfront and ongoing costs;
- To ease concern about electric vehicle ranges, development of public charging infrastructure that will soon place a fast-charging public station within 30 miles of nearly all Vermont residences, with continued expansion planned;
- Installation of over 400MW of solar power generation and approximately 50 MW of solar-energy storage, with permits to interconnect to the grid;
- Continued improvement of the net-metering programs, including review of siting and rates to better reflect development costs and relative contribution toward meeting targets and reducing cost shift to non-participating customers;
- Updated building energy codes to put Vermont on a path to net-zero-ready for new buildings by 2030;
- Increased access to affordable financing for residential and commercial borrowers through a variety of financial institutions, for investments and measures that help Vermont reach its energy and emissions goals; and
- Development and approval, under Act 174, of enhanced energy plans for all 11 regional planning commissions and roughly 30% of Vermont's municipalities.

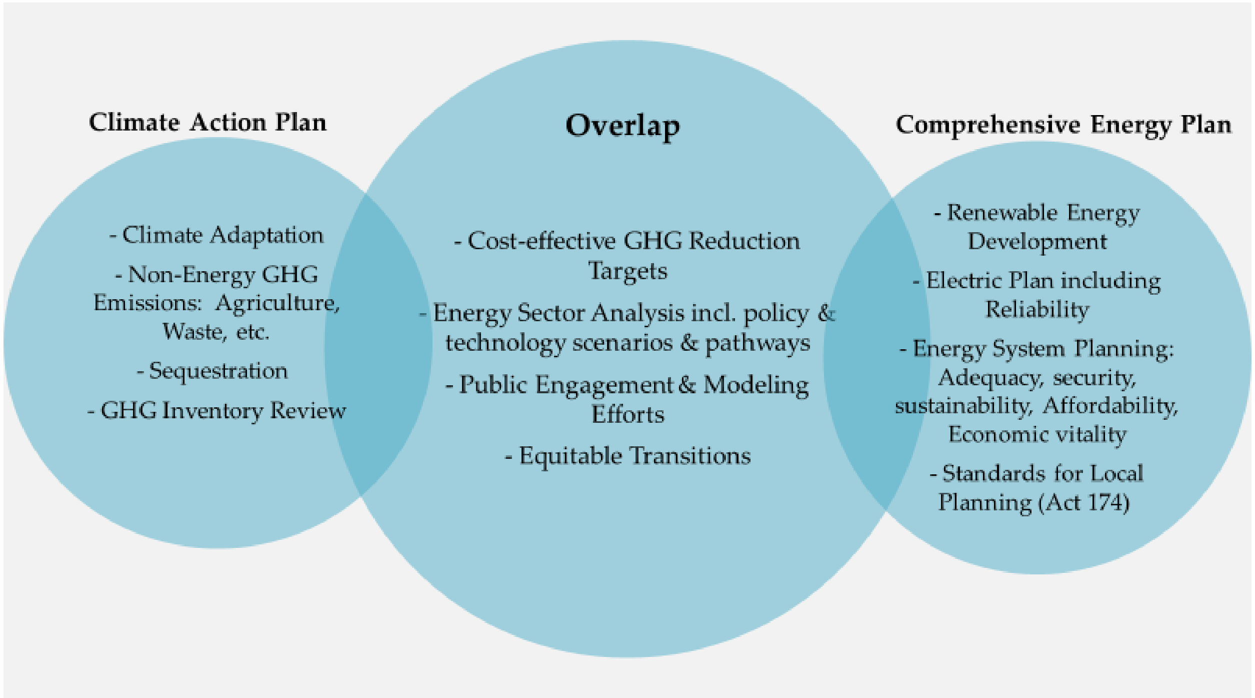
These, and many other, successes are discussed throughout the remainder of this CEP.

The Vermont Climate Council and Climate Action Plan

The development of this CEP has coincided with development of the Vermont Climate Council's Climate Action Plan (CAP), as required by the Global Warming Solutions Act (GWSA, 10 V.S.A. § 592). The CEP is a mechanism for implementing statutory energy policy, based on a comprehensive analysis of challenges and opportunities in Vermont. The CAP is an action plan specifically for greenhouse gas mitigation, sequestration, and adaptation strategies in the face of climate change.

As Exhibit ES-1 shows, while the CEP and the CAP have considerable areas of overlap, they remain distinct planning requirements with different objectives. While the CEP must be consistent with and fundamentally aligned with meeting the state's GHG requirements, it is not a climate change plan, nor is it a comprehensive look at Vermont's non-energy GHG emissions or climate adaptation needs.

Exhibit ES-1. Comprehensive Energy Plan and Climate Action Plan



The CEP reviews energy-system planning in ways that are beyond the scope of the Global Warming Solutions Act. For example, it focuses on planning for electric-system reliability, given the pathways necessary to meet our climate goals. In turn, the CAP looks at the impacts of climate change beyond the scope of the CEP, addressing resiliency in the natural and built environment, adaptation, sequestration, and non-energy mitigation.

Of course, energy consumption drives a large majority of Vermont's greenhouse gas emissions, and it was important that the processes for the CAP and CEP aligned. Accordingly, the Department of Public Service, in its role developing the CEP, and the Agency of Natural Resources, in its role supporting the Climate Council, have closely coordinated these two required plans. Public engagement efforts have notably been aligned, with the Department of Public Service supporting technical workshops with Climate Council participation, and the Climate Council supporting robust public engagement with Department of Public Service participation. As a result, targeted outreach to both Vermonters and technical experts was not duplicated. In addition, modeling that was conducted for the CEP was reviewed, modified, and adopted for the CAP, ensuring that there is one set of energy-related assumptions on which the two plans are based. (See Appendix D regarding modeling for a detailed summary of these efforts). State agency staff have diligently worked on both the CAP and the CEP.

The CEP is required to be consistent with the requirements of the GWSA and the CAP, and the CAP is required to be informed by the CEP. The requirements to closely coordinate these efforts has allowed for clearer consideration of the issues, rather than a debate of the facts — and even if the resulting actions are not necessarily identical, the basis on which they are formed was efficient and practical.

Public Engagement and Support

Development of this CEP included a range of inputs and actions designed to obtain insights and expertise from state agencies and the Climate Council members, combined with input from community, business, nonprofit, and regional planning organizations along with academic institutions, municipalities, advocacy groups, and citizens from across the state. As just noted, significant coordination among state agencies on the two plans took place, given the substantial overlap of the CEP with the Climate Action Plan, and to prevent duplicative meetings that might have confused participants and muddled their feedback.

Core components of the Department's engagement throughout the course of 2021 included:

- *Request for Information (RFI)* on what should be considered in the plan, and what should be modeled;
- *Public regional forums*, focused on gathering input from municipalities and regional planning commissions on what they need from the Comprehensive Energy Plan in terms of guidance and standards for Act 174 enhanced energy planning;
- *Topical stakeholder meetings*, led by the Department in coordination with the Climate Council, where industry experts were invited to provide technical feedback related to the electric, thermal, and transportation sectors, with an additional workshop related to electric grid evolution; and
- *Public engagement*, led by the Climate Council in coordination with the Department of Public Service, to meet Vermonters through several in-person meetings and — following publication of the draft CEP — additional public hearings around the state and online to gather more feedback on the draft.

Each of these efforts has resulted in valuable comments that are addressed in the plan. The final CEP will include an appendix of comments and feedback received, and how such feedback was considered.

Vermont can only meet the goals established in this plan with the support and active involvement of individuals, businesses, non-governmental organizations, and all levels of government. Individual decisions — for example, about where to live, what car to buy (or whether to buy a car at all), what appliances to buy, whether and how to weatherize your home or invest in renewable energy — will have a significant impact in shaping Vermont's energy future. The same is true of business decisions. Engagement on the pathways and strategies included in this plan will continue upon release of the final CEP, in coordination with the Climate Council's engagement on the Climate Action Plan.

Pathways and Strategies to Meet Vermont's Energy Needs

Addressing Vermont's energy policy and meeting statutory requirements requires not only a vision, as articulated by previous energy plans, but also a clear direction for tackling the presented challenges and seizing the opportunities before us. This CEP is organized around two key themes: equitable solutions and grid evolution. Within that context, three major energy sectors are discussed: transportation, thermal, and electricity. Although technology and policy priority evolution has blurred the lines between these sectors, they remain useful distinctions for discussing the specific challenges and opportunities associated with each end-use energy service.

An all-of-the-above approach is necessary to equitably meet Vermont's energy service needs and reduce greenhouse gas emissions. Within each chapter, the CEP describes pathways, strategies, and recommendations for actions. In this plan, a *pathway* is a general means of reaching energy goals; *strategies* are coordinated efforts for advancing along a pathway; and *recommendations* are more specific tactics or actions that can be taken to further the strategy.

This general structure is meant to be consistent with the general structure of the Climate Action Plan. Indeed, many of the pathways, strategies, and recommendations presented by the two plans are similar, though not identical — a result of the close coordination between plans with overlapping but differing scopes.

Electric Sector

Because Vermont's electric sector will play a critical role in decarbonizing the transportation and thermal sectors, this raises the importance of affordable electric rates and an electric system that is reliable and resilient for all Vermonters. Currently, Vermont's electric generation mix is 94% carbon-free, and the statutory Renewable Energy Standard requires that all electric utilities meet at least 66% of electricity deliveries with renewable power. Overall, the electric sector contributed less than 6% of Vermont's GHG emissions in 2017, a number that is forecasted to decline even further.

Pathway: Carbon-Free Power Supply

This CEP sets a goal for the electric sector to be fully decarbonized and at least 75% renewable by 2032. Vermont benefits from a strong regional transmission grid that includes ties to neighboring areas. Working collaboratively, the region can more effectively achieve greater reliability, access to renewable generation, and decreases in costs than if Vermont were to try reaching all these goals by itself. This will be increasingly important as load from electric vehicles and heat pumps increases, particularly during the winter months when heat pumps draw the most power, and the cold affects charging time and capacity for EV batteries.

Consider a requirement for carbon-free power supply

While some utilities have internal goals of increasing the carbon-free portion of power they supply to customers, there is no binding requirement, beyond the Tier I Renewable Energy Standard that utilities must procure 75% of their retail electric sales from any source of renewable energy by 2032. Vermont should develop a carbon-free power supply requirement, designed to equitably reduce GHG emissions in the electricity sector — which in turn will deepen the GHG emission reductions achieved through electrification measures.

Power supply choices are long-lived, and electricity costs are key to customer decision-making on whether to electrify home heating and personal transportation. Thus, it is crucial that any changes to the Renewable Energy Standard be made in a deliberative and careful manner, to minimize the economic burden on Vermonters and to make electrification of the transport and thermal sectors as cost-effective as possible.

The development of a carbon-free power supply requirement should consider and include transparent information on the costs and benefits of different design considerations, including, at a minimum, (1) the addition of new resources, (2) time and locational considerations, and (3) resource size and diversity.

Transportation and Land Use

Vermont's transportation system is critical to the state's economy and quality of life. It provides access to jobs and mobility for the movement of goods and services that are essential to Vermont businesses; it brings tourists and other visitors to the state; it makes many daily activities convenient and feasible for Vermonters; and it delivers food and other products that Vermonters need for everyday living. Transportation fuels continue to account for the largest portion of Vermont's total energy consumption, and they include more fossil fuels than any other energy source. Transportation makes up 38% of the total energy consumed in Vermont, and produces more GHG emissions — around 40% — than any other sector.

This CEP sets goals for the transportation sector of increasing the number of electric vehicles in Vermont, and of having zero-emission vehicles account for 100% of light-duty vehicle sales in Vermont by 2035. In addition, this CEP aims to increase the share of renewable energy in transportation through both electrification and encouraging the use of other renewable and less carbon-intensive fuels. While it does not specify targets for reducing transportation demand, **this CEP continues to prioritize Transportation Demand Management (TDM) due to its broad benefits across Vermont's energy policy goals**, recognizing that the choices available to Vermonters about where they live, work, shop, and recreate affect the amount of energy and money that is spent in moving across the landscape.

Pathway: Vehicle Electrification

Vermont must continue to advance the market share of electric cars and trucks as quickly as possible. A robust policy environment is critical for rapidly increasing the market share of plug-in electric vehicles (EVs), and is supported by ongoing and dramatic advances in electric vehicle technology, especially batteries. Strategies along this pathway can move the transportation sector toward energy and emissions goals faster than any other single measure.

Accelerate electric vehicle market share through incentives

The principal strategy for advancing vehicle electrification is ramping up deployment of electric vehicle technology. Electric technology can power light- and medium-duty cars and trucks, transit and school buses, short-haul aviation, and short-haul marine in the immediate and near terms, and possibly heavy-duty trucking in coming years. The overall objective of vehicle electrification policies is to create an economic and regulatory environment where market forces can move forward without the need for government support. This plan supports incentive programs for new and used electric vehicles, as well as continuation of programs such as MileageSmart and Replace your Ride, and it recommends enhanced support for medium- and heavy-duty electric vehicles.

Accelerate EV market share through supporting infrastructure and policy

Electrifying Vermont's entire fleet will require a vast expansion of the state's charging network. Until EVs reach some critical mass, charging infrastructure will continue to require some public support to help accelerate EV market share. This plan recommends support for both direct current fast charging (DCFC), also known as Level 3 charging, as well as Level 2 charging until a sufficient free-market charging network can stand on its own. It also seeks to address the EV barrier of model availability, through continuing participation in California's Advanced Clean Car program; and it calls for the undertaking of a rulemaking process for adopting California's Clean Cars II regulations, to require that 100% of light-duty vehicles available for sale in Vermont be Zero-Emission Vehicles by 2035.

The transition to EVs also will require new regulations and oversight to ensure strong consumer protection and transparency associated with charging electric vehicles. This plan calls for the Agency of Agriculture, Food, & Markets to adopt appropriate protocols in this area.

Managing electric grid impacts

Increasing loads from vehicle electrification, as well as other forms of electrification, will eventually reverse years of declining loads that have resulted from energy efficiency. To the extent that Vermont electric distribution utilities can accommodate increasing off-peak loads from vehicle electrification without significant system upgrades, the result will be downward rate pressure for all customers, as more electricity is sold based on fixed or moderately increasing costs associated with local upgrades to substations, transformers, and other supporting infrastructure.

The Vermont grid may currently have some "headroom" to accommodate the early stages of electrification, but it will be critical to manage loads associated with the electrification of Vermont's vehicle fleet, to ensure that objectives of affordability and reliability are achieved. Efficient rate design, including appropriately addressing demand charges, is a supporting strategy needed to manage the impacts of electric vehicles on the grid as we continue to encourage EV adoption.

Pathway: Cleaner Vehicles and Fuels

Even though Vermont and other jurisdictions are working to electrify their transportation systems as quickly as possible, combustion vehicles will still be on the road for years to come. More fuel-efficient combustion vehicles and the use of lower carbon-intensity combustion fuels, like biofuels and renewable natural gas, could significantly reduce GHG emissions from combustion vehicles while the transportation sector electrifies. Low-carbon fuels could also potentially provide an alternative to combustion fuels for heavy-duty transportation modes, like long-haul trucking or aviation.

Increase vehicle fuel efficiency

The many factors that shape the number, type, and relative efficiency of the vehicles registered in Vermont include federal and state emissions and efficiency standards, the diversity and quantity of vehicles available in new and used markets, the price of gasoline or other fossil fuels, consumer preferences, and evolving consumer knowledge about vehicle technologies. While the pace of the transformation of vehicle markets is a complex process, much of which is out of Vermont's control, state government and partner organizations can play a role in spurring change. Vermont can and should support increasingly stringent federal fuel efficiency standards, and should continue to explore options for improving the average fuel economy of the state's vehicle fleet.

Increase targeted use of low-carbon fuels and biofuels

While electrification for Vermont's light-duty fleet is a viable option, there are many heavy- and medium-duty applications for which electric options are limited. In those applications, alternative fuels — including biodiesel, ethanol, compressed or liquefied natural gas, and potentially hydrogen — could offer a lower-carbon alternative to gasoline and diesel, with significant GHG savings and fewer emissions. While biodiesel is preferred to natural gas for heavy- and medium-duty applications, both biodiesel and natural gas are preferred over petroleum products, and renewable natural gas is increasingly being used to meet national low-carbon transportation standards. Vermont can and should continue to support targeted use of low-carbon fuels and biofuels, particularly in hard-to-electrify sectors.

Pathway: Supporting Land Use Patterns that Increase Transportation System Efficiency

Land use patterns—what we build and where we build it— are a foundational building block of our transportation system. The choices we make about what and where we build have significant impacts on how the transportation system is designed and operated to facilitate the movement of people and goods. The decisions we make today will be long-lived and will define many aspects of our daily lives in the future, including our energy use. Land use choices that support compact and mixed-use settlement can improve transportation system efficiency overall, by reducing the distances between the places to which Vermonters regularly travel.

Enhance integration of land use planning into transportation decision-making frameworks

Vermont has worked hard to support land use decisions that can meet multiple state goals, including revitalizing communities, increasing affordable housing and transportation options available to Vermonters, reducing energy consumption, and protecting important natural resources. The decisions we make around land use can either enable or impede our energy goals. Land use planning in Vermont includes a diverse set of actors with different expertise, interest, and authority. Better outcomes develop from a common framework for evaluating and balancing land use goals for public infrastructure, energy supply, housing, transportation, working lands for agriculture and forestry, conservation lands, and other purposes.

Pathway: Increasing Transportation Choices

Transportation infrastructure that increases the quality and types of available transportation choices is often called Transportation Demand Management, or TDM. Choices like public transit, ride share, bicycling, and walking — all of which provide alternatives to getting around by single-occupancy vehicle — can increase the affordability of transport for Vermonters, encourage economic development in downtown and city centers, provide options for those who may have no alternative means, and promote an active and healthy lifestyle. These choices make the transportation system more accessible and equitable. They also create more livable, vibrant communities, and they can reduce transportation-related energy use and emissions.

Provide safe, reliable, and equitable public and active transportation options

Transportation Demand Management options can reduce vehicle miles traveled, decreasing both energy use and greenhouse gas emissions. This CEP describes the current status of public transit, park & ride availability, rideshare programs, telecommuting, biking and pedestrian programs, and rail. Vermont already invests substantially in TDM options, and should continue to do so.

Thermal and Process Energy Use

The heating of Vermont's residential, commercial, and industrial buildings and the fueling of our industrial processes are responsible for nearly 50% of Vermont's total site energy consumption, and 34% of our greenhouse gas emissions. Renewable sources, primarily wood, currently provide approximately 25% of the energy used to heat buildings, and to supply process heat for industrial applications.

This Comprehensive Energy Plan expands the target of increasing renewable thermal and process supply to 30% by 2025, increasing to 45% by 2032 and 70% by 2042. With support from current programs, over 10,000 cold-climate heat pumps have been installed in 2020, and even more are expected to be installed in 2021, heating more and more of our buildings with renewable electricity. But more needs to be done. Reaching these goals will also require more weatherization measures, increasing the use of bioenergy, and continuing progress on heat pumps to significantly reduce the amount of thermal energy that Vermonters need.

Pathway: Reduce Thermal Energy Demand

The two dominant areas of strategic focus for reducing thermal energy demand are, first, significantly scaling up weatherization activities; and second, making new buildings as efficient as possible.

Weatherization at scale

Investing in thermal efficiency improvements can dramatically reduce a building's thermal fuel requirements while increasing its affordability, health, and comfort. Investments in thermal demand reductions through weatherization programs are good for Vermont's economy and, perhaps more importantly, for the health of Vermonters. Previous weatherization targets have come and gone without being met, but the efforts to reach them have highlighted key barriers to address — including lack of information and access to capital, differing tenant and landlord investment priorities, and a qualified workforce that is currently not large enough to meet the need. Low-income Vermonters are particularly sensitive to these challenges, even if they may benefit the most from tighter buildings.

This Comprehensive Energy Plan sets a new target of weatherizing 120,000 households by 2030, relative to a 2008 baseline. Consistent with the recommendations of the Climate Action Plan, this target is intended to be aggressive but technically feasible, and will require the expansion of Vermont's weatherization workforce. Progress will not happen overnight; significant public and private investments will be necessary to ramp up programs and services available to Vermonters. Actions recommended in this plan include devoting significant federal monies to kickstart the pace of weatherization, while building the workforce and exploring opportunities for sustainable funding — including the development of partnerships in areas where weatherization leads to positive outcomes across sectors, such as healthcare and property insurance. The plan also supports initiatives, such as energy counseling programs, that make the weatherization process easier and more productive for customers.

Encourage efficient new buildings

Ensuring that new buildings are constructed with the best available cost-effective technologies and practices is critical to avoiding lost opportunities for reducing Vermont's thermal demand. Around 1,000 single family homes are built in Vermont each year, as well as hundreds of commercial buildings; and once built, they can last 75 to 100 years or more. These buildings must comply with residential or commercial building energy standards that are updated every three years. **This Comprehensive Energy Plan maintains the target to achieve net-zero ready construction for all newly constructed buildings by 2030** through building energy standards. *Net-zero ready* is defined as "a highly efficient and cost-effective building, designed and constructed so that renewable energy could offset all or most of its annual energy consumption."

Pathway: Enhance Low-Carbon Technology and Fuel Choices

Energy consumption serves a variety of end uses, in different types of processes and buildings, and the choice of energy fuel and enabling technologies should match end-use application and space with the most efficient, renewable, affordable, stably priced option that fully serves the end use. Vermont home and business owners are often limited, however, in the types of fuel they can use to meet their energy needs, due to significant past capital investments in heating systems and/or limitations in delivery infrastructure.

It is critical that energy needs for end users be met adequately and equitably with low- or no- carbon fuels, and providing Vermont homes and businesses access to a wide variety of fuel choices will allow them to select the most effective fuel for their application. In this light, strategies are necessary for advancing access to low-carbon fuels and the technologies for using them. The two main strategies here include consideration of a Clean Heat Standard (CHS), a performance-based obligation to reduce emissions from this sector; and the continued promotion of the use of low-carbon fuels such as electricity, advanced wood heat, biodiesel, renewable natural gas, and hydrogen, among others.

Consider a Clean Heat Standard

Although Vermont has a variety of programs that seek to promote low-carbon fuel choices in various ways, the state does not have a unifying mechanism to ensure reduced emissions from this sector. Over the past year, the Energy Action Network has convened a Network Action Team to evaluate and design a Clean Heat Standard that would create a market for a range of clean fuel choices.

Much as Vermont's Renewable Energy Standard does for electricity, a Clean Heat Standard would seek to create a performance-based, technology- and fuel-neutral obligation on affected heating fuel providers, either wholesale or retail, to procure an increasing percentage of their retail sales from low-carbon thermal solutions, at a pace set by the Legislature. Obligated providers could comply with the requirement through an array of supply- or demand-side opportunities, such as increasing the supply of renewable fuels (e.g., biodiesel or renewable natural gas) or installing clean heat measures (e.g., weatherization, advanced wood heat, or cold-climate heat pumps).

This Comprehensive Energy Plan calls for the formal consideration of a Clean Heat Standard. Consistent with the Climate Action Plan, this measured step will allow for full evaluation of equity considerations together with the total costs and benefits to all Vermonters.

Continue to encourage cleaner technologies and fuels

It is critical to expand low-carbon and renewable fuel supply to meet the demand, including electrification, and to develop enough sustainable biofuels to supply difficult-to-convert segments of the fossil fuel market. To respond to this challenge and improve access to fuel choice, the state must encourage use of the most efficient, renewable, cost-effective technology that will meet fuel users' end needs. This is done through the promotion of electrification of thermal loads, development of the advanced wood heat market, and support for district heat, biofuels, and alternatives to natural gas such as renewable natural gas, syngas, and hydrogen.

Affordability and Economic Vitality

Pursuing the goals and strategies in this CEP will support a vibrant economy, promoting an affordable and stable cost of living and doing business. Vermonters spend an average of about $2.8 billion per year on energy across sectors, from 70% to 75% of that on imported fossil fuels. These purchases have little benefit in terms of local economic activity. Per dollar spent, investments in energy efficiency, electricity, and wood heat contribute far more to local economic activity.

Fossil fuels are expensive, and price swings are challenging for customers to budget for; electricity rates are generally more stable. As Vermont electrifies its transport and thermal use, it is imperative to keep in mind that electric bills will have increasing importance. To ensure that our energy transformation is equitable, cost pressures in the electric sector need to be transparent and carefully considered.

The clean energy transition creates many challenges, but many opportunities as well. Vermont has a cutting-edge energy industry and infrastructure with which entrepreneurs can engage: innovative utilities, leading efficiency and regulatory expertise, a near-statewide deployment of advanced metering infrastructure, and a robust renewable energy development community. Our transition to clean energy can ensure an affordable and stable cost of living and doing business, while creating well-paying jobs in industries that support renewable energy and efficiency services. It will be critical, however, to transition carefully, making sure that opportunities are equitably distributed and costs are not shifted onto Vermonters or Vermont businesses that are not positioned to pay. (See Chapters 2 and 3.)

Conclusion

This CEP recognizes that there are many paths that must be pursued to meet our energy policy goals. It identifies many strategies that collectively can transform our energy future. Vermont must work through both public and private sector partnerships to advance an energy future that is affordable, reliable, environmentally sound, and equitably distributes the benefits and burdens of the state's energy service needs.

Chapter 1 introduces this energy plan, including the statutory framework and introduction of key themes of equity and grid evolution that are addressed in Chapters 3 and 4, respectively. Chapter 2 describes the plan development process, including the analytical basis for the CEP.

Chapters 5, 6, and 7 detail historical and current energy use and prices in the transportation, thermal, and electricity sectors, respectively. Chapter 8 describes clean energy financing opportunities that can support the strategies outlined in the previous three chapters. Finally, Chapter 9 provides Vermont's State Agency Energy Plan.

The appendices provide additional resources, including a description and results of the modeling efforts and Act 174 Energy Planning Standards for issuing a determination of energy compliance pursuant to 24 V.S.A. § 4352.

1 Introduction

Vermont faces a moment of great opportunity to take control of its energy future. Technology changes over the last decade have set the foundation for a just and equitable transition to a cleaner and more affordable, efficient, and reliable energy future for Vermont's residents and businesses. While significant challenges remain and the transition will take time to implement, advances in technology, strategy, and application have positioned Vermont to make significant strides in the next decade and beyond.

This Comprehensive Energy Plan (CEP) intends, at is core, to provide a factual basis that informs readers of the energy challenges and opportunities facing Vermont. The CEP acts as a reference tool where readers can, in one place, understand current energy initiatives and programs, and how Vermont's energy issues relate to developments outside the state's borders. The CEP also serves as a policy tool, setting aspirational goals and outlining pathways, strategies, and actions for progressing toward those goals.

Recognizing that the underpinnings of any plan are affected by the dynamic and interrelated nature of energy policy, this plan identifies and addresses current energy challenges. It endeavors to describe the tradeoffs inherent in each policy framework, including impacts to energy consumption, cost, and emissions; and it highlights what may be needed in specific program design to ensure an equitable energy future.

1.1 CEP Goals

This plan builds upon the 2011 and 2016 editions of the CEP, which established Vermont's goal of **meeting 25% of the state's energy needs through renewable sources by 2025, 45% by 2035, and 90% by 2050**. This edition of the CEP is structured to meet the greenhouse gas requirements of the Global Warming Solutions Act, and to be consistent with the Climate Action Plan as required by 10 V.S.A. § 592. In addition, and in support of the greenhouse gas reduction requirements, this CEP establishes the following sector-specific goals:

- In the Transportation Sector, meet 10% of energy needs from renewable energy by 2025, and 45% by 2040;
- In the Thermal Sector, meet 30% of energy needs from renewable energy by 2025, and 70% by 2042; and
- In the Electric Sector, meet 100% of energy needs from carbon-free resources by 2032, with at least 75% from renewable energy.

These targets will not be easy to reach, particularly in the transportation and thermal sectors. The context, implications, and tradeoffs associated with programs and policies aimed at achieving these goals are described in the sector-specific chapters of this plan. There is no silver bullet, no single pathway that can easily meet our goals. What will be necessary, instead, are incremental changes that kickstart more fundamental shifts in the way we design programs and use energy.

This plan reflects the policies, programs, and actions in play at the time of its publication. The broad energy system is complex, and the variables that serve as inputs to decision making are ever-changing. This CEP endeavors to look comprehensively at challenges and opportunities using the information available. As impacts are better understood or variables change, so too should the analysis that underpins the CEP.

This plan reflects insights gained from numerous reports, meetings, and conversations with stakeholders and members of the public since the last CEP, as well as engagement, specific to this CEP, with the Vermont Climate Council and its subcommittees, and coordination with the Climate Council's public engagement process as described further below. Input and expertise are incorporated from across state government, including the Agencies of Transportation; Natural Resources; Agriculture, Food & Markets; Commerce and Community Development, and others.

1.2 Statutory Framework

It is Vermont's state energy policy:

1. To assure, to the greatest extent practicable, that Vermont can meet its energy service needs in a manner that is adequate, reliable, secure, and sustainable; that assures affordability and encourages the state's economic vitality, the efficient use of energy resources and cost-effective demand side management; and that is environmentally sound.
2. To identify and evaluate, on an ongoing basis, resources that will meet Vermont's energy service needs in accordance with the principles of least-cost integrated planning, including efficiency, conservation and load management alternatives, wise use of renewable resources, and environmentally sound energy supply.
3. To meet Vermont's energy service needs in a manner that will achieve the greenhouse gas emissions reductions requirements pursuant to 10 V.S.A. § 578 and is consistent with the Vermont Climate Action Plan adopted and updated pursuant to 10 V.S.A. § 592.

   (30 V.S.A. § 202a)

Vermont law requires the Department of Public Service (DPS) to produce a CEP for the state covering at least a 20-year period, as stated in 30 V.S.A. § 202(b):

1. The DPS, in conjunction with other state agencies designated by the governor, shall prepare a comprehensive state energy plan covering at least a 20-year period. The plan shall seek to implement the state energy policy set forth in section 202a of this title. The plan shall include:
   a. A comprehensive analysis and projections regarding the use, cost, supply, and environmental effects of all forms of energy resources used within Vermont.
   b. Recommendations for state implementation actions, regulation, legislation, and other public and private action to carry out the Comprehensive Energy Plan.

The CEP is designed to serve as an actionable framework for moving toward the goals defined in the statute. In addition, the CEP must be consistent with the Climate Action Plan established under the 2019 Global Warming Solutions Act (see 10 V.S.A. § 592). That act also updated 10 V.S.A. § 578 to require reductions of greenhouse gas emissions:

> (a) Greenhouse gas reduction requirements. Vermont shall reduce emissions of greenhouse gases from within the geographical boundaries of the State and those emissions outside the boundaries of the State that are caused by the use of energy in Vermont, as measured and inventoried pursuant to section 582 of this title, by:
>
> > (1) not less than 26 percent from 2005 greenhouse gas emissions by January 1, 2025 pursuant to the State's membership in the United States Climate Alliance and commitment to implement policies to achieve the objectives of the 2016 Paris Agreement;
> >
> > (2) not less than 40 percent from 1990 greenhouse gas emissions by January 1, 2030 pursuant to the State's 2016 Comprehensive Energy Plan; and
> >
> > (3) not less than 80 percent from 1990 greenhouse gas emissions by January 1, 2050 pursuant to the State's 2016 Comprehensive Energy Plan.

In addition to the Comprehensive Energy Plan, the Department of Public Service is also required to produce an electric plan per 30 V.S.A. § 202 Electrical Energy Planning, which states, in part:

> (b) The Department shall prepare an electrical energy plan for the state. The plan shall be for a 20-year period and shall serve as a basis for state electrical energy policy. The electric energy plan shall be based on the principles of "least cost integrated planning" set out in and developed under section 218c of this title. The plan shall include at a minimum:
>
> > (1) An overview, looking 20 years ahead, of statewide growth and development as they relate to future requirements for electrical energy, including patterns of urban expansion, statewide and service area economic growth, shifts in transportation modes, modifications in housing types and design, conservation and other trends and factors which, as determined by the director, will significantly affect state electrical energy policy and programs;
> >
> > (2) An assessment of all energy resources available to the state for electrical generation or to supply electrical power, including among others, fossil fuels, nuclear, hydro-electric, biomass, wind, fuel cells, and solar energy and strategies for minimizing the economic and environmental costs of energy supply, including the production of pollutants, by means of efficiency and emission improvements, fuel shifting, and other appropriate means;
> >
> > (3) Estimates of the projected level of electrical energy demand;

(4) A detailed exposition, including capital requirements and the estimated cost to consumers, of how such demand shall be met based on the assumptions made in subdivision (1) of this subsection and the policies set out in subsection (c) of this section; and

(5) Specific strategies for reducing electric rates to the greatest extent possible in Vermont over the most immediate five-year period, for the next succeeding five-year period, and long-term sustainable strategies for achieving and maintaining the lowest possible electric rates over the full 20-year planning horizon consistent with the goal of maintaining a financially stable electric utility industry in Vermont.

(c) In developing the plan, the Department shall take into account the protection of public health and safety; preservation of environmental quality; the potential for reduction of rates paid by all retail electricity customers; the potential for reduction of electrical demand through conservation, including alternative utility rate structures; use of load management technologies; efficiency of electrical usage; utilization of waste heat from generation; and utility assistance to consumers in energy conservation.

This CEP serves as the electric plan pursuant to 30 V.S.A. § 202.

The Renewable Energy Standard (RES) (30 V.S.A. § 8004 and § 8005) requires electric power to be:

- 55% renewable in 2017, rising 4% every three years to 75% in 2032; and
- 1% from distributed generators connected to Vermont's electric grid in 2017, rising 0.6% per year, to 10% in 2032.

The RES also requires electric utilities to reduce fossil fuel use by their customers by an amount equivalent to 2% of retail electric sales in 2017, rising two-thirds of a percent per year to 12% by 2032.

The Comprehensive Energy Plan must also consider many other complementary state policies and guidance set forth in other statutes that are relevant to the energy system, including but not limited to 30 V.S.A. § 218e (economic development goals), 30 V.S.A. § 8001 (providing guidance in implementation of state policy related to renewable energy deployment), and 10 V.S.A. § 581 (related to weatherization of buildings). Act 174 of 2016 directs the energy plan to provide "enhanced energy planning" guidance and standards for regional planning commissions and municipalities. Land use goals relevant to the energy system are articulated in 24 V.S.A. §4302. References to other statutes that guide policies and programs are noted throughout this plan.

30 V.S.A. § 218e states:

To give effect to the policies of section 202a of Title 30: to provide reliable and affordable energy, and assure the state's economic vitality, it is critical to retain and recruit manufacturing and other businesses, and to consider the impact on manufacturing and other businesses when issuing orders, adopting rules, and making other decisions that affect the cost and reliability of electricity and other fuels. Implementation of the state's energy policy should:

1. Encourage recruitment and retention of employers providing high-quality jobs and related economic investment, and support the state's economic welfare; and

2. Appropriately balance the objectives of this section with the other policy goals and criteria established in this title. (30 V.S.A. § 218e)

30 V.S.A. §8001 provides guidance:

To promote the state energy policy established in § 202a of this title by:

(1) Balancing the benefits, lifetime costs, and rates of the State's overall energy portfolio to ensure that to the greatest extent possible the economic benefits of renewable energy in the State flow to the Vermont economy in general, and to the rate paying citizens of the State in particular.

(2) Supporting development of renewable energy that uses natural resources efficiently and related planned energy industries in Vermont, and the jobs and economic benefits associated with such development, while retaining and supporting existing renewable energy infrastructure.

(3) Providing an incentive for the State's retail electricity providers to enter into affordable, long-term, stably priced renewable energy contracts that mitigate market price fluctuation for Vermonters.

(4) Developing viable markets for renewable energy and energy efficiency projects.

(5) Protecting and promoting air and water quality in the State and region through the displacement of those fuels, including fossil fuels, which are known to emit or discharge pollutants.

(6) Contributing to reductions in global climate change and anticipating the impacts on the State's economy that might be caused by federal regulation designed to attain those reductions.

(7) Providing support and incentives to locate renewable energy plants of small and moderate size in a manner that is distributed across the State's electric grid, including locating such plants in areas that will provide benefit to the operation and management of that grid through such means as reducing line losses and addressing transmission and distribution constraints.

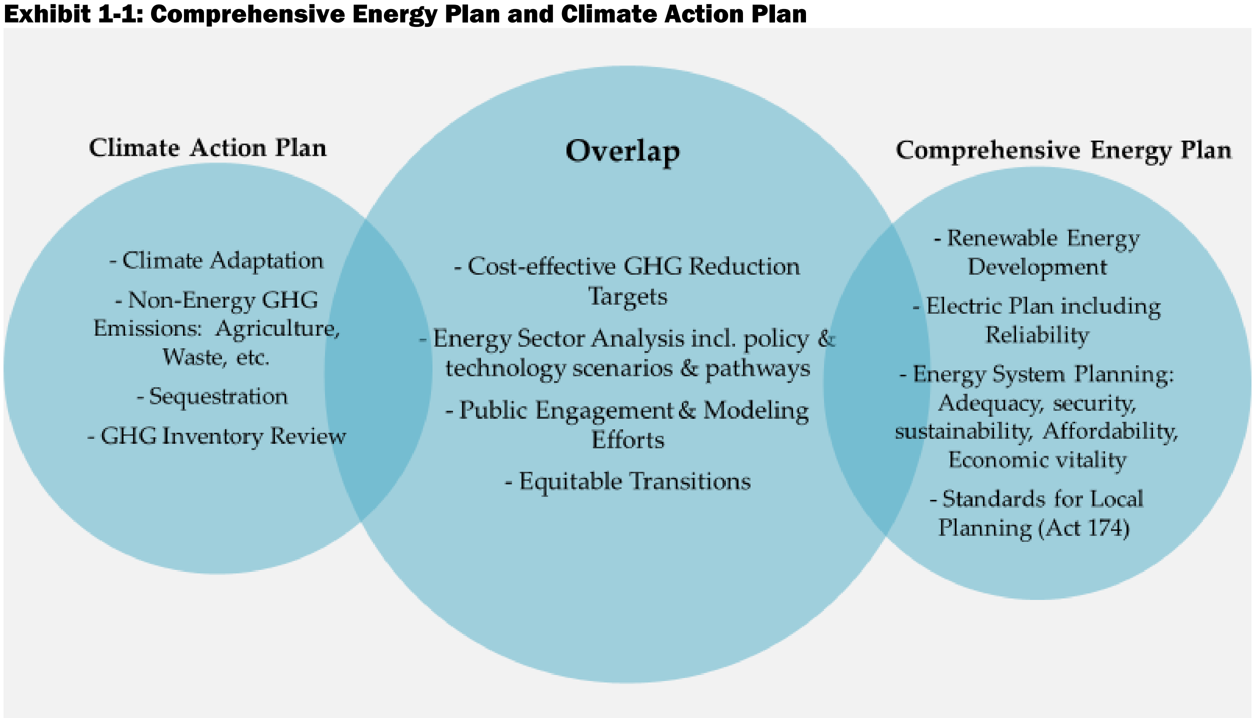
(8) Promoting the inclusion, in Vermont's electric supply portfolio, of renewable energy plants that are diverse in plant capacity and type of renewable energy technology. (30 V.S.A. § 8001)

1.3 Climate Council and Climate Action Plan

The development of this CEP has coincided with development of the Vermont Climate Council's Climate Action Plan (CAP), as required by the Global Warming Solutions Act (GWSA, 10 V.S.A. § 592). As described herein, the CEP is a mechanism to implement statutory energy policy based on a comprehensive analysis of challenges and opportunities in Vermont. The CAP is an action plan specifically for greenhouse gas mitigation, sequestration, and adaptation strategies in the face of climate change.

As shown in Exhibit 1-1, while the CEP and the CAP have considerable areas of overlap, they have distinct planning requirements, with different objectives. While the CEP must be consistent with and fundamentally aligned with meeting the state's GHG requirements, it is not a climate change plan, nor is it a comprehensive look at Vermont's non-energy GHG emissions or climate adaptation needs.

Exhibit 1-1: Comprehensive Energy Plan and Climate Action Plan



The CEP reviews energy system planning in ways that are beyond the scope of the Global Warming Solutions Act; for example, it focuses on planning for reliability of the electric system, given the pathways necessary to meet our climate goals. In turn, the Climate Action Plan looks at impacts of climate change that are beyond the scope of the CEP, addressing resiliency in the natural and built environment, adaptation, sequestration, and non-energy mitigation.

Of course, energy consumption drives a large majority of Vermont's greenhouse gas emissions, necessitating alignment between the development processes for the CAP and CEP. Thus, the Department of Public Service, in its role developing the CEP, and the Agency of Natural Resources, in its role supporting the Climate Council, have closely coordinated these two required plans. Notably, public engagement efforts have been aligned, with the Department of Public Service supporting technical workshops with Climate Council participation, and the Climate Council supporting robust public engagement with participation by the Department of Public Service. As a result, targeted outreach to both Vermonters and technical experts was not duplicated. In addition, modeling (See Section 2.2.1.1 below, and Appendices) was initiated for purposes of the CEP but was reviewed, modified, and adopted for the CAP, providing one consistent set of energy-related assumptions to support the two plans. State agency staff have diligently worked on both the CAP and the CEP.

Pursuant to the GWSA, the CEP must be consistent with the requirements of the GWSA and the CAP, while at the same time the CAP must be informed by the CEP. The requirements that these planning efforts must be closely coordinated — even if the resulting actions are not necessarily identical — ensured that the basis on which they are formed was efficient and practical, and that it allows for clearer consideration of the issues rather than a debate of the facts.

1.4 What the CEP Does Not Do

The CEP offers a forward-looking plan but does not address all issues. It does not prescribe outcomes or make recommendations for specific projects, and it does not analyze specific projects that are pending before the Vermont Public Utility Commission. The CEP also does not presume to know all the choices Vermont will make to reach the goals set forth herein, or the exact timeline by which some will be achieved. For example, although the plan sets forth goals for renewable energy and weatherization, the precise mix of renewable energy or number of homes weatherized remains less important than the energy impacts of those choices: using less fossil fuels, making energy use more affordable, etc.

As noted above, the CEP does not serve as Vermont's climate change action plan; that falls under the purview of the Vermont Climate Council. The goals and recommendations included here are consistent with, and will be a key component of, meeting the state's greenhouse gas emission reduction goals, and the CEP reflects planning for some impacts of climate change on the energy system. However, the CEP does not present a comprehensive look at Vermont's non-energy-related GHG emissions, or its other planning needs for climate adaptation.

The dynamics involving energy and environmental change frequently intersect, and the CEP must be responsive to the changes occurring throughout Vermont. This CEP does not, and should not, be a static set of policies; instead, it endeavors to lay out the framework for guiding decision-making on issues related to energy, and to present a plan based on current information.

1.5 Organization of this CEP

Chapter 2 of this CEP describes the planning process undertaken to produce the plan. From that process, equity and grid evolution emerged as two main themes that must be addressed in this version of the plan. They are discussed in chapters 3 and 4. Pathways, strategies, and actions in the transportation, thermal, and electric sectors are then described in chapters 5-7, even while recognizing that these formerly quite distinct sectors are beginning to converge. Chapter 8 describes clean energy financing opportunities to support the strategies outlined in the previous chapters. Finally, Chapter 9 provides

Vermont's State Agency Energy Plan, and the appendices that follow provide supporting materials for the entire CEP.

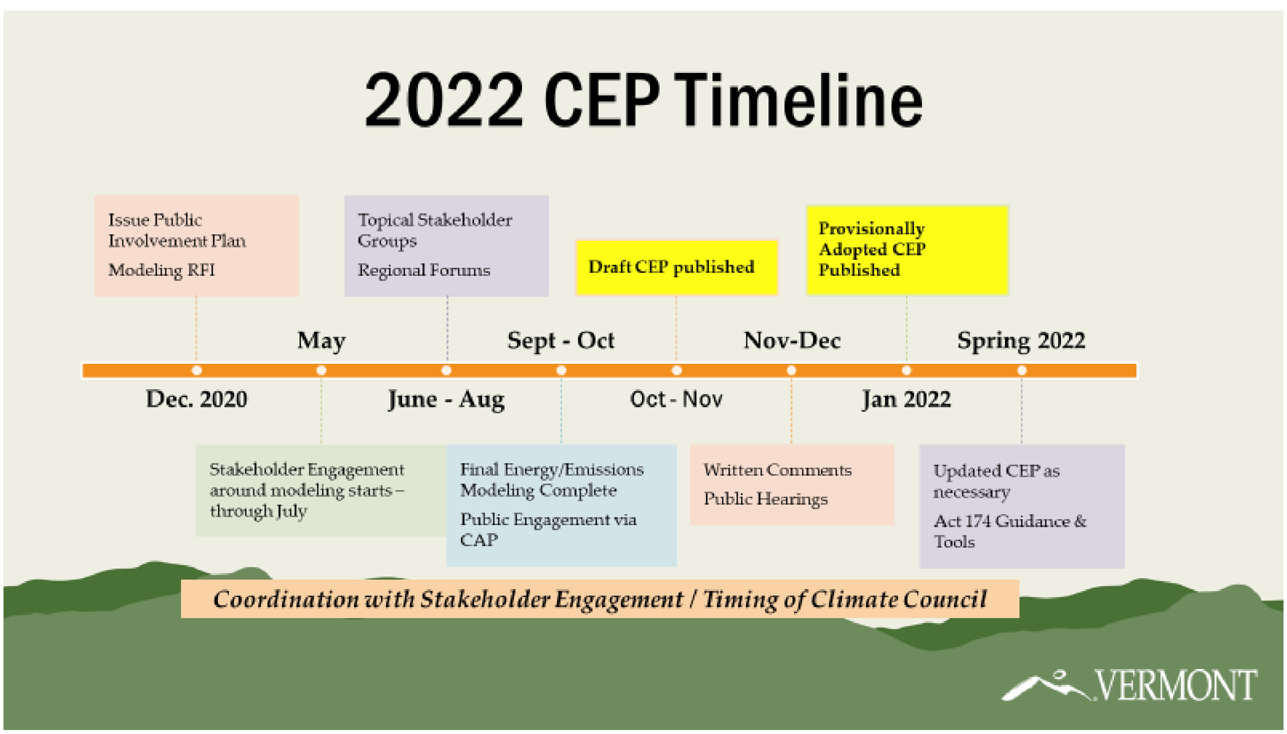
2 CEP Planning Process

The Department of Public Service (PSD) is identified in 30 V.S.A. § 202b as the entity responsible for developing the Comprehensive Energy Plan. However, as described in Chapter 1, development of the plan involved a range of inputs and actions designed to obtain insights and expertise from state agencies and the Climate Council members, combined with input from community, business, nonprofit, and regional planning organizations as well as academic institutions, municipalities, advocacy groups, and citizens from across the state. Because of the substantial overlap with the Climate Action Plan, significant coordination on the two plans took place among state agencies. This chapter details the approach to CEP development and public engagement.

2.1 Public Processes

To engage the public regarding the state's planning efforts and to update its understanding from the last CEP, the PSD developed a public involvement and stakeholder engagement process aimed at providing opportunities and channels for Vermonters to share their thoughts and comments on the CEP. This year's CEP process was coordinated with the Climate Council and leveraged its parallel public engagement processes.

Exhibit 2-1. CEP Timeline



The 2022 CEP public process included:

- **The CEP 2022 website** (https://publicservice.vermont.gov/content/2022-plan), featuring regular updates and an email comment portal (PSD.ComprehensiveEnergyPlan@Vermont.gov).
- **A Request for Information** issued via the PSD website on December 8, 2020. This provided an opportunity for the public to participate in identifying and clarifying policy and technology pathways toward reaching Vermont's energy goals. Input was collected until February 15, 2021. The Department welcomed written comments with regard to previously identified technologies and pathways, or new ones that have materialized since the last Comprehensive Energy Plan.
- **Regional meetings** that were held virtually in June 2021, focused on energy planning efforts by Regional Planning Commissions and municipalities. The following forums were specifically designed for those involved in energy planning efforts at the local level, to provide input on the key energy issues, elements, challenges, and considerations unique to their area of Vermont:
    - **Southeastern Forum**, June 1, 2021, with the Mount Ascutney Regional Commission, Two Rivers-Ottauquechee Regional Commission, and Windham Regional Commission
    - **Northern Forum**, June 2, 2021, with the Northeastern Vermont Development Association, Lamoille County Planning Commission, and Northwest Regional Planning Commission
    - **Southwestern Forum**, June 8, 2021, with the Addison County Regional Planning Commission, Rutland Regional Planning Commission, and Bennington County Regional Planning Commission
    - **Central Forum**, June 28, 2021, with Chittenden County Regional Planning Commission and Central Vermont Regional Planning Commission
- **Workshops** that were led by the PSD and coordinated with members of the Climate Council:
    - **Energy Sector Technical Workshops** in August 2021, a series of sector-specific technical workshops conducted in partnership with task leads from the Cross-Sector Mitigation Subcommittee of the Climate Council. Each workshop included a mix of presentations and facilitated discussions:
        - Electric Sector Technical Workshop, August 10, 2021
        - Thermal/Buildings Sector Technical Workshop, August 19, 2021
        - Transportation Sector Technical Workshop, August 26, 2021
    - **Public workshops and engagement,** led by the Climate Council in September 2021, in coordination with the Department of Public Service, that engaged over 1,600 Vermonters[2]:
        - Elmore State Park, Elmore, September 21, 2021
        - Emerald Lake State Park, East Dorset, September 22, 2021
        - Lakeside Park Pavilion, Island Pond, September 23, 2021
        - Airport Park Pavilion, Colchester, September 26, 2021

2 https://outside.vermont.gov/agency/anr/climatecouncil/Shared%20Documents/VT%20CAP%20Public%20Engagement%20Findings%2010.25.21.pdf

        - Virtual event via Zoom, September 30, 2021
        - Virtual event via Zoom, October 6, 2021
        - Online survey between September 20 and October 15, 2021

- **Presentations** for feedback to the Science & Data and Cross-Sector Mitigation Subcommittees of the Climate Council, and to industry groups including but not limited to VECAN, EAN Annual Summit, REV Annual Conference, VLITE Board, Vermont System Planning Committee, and others.
- **Public comment period**, beginning upon release of draft CEP on November 19, 2021, and concluding on December, 20, 2021.
- **Five in-person public hearings** with two additional virtual hearings during November and December with description of comments received, and response to those comments to be addressed in this CEP's appendices.
    - **Virtual Public Meetings**, November 30 and December 2, 2021
    - **St. Johnsbury,** December 5, 2021
    - **Randolph,** December 6, 2021
    - **Rutland,** December 8, 2021
    - **Brattleboro,** December 9, 2021
    - **Williston,** December 12, 2021

2.2 Developing a Strategic Energy Plan

This CEP update moves from the assemblage of unconsolidated recommendations across the electric, thermal, and transportation energy subsectors presented in 2016 toward a sequenced set of linked activities and policies, designed to generate and sustain momentum toward meeting state energy policy goals and greenhouse gas emissions requirements.

As described in Chapter 1, the Vermont Global Warming Solutions Act of 2020 (Act 153) stipulates that the CEP shall be consistent with the Vermont Climate Action Plan, with the Climate Action Plan required to be informed by the CEP.[3] To meet this requirement, the planning process for the CEP in 2021 dovetailed with the work of the Vermont Climate Council.

In order to facilitate consistency, the CEP adopts language such as *pathways, strategies, and actions* in line with the Climate Action Plan:

- A **pathway** is a high-level means of achieving GHG emissions reductions or adaptation, resilience, and sequestration goals. While written broadly, pathways should be stated specifically enough so that it is possible to assess whether progress has been made in achieving them.
- A **strategy** is a statement of measurable activity, a benchmark to be reached in pursuit of the pathway. Strategies should be measurable and are a more specific subset of pathways.

[3] Act 153 of 2020. https://legislature.vermont.gov/Documents/2020/Docs/ACTS/ACT153/ACT153%20As%20Enacted.pdf

- **Actions** are the "operational" tasks the state will undertake to meet the pathways and strategies. Actions may be written around existing — or propose new — policies, programs, projects, initiatives, plans, etc.

Each of these levels of focus has corollaries in the CEP, which follows the same basic structure. The CEP provides additional details, data, and policy analysis.

Achieving Vermont's at times competing energy policy priorities and greenhouse gas reduction requirements will not be easy. As we continue to emerge from the second year of a pandemic, the level of risk and uncertainty about the future may never have been higher. Thus, a decision-making process that considers risks when making decisions is vital. While previous iterations of the CEP outlined a high-level vision and actions to further that vision, this section of the 2022 CEP intends to describe the variables and perspectives the state should consider when making decisions. It allows the plan to be nimble in the face of change, acknowledging that the state must remain flexible to consider changing circumstances and act accordingly.

In developing the 2022 CEP, PSD staff began by reviewing strategic energy planning documents from other states, along with planning documents and energy publications from the Climate Council and other state agencies. Informed by that recent work, the PSD advanced the analytic framework that informs many of the recommendations contained herein, and that articulates the types of tradeoffs and analysis which should be considered during ongoing analyses of energy options.

2.2.1 Analytic Basis

2.2.1.1 Energy System Modeling

The PSD engaged with the Agency of Natural Resources, the Northeast States for Coordinated Air Use Management (NESCAUM), and the Stockholm Environment Institute (SEI) to use modeling tools for helping to analyze potential policy pathways toward meeting state energy and greenhouse gas emissions goals. The organizations used the Low Emissions Analysis Platform (LEAP) to develop a reference or "business as usual" case, followed by a set of plausible technology scenarios that would meet greenhouse gas reduction requirements and would help the state understand the implications of the energy transition. The analysis is not prescriptive or designed to produce strict targets for low-carbon technology penetration. Instead, it provides an indicative analysis designed to show the estimated magnitude and timing of needed changes, and the relative importance of major economic sectors.

Using the Vermont LEAP model, one central GHG mitigation scenario and two sub-scenarios were developed to evaluate a range of technologies that can be implemented to achieve Vermont's goals for GHG reduction. The rate of adoption, or penetration pathways, of low-carbon technology for each sector varies across each of these scenarios. The two sub-scenarios model varying utilization levels of biofuels and local electricity resources. These scenarios demonstrate that Vermont could achieve climate action and renewable energy goals through deploying a range of technologies. In this analysis, near-zero carbon electricity services are a necessary condition central to all scenarios for meeting those GHG reduction goals that also rely heavily on electrifying the transportation sector and more fully electrifying the residential and commercial thermal sector.

These are the findings and caveats from the Vermont LEAP analysis, completed by SEI and as described in the appendices:

- The three GHG mitigation scenarios analyzed differ in the implementation rates of some mitigation measures, and in combinations of mitigation measures. In general, however, all scenarios share common features — such as relying upon deep decarbonization of the electricity sector, coupled with extensive electrification of the thermal and transportation sectors in order to achieve Vermont's 2030 and 2050 GHG emissions reduction targets.
- In all three mitigation scenarios, forecasted GHG emission reductions exceed the abatement necessary to achieve Vermont's GWSA requirement of 26 percent from 1990 levels by 2025.
- The scenario analysis shows that the GHG targets for 2030 and 2050 can be met using different mixes of technologies and fuels.
- The 2030 target is an ambitious one that requires immediate and increased introduction of GHG-reducing technologies, such as heat pumps and electric vehicles. Given the slow current rates of vehicle fleet turnover and retirement of household heating and other systems, technology introduction needs to begin immediately and ramp up quickly.
- The 2050 target is achievable but requires substantial contributions from all sectors. The three mitigation scenarios converge given the need to achieve substantial reductions from all sectors.
- Market availability of biofuels to meet the demand in each scenario has not been evaluated. The analysis assumes there will be sufficient volumes available, even though a market analysis has not been conducted.[4]
- Dynamic load flexibility will be important for electric sector reliability and cost mitigation. Technical approaches to achieve this flexibility have not been explored in the analysis. The modeling assumes some energy storage technology introduction, but doesn't include a re-allocation of energy demand to smooth out demand at peak times.
- Because the introduction of electrification in all sectors will increase peak electricity load, complementary policies are needed to ensure that peak loads are managed. These could be in the form of time-of-use rates, incentives or requirements for additional storage, or other policies and approaches.
- In the modeled scenarios there is over-production of electricity due to assumed increases in renewable energy. This poses a challenge and an opportunity. Reducing peak load — through measures that Vermont is already engaging in, such as EV load management — can result in the same lower overall GHG emissions, but will require additional policies and/or technology introduction than what was modeled.

The model provides the basis for developing long-range mitigation scenarios — scenarios that are indicative of the level of required deployment for key technologies, and which help the state to understand the consequences of different options for reducing GHG emissions. The model provides an analytical tool that estimates the self-consistent impact of different choices on the energy system, often using basic (though detailed) energy, emissions, and cost accounting. The model does not prescribe a

[4] Conducting such analyses will be important to shaping continued biofuel policy, particularly for use in a rural setting.

single scenario or set of directives that state policymakers should follow, but instead helps to answer policymakers' "what if?" questions by comparing costs, emissions, or other impacts across a range of different input assumptions.

Following on the PSD's core work, the Climate Council engaged Energy Futures Group and Cadmus to refine the modeling and analyze strategies consistent with the Climate Council's needs. Instead of creating two separate models with multiple inputs, the CEP and Climate Action Plan again were coordinated for consistency in assumptions. There is one final model with core assumptions that serve both plans.

One of the benefits of the LEAP model is that the State of Vermont will be able to maintain a license and be trained on use of the model. This will allow for LEAP to be used as a monitoring and assessment tool going forward. Unlike previous modeling efforts, this should not be a "black box" that the state cannot update and use in the future when assumptions change.

2.2.1.2 Emissions Accounting

Vermont tracks its emissions through a Greenhouse Gas Inventory that is prepared annually by the Department of Environmental Conservation, within the Agency of Natural Resources, which released the most recent update in May 2021.[5] Consistent with inventory guidelines from the Intergovernmental Panel on Climate Change (IPCC) and the U.S. Environmental Protection Agency (EPA), Vermont's GHG Inventory reports on gross emissions. The inventory serves as the basis for the emissions reduction requirements established by the Global Warming Solutions Act, and for considering emissions impacts from energy policy in this CEP.

As described by the Vermont Climate Council (see Chapter 9 of the Climate Action Plan), it is critical that tracking of greenhouse gas emissions continues to be as transparent and accurate as possible. Through the work of its Science & Data Subcommittee, the Climate Council reviewed the methodology and assumptions in the inventory, including a report developed by Energy Futures Group under contract to the Agency of Natural Resources.[6] In summary, the Subcommittee recommended, and the Climate Action Plan includes, recommendations to[7]:

- Maintain and continue to update and improve the current GHG Inventory methodology,
- Continue to report on gross emissions while improving articulation of net emissions,

[5] https://dec.vermont.gov/sites/dec/files/aqc/climate-change/documents/_Vermont_Greenhouse_Gas_Emissions_Inventory_Update_1990-2017_Final.pdf

[6] Energy Futures Group "Greenhouse Gas Inventory Review: Vermont's Current Methods, Comparison with Accepted Practices, and Recommendations", August 10, 2021. Available at https://outside.vermont.gov/agency/anr/climatecouncil/Shared%20Documents/GHG%20Inventory%20Report%208-10-2021.pdf

[7] Recommendations available at: https://climatechange.vermont.gov/node/85

- Include supplemental information and sensitivity analysis related to differing Global Warming Potential[8] timeframes, biogenic greenhouse gases, and information as it is updated from the IPCC, and
- Maintain Renewable Energy Credit (REC) accounting as the basis for calculating electricity sector emissions (i.e., emissions from our purchase and consumption of electricity and associated RECs).

The Science & Data Subcommittee further recommended that additional accounting and research are needed. These additional analyses would allow for supplemental upstream and/or lifecycle accounting of emissions, and for better understanding of gaps in quantifying emissions, particularly related to evaluating greenhouse gas emissions in the agriculture and related land-use sectors. Importantly, any future lifecycle or upstream emissions accounting will be expected to stand alongside the current GHG Inventory. The Climate Council adopted this recommendation as well.

As described further below, using all the information available to support a comprehensive understanding of the impact of Vermont's actions under a range of possible assumptions and variables will prove to be a critical component of choosing the best path forward for achieving the state's GHG reduction requirements.

2.2.1.3 The Role of Data

Data plays a critical role throughout the lifecycle of the energy planning process, particularly as Vermont seeks to address the hardest-to-reach aspects of the state's requirements for renewable energy and reduction of greenhouse gas emissions. Data that is geographically granular and readily available — data that, at present, is often inaccessible — will be vital to enabling the capacity of planners across Vermont, from those within state agencies down to the town level, to achieve the state's objectives. Accurate, transparent, and trusted sources of data are foundational for numerous core planning activities, including:

- Understanding the context in which programs and policies operate, through setting historical baselines regarding energy usage, understanding current system conditions, determining driving causes of vulnerabilities and challenges for which solutions must be designed, and setting targets for future progress;
- Modeling and analyzing how to reach those targets, through exploration of potential pathways and scenario analyses regarding the preferred methods for achieving goals given various decision-making criteria around cost-effectiveness, equity, and environmental considerations, among others;
- Developing and implementing programs and policies to enhance the clean energy benefits that flow to Vermonters while also targeting efforts to address specific needs, such as equity concerns or particularly challenging reductions in greenhouse gas emissions;
- Monitoring and assessing progress toward achieving desired goals through the identification of intermediate benchmarks and milestones, and measuring progress against those metrics to understand whether policies and programs are on track or course correction is needed; and

[8] Global Warming Potential (GWP) is "a measure of how much energy the emissions of 1 ton of a gas will absorb over a given period of time, relative to the emissions of 1 ton of carbon dioxide (CO2)."For more, see: https://www.epa.gov/ghgemissions/understanding-global-warming-potentials

- Communicating the imperative for action, and holding decision-makers accountable to achieving objectives in a manner that best serves Vermonters.

What does this mean for the energy system in Vermont, and for the role of data in reaching goals for renewable energy and GHG emission reduction requirements? Where possible, Vermont will need trusted data on the status of energy use across the electricity, thermal, and transportation sectors, across customer classes (residential, commercial, and industrial), and even down to the end-use case (ex., within buildings), along with ways to communicate and manage that information. This data will be needed at a granular specificity down to the regional planning commission and town level, to support enhanced energy planning efforts under Act 174. Such locally specific data sources will prove useful for more accurately understanding the statewide context, while ensuring that policies and programs appropriately direct support to and enable the capacity of Vermont's communities, particularly those that have been or will be disproportionately impacted by changes in the energy system.

In addition, as Vermont seeks to analyze various pathways, strategies, and actions through trade-off analyses that equally weigh considerations around program cost effectiveness, equity, and environmental impacts, needs for supporting data will range beyond traditional energy-use information. For example and where appropriate, such analyses will need information on socio-economic demographics to ensure equitable distribution of the benefits and burdens of the renewable energy transition, along with consideration of new metrics that help in holistically assessing potential programs and policies.

Vermont currently has its most reliable and consistent data in the electricity sector, particularly within the realm of the regulated utilities — data on electric and gas distribution, energy efficiency, the transmission utilities, and statewide initiatives such as weatherization efforts. Utilities report electricity usage data by customer class (residential, commercial, and industrial) through a variety of means to the Department of Public Service, and in recent years Efficiency Vermont has been able to consistently provide regional planning commissions and towns with estimates of electricity demand. In addition, the Energy Action Network has been able, through its Community Dashboard, to provide relatively consistent data by region and municipality on generation within the state (i.e., type of generation and total capacity).

More limited information exists on energy usage in the thermal (e.g., oil, propane, and kerosene) and transportation (e.g., gasoline and diesel) sectors, especially at the local level. This presents challenges, as these sectors currently contribute the largest shares of Vermont's greenhouse gas emissions and are therefore the sectors most critical to target successfully with programs and policies for advancing clean energy solutions and transitioning away from fossil fuels. Current estimates of fuel usage in these sectors require referencing national datasets (e.g., through sources such as those provided by the Energy Information Administration State Energy Data System or the Census-based American Community Survey), or data collected by the Department of Taxes and Joint Fiscal Office based on fuel taxes.

While such data sets offer a high-level and regularly updated assessment of thermal and transportation fuel sales for the state, they also have several limitations — particularly around the ability to disaggregate data on fuel sold by specific fuel, or on usage by regional planning commission or town — due to data privacy concerns and the way in which information is currently collected. Disaggregating such data to the level currently required for energy planning efforts requires several layers of assumption and/or interpolation and makes it very difficult to track town- or region-specific fossil fuel use, along with progress towards reducing that use. Further assumptions are required to assess such fuel usage across customer class and end uses (like space heating and water heating across residential, commercial, and industrial buildings in the thermal sector, and light-duty vehicle versus medium-duty or industrial vehicle usage in the transportation sectors) — and this information is critical for successful program design and development.

Without better sources of data on fuel usage, planners must rely on the proxy of beneficial measures installed to monitor and assess progress toward meeting clean energy goals. This includes tracking data on the "positive things" happening, such as the adoption of cold climate heat pumps, electric vehicles, and other efficiency measures. While such information on positive actions provides some path for estimating the direction and potential impacts of programs and policies, it is still uncertain whether this provides sufficient indicators of whether ultimate goals around renewable energy and reductions of greenhouse gas emissions are being achieved.

Translation of statewide information to more granular levels requires significant capacity and resources, which regional planning commissions and towns do not currently have on a sustainable basis. While the Department of Public Service and the Agency of Commerce and Community Development have been able to allocate some funding to support Act 174 enhanced energy planning, no dedicated and long-term funding exists to support the efforts needed. Even at the state level, the lack of geographically granular data inhibits the ability to develop regional and town-level analyses to support these efforts.

Moving forward, it will be essential for Vermont to work collaboratively across stakeholders such as state agencies, regional and town energy planners, fuel dealers, utilities, program administrators, and legislators to develop more robust and transparent data sources regarding the type and amount of energy use, particularly in the thermal and transportation sectors. These data sets will be critical for monitoring and assessing progress toward meeting Vermont's clean energy objectives in a transparent way.

As these data sets are developed, efforts should be made to limit the burdens of data reporting placed on implicated stakeholders. This can be achieved through means such as ensuring that only data critically necessary to planning efforts are collected; ensuring that data are openly published; making data as available as possible to all relevant stakeholders; and communicating and visualizing this data in ways that are accessible to all Vermonters. The ongoing efforts by the Department of Public Service to modernize its energy data infrastructure through streamlining data collection, management, and publication, building off efforts by organizations like the Energy Action Network, seek to provide the necessary infrastructure to steward such data, and to enhance the capacity of energy planning across all scales in Vermont. Further, through collaboration with the Science & Data subcommittee of the Vermont Climate Council, the Department of Public Service will continue to work to identify strategies to remedy the data gaps discussed throughout this section, with the aim of supporting enhanced energy planning throughout the state.

2.2.2 Analyzing Strategies — Decision Making Framework

Many factors must be considered when analyzing the ability for pathways, strategies, and actions to help achieve renewable energy goals and GHG reduction requirements. This section describes several core components of the decision-making framework necessary to develop a CEP.

2.2.2.1 Cost Effectiveness and Benefit/Cost Tests

Cost-effectiveness and benefit-cost tests provide one lens of analyses when evaluating potential programs and policies. The cost-effectiveness of an action can simply be defined as its net cost ($ cost less $ benefit) per unit of desired outcome. For example, a policy measure for greenhouse gas reduction might have a net cost (costs less benefits) of $100/ton of carbon dioxide mitigated. If that $100 is worth the desired outcome of GHG avoidance, then the measure is considered cost-effective.

Benefit-cost tests provide a path for helping to define the cost component of a cost-effectiveness analysis, seeking to ensure the consideration of a full range of perspectives on a proposed policy or program. There are several types of benefit-cost analyses; each considers different types of information in quantifying the costs and benefits of a potential measure, and each is potentially useful for different purposes. Here are the four main types of tests for programs or policy actions[9]:

- The **Societal Test** answers the question "what are the net costs to society?" of a specific policy or program, and includes the costs and benefits of that policy or program to all members of society — including the program administrator, customer, impacted participants, and anyone else. This test necessitates defining whether "society" encompasses the state of Vermont, the New England region, the nation, or the globe. The Societal Test generally offers the most comprehensive assessment of estimated costs and benefits, because it includes externalities regardless of who experiences them. Those externalities include GHG emissions, health benefits, and other impacts that may not otherwise be quantified.[10] These externalities — external to traditional, immediate economic analysis — can be quite large and challenging to quantify.
- The **Total Resource Test** (TRT) answers the question "what are the net costs to the program administrator, participants, and non-participants, collectively?" Accordingly, this test accounts for costs and benefits experienced by both participants and non-participants of the program. Costs include those incurred by a program administrator and the participating customer; benefits include those that accrue to both participating and non-participating customers that are affected. Second to the Societal Test, the TRT provides the next most comprehensive assessment, by including all impacts to the program administrator and all its customers while excluding externalities.
- The **Program Administrator Test** (also called the Utility Cost Test) assesses "what are the net costs to the program administrator?" and includes only the net costs to the entity tasked with administering a program or policy, such as a government agency or utility. These costs can include those for marketing and incentives, and for monitoring and evaluation. For example, if the program administrator is the state, this test may consider program implementation costs relative to the benefits to Vermont, but exclude the costs incurred directly by customers who participate in the program.

[9] For a full description of different benefit cost tests, see the National Action Plan for Energy Efficiency developed by the Environmental Protection Agency, which summarizes these tests. https://www.epa.gov/energy/national-action-plan-energy-efficiency

[10] Note, while some argue for economic development impacts to be included in a societal test, economic development impacts are generally NOT counted in benefit-costs tests because much of the benefit comes in the form of cost savings that are already captured in the core test. See Synapse Energy Economics "New Hampshire Cost-Effectiveness Review", October 2019: https://www.synapse-energy.com/sites/default/files/Synapse-Report-NH-NSPM-Final-2019.10.14_0.pdf

- Finally, the **Participant Test** evaluates "what are the net costs to the participant?" and includes costs and benefits experienced by the participating customer. For example, this test might consider the cost beyond a program incentive paid by a homeowner for weatherizing their home, compared to the benefit of energy saved on their bill. For example, energy efficiency programs may increase rates for all customers, including the participant, but only the participant's costs (and benefits) are counted.

The results of a benefit-cost test vary depending on the perspective taken, and each of the perspectives outlined above provides an important lens of analyses to inform decision-making, from determining whether a program is worthwhile to informing program design. Because energy usage patterns, technologies, costs, and benefits continue to evolve over time, periodically updating benefit-cost tests with the most recently available data and forecasts will support informed decision-making as Vermont strives to achieve the goals outlined in this CEP. It is important to note that these benefit-cost tests generally do not describe any transfer of costs between participants — one reason why benefit-cost tests should constitute only one part of the equation.

Valuing Avoidance of Greenhouse Gas Emissions

Because this CEP is structured to meet requirements for reductions of greenhouse gas emissions, it is important to understand the value of the avoided emissions, and to include that value in any Societal Test analysis. The Vermont Climate Council, through its Science & Data Subcommittee, has overseen the development and presentation of material for estimating a "Social Cost of Carbon."[11] The Council recommends "the use of a stream of values that can be used to estimate the avoided damages of emissions associated with greenhouse gas mitigation measures," and notes that:

> The National Academy of Sciences defines the Social Cost of Carbon as "an estimate, in dollars, of the present discounted value of the future damage caused by a metric ton increase in carbon dioxide (CO_2) emissions into the atmosphere in that year or, equivalently, the benefits of reducing CO_2 emissions by the same amount in that year."

These recommendations are consistent with those made by the PSD in Public Utility Commission Case No. 21-2436, to value emissions based on the Social Cost of Carbon as developed for the New York Department of Environmental Conservation,[12] utilizing a central discount rate (in other words, a method to value future costs and benefits in present dollar terms) of 2%. Both the Department of Public Service

[11] The Subcommittee's draft language for the Climate Action Plan can be found at https://outside.vermont.gov/agency/anr/climatecouncil/Shared%20Documents/(9)%20Cost%20of%20Carbon%20%26%20Social%20Cost%20of%20Carbon%20-%20CLEAN%20-%2011-2-21.pdf The report, completed by Energy Futures Group, is titled "Social Cost of Carbon and Cost of Carbon Model Review Analyses and Recommendations to Support Vermont's Climate Council and Climate Action Plan", https://aoa.vermont.gov/sites/aoa/files/Boards/VCC/SCC%20and%20Cost%20of%20Carbon%208-31%20DH%20revised.pdf.

[12] See Case 21-2436 Prefiled Direct Testimony of Walter (TJ) Poor filed August 11, 2021. Greenhouse Gas Emissions other than CO2 can and should appropriately value the cost of greenhouse gas emissions or benefit associated with mitigation of those emissions. The Energy Futures Group report referenced in the previous footnote presents Social Cost of Methane and a Social Cost of Nitrous Oxide values. Other gases, until better information can be developed, can and should be converted to Carbon Equivalent emissions.

and the Council recommended modifying this value as appropriate as new information becomes available.

2.2.2.2 Technological Feasibility

The technologies and systems needed to achieve greenhouse gas reductions and hit the state's energy targets are in a constant state of flux. Updates to existing systems emerge nearly every day, with innovations pushing rapidly into the markets for electricity, building systems, and transportation. Some technologies and services are mature and ready for deployment, while others remain at some earlier stage of development (proof of concept, early-stage market testing, pre-investment, etc.). Reviewing strategies and actions entails questioning whether the proposed technologies and services can be readily advanced, at scale, without the need for additional work (i.e., research & development, investment).

Many strategies and recommended actions presented in the CEP focus on the adoption of existing technologies, with proven track records that are readily available and familiar to regulators and financiers. This preference for proven equipment rests on the recognition that many available choices designed to meet different customer needs and preferences can provide immediate energy savings and carbon reductions, without waiting the often-prolonged periods for new products to enter the market, or struggling to identify which new products or services may be better than those now available.

However, not all technologies proven in one part of the market (e.g., a consumer market segment like residential buildings, or the developed urban core) will prove effective in others. For example, while more and more light duty EVs are becoming available to consumers at competitive price points, medium- and heavy-duty EV options continue to be limited and less competitive. Similarly, new technologies may have achieved some initial degree of success with early adopters — who might be more forgiving in their expectations regarding performance, safety, battery life, and other key factors — but may not be well-adopted by larger segments of the market who tend to weigh these factors differently.

By focusing on known technologies, the CEP builds upon products in the market; but this does not imply that there is no role for innovative products or services. Indeed, there are numerous places where appropriate testing and piloting of emergent technologies or processes can help establish performance records that are essential to broaden their uptake. When considering pathways and strategies, a focus on technological feasibility considers the trade-offs for devoting resources to a known pathway that may be surpassed at some future time by more effective solutions yet to emerge.

As another example, consider a pathway such as the widespread adoption of electric vehicles, and electric vehicle supply equipment, that require consumers to purchase and use rapidly evolving automotive technologies such as batteries and charging infrastructure. While the state seeks to incentivize adoption of known carbon and energy saving technologies, a case can be made for keeping a watchful eye on the horizon, where new products may disrupt supply chains or replace today's options. The use of the technological-feasibility filter provides an opportunity to consider emerging entrants onto the field, but does not necessarily suggest waiting for something better to come along.

As technological progress pushes the boundaries, better products and services will emerge. The key is to make effective decisions that generate savings and carbon reductions now, while avoiding over-investment in technologies that may reasonably become obsolete or potentially detrimental once adopted by large numbers of market actors.

2.2.2.3 Equity

Acknowledging that "every one of us benefits when we make society fairer and more just," as noted by Vermont's Director of Racial Equity in her 2021 report to the Legislature, the principles of building Vermont's renewable energy future through a lens of equity and just transition run throughout this 2022 CEP. As Vermont moves towards a cleaner energy future and develops the policies and programs to support those changes, it will be critical to do so through a lens of equity and justice that focuses on ensuring that no Vermonter is left behind. Historically, that has not been the case.

The average statewide total energy burden, defined as energy spending as a percent of income, is about 10%. But because there is a broad range of costs, given Vermont's rural character, old buildings, and variable weather, the energy burden for some Vermonters can be much higher — and the average for towns across the state ranges from 6% to 20%. Clean energy technologies that can reduce costs and energy burden are generally not adopted in areas with the highest energy burden.[13]

The energy system, at its roots, was built to serve people through enabling the provision of critical services, such as keeping homes warm and healthy on cold winter evenings and providing the fuel to support operations of local businesses. Approaching the clean energy transition through an equity and justice lens will help ensure that the needs of Vermont's citizens, communities, businesses, and other institutions are met — particularly among those that have historically been marginalized or underserved, and those most impacted by the transition. This transition opens the door not just to meet renewable energy and climate objectives, but to do so in a way that better serves all Vermonters; uplifts those who have previously not had access or the ability to participate; addresses and repairs the root causes of existing inequities; and in the process builds a more inclusive energy system for Vermont.

Leveraging the foundational work of the Just Transitions subcommittee of the Vermont Climate Council, Chapter 3 grounds this CEP in a clear understanding of what is meant by energy equity and a just transition for the system, and seeks to lay the foundation for how these considerations should be integrated as core decision-making criteria when deciding what policies and programs to pursue. Chapter 3 also considers what this means for Vermont moving forward, and provides recommendations for steps to broadly advance a just and equitable energy transition while implementing the programmatic and policy actions outlined in the plan.

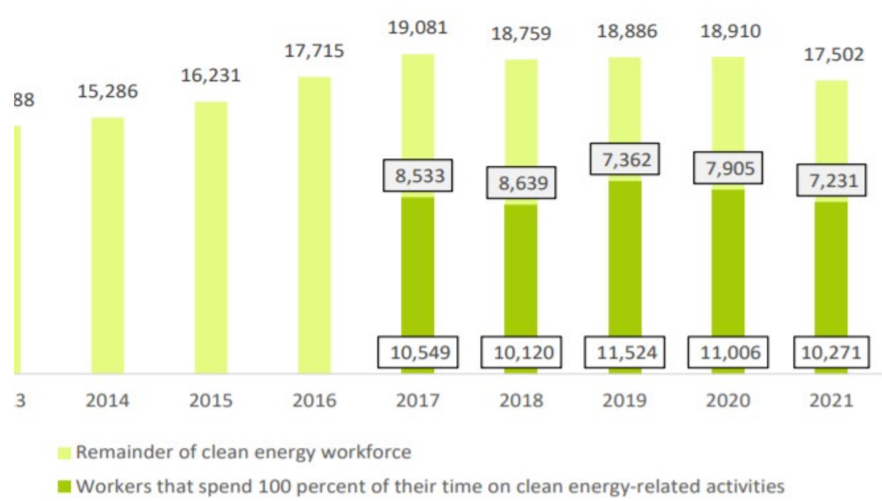
[13] Efficiency Vermont, Vermont Energy Burden Report, Oct 2019, Sears & Lucci.

2.2.2.4 Economic Development and Energy Production

The priorities of any good state policy must be centered on the needs of Vermonters as a whole, while considering the policy's impacts as they relate to those needs. One such consideration is economic development impacts.

Decarbonizing the Vermont economy will involve a significant transition in the Vermont economy. Vermonters currently pay almost $3 billion per year in energy costs, including transportation, heating, and electricity. As explained further in this plan, lowering GHG emissions to meet the GWSA requirements will require significant electrification of the transportation and heating sectors, with electricity expenditures remaining in Vermont's economy at a much higher rate than fossil fuel expenditures. With electrification, Vermonters' energy costs will become increasingly concentrated in their electric bills. Minimizing upward pressure on rates will be imperative, given the need to support the economic advantages for customers to electrify. The promotion of economic development in the clean energy industry should be balanced with understanding and accounting for the costs that all Vermonters bear in supporting such development.

Since 2014, the PSD has tracked clean energy industry employment trends via the annual *Vermont Clean Energy Industry Report* series. Over that period, Vermont's clean energy industry has either grown or maintained consistent employment levels, save for the workforce reductions associated with the pandemic in 2020. Even after accounting for the impacts of COVID-19 on the state economy (which hit the clean energy industry less hard relative to overall statewide job losses), the number of clean energy jobs increased by 18 percent from 14,788 in 2014 to 17,502 in 2021. Clean energy jobs made up about six percent of the state's total employment at the end of 2020.[14] (Exhibit 2-2)**Exhibit 2-2. Clean Energy Employment in Vermont, 2013-2021**



Source: 2021 Vermont Clean Energy Industry

[14] 2021 Vermont Clean Energy Industry Report. Vermont Department of Public Service. June 2021. https://publicservice.vermont.gov/sites/dps/files/documents/Renewable_Energy/CEDF/Reports/2021_VCEIR_FINAL.pdf. Pg. 6

Looking at the more recent clean energy jobs data shows changes in parts of the clean energy industry over the past several years unevenly spread among sub-sectors, with energy efficiency increasing and renewable energy decreasing. For example, the number of renewable energy workers decreased by 494 (4.5%) from 2017 to 2020 (pre-pandemic). Among these were 408 jobs consolidated in the solar sub-sector. However, clean energy businesses in Vermont shed fewer jobs compared to overall statewide job losses. For comparison, Massachusetts reported a loss of 1,949 solar jobs over the same period.[15] In Vermont, the renewable energy job losses occurred in the woody biomass, non-woody biomass fuels, renewable heating and cooling, wind, and solar sub-sectors. Jobs in energy efficiency grew relatively consistently until the beginning of the COVID-19 pandemic last year. Factors that may impact the number of clean energy jobs include the consolidation of part-time positions into full-time employment, regional competition, overall economic conditions, and policy considerations.

The pursuit of the strategies and actions outlined in this plan will require a robust, well-trained, and diverse workforce capable of delivering high-quality products and services to consumers around the state. Whether it be through installation of cold climate heat pumps or advanced wood heating systems, mounting solar PV racks on a roof, auditing energy performance in buildings, or conducting whole house weatherization, well-trained clean energy workers will be needed in larger numbers over the coming years.

Because the work is local, jobs in clean energy— such as energy efficiency workers, HVAC installers, or EV technicians — are not subject to outsourcing. About 89 percent of employers who were hiring in 2020 reported some difficulty in finding workers[16]; but at the time of this writing, as many firms resumed work on projects around the state, demand for workers had returned in parts of the clean energy industry. However, finding workers to fill positions remains a challenge. The workforce must be built and sustained, better preparing Vermont's young people to stay within the state and attracting people from outside Vermont to aid in the energy transition.

In 2021, the General Assembly passed Act 74, which included formation of a Weatherization Workforce Group to develop plans for the coordinated delivery of a standardized statewide building services curriculum that includes weatherization. [17] The Workforce Group documented the challenges facing the state, including unclear pathways in Vermont's construction trades and difficulty finding workers with interest in energy efficiency jobs that often involve uncomfortable working conditions. The final report outlines a curriculum and certification delivery framework for consideration, but recognizes that more work is necessary to address core barriers to increasing the clean energy workforce.[18]

In addition, as the energy efficiency job market matures, there will be jobs available for workers transitioning from fossil fuels to renewables and to innovative electric technologies, leading to inevitable changes in the employment composition of these energy subsectors. It will be important to promote job

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[15] Massachusetts Clean Energy Industry Reports, MassCEC, www.masscec.com
[16] 2021 Vermont Clean Energy Industry Report Pg.17
[17] Act 74 of 2021. Section. E. 234.3. https://legislature.vermont.gov/Documents/2022/Docs/BILLS/H-0439/H-0439%20As%20Passed%20by%20Both%20House%20and%20Senate%20Official.pdf
[18] Weatherization Workforce Plan. Workgroup Report to the Vermont General Assembly on the Coordinated Delivery of a Standardized Statewide Building Science Curriculum. Laura Capps. Efficiency Vermont. October 1, 2021

training and career-transition support for workers whose jobs are impacted by shifting consumer demand and changes in policy, recognizing that just because new and emerging jobs are in the energy industry doesn't mean they won't be different, or require time for workers to transition.

Despite the growth of clean energy employment, the energy economy workforce tends to be dominated by male workers and lacks racial diversity when compared with national workforce averages.[19] As the state pursues policies and pathways to achieve the goals of the CEP and Climate Action Plan, there are opportunities to diversify the workforce and ensure that clean energy careers become open to anyone wishing to help build the low-carbon renewable energy economy.

2.2.2.5 Uncertainty

When considering policy pathways, technologies, customer preferences, and resource allocations, a range of uncertainties go along with any decision. The rapid pace of innovation, along with the changing focus of state administrations, can make it difficult for consumers and policymakers to place what may feel like a bet on some desired pathway and outcome. In the background, there are always conditions with the potential for making dramatic changes to prevailing thought or action: for example, little consideration was given during the development of the 2016 CEP to the prospects that a global pandemic would have profound impacts on the state. In the next few years, will some new factor or set of unforeseen conditions impact, derail, or accelerate progress towards greenhouse gas reductions and energy transitions? What "black swan" events of sufficient magnitude and consequence may lead to substantial financial, health, ecosystem, or societal disruption? Which might be harmful, and which beneficial?

Given the wide range of variables, how can Vermont's public servants, citizens, businesses, organizations, and decision makers reasonably assess the probabilities of disruption or inadequacy for chosen pathways, and whether uncertainties should forestall action? Does the prospect of "getting it wrong" demand spending more time and resources on studies at the expense of action? Should we move forward with the recognition that course corrections will be needed? How can the state help build a degree of robustness into prospective actions that could help cope with unpredictable situations, yet benefit the common good in the absence of negatives?

These are the kinds of questions contemplated under an uncertainty analysis, but they cannot be an excuse to forestall action. Rather, it is critical to analyze options under a range of possible outcomes and to determine the most likely or reasonable path forward. No one can predict the future — but understanding the implications of an action under a range of potential outcomes can inform decision making and reduce the possibility of failure while improving the chances for success.

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[19] Advancing Inclusion Through Clean Energy Jobs, Mark Muro, Adie Tomer, Ranjitha Shivaram, Joseph Kane. Metropolitan Policy Program at Brookings. April 2019. https://www.brookings.edu/wp-content/uploads/2019/04/2019.04_metro_Clean-Energy-Jobs_Report_Muro-Tomer-Shivaran-Kane.pdf; See also 2020 United States Energy and Employment Report. NASEO and Energy Futures Initiative. https://www.usenergyjobs.org

2.2.2.6 Setting Milestones to Trigger Policy Shifts

Much of the work for this CEP update derives from the knowledge that today's policies, resources, and markets are insufficient to meet Vermont's energy policy goals and requirements for greenhouse gas reductions. What kinds of guideposts, milestones, or benchmarks would provide the necessary insights to inform progress under new policies? Setting these navigational tools can help guide the work for the future.

Consideration of uncertainty can factor into the CEP, by including benchmarks and milestones into recommended implementation plans that require periodic review. Are the decisions made in 2022 still producing the desired effects in 2025? In 2030? What kinds of milestones will help future Vermont citizens and decision makers know that we are making progress at the necessary rates, and in the intended directions? Some of these features are built into current policies, such as the state's goals for building weatherization and requirements for reductions of greenhouse gas emissions. However, new strategies and actions that emerge from this update will need new markers, both to gauge progress and to help inform decisions that may lead to a shift in strategy.

3 Achieving CEP Goals in a Just and Equitable Manner

The transitions required to meet Vermont's renewable energy goals and GHG reduction requirements will necessitate significant changes to the energy system in Vermont. As the state moves towards that future and develops the policies and programs to support those changes, it will be critical to view this work through a lens of equity and justice.

The current energy system is marked by systemic inequities that have had and continue to have a disproportionate impact on many of Vermont's communities, in terms of issues such as energy burden and access to renewable energy opportunities. These inequities and many others have been starkly highlighted during the COVID-19 pandemic. Its onset brought an unprecedented number of Vermonters into arrears on their energy bills; and while programs like the Vermont COVID-19 Arrearage Assistance Program and Vermont Emergency Rental Assistance Program for Utility Services have provided short-term bill assistance to those in need, the pandemic has showcased how crises can disproportionately harm some communities while sparing others. With climate change expected to give rise to more frequent storm events that produce damaging environmental impacts and economic dislocation, it is imperative for policies and programs to be put in place that advance attaining renewable energy goals while also rooting out and redressing existing inequities.

The energy system was built over time in a piecemeal fashion, to serve people by delivering power and light for warm and healthy homes on cold winter evenings and to fuel economic and civic activities in a given service territory. Today's renewable energy transition opens the door not just to meeting renewable energy and climate objectives, but also to do so in a way that better serves all Vermonters. When contemplated through the lens of equity and justice, the transition presents an opportunity to lift up those who previously have not had access or the ability to participate in building and sharing in a more inclusive energy system.

Acknowledging that "every one of us benefits when we make society fairer and more just,[20]" the principle of building Vermont's renewable energy future as viewed through a lens of equity and a just transition runs throughout this 2022 CEP. This chapter sets the foundation for that work, grounding the CEP in a clear understanding of what is meant by energy equity and a just transition for the system, and contemplating what this means for Vermont moving forward. In addition, the chapter provides a high-level overview of some of the work that is underway to advance equity in Vermont, while also highlighting inequities and areas for improvement. While energy equity and justice considerations and recommended actions that are specific to certain policies and programs will be discussed in the appropriate sectoral chapters, this chapter concludes with several recommendations for how Vermont should take steps to broadly advance these principles across all its work moving forward.

[20] Report of the Executive Director of Racial Equity (Jan. 15, 2021). https://legislature.vermont.gov/assets/Legislative-Reports/EDRE-Report-to-GA-2021.pdf (quoting Xusana Davis, Director of Racial Equity, in her 2021 report to the Vermont General Assembly)

3.1 Background and Definitions

What is meant when discussing the principles of energy equity, justice, and a just transition for Vermont's energy system? As the state works to embed these principles in policies, programs, and decision-making, it is critical to begin by grounding that work in definitions of what these terms are understood to mean in Vermont. As used in the 2022 CEP, the terms *equity* and *just transition* reference and build upon the definitions adopted by the Just Transitions Subcommittee of the Vermont Climate Council. This ensures consistency between the 2022 CEP and the Vermont Climate Action Plan (CAP).

Energy equity (sometimes also discussed as **energy justice**[21]) "aims to make energy accessible, affordable, cleaner, and democratically managed for all communities."[22] While considerations of *equality* promote availability of equal opportunities for all, *equity* points a step further, toward recognizing and healing past harms perpetrated and perpetuated by the current energy system, whose detrimental impacts have been disproportionately — and therefore unjustly — distributed among the communities the system has served.[23]

The concept of energy equity is intertwined with and builds on the long history of the movement for environmental and climate justice. These related concepts focus on equitable access to environmental benefits, addressing the proportional distribution of environmental burdens and benefits, fostering meaningful involvement in decision making, and recognizing that people of different racial and ethnic groups, cultures, and socioeconomic status have different needs, all the while seeking to transition to a more sustainable society.[24]

Under the broad umbrella of equity, there are several specific dimensions to consider when designing policies and programs to serve all communities[25]:

- **Distributive equity** is outcome-focused[26] and considers the disparities in allocation of resources, benefits, and health outcomes, and the inequities experienced by communities related to living conditions, political power, and the risks and vulnerabilities posed to these communities as a result. Distributive equity asks whether Vermonters, regardless of racial and other socioeconomic factors, equitably share both the benefits and burdens of our energy system. This includes ensuring that all communities, particularly those that have been historically underserved, have access to renewable and low-carbon energy opportunities such as electric vehicles, cold climate heat pumps, solar PV, and weatherization, along with the connectivity required to access

[21] Initiative for Energy Justice, https://iejusa.org/section-1-defining-energy-justice/
[22] Vermont Climate Council, Just Transitions Subcommittee, August 2021. Guiding Principles for a Just Transition. https://outside.vermont.gov/agency/anr/climatecouncil/Shared%20Documents/Guiding%20Principles%20for%20a%20Just%20Transition%20-%20Final%20Approved%208.2021.pdf
[23] Initiative for Energy Justice, December 2019. The Energy Justice Workbook, https://iejusa.org/wp-content/uploads/2019/12/The-Energy-Justice-Workbook-2019-web.pdf
[24] Vermont Climate Council, Just Transitions Subcommittee, August 2021. Guiding Principles for a Just Transition. https://outside.vermont.gov/agency/anr/climatecouncil/Shared%20Documents/Guiding%20Principles%20for%20a%20Just%20Transition%20-%20Final%20Approved%208.2021.pdf
[25] Ibid.
[26] Initiative for Energy Justice, December 2019. The Energy Justice Workbook, https://iejusa.org/wp-content/uploads/2019/12/The-Energy-Justice-Workbook-2019-web.pdf

modern, innovative energy services. This further requires acknowledging where policies and programs in Vermont shift burdens outside our borders, such as from mining materials required for batteries or electric vehicles, and minimizing those burdens where possible.

- **Procedural equity** focuses on equitable planning and implementation, acknowledging the right of all communities to meaningfully participate in decision-making around policies and programs. This dimension of equity requires considering which stakeholders and communities have seats at the table, and whose voices are heard during public engagement on and discussions of issues such as the siting of new generation infrastructure and compensation for renewable energy programs. This applies both in formal proceedings such as statutorily required public hearings or cases before the Public Utility Commission, and in informal work groups during critical design phases of energy sector policies and programs. Procedural equity includes developing appropriate timelines to facilitate full engagement of communities, providing support to communities that are less familiar with how to engage with formal processes, and accommodating needs around translation, childcare, and appropriate meeting times to ensure participation by the broadest possible array of stakeholders.
- **Contextual equity** calls for programs and policies to acknowledge that some communities are more likely to experience adverse impacts — such as those of pandemics or natural disasters — due to various contextual factors, and that policies and programs designed to adapt to or mitigate these adverse impacts must account for such factors such as greater community vulnerability. This means that programs and policies must reflect awareness of how language barriers, racism, income, living conditions, occupations, and related considerations can influence and shape a community's ability — or inability — to access or participate in initiatives seeking to advance renewable energy goals[27]; and that reaching some communities may require solutions tailored to the particular lived experiences and needs of its members, including customized incentive values or structures and outreach methods.
- Finally, **corrective equity** highlights the need for clear processes through which communities can hold decision-makers accountable to their equity commitments, such as through advisory committees or oversight boards that meet periodically to review clean energy program implementation and results, with the aim of ensuring that impacted communities are being appropriately served.

In the realm of energy equity, inequities are often assessed through metrics like *energy burden*, which evaluates the percentage of energy expenditures relative to a household's income (and is discussed in detail in Efficiency Vermont's *2019 Energy Burden Report*[28]). Other metrics include *energy insecurity*, *energy poverty*, and *energy democracy*, which focus respectively on hardships that households face when meeting basic needs, lack of access to energy altogether, and the ability for communities to have agency in shaping their energy future[29].

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[27] Presentation by Nadia Marquez Pabst on August 10, 2021 for the Comprehensive Energy Plan / Vermont Climate Council Electric Sector Technical Workshop. Slides available here: Electric Sector Workshop Slides.081021.pdf

[28] https://www.efficiencyvermont.com/Media/Default/docs/whitepapers/2019%20Vermont%20Energy%20Burden%20Report.pdf

[29] Initiative for Energy Justice, https://iejusa.org/section-1-defining-energy-justice/

In addition to energy equity, the concept of **just transition** helps to frame actions that governmental, civic, and commercial institutions should take to support the energy transition required to address climate concerns.[30] As it relates to Vermont's energy sector, work to advance a just transition acknowledges the need to address the adverse impacts of requiring industry to transition away from fossil fuels, and the related implications for jobs and livelihoods (the transition "out") while promoting the clean energy jobs and livelihoods of a sustainable society (the transition "in")[31].

3.2 Principles and Priorities for an Equitable and Just Transition

In 2016, the CEP put forward a number of priorities for Vermont energy policy to strive to achieve, including a vibrant and equitable economy and supporting healthy Vermonters. Many of these priorities promoted the dimensions of equity and just transitions: among their aims, the priorities focused on ensuring an affordable and stable cost of living and doing business in Vermont; increased entrepreneurship opportunities and improved labor market conditions; ensuring equitable distribution of the benefits and burdens of Vermont's energy system; and assessing and reducing negative health impacts of our energy system[32]. This 2022 CEP reaffirms Vermont's commitment to achieving those goals. For the benefit of all Vermonters, it seeks to build upon and expand these priorities and the extent to which policies and programs embody them.

In seeking to do so, the 2022 CEP references the six *Guiding Principles for a Just Transition*[33] that were developed by the Just Transitions Subcommittee of the Vermont Climate Council. These principles offer a foundational and comprehensive lens to train on building energy equity and justice work. Developed through a collaborative process, with a diverse set of voices representing many lived experiences from throughout Vermont's communities, the Guiding Principles offer a strong vision and guideposts for work on climate and energy issues.

Here are the six Guiding Principles, intended to shape the work, recommendations, investments, and implementation of the Vermont Climate Action Plan, and the work, recommendations, investments, implementation and oversight of the Comprehensive Energy Plan:

- Inclusive, Transparent, and Innovative Engagement in the development of all policies and programs associated with the plan, involving wide community engagement, recognition that communities are experts regarding their own energy experience, and acknowledgment of the known impacts, benefits, and burdens of recommendations.

[30] Vermont Climate Council, Just Transitions Subcommittee, August 2021. Guiding Principles for a Just Transition. https://outside.vermont.gov/agency/anr/climatecouncil/Shared%20Documents/Guiding%20Principles%20for%20a%20Just%20Transition%20-%20Final%20Approved%208.2021.pdf
[31] Ibid.
[32] A full list and description of these priorities can be found on page 22-27 of the 2016 CEP, available https://publicservice.vermont.gov/publications-resources/publications/energy_plan/2016_plan
[33] A full draft of the Guiding Principles can be accessed https://outside.vermont.gov/agency/anr/climatecouncil/Shared%20Documents/Guiding%20Principles%20for%20a%20Just%20Transition%20-%20Final%20Approved%208.2021.pdf

- Accountable & Restorative recommendations which acknowledge that the status quo perpetuates ingrained inequities, recognize those inequities where they currently exist, and seek to address them through clearly identified strategies.
- Moving at the Speed of Trust, acknowledging that candor and honesty will be critical for building and maintaining public trust and preparing for the transition to a sustainable energy future.
- Solidarity in creating inclusionary spaces for all traditions and cultures within Vermont, particularly for Indigenous communities.
- The Most Impacted First, prioritizing the needs of impacted and frontline communities in recommendations — ensuring that these Vermonters receive the greatest benefits of this transition, and that recommendations are broad enough for the well-being of all Vermonters but include targeted strategies for different groups that consider their specific histories and sociocultural and economic realities.
- Support Workers, Families, and Communities, through development of support systems that consider and plan for the impacts on workers and their families and communities caused by the implementation of the plan, including considering the current and needed capacity of local and regional governments, organizations, and families to implement actions.

The Principles recognize Vermont's impacted and frontline communities as those that:

- Are highly exposed to climate risks, including health impacts, flooding, extreme temperatures,
- Experience oppression and racism, are excluded from opportunities, or have less resources to adapt to climate and economic change,
- Bear the brunt of pollution and negative effects from fossil fuel and extractive economies, and
- Are more likely to experience job transitions as Vermont addresses climate change.

As Vermont seeks to advance renewable energy and decarbonization objectives in a way that puts these priorities and principles front and center, several tools exist to guide this work. As of 2021, all state agencies must now screen policy and budget proposals through a standardized Equity Impact Assessment (EIA) tool[34]. This outlines a number of data-driven questions that are designed to assess whether proposals will create disparities or promote equitable distribution of benefits and burdens. Although developed before the Guiding Principles, the EIA tool addresses many of the same concerns and considerations — including those involving populations that a proposal will impact, meaningful engagement with those communities, and the data and analytic capabilities required to understand the implications of the proposal and whether mitigation of adverse effects may be necessary.

In addition to the agency-wide use of the EIA tool, the Just Transitions subcommittee has developed a series of assessment questions, and a related scoring rubric,[35] aimed at providing a process for evaluating equity and justice considerations in the development of the Climate Action Plan. The questions and

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[34]Report of the Executive Director of Racial Equity (Jan. 15, 2021). https://legislature.vermont.gov/assets/Legislative-Reports/EDRE-Report-to-GA-2021.pdf

[35] Full drafts of the assessment questions and scoring rubric are available for review https://outside.vermont.gov/agency/anr/climatecouncil/Shared%20Documents/Guiding%20Principles%20for%20a%20Just%20Transition%20-%20Final%20Approved%208.2021.pdf

rubric are designed to help those involved in the design, development, and implementation of policies, programs, and recommendations to reflect on and evaluate:

- Which impacted or frontline communities may be implicated by recommendations;
- How resulting benefits and burdens will be distributed, and how the recommendation will create a more equitable future moving forward;
- Whether equitable and just engagement has or will occur during the design and implementation process, and if recommendations are easy to understand for all Vermonters;
- What funding and data will be required to assess, evaluate, and implement the recommendation, and whether impacted communities will be consulted during assessment activities; and
- The outcomes expected to result from and the capacity required to implement the recommendations.

In addition to these Vermont-specific tools, a variety of others focused on advancing energy equity and justice exist or are in development from nationally recognized organizations and efforts such as the American Council for an Energy Efficiency Economy[36], the Initiative for Energy Justice[37], and the Energy Equity Project.[38] These are likely to prove helpful to Vermont in advancing its efforts, particularly around the development or identification of necessary data and metrics to track progress toward achieving the objectives of energy equity and just transitions.

3.3 Equity and Justice in Vermont's Energy System: Current Status and Paths Forward

Considering the priorities and principles outlined here, the question remains: what does this mean for policies and programs in Vermont as the state works toward transitioning to a renewable and decarbonized energy future?

In part, it means continuing and expanding many of Vermont's present-day programs and practices. Many state agencies are working collaboratively with external partners to support programs that seek to more equitably distribute the benefits of clean and renewable energy across Vermont and across income levels. These include:

- the Renewable Energy Standard Tier III energy transformation program, which requires electric distribution utilities to offer programs targeted at low-income communities, and to set targets for minimum spending for these programs;
- Energy Efficiency Utility minimum performance requirements, to ensure broad geographic and income distribution of benefits; and
- EV incentive programs such as MileageSmart, to help Vermonters with low and moderate incomes pursue clean transportation options.

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[36] https://www.aceee.org/energy-equity-initiative
[37] https://iejusa.org/
[38] https://energyequityproject.com/

As a core part of its mission, the Department of Public Service continues to advocate for least-cost, reliable, and environmentally sound energy for all Vermont ratepayers in cases before the Public Utility Commission, and to ensure that the impacts of renewable energy development are equitably distributed. Continued support for enhanced energy planning at the regional and local level through implementation of Act 174 seeks to give communities greater say about the renewable energy development they would and would not like to see. Vermont also continues to advocate for and collaborate with regional and federal partners, to ensure that equity is central in planning for the future power grid — for example, by participating in efforts through the New England States Committee on Electricity to envision what actions will be necessary to achieve a clean, affordable, and reliable future grid[39].

At the same time, advancing principles of equity and a just transition will require making a deeper dive into understanding and acknowledging the inequities that continue to exist in Vermont and beyond our borders, along with the root causes of those inequities; and working collaboratively across state agencies, external partners, and communities to develop solutions that address those inequities. Analysis from organizations such as the Energy Action Network, Efficiency Vermont, and the Department of Public Service highlight that the benefits of the clean energy transition to date have primarily accrued to those who can afford the upfront costs required to participate.

According to Efficiency Vermont's *2019 Vermont Energy Burden* report, energy burden in Vermont averages 10 percent, and is as high as 20 percent some communities — meaning that households in these communities on average spend 20 percent of their household income on energy-related expenditures. The report also shows that adoption of clean energy technologies has primarily occurred in communities that experience a relatively low energy burden.[40] Analysis shows, for example, that a Vermont household located in a town with a higher average income is more likely to have adopted a solar net-metered system than a household in a low-earning town[41]. Similar research by the Energy Action Network shows that adoption of electric vehicles in Vermont has largely been concentrated in more affluent and urban areas, even with funding targeted at low- and moderate-income communities — and that EV adoption has not necessarily overlapped with the parts of Vermont that have the largest transportation burden[42].

Addressing these inequities will require a more holistic appraisal of the context within which programs and policies operate, including the extent to which they create or perpetuate inequities outside of Vermont's borders, and consideration of the new business models or technology ownership structures required to advance equitable distribution of energy benefits and reduce barriers to adoption. Many programs exist to support Vermonters based on income, but available data highlight a need to consider a broader set of contextual factors. For example, according to survey research from the University of Vermont, non-white and renter respondents in Vermont are more likely to experience energy

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[39] NESCOE: Report to the Governors — Advancing the Vision (June 29, 2021) https://yq5v214uei4489eww27gbgsu-wpengine.netdna-ssl.com/wp-content/uploads/2021/06/Advancing_Vision_Report_6-29-21.pdf

[40] Efficiency Vermont (October 2019). Vermont Energy Burden Report, https://www.efficiencyvermont.com/Media/Default/docs/white-papers/2019%20Vermont%20Energy%20Burden%20Report.pdf

[41] Department of Public Service Report on Public Utility Commission Net-Metering Information Requests (19-0855-RULE). Filed January 1, 2019.

[42] Curtis, E. (August 2021) Assessing Vermont's Progress in Equitable Clean Vehicle Incentive Distribution. https://www.eanvt.org/ean-interns/ean-summer-2021-interns/equitable-ev-access/

vulnerability than white and homeowner populations, respectively, suggesting that non-white Vermonters and those who rent their housing lack access to sufficient and affordable energy[43]. Statistical analysis of survey results also showed that renters were nine times as likely to have gone without electricity and two times more likely to have gone without heat in the previous year, compared to homeowners; and non-white respondents were seven times more likely to report going without heat than respondents who identified as white.

As noted by the authors, while the survey represents a convenience sample and therefore cannot prove causality, the initial results highlight "energy related issues among communities with higher environmental burdens in Vermont, which is valuable for understanding distributive injustices in Vermont, for which there is little previous data"[44]. Further research in Vermont has shown that Black, indigenous, and people of color (BIPOC) communities in Vermont are twice as likely as their white counterparts to lack access to public transportation or own a vehicle[45]. Significant differences also exist in the rate of homeownership between Vermont residents of color and white residents[46]: while the ratio of homeowners to renters was 71% to 29% for white Vermonters as of 2020, the same ratio was 22% to 78% for black or African American residents[47]. This relates to issues like zoning restrictions, aging housing stock, and overarching economic disparities that reduce opportunity for people of color.[48]

These and other disparities have significant implications for the abilities of different communities to participate in and access the benefits of clean energy programs and policies — and they illustrate the imperative that Vermont policies and programs be calibrated to specifically recognize these contexts and prioritize these communities. This will require, in part, providing all Vermonters the opportunity to equitably participate in public processes and make sure their voices are heard. Such engagement will necessitate considering appropriate timelines for processes that afford adequate engagement opportunities with communities, timing of events (ex., in the evenings as opposed to during the workday), availability of childcare, compensation for attendees, the creation of inclusive spaces, and the need to translate technical language into accessible language, including into languages beyond English. Consideration of such needs will be necessary to engage with communities in all public processes, such as intervening in cases before the PUC or in statutorily mandated public hearings, and in more informal engagements in the program development phase.

As regards a just transition for Vermont's workforce, while clean energy employment has grown, the field lacks diversity. As the state pursues policies and pathways to achieve the goals of the CEP, there are opportunities to diversify the workforce and ensure that clean energy careers remain open to anyone wishing to help build the emerging low-carbon renewable energy economy. In addition, as jobs transition

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[43] Keady, W., Panikkar, B, Nelson, I.L., & Zia, A. (2021). Energy justice gaps in renewable energy transition policy initiatives in Vermont. Energy Policy, 159. DOI: 10.1016/j.enpol.2021.112608

[44] Ibid, page 6

[45] Presentation by Dr. Bindu Panikkar at the Vermont Climate Council Just Transitions Subcommittee Climate and Environmental Justice Workshop, April 7 2021. Video recording available here: https://www.youtube.com/watch?v=GQDe-IqMZMI

[46] Keady et al, 2021

[47] Vermont Housing Finance Authority, February 2020: Vermont Housing Needs Assessment: 2020-2024. https://www.vhfa.org/documents/publications/vt_hna_2020_report.pdf

[48] https://legislature.vermont.gov/assets/Legislative-Reports/EDRE-Report-to-GA-2021.pdf

from fossil fuels to renewables, there will be inevitable changes in employment composition in energy subsectors. It will be important to promote job training and career transition support for workers whose jobs are impacted by shifting consumer fuel choices and usage.

Ultimately, the inequities and challenges acknowledged in the 2022 CEP will require reflection on and visioning regarding how current and future policies, programs, and processes can be revised or designed to support a more equitable and just energy system for Vermonters, with development and consideration of the data required to design and evaluate those efforts. Considerations of equity and just transitions as applied to specific policies and programs will be addressed throughout the 2022 CEP, appearing through overviews and trade-off analyses in each of the sectoral chapters. The recommendations here offer broad actions to promote equity in general across the state of Vermont and within internal agency processes.

Recommendations

- *The Department of Public Service, as both the consumer advocate in regulated utility matters and the State Energy Office, should develop a diversity, equity, and inclusion strategy to advance the transition to a just and equitable energy system for Vermonters and to guide actions moving forward. Staff training opportunities in diversity, equity, and inclusion should be pursued to enhance agency capacity to understand, analyze, and integrate equity considerations in all policies and programs.*

- *Equity should be considered as core criteria in all decision-making, alongside least-cost and environmentally sound principles as defined within the statutes that guide energy policy in Vermont, including 30 VSA 202(a), 209, 218(c), 225, 248, 8005, and 8010, among others.*

- *All strategies to promote the energy system transition should be designed to collect the robust and reliable data required to better understand baseline and historical inequities, and to measure progress towards remediating them.*

- *The Department of Public Service should complete a review of existing practices and procedures for energy-related public processes and recommend changes, as warranted, to encourage more inclusive and transparent engagement with Vermonters.*

- *The Department of Public Service should continue working with sister agencies to establish and implement frameworks for consistently addressing issues of equity and justice across Vermont energy policy.*

- *Act 174 enhanced energy plans completed by regional planning commissions and towns should include analyses of the potential equity impacts of proposed policies, objectives, and goals in the plans.*

4 Grid Evolution

Grid modernization, grid optimization, distribution system planning — these are terms that variously describe transformational changes to the way we generate, deliver, and use electricity. They encompass a wide array of functions and technologies, from real-time visibility through sensors and meters to orchestration of distributed resources with control platforms and even artificial intelligence. While the goals of grid modernization can vary, they generally focus on making the grid more resilient, responsive, and interactive, ultimately to benefit all electric consumers. This chapter will lay out a structure for thinking about the parameters of the challenging problem of directing the evolution of a very complex system, without the benefits of a blank check or returning to a clean slate. Suggestions will be offered for north stars and guideposts to direct our course to the highly dynamic, distributed, resilient, and sustainable future state of the grid that will provide the energy services needed to facilitate the greenhouse gas reductions that are so necessary to achieve.

4.1 Overview

According to the U.S. Department of Energy, a modern grid must have the following:

- Greater **resilience** to hazards of all types,
- Improved **reliability** for everyday operations,
- Enhanced **security** from an increasing and evolving number of threats,
- Additional **affordability** to maintain our economic prosperity,
- Superior **flexibility** to respond to the variability and uncertainty of conditions at one or more timescales, including a range of energy futures, and
- Increased **sustainability** through energy-efficient and renewable resources.[49]

California offers one example of how states are considering how to modernize their grids in the ways this DOE definition captures. The California Public Utility Commission provides one more specific definition:

> *A modern grid allows for the integration of distributed energy resources (DERs) while maintaining and improving safety and reliability. A modern grid facilitates the efficient integration of DERs into all stages of distribution system planning and operations to fully utilize the capabilities that the resources offer, without undue cost or delay, allowing markets and customers to more fully realize the value of the resources, to the extent cost-effective to ratepayers, while ensuring equitable access to the benefits of DERs. A modern grid achieves safety and reliability of the grid through technology innovation to the extent that is cost-effective to ratepayers relative to other legacy investments of a less modern character.*[50]

[49] https://www.energy.gov/gmi/about-grid-modernization-initiative
[50] CPUC docket 14-08-013

In other words, the grid must continue to perform — to reliably deliver the energy that customers need, every hour of the year — to and from exponentially more distributed, diverse, and variable resources (distributed solar, storage, electric vehicles, heat pumps, smart appliances), under increasing pressure from severe weather events and cyberattacks, while transitioning from fossil resources and remaining affordable. Add to that the complexity of the many diverse stakeholders and their different motivations and actions — customers, developers, various types of utilities, transmission and market operators, regulators, and policymakers — as well as evolving technologies, markets, laws and regulations, and the challenge becomes daunting indeed.

It helps, then, to start by taking a step back and thinking about the desirable end state. Only by determining the high-level objectives of a modernized grid can Vermont, as just one small state that is part of a larger, regional grid, determine a course and strive to direct all the moving pieces over which we have influence in the same general direction.

Why, then, is a modern grid important? Here are some reasons:

- To reach the state's energy goals in the most cost-effective manner with due regard for other important policy considerations.
- To make the future electric system cleaner, more reliable, and more cost-effective.
- To enable and remove barriers to equitable participation of customers and devices in the grid.
- To capitalize on the full suite of grid services that can or will soon be provided by DERs.
- To enable aggregation of fleets of DERs that can respond to system needs.
- To accommodate high penetrations of distributed renewable energy.
- To manage the increasing penetration of EVs and heat pumps that is needed to transition the heating and transportation sectors away from fossil fuels.
- To be responsive and adaptable to the pace of technological and market changes, which are only accelerating; and,
- To ensure the reliability, resiliency, and security of the grid in light of increasing use of software, multiplying points of entry, severe weather, winter fuel constraints, etc.

What is a Distributed Energy Resource?

Distributed generation (e.g., rooftop solar) is one of many types of distributed energy resources (DERs) that together comprise a growing component of the grid. The Department embraces the expansive definition of DERs adopted by the Federal Energy Regulatory Commission in Order 2222:

We define a distributed energy resource as any resource located on the distribution system, any subsystem hereof, or behind a customer meter. These resources may include, but are not limited to, electric storage resources, distributed generation, demand response, energy efficiency, thermal storage, and electric vehicles and their supply equipment.

As technologies advance, more types of DERs are expected to materialize. For instance, with so-called "smart panels," a whole building could become a DER, with component pieces such as solar and storage acting in concert to flatten the building's load shape.

With all these aims considered, Vermont's overarching goal for the grid of the future should be: *A secure and affordable grid that can efficiently integrate, use, and optimize high penetrations of distributed energy resources to enhance resilience and reduce greenhouse gas emissions.*

It is important to unpack each element of that stated goal, to understand exactly what is at stake and where tensions and tradeoffs are likely to occur. For example:

- Any grid investments — whether in security, distributed energy resources, resilience, or reducing greenhouse gas emissions — must be evaluated in terms of cost-effectiveness; otherwise they may work at odds with affordability. It is essential to keep electricity affordable (including the cost increases driven by upgrading and maintaining the grid), not only for the sake of equity but so that customers are willing and able to choose electricity over fossil fuels for their heating and transportation needs — a choice that is essential for reducing greenhouse gas emissions. The time horizon and perspective used for this evaluation — whether from point of view of the individual customer, Vermont ratepayers collectively, or society more broadly — will influence the outcome, as will any contributions from dollars outside of electric rates (e.g., federal dollars).
- The addition of many distributed energy resources, especially electric vehicles, electric cold-climate heat pumps, and battery storage, can help increase grid efficiency and reduce greenhouse gas emissions, especially if deployed to use electricity when and where the grid is cleanest (e.g., during hours of and in proximity to wind or solar generation). However, if it is not deployed thoughtfully — such as under direct utility control, or influenced by rates that align costs with a dirtier or more stressed grid — the grid will need to be overbuilt, which works against efficiency and affordability.
- Distributed energy resources that generate electricity, such as wind, solar, hydropower, and anaerobic digesters, can also help to reduce greenhouse gas emissions, again especially if they produce electricity where and when (on an hourly basis) it is needed. That means aligning resources in time and space with load, or at least in areas of the system that have available headroom; and it means valuing production from those resources more when that production coincides, in real time, with the times of highest load and dirtiest power supply. Not doing so will again lead to overbuilding the grid, which works against efficiency and affordability.
- As Vermont comes to rely more on distributed energy resources to (if deployed smartly) reduce greenhouse gas emissions, so too will we rely even more on a *resilient* grid to serve a growing share of our daily energy needs, including for heating our homes and transporting us to and from those homes. Distributed generation only provides resilience to the extent that it delivers energy when and where it is needed, for the duration of the need. In the event of an upstream outage, on-site distributed generation can only serve a customer's energy needs if it is coupled with energy storage and appropriate controls. The costs and benefits of customer-sited storage and generation must be weighed against the costs and benefits of enhancing the upstream resilience of the grid itself (e.g., through vegetation management, hardened overhead distribution lines, and strategic relocation or undergrounding of lines), in order to ensure efficient and equitable resilience for all — or at least the greatest number of — customers. Also, many distributed energy resources are inverter-based and communicate with upstream controls via customer internet. Without adequate safeguards around the interconnection of and communication to and with

these resources, distributed energy resources can become a liability in pursuing grid security and resilience.

These are just a few illustrations of the tradeoffs of a modern grid that should be explored when setting up an overarching set of objectives, exploring a stepwise plan, or pursuing specific investments. Different stakeholders will naturally emphasize different aspects of a set of grid modernization goals; the Department's objective is to make sure all perspectives are on the table and included in the conversation about how to best proceed, especially when ratepayers are being asked to pay for — and are the presumed beneficiaries of — grid modernization.

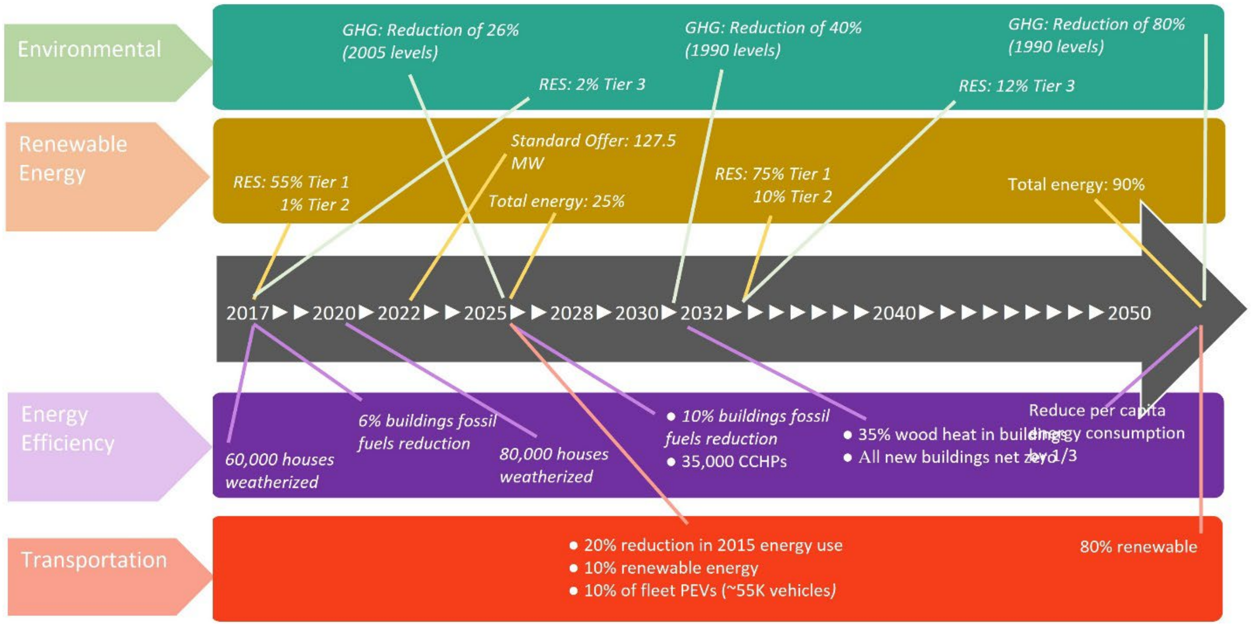
With reducing greenhouse gas emissions as our north star, we must carefully steer toward it on a path bounded by markers of affordability, security, resilience, and efficiency, as well as equity. Pursuing grid modernization without clear objectives or a mechanism for understanding and navigating tradeoffs is a good way to end up with an unaffordable and inefficient grid: one that sub-optimally and inequitably integrates DERs, with minimal impact on reducing emissions.

In this chapter, we explore the status of grid modernization action in Vermont, and we examine gaps and areas of urgent focus for the near future. In particular, we examine how existing tools can be enhanced, how new ones can be brought to bear, and how foundational, no- or low-regrets actions and investments can be undertaken to guide Vermont toward a *secure and affordable grid that can efficiently integrate, use, and optimize high penetrations of distributed energy resources to enhance resilience and reduce greenhouse gas emissions.*

4.2 Grid Planning Policy Drivers

The grid Vermont has today was shaped by yesterday's customer needs and policy priorities, just as Vermont's future grid will be shaped by today's policy priorities and our projections for how the future will unfold. Thus, the starting point for grid modernization planning is the legacy of past policy frameworks and investments. Today's energy planning policy drivers — principally greenhouse gas reduction and renewable energy mandates, electric vehicle fleet expansion, and goals for reducing fossil fuel use in buildings — assume that the needed grid will materialize to realize those goals. And it likely will — but perhaps not efficiently, or affordably, or even securely, without a plan that is *specific to the Vermont grid as it presently exists, and as it continues to be shaped by the physical and regulatory legacy of its origins*.

Exhibit 4-1. Vermont Energy Policy Drivers



Fortunately, extensive grid planning takes place on regular cycles (at least every three years) for the transmission and distribution systems that serve Vermont, and it is increasingly focused on comprehensively accounting for and balancing state energy policy drivers. The next several sections provide an overview of this planning activity, and they highlight many considerations and conclusions that policymakers, regulators, and other stakeholders who are engaged in the grid planning space need to consider in framing and crafting future energy policies.

4.3 New England Regional Transmission Grid Planning

At the regional level (i.e., New England, whose six states share a backbone transmission grid in addition to a wholesale energy market), grid planning is managed by ISO-NE, an independent regional transmission organization, and is focused primarily on reliability as mandated by the Federal Energy Regulatory Commission (FERC), the authority that supervises and regulates ISO-NE.[51] At least every third year, ISO-NE prepares a Regional System Plan (RSP) to forecast energy, capacity, and transmission needs for the region over a 10-year horizon.[52] The RSP also examines emerging trends, such as increasing penetrations of DERs; and it outlines forward-looking transmission planning, in part to "determine whether the existing transmission system and planning practices adequately accommodate the future of the power system, or whether reinforcements to the transmission system or changes to … study practices may be necessary."

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[51] "All users, owners and operators of the bulk power system must comply with the mandatory Reliability Standards developed by the electric reliability organization and approved by FERC." https://www.ferc.gov/sites/default/files/2020-04/reliability-primer_1.pdf, p. 39.

[52] https://www.iso-ne.com/static-assets/documents/2021/11/rsp21_final.docx. In addition, the CELT (capacity, Energy, Load, and Transmission) forecast is updated every year.

Several ambitious and complex, stakeholder-informed studies that are underway in the region have begun to sketch the outlines of a future transmission grid.[53] Though they are in the early stages, these studies have started to yield some important insights. Those insights, alongside emerging challenges now being faced by grid operators, can be thought of as "postcards from the future grid." By examining these messages, stakeholders can begin to envision how the near-future grid and the distant-future grid might need to perform, and can take the first steps to chart a route forward, keeping within acceptable bounds of reliability.

Postcard from the Regional Transmission Grid in 2030

- Electrification of heating and transportation adds 675 MW of demand in the summer and 2,472 MW in winter, driving the region further toward becoming winter-peaking. (ISO-NE 2021 Regional System Plan, p. 47)
- With existing state policy, the region will have over 10 GW (12.6 TWh) of solar in 2030, up from about 4 GW today. (Vermont in 2021 has about 400 MW, or 10%, of that, and is forecast to have over 600 MW in 2030.) (RSP, p. 41)
- While distributed solar grows by approximately 6,000 MW over the next decade, its net effect on reducing summer peaks only grows by about 250 MW, as net peaks shift further into evening hours. (RSP, pp. 47-48)
- Dynamic reactive control devices will need to be deployed grid-wide to mitigate the risk of a loss of legacy distributed solar after a fault. (Future solar is expected to interconnect with modern inverters set to ride through such faults.) (RSP, p. 99)

Postcard from the Regional Transmission Grid in 2050

- The grid is most stressed when load conditions are at a minimum (springtime) and maximum (currently summer, but likely winter by 2050), especially when high renewables production coincides with low loads, and low renewables production coincides with high loads. (RSP, p. 98)
- Aggressive electrification of heating and transportation has taken place, as has deployment of solar, offshore wind, and battery storage. Even with maximizing "banking" of excess renewables in Hydro-Quebec reservoirs, massive amounts of renewables are curtailed. (RSP, p. 81; 2021 Economic Study - Future Grid Reliability Study Phase I - Preliminary Production Cost Results Part 3 Rev. 1 - Clean , slide 61)

[53] These include the 2050 Transmission Study, Cape Cod offshore wind interconnection cluster studies, Transition Planning for the Clean Energy Transition Pilot Study, Future Grid Reliability Study, storage as a transmission solution, etc.

The 2050 postcard tells us a few things:

- DER production and consumption need to be aligned as much as possible;
- Renewable generation projects need to become inexpensive enough that significant curtailment doesn't upend their economics;
- Accelerated progress is needed on commercialization and cost-effectiveness of extremely long-duration storage;
- Care must be taken to develop state policies that recognize and attempt to mitigate grid stress; and
- Eliminating fossil fuels from the regional fuel mix means there is a need to either find clean baseload alternatives, or rethink the amount of reliability risk that is acceptable to Vermont.

Forging ahead without due consideration of the red flags raised by grid planners and operators will lead to inefficient grid development that risks adding costs without necessarily reducing emissions.

Building out or enhancing the regional grid is possible and will certainly occur, but it is *expensive*: $11.7 billion has been invested over the last two decades, with another $1.1 billion in projects anticipated to come into service in the next decade.[54] Transmission costs for reliability projects are spread to all ratepayers in New England, including Vermont electric customers, although non-reliability projects are paid for by the customers in the area needing the upgrade.

FERC Order 2222

In September 2020, FERC issued Order 2222, which it says "will help usher in the electric grid of the future and promote competition in electric markets by removing the barriers preventing distributed energy resources (DERs) from competing on a level playing field in the organized capacity, energy and ancillary services markets run by regional grid operators." https://www.ferc.gov/media/ferc-order-no-2222-fact-sheet)

ISO-NE is in the process of revising its tariff to comply with the order, with revisions due to FERC 2/2/22. https://www.iso-ne.com/committees/key-projects/order-no-2222-key-project/

It's unclear at this time how much additional wholesale DER participation Order 2222 will unlock in New England, given the significantly more generous state policies; but Vermont must prepare nonetheless, especially when it comes to coordination between ISO-NE, distribution utilities, aggregators, and the PUC.

Under Order 2222, a DER might participate in an aggregation bid into, for instance, the regional capacity market — but it would interconnect to the Vermont distribution system under Vermont's interconnection rules. Vermont must consider such a situation as it revises interconnection rules and considers DER control platforms, to ensure that a DER responding to a regional dispatch signal does not adversely impact distribution system reliability or add costs for Vermonters.

Transmission costs, unlike energy or capacity costs, are a main driver of increasing electric bills in Vermont. Therefore, the more Vermont and its neighbors can do to make efficient use of the transmission system we already have — while being strategic about any new transmission investments — the less additional transmission cost the region will incur. But without explicit state policies, programs, and other

54 RSP, p. 99

tools in place that ISO-NE can count on, regional grid planners are likely to err on the side of caution in assuming the worst (e.g., EVs and heat pumps adding to load at peak times; solar tripping offline in vast quantities during these times, or decreasing load at minimum load times), potentially overbuilding in order to meet the reliability mandates imposed by FERC.

4.4 Vermont Statewide Transmission Grid Planning

VELCO, the Vermont-wide transmission operator, recently released its 2021 Long-Range Transmission Plan (LRTP).[55] VELCO updates the LRTP every three years, looking out 10-20 years and with a requirement to meet mandatory reliability standards.[56] The growth of DERs as a component of load and supply (and sometimes both, as with battery storage) has been garnering increasing scrutiny from organizations setting reliability standards. NPCC, for instance, recently released the second version of its publication, *NPCC DER Guidance Document, Distributed Energy Resource (DER) Considerations to Optimize and Enhance System Resilience and Reliability*.[57]

In its 2021 LRTP, VELCO looks at forecasts of future load and DER growth in the context of a reliable transmission system. The plan examines low, medium, and high scenarios for demand from electrification of heating and transportation, along with growth in energy efficiency and distributed generation, and finds that the transmission system will serve expected load growth out to 2030. However, to avoid upgrades beyond 2030, the system must include two key components:

- Load management mechanisms, particularly of electric vehicles, to keep winter loads below 1,470 MW and summer loads below 1,210 MW; and
- Coordinated planning of where and how distributed generation is deployed, as well as how it's interconnected.

At this time, the phenomenon of DERs as a system planning driver for VELCO is perhaps even more pronounced than it is for ISO-NE. Historically, load growth has been the central driver for investments in the state transmission system. Like investments in the ISO-NE grid, costs for reliability investments to accommodate load growth in Vermont are spread across ratepayers: those costs are assessed to Vermonters if the investment is not needed for New England-wide reliability in what's called Pool Transmission Facilities, or PTFs. In 2007, the Vermont Public Utility Commission (then the Public Service Board) approved the creation of the Vermont System Planning Committee (VSPC), a stakeholder-driven process for examining whether non-transmission alternatives (NTAs), including energy efficiency and distributed generation, are more cost-effective than building new transmission lines to meet load.

As Vermont's loads have gradually declined in the last 15 years, the focus of VSPC discussions has increasingly turned to the impact on the transmission system of increasing amounts of distribution-

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[55] 30 V.S.A. § 218c(d). See, https://www.velco.com/assets/documents/2021%20VLRTP%20to%20PUC_FINAL.pdf

[56] Both ISO-NE and VELCO must comply with standards set by the North American Electric Reliability Corporation (NERC) and the Northeast Power Coordinating Council (NPCC). See https://www.ferc.gov/industries-data/electric/industry-activities/nerc-standards and https://www.npcc.org/program-areas/standards-and-criteria/regional-standards.

[57] https://www.npcc.org/content/docs/public/program-areas/standards-and-criteria/der-forum/2020/der-v2-11-20-2020.pdf

connected generation. Unlike load, incremental distributed generation is examined for reliability impacts on the distribution system by the interconnecting distribution utility on a project-by-project basis; generators are required to demonstrate they can interconnect reliably, and must pay for any upgrades needed. (These costs are added to overall project costs, and are generally passed through to project off-takers.) Projects interconnected with the *transmission* grid (generally projects larger than 5 MW) are subject to ISO-NE interconnection requirements. In its review of reliability impacts, ISO-NE assumes that generators with curtailment capabilities (both new and existing), such as wind, will be curtailed to maintain reliability. (This review does not take into account economic implications to the generators of that curtailment.)

In northern Vermont, an area where the transmission system was built to deliver energy from elsewhere to local consumer loads, subsequent additions of substantial amounts of generation, relative to loads, has resulted in the so-called Sheffield-Highgate Export Interface (SHEI) generation constraint.[58] New renewable generation added here often simply reduces the output of existing renewable generation, primarily from two large wind projects. This export-constrained area is forecast to expand southward as distributed generation proliferates. This is one of the many emerging areas where the once-clear boundary between transmission and distribution operations and markets is increasingly blurred.

In developing its 2021 LRTP, VELCO examined the potential transmission system upgrades that would be triggered by various incremental amounts of additional distributed solar. They looked at a scenario for "optimizing" distributed-solar hosting capacity — assigning future solar to load zone, utility, or regional planning commission based on transmission system "headroom," as well as distribution transformer thermal limits — rather than by historical deployment patterns, or targets set by regional planning commissions in their enhanced energy planning process.[59]

As this table shows, when VELCO optimized for transmission headroom by Regional Planning Commission (RPC), the analysis revealed a delta between what the transmission system can handle without triggering upgrades ("Optimized Solar PV Distribution") and some 2025, 2035, and 2050 "targets" set by RPCs:

[58] https://www.vermontspc.com/grid-planning/shei-info
[59] https://publicservice.vermont.gov/content/act-174-recommendations-and-determination-standards

Exhibit 4-2. Statewide Transmission Solar Hosting Capacity: Optimal Distribution vs. RPC Targets

Zone Names	INSTALLED SOLAR PV AS OF 2020 (MW)	ADDITIONAL SOLAR PV (MW)	OPTIMIZED SOLAR PV DISTRIBUTION (MW)	REGIONAL TARGETS (EXISTING SOLAR + ALL NEW RENEWABLES) 2050 (MW)	REGIONAL TARGETS (EXISTING SOLAR + ALL NEW RENEWABLES) 2035 (MW)	REGIONAL TARGETS (EXISTING SOLAR + ALL NEW RENEWABLES) 2025 (MW)	NOTES
ADDISON (ACRPC)	49.7	30.1	79.8	143.6	109.8	71.8	
BENNINGTON (BCRC)	17.5	66.4	83.9	121.9	85.9	48.9	1
CENTRAL VERMONT (CVRPC)	29.1	44	73.1	342.5	151.4	103.6	2
CHITTENDEN (CCRPC)	74.1	41.5	115.6	393.6	275.7	157.9	3
LAMOILLE (LCPC)	9.1	25.5	34.6	135.0	91.9	48.7	4
NORTHEASTERN (NVDA)	20.67	28	48.6	27.4	22.6	17.9	5
NORTHWEST (NRPC)	34.2	8.6	42.8	247.0	166.2	87.9	
RUTLAND (RRPC)	41	126.6	167.6	304.4	113.4	50.4	
SOUTHERN WINDSOR (SWCRPC)	18.8	56.7	75.5	154.7	80.7	43.6	2
TWO RIVER OTQ (TRORC)	38.7	59.3	98	190.5	125.5	66.5	6
WINDHAM (WRC)	28.1	148.2	176.3	60.7	45.7	30.7	4
TOTALS	360.87	636	996.88	2121.2	1268.8	728.0	

Source: VELCO 2021 Long Range Transmission Plan[60]

This analysis is revealing, if not surprising. Most RPCs used the 2016 CEP's exploratory scenarios of at least half of Vermont's future generating capacity being sited in-state, and being served in an electrified future almost if not entirely by renewables, equivalent — compared to what exist today — to about 3,500 MW of additional solar panels, wind turbines, methane digesters, combined heat and power plants, and hydroelectric facilities. As noted in the 2016 CEP, the "intention is simply to explore a range of possible portfolios and land use impacts." With the 2021 LRTP, and with additional analysis being conducted by distribution utilities (see below), it's time to examine the *grid* impacts of these targets, to begin the discussion of additional planning scenarios that should be considered by land-use planners from a grid perspective, while utilities and developers continue delving into the land-use impacts of grid scenarios.[61]

[60] LRTP, p. 45
[61] 2016 CEP, p. 239

“These results indicate that with DG levels just above the currently installed amount, the system may not have sufficient capacity to accommodate all renewable generators operating at full output. This does not mean that upgrades are necessarily needed. Dispatchable generators can be reduced and future storage or load management can be utilized if they are properly designed and installed in the right locations. Currently, these mitigating measures are not specifically designed to maximize DG, and they are not coordinated. For example, curtailment of dispatchable generators is an unfortunate outcome as opposed to a planned overbuild of DG that incorporates some amount of economically acceptable curtailment. Most storage and load management programs are currently designed to reduce peak demand. Some storage projects participate in the frequency regulation market. Both of these objectives are currently achieved without explicitly incorporating a DG maximization objective. Further, managing mitigating measures in a way that optimizes various competing objectives is complex, and this complexity is greater when the benefits and costs cut across different entities, as is the case in Vermont.” (VELCO 2021 LRTP, p. 37)

With distribution-level interconnections and transmission reliability considerations starting to impact each other, and land-use and grid planning also coming into friction, all stakeholders in a grid modernization future — policymakers, regulators, developers, and others — are challenged to expand their horizons and develop new ways of sharing information, evaluating policies, programs, and projects, and even considering some level of joint planning and operations.

For example, VELCO and other utilities can work with RPCs when they update their enhanced energy plans, bringing grid considerations into greater focus. Similarly, distribution utilities can coordinate with VELCO when reviewing distribution-level projects for interconnection impacts, bringing cumulative impacts into greater focus. In fact, at least one new mechanism, cluster studies, has been recently developed to review such cumulative impacts.[62]

[62] https://www.vermontspc.com/library/document/download/7357/VSPC_ISO-NE_DG_study_procedures.pdf

Postcard from the State Transmission Grid in 2030

- Vermont's EV fleet has grown from 3,716 in 2020 to over 71,000 light-duty vehicles. In the absence of load management, these EVs have added 46 MW to summer peaks and 66 MW to winter peaks by 2030. (LRTP, p. 22)
- Vermont continues to see installation of over 10,000 cold-climate heat pumps per year. Demand from these units during the winter peak hour grows from 5 MW in 2020 to 91 MW. (LRTP, p. 23)
- By 2032, Vermont has 562 MW of net-metering solar and 683 MW of total solar PV, up from ~400 MW of total solar PV in 2020. As in 2020 — and absent time-shifting PV production from day to night with storage — new solar has no effect on reducing peak demand, which has shifted to evening. (LRTP, pp. 7 & 23)
- The cumulative impact of this amount of solar on the transmission system could result in over $300 million of upgrade costs, primarily to avoid thermal overloads. Depending on where new solar is located, mitigation measures (curtailment, storage, load management) may help. (LRTP, p. 37-39)

Postcard from the State Transmission Grid in 2050

- Vermont's EV fleet has grown from 3,716 in 2020 to 279,000 light-duty vehicles. In the absence of load management, by 2040 these EVs have added 173 MW to summer peaks and 250 MW to winter peaks. (LRTP, p. 22)
- Vermont has 282,000 heat pumps deployed by 2040, on the way to the 2016 CEP goal of 300,000 by 2050. Winter peak-hour demand from these units in 2040 is 172 MW; and since heat pumps can also air-condition, they increase summer peak-hour demand by 43 MW in 2040. (LRTP, p. 23)
- By 2040, total solar PV is 733 MW or more, potentially causing a cumulative $500 million in upgrade costs. Strategic locational deployment of solar, and use of measures to "soak up" overgeneration, can mitigate some, but not all, of these costs. (LRTP, p. 23 & 37-42)
- Storage has helped, especially when sited with solar; but the benefits of the state's current 250-400 MW of five-hour storage depend on how optimally the solar is sited from a transmission grid perspective. Poorly sited and deployed storage can exacerbate constraints. (LRTP, p. 46.)

These "postcards from the future" convey some important messages:

- Land-use planning for energy siting must be coordinated with grid planning and hosting capacity considerations;
- A mechanism is needed to assign aggregated transmission-upgrade costs to distribution-level-interconnecting resources;
- A significant amount of strategic storage and load management will likely be needed to manage grid impacts;
- Thinking must start today about ways to orchestrate and optimize resources such as solar, storage, and flexible loads;
- There is a need to come to terms with the costs and benefits of curtailment; and
- Vermont will need to explore how to evaluate transmission-level constraints to generation growth (as opposed to load growth, for which the Vermont System Planning Committee provides a forum), along with related non-transmission alternatives and the very thorny question of cost allocation.

Vermont should also consider whether "unlocking" another 600 MW of in-state PV is the best use of $500 million for achieving its energy and emissions goals. A $500 million transmission investment translates to roughly a 6% increase in electric rates — and this does not include the sub-transmission and distribution-level costs of interconnecting this much more solar, along with any ratepayer costs for the production of that solar. For perspective, $500 million could potentially buy about 17,000 electric vehicles, or 90,000 heat pumps, or 58,000 low-income homes weatherized. Of course, if $500 million materialized, these options are not mutually exclusive; some can even unlock more solar hosting capacity, if loads are coordinated to match times of solar production. But this thought exercise reinforces the importance of strategic planning toward the goal of maximizing emissions reductions while causing the least amount of cost to ratepayers.

Energy Storage

Energy storage intersects in some way with all of the scales and most of the attributes discussed in this chapter. In its 2017 report on deploying energy storage, the Department discussed the "Swiss army knife" nature of storage, which can help manage peaks, time-shift demand and supply, smooth renewables integration, provide frequency regulation and other grid support, and — if properly configured — provide resilience during grid outages.

The residential, commercial, and community storage that is being developed in Vermont can perform many of these functions, with some services (such as peak shaving and regulation) helping offset the costs for other services that are harder to monetize, such as resilience. As of September 2021, Vermont had about 50 MW of installed storage, and was identified by the EIA as one of the three states outside of California with the most small-scale battery storage capacity.

In its subsequent 2019 report on regulating energy storage, the Department presented a set of regulatory reforms to unlock and ensure safe deployment. These were enabled by Act 54 of 2021 and PUC rulemaking in Case No. 21-3883-RULE.

Storage technologies and markets are evolving rapidly. To both keep pace and ensure that storage deployment benefits Vermonters, nimble and flexible regulatory and policy frameworks will need to be embraced.

At the same time, Vermont must use what levers it can to promote vital innovations in storage technologies, from seasonal storage to support a high-renewables future to materials innovations that reduce or eliminate the need to mine rare earth minerals, reduce the impacts of battery manufacturing, and recycle end-of-life waste.

4.5 Vermont Distribution Grid Planning

Vermont's 17 distribution utilities (DUs) are all advancing grid modernization in various ways, depending on their structure, strategic priorities, and customer interests. Every three years, Vermont's DUs are required to update their least-cost integrated plans (IRPs) and submit them to the PSD and PUC for review, pursuant to 30 V.S.A. § 218(c):

(a)(1) A "least cost integrated plan" for a regulated electric or gas utility is a plan for meeting the public's need for energy services, after safety concerns are addressed, at the lowest present value life cycle cost, including environmental and economic costs, through a strategy combining investments and expenditures on energy supply, transmission and distribution capacity, transmission and distribution efficiency, and comprehensive energy efficiency programs. Economic costs shall be assessed with due regard to:

> *(A) the greenhouse gas inventory developed under the provisions of 10 V.S.A. § 582;*
>
> *(B) the state's progress in meeting its greenhouse gas reduction goals;*
>
> *(C) the value of the financial risks associated with greenhouse gas emissions from various power sources; and*
>
> *(D) consistency with section 8001 (renewable energy goals) of this title.*

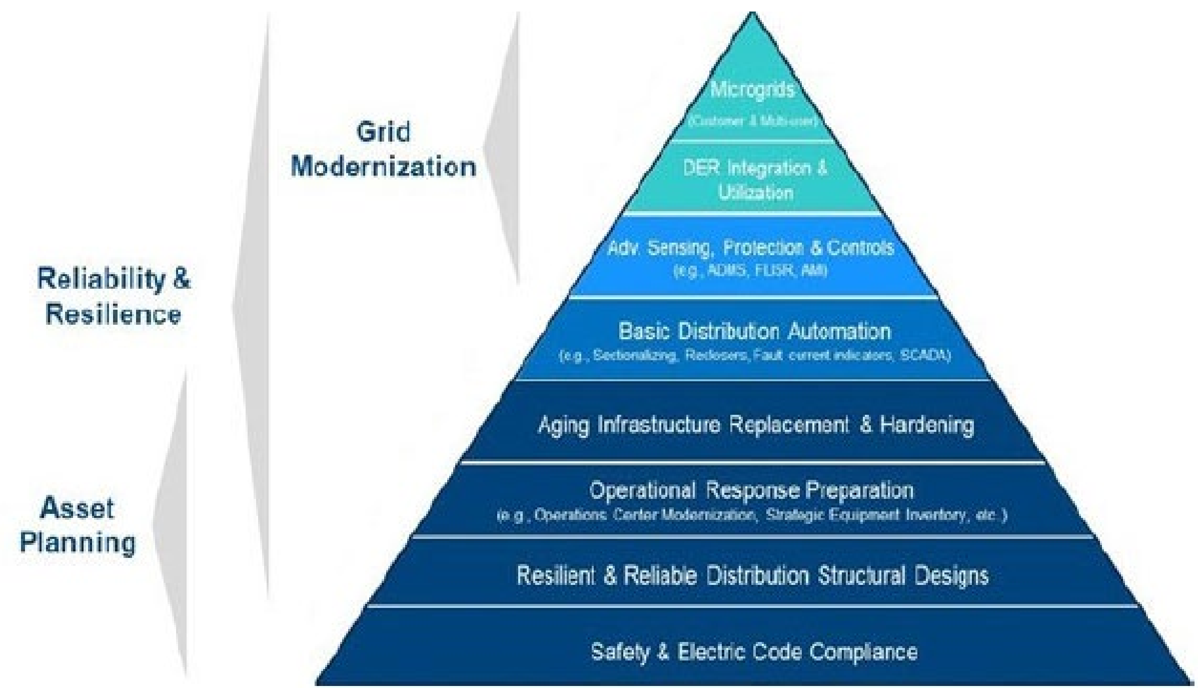
The Department issues and periodically updates its Guidance for Integrated Resource Plans and 202(f) Determination Requests (IRP Guidance), which was last updated in 2016 as Appendix B of the Comprehensive Energy Plan. Section 4.6 of this guidance speaks specifically to grid modernization:

> *"Grid Modernization" and "Smart Grid" generally refer to a class of technology that is being used to modernize utility electricity delivery systems by implementing measurements of circuit parameters, two-way communications technology, and computer processing. This technology includes "advanced meters" which are digital meters that play a key role in grid modernization by measuring voltage, demand (kW), and energy (kWh) at hourly or sub-hourly intervals, and by enabling two-way communications. For example, utilities could use these voltage measurements to optimize the voltage on a distribution circuit, and employ conservation voltage reduction where appropriate. The potential benefits are that a smart grid would enable utilities and their customers to track and manage the flow of energy more effectively (including the cost of electricity at a given time), curb peak demand, lower energy bills, reduce blackouts, and integrate renewable energy sources and storage to the grid (including electric and plug-in hybrid vehicle batteries). The smart grid also has the potential to increase energy efficiency, thereby reducing environmental impacts of energy consumption, and empower consumers to manage their energy choices. Distribution Automation is also a term that includes technologies that enable a utility to remotely monitor and operate its distribution system, which should result in improved reliability and operational efficiencies. The Department encourages utilities to investigate grid modernization technologies and to implement those that are cost effective.*

This guidance suggests that utilities organize their IRPs sequentially, looking at forecasts for load growth (followed by assessments of resources to meet that demand), financial impacts, transmission & distribution (T&D) needs, environmental impacts, and an action plan that takes those evaluations into consideration. Like VELCO, distribution utilities must continue to focus on planning challenges from distributed generation, solar in particular, with a constant eye on the horizon for potential impacts from other future DERs. And, while grid modernization traditionally lived squarely in the T&D section of these plans, as DER growth increasingly interacts with the bulk power system and even wholesale markets, it is finding its way into other sections of IRPs.

The Department's next iteration of IRP Guidance will be updated to reflect this rapid evolution, and to reflect the expansion of focus from transmission and distribution system safety, reliability, and operational efficiency to themes of DER integration and utilization, and resilience. Overall, it is likely that IRPs will need to become more spatially and temporally granular — which will require similarly granular load and DER adoption forecasting, and will need to consider resilience to major weather events and cyber intrusions.

Exhibit 4-3. Distribution Infrastructure Investment Prioritization Pyramid

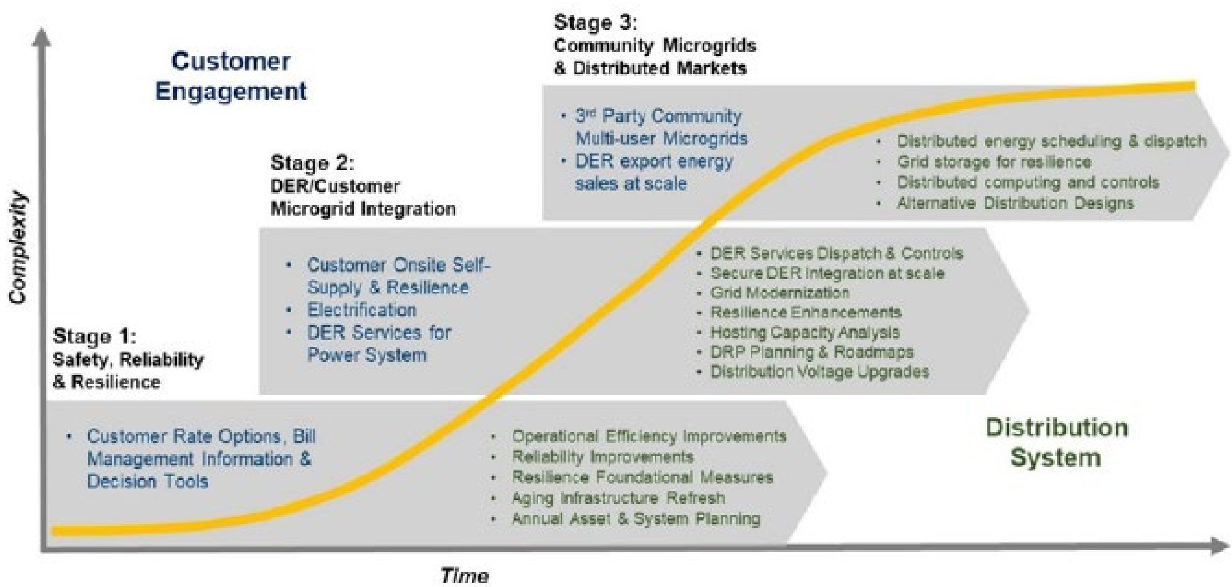


[63]

The sections below offer a snapshot of DU grid modernization activities, pulled from recent IRPs and other sources. They are organized by theme rather than DU, to demonstrate the variety of ways in which elements of the modern grid are being considered by diverse utilities. As Vermont seeks to define what a modern grid looks like for the state, stakeholders will need to wrestle with this diversity and discuss what it means for the end-state. In its *Modern Distribution Grid Report, Volume IV*, the U.S. DOE offers the following graphic to depict the stepwise advancement of distribution system capabilities and foundational architectures, from coordination of DERs to management of two-way power flows to intelligent and sophisticated real-time orchestration of ubiquitous DERs.[64]

[63] https://gridarchitecture.pnnl.gov/media/Modern-Distribution-Grid_Volume_IV_v1_0_draft.pdf, p. 19
[64] https://gridarchitecture.pnnl.gov/media/Modern-Distribution-Grid_Volume_IV_v1_0_draft.pdf, p. 10

Exhibit 4-4. Planning Stages Toward a Modern Grid



The authors write:

> Grid architecture is the synthesis of system engineering, network theory, and control theory as applied to the electric power grid. The discipline of grid architecture allows grid planners and designers to examine the structure, behavior, and essential limits of an electrical system at any scale. At the highest level, the interrelated structures of concern include the physical electrical infrastructure; systems for sensing, communication, control, computing, and information management; the industry structure; market structure; and regulatory structure. Understanding how these structures interact provides insight into the formation of simplified design solutions.
>
> The practice of grid architecture is based on the view that once structural relationships are understood, more detailed system designs can be advanced that attempt to minimize unintended consequences. This view also extends to the many elements that exist outside the utility but that interact with the grid, such as buildings, merchant DER, microgrids, and electric vehicles.
>
> Much like how an architect designs buildings, the grid architect must understand both the objectives and constraints before beginning design work. This approach focuses on first defining customer needs, understanding policy objectives, and determining required functionality early in the development cycle; then documenting requirements; and then proceeding with design synthesis and system validation while considering the complete problem.[65]

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[65] https://gridarchitecture.pnnl.gov/media/Modern-Distribution-Grid_Volume_IV_v1_0_draft.pdf, p. 11

Here, the Department does not lay out specific principles and objectives — an "end state," in other words. Such an exercise is best conducted through open and collaborative stakeholder dialogue, with outcomes expressed as statutory or regulatory requirements. Instead, the following discussion of activities and challenges attempts to provide a snapshot of where Vermont's distribution utilities stand in terms of having the real-time visibility, communications, and operational control capabilities needed to serve a variety of modern grid end states — and also to manage the impacts and optimize the use of the burgeoning fleet of DERs, as so clearly indicated by the "postcards from the future."

4.5.1 Smart Grid

Academic thought on grid modernization in the last few years has focused strongly on the objectives and necessary functions of an ideal, end-state modern grid.[66] In reality, the path forward for each state and distribution utility is going to look very different than the theoretical ideal, and probably much less premeditated. Even so, Advanced Metering Infrastructure (AMI, or smart meters) is considered a foundational architectural element of the modern DER-friendly grid, as one tool to enhance visibility and communications at the grid-edge (along with many others, such as SCADA and OMS; see definitions in sidebar). Vermont is ahead of many other states in AMI deployment, with widespread (94%) smart meter coverage, but still needs to figure out how to realize all the capabilities that this tool offers.

Technology for a Modern Grid

This chapter includes discussion of several key information and operational technologies needed to realize a modern grid. The U.S. DOE's Modern Distribution Grid report, Volume 1, defines these as follows:

AMI: Advanced **M**etering **I**nfrastructure typically refers to the full measurement and collection system, including meters at the customer site; communication networks between the customer and a service provider, such as an electric, gas, or water utility; and data reception and management systems that make the information available to the service provider and the customer

SCADA: Supervisory **C**ontrol **a**nd **D**ata **A**cquisition systems operate with coded signals over communications channels, to provide control of remote equipment of assets.

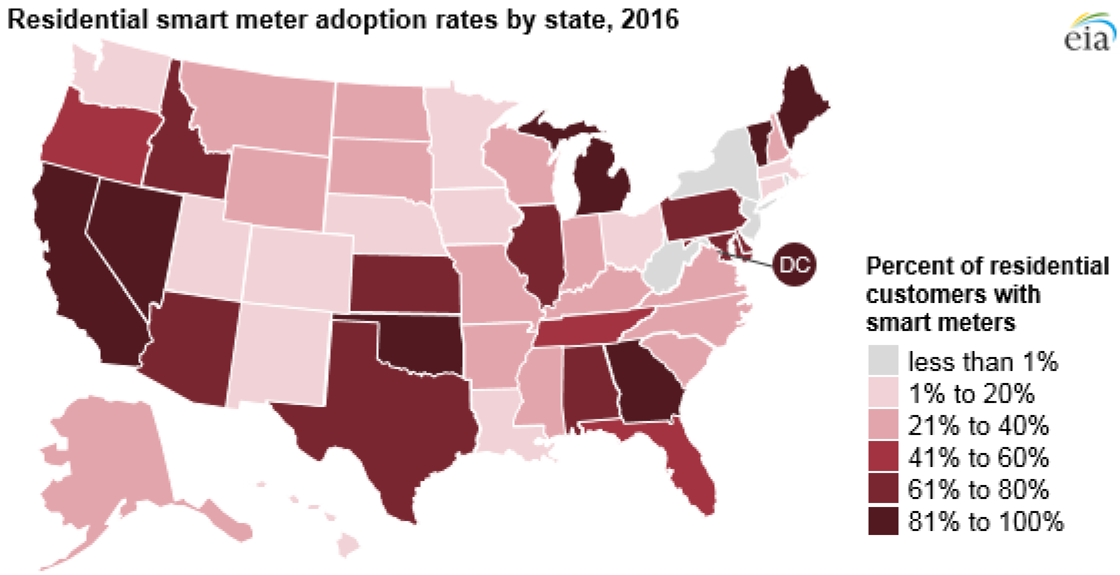
OMS: Outage **M**anagement **S**ystem is a computer-aided system used by operators of electric utilities to better manage their response to power outages.

DERMS: Distributed **E**nergy **R**esource **M**anagement **S**ystem is a software-based solution that increases an operator's real-time visibility into the status of distributed energy resources, and allows distribution utilities to have the heightened level of control and flexibility necessary to more effectively manage the technical challenges posed by an increasingly distributed grid.

ADMS: Advanced **D**istribution **M**anagement **S**ystems are software platforms that integrate numerous utility systems and provide automated outage restoration and optimization of distribution grid performance. ADMS functions can include automated fault location, isolation, and service restoration (FLISR); conservation voltage reduction; peak demand management; and volt/volt-ampere reactive (Volt-var) optimization. In effect, ADMS transitions utilities from paperwork, manual processes, and siloed software systems to systems with real-time and near-real-time data, automated processes, and integrated systems.

[66] https://gridarchitecture.pnnl.gov/modern-grid-distribution-project.aspx

Exhibit 4-5. Residential Smart Meter Adoption Rates by State (2016)



[67]

Source: US Energy Information Administration.

Burlington Electric Department, Green Mountain Power, Washington Electric Cooperative, Stowe Electric Department, and Vermont Electric Cooperative have all deployed smart meters, funded in large part by the American Recovery and Reinvestment Act (ARRA) in 2009. These systems are not uniform and have different capabilities. More recently, the Vermont Public Power Supply Authority (VPPSA) has started a project on behalf of its 11 member municipal utilities to procure smart meters using a centralized approach, which is expected to roll out over the next two to three years. One benefit of implementing smart meters now is that utilities can benefit from technology advancements over the last decade, as well as lessons learned from deployments.

For several reasons, smart meters have not quite lived up to the expansive promise that was advertised years ago, whether nationwide or in Vermont.[68] For sure, they have succeeded in supplanting physical meter readers (a major cost savings), helped utilities remotely scope the extent of outages, and provided

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[67] https://www.eia.gov/todayinenergy/detail.php?id=34012

[68] For example, CVPS's plan (Docket 7612) noted, "The AMI Implementation Plan is being designed to provide customers the opportunity to obtain enhanced information about their energy usage so they can take a more active role to improve the efficiency with which they use electricity and to participate in new Dynamic Pricing and Demand Response programs." And, "Vehicle to Grid, Distribution Automation, and Distributed Generation are examples of emerging Smart Grid concepts and technologies which will be enabled by the infrastructure that the SmartPower program establishes." And, "The Plan also defines a process for integrating the delivery of additional services by Efficiency Vermont ("EVt") to help customers benefit from the opportunities created via the introduction of AMI and other Smart Power initiatives. This will include efforts to implement the customer-focused elements of the eEnergy Vermont Project (the "Project") to promote coordination and interoperability between and among utilities, and to develop skills to help improve the statewide implementation of new AMI-enabled services." (pp. 4-8) More information on VT's AMI dockets is available here: https://publicservice.vermont.gov/electric/amiplans.

historical load and system performance metrics that can be used to help model the system; yet smart meters generally haven't provided actionable, real-time intelligence that customers and utilities can use.

For some utilities, that's due in part to physical limitations of communications networks, especially in systems that use power line carrier communications to transmit data, and also to the challenge of managing and applying the sheer volume of data coming from smart meters. For others, the ability to integrate with an increasing and evolving diversity of energy devices in buildings has been disappointing, leading in a refocus on connecting to those devices via the internet. The "internet-of-things" includes energy "things," and is one more impetus for building out and future-proofing robust, secure statewide communications networks.

As some utilities implement smart meters for the first time, and others start considering replacing legacy fleets (with smart meters or alternatives), getting more grid-modernization value out of these investments is essential. As technology advances, new ways of communicating with customers and DERs will materialize that may ultimately supplant one or more roles that AMI currently plays or has potential to play (including as replacements for traditional grid sensing technology). These include smart inverters paired with DERs, smart plugs, and smart load panels. As these are implemented, utilities and other partners should think realistically and strategically about the costs, benefits, data management, communications pathways, cybersecurity, integration with legacy systems, and interoperability of these emerging resources and develop plans to ensure an optimal rollout. As part of these plans, the role of the customer — including their ability to elect for a wired communication pathway and some ability to opt out of utility control of their resources should they so desire — should be factored in.

4.5.2 Flexible Load Management (FLM)

Once the smart meter communication and data management challenges are surmounted — for example, through expanded broadband initiatives, software upgrades, and business query tools to analyze and generate reports — will the promise of AMI materialize, to "improve grid analytics, support advanced demand response, support next-generation efficiency, and enable energy savings from new technologies such as smart thermostats to be readily measured"[69]? Like other tools, smart meters are only as useful as they are effectively applied. How and whether to incorporate smart grid intelligence into utility operations (beyond outage management) and customer programs (beyond billing) is an increasingly complex question.

At present, the most actionable next step appears to be enabling customers to use smart meter data, in real time, to respond to rate signals from utilities. Smart rates, such as time-of-use rates, align system costs — those to build and maintain poles and wires, secure and deliver energy when needed, and maintain power quality — from source to use, rather than bundling and averaging these costs over time. In a sense, smart rates make visible to customers the actual costs they incur; they can also make visible the actual benefits they might be providing by, for example, reducing loads or generating solar at specific times.

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[69] 2016 CEP, p. 222

At present, there is no real incentive for utilities to promote whole-home time-of-use smart rates, or for customers to switch to them, though those incentives do exist.[70] At worst, they can be complex and offer marginal benefits. At best, intermediaries absorb the complexity and assist customers in managing loads with real saving benefits, to both the customer *and* the system at large.

Smart rates associated with specific end uses, such as electric vehicle charging, may be a simpler starting point. Act 55 of 2021 requires Vermont's utilities to develop and offer electric vehicle charging rates — which may include whole-premises rates — by June 30, 2024. And with Act 13 of 2021, utilities statewide are now able to develop and offer innovative rates and services as pilots, which will enable them to test the viability of other types of smart rates.[71]

In 2019, the PSD initiated a Rate Design Initiative (RDI) to "analyze innovative retail rate applications and other forms of Load Control Programs for electric utilities in the State of Vermont in response to the anticipated rapid adoption of Emerging Technologies."[72]

[70] For example, GMP's Rate 11 offers $0.28027/kWh during on-peak hours, currently 1-9 p.m., and $0.11946/kWh during off-peak hours. VEC also offers a residential TOU rate, currently with on-peak hours from 6 a.m. to 10 p.m., an on-peak rate of $020440/kWh, and an off-peak rate of $0.14742/kWh.
[71] https://legislature.vermont.gov/Documents/2022/Docs/ACTS/ACT055/ACT055%20As%20Enacted.pdf and https://legislature.vermont.gov/Documents/2022/Docs/ACTS/ACT013/ACT013%20As%20Enacted.pdf
[72] https://publicservice.vermont.gov/sites/dps/files/documents/Vermont%20PSD_Innovative%20Rate%20Design%20Study_08-12-20.pdf

Exhibit 4-6. Emerging Technologies and Load Shape Impacts

Source: Rate Design Study, 2020.[73]

The RDI looked not only at rate design, but also at the increasing reality of DERs as resources that can be controlled individually (think of directing your smart thermostat to preheat a home); as a same-DER fleet (think of GMP directing the ~3,000 home batteries in its Powerwall program to discharge when the region's demand is peaking); or as any number of hybrids: think of directing your home battery to charge from your solar during the day, and using that stored solar to meet your home's load in the evening — and the utility doing the same thing with grid-sited solar + storage, so the home's load and also the utility's load is flattened and optimized.

In one sense, smart rates and direct-controlled DERs and fleets are competing visions. But they need not be. "Specifically," write the report's authors, NewGen Strategies & Solutions, LLC, "Rate Design has

73 https://publicservice.vermont.gov/sites/dps/files/documents/Vermont%20PSD_Innovative%20Rate%20Design%20Study_08-12-20.pdf, page 5.

traditionally been seen as a cost accounting exercise and a mechanism by which a utility recovers its investments and ongoing operating costs. However, specific charges and elements within Rate Design are quickly becoming part of a more strategic effort coupled with Direct Load Control to foster more efficient use of the electric system. Combining strategic Rate Design and Direct Load Control may avoid future system costs through proactively managing load shapes."

"The flexibility of Emerging Technologies," they write, "offers utilities the opportunity to manage customer load shapes through Load Control Programs and Rate Design pricing signals. Rate Design can send substantial pricing signals to customers in certain hours of the year, thus changing load shapes. Such a Rate Design also allows a customer the choice to pay more to consume electricity during more expensive times of the day and year. Direct load control allows the utility to leverage its core competency in system dispatch and management by curtailing or accruing value-added services from the customers load on their behalf, or reducing load during expensive hours (e.g., peak periods on the system). In exchange for the reduction in customer load, they are compensated with direct payments or other incentives (such as certain investments made by the utility)."[74]

Next-generation smart rates will need flexibility, however, to accompany the dynamic nature of the modern grid; and that introduces variability as another element of complexity for customers. Some customers may welcome that challenge, or prefer that level of control. Others may enlist third-party intermediaries to manage the complexity on their behalf. Providing customers with options may be the best path forward. For the foreseeable future, direct load control is likely to be the most hands-off option for customers.

[74] Ibid, p. 2

Exhibit 4-7. Tools to Flatten Load Shapes, Optimize DERs, and Use the Grid Efficiently: Rate Design and Direct Load Control

[75]

The report — issued at the end of extensive consultation with many stakeholders, from utilities to renewable developers to EV charging companies — summarized the recommendations and challenges:

1. Electric rates should create stability and equity and recover costs, but can also be seen as a resource for managing future costs through price signals, to change consumer behavior and incentivize participation in flexible load management.
2. Although the implementation of innovative rates faces enrollment challenges, success may be improved by rate designs, and by regulatory encouragement (e.g., relying more heavily on default rate plans that encourage participation, or mandating participation through regulation).

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[75] Ibid, p. 6

3. Electric rates that target certain types of loads (e.g., flexible load) and specific rate offerings (e.g., EV-only, or EV-linked rates or rate riders) are more responsive to price signals, which improves response and program enrollment. Specific rate implementation strategies should be tailored and developed uniquely by each utility.
4. Utilities should actively market innovative rate and related program offerings. For example, creatively and proactively targeting customers where electric consumption is part of the transaction (e.g., when disbursing incentives, such as EV chargers, or engaging the customer at the point of sale for EVs, electric heat pumps, etc.) leads to increased customer participation. Marketing efforts should include clear and concise educational campaigns regarding the benefits of rate designs targeted to specific customer segments.
5. Utilities and state regulators should look to new business/service models as technologies further evolve. These new business models should allow and encourage participation of third parties in the market as partners to both utilities and their customers.[76]

While the specifics of advanced rate design implementation will look different for each utility, the report offers the following general path forward:

Exhibit 4-8. Rate Design Path to Foster a Modern Grid

Some of Vermont's utilities have progressed beyond Step 1. For instance, Green Mountain Power (GMP) and Burlington Electric Department (BED) offer EV-specific rates, applied to the consumption as measured by the EV charger. GMP has two rates: Rate 72, under which it manages the charging to avoid peaks, though customers can opt to charge during a peak and pay more; and Rate 74, under which customers control their charging informed by a time-of-use rate schedule.[77]

One size will certainly not fit all when it comes to directing load (for instance, EV charging) away from peak times, which is one reason the PUC recommended in a 2019 report that the Legislature not mandate that utilities develop EV-specific rates. The PUC noted, citing comments from BED and VPPSA: "There are many ways to achieve beneficial electrification and encourage charging during off-peak times without the use of an EV rate. Some examples include … whole-house time-of-use rates, rates specifically for *public* charging stations, or other programs that utilities may envision. Legislatively mandated EV-end-use-rates are not necessary to achieve the policy objectives of off-peak charging and beneficial electrification."[78]

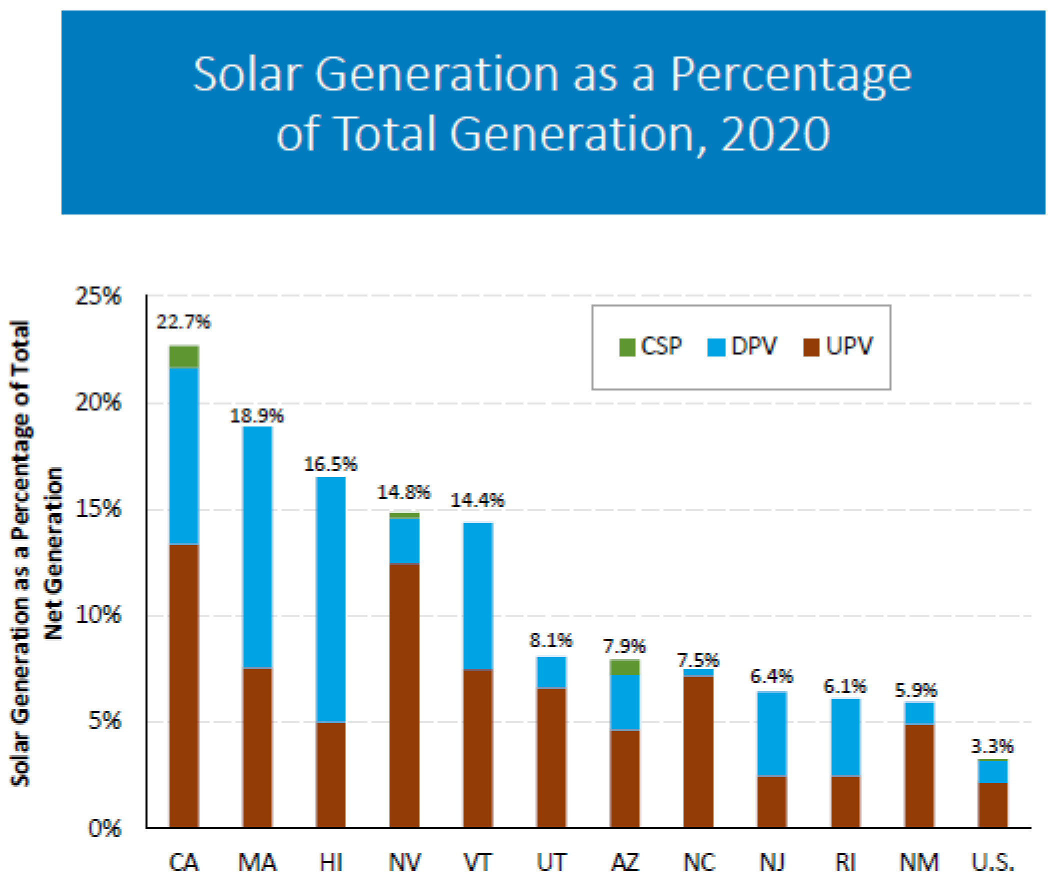
[76] Ibid, pp. 3-4
[77] https://greenmountainpower.com/rebates-programs/electric-vehicles/ev-charging-rates/
[78] https://www.driveelectricvt.com/Media/Default/docs/Vermont_PUC_EV_Fee_Investigation_Report_Dec2019.pdf

Utilities have a clear and starring role to play in managing loads, including DERs, to maximize grid efficiency. They should have flexibility about the specific path they take, but should have a clear strategy for getting there — including forecasting DER deployment, using those forecasts to study potential distribution-level impacts, and using those findings to develop strategies to manage these new loads to minimize integration challenges and costs. Nearly all distribution utilities in Vermont have committed to examining DERs in this granular, forward-looking way in their next round of IRPs.

4.5.3 Hosting Capacity

For most utilities, a pressing modern grid challenge is integrating and optimizing high penetrations of solar PV. Vermont has one of the highest penetrations of solar in the nation (as a percentage of total generation but especially as a percentage of total load, at about 40%), and thus faces the challenge and opportunity to lead the way on solutions to integrate additional solar without making the grid unreliable or unaffordable.

Exhibit 4-9. Solar Penetration by State, 2020



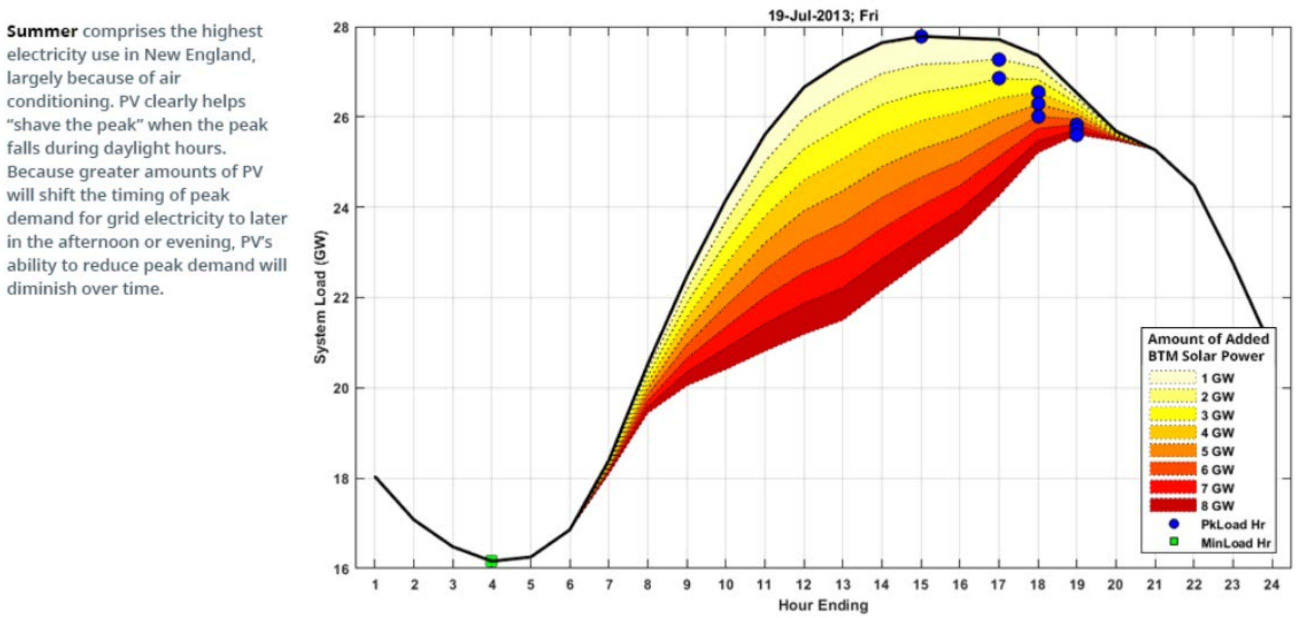
[79]

Vermont's experience with solar deployment over the last decade shows that, in many areas of the state, solar penetration has consumed available "headroom" on substation transformers — and upgrades to

[79] https://www.nrel.gov/docs/fy21osti/79758.pdf, slide 20

accommodate some (but not an unlimited amount) more could be extremely expensive. Extensive solar penetration to date has also “pushed” net peaks out to evenings in Vermont, and increasingly in all of New England. As a result, each incremental addition provides very little benefit in terms of flattening load shapes, reducing peak-related costs, and optimizing the grid.

Exhibit 4-10. ISO-NE Summer Load Profile with Additional Behind-the-Meter Solar



[80]

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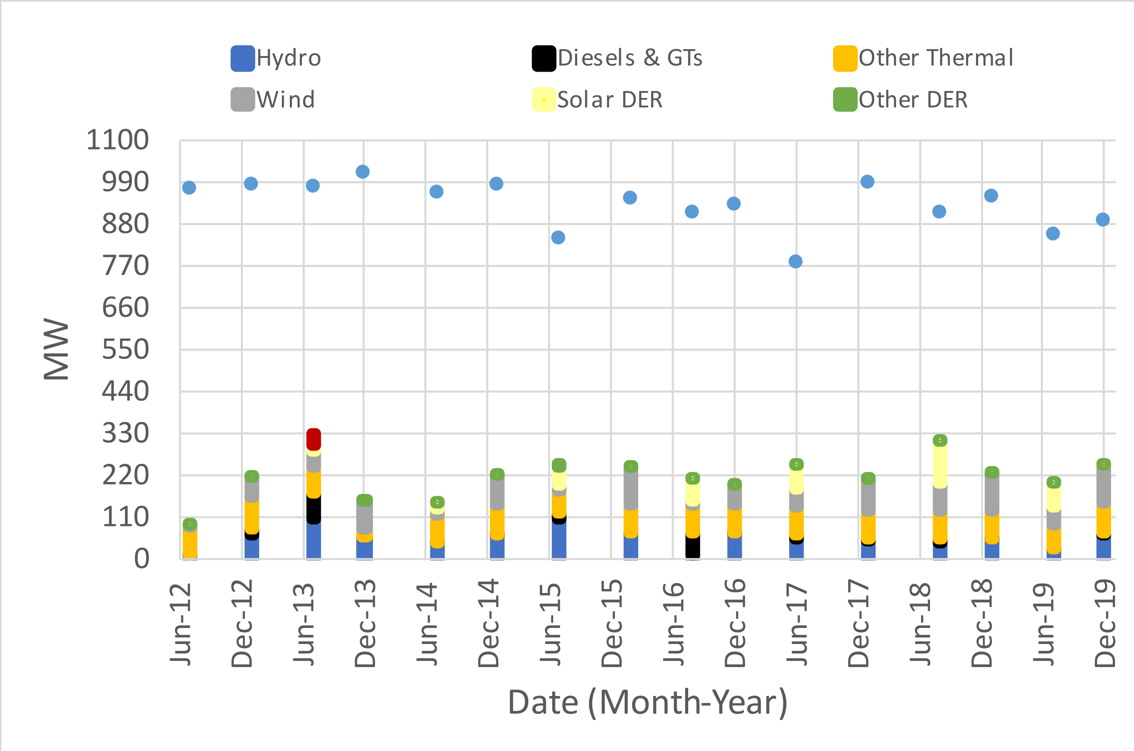
[80] https://www.iso-ne.com/about/what-we-do/in-depth/solar-power-in-new-england-locations-and-impact

Exhibit 4-11. Vermont Generation During the New England Peak Hour



[81]

Here, rate design too — coupled with strategic use of storage, emerging advancements in inverter technology, and careful planning — will enable more efficient use of the grid we have before we consider burdening ratepayers with additional costs of expanded infrastructure. It's especially important to note, here, that: (a) the biggest carbon reductions are needed in the transportation and heating sectors; (b) the primary pathway for decarbonizing these sectors is electrification; and (c) adding to electricity costs will disincentivize customers away from switching to electric from fossil fuel.

In a 2018 study, the National Renewable Energy Laboratory (NREL) sought to understand potential distribution upgrade costs as a function of increasing penetration of solar power as distributed solar photovoltaics, or DPV. They noted:

> *Because the power system was originally designed for one way power flow from centralized generators to distributed loads, this increasing deployment of DPV can impact operations at the distribution level and, for higher penetrations, at the transmission level. When these issues occur, upgrades are required to mitigate them and maintain voltage, reliability, and power quality, incurring a cost; we refer to these costs as distribution upgrade costs. While today these costs are typically analyzed reactively as individual DPV systems apply for interconnection to the grid, it is important to develop and implement forward-looking approaches for calculating distribution upgrade costs that can be used to inform system planning, market and tariff design, cost allocation, and other policymaking as penetration levels of DPV increase.*[82]

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[81] LRTP, p. 19

[82] https://www.nrel.gov/docs/fy18osti/70710.pdf, p. v

The NREL team examined three representative feeders (a *feeder* is a distribution line extending out to consumers from a substation) of various configurations. They stress-tested additions of distributed solar at various locations on the feeder, and considered traditional solution sets (e.g., adding voltage regulators, modifying their set points, reconductoring, upgrading distribution transformers) along with limited deployment of advanced inverter functionality. (IEEE 1547 has been updated since the publication of the study, and conforming, advanced inverters have begun to emerge that will make this functionality more ubiquitous in the future.)[83]

The team found that:

- Hosting capacity and upgrade costs vary significantly, depending on the size and location of solar PV systems on a feeder;
- PV between 6% and 88% of peak load can be integrated on a feeder with advanced inverters and traditional upgrades, with cumulative costs ranging from $0 to $0.07/rated DC watts (3.8% and 2.5% of total installed costs for commercial and residential PV systems, respectively);
- Higher penetrations can sometimes be reached, at greater expense;
- Advanced inverters are capable of significantly increasing hosting capacity at little or no cost, except when PV is clustered far from the substation;
- The use of advanced inverter-fixed power factor of 0.95 absorbing, and in some cases volt/var control, resulted in the greatest expansion of hosting capacity;
- Integration costs can be minimized by guiding PV systems into low-cost or low-impact locations (e.g., close to substation or at least spread evenly throughout);
- Hosting capacity was initially limited by voltage constraints, mostly overvoltage, and could be mitigated in most cases with lower-cost solutions (advanced inverters, line voltage regulators or capacitors or adjusting set points of voltage-regulating equipment). However, if a substation load tap changer is required, this is a substantial expense, as is reconductoring; and
- Upgrades to mitigate thermal overloads are expensive.

In Vermont, given the high solar penetration (~44% of 2020 peak loads statewide; over 80% of substation transformer rated capacity in at least 41 substations, and over 100% of substation capacity in at least 17 substations), additional interconnections are increasingly limited by substation transformer thermal overloads. The traditional T&D tool to address the resulting high *backfeed* (exceeding the transformer's thermal rating) from the generation is to upsize substation transformers — which have cost several million dollars apiece. The long-standing regulatory principle of assigning costs to cost causers, in this case the solar PV systems, breaks down when the context changes from the next incremental, individual system to the cumulative effect of tens or hundreds of existing net-metering generators that eat away at the remaining headroom on a substation transformer (or the desire to accommodate the next dozen or hundred net-metering customers). However, new approaches of distributing costs to interconnected DERs are emerging.[84]

For at least one type of upgrade — Transmission Ground Fault Overvoltage (TGFOV) — the Public Utility Commission has approved a methodology for addressing a potential threat to grid reliability: it

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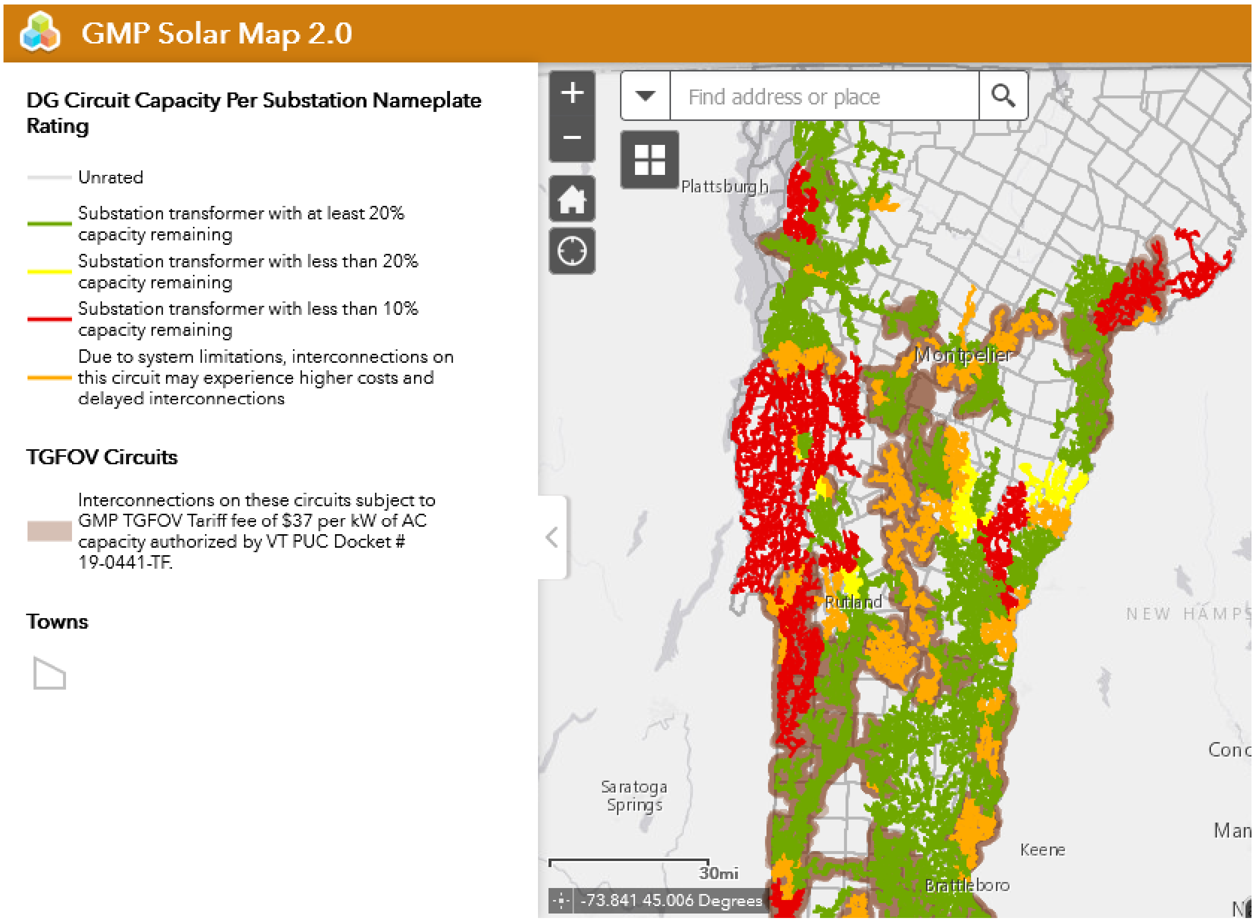
[83] https://www.nrel.gov/grid/ieee-standard-1547/assets/pdfs/smart-inverters-applications-in-power-systems.pdf
[84] https://www.nrel.gov/dgic/interconnection-insights-2018-08-31.html

has allowed Green Mountain Power to collect an additional fee from interconnecting net-metering resources that goes into a pool, used to pay for mitigating upgrades in order of priority.[85] The map below shows circuits in GMP service territory, color-coded according to headroom for additional generation on the substation transformer. Projects proposed in areas outlined in gray are subject to the TGFOV fee. The key explains limitations in other shaded areas (for example, red circuits connect to the most highly generation-constrained substations).[86]

Exhibit 4-12. GMP Solar Hosting Capacity Map



[85] See Case No. 19-0441-TF

[86] GMP Solar Map, available at https://www.arcgis.com/apps/webappviewer/index.html?id=4eaec2b58c4c4820b24c408a95ee8956, accessed 10/5/21. Red corresponds to 32 substations, yellow to 41 substations, and gray to 46 substations (which may also have secondary red or yellow limitations, TGFOV being the most limiting condition). Burlington Electric Department has a similar map available here: http://burlingtonvt.maps.arcgis.com/apps/Embed/index.html?webmap=bb1b9156d8294e308ecfe803131e8c00&extent=-73.2731,44.4574,-73.1094,44.5091&zoom=true&scale=true&legend=true&disable_scroll=false.

GMP provided the data informing the map to the Department in tabular form, with remaining substation capacity broken down by Regional Planning Commission (RPC) area. Some caveats: Some substations serve more than one RPC area, so may be counted twice; individual feeders to a substation, or substations in an RPC, may not have remaining headroom, so that headroom is not evenly spread throughout a region; some RPCs are served by more than one utility, and the data does not reflect those utilities' hosting capacity; and the term *headroom* assumes that solar capacity can add up to the maximum rating of the substation transformer, which may not always be the case.

With those caveats in mind, some initial and general assumptions can be made when comparing the solar-hosting capacity data for the GMP distribution system and for the VELCO transmission system. The table below shows the comparison; the limiting factor in an RPC area, whether transmission or distribution headroom, is noted in red text. In seven of 11 regions, transmission is the limiting factor (as it is statewide). In three regions in particular (BCRC, CCRPC, and TRORC), at least 100 MW of distribution headroom remains beyond transmission limits. Most of the available transmission-hosting capacity is in southern Vermont (southern VT RPCs are highlighted in green below). In these regions, distribution headroom is only a meaningful limiting factor in RRPC — so this could be a good area for focusing either traditional or innovative efforts to increase distribution-hosting capacity.

Exhibit 4-13. Transmission Vs. Distribution Hosting Capacity

RPC	Additional Transmission Headroom (MW)	Additional Distribution Headroom (MW)	Headroom Limited by Lower of T or D
Addison (ACRPC)	30.1	14.2	14.2
Bennington (BCRC)	66.4	304	66.4
Central Vermont (CVRPC)	44	101.3	44
Chittenden (CCRPC)*	41.5	512.3	41.5
Lamoille (LCPC)*	25.5	22.6	22.6
Mt. Ascutney (MARC)	56.7	101.8	56.7
Northeastern (NVDA)*	28	45	28
Northwest (NRPC)*	8.6	57.3	8.6
Rutland (RRPC)	126.6	64.7	64.7
Two Rivers (TRORC)*	59.3	209.3	59.3
Windham (WRC)	148.2	142.4	142.4
Totals	**636**	**1574.9**	**548.4**

If hosting-capacity challenges are not addressed preventively and holistically, stakeholders will be forced to reckon with the consequences after they arise, and while projects are on hold. Present-day examples include the TGFOV tariff, concerns with allowing new net-metering projects in the SHEI area of Vermont's transmission system, and increasing constrained "red zones" on Vermont's distribution grid.[87]

In their study, the NREL authors note that their methodology "does not capture time-varying behavior of loads, DPV systems, or voltage regulating devices on the feeder; additionally, it does not allow for

[87] See Case No. 20-3304-PET.

assessment of the potential for DPV to defer distribution system upgrades."[88] In their summary, they also note: "Future approaches to grid integration that might lower costs and increase PV penetrations include dynamic PV curtailment, advanced communication and control schemes, battery storage, and new, forward-looking planning approaches."[89]

These more innovative approaches could help unlock hosting capacity in *both* distribution and transmission, although it is complicated and challenging to integrate those efforts into our current suite of policies, programs, regulations, and tariffs, from net metering to transmission planning and interconnection requirements. One starting point might be to require all distribution utilities to create and maintain publicly accessible distribution hosting capacity maps, using a common methodology. These could focus not just on solar hosting capacity but also on hosting capacity for other DERs — including areas where strategic electrification could "soak up" excess solar, which would likely look like the inverse of the solar hosting capacity maps. These maps could become a tool used across policies and programs: they could be valuable for indicating locational value for future solar projects, for focusing workplace or fast-charging deployments, and as a foundation for grid-scale storage solicitations.

The Department and many other stakeholders are examining this and other least-cost and emerging solutions to address the issue of overgeneration, as compared to a traditional wires solution for upgrading substation transformers (though that may well be the best solution in some cases, especially when increased hosting capacity is a co-benefit of upgrades made for reliability reasons, such as GMP's upgrades of its substations in Barre, or to support future electrification related to EVs and heat pumps). For example, discussions led by Department staff in an ad-hoc subcommittee of the Vermont System Planning Committee began the process of examining how flexible loads, energy storage, and curtailment can be used — singly or in concert — to enable additional distributed generation on a constrained circuit.[90]

The key to many of these solutions, as discussed above, is likely to be implementation of *rate signals* that direct a DER, including a load, to alter its behavior in response to a price signal associated with a grid requirement, likely with the assistance of smart meters, and *direct control* of DERs by a utility (or a third party on behalf of a utility), and likely with the assistance of smart inverters. The latter will probably require investment in real-time situational awareness, monitoring, and control platforms.

It's also likely prudent to at least start exploring alternative cost allocation — and possibly interconnection — methodologies, for generating DERs to better accommodate the pace of customer demand, account for costs and benefits, and enable multiple-use applications (including dual retail-wholesale applications). In a 2020 submittal to the Massachusetts Department of Public Utilities in its *Distributed Generation Interconnection* docket (19-55), Strategen Consulting proposed two potential alternative cost-allocation methodologies, based on four guiding principles: beneficiary pays, differentiation, efficient greenhouse gas reduction, and transparency.[91]

[88] https://www.nrel.gov/docs/fy18osti/70710.pdf, p. v
[89] https://www.osti.gov/servlets/purl/1462940, p. 2
[90] https://www.vermontspc.com/vspc-at-work/subcommittees, Generation Constraint Subcommittee
[91] https://fileservice.eea.comacloud.net/FileService.Api/file/FileRoom/11883913

4.5.4 Interconnection

Cost allocation is a fundamental regulatory principle that, in current practice (cost-causer pays), is coming into friction with some visions of the modern grid. This is especially apparent in the context of solar PV interconnections. As penetrations increase, each incremental project must be evaluated with greater scrutiny for potential impacts to system stability and reliability, and must pay for necessary upgrades. At some point, the necessary upgrade might be upsizing a substation transformer, which is likely out of reach for a single project. That can effectively halt future development in an area except for very small projects, which are given less scrutiny but continue to eat up available headroom. And transmission operators aren't typically involved in the distribution utility's review for cumulative impacts, although there is increasing information sharing on interconnections that could help identify the need for additional transmission-level study. Nor is there yet any mechanism to assign a portion of cumulative upstream upgrade costs to the project.

The PUC is exploring cumulative impacts — and a host of other thorny questions — in its ongoing process of updating Vermont's interconnection standards (Rule 5.500).[92] The PUC opened a rulemaking in 2019 to consider modifications proposed by a 2016 working group, and to gather additional feedback. Several additional issues were raised, including: inconsistencies in timelines for review of certain projects under the net-metering (5.500) vs. the interconnection (5.100) rules; how to evaluate storage resources under various interconnection configurations; collective impacts and cluster studies; distributed aggregations, smart inverters, and DER cybersecurity.

As time passes and the ecosystem of the grid, DERs, and various actors becomes increasingly complex, a core question is: can the rule keep up with the pace of evolution in this space? How? Is there a better structure than an inflexible rule to guide fair and nondiscriminatory evaluation of interconnections, one that can also keep pace with evolving standards (e.g., ISO-NE's Source Requirements Document to prevent inverters from tripping offline unnecessarily[93]) within the inflexible structure of a rule? If past predicts future, certainly not: developers and utilities are currently operating under a rule revised in *2006*.

In workshops convened in 2021, the PUC began exploring these questions. It is working toward a deadline, set in Act 54 of 2021, of proposing updates to the rule by March 15, 2022.[94] One path forward may be to limit the rule language to process, and put the elements that are expected to evolve (e.g., standards) into a companion Order that is updated on a regular basis (much like the biennial compensation order issued by the PUC under Rule 5.100). Howsoever it's accomplished, enabling interconnection procedures to evolve over time — to adjust to changing technologies, applications, and implications — is an essential regulatory action to foster a modern grid.

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[92] https://puc.vermont.gov/about-us/statutes-and-rules/proposed-changes-rule-5500 and the draft updates to the rule issued 12/20/21

[93] https://www.iso-ne.com/static-assets/documents/2018/02/a2_implementation_of_revised_ieee_standard_1547_iso_source_document.pdf

[94] https://legislature.vermont.gov/Documents/2022/Docs/ACTS/ACT054/ACT054%20As%20Enacted.pdf

4.5.5 Resilience

The interconnection process evaluates distributed generation, and now storage, for reliability impacts on a project-by-project basis; to get a Certificate of Public Good, each project must demonstrate it will not adversely impact system stability and reliability. Reliability, as a concept, is a core tenet of Vermont energy policy (30 V.S.A. § 202a*)*:

> *It is the general policy of the State of Vermont:*
>
> *(1) To assure, to the greatest extent practicable, that Vermont can meet its energy service needs in a manner that is adequate, reliable, secure, and sustainable; that assures affordability and encourages the State's economic vitality, the efficient use of energy resources, and cost-effective demand-side management; and that is environmentally sound.*

Distribution grid reliability is governed by specific requirements and standards.[95] Distribution utilities are also required to file Service Quality and Reliability Plans with the PUC and PSD, reporting on reliability performance metrics such as the frequency and duration of outages, along with a list of the utility's worst-performing circuits and plans to improve their reliability.[96]

Reliability is also a core tenet of the concept of "energy assurance," as articulated in Vermont's Energy Assurance Plan (itself part of the state's Emergency Operations Plan). It defines energy assurance as:

> *"The ability to obtain, on an acceptably reliable basis, in an economically viable manner, without significant impacts due to Energy Supply Disruption Event(s), or the potential for such events, sufficient supplies of the energy inputs necessary to satisfy Residential, Commercial, Governmental, and non-governmental requirements for Transportation, Heating (space and process heat), and Electrical Generation."*[97]

In other words, reliability is a strictly defined term subject to specific standards, metrics, reporting, enforcement, and penalties. It is, foundationally, about avoiding "loss of load" (or power outages), both in number and duration, during day-to-day operations, with metrics focusing on reliability performance over a specified period of time. NERC defines a reliable bulk power system as "one that is able to meet the electricity needs of end-use customers even when unexpected equipment failures or other factors reduce the amount of available electricity."[98] The concept includes both *resource adequacy* — i.e., sufficient supply — and *security*, or the ability to withstand sudden unexpected disturbances, either natural or man-made.

Resilience (or resiliency), on the other hand, is more of a term of art, subject to a variety of proposed definitions, with an evolving landscape of potential metrics but without specific regulatory "teeth."

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[95] See https://www.ferc.gov/sites/default/files/2020-04/reliability-primer_1.pdf, https://www.ferc.gov/industries-data/electric/industry-activities/nerc-standards, and https://www.npcc.org/program-areas/standards-and-criteria/regional-standards.
[96] https://puc.vermont.gov/sites/psbnew/files/doc_library/4900-electricity-outage-reporting_0.pdf
[97] https://publicservice.vermont.gov/sites/dps/files/documents/VT%20Energy%20Assurance%20Plan%20August%202013.pdf
[98] https://www.nerc.com/AboutNERC/Documents/NERC FAQs AUG13.pdf

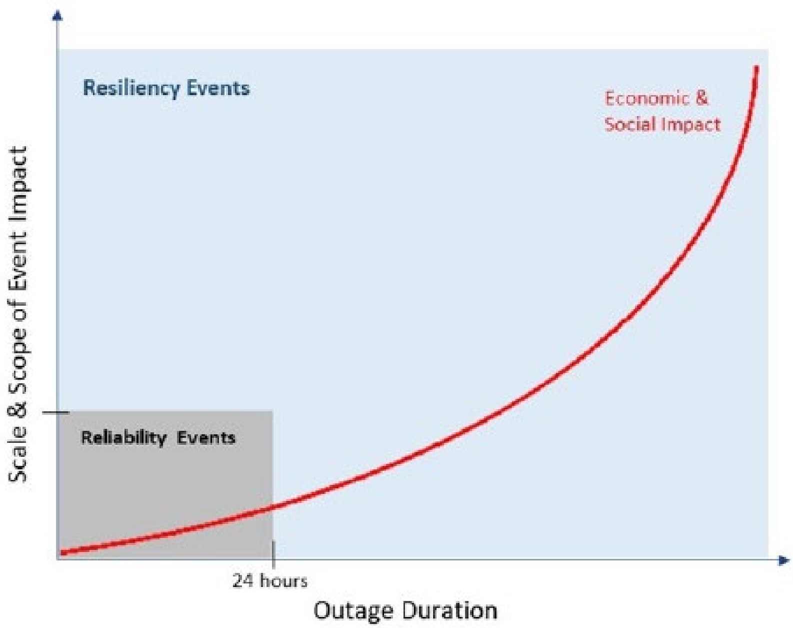
Nevertheless, it is increasingly heralded, including by stakeholders in Vermont, as an objective of the modern grid and an attribute of various DERs.

FERC has proposed the following definition of resilience, which has been adopted by NERC: "The ability to withstand and reduce the magnitude and/or duration of disruptive events, which includes the capability to anticipate, absorb, adapt to, and/or rapidly recover from such an event."[99] Unlike reliability, resilience is usually thought of in terms of a specific, low-probability, high-impact event. But without imposition of a measurement or valuation framework, it is not particularly meaningful to describe a grid as resilient, or to describe a resource as providing grid resilience.

The *Modern Distribution Grid* report describes reliability as an *objective* of the modern grid, while resilience is an *attribute*:

- ***Resilience events*** *cause larger geographic impact on distribution and/or bulk power system with long-duration outage — typically greater than 24 hours and classified as "Major Events" according to IEEE 1366.*
- ***Distribution-level resilience events*** *occur when there are similar infrastructure failures as ones that happen in reliability events (e.g., wires down, poles broken, transformer failure, fuses blown) but at a greater scale that requires significant complexity to address.*
- ***Reliability events*** *have a local impact with short duration outage — generally less than 24 hours and not classified as "Major Events" according to IEEE 1366.*

Exhibit 4-14. Reliablity-Resilience Event Continuum



[100]

[99] https://elibrary.ferc.gov/eLibrary/#, Order Terminating Rulemaking Proceeding, Initiating New Proceeding, and Establishing
Additional Procedures, 162 FERC ¶ 61,012, para. 14, FERC Dkt. No. AD18-7-000 (Jan. 8, 2018). Pp. 12-13. Accessed 12/5/20.
[100] https://gridarchitecture.pnnl.gov/media/Modern-Distribution-Grid_Volume_IV_v1_0_draft.pdf, p. 30

The authors state: "Resilience planning involves assessing the potential distribution system impacts from major resilience events, while reliability planning focuses on maintaining or improving a distribution system's performance in relation to minor outages as measured by the IEEE 1366 reliability metrics (e.g., CAIDI, SAIDI)." They highlight a three-pronged planning approach, developed by the Electric Power Research Institute:

> • ***Prevention:*** *Preventing damage in the distribution system requires changes in design standards, construction guidelines, maintenance routines, and inspection procedures using innovative technologies.*
>
> • ***Survivability:*** *The ability to maintain some basic level of electrical service using resilient technologies to critical consumers or communities in the event of a complete loss of electrical service from the distribution system.*
>
> • ***Recovery****: Rapid damage assessment, flexible grid designs, prompt crew deployment to damaged assets, and readily available replacement components.*

"Fundamental to resilience planning is determining a risk strategy integrated with the approach above," they note in conclusion. "This involves determining the risk associated with threat impacts, determining the appropriate risk tolerance and related strategic approach for accepting certain level of risks, mitigating the impact of certain risks, and enabling the avoidance of other risks. These strategies for various risks inform the development of various grid, customer, and third-party solutions.[101]

The Department assisted the Rural Resilience & Adaptation Subcommittee of the Climate Council in developing Climate Action Plan recommendations related to energy infrastructure resilience. The strategies and actions included in the initial adopted plan encompass the domains of prevention, survivability, and recovery, with numerous specific actions under each of the following strategies:

A. Create a policy, planning, and organizational foundation to support effective investments in infrastructure resilience.
B. Public, private, and nonprofit entities should be prepared to respond and recover quickly to disruptions caused by severe weather and other climate change threats.
C. Increase the resilience of critical infrastructure to severe weather and other climate change threats by reducing vulnerabilities of specific facilities.
D. Increase the resilience of critical infrastructure to severe weather and other climate change threats by improving system efficiency, reliability, and redundancies.[102]

Several key questions remain. Who is the responsible entity for each action? How will the necessary action be funded? And how will we know when resiliency has been increased, especially when the threat landscape (in this case, climate-change-induced baseline as well as severe weather) keeps getting worse?

Along with understanding how climate change will impact weather and infrastructure in Vermont, it will be necessary to develop metrics to measure the impact of investments, especially if ratepayer dollars are

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101 https://gridarchitecture.pnnl.gov/media/Modern-Distribution-Grid_Volume_IV_v1_0_draft.pdf, p. 30

102 https://outside.vermont.gov/agency/anr/climatecouncil/Shared%20Documents/Initial%20Climate%20Action%20Plan%20-%20Final%20-%2012-1-21.pdf, pp. 148-152

proposed to be used. Lawrence Berkeley National Laboratory's Joe Eto has proposed the following as potential metrics for measuring the impacts of resilience investments:

Exhibit 4-15. Grid Modernization Lab Consortium Resilience Metrics

GMLC Resilience Metrics	Data Requirements
Cumulative customer-hours of outages	customer interruption duration (hours)
Cumulative customer energy demand not served	total kVA of load interrupted
Avg (or %) customers experiencing an outage during a specified time period	total kVA of load served
Cumulative critical customer-hours of outages	critical customer interruption duration
Critical customer energy demand not served	total kVA of load interrupted for critical customers
Avg (or %) of critical loads that experience an outage	total kVA of load severed to critical customers
Time to recovery	
Cost of recovery	
Loss of utility revenue	outage cost for utility ($)
Cost of grid damages (e.g., repair or replace lines, transformers)	total cost of equipment repair
Avoided outage cost	total kVA of interrupted load avoided
	$ / kVA
Critical services without power	number of critical services without power
	total number of critical services
Critical services without power after backup fails	total number of critical services with backup power
	duration of backup power for critical services
Loss of assets and perishables	
Business interruption costs	avg business losses per day (other than utility)
Impact on GMP or GRP	
Key production facilities w/o power	total number of key production facilities w/o power (how is this different from total kVA interrupted for critical customers?)
Key military facilities w/o power	total number of military facilities w/o power (same comment as above)

[103]

For example, one of the infrastructure resilience actions included in the Climate Action Plan is:

> *Identify mission critical facilities in collaboration with local and regional planners, utilities, and transportation providers to identify actions, procedures, or investments to mitigate the impact of extreme weather events to services provided by these facilities. Examples of mission-critical facilities include designated emergency shelters, first responder facilities, hospitals and other medical facilities, key infrastructure such as water/wastewater pumping and treatment and sewer, key communications infrastructure such as fiber nodes, government offices, fuel suppliers, transportation hubs, supermarkets and other facilities municipalities identify as critical to serving communities during extreme weather events.*

An investment proposed to enhance resilience at such a facility could be tied to a metric such as "time to recovery," "critical services without power," or "loss of assets and perishables." Projects to serve mission-critical facilities could look like backup power at a single facility, or perhaps a microgrid serving a number of facilities that are both physically close and on the same "part" of the grid (such as GMP's forthcoming microgrid in Panton, and similar projects being evaluated under its "Resiliency Zones" initiative).[104]

A microgrid serving a community facility or facilities falls somewhere in between the spectrum of "resilience for one" (residential storage) and "resilience for all" (increased tree trimming,

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[103] https://eta-publications.lbl.gov/sites/default/files/5_-_eto_reliability_and_resilience_based_planning_4.pdf. In this table, "GMP" refers to Gross Municipal Product and "GRP" refers to Gross Regional Product.

[104] https://greenmountainpower.com/gmp-announces-pioneering-microgrid-in-panton-vt/

undergrounding lines, etc.), and matters from the perspective of assigning costs (or attributing benefits). Utilities are required to provide every customer with reliable electric supply, and "upstream" investments (vegetation management, moving cross-country lines to roadsides, even strategic undergrounding) will likely benefit more customers for every dollar invested, making these types of investments potentially the most equitable.

Meanwhile, there are instances where customers may make individual investments, with or without utility involvement, to enhance their individual reliability (or, potentially, resiliency). One example is customer-sited generators, or batteries, such as those deployed under Green Mountain Power's Powerwall and Bring Your Own Device tariffs.[105] In those programs, customers pay for the enhanced personal grid reliability that the battery storage offers, while all the utility's customers both pay for and gain benefit from the other values provided by the storage in the aggregate, such as reducing peak-related charges. A microgrid benefits a specific group of customers (campus, community, etc.), but can also provide system-wide values to all customers, akin to the fleet of residential batteries, which may help offset a large portion of its own costs.

Exhibit 4-16. Resilience Solutions Map

[106]

4.5.6 Communications

Of course, realization of the modern grid will succeed or fail in large part based on the availability and attributes of communications infrastructure. Ubiquitous communications networks that reach the grid edge, with sufficient speeds, information-carrying capabilities, and both physical and cyber security

[105] https://greenmountainpower.com/rebates-programs/home-energy-storage/
[106] https://gridarchitecture.pnnl.gov/media/Modern-Distribution-Grid_Volume_IV_v1_0_draft.pdf, p. 38

protections, are essential to the grand orchestration of DERs that is needed to use the grid efficiently and minimize costly integration needs. As the authors of *Modern Distribution Grid* note: "Relative to other investments in grid modernization, operational communication networks, like the physical grid, represent a fundamental enabling technology required by all the capabilities described in Volume I. Proper architecture, design, and implementation will also lower the incremental cost of adding capabilities as required."[107]

The Department's most recent *10-Year Telecom Plan* describes the state of broadband deployment in Vermont, and offers suggestions to reach under- and unserved areas,[108] and the newly created Broadband Board will be working to advance community broadband expansion efforts.[109] Utilities are also deeply involved in assisting with these efforts, in particular allowing access to their infrastructure — such as VELCO's fiber network, and distribution utility pole networks — as a foundation for community and private network expansion.[110]

Another key modern grid communications issue is *interoperability*. The National Institute of Standards and Technologies defines smart grid interoperability as: "The capability of two or more networks, systems, devices, applications, or components to work together and to exchange and readily use information — securely, effectively, and with little or no inconvenience to the user. The smart grid will be a system of interoperable systems; that is, different systems will exchange meaningful, actionable information in support of the safe, secure, efficient, and reliable operations of electric systems. The systems will share a common meaning of the exchanged information, and this information will elicit various agreed-upon responses. The reliability, fidelity, and security of information exchanges between and among smart grid systems must achieve required performance levels."[111]

The selection of DER technologies should prioritize interoperability as much as possible, to avoid vendor lock-in, proprietary protocols, and subsequent integration challenges that will inevitably arise as grid modernization rolls out. Stakeholders have raised the issue in Vermont's interconnection rulemaking — which may be the logical home for interoperability, although it enlarges the scope of that rule somewhat. California's Rule 21 tariff may serve as an example: in addition to interconnection, operations, and metering of distributed generation, it addresses smart inverter functions and communications protocols (specifically IEEE 2030.5 as the default).[112] From the interconnection docket, the conversation should expand to encompass other relevant realms, such as deployment of electrification measures. The more that modern-grid-ready DERs can be deployed now, the more effective future control platforms will be out of the gate.

Finally, ensuring cybersecurity in an increasingly digital grid with ubiquitous, interconnected, cloud-controlled DERs is imperative to safeguarding grid reliability and resilience, especially as transportation

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[107] https://gridarchitecture.pnnl.gov/media/Modern-Distribution-Grid_Volume_IV_v1_0_draft.pdf, p. 72
[108] https://legislature.vermont.gov/assets/Legislative-Reports/10-Year-Telecom-Plan_Final_June30_2021.pdf
[109] https://publicservice.vermont.gov/vcbb
[110] https://legislature.vermont.gov/assets/Legislative-Reports/Feasibility-Study-of-Electric-Companies-Offering-Broadband-in-Vermont.pdf
[111] https://www.naruc.org/cpi-1/energy-infrastructure-modernization/smart-grid/interoperability-glossary/
[112] https://standards.ieee.org/content/dam/ieee-standards/standards/web/documents/presentations/smart_energy_slides.pdf

and heating electrify and become reliant upon that grid. The distributed locations of resources as well as their aggregated system impacts must be considered; this makes necessary multiple and mutually aware layers of protections, from the in-home DER connected to operational software through Wi-Fi, to third-party operations and to utility information and operational technology.

After more than a decade of work with stakeholders, in December 2019 the PUC approved a *Statement of Principles Relative to Cyber Security for Electric Utilities*, with a specific focus on smart meters.[113] These Principles include keeping current on industry standards and best practices; development and maintenance of cybersecurity programs by all utilities; annual discussions with the Department; and reporting requirements. Regional and national organizations, including associations of utility regulators and the U.S. Department of Energy, also provide regularly updated best practices and trainings to enable stakeholders to keep up with the evolving threat landscape — and this is a practice that must remain front and center, for all of Vermont's utilities and for third parties that install or operate DERs.[114]

[113] https://epuc.vermont.gov/?q=node/104/27047

[114] See for example: https://www.energy.gov/sites/prod/files/2015/01/f19/Energy%20Sector%20Cybersecurity%20Framework%20Implementation%20Guidance_FINAL_01-05-15.pdf, https://www.nist.gov/cyberframework/new-framework, https://www.federalregister.gov/documents/2013/10/25/2013-25168/request-for-comments-on-draft-nist-interagency-report-nistir-7628-rev-1-guidelines-for-smart-grid, https://www.naruc.org/cpi-1/critical-infrastructure-cybersecurity-and-resilience/cybersecurity/cybersecurity-manual/

Postcard from the Vermont Distribution Grid in 2030

- Vermont has ubiquitous advanced smart meter (or equivalent) deployment. These increasingly make use of expanded connectivity solution to communicate with utility control rooms in real time. Utilities make increasing use of use this data for real-time grid-edge intelligence and control.
- Utilities offer tariffs with time-based pricing, such as a whole-house or several end-use-specific rates. Customers can make use of these together with access to real-time smart meter data, and/or they can deploy direct-control software and offerings.
- Utilities have adopted or are exploring the adoption of DER visibility and control platforms, including direct-to-DER as well as direct-to-aggregator.
- Utilities have developed web-accessible solar and DER hosting capacity maps, and they incorporate spatially granular DER adoption assumptions into their forecasts.
- Every new inverter-based resource, in particular solar PV, uses a smart inverter that complies with the most current IEEE 1547 standard, and is certified based on the most current UL 1741 standard. (Legacy inverters are replaced with smart inverters.)
- A process exists for utilities to evaluate non-transmission alternatives to grid upgrades, to accommodate not just load but also generation. Utilities also issue periodic procurements for flexible DERs, including storage, to address system needs.
- Energy planning is better coordinated across land use and utility distribution system disciplines, facilitating locational optimization of DERs, especially distributed generation.

Postcard from the Vermont Distribution Grid in 2050

- Vermont's distribution utilities have a suite of tools for real-time grid visibility, communications, and control. They have access to Distributed Energy Resource Management Systems and Advanced Distribution Management Systems to manage a fleet of DERs to maximize grid efficiency.
- Vermont has in place one or more mechanisms to orchestrate and optimize generation, load, and DERs statewide.
- Vermont's distribution systems and DERs are resilient in the face of threats including climate change and cyber intrusions. Vermonters have access to energy services in major storms, either within their homes or within their communities.
- Vehicle-to-grid technology is ubiquitous, providing Vermonters with a source of home-based resilience that can also be used when idle as part of a grid-optimizing fleet.
- New buildings are smart-grid-ready by default, and existing homes are retrofitted with smart panels for a plug-and-play DER experience.

4.6 Next Steps

Moving toward *a secure and affordable grid that can efficiently integrate, use, and optimize high penetrations of distributed energy resources to enhance resilience and reduce greenhouse gas emissions* clearly involves a complex set of interrelated actors and actions across a number of disciplines. It's difficult to know where to dive in. There are many relevant proceedings and many active initiatives, but at present there is no unifying docket or planning framework to tie everything together into a coherent narrative, or vision of the future grid.

Here are just a few of the initiatives now underway, to advance the concepts discussed here:

- Utilities have explored — or will soon be exploring — myriad active pilot programs, many of which probe aspects of the modern grid, from smart panels to workplace charging and flexible load management.[115]
- The Department has proposed to reform net-metering compensation to value production consumed on-site higher than production exported beyond the customer meter, and to adjust the compensation for exports based on time and location. In addition to realigning ratepayer-funded incentives with ratepayer value for the energy produced, this would help to mitigate backfeed issues, or overgeneration that accumulates up-feeders to substation transformers, and would lessen related infrastructure costs.[116]
- The Department is proposing to use $5 million of allocated ARPA funds to build Vermont's capability to deploy and use grid-interactive flexible DERs and control platforms, in particular to enable low- and moderate-income Vermonters to participate in the clean energy transition, and to expand the availability of FLM tools to Vermont's municipal and cooperative electric utilities. The Department issued an RFI in December 2021 to gather additional feedback on how to best allocate these funds for grid and DER management.
- The electric energy efficiency charge was recently approved to support installation of end uses that are capable of being controlled by the area distribution utility, through FLM programs. Efficiency Vermont has a budget of $3.4 million for a three-year pilot (2021-2023) with a goal of being capable of getting 2.7 MW of load under control in cooperation with distribution utilities (see Chapter 7, section 5).
- A partnership between the Pacific Northwest National Laboratory and VELCO was awarded $5 million from the U.S. Department of Energy to advance development of a standards-based data management platform that will enable greater information exchange and improve operational control between VELCO and distribution utilities. The initial focus of this work will be to develop more dynamic, telemetry-driven operating procedures for Under Frequency Load Shedding (UFLS) events requested by VELCO and executed by distribution utilities in order to maintain grid reliability. UFLS represents the first use case within a larger, ongoing VELCO initiative to pursue implementation of a statewide data management and message exchange platform. This platform would be capable of capturing and standardizing DER telemetry data from the field of

[115] https://greenmountainpower.com/wp-content/uploads/2021/06/Schedule-G-New-Initiatives-Innovative-Pilot-Summary.pdf; https://legislature.vermont.gov/bill/status/2022/S.60

[116] See Case No. 19-0855-RULE, 11/1/19 Department of Public Service Report on Public Utility Commission Net-Metering Information Requests

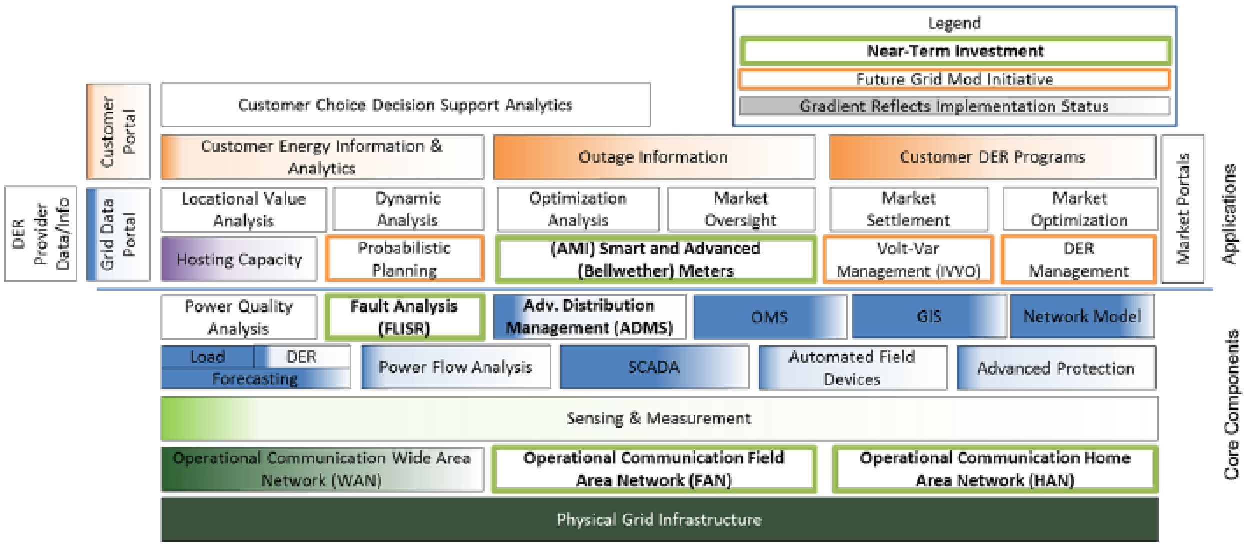
participating distribution utilities and routing it to various distribution utility and VELCO software and backend systems.[117]

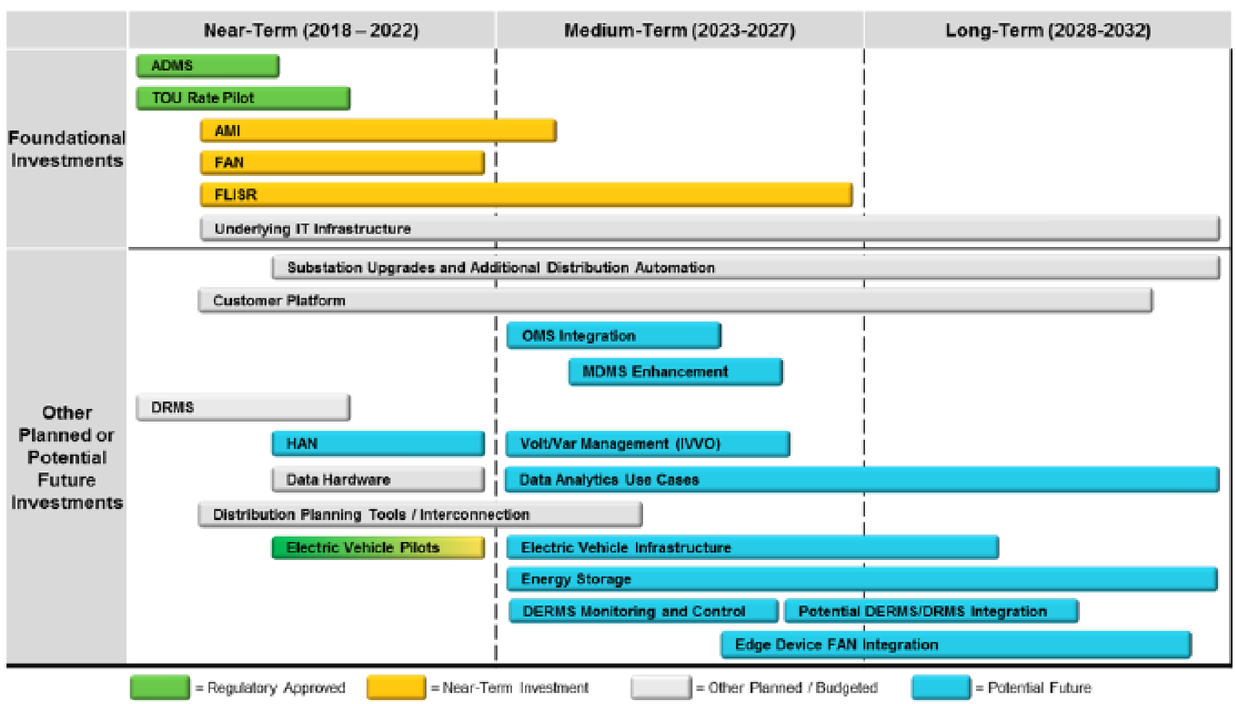
This "laboratory" approach, where modern grid themes are being explored voluntarily and enthusiastically by utilities and other stakeholders seeking answers to existing or anticipated challenges, has costs and benefits that should be weighed against the costs and benefits of a more structured approach.[118] The resources of Vermont's policymakers, regulators, utilities, developers, and other stakeholders are extremely limited, especially when compared with those of other states (the California Energy Commission, akin to Vermont's Department of Public Service, has close to 800 staff). Vermont must use its limited resources wisely — which may mean not saddling everyone with a time-intensive proceeding in place of getting to the business of grid modernization.

That being said, without at least laying out a set of objectives and capabilities for a modern grid and periodically assessing where utilities stand, it's difficult for policymakers and regulators to know where to focus their time and attention. One stepwise way to progress would be for the Department to propose capabilities and objectives in its next IRP guidance document — starting with, as DOE states, "understanding the functional capabilities and structure of the current distribution system. This," says DOE's *Modern Distribution Grid* report, "sets the context for any changes or additions that may be required and is a recommended precursor to active engagement with stakeholders regarding grid modernization planning."

The report cites the example of Xcel Energy, a Minnesota utility that provides a snapshot (first figure) and a roadmap (second figure) for their grid modernization implementation status, and for their planned investments in the utility's Integrated Distribution Plan:

[117] https://www.energy.gov/sites/default/files/2021-06/doe-fy2022-budget-volume-3.1-v2.pdf p. 25
[118] https://www.ncsl.org/research/energy/modernizing-the-electric-grid-state-role-and-policy-options.aspx, https://nccleantech.ncsu.edu/2020/02/05/4683/





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In the "snapshot" (first figure), grid modernization investments are separated into "core components" such as physical grid infrastructure, sensors, and communications pathways, and "applications" that build on that core, such as DER management, locational value analysis, and market operations. Investments are then prioritized and their approximate implementation status noted. This type of figure grounds utilities, regulators, and other stakeholders in an understanding of the utility's grid modernization status, priorities, and plans, and informs a stepwise grid modernization plan specific to

[119] https://gridarchitecture.pnnl.gov/media/Modern-Distribution-Grid_Volume_IV_v1_0_draft.pdf, p. 76-77

each utility, such as that illustrated in the second figure, where a timeline for implementation of various investments is provided.

More broadly, the Department proposes that Vermont immediately pursue several foundational steps that are necessary to unlock many aspects and alternatives for a modern grid. These can be considered "no- or low-regrets" steps. To borrow from the structure of California's DER Action Plan 2.0, [120] they include:

A. Load Flexibility & Rates
   a. Principles
      i. Costs and benefits relating to the timing and location of DERs, as well as their ability to be flexible to changing circumstances, should be reflected in policies, programs, and rates wherever possible in order to steer DERs to the optimal locations on the grid and incentivize load and generation at times that optimize use of existing grid infrastructure, and do not trigger infrastructure upgrades.
      ii. Grid-friendly DERs should be the focus of DER programs. These include DERs that can adapt to grid conditions, either by reducing impacts caused by the DER or actively supporting the grid (e.g., with voltage ride through, autonomous frequency response, ability to time-shift load or production, etc.).

   b. Forums
      i. Renewable Energy Standard, Standard Offer successor program and net-metering programs, demand response, and other utility programs.

   c. Actions
      i. Utilities without them should develop time-of-use rates (whole-home or end-use specific) and begin exploring tools to enable direct control of grid-edge DERs, moving toward more widespread control capabilities over time.
      ii. Load flexibility initiatives should be codified in policies, regulations, and programs as much as possible, so they can be relied upon as inputs to grid planning efforts. For example, electric vehicle incentives should be tied, to the extent possible, to time-of-use rates or direct control schemes that can be clearly identified and used by distribution and transmission planners to evaluate demand implications, thus avoiding "worst-case scenario" planning. Such initiatives should also allow flexibility to adapt to changing conditions over time.

B. Grid & Communications Infrastructure
   a. Principles
      i. Grid planning should be increasingly focused on the distribution system, with a goal of grid-edge visibility, communication, and control in order to optimize use of existing grid infrastructure and strategically prepare for a highly inverter-based, variable-generation rich, climate-resilient future.
      ii. The future grid should be DER-friendly, interoperable, aggregation-friendly, and foster compatibility between transmission and distribution.

[120] https://www.cpuc.ca.gov/about-cpuc/divisions/energy-division/der-action-plan

b. Forums
    i. Interconnection standards, utility integrated resource, demand resource, and capital plans and pilots, VSPC, state telecommunications planning, Vermont Broadband Board.

c. Actions
    i. The state, utilities, CUDs, and others should continue the multi-pronged push to expand broadband statewide.
    ii. Municipalities, regions, emergency management professionals, communications providers, DER developers, transportation planners, and utilities should have forums and mechanisms to plan collaboratively toward an optimized grid.
    iii. Utilities should develop or expand hosting capacity maps for solar and other DERs that will inform locational pricing, DER programs, and land use planning.
    iv. Rule 5.500 should be updated to incorporate: storage, collective impacts and cluster studies; distributed aggregations; smart inverters; interoperability; and DER cybersecurity and should reform to enable frequent updates as technologies and standards evolve.
    v. Stakeholders should work toward the adoption of open communication standards (between devices and platforms or aggregators as well as between platforms or aggregators and utilities) to advance equitable and scalable flexible load management capabilities.

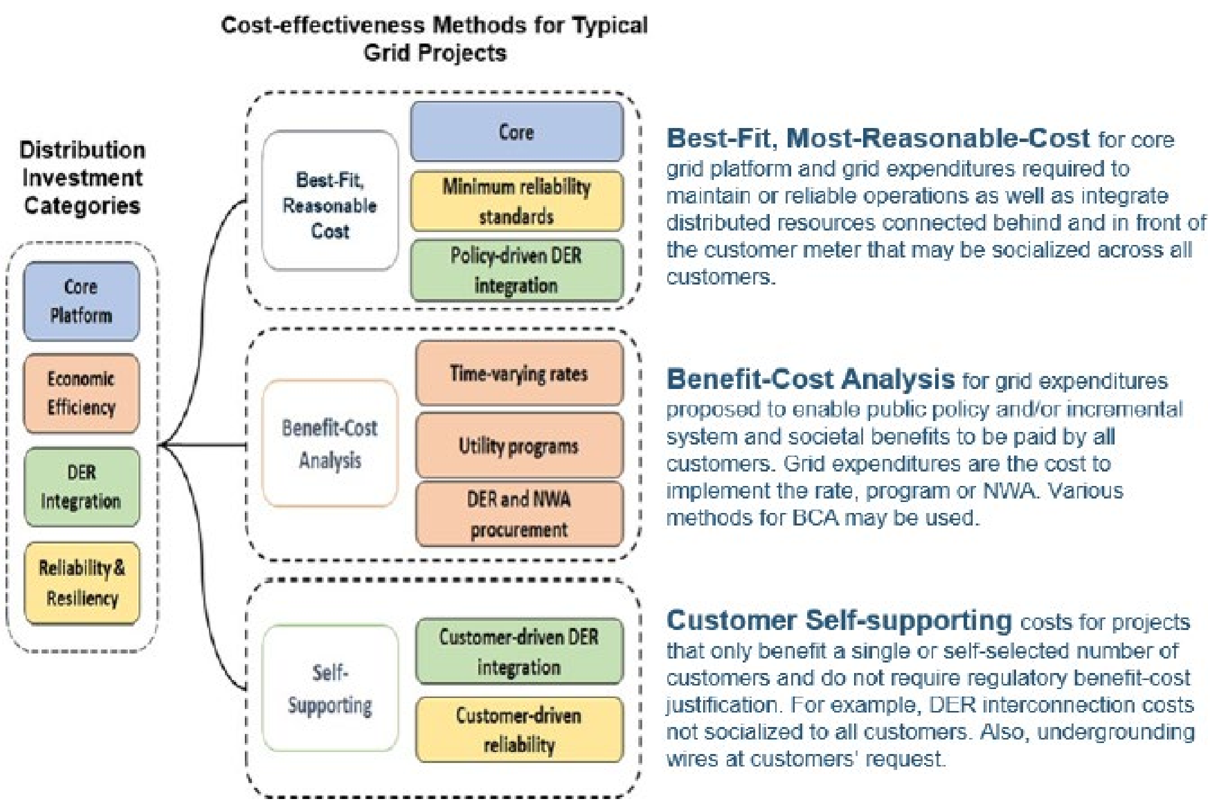
C. DER Market Integration and Customer Programs
  a. Principles
    i. DER programs should be designed to value the full suite of DER capabilities, to expand customer choice and capture distribution system benefits that might otherwise be lost if resources were aggregated for regional benefits.

  b. Forums
    i. Net metering, community solar, energy efficiency, demand response, and flexible load management programs; transportation electrification; storage rulemaking; grid-interactive efficient buildings.

  c. Actions
    i. DER programs should incorporate time- and locational pricing, informed by and aligned with system costs and benefits, which can be modified frequently as conditions change
    ii. Utilities who haven't should make real-time usage and rate data available to customers and actionable by customers with DER, including with the assistance of third-party intermediaries
    iii. Forums that allow distribution and efficiency utilities to effectively coordinate and facilitate a shared approach to standards for behind-the-meter DERs should be encouraged or developed

These are just a handful of suggested concrete and near-terms steps to take to realize *a secure and affordable grid that can efficiently integrate, use, and optimize high penetrations of distributed energy resources to enhance resilience and reduce greenhouse gas emissions.* There are plenty of other considerations and activities not reflected so far — equity in particular — that should be brought into continued discussion of grid optimization. And there will be plenty of big, thorny, paradigm-challenging discussions ahead, in particular addressing the questions of "how much do we want to pay beyond what's cost-effective now?", "ok, now who pays?", and "given limited resources, how do we prioritize investments?"

When Vermont embarks on that discussion, there will hopefully be some examples to consider — for example, further progress on the previously mentioned Strategen proposal to the Massachusetts Department of Public Utilities. The *Modern Distribution Grid* authors also offer a way to begin to think about how different types of grid modernization investments can be evaluated in different ways for cost-effectiveness, based on objectives (e.g., core investments) and beneficiaries (e.g., all ratepayers):



[121]

"Approaches to categorizing investments will vary across jurisdictions," they further note, "particularly for grid modernization investments to support DER. Policymakers and regulators in some jurisdictions will direct utilities to proactively invest in the grid to prepare for DER adoption (policy-driven DER integration), whereas regulators in other jurisdictions may require utilities to demonstrate that grid modernization investments that support DER are cost-effective for ratepayers. In yet other jurisdictions,

[121] https://gridarchitecture.pnnl.gov/media/Modern-Distribution-Grid_Volume_IV_v1_0_draft.pdf, p. 114

regulators may work to ensure margin-neutral rates for DERs, which require DER customers to pay for any incremental grid costs associated with DER interconnection and operation."

Vermont doesn't have a clear direction on how to assess grid-modernization costs, or for that matter a clear grid-modernization plan. Nevertheless, utilities, DER developers, and other stakeholder are managing to forge ahead toward some version of *a secure and affordable grid that can efficiently integrate, use, and optimize high penetrations of distributed energy resources to enhance resilience and reduce greenhouse gas emissions*. Continued conversation among these entities — perhaps informed by this CEP — hold promise to help bring into focus the grid modernization path ahead.

5 Transportation and Land Use

5.1 Introduction

The transportation system is critical to the state's economy and quality of life. It provides access to jobs and mobility for the movement of goods and services that are essential to Vermont businesses, brings tourists and other visitors to the state, and provides access for residents' daily activities.

Transportation fuels continue to account for the largest portion of Vermont's total energy consumption, and they include more fossil fuels than any other energy source. Transportation makes up 38% of the total energy consumed in Vermont and produces more GHG emissions — around 40% of the state's total — than any other sector.

This chapter identifies pathways, strategies, and recommendations for actions to set Vermont on a path toward affordable, reliable, and clean energy for transportation that meets the state's greenhouse gas requirements. Transportation system efficiency is overarching and comes from each of four pathways: (1) accelerating vehicle electrification; (2) cleaner vehicles and fuels; (3) supporting land use patterns that increase transportation system efficiency; and (4) increasing transportation choices. Vermont is well-positioned to take on the challenge of reducing energy demands in the transportation sector, in a manner that enhances quality of life for residences and increases the economic vitality of Vermont's businesses.

Vermont must continue to expand, as quickly as possible, the market share of electric cars and trucks. A robust policy environment is critical for rapidly increasing the market share of plug-in electric vehicles (EVs), and is supported by ongoing and dramatic advances in electric vehicle technology, especially batteries. This strategy can move the transportation sector toward energy and emissions goals faster than any other single measure.

While electrification for Vermont's light-duty fleet is a viable option, there are many heavy- and medium-duty applications for which battery electric options are limited. In those applications, alternative fuels — including biodiesel, ethanol, compressed or liquefied natural gas, and potentially hydrogen — could offer a lower-carbon alternative to gasoline and diesel, with significant GHG savings and fewer emissions.

Land use patterns, what we build and where we build it, are a foundational building block of our transportation system. The choices we make about what and where to build has significant impact on how the transportation system is designed and operated to facilitate the movement of people and goods. Land use choices that support compact and mixed-use settlement can improve transportation system efficiency overall, by reducing the distances between the places where people regularly need to go.

Transportation infrastructure that increases the quality and types of transportation choices available (often called Transportation Demand Management, or TDM), like public transit, ride share, bicycling and walking, provides alternatives to getting around by single-occupancy vehicle. These choices make the transportation system more accessible and equitable, while also helping to make communities more livable and vibrant and reducing energy use and emissions.

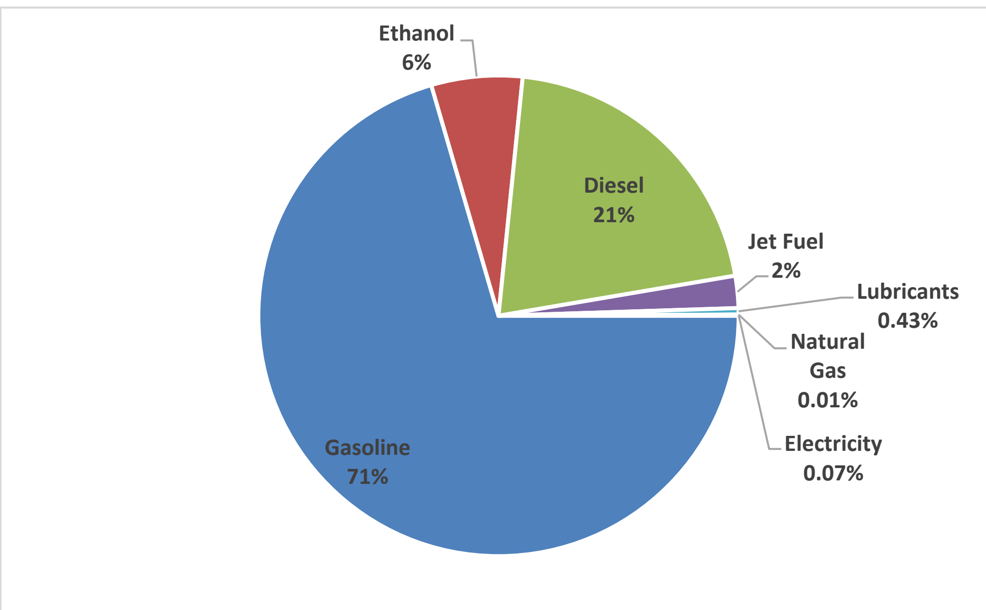
Increasing transportation choices and promoting land use patterns that support compact and mixed-use settlement are mutually reinforcing strategies that can, when implemented together, drastically improve outcomes for the transportation system. Integrating land use and transportation planning can provide a critical foundation for a more efficient and lower-carbon transportation system — and switching the fuels used from fossil fuel to electricity is a critical strategy for meeting energy and emissions goals, especially in the near term.

For each of these pathways, this chapter describes a number of strategies and offers specific recommendations. This chapter also sets goals by which progress can be measured, consistent with the greenhouse gas reduction requirements and energy policy principles articulated in Chapter 1 and in the last CEP.

5.2 Transportation Energy Use

Vermont's transportation energy use remains predominately fossil-based. Just 6.1% of fuel used is renewable,[122] mainly ethanol in gasoline, and a smaller portion from renewably generated electricity.

Exhibit 5-1. Estimated Transportation Energy Consumption by Fuel Type, 2019[123]



Source: US Energy Information Administration, Bureau of Transportation Statistics, and PSD Estimates

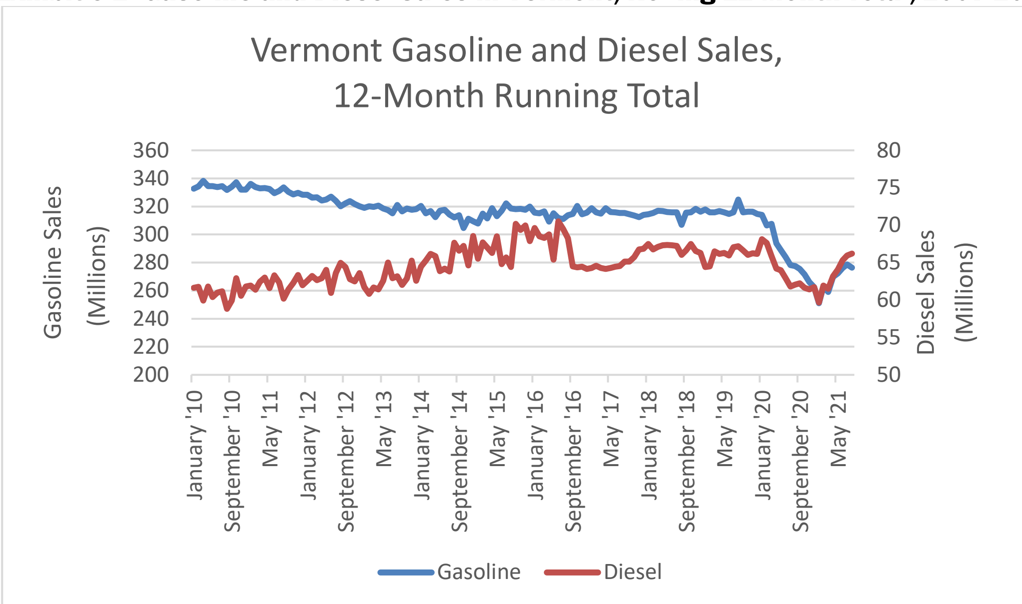
Gasoline sales in Vermont remained stable between 2015 and early 2020, followed by a pandemic-related rapid fall and partial recovery. The general decline in gasoline sales between 2007 and 2015 was primarily

[122] Data for 2019. Source: 2021 Transportation Energy Profile, UVM Transportation Research Center. https://vtrans.vermont.gov/sites/aot/files/planning/documents/planning/2021%20Vermont%20Transportation%20Energy%20Profile.pdf.

[123] Source: US Energy Information Administration (Table C8 for 2019) and PSD estimate. "Diesel" includes an unknown share if biodiesel.

related to improvements in the overall fuel efficiency of light-duty vehicles, as well as a decline in vehicle miles travelled during this period.

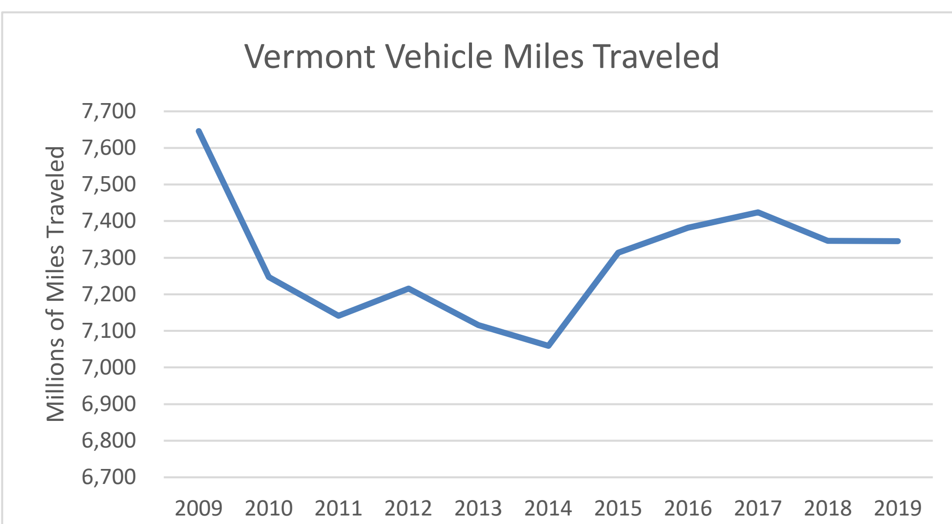
Exhibit 5-2. Gasoline and Diesel Sales in Vermont, Rolling 12-Month Total, 2007-2015



Source: Joint Fiscal Office, 2021

VMT (vehicle miles traveled) is the number of miles traveled within Vermont, and is a common measure of all the usage of cars and trucks on the state's transportation system. After decades of growth and a doubling of the number of cars and trucks on Vermont roadways between 1975 and 2009, VMT rose from 3.3 billion in 1975 to 7.1 billion in 2009, then declined between 2009 and 2014 before stabilizing through 2019.

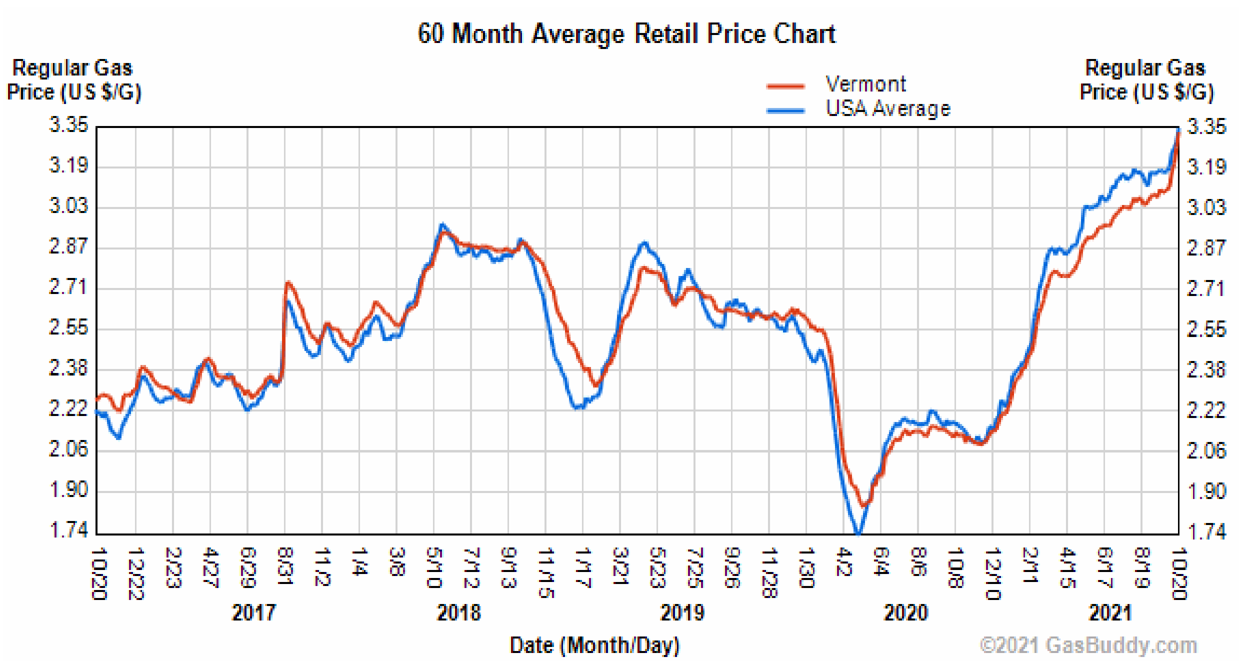
Exhibit 5-3. Vehicle Miles Traveled in Vermont, 2009-2019, in Millions



Source: US DOT, Bureau of Transportation Statistics

Gasoline and diesel prices are volatile over time. Prices fell rapidly in March 2020 in response to the pandemic-related dramatic reductions in travel and global demand for petroleum. Prices stabilized at lower levels by June 2020, before climbing in 2021 as travel resumed. While gasoline prices are unpredictable, the U.S. Energy Information Administration expects they will remain steady in 2022, with average per-gallon prices around $2.74 for gasoline and $3.09 for diesel. The Department of Energy estimates that the average cost of electricity in Vermont is equivalent to a gasoline price of $1.73 per gallon.

Exhibit 5-4. Average Vermont and National Gasoline Prices, October 2017—October 2021[124]



Most Vermont households spend more on transportation energy than on electricity or home heating. Efficiency Vermont's 2019 *Energy Burden Report* estimated that 45% of the average household's energy spending goes toward transportation. Measured as a proportion of total household income, the transportation energy burden is greatest in low-density towns at the fringes of commuting regions. Although Vermont has high rates of car ownership and licensure, this is often out of necessity, and results in a higher cost burden for low-income households without access to more affordable modes of transportation.

Not everyone is able to afford or drive a vehicle. Supporting safe and accessible multimodal infrastructure for all Vermonters ensures that everyone can have access to options that reliably and affordably get them where they need to go. Walking, bicycling, and riding on public transit is more

[124] Source: Gas Buddy LLC, December 2021.

affordable than single-occupancy vehicle ownership, which AAA estimates to cost nearly $10,000 per year.

Households without cars, people with disabilities and impairments, those who are not old enough to drive, and those who would simply enjoy not having to drive face significant challenges in getting around, as alternatives to driving are not available everywhere in Vermont, and do not meet a level of service that provide equitable transportation options. Multimodal centers provide transportation choice, expand opportunity, and deliver on equity in ways that car-only places cannot.

Using lower-cost transportation fuels (such as electricity), improving vehicle efficiency, and reducing vehicle use all address transportation burden by requiring Vermonters to spend less on transportation energy.

5.3 Goals for Transportation Electrification and Renewable Energy

In order to provide a vision to structure pathways, strategies, and recommendations for action, this CEP sets several high-level goals for decreasing transportation energy use and greenhouse gas emissions, and for increasing the use of renewable energy.

The primary target is to **reduce total transportation greenhouse gas emissions by 26% below 2005 levels by 2025, 40% below 1990 levels by 2030, and 80% below 1990 levels by 2050**, consistent with the Climate Action Plan. This can be accomplished through a combination of strategies: improved energy efficiency in vehicle technology; through cleaner vehicles and fuels; supporting the shift toward home-based work and telecommuting; promoting public transit, passenger rail, ridesharing, vanpooling, car sharing, biking, walking, and other transportation options that are less energy-intensive than single occupancy automobiles; and supporting land use and development that reduces daily trips.

To facilitate progress toward reaching the goals set in this CEP, the following interim or parallel targets are enabled by the plan's pathways, strategies, and recommendations for action:

- **Increase renewable energy use.** In the transportation sector, meet at least 10% of energy needs from renewable energy by 2025, and 45% by 2040.

- **Increase the adoption of electric vehicles.** Electric vehicle adoption and promotion is a high-priority strategy for reducing greenhouse gas emissions. Vermont requires that a certain percentage of vehicles delivered to Vermont be electric, but overall has limited control on the availability of makes and models of electric vehicles available to Vermont consumers.

- **Move toward 100% of light-duty vehicle sales in Vermont to be Zero Emission Vehicles by 2035.** Zero Emission Vehicles (ZEVs) include full all-electric and hydrogen fuel cell vehicles. These targets are consistent with the modeling, done for the CEP and the state's Climate Action Plan, that will allow Vermont to reach its GHG requirements. Vermont is dependent on the national vehicle market, and will need to re-evaluate this target regularly to ensure it does not conflict with other principles of the plan. Vermont can increase its influence on the national market by adopting more stringent amendments to California's ZEV standards through Section 177 of the Federal Clean Air Act.

- **Increase the share of renewable energy in transportation** by promoting the adoption of electric vehicles and by increasing the use of other renewable and less carbon-intensive fuels, such as biofuels and renewably sourced compressed natural gas, especially in segments of the transportation sector where electrification is a less feasible or affordable alternative.

While this plan does not specify targets for transportation demand-reducing activities, it continues to **prioritize Transportation Demand Management (TDM), due to its broad benefits across Vermont's energy policy goals**.[125] In addition to supporting the CEP's energy use goals, TDM programs also support its equity and affordability goals. First, TDM can reduce household spending on transportation. Second, providing transportation choices reduces a household's exposure to fuel price volatility. And third, TDM can help manage the impacts on the electric grid of greatly rising numbers of electric vehicles and associated charging needs. Strategically managing the energy consumption of electric vehicles lowers electricity grid costs for all Vermonters.

TDM programs also offer a variety of non-energy benefits. Public transit connects thousands of Vermonters to workplaces and essential services. Reducing vehicle miles traveled lessens the emission of particulate matter from tire and brake wear. Making roads safer for walking and bicycling increases physical activity levels and reduces healthcare costs. Electrifying transportation is critical to achieving the state's greenhouse gas requirements; reducing overall transportation demand is also critical to delivering important energy and non-energy benefits.

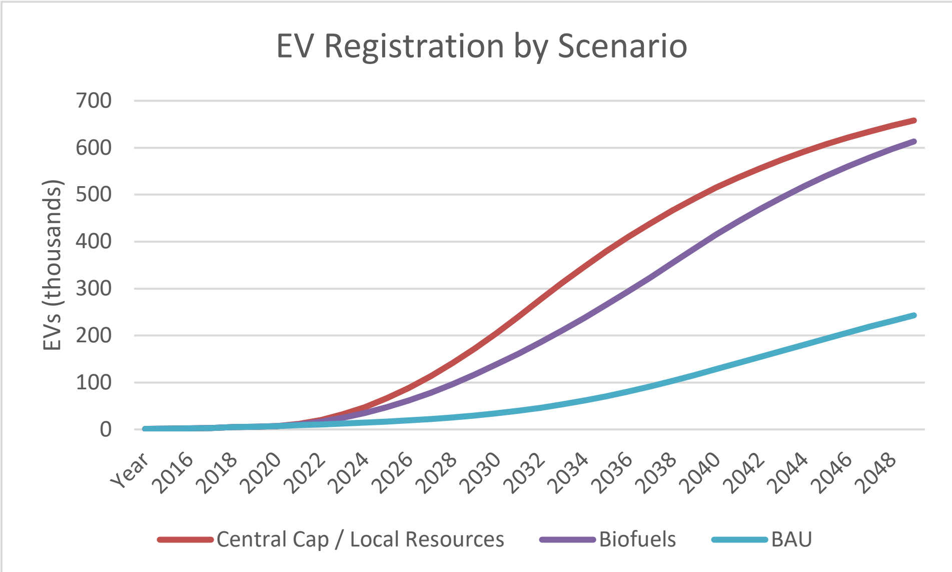
5.4 Transportation Pathway: Vehicle Electrification

To meet its climate goals, Vermont must continue to advance the market share of electric cars and trucks as quickly as possible. A robust policy environment is critical, in particular, for increasing the market share of plug-in electric vehicles (EVs). Rapid vehicle electrification is a policy imperative made achievable by ongoing dramatic advances in electric vehicle technology, especially batteries — and pursuing this strategy can move the transportation sector toward renewability faster than any other single measure.

EVs, combined with Vermont's increasingly renewable power production sector, can drastically reduce energy use and GHG emissions from the transportation sector, as well as other tailpipe pollutants, while requiring only minor changes in consumer behavior. In every mitigation scenario modeled by both the CEP and the CAP (including the business-as-usual scenario), electric vehicles play a primary role in reducing energy consumption while meeting our greenhouse gas reduction requirements.

[125] The 2016 Comprehensive Energy Plan set goals for transportation energy use and included seven objectives for transportation demand management activities. Those objectives proved overly prescriptive, such as targeting a specific number of park-and-ride spaces or transit ridership levels, without evaluating their feasibility or sensitivity to external economic factors.

Exhibit 5-5. Number of Vermont Registered On-Road Electric Vehicles by Modeling Scenario



Vermont requires that a certain percentage of vehicles delivered to Vermont be electric, but overall has limited control on the availability of makes and models of electric vehicles available to Vermont consumers.. VTrans, DEC,and the Department of Public Service should review these targets and revise accordingly based on availability, cost, the pace at which we are meeting our greenhouse gas requirements, equitable distribution of benefits and burdens of energy policy, and other factors that may be appropriate.

Along with GHG reduction, vehicle electrification comes with important co-benefits. EVs will eliminate the water and air pollution caused by tailpipe emissions and by the extraction, refinement, and transportation of fossil fuels. By eliminating expenditures on oil extracted and refined outside Vermont, EVs will allow that money to be recirculated within Vermont's economy. EV drivers report high levels of satisfaction with their vehicles, including quicker acceleration, a smoother and quieter ride, the convenience of charging at home or at work, and lower operation and maintenance costs compared to combustion vehicles.[126]

The major barriers to EV adoption are upfront costs, lack of charging infrastructure, lack of model availability, and lack of consumer and dealer awareness. Range is reduced in cold temperatures. Towing and plowing capabilities are found in only some models. Some home electric panels may require an upgrade for Level 2 charging. Other ongoing challenges in Vermont and elsewhere include the electric utility policy framework around vehicle charging; weights and measures and other consumer protection rules for electric vehicle supply equipment (EVSE); and the unresolved issue of highway user fees for EVs to replace taxes on motor vehicle fuels. EVs have been growing in popularity in Vermont despite these challenges, but there is more to do. The actions recommended in the strategies that follow can power the acceleration of EV uptake in Vermont.

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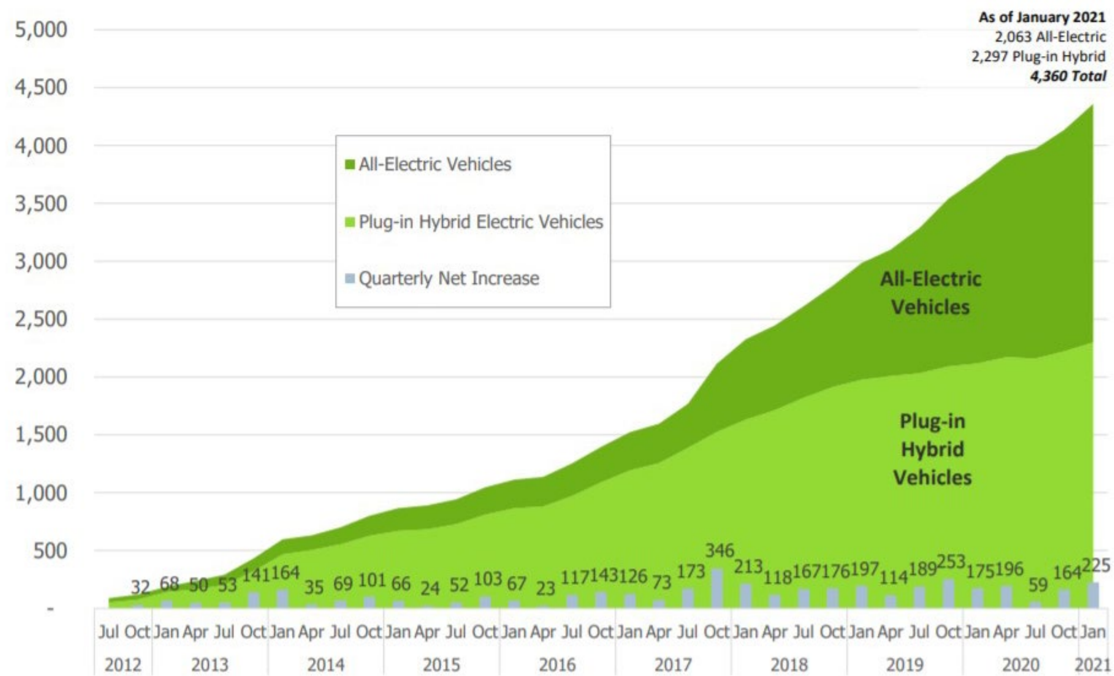
[126] J.D. Power U.S. Electric Vehicle Experience Ownership Study, 21 January 2021, https://www.jdpower.com/business/press-releases/2021-us-electric-vehicle-experience-evx-ownership-study.

Exhibit 5-6. Electric Vehicle Registrations by Vehicle Type, July 2012—January 2021



Source: Drive Electric Vermont[127]

5.4.1 Strategy: Expand Electric Vehicle Market Share Through Incentives

The principal strategy for advancing the vehicle-electrification pathway is electric technology. Electric vehicle technology can power light- and medium-duty cars and trucks, transit and school buses, short-haul aviation, and short-haul marine in the immediate and near terms, and possibly heavy-duty trucking in coming years.[128] The overall objective of vehicle electrification policies is to establish an economic and regulatory environment where market forces can move forward without the need for government support.

Although not widely commercially available at present, in the longer term, renewable hydrogen-electric technology may become a practical or preferred strategy for specific applications by using hydrogen fuel cells to power electric motors. These sectors include heavy-duty trucking, long-haul aviation, maritime shipping, and train transportation. Hydrogen for fuel cells can be generated through a number of processes. Among these, "green hydrogen" is the product of electrolysis powered by renewably-generated electricity. Distributing hydrogen requires transportation via pipeline or tank (in condensed or liquified form), meaning most production occurs near where it is used. In the US, retail hydrogen fueling

[127] https://www.driveelectricvt.com/Media/Default/docs/maps/vt_ev_registration_trends.pdf
[128] Battery electric technology is also currently and increasingly practical for off-road applications, including for example, lawn-care equipment.

stations are limited to California,[129] where three fuel-cell car models are available for sale. Other states host demonstration projects, and a green hydrogen production facility is under construction in Western New York.

Widespread adoption of green hydrogen for transportation purposes is likely to require coordinated regional efforts among multiple states. Recent climate action plans and decarbonization roadmaps from New York, Massachusetts, and Maine suggest those states will focus their hydrogen efforts solely on the difficult-to-electrify vehicle categories mentioned above, and not on light-duty vehicles.

All energy choices have tradeoffs. Electric vehicle batteries rely on the mining of lithium and other metals that may have adverse impact to air and water quality where the resources are extracted and refined. Petroleum production also poses significant pollution risks, at well sites and at refineries where gasoline and diesel are distilled and additives produced. Rare earth metals are used in both electric motors and in internal combustion vehicles. Manufacturers are developing and — in some cases already producing — electric motors without rare earth metals and electric batteries without cobalt. These advances will reduce reliance on certain minerals, and research continues into cost-effective recycling of EV batteries. These concerns will remain priorities for the global EV industry over the next decade, and demonstrate the challenge of comparing EV manufacturing and operation versus that of traditional petroleum-fueled vehicles.

The balance of this chapter will outline the actions necessary to advance vehicle electrification and TDM strategies in Vermont. This chapter will also take up the questions around improving the efficiency of internal combustion vehicles and fuels. As appropriate, this chapter will explain the rationale for certain actions, describe the policy tradeoffs in some decisions, identify the need for additional research, and/or address decision-making priorities. The chapter will conclude with the overarching pathway of finding committed investments in transportation and climate policies and programs that are sufficient to operationalize the actions recommended here.

5.4.1.1 New and Used EV Incentive Programs

Two main types of incentives are available to Vermonters purchasing or leasing an EV. Each distribution utility offers upfront incentives ranging from $250 to $4,000 depending on utility, vehicle type (i.e., all-electric or plug-in hybrid electric vehicle), household income, and whether the vehicle is new or used and owned or leased. These incentives are part of a utility’s energy transformation program, as required by the Renewable Energy Standard’s Tier III requirement to help customers reduce fossil fuel consumption.

In addition to the utility Tier III incentives, state-funded incentives were introduced in the 2019 Transportation Bill. Only new EVs qualify; used vehicles do not. Incentives are available for income-qualified individuals, with greater incentives available for those with lower incomes and for those who purchase or lease full all-electric vehicles (AEVs) rather than plug-in hybrid electric vehicles (PHEVs). An individual with an adjusted gross income (AGI) of $50,000 or less can receive an incentive of $3,000 for a PHEV or $4,000 for a AEV. For an individual with an AGI over $50,000 and up to $100,000, the maximum

[129] US DOE Alternative Fuels Data Center, https://afdc.energy.gov/fuels/hydrogen_locations.html.

incentives for AEVs and PHEVs are $1,500 and $2,500, respectively. Incentives are limited to EVs with a base MSRP of $40,000 or less for the lowest trim line.

Eligible customers may receive their incentives directly from participating car dealers in the form of reduced purchase or lease prices, or they may receive direct cash reimbursements from the state. The program is limited to Vermont residents, and incentives from the point of sale or lease are limited to Vermont dealers. Consumer-direct incentives extend to out-of-state dealers and to vehicles purchased directly from manufacturers. Incentives are limited to one per person per year, as determined by a minimum 12-month lapsed time from a prior state EV incentive.

Accelerating EV uptake requires moving all drivers into the electric versions of the types of vehicles they need or prefer. Although many EVs fall under the current vehicle-eligibility cap of $40,000 base MSRP, many others do not. This presents a particular problem in rural areas of the state where AWD vehicles are a necessity, as many AWD vehicles do not qualify under the current MSRP cap. Even for relatively well-off drivers, purchasing or leasing a new vehicle is a major capital investment, second only to buying a home. Prospective EV purchasers are faced with the fear of the unknown, the risk of technology obsolescence, and the need to change some longstanding driving habits. Higher incentive amounts will help accelerate the EV market, encouraging consumers to purchase EVs sooner than they otherwise might.

In its current form, the incentive program for new EVs includes an equity component by providing enhanced incentives for lower-income Vermonters. Research is needed to determine the optimal amount of the vehicle incentives offered for each income category, the optimal amount of the vehicle-eligibility cap, and the optimal income-eligibility cap. The objective is to maximize EV uptake while minimizing free-ridership (this is when the incentive has no practical effect, because the purchase would have been made without the incentive), and continuing to support equitable distribution of the burdens and benefits of the program. However, limitations on available data and predictive models should not deter modifications of the program's structure. Bringing new EVs to market can also help increase the used EV market, making EVs available to the majority of vehicle purchasers who prefer to buy used.

Whether and to what extent to change the incentive program for new EVs may depend in part on the extent to which the federal government provides PEV incentives going forward. State EV incentives should continue to apply, along with other available incentives from the federal government, electric distribution utilities, energy efficiency utilities, or other actors. Increasing available EV incentives at the state level will require significant additional program funding. In the short term and for low-income customers, ARPA funds can be used to continue providing robust incentives.

Recommendations

- *The Agency of Transportation should lead research to examine the optimal vehicle incentives that should be offered for each income category, the optimal amount of vehicle-eligibility cap, and the optimal income-eligibility cap, given the principles of this CEP.*

- *Continue to support the EV marketplace by continuing and enhancing new and used EV purchase incentives, with a focus on ensuring equitable distribution of the burdens and benefits of such support.*

5.4.1.2 MileageSmart Used High-MPG Incentive Program

Vermont established a used high-MPG vehicle incentive program through the 2019 Transportation Bill. This program, now known as MileageSmart, is run by Capstone Community Action and provides point-of-sale financial assistance to low-income Vermonters to purchase used fuel-efficient vehicles. MileageSmart has been able to direct its incentives exclusively toward AEVs, PHEVs, and conventional hybrid vehicles and will work toward focusing entirely on AEVs and PHEVs as the used market for these vehicles continues to expand. Capstone assists MileageSmart applicants with the application process and provides counseling on purchasing and owning a motor vehicle.

Vermont should fund MileageSmart at levels that meet customer demand, and should set incentives at levels between AEVs and PHEVs that are aimed at achieving the most affordable option for the customer that reduces the most GHGs. As the used EV market develops, it may also be possible to turn MileageSmart into a broader used-EV incentive program that extends to higher income brackets, or to create a separate used EV incentive program for consumers who are not income eligible for MileageSmart.

Recommendations

- *Vermont should fund MileageSmart at levels that meet customer demand. Incentives for AEVs and PHEVs should reflect their contribution toward customer affordability and greenhouse gas reductions, and should aim to help assure equitable participation in EV deployment.*

5.4.1.3 Replace Your Ride and Electric Bicycle Incentive Programs

The 2021 Transportation Bill created new Replace Your Ride and electric bicycle incentive programs. VTrans is in the process of building these programs, and expects to launch them in early 2022. Replace Your Ride encourages owners of older, higher-polluting vehicles to switch to cleaner transportation options. Eligible applicants must either meet the lower-income thresholds of the EV incentive program or meet the eligibility criteria for the MileageSmart program.

Up to $3,000 in incentives will be available to participants who retire a high-polluting vehicle toward a purchase of either a used or new EV, bicycle, electric bicycle, fully electric motorcycle, and/or shared mobility services that reduce the need for vehicle ownership. Incentives through this program may be applied in combination with incentives available through the MileageSmart, new EV, and electric bike incentive programs.

All Vermont residents currently eligible under the incentive program for new EVs will also be eligible on a first-come, first-served basis for a new $200 state incentive toward the purchase of an electric bicycle. Incentives will be available for up to 250 recipients. VTrans is building this program and expects to launch it with Replace Your Ride in early 2022. State incentives may be paired with utility Tier III incentives, which range from $100 to $200.

Vermont should continue to work toward launching and successfully operating the Replace Your Ride and electric bicycle incentive programs, and should ensure that these programs are sufficiently funded to meet the demand.

5.4.1.4 Medium- and Heavy-Duty Vehicle Incentive Programs

Vermont needs not only to electrify the light-duty vehicle fleet; to reach its targets, electrification of at least portions of the medium- and heavy-duty fleet will also be necessary. An all-out effort to modernize the entire fleet with zero-emission vehicles would mean extending vehicle incentives to encompass medium- and heavy-duty vehicles (MHDs), which would include transit buses, school buses, and commercial trucks. In 2020, Vermont joined 15 other states in signing an agreement calling for 100% of all new MHD vehicle sales to be zero-emission vehicles by 2050.

Using Federal Transit Administration grants and Volkswagen settlement funds, Vermont has started to fund electric transit and school bus purchases. The Electric Bus Pilot Program, funded with VW settlement funds, is testing the operation of six electric school buses and two electric transit buses. Additional electric transit buses are being procured with Federal Transit Administration support through the Low or No Vehicle Emissions Program. These pilot programs will help Vermont determine the pace at which it would be practical to replace diesel buses with electric buses, and to provide transit and school bus operators with some practical experience in operating this emerging technology. Transit and school buses typically charge outside peak times, such as at night or midday. VTrans has commissioned a study to determine the technical feasibility and costs of converting Vermont's diesel transit bus fleet to battery electric technology — and, if this is technically feasible and reasonable in cost, to identify a timeline for doing so. Vermont has also used Volkswagen settlement money to fund a limited number of electric heavy-duty commercial vehicles, for example including an electric bucket truck for Green Mountain Power.

Electric transit buses have experienced some operational challenges, especially over Vermont's hilly bus routes. The upfront costs of electric transit buses are still much higher than their combustion counterparts. Lifecycle costs of electric transit buses are approaching parity with combustion technology, due to the lower operation and maintenance costs of the electric versions, but electric transit buses are still more expensive than diesel transit buses on a lifecycle basis. Electric school buses are far more costly than diesel versions; this is because school buses are cheaper than transit buses, making the conversion to electric technology a larger portion of a school bus's overall price. As this technology matures and comes up to scale, both the initial purchase prices and the operation and maintenance costs of electric transit and school buses will likely continue to fall.

Technology is still limited for some heavy-duty battery electric vehicles, such as long-haul trucks. The state should consider incentivizing this technology as it matures, in comparison with other options that may emerge. Incentives for MHDs will require significant program funding, and may need to include funding for dedicated charging infrastructure.

Recommendations

- *Vermont should establish an incentive program for electric MHD vehicles to help move that market, and should consider making this program available to both individuals and commercial enterprises, including farms.*
- *Based on a VTrans study of technical feasibility and costs and the outcome of ANR's Electric School and Transit Bus Pilot Program, determine the viability and cost-effectiveness of converting Vermont's diesel transit bus fleet to electric, and implement recommendations of that study.*

5.4.1.5 State Government Vehicle Fleet

Vermont's transportation bills have set increasingly aggressive targets for electrifying the state government's passenger vehicle fleet. The Department of Buildings and General Services (BGS) is responsible for that fleet, and is committed to meeting the statutory targets. VTrans is responsible for its own medium- and heavy-duty truck fleet, and is planning to replace combustion vehicles with electric vehicles as funding and vehicle technology allows. BGS, VTrans, the Vermont League of Cities and Towns, and Green Mountain Power have launched a work group to collaborate on fleet electrification and to explore the possibility of joint procurement.

BGS owns over 230 buildings, manages 28 electric vehicles, and operates EVSE at 10 locations to serve the state fleet. Separately, VTrans owns or leases over 80 buildings across the state, and has begun planning to build EV-charging infrastructure at these facilities to support its expanding electric vehicle fleet. VTrans envisions that most of its facilities will be supported by Level 2 charging, but that some strategically located facilities will host fast-charging stations to facilitate long trips in fleet EVs or quick fleet EV turnround.

The State of Vermont does not intend to enter the business of vehicle charging, and is focused instead focused on creating a policy environment that will foster a successful private vehicle-charging environment. Nevertheless, state agencies may at times serve as site hosts for charging stations. In addition, the state may wish to make EVSE that it owns or controls for its own fleet available to employees or members of the public. Smart charging stations that would enable the state to recover costs from employees or members of the public will also help the state track utilization of charging stations.

The 2019 Transportation Bill authorizes state agencies to recover EVSE expenses by covering some or all costs, or by charging the retail electricity rate paid by the agency. This authorization sunsets on July 1, 2022, to enable the Legislature to review agency-set EVSE charges and to determine whether changes are needed. The Legislature should continue the state's authorization to recover reasonable costs from users of state charging infrastructure. These charges help keep the taxpayers whole, and prevent the state from undermining the private charging business.

5.4.2 Strategy: Facilitate Increased EV Market Share through Supporting Infrastructure and Policy

5.4.2.1 Continuing Support for Public Electric Vehicle Charging Infrastructure

Electrifying Vermont's entire fleet will require a vast expansion of the state's charging network. Until EVs reach some critical mass, charging infrastructure will continue to require some public support to help accelerate EV market share. Until a sufficient free-market charging network can stand on its own, Vermont should continue to support both Direct Current Fast Charging (DCFC) and Level 2 charging.

Private activity in the EVSE business is increasing, but the EV market is not yet mature enough to leave charging infrastructure entirely to the private sector. Numerous charging companies are doing business in Vermont and elsewhere, but these companies continue to rely on public investments, both state and municipal, for at least some of their business. Tesla has built a network of charging stations across the U.S., including in Vermont; but these stations are not yet accessible to EVs other than Teslas, and are not sufficient to meet all the charging needs of Tesla drivers. Tesla plans to open these stations to other EVs eventually, possibly within the next year or two.

The Department of Housing and Community Development (DHCD) started Vermont's EVSE Grant Program in 2014 with funding from the Department of Environmental Conservation (DEC), investing $200,000 in 15 projects in designated downtowns and village centers. In 2017, the nationwide settlement agreement relating to Volkswagen's use of fraudulent emission-defeat systems provided Vermont with up to $2.8 million in funding to expand its network of EV charging stations for passenger vehicles. Vermont decided to use this entire amount for this purpose. DHCD administers these funds with the DEC, VTrans, Vermont Department of Health, and the Department of Public Service through the EVSE Grant Program.

In 2019, the EVSE Grant Program received 141 applications in two grant rounds, requesting over $4M in funding. Thirty projects were awarded over $1M in funding to install 75 Level 2 and five DCFC units in state-designated centers, highway corridors, public park and rides, major attractions and institutions, multi-family housing, and workplaces.

In 2020, the EVSE Grant Program awarded a contract to Blink Charging to construct and operate 11 highway-corridor DCFC stations at strategically located sites across the state, using $1.7 million in VW funding plus a 20% match. Six of these stations will have 50 kW of power; the remaining five will have 150 kW of power. This third round of funding will ensure that DCFC stations are conveniently available along interstate and other priority highway corridors, such as Interstates 89 and 91, U.S. Route 4, and Vermont Route 100. The EVSE Grant Program sought a single bidder so that less profitable, lower-utilization sites could be paired with the more profitable higher-utilization sites.

Construction of these 11 sites is expected to be completed in 2021. Once the stations are up and running, Vermont will have a fast-charging station within 30 miles of nearly every address in the state, achieving one of VTrans' priority strategic goals. All these charging stations will be future-proofed; they will be able to be upgraded to higher power as EV demand takes hold and batteries become larger.

Charging stations with 350 kW of power are already being constructed by VW subsidiary Electrify America. These superchargers provide up to 20 miles of charge per minute, which means 100 miles in five minutes and 400 miles in 20 minutes, for the few vehicle models that can currently accept that level of power. Electrify America recently opened a 350-kW supercharging station in Lebanon, New Hampshire. In coming years, fast-charging stations will become even more powerful, and will likely enable five-minute stops for electricity refueling, bringing EV charging stations closer to the quick-stop gasoline filling station model. But higher-power charging equipment is more expensive to purchase, requiring operators to balance investment between charging speed, number of locations, and number of chargers at each location. In addition, few current vehicle models are capable of charging at 350 kW.

Through the Transportation Bill, the Legislature appropriated up to $750,000 of state funds for additional grants to support the construction and operation of DCFC across the state through the EVSE Grant Program. The state is in contract negotiations with Norwich Solar Technologies to build and operate six highway-corridor charging stations. Construction will likely be completed in 2022 or 2023.

At this stage, the business case for DCFC stations in Vermont is still not strong, especially at lower utilization sites. Funding from the DCFC backbone, the EVSE Grant Program, is necessary to build consumer confidence in EVs and charging availability, to service out-of-state electric motorists, and to provide publicly available charging options for consumers who may not be able to charge at home or at work. Significant federal funding for fast-charging buildout would most likely need to subsidize the operation of new stations for a period of years, to allow EV market share to increase to a point where it can create sufficient demand to enable a vastly expanded fast-charging network to operate profitably.

Both highway corridor and community charging networks are important for accelerating EV uptake. The 2021 Transportation Bill authorized the EVSE Grant Program to invest up to $1 million in a pilot program for Level 2 charging at affordable multiunit dwellings (MUDs). Focusing support for MUD charging stations on affordable housing will help bring lower-income demographics into the electric vehicle market, ensuring that all Vermonters can enjoy the benefits of vehicle electrification and building broad based buy-in to vehicle electrification policies. Level 2 charging is appropriate where electric motorists plan to leave their cars for many hours, typically where they sleep or work, or at certain travel destinations.

Because the business case continues to be weak, it will also be important for the state to provide financial support for Level 2 workplace charging. First, the availability of workplace charging makes it more likely that a consumer will purchase a EV. Second, there could be an opportunity for vehicle charging to help balance renewable generation located in Vermont with loads, to support grid efficiency. Lodging, destination, and downtown locations could also benefit from additional Level 2 funding. While most EV drivers charge most of the time at home, these early adopters may be more likely than other consumers to live in single, detached homes that can accommodate home charging units. Expanding the network of publicly available DCFC and Level 2 charging will help draw additional demographics to EVs.

While the EVSE Grant Program has made significant headway in building out EVSE, Vermont remains a long way from the number of Level 2 and DCFC units needed to support its transportation electrification goals. Open grant rounds have been oversubscribed. Grant rounds limited to single bidders for limited numbers of fast-charging stations have had to use a triage system, to prioritize the biggest gaps in the fast-charging network. The power levels of the funded fast-charging stations have often been suboptimal (e.g., 50 kW). To the extent that funding is available, Vermont needs to substantially boost its investment in EVSE. This may need to include funding to operate fast-charging stations at unprofitable sites for a period of years, until the market share of EVs increases enough to make these stations profitable.

The 2021 Transportation Bill has established a goal of placing a DCFC within five miles of every interstate interchange, and no farther than 50 miles apart along all Vermont state highways. VTrans leadership sees value in exceeding the statutory goal, and aims to locate DCFC no more than 25 miles apart along state highways. The 2021 Transportation Bill requires VTrans to report back to the Legislature on progress, and VTrans is working with Drive Electric Vermont to develop an EVSE deployment plan with a 10-year build-out horizon.

With the expectation that Vermont will continue to invest state funds in EVSE buildout and the possibility that Vermont will receive significant federal funds for this purpose, VTrans has commissioned VEIC to develop a comprehensive EVSE buildout plan with a ten-year horizon through Drive Electric Vermont. DEV works to increase the market share of EVs through consumer and dealer education and outreach, research, metrics, stakeholder coordination, and technical assistance to agencies, municipalities, utilities, and businesses.

VTrans continues to participate in the Federal Highway Administration's alternative-fuels corridor designation program to help coordinate DCFC investments with Quebec and neighboring states, and to ensure that Vermont can take full advantage of federal funding opportunities, which could be linked to alternative-fuel corridor designations. Through VTrans and DEC, Vermont also engages in regional and cross-border EVSE network planning efforts through the Northeast States for Coordianted Air Use Management and the New England Governors and Eastern Canadian Premiers Transportation Air Quality Committee.

Recommendations

- *Advance the implementation of the EVSE Deployment Plan currently under development by VEIC for VTrans, including public fast charging, workplace charging, and — especially — charging for residents of multi-unit dwellings (such as apartments and condos).*

- *Advance the goal of the Vermont Legislature, as articulated in the Transportation Bill of 2021 (Act 55 of 2021) to have, as much as practicable, a DCFC EVSE charging port available to the public within five miles of every Interstate interchange and every 50 miles along state highways.*

5.4.2.2 Continue to Support Increased EV Model Availability through Zero-Emission Vehicle Memorandum of Understanding

A key barrier to EV adoption in Vermont is model availability. While a broad range of moderately priced EVs are available, many Vermonters prefer driving AWD vehicles, larger vehicles, and vehicles with high ground clearance: pickup trucks, SUVs, and crossovers. The availability of affordable electric versions of these vehicles is especially important in Vermont, where less than half of our public highways are paved and our roads are often hilly, snowy, icy, and/or muddy.

Section 177 of the federal Clean Air Act allows states to adopt California's motor vehicle emission standards, which are stricter than the national standards promulgated by the U.S. EPA. California's Advanced Clean Car program, which has been adopted in Vermont, requires manufacturers to deliver for sale a certain number of ZEVs to California and the Section 177 states, in order to achieve greenhouse gas emissions reductions. These provisions, along with federal corporate average fuel economy (CAFE) standards, put pressure on the automobile industry to make and sell ZEVs.

According to the California Air Resources Board, ZEV technologies include full all-electric (or battery-electric), hydrogen fuel cell, and plug-in hybrid-electric vehicles.[130] These technologies have become increasingly available, due to a variety of factors; both private industry innovation and government intervention are responsible for the increase in ZEVs on the road. Vermont can partake in the resulting benefits by adopting the most recent California standards to continue to increase the rate of EV adoption.

Since 2013, Vermont has been involved in a multi-state effort designed to increase the market share of ZEVs. This group effort aims to put 2.2 million ZEVs on the road by 2025. VTrans funds VEIC to help advance its ZEV goals through Drive Electric Vermont. California's ZEV regulation works by requiring auto manufacturers to deliver, for sale in California and Section 177 states, a certain percentage of ZEVs and PHEVs. Manufacturers receive credits based on the number of AEVs and PHEVs they are able to deliver to participating stages, with vehicles that have a greater range receiving more credits. These credits can be banked for limited use in future years or sold to other manufacturers. The California Air Resources Board predicts that 8% of new vehicle sales in 2025 will be ZEV and plug-in hybrids.[131] For comparison, in Vermont under the same ZEV requirements, ZEVs and plug-in hybrids are estimated to make up 5.4% of new vehicle sales by 2025.[132]

Vermont has had a low-emissions vehicle (LEV) program authorized under Section 177 of the Clean Air Act since 1996, and is one of 14 states that have adopted the ZEV program, alongside neighbors such as Massachusetts and New York. However, the federal Clean Air Act stipulates that for states to adopt more stringent standards than the federal law requires, those standards must be identical to California's. Put simply, there are two options: California's way or the federal government's way. This is to prevent all 50 states from implementing different standards and overburdening auto manufacturers. It also means that as the State of California periodically updates its ZEV regulations, Vermont and other states must adopt amendments to remain in compliance with the Federal Clean Air Act's California Waiver.

As of October 2021, the California Air Resources Board was still collecting public input on the development of the Advanced Clean Cars II regulations (ACC II).[133] In 2022, California is expected to finalize its rule, which seeks "to reduce criteria and greenhouse gas emissions from new light-and

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130 https://ww2.arb.ca.gov/our-work/programs/zero-emission-vehicle-program/about
131 https://ww2.arb.ca.gov/our-work/programs/zero-emission-vehicle-program/about
132 https://dec.vermont.gov/air-quality/mobile-sources/zev
133 https://ww2.arb.ca.gov/our-work/programs/advanced-clean-cars-program/advanced-clean-cars-ii-meetings-workshops

medium-duty vehicles beyond the 2025 model year, and increase the number of ZEVs for sale." To meet Vermont's EV adoption goals, Vermont should undergo the rulemaking process pursuant to ANR's authority and adopt California's Clean Cars II amendments. Ideally, this would begin no later than Model Year 2026, and would include a 100% ZEV sales requirement by 2035. Doing so will increase the market share of EVs available in Vermont, resulting in wider availability of model options, more stringent emissions, and other co-benefits. As proposed, PHEVs could meet a portion of the ZEV requirement if those vehicles meet strict emissions standards and offer suitable electric-only range.

Similar to ACC II, the Advanced Clean Trucks rule requires manufacturers to sell a certain proportion of zero-emissions trucks in the medium- and heavy-duty vehicle categories. The share of zero-emissions trucks sold would increase each year from the time of adoption until 2035, when sales would need to be 40%, 55% or 75% zero-emissions vehicles, depending on vehicle class.

ZEV requirements can be paired with policies that promote the use of biofuels (see the discussion on biofuels below). In this way, biofuels can act as a transitional fuel to help Vermont reduce emissions in the years leading up to 2035. While biofuels are not a long-term solution, they are an emissions-reducing option for the immediate future that is worth considering. If a ZEV requirement by a date certain is implemented, then all other vehicle electrification policies and programs should then be organized around this step. Many of these policies and programs will be able to be discontinued once sales of new combustion vehicles come to an end, if not sooner.

Recommendations

- *This CEP sets a target for 100% of sales of all light-duty vehicles to be Zero Emission Vehicles by 2035.*
- *Vermont should undertake the rulemaking process pursuant to ANR's existing authority and adopt amendments to California's Advanced Clean Cars II and Advanced Clean Trucks regulations.*

5.4.2.3 Continue to Increase Consumer and Dealer Awareness and Support for EVs

Consumer and dealer education and outreach are key elements of an effective vehicle electrification policy. Drive Electric Vermont (DEV) supports a variety of EV stakeholders, including state agencies, electric distribution utilities, automobile dealers, and consumers. DEV maintains a website that provides consumers with information about EVs and EV incentive programs, and it conducts ride-and-drive and other consumer outreach activities. DEV also provides technical support to the state agencies, and assists with implementing Vermont ZEV Action Plans. The state provides significant funding to DEV, and needs to continue to do so to meet its vehicle electrification goals.

In 2020, the Vermont Legislature authorized the state's electric energy efficiency utilities, Efficiency Vermont (EVT) and Burlington Electric Department (BED), to spend a portion of the state's energy efficiency charges on transportation and thermal efficiency programs. EVT and BED have launched comprehensive programs to research and increase consumer and dealer awareness around EVs, and to provide dealers with technical, financial, and promotional assistance to more effectively sell and service EVs. PSD will evaluate the EVT's transportation programs; Vermont can then consider whether these services continue to be needed, and/or whether EEUs should continue to deliver them using electric ratepayer funds. Indeed, once EVs reach a critical mass and market forces can take over (most likely within a regulatory framework), most EV policies and programs can be reconsidered, and funds dedicated to where they provide the most value. ANR should also continue to advocate, through California's regulatory process on Advanced Clean Cars II, for auto manufacturers to be required to support their representative dealers and count compliance with these regulations once vehicles are placed in service, rather than delivered for sale.

5.4.2.4 Price-Transparency Systems for EVSE

Consumer confidence in EVSE pricing is an important component of a multi-pronged strategy for accelerating EV market share. Eventually, the National Institute of Standards and Technology (NIST) will release formal protocols for adoption by the states that will enable the Agency of Agriculture, Food & Markets (AAFM) to develop a comprehensive weights-and-measures program for EVSE in Vermont. The 2019 Transportation Bill gave responsibility for EVSE weights and measures to AAFM, which also handles weights and measures for other matters.

Based on changes the 2019 Transportation Bill made to the law of weights and measures, AAFM has enforcement authority (including injunctions, fines, and imprisonment) to address deceptive practices relating to EVSE prices, even if NIST has not acted. AAFM does not currently have the personnel to develop an interim program, or to stand up a comprehensive weights-and-measures program for EVSE once NIST acts. However, Vermont has automatically adopted the most recent version of NIST's Handbook 130 (Uniform Laws and Regulations in the Areas of Legal Metrology and Fuel Quality). Section 2.34.3 of Handbook 130 covers "Retail Electric Vehicle Supply Equipment (EVSE) Labeling" and is in effect in Vermont now.

Handbook 130 requires the method of sale to be by either megajoule (MJ) or kilowatt-hour (kWh) for the quantity of electricity sold at EVSE. Fixed fees or time fees (based on time it takes to charge) are also permitted in addition to kWh or MJ charges. Pricing, broken down by electricity sold and separately for fixed fees or holdover charges, must be displayed on the EVSE and on any signs or advertisements. In addition, the EVSE and associated signs and advertisements must display the charging power throughout the charging session.

Section 39 of the 2019 Transportation Bill (which amends 30 V.S.A. § 203) authorized the sale of electricity at EVSEs by the kWh. There is no authorization to sell electricity at EVSEs by the MJ. This means that under Handbook 130, EVSE pricing must be displayed by the kWh in Vermont, along with any additional fixed fees, time fees, or holdover charges.

Vermont also has a general requirement for EVSE price transparency on the books. Section 30 of the 2019 Transportation Bill added an expansive definition of "electric vehicle supply equipment available to the public" to 30 V.S.A. § 201. This new definition requires, among other things, that the equipment "disclose all charges for the use of the electric vehicle supply equipment at the point of sale."

The Attorney General's Consumer Assistance Program can use this provision, along with background laws against consumer fraud, to help keep EVSE pricing honest until NIST finishes its work and AAFM can develop a more comprehensive system of weights and measures for EVSE. In some cases, it could be difficult for the AGO to make a case without an organized system of weights and measures. For example, if a consumer complains that the price per kWh is not as advertised, the state may need to test the EVSE with calibrated devices that measure the amount of electricity delivered, to show that the quantity delivered does not match the quantity displayed. Equipment that tests the accuracy of chargers may now be available, but the tests are time-consuming, and AAFM is not budgeted to acquire or deploy this equipment. However, the AGO can help ensure that pricing is properly displayed.

In summary, Vermont has enacted some general requirements for EVSE price transparency, and Vermont has also adopted NIST Handbook 130, which includes some more specific requirements. EVSE pricing in Vermont must state the per kWh charge and describe any fixed fees, time fees, and holdover fees. In addition, this information, along with the power of the charger, must be displayed on the charging unit and on any associated signage. So even as Vermont waits for NIST to release its EVSE protocols so that AAFM can develop a system of weights and measures that will make EVSE legal for trade, the state has a system in place to provide EVSE consumers with some measure of protection.

Possible missing pieces are a EVSE registration system that would enable AAFM to communicate current and future requirements to EVSE providers. In addition, the agencies could make a uniform practice of including current and potential future EVSE price transparency requirements in grant terms and contracts. It may also be possible to require fair pricing information to be included in a statewide portal on EVSE availability.

Eventually, AAFM will do the work for EVSE that it does for fossil-fueling stations. As part of a comprehensive program, and perhaps beforehand, it may be helpful or possible for AAFM to work with EVSE providers on communicating transparent pricing at the charging unit, through any signage and through an online dashboard of current EVSE locations. It may also be helpful or possible for AAFM to build a communications database with EVSE providers (maybe like AAFM's system of communications with gas station owners) to be able to provide notice of forthcoming requirements from NIST, interim requirements that currently apply or that the agencies may be able to develop, and the present and ongoing general requirement of fair pricing. AAFM may need to charge a licensing fee to EVSE providers, to help fund a weights and measures program.

To date, Vermont state agencies have received few complaints about lack of transparency in EVSE pricing. The agencies have received some complaints about the level of charging fees, particularly at DCFC, but not so much about how the fees are displayed or structured. The level of charging fees is not regulated in Vermont, but is appropriately left to market forces. Complaints have also been received about chargers that are out of service. Currently service quality is not regulated; however, public EVSE grants include requirements for maintenance.

NIST is making slow progress, with no estimated date for its adoption of a final EVSE code. Unaddressed needs for an EVSE weights and measures program include these: 1) establish correct and uniform inspection and testing protocols, 2) establish a potential license fee structure, 3) advise owners of appropriate equipment that meets code, 4) enforce the testing and inspection requirements, and 5) maintain uniformity between bordering states.

EVSE licensing fees will depend on the time and complexity of testing EVSE under NIST's protocols. EVSE may not be available to consumers while undergoing testing. It has not been determined whether NIST's protocols will apply retroactively to preexisting EVSE, nor is the definition of what constitutes a public charging station obvious.

Finally, Vermont may want to consider whether charges in addition to per kWh charges and holdover charges should be authorized. As noted, per-kW charges are required by Vermont law. Holdover charges are important to motivate drivers to move their vehicles after their charging sessions are complete, at least for fast chargers and Level 2 chargers in some locations. Charging stations are currently permitted to charge higher rates for customers who do not have membership cards. Arguably, this practice may be acceptable because gasoline filling stations do the same thing. However, some charging stations also charge fees for hooking up to the charger, or fees for the time the vehicle takes to charge. These fixed and fees based on the time it takes to charge can complicate price comparison, and the time it takes a vehicle to charge may depend on the battery size, which can lead to arbitrary pricing. Vermont might consider prohibiting hookup and time fees at EVSE, while continuing to allow holdover fees and membership benefits.

Recommendations

- *Provide staffing to the Agency of Agriculture, Food, & Markets to develop, implement, and enforce the EV charging program by implementing Handbook 130 requirements, and by training staff on the use of meters in preparation for NIST to finalize protocols.*
- *Determine how to manage legacy EV charging infrastructure that does not meet NIST Handbook 130 requirements, including a timeline for compliance or replacement of EVSE equipment.*

5.4.2.5 Continuing to Address the Impact of EVs on the Transportation Fund

The transportation fund in Vermont — as well as in states across the country, and at the federal level — is primarily funded through gasoline- and diesel-tax revenue. As transportation needs evolve and vehicle options expand, this present-day system is becoming outdated and inadequate for maintaining Vermont's transportation infrastructure and services. In its 2019 reports to the Legislature on EVs,[134] the Vermont Public Utility Commission identified the two most significant reasons for the current shortfall of gas tax revenue in Vermont's transportation fund: changes to fuel efficiencies and the effects of inflation. EV adoption currently has a relatively small impact on gas revenue receipts; but absent action, gas tax shortfalls will enlarge as penetration of EVs increase.

[134] https://puc.vermont.gov/press-release/press-release-puc-issues-recommendations-accelerate-electric-vehicle-use-vermont and https://puc.vermont.gov/document/report-vermont-legislature-potential-fees-electric-vehicle-charging.

Increases in vehicle fuel efficiencies have allowed drivers to travel longer distances on a single gallon of fuel while paying the same amount of gas tax — which has resulted in significantly decreased revenue. In attempts to compensate, the tax was changed from a flat tax (per pennies on the gallon) to a combination of fixed and variable rate. Although the per-gallon gas tax does not adjust for the general rate of inflation, it does include price inflation components for both fixed and variable rates.

The fixed per gallon gas tax of 13.1 cents per gallon splits proceeds between four funds: 11.245 cents per gallon to the Transportation Fund, 0.855 cents split between DUI Fund and Fish and Wildlife Fund, and 1 cent per gallon to the Petroleum Clean Up Fund. The variable component of the gas assessment is approximately 4%, and is similar to a special sales tax on the average retail price of gas. This variable is subject to a floor of 13.4 cents and a ceiling of 18 cents per gallon (these apply when gas falls below $3.87 or exceeds $5.08). Due to the increased efficiency of cars on the road, the type of vehicle driven has a significant influence on transportation funding. This predicament mainly applies to revenue generated from light-duty vehicles, as diesel tax is fixed at 29 cents per gallon, with 28 cents going to the Transportation fund and 1 cent to the Petroleum Clean Up Fund.

As the transportation sector continues to electrify, state governments are exploring ways to develop equitable and sustainable financial systems for maintaining their transportation networks while also incentivizing EVs. Although the increase in EVs is not currently a primary causal factor for the current shortfall in transportation funding, any funding solutions that are considered should prioritize EVs in the design, with the understanding that these vehicles will continue to replace combustion vehicles at an accelerating rate.

The decline in motor vehicle fuel taxes presents a significant barrier to EV adoption for at least three reasons. First, legislators' understandable concern about the future of transportation revenues, and the potential effects of increasing numbers of EVs on those revenues, tends to divert attention from other important policy discussions around vehicle electrification. Second, 28 states[135] have established annual flat fees for EVs that are generally based on the average miles driven and the average fuel efficiency of combustion vehicles, and some of these fee structures may deter potential EV purchases.

As with many policy challenges, the states will most likely need to act before the federal government considers a national approach. State policies should be able to easily expand or adapt to a regional or national program. VTrans has retained a consultant to evaluate the feasibility of a hybridized system of roadway user charges and flat fees for drivers who do not want their mileage tracked. Guiding principles established by the Study Advisory Committee for Vermont's evaluation of EV roadway user charges include revenue neutrality, sustained EV adoption, equitableness and fairness, feasibility and efficiency, transparency and accountability, and adaptability for the future.

The consultant is also evaluating the feasibility of a per-kilowatt-hour fee on public EVSE. About 26% of the on-road gasoline and diesel sold in Vermont is purchased by motorists who live out of state.[136] While a flat fee or mileage-based user fee could only be applied only to Vermont EV drivers, a per-kilowatt-

[135] National Conference of State Legislatures 12/1/2020

[136] Agency of Commerce and Community Development estimate for calendar year 2019, based on credit card swipes.

hour fee would apply to out-of-state EV drivers. One challenge to be addressed is to avoid double-charging Vermont-registered EVs that use public charging stations. Any per-kilowatt-hour charges should have the goal of being set at a level low enough to preserve the cost advantages of driving a EV compared to a combustion vehicle, at least until sufficient market share is achieved.

Significant controversy exists over when to institute a system of road user charges in Vermont and whether these charges, when instituted, should be limited to EVs or extend to all motor vehicles. A 2016 VTrans report indicated that any road usage charge on EVs to make up for lost motor vehicle fuels tax revenue should not be required until EVs have reached at least 15% of market share, at which point EVs will have graduated from the early-adopter phase on the adoption-of-innovation-and-technology curve.[137]

5.4.3 Strategy: Managing Electric Grid Impacts of EVs

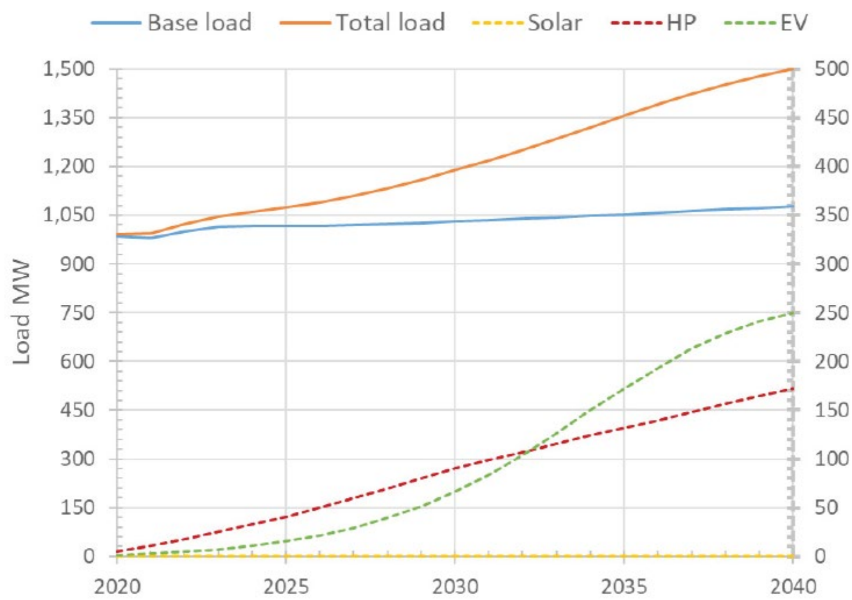
Increasing loads from vehicle electrification, as well as other forms of electrification, will eventually reverse the recent years of declining loads that have resulted from energy efficiency. To the extent that Vermont electric distribution utilities can accommodate increasing off-peak loads from vehicle electrification without significant system upgrades, the result will be downward rate pressure for all customers, as more electricity is sold based on the fixed or moderately increasing costs associated with local upgrades to substations, transformers, and other supporting infrastructure. The Vermont grid may currently have some "headroom" to accommodate the early stages of electrification, but it will be critical to manage loads associated with the electrification of Vermont's vehicle fleet, in order to ensure that objectives of affordability and reliability are achieved. Chapter 4 of this CEP goes into great detail on grid impacts of electrification and the opportunity to optimize operation of the electric grid.

5.4.3.1 Rate Design

Electric vehicle adoption is one of several major technological trends contributing to the evolution of the electric grid. If unmanaged, EV charging could double Vermont's peak load by 2040. However, compared to other existing and emerging loads such as heating electrification, EV charging is more flexible: most consumers can schedule it for the least costly hours of each day.

[137] https://legislature.vermont.gov/assets/Legislative-Reports/2016-Legislative-EV-Study-FINAL-formatted.pdf.

Exhibit 5-7. Projected Vermont Winter Peak Load (with Components), 2020-2040.



Source: VELCO 2021 Long-Range Transmission Plan[138]

Managing home and workplace EV charging through electric rates and direct load controls creates downward cost pressure for all customers, improves grid stability and flexibility, and can reduce energy costs for EV drivers. Failure to incorporate managed charging undermines Vermont's electricity system objectives. Consultants for the PSD's Rate Design Initiative estimated that electrification technologies — including EV charging and heat pump use — could increase 2040 system costs by $500 million per year in the absence of load control programs such as managed charging.[139]

Public fast charging has different characteristics than home and workplace charging. Fast charging using direct current (DC) technology recharges EV batteries in under an hour, compared to the multiple hours used by Level 1 and 2 equipment, and is typically used by travelers in the middle of their journey. While this means that load controls are less applicable, traditional electric rates that separate demand charges are a financial barrier for operators of fast-charging electric vehicle supply equipment. This traditional rate structure discourages station construction and makes fast charging harder to find for the traveling public. Drivers concerned about sufficient fast-charging locations tend to have "range anxiety," and the PUC has noted that a lack of public charging locations is a major barrier to EV adoption in Vermont.

In Act 55 of 2021, the Legislature instituted a requirement that by June 30, 2024, each distribution utility must offer EV rates for public charging and for private charging. Rates are subject to PUC approval, and are evaluated on their ability to adequately compensate EV operators for the value of their grid services

[138] VELCO (2021). 2021 Vermont Long-Range Transmission Plan, page 21. https://www.velco.com/our-work/planning/long-range-plan.

[139] NewGen Strategies & Solutions (August 2020), "Advanced Rate Design Initiative", page 3-1. https://publicservice.vermont.gov/content/rate-design-initiative.

and their benefit to ratepayers overall, among other factors. The policy provides flexibility to distribution utilities regarding how each EV rate is structured.

Three distribution utilities already offer EV-specific rates for at least some customer categories. These rates provide significant discounts to customer who charge during off-peak hours, or agree to suspend charging during unscheduled periods of high electricity costs. Two utilities also allow EV charging operators to avoid paying separate demand charges on public-serving fast chargers, thereby providing more affordable electricity service to the operators of fast-charging locations.

Currently, no policy exists that sets managed charging as a default for EV charging at homes and workplaces. While some utilities have tied mandatory EV rate participation to particular Tier III offerings, that is not universal. State policy should set EV load management as the default option, and require opting out for customers who wish to use standard rates.

Act 55 explains the objectives of EV rate design and directs the PUC to evaluate each proposed rate. Prompt adoption, before or by June 2024, will reduce the missed opportunities of EV charging that is set up without utility management.

Demand charges are one of the largest barriers to expanding Vermont's network of DC fast chargers in many municipal and co-op utility territories. Demand charges reflect the cost to deliver energy to customers during peak periods. Fast-charging EVSE electric load is "spiky" — very high while a vehicle charges, and almost zero when it is empty. However, many utilities assess demand charges on that peak load regardless of whether it occurs during a specific peak hour.

Evidence from currently operating Vermont fast chargers shows minimal coincidence between vehicle charging and peak hours. For example, in early 2021, GMP reported that peak hours (weekdays, 5 to 9 p.m.) represented only 13% of total charging activity at its most-used public fast charger. Further, the charger during those hours featured a load factor of only 4%. (This would mean, for example, that a 50 kW charger averaged just 2 kW of load during those hours.) Allowing public-serving fast chargers to pay a bundled rate for energy and demand reduces financial risk to operators, thus encouraging construction of fast charging locations in underserved parts of Vermont.

Recommendations:

- *Encourage distribution utilities to include utility load management for all new home and workplace EV charging. This is best accomplished by establishing load management as the default for new EVs.*

- *Encourage regional and municipal planning to identify preferred locations for public-serving DC fast chargers, such as downtowns and village centers. The Legislature has established a goal to locate DC fast charging within five miles of every interstate exit, and within 50 miles of another fast charger on the state highway network.*

5.4.3.2 EVSE Demand Charges

Demand charges represent a significant barrier to increasing the number of fast-charging stations in Vermont (and elsewhere). In addition to service charges that defray the costs of equipment and energy charges for the electricity provided, utilities also assess demand charges to cover the costs of making an adequate supply of electricity available when needed. For customers who consistently use a lot of electricity, demand charges represent a small proportion of their total bill, overshadowed by the energy charges. But if a customer uses electricity in sporadic high spikes, the demand charges that compensate the utility for accommodating these spikes may far exceed the energy charges for the total electricity consumed in the billing cycle.

Under prevailing electric utility billing practices, EV fast-charging stations present a worst-case scenario. Fast-charging sessions cause big spikes in electricity load, leading to high demand charges — yet overall utilization of fast-charging stations remains very low, especially in rural areas. At present rates of utilization, reasonable fees for the use of fast-charging stations cannot come close to covering the demand charges. Demand charges present such a serious challenge to the EV charging industry that Electrify America has, at great expense, installed local power production and storage facilities at some of its rural highway corridor stations.

As part of its mission to bring EVs up to scale as rapidly as possible, Vermont needs to find a long-term solution to the problem of high demand charges for fast-charging stations. Green Mountain Power and Vermont Electric Coop, the state's largest electric distribution utilities, have adopted special rates that eliminate demand charges for EVSE in exchange for higher energy charges. While some of Vermont's other distribution utilities in Vermont may be able to follow these examples, doing so may be difficult for smaller utilities. Demand charges represent a significant barrier to bringing EVs up to scale at a pace consistent with Vermont's climate and energy requirements.

Recommendations

- *Encourage distribution utilities to offer appropriate alternatives to standalone demand charges for public-serving fast chargers. Vermont utilities should consider offering rates that relieve fast-charging load from traditional demand charges, provided that the rate covers marginal costs and reasonably protects the system from the burdens of new coincident system peak loads.*

5.5 Transportation Pathway: Cleaner Vehicles and Fuels

Although Vermont and other jurisdictions are working to electrify their transportation systems as quickly as possible, combustion vehicles will be on the road for years to come. Even if all new vehicles are required to be zero-emission, or the global auto industry eventually stops manufacturing combustion vehicles on its own, neither of those events is likely to happen until at least 2030. Heavy-duty combustion vehicles may continue to be produced for some years after the production of new passenger combustion vehicles has ceased. Once the end point for producing a class of combustion vehicles arrives, the last ones to roll off the assembly lines could take well over a decade to reach the ends of their serviceable lives. In view of these realities, continuing to increase the fossil-fuel efficiency of Vermont's fleet, and to advocate for renewable fuels (to the extent that this is cost-effective), can help the state make near-term progress.

More fuel-efficient combustion vehicles and lower carbon-intensity combustion fuels, like biofuels or renewable natural gas, could significantly reduce GHG emissions from combustion vehicles while the transportation sector electrifies. Low-carbon fuels could also potentially provide an alternative to combustion fuels for heavy-duty transportation modes, like long-haul trucking or aviation.

Biofuels can be useful for improving vehicles' emissions impact where electric technologies are not yet readily available, such as in heavy-duty fleets used to transport cargo. They may also provide a good alternative for agricultural, construction, or forestry vehicles, and for rail and marine vehicles using diesel. Their use in these applications can be increased without any new investments in specialized vehicles, equipment, or infrastructure.

This pathway discusses the role that increased efficiency and biofuels can play in meeting our energy and climate needs.

5.5.1 Strategy: Increase Vehicle Fuel Efficiency

Many factors shape the number, type, and relative efficiency of the vehicles registered in Vermont; these include federal and state vehicle emissions and efficiency standards, the diversity and quantity of vehicles available in new and used markets, the price of gasoline or other fossil fuels, consumer preferences, and evolving consumer knowledge about vehicle technologies. Even though the pace of the transformation of vehicle markets is a complex process driven by many factors, many of which are out of Vermont's control, state government and partner organizations can play a role in spurring change.

5.5.1.1 Federal Emissions and Fuel Economy Standards

The U.S. EPA and the National Highway Traffic Safety Administration (NHTSA) jointly regulate vehicle GHG emissions and fuel economy. EPA has established national GHG emissions standards for vehicles under the Clean Air Act, and NHTSA has set Corporate Average Fuel Economy (CAFE) standards under the Energy Policy and Conservation Act, as amended by the Energy Independence and Security Act. CAFE standards set fuel economy requirements for classes of vehicles sold by vehicle manufacturers.

Because states are pre-empted by the federal government from setting their own vehicle fuel economy standards, Vermont has limited options for increasing the average efficiency of vehicles registered in this state. However, Vermont can monitor average fleet efficiency, and can implement non-regulatory strategies that promote the purchase of the most fuel-efficient vehicles available. The state can and should also support increasingly stringent federal fuel efficiency standards.

5.5.1.2 Improving Average Fuel Efficiency in Vermont's Fleet

In the transitional period between when vehicles are electrified and/or using cleaner fuels, strategies to encourage the selection of highly fuel-efficient conventional vehicles, and to encourage more efficient driving habits (such as reducing driving speed, eliminating idling, and keeping vehicles well maintained), could have a dramatic impact on the energy used in daily transportation, and on emissions of GHGs and other air pollutants.

The state gathers data about registrations of electric vehicles, but does not have methods for evaluating the efficiency of Vermont's total light-duty fleet. Developing baseline data and tracking trends over time would enable state agencies and their partners to measure progress toward promoting greater efficiency through consumer choices when buying vehicles, and through greater adoption of practices long known to improve fuel economy. The latter is a set of actions that all Vermonters can take today, contributing to progress in meeting energy and climate goals, reducing air pollution that affects our communities, and saving money.

Financial incentives could spur greater average fuel efficiency. For example, fees charged at the time of registration can be structured so that more efficient vehicles receive an incentive or a rebate, or so that less efficient vehicles receive a higher fee. "Feebates" can be designed to be revenue-neutral, or they can be designed to raise revenue that in turn can be used to provide purchase incentives for plug-in hybrid and all-electric vehicles.

At the direction of the Legislature, VTrans produced a report on options for creating a vehicle feebate program, and presented the report to legislative committees early in the 2020 legislative session. A feebate program would charge a fee to manufacturers or purchasers of inefficient vehicles, and would use those revenues to fund incentives (or rebates) to manufacturers or purchasers of efficient vehicles. VTrans does not support a vehicle feebate program at this time, because the result could pressure consumers into purchasing smaller vehicles. This could be unfair to consumers with large families, and those who need or prefer larger vehicles for their work or AWD vehicles to navigate dirt roads in the winter and spring. The messaging around EVs — and the experience — should be that transitioning to a EV is an improvement, not a sacrifice.

Automakers are now bringing an increasing variety of electric SUVs, pickup trucks, and crossovers to the Vermont market. With an electric answer to every type of combustion passenger vehicle, a feebate program could reduce or eliminate the higher upfront costs of the electric versions and incentivize the switch from combustion to electric. Eventually, electric MHDs will also be widely available.

Implementation of any financial incentive or disincentive would need to be designed to minimize or eliminate financial impacts on Vermonters who are least able to afford alternative technologies that are more expensive than conventional ones.

5.5.2 Strategy: Increase Targeted Use of Low-Carbon Fuels

While electrification for Vermont's light-duty fleet is a viable option, and some heavy-duty freight transportation needs can be met by shifting freight from trucking to rail, there are many heavy- and medium-duty applications for which no electric or rail options are available. In those applications, alternative fuels — including biodiesel, ethanol, compressed or liquefied natural gas, and potentially hydrogen — could offer a lower-carbon alternative to gasoline and diesel, with significant GHG savings and fewer emissions.

Because biodiesel can be blended with diesel and used in existing medium and heavy vehicles, biodiesel in particular offers a unique opportunity to reduce the GHG emissions of Vermont's vehicle fleet without any new investments in specialized vehicles, equipment, or infrastructure. (The section on liquid biofuels in Chapter 6 offers a more detailed discussion of biofuels, including sustainability, commercial availability, price, and appropriate applications.) The use of renewable natural gas in transportation should also be evaluated. Chapter 6 also includes a more detailed discussion of natural gas, including market dynamics and environmental concerns.

5.5.2.1 Biodiesel

Biodiesel, a cleaner-burning renewable fuel, can be used on its own as a fuel or as an additive for any petroleum-based diesel equipment. Biodiesel blends are available in Vermont for some heavy-duty vehicles. Biodiesel can be blended with diesel in different proportions, such as 5%, or "B5." Low-level blends such as B5 are approved for safe operation in any compression-ignition engine designed to be operated in petroleum diesel, including light- and heavy-duty diesel cars, trucks, tractors, boats, and electrical generators. Blends up to B20 are available in the market and must meet prescribed quality standards specified by ASTM D7467. Generally, blends of B20 and below can be used in current engines without modifications, and many original equipment manufacturers approve the use of B20. Users are advised to always consult their vehicle and engine warranty statements before using biodiesel.[140]

The National Biodiesel Board reports that most major engine companies have stated formally that the use of blends up to B20 will not void their parts and workmanship warranties. This includes blends below 20% biodiesel, such as the 2% biodiesel blends that are becoming more common.[141]

In colder climates, special steps are needed to use biodiesel at 20% (B20) blends and higher — specifically, the use of cold-flow additives or fuel heaters. To avoid potential problems with biodiesel blends, B5 is often used in the winter months, with a higher-biodiesel percentage blend used in the summer. Biodiesel's greater lubricity can reduce wear on engines.

Biodiesel has the potential to reduce carbon emissions, with the actual amount calculated using lifecycle assessments for production through combustion. Biomass biodiesel is one of the approved fuels for use under the federal Renewable Fuels Standard (RFS). Approved fuels in the RFS must pass a lifecycle analysis that assesses overall greenhouse gas reduction from a fuel, including each stage of its production and use.[142]

[140] Biodiesel Blends. Alternative Fuels Data Center. US Department of Energy. https://afdc.energy.gov/fuels/biodiesel_blends.html
[141] OEM Information, National Biodiesel Board. https://www.biodiesel.org/using-biodiesel/oem-information
[142] *Overview for Renewable Fuel Standard*. US EPA. https://www.epa.gov/renewable-fuel-standard-program/overview-renewable-fuel-standard

5.5.2.2 Ethanol

Ethanol is ethyl alcohol, which can be blended with gasoline and used in any vehicle that runs on regular gasoline. It is derived from the fermentation of agricultural products — such as corn, sugar, or grains — to convert starches and sugars to ethanol, or from the processing of agricultural wastes, grasses, or wood to convert cellulosic matter into ethanol. In the U.S., most ethanol is derived from corn starches and sugars.

Ethanol can be blended up to 10% with gasoline to form E10, and can be used in any engine that takes regular gasoline. Because ethanol corrodes rubber fuel system parts, specialized adaptations are necessary for blends greater than 10%. Alternatively, consumers can use "flex-fuel" vehicles that are designed to run on higher percentages of ethanol. Ethanol is suitable for use in light-duty transportation applications. According to the VTrans 2021 Transportation Energy Profile,[143] last year approximately 6.1% of the energy consumed in the transportation sector was renewable, consisting mostly of ethanol blended into the gasoline that is purchased by consumers for light duty vehicles. Vermont does not promote the deployment of E-85 flex fuel vehicles or E-85 refueling stations in the state, and significant increases in ethanol consumption in Vermont are only likely to be linked to national market trends — which are not expected.

Advanced cellulosic ethanol is significantly more environmentally sustainable than current ethanol stocks, especially when produced from agricultural waste, and it garners much more valuable credits in the RFS because of its lower amount of lifecycle GHG emissions. It is important to consider the overall amount of energy required to product ethanol including the embedded fossil fuels used to obtain and process the feedstock into a usable fuel.

5.5.2.3 Conventional Natural Gas and Renewable Natural Gas

To be used in transportation applications, natural gas must be compressed to form compressed natural gas (CNG), or liquefied through chilling to form liquified natural gas (LNG). Both these fuels require specialized vehicles and specialized refueling stations. Renewable natural gas (RNG) and conventional natural gas are the same fuel; the difference is that RNG is created by fermenting organic wastes, such as manure, or food-processing byproducts instead of being extracted from geological formations. Fueling infrastructure and vehicles for the two fuels are identical. The lifecycle GHG emissions from RNG can be far lower than conventional natural gas.

Conventional natural gas offers several advantages over diesel fuel for medium- and heavy-duty applications. Especially in some medium- and heavy-duty applications where electrification is not possible, natural gas is preferable to gasoline, diesel, or propane for fueling vehicles, as long as lifecycle GHG emissions for CNG and LNG in medium- and heavy-duty applications are lower than for gasoline and diesel counterparts. Increasingly stringent regulations of tailpipe emissions for new gasoline and diesel vehicles have resulted in newer engines for those vehicles that are nearly on par with natural gas in

[143] Accessible at https://vtrans.vermont.gov/sites/aot/files/planning/documents/planning/2021%20Vermont%20Transportation%20Energy%20Profile.pdf.

emissions of hydrocarbons, oxides of nitrogen (NO_x), carbon monoxide (CO), and carbon dioxide (CO_2).[144]

Taking into account new tailpipe emission regulations, the main advantage of conventional natural gas over gasoline and diesel fuel is cost and price stability. RNG sells for a premium price, and can have lifecycle emissions lower than zero because capturing gas from manure and food waste already reduces emissions in advance of the savings in GHG emissions from the use of fossil fuel. RNG-powered CNG vehicles are also eligible for Federal Renewable Fuel Standard incentives which will offset some or most of the price premium associated with RNG. These incentives may make more fleets consider the conversion to CNG vehicles.

In Vermont, natural gas is still a fledgling transportation fuel; a very small share of the state's natural gas consumption goes to that use. For longer trips, a lack of refueling infrastructure is a limitation on the use of natural gas. Vermont has four CNG stations (one public station in Burlington and three private fleet stations). Natural gas can be trucked or piped, making fueling infrastructure possible anywhere. Vermont Gas Systems provides gas to Swanton, St. Albans, the Route 105 corridor east to Enosburg Falls, Burlington and its suburbs, Vergennes, New Haven, and Middlebury. The service territory includes the most travelled parts of Interstate 89 and US Route 7. Fleet vehicles with regular local or circular routes or vehicles used for local public transportation are prime targets for natural gas deployment. Using CNG in longer routes would require a handful of new stations in Vermont, so that truckers could reach other urban centers which already have CNG fueling (Montreal and Sherbrooke in Quebec; Albany, NY, and New York City; Concord, NH; Worcester and Boston, MA; and the I-91 corridor in Connecticut).[145] Heavy-duty (Class 7/8) CNG trucks can travel between 250 and 400 miles per tank.[146]

Although the use of conventional natural gas in transportation reduces overall emissions compared to petroleum-based products, in the long run moving away from fossil natural gas will continue to be a priority. Renewable natural gas is a low-carbon bridge.

See Chapter 6 for more information on renewable natural gas, both generally and as a fuel for heating buildings and providing industrial process heat.

5.5.2.4 Low-Carbon Fuels Programs

Effective utilization of alternative fuels in transportation, particularly as a transition fuel for heavy-duty and some medium-duty vehicles, will require strong state and regional markets. There are a number of actions that Vermont can take to stimulate the adoption of alternative fuels. The 2016 Comprehensive Energy Plan placed significant weight on biofuels as a pathway to renewable transportation. Since that

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[144] Alternative Fuel Data Center, U.S. DOE, Natural Gas Vehicle Emissions, www.afdc.energy.gov/vehicles/natural_gas_emissions.html

[145] Alternative Fuels Data Center: Alternative Fueling Station Locator (energy.gov)

[146] 9562-114sd_brochure-2019-04-04-1.pdf (azureedge.net) (400 miles).
Case Study - Natural Gas Regional Transport Trucks (energy.gov) page 5: 275-325 for CNG, 550-650 for a larger truck using LNG.

time, Vermont has enacted no policy toward instituting a low-carbon fuels standard or otherwise accelerating biofuel use, beyond what is happening at the regional or national level.

The market for biofuels is a national and international commodity market, driven to a great extent by the federal Renewable Fuel Standard (RFS) and other policies such as the California Low Carbon Fuel Standard.[147] The RFS includes biodiesel, ethanol, RNG and other categories of biofuel, and requires that renewable fuels emit less GHGs than fossil fuels. The EPA adjusts the requirements periodically to reflect market conditions.[148] A federal $1 per gallon tax credit for biodiesel blending also provides a strong incentive for biodiesel production. It has been subject to several cycles of expiration and renewal since 2011. A stable, long-term federal tax credit would provide greater certainty to producers. The credit was reinstated once again in December 2019 through 2022.[149]

The annually increasing national requirements in the Renewable Fuel Standard have stimulated investment in supply and delivery infrastructure for biofuels. Future growth in the Renewable Fuel Standard targets cellulosic ethanol, biodiesel, and other advanced fuels, including fuel derived from algae.

California and Oregon have instituted low-carbon fuel standards; other states, like Minnesota, have directly mandated biofuel blends for diesel engines.[150] To adopt such policies, Vermont would have to verify lifecycle reductions in GHG emissions, including emissions from growing crops; these verifications would require the best available tools, such as EPA's lifecycle analysis for the RFS[151] and Argonne National Laboratory's GREET model[152], both of which include the GHG impact of growing feedstock[153] — including, for example, cultivating new land (or not). Vermont could either stand up an independent low-carbon fuels standard or biofuels mandate for transportation, or coordinate with other jurisdictions. Meanwhile, state agencies contributed to the development of the Transportation and Climate Initiative (TCI) regional cap-and-invest program for transportation fuels, which has no lifecycle GHG standard and could operate in parallel with a low-carbon fuels standard or a biodiesel mandate (see Section 5.5.2.4). Finally, it should be noted that a biofuels standard or mandate would need to consider the implications of demand across energy sectors, where biofuels may also be considered as a pathway in the buildings sectors (See Section 6.4.2.5).

At this time, Vermont should continue to pursue strategies and actions to support application of biofuels, particularly in the heavy-duty transportation sector. However, until TCI and building sector pathways

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[147] Low Carbon Fuel Standard, California Air Resources Board, LCFS Basics with Notes (ca.gov)
[148] For information on the RFS, see the EPA's Renewable Fuel Standard Program website, www.epa.gov/renewable-fuel-standard-program
[149] U.S. biomass-based diesel tax credit renewed through 2022 in government spending bill. January 28, 2020. U.S. Energy Information Administration (www.eia.gov/todayinenergy/detail.php?id=42616).
[150] Biomass-based biodiesel is used for transportation in the state as covered in this section, and also for heating purposes as covered in the Heating chapter of the CEP.
[151] Lifecycle Analysis of Greenhouse Gas Emissions under the Renewable Fuel Standard | US EPA
[152] Argonne GREET Model (anl.gov)
[153] Argonne GREET Publication : Life Cycle Analysis (LCA) of Biofuels and Land Use Change with the GREET® Model (anl.gov)

and strategies are further examined and either enacted or ruled out, Vermont should not prioritize a low-carbon fuel standard or other broad-based biofuels requirement for the transport sector.

With adequate agency time, including time to engage stakeholders, Vermont can develop relatively detailed policy proposals for a low-carbon fuel standard, and for a renewable transportation fuels standard (akin to our renewable electricity standard), while continuing to pursue TCI if and when regional market viability exists. The three types of policies could be designed to be compatible — or at least "no regrets" — in case federal or regional policies change significantly.

5.6 Funding Transportation Climate Mitigation

As part of a plan to identify measurable pathways to its climate and energy goals, Vermont must determine what these pathways will cost and where the funding will come from. The annual investments needed to reach Vermont's climate goals will be significant. There is an opportunity to use American Rescue Plan Act (ARPA) funding to equitably address climate issues in the near term, but transforming markets will require sustainable funding sources, particularly those that leverage private capital.

Through the Transportation and Climate Initiative, Vermont has worked closely with neighboring jurisdictions on the design of a regional cap-and-invest program for transportation fuels. This program, called TCI-P, would require the owners of on-road motor vehicle fuels, delivered across terminal racks or transported into a TCI jurisdiction for sale, to purchase allowances based on the carbon dioxide these fuels would emit when combusted. The number of allowances available to be purchased toward compliance is capped, which results in a guaranteed declining cap on total emissions from the transportation sector. Modest increases in fuel prices, starting at a few cents per gallon, would lead to billions of dollars of annual revenues for the TCI region, with an estimated $20 million per year coming to Vermont at the outset.

Modeling indicates that investing these revenues in carbon reduction strategies, including vehicle electrification, would moderately improve economies over a ten-year period and significantly benefit public health. Reducing carbon emissions from the Northeast and Mid-Atlantic transportation sectors will also help mitigate the impacts of climate change over the long term. Targeted investments of allowance auction proceeds could help mitigate the impacts of slightly higher gas and diesel prices on low-income and rural populations, and could address the unique impacts of carbon pollution on certain demographics.

Thirteen jurisdictions spread across the Northeast and Mid-Atlantic worked together to develop TCI-P. If a critical mass of the 13 were to participate, the cap and the investments could together significantly accelerate the movement away from combustion to electric engines by the car and truck industry, at the same time supporting TDM strategies and advancing low-carbon fuels.

The viability of TCI-P and the program timeline for regional action remain uncertain. Although Vermont continues to support program development, like most other states, it has not committed to participate in TCI-P. If Vermont chooses not to participate in TCI-P, the state could still participate in other TCI programs, like the Clean Vehicles and Fuels Workgroup. In determining whether or not it is in the state's interest to participate, it will be critical to understand the full scope of impacts associated with TCI, including the impacts of upfront costs associated with participation, and how any revenue generated would be equitably distributed into programs that aim to reduce energy use and carbon emissions from the transportation sector. Understanding the breadth of the program — how many states are participating — will also be critical to understanding the costs and benefits of such a commitment. As it determines whether TCI-P is appropriate, Vermont should continue to work on the design and to understand the impacts.

Recommendations

- *Continue to work with other jurisdictions on implementing the TCI-P cap-and-invest program for transportation fuels. Once a viable regional market exists, consider participating in TCI-P, with viability based on a clear evaluation of the societal, Vermont-specific, and customer benefits and costs of TCI-P and the uses of potential revenue from the program.*

5.7 Transportation Pathway: Support Land Use Patterns that Increase Transportation System Efficiency

Vermont's longstanding land use goal is to plan development that maintains the historic settlement pattern of compact village and urban centers separated by rural countryside (24 V.S.A. Chapter 117). Compact and mixed-use development patterns reduce transportation energy use by reducing the distance between daily travel destinations, and by increasing the viability of healthier, more sustainable travel options, such as walking, biking, carpooling, and transit services. What we build and where we build it is a foundational building block of our transportation and energy systems.

The choices available to Vermonters about where they live, work, go to school, shop, and recreate affects both their transportation needs and the energy delivery and infrastructure system that is built to meet those needs. In turn, the transportation system, specifically the transportation options available to and used by Vermonters, also affects the amount, the type, and the cost of energy needed to move across the landscape, and contributes to the state's total VMT, transportation energy use, and air pollutants, including GHG emissions. To achieve greater transportation system efficiency that reduces the environmental, health, and cost impacts of getting people where they need to go, land use and transportation planning must be integrated.

Today's land use patterns, built environment, and supporting infrastructure are the result of decisions made decades, even centuries ago. For example, in large part because of land use and infrastructure decisions made 50 or more years ago, Vermonters spend many hours driving to work or to meet their daily needs, because alternative means of doing so are unsafe, inconvenient, or even impossible. In the same way, the decisions we make today will be long-lived and will define many aspects of our daily lives in the future — such as how comfortable we are in our homes, how healthy we are, what options we have to easily move around to different places, and how resilient we are to disruptions.

It takes generations to realize the benefits of the changes we make in our land use decisions today, and to see the cumulative impacts of those changes. However, the decisions we make today about land use are critical, and present an opportunity to avoid locking ourselves into a future that at best does not support our goals, and at worst exacerbates the equity, affordability, and environmental challenges we are trying to meet.

Vermont is often described as a rural state because few areas here have more than 500 people per square mile, and therefore do not meet the U.S. Census definition of urban. But the Census definitions, which define rural as the default for any area that is not urban, do not reflect Vermont's historic settlement pattern of compact village and urban centers surrounded by countryside. Much of Vermont's population lives or works in its core communities. The 23 municipalities that each host one of Vermont's designated downtowns account for more than 30% of the state's population.

In support of Vermont's land use goal of maintaining the pattern of compact settlements separated by rural countryside, the state has designation programs for village centers, downtowns, and new town centers. Add-on designations for neighborhood development and growth centers convey additional benefits for targeted growth.[154] These designation programs help communities of all sizes plan for development in a way that meets the state's land use goal while addressing local issues such as restoring community vitality, expanding economic development opportunities, financing infrastructure improvements, building complete streets, and creating more housing opportunities near work or transit. Many municipalities have maximized the benefits of these programs by layering multiple state designations. Planning the state's energy future thus depends on local and regional planning entities planning for development within a land use pattern that is compact, mixed-use, and therefore sustainable.

The designation program also gives participating communities priority consideration in competitive grant opportunities. Across the state, this has successfully channeled public and private resources into restoring historic buildings, creating safe and pleasant pedestrian streets, reviving commercial districts, planning for thoughtful growth, and building new housing. Communities have used the programs to reverse declines in their grand list, get the most from their substantial public investments in infrastructure like roads, sidewalks, and wastewater treatment, and create places where businesses can thrive and families can live close to jobs, schools, shops, and transportation options. Yet despite these successes, an estimated 78% of residential structures built between 2005 and 2014 were built outside of areas identified as "community centers" by Regional Planning Commissions.

Compact settlement is critical to reaching our long-term goals, but it alone will not sufficiently increase the efficiency of the transportation system. Studies have revealed that the biggest determinants in whether people decide to walk or bike, instead of using an automobile, are design, density, destination accessibility, diversity of uses, access to transit, and availability of free parking[155]. Lowering vehicle miles traveled by getting people out of their automobiles requires investment in careful planning and design that accounts for all these factors.

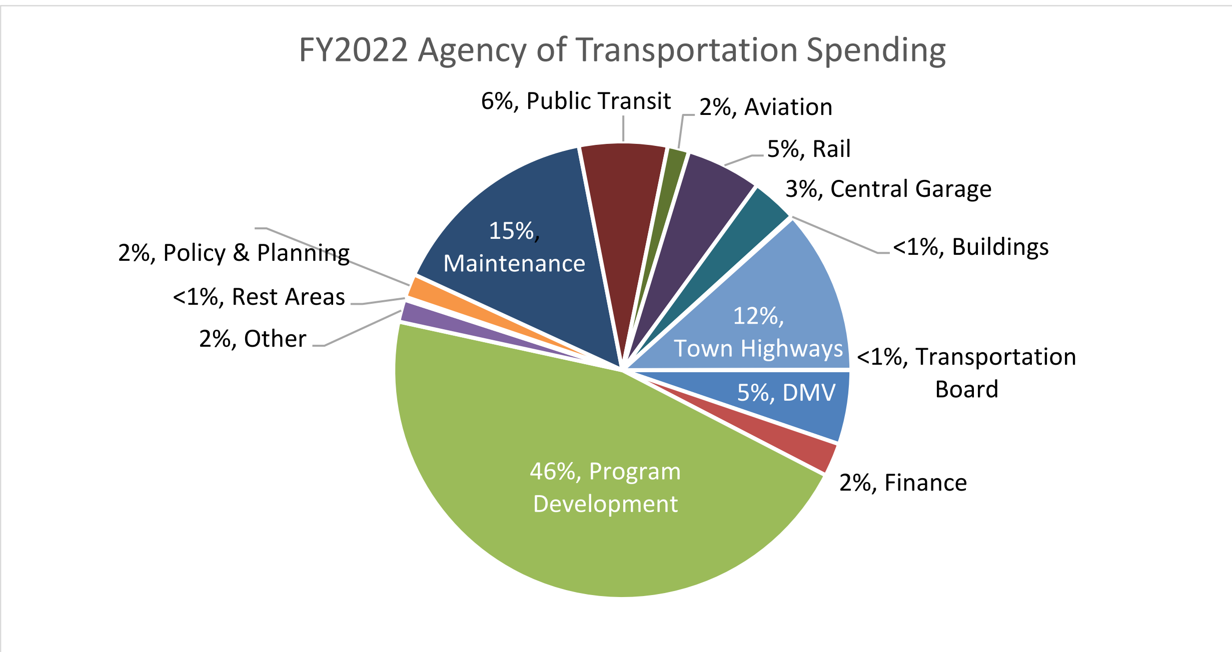
[154] 24 V.S.A. §4302

[155] Julie Campoli, Made for Walking: Density and Urban Form (Lincoln Institute of Land Policy, Cambridge, Mass., 2012), www.lincolninst.edu/pubs/2150_Made-for-Walking

Such careful planning will require a shift in the way transportation is planned, funded, and used — from being an issue of physical infrastructure, dominated by accommodating automobiles and freight on roads and bridges, to becoming an energy-efficient and sustainable system that provides mobility options for all and serves drivers as well as passengers, pedestrians, and cyclists.

State transportation priorities to reduce vehicle miles traveled include significant investments in transit, rail, bike-ped networks, and transportation demand management. On a per capita basis, Vermont invests more in public transit than any rural state in the U.S. The VTrans program *Go! Vermont* has been nationally recognized for enhancing transportation connections for travelers in Vermont using technology-based solutions. The 2022 Capital Budget of the Vermont Agency of Transportation (VTrans) outlines the agency's investment profile.

Exhibit 5-8. VTrans Budget by Program Area, Fiscal Year 2022



Source: VTrans FY2022 Capital Program. ("Program Development" primarily involves state roadway projects, such as paving and bridge construction, with around 5% of those funds for bicycle and pedestrian facilities.)

Transit, passenger rail, walking, biking, car sharing, and ridesharing — all less energy-intensive than single occupancy vehicles — are a state priority. This is reflected in VTrans's strategic vision: *A safe, reliable and multimodal transportation system that grows the economy, is affordable to use and operate and serves vulnerable populations.* The strategies outlined to advance along this pathway include integrating land use into decision-making criteria and increasing consumer choices.

5.7.1 Strategy: Integration of Land Use Planning into Transportation Decision-Making Frameworks

5.7.1.1 Aligning Planning Across Government

Vermont has worked hard to support land use decisions that can meet multiple state goals, including revitalizing communities, increasing affordable housing and transportation options available to Vermonters, reducing energy consumption, and protecting important natural resources. The decisions we make around land use can either enable or impede our energy goals. Better land use outcomes come from a common framework for evaluating and balancing land use-related goals for public infrastructure, energy supply, housing, transportation, working lands for agriculture and forestry, conservation lands, and other purposes. Disjointed, siloed and uncompromising approaches to land use decisions can make it more challenging and costly to work toward our energy and climate goals, and can result in inefficient and wasteful use of Vermont’s land resources.

Land use planning in Vermont involves a variety of actors with diverse expertise, interest, and authority. The engagement of different actors in land use decisions also changes depending on the scale, location, or type of land use being considered, leading to disparate outcomes. While land use planning can often serve complementary objectives, tensions between competing land uses inevitably arise. For example, Title 24 Chapter 117 calls for compact development in historic settlements, which relieves development pressure on natural and working lands and revitalizes and retains the character of Vermont’s historic settlement pattern. But settlements often grew up along river corridors, raising concerns today that focusing new development in these areas, to advance compact settlement patterns, will further compromise river resources.

The tension between the goals of encouraging growth in compact historic centers and protecting natural resources requires objective information that can facilitate negotiation and consensus-building, so that land use decisions can achieve the greatest possible outcome for multiple, sometimes competing objectives. How the state’s goal of planning development that maintains the pattern of compact village and urban centers, separated by rural countryside, is incorporated into the many decisions that impact where land use activity occurs lacks coordination — and its application is inconsistent across jurisdictions and decision makers, leading to land use outcomes that do not advance the goal.

Various attempts have been made over the years to address the lack of alignment of land use planning, with varying levels of success. In 1988 the Legislature passed Act 200, the Growth Management Act, to create a common set of planning guidelines for all levels of planning, and as a complement to Act 250. The Agency of Commerce & Community Development wrote a report in 2003 analyzing reasons for the ultimate failure of the parts of Act 200 that were designed to foster both coordinated planning among state agencies and vertical integration of state, regional, and local planning. In the end, the complexity involved in this type of multi-dimensional planning proved too insurmountable a challenge. But today’s realities of climate change, habitat loss, and sprawl in Vermont warrant revisiting the concept of a comprehensive and coordinated land-use planning system that will do a better job than the state’s current land use policies of fostering and facilitating economic development, and protecting longstanding environmental values.

The lack of quantitative and Vermont-specific data that demonstrate the value and tradeoffs of different land use decisions, particularly of compact development over dispersed land use patterns, presents a challenge to making sound land use decisions that are coordinated to advance state goals. The impacts of land-use decisions are often slow to accumulate and can be indirect, making them difficult to measure and attribute to specific land-use decisions over time. Research and data on land use in other states and jurisdictions can be difficult to scale to Vermont with enough confidence to support decision making, as the rural nature of this state is assumed to have a significant impact on the outcomes of different land use decisions.

The lack of data further complicates alignment between state, regional, and local land use planning and regulation. Without objective information on the impacts of land use decisions, it is difficult to build consensus and engage stakeholders in coordinated planning and implementation. In addition to collective knowledge and data on the tradeoffs of land use decisions, there is also a lack of human resources and capacity to lead a diverse group of stakeholders in collaboration, consensus building and coordination around land use decisions in a way that achieves greatest possible outcomes across multiple goals and objectives. Data and analysis on the impacts that various land use decisions could have in relation to key goals (energy use reductions, emissions reductions, energy reliability and affordability, economic development, equity, community resilience, forest conservation, agricultural preservation, etc.) is a necessary foundation for a more transparent, collaborative, and coordinated process for making land use decisions.

Recommendations:

- *With consultant support, ACCD — working in partnership with the Agency of Transportation and in collaboration with the Department of Public Service, the Agency of Natural Resources, regional planning commissions, and other agencies with a significant interest in and authority over land use policy — should develop and execute a shared research agenda to build collective knowledge and understanding about the impact that land use decisions can have on achieving state goals. These impacts should be broadly defined, to include Vermont-specific land use decisions that both directly impact and indirectly enable the achievement of state goals for energy, climate, transportation, economic development, and land use. The research agenda should support the development of a land use decision-making framework that supports consensus building. It should also seek to better understand and inform improvements in the programmatic and regulatory structures that currently govern land use, including at the regional and municipal levels.*

5.7.1.2 Multimodal, Compact Development

Supporting multimodal transportation infrastructure can reduce energy demand by creating safer, more enjoyable, more affordable, and more energy-efficient ways of getting to different destinations, both within and between compact, mixed-use centers. Expanded and improved multimodal infrastructure, such as sidewalks, crosswalks, bus routes, bus shelters, shared transportation hubs, and bicycle lanes, can attract new users and encourage a shift from trips made by single occupancy vehicles to healthier and more efficient modes of travel — thereby making the most sustainable choice also a preferred choice.

Supporting multimodal transportation infrastructure can reduce the need for space and land dedicated to cars, particularly for parking cars, freeing up space for other uses, including renewable energy infrastructure. Supporting people's ability to shift the ways they get around in favor of more trips made by walking, biking, and transit delivers a public benefit, not only for achieving Vermont's energy goals, but also for achieving other well-documented climate, public health, equity, and economic goals.

Shifting just one daily trip from driving to walking, biking and transit within and among Vermont's compact centers would incrementally reduce energy demand and emissions. This shift is far easier to make when daily destinations are closer together, making common trips shorter. Shifting from driving for short and medium trips is also made easier with electrified micro-mobility options, such as e-bicycles, which provide an energy boost that extend the range of trip lengths people are willing to take using micro-mobility.

An increasing amount of place-based research finds that mode shifts and energy savings can be achieved through policy action; but current policies, subsidies, and conditions do not make choosing the most sustainable forms of transportation a practical or safe choice, even within many of Vermont's compact, mixed-use centers with convenient daily destinations. For example, research in Massachusetts on the impacts of shared-use pathways confirmed that most people (88%) feel uncomfortable interacting with motor vehicle traffic while biking. Similar findings are repeated in the City of Montpelier's Complete Streets Design Guidelines of 2018, citing studies where protected cycling lanes lead to higher rates of cycling and greater feelings of safety among cyclists and drivers alike. Smart infrastructure investments in the right locations support smart transportation choices.

Compact and mixed-use development, which reduces the distance between the places people need to get to and from, is not enough to encourage mode shift. To achieve mode shift, transformative investments are needed that make walking and biking more comfortable, convenient, and safe within and among compact centers. Vermont must focus planning, design, and investment on connected, multimodal transportation and transit centers to make sustainable transportation a preferred choice.

Without changes to Vermont's land use planning and targeted actions toward mode shift reduction, the likely outcome is continued or increased use of single-occupancy vehicles, new dispersed car-dependent development among working farms and forestlands, higher healthcare costs, comparatively higher transportation costs, and economic opportunity costs given the high economic productivity of multimodal places.

According to Sustainable Transportation Vermont, 87% of trips are currently made by motor vehicle in Vermont, and 67% of those trips are under two miles in length. Additionally, 89% of Vermonters sometimes walk to destinations, 45% bicycle, and 30% of Vermonters live in one of the 23 communities with a designated downtown. This presents a significant opportunity for shifting mode share through improved multimodal infrastructure.

Vermont state agencies and organizations are already making significant efforts to shift travel mode share toward more active transportation across the state. These efforts include funding and investment for multi-use pathways like the Lamoille Valley Rail Trail; completing a statewide bicycle and pedestrian plan that evaluates users' levels of comfort; funding grants for integrated land use and multimodal transportation planning through the Better Connections Grant program; and providing subsidies for electric bicycle ownership.[156]

These efforts are making a difference — and they can be improved and leveraged to increase mode shift through improved place-based investment targeting, coordination, and planning. However, the lack of a coordinated platform to strategically align the investments of state, regional, municipal, and transit provider authorities in support of multimodal community centers impedes Vermont's ability to go "all-in" on transformative improvements that could make sustainable transportation a preferred choice for more trips.

To achieve quantifiable results in mode shift and energy savings, improvements to multimodal infrastructure must be connected, convenient, and comfortable. This is difficult to achieve incrementally. Progress is being made in slow and steady ways by municipalities, despite funding limitations and regulatory constraints — such as today's lack of a phased funding structure that aligns planning, designs, and construction to transform a system and meaningfully shift transportation preferences. The potential impact from Vermont's current funding is also diluted by a preference for small projects distributed over wide geographies, which limits both overall efficiency and the ability to measure the energy-saving impacts of investments.

There is also a lack of capacity to collaborate, coordinate, and lead a diverse group of stakeholders in building consensus and alignment to plan for and invest in multimodal transportation corridors and districts. An "All-In for Active Transportation and Transit Innovation Districts" program would establish an infrastructure improvement planning, design, and construction pipeline, with opportunities to streamline regulatory approvals, and wrap-around consumer education and incentives to encourage use of new multimodal infrastructure. A successful all-in program could increase the share of trips made by walking, bicycling, and public transit, resulting in reduced VMT, energy use, and emissions.

5.7.1.3 State Smart Growth Designation Programs

Since the 1970s, the state has promoted development policies and programs intended to enhance Vermont's historic development pattern of compact centers connected by rural lands. The five current state designation programs — for downtowns, village centers, neighborhoods, new town centers, and growth centers — provide a key platform for implementing land-use planning in places where state, regional, and local actors mostly agree on the location and type of development. The five programs support the state's land use goal by providing financial incentives, aligning regulations, and giving communities the technical assistance needed to encourage new development and redevelopment in our compact, walkable centers.

[156] See Act 55 (2021), secs. 27 and 28.

The designation programs were created at different times for different purposes, and they support compact development by addressing a variety of concerns, from vacant and underused buildings within a downtown and village center to housing and to planning and managing future growth. The results of these efforts are mixed. While the designation programs have successfully channeled reinvestment and revitalization in support of the traditional settlement pattern, residential growth has continued to occur outside of designated centers, and parcel data shows an increase in the number of smaller area lots, suggesting a trend toward less compact development.

Vermont's smart growth and land use policies can be improved to overcome barriers and direct more growth toward state designated centers, as a strategy for reducing energy and emissions and helping our communities become more resilient to climate change. But it will not be easy. Land use planning in Vermont includes a diverse set of actors with different expertise, interest, and authority, and there is limited alignment between state, regional, and local land use planning and regulation.

The cost and complexity of developing within centers can be a disincentive when compared to developing in rural areas where land and permitting costs are less. When evaluating the cost and affordability of housing, total household costs — including those to heat and cool a home, and those for transportation for work, school, and basic amenities — are not commonly used to compare the true total costs of different housing options.

Even though many Vermont residents and municipalities express a desire to increase housing in compact, walkable centers, insufficient funding to upgrade infrastructure is also a barrier to support this growth. Drinking water and wastewater systems are especially critical for the building of new housing in existing downtowns and village centers. Finally, many municipalities lack the local and regional staff with planning expertise needed to develop and implement local plans that would support compact development in their communities, and there is limited political support to invest in professional local and regional planning staff.

Reforming the state's designation program to better align goals and activities around land use and identify more places where agreement can be reached around land use decisions can have a significant impact on reaching many of the state's goals. In particular, there is opportunity to reform the designation programs so that they better align with and support the Comprehensive Energy Plan and the Climate Action Plan. This could help to prioritize public investment for land use policies that directly and indirectly reduce energy use and emissions. It could also increase the resiliency of built and natural landscapes to climate change impacts, and reduce both municipal and household costs related to energy and transportation.

It should be noted that the state's housing crisis presents both challenges and opportunities related to reforming state designation reform. Any planning process that is viewed as slowing or stalling the growth of housing could challenge today's urgent efforts to address housing needs in Vermont. Meeting the urgency by building where capital cost of the development are lowest can result in residential sprawl not aligned to compact centers. However, the housing crisis also opens a window of opportunity to evaluate the designation programs with respect to housing, and make changes to the designations that make housing development in designated towns and villages more competitive in the development marketplace.

Federal funding from the American Rescue Plan Act elevates the need for, and amplifies the benefits of, reforming the state designation programs. This once-in-a-lifetime funding has the potential to kickstart major transformational changes in land use and development. The pandemic also made it clear that the state has not taken the steps needed to prepare for major or permanent disruptions, or for orderly growth. While population growth projections for Vermont are modest, these reflect historic growth patterns — and not the potential for major and persistent climate-related changes and disasters to influence Vermont's population growth. While the pandemic caught the state off guard, climate migration presents an opportunity to plan for sudden increases in growth, if or when they should happen.

More robust data and analysis is needed to determine the ROI on smart growth policy. An analysis from Rocky Mountain Institute (RMI) finds that by the end of the decade, the U.S. must reduce VMT by 20%, or 14,000 miles for each licensed driver. According to the report, even under aggressive EV adoption scenarios, drastic VMT reductions are necessary to limit warming to 1.5°C. The report also acknowledges the reality that individual citizens have little agency to combat the car-centric transportation system around which America is built.

RMI concludes that the solution is smart growth: planning for housing and communities concentrated around downtown city centers, with considerations such as infill development, transit-oriented development, and revised city regulations that promote single and multifamily housing in downtown areas. The RMI report estimates that smart growth alone can bring VMT down by 5% to 10%, but does not indicate over what time frame these reductions will take place and whether they are practical in a rural state like Vermont.

Better data an analysis could also help overcome the challenges of building consensus around changes to the designation programs across many stakeholders with many different and sometime competing objectives.

Recommendations

- *ACCD should simplify the programs that designate Vermont's settlement areas, and support local policies and programs that provide a mix of equitable housing choices for both renters and homeowners.*

- *ACCD, in partnership with other state agencies, should estimate the range of benefits, including energy and climate benefits, associated with land use planning and transportation demand management investments.*

5.8 Transportation Pathway: Increasing Transportation Choices

Transportation Demand Management (TDM) includes multiple strategies to reduce VMT by increasing the quality and quantity of choices for consumer and business mobility: public transit, ride share, passenger and freight rail, bike-ped, smart growth, improved transportation system operations, and other measures like facilitating telecommuting through broadband infrastructure. While additional research is needed to better understand the extent to which TDM can mitigate GHG emissions in Vermont, modeling in other jurisdictions in the Northeast indicates that a 10% reduction may be achievable.

A 10% reduction in VMT may seem small relative to the magnitude of our energy goals, and it comes with significant costs; yet it remains an important pathway because it strengthens communities. TDM improves transportation efficiency by reducing congestion, builds resilience by providing travel options, makes transportation systems more accessible and equitable by providing alternatives to single occupancy vehicles, and creates more livable, vibrant communities by accommodating bicyclists and pedestrians.

The following describes transportation strategies other than driving a personal vehicle, and how these options can be incorporated into the everyday lives of Vermonters to help reduce our statewide VMT and cut back on transportation-related GHG emissions. Psychological elements impact the transportation decisions that each Vermonter makes. While encouraging behavior change is more complicated than systems change or targeted marketing (for example, convincing someone to take the bus is more complicated than switching all existing buses to electric, or persuading someone to buy an electric vehicle), the benefits of reducing the number of vehicles on the road make TDM and the resulting VMT reduction worthy goals for energy savings and environmental concerns.

5.8.1 Strategy: Provide Safe, Reliable, and Equitable Public and Active Transportation Options

TDM requires an understanding of how people make transportation-related decisions, and encourages the use of options other than single-occupancy vehicles (SOVs) such as public transit, rideshare, and active transport. At its core, TDM is about shifting our society away from driving through policies that incentivize driving less and discourage driving more. Examples of applicable TDM strategies include public transit, protected bike lanes, on-street parking fees, monetary incentives to switch modes of travel, passenger rail, and car and bike-sharing programs. For policies like these to be successful, they must include efforts to educate the public about the variety of options available.

All of these efforts for managing transportation demand are in service of reducing vehicle miles traveled. VMT is used to estimate fuel consumption and mobile source emissions in combination with other factors such as fuel efficiency, speed, and delay; and while vehicle occupancy is not a factor in fuel consumption or emission estimates, reducing SOV trips plainly does reduce VMT.

As Vermont's transportation fleets electrify and become powered by more renewable energy, VMT policies will have a smaller and smaller effect on greenhouse gas emissions. The various TDM strategies to reduce VMT in Vermont have numerous co-benefits. They do serve to reduce GHG emissions from the transportation sector. Importantly, they also increase affordability of alternative options while decreasing the need for a personal vehicle; incentivize economic development in downtown and city centers; strengthen communities by increasing access to town centers and shared resources; improve equity by providing transport options for those without personal vehicles; and promote an active and healthy lifestyle by encouraging use of bike and pedestrian infrastructure.

The 2016 CEP established VMT reduction as one of its nine Supporting Transportation Objectives, aiming to hold per capita VMT to 2011 levels and increase the number of trips taken using travel options with lower energy intensities. As of the 2021 Transportation Energy Profile, none of those 2016 CEP objectives are on track to reach their intended target.

2016 CEP Goal	**Goal Number**	**Current Status per the 2021 Annual Energy Report**[157]
Triple the number of state park-and-ride spaces	3,426	1,525
Increase public transit ridership by 110%	8.7 million annual trips	4.71 million annual trips
Quadruple VT-based passenger rail trips	400,000 annual trips	149,795 annual trips
Double the rail freight tonnage in VT	13.2 million tons	6.7 million tons
Increase the percentage of EVs	10% of vehicle fleet	0.6%
Increase the number of HD and MD vehicles powered by renewable energy	10% of vehicles	4-10 transit and school buses; biodiesel ~0.02% of total fuel portfolio

Per capita VMT in Vermont is above the national average and, although below its 2007 peak, it increased 5% between 2014 and 2019. Research suggests that compact development can reduce VMT, though the scale of the impact needs to be better quantified, especially in the Vermont context.

A study from Transportation for America explores the degree to which TDM is a necessary climate strategy. The report found that vehicle emissions are only the tip of the iceberg when it comes to transportation-related emissions — meaning that EVs are only part of the solution. Pavement and

157 https://publicservice.vermont.gov/sites/dps/files/documents/Pubs_Plans_Reports/Legislative_Reports/2021%20Annual%20Energy%20Report%20Final.pdf

concrete production, urban heat island effects, impervious surface runoff, particulate matter, vehicle manufacturing, loss of natural land due to sprawl, and parking construction and maintenance projects are all negative externalities that result from our car-centric society.

Instead of re-establishing the VMT goals from the 2016 version, this CEP calls for a more thorough assessment — beyond just climate — of all of the costs and benefits associated with transportation demand management. This assessment should set plausible targets that can help to guide TDM program progress and the allocation of incremental funding to reach such goals responsibly.

Recommendations

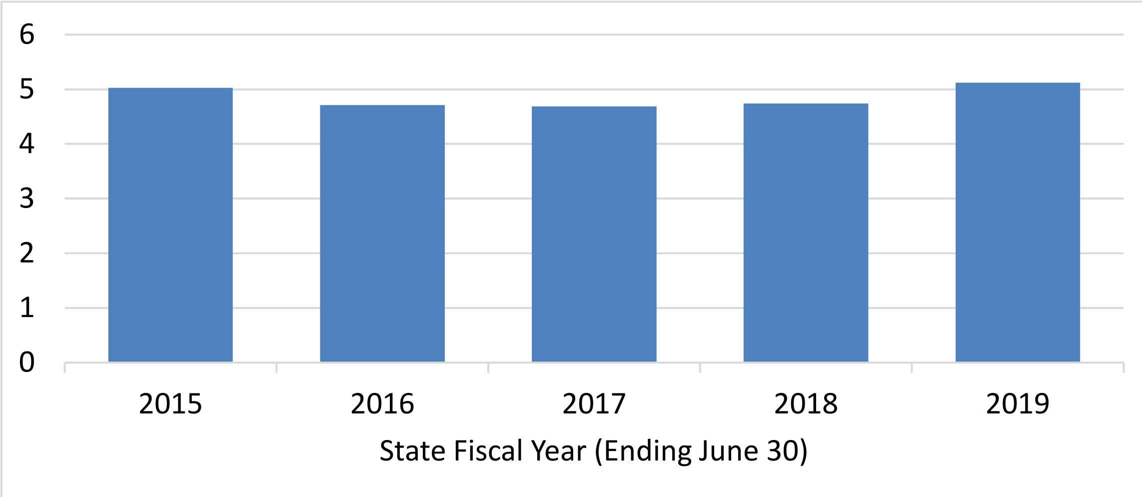
- *The Agency of Transportation, in collaboration with ACCD, should commission a thorough study of all of the costs and benefits associated with Transportation Demand Management, including but not limited to climate and energy impact.*

5.8.1.1 Public Transit

Because of factors such as our small population, low population density, and total percentage of farmland, Vermont is among the five most rural states in the country. Although such a title comes with many benefits — along with a way of life of which Vermonters are proud — rural states like ours face unique challenges when it comes to curbing transportation-related GHG emissions. Statewide, Vermont has a total of 15,765 miles of road, of which less than half are paved (7,172 miles of paved roads, 8,593 miles of gravel roads).

Over 60% of Vermont's public transit budget comes from state and Federal Highway Administration (FHWA) funds, outside of Federal Transit Administration funding. This means that Vermont dedicates more FHWA funds, and uses more state funds as a percentage of its public transit budget, than any other rural state. As a result, Vermont offers more public-transit service than other rural states, and is a leader in demand-response service, or non-fixed routes supporting job access, tourism, and economic activities in our communities. Future investments in micro-transit and rider amenities can play a role in helping people live without a car (or without a second or third car); but these and other public-transit investments in Vermont are undertaken mostly to address equity and basic mobility needs, rather than to mitigate the transportation sector's GHG emissions.

Exhibit 5-9. Public Transit Ridership, 2015-2019, in Millions of Riders.



Public transit is a matter of equity. Ensuring that the most vulnerable members of Vermont's population have access to safe and reliable transportation to school, work, and everyday necessities is essential. The 2020 Vermont Public Transit Policy Plan (PTPP) sets out a variety of strategies, activities, and projects to continually improve public transit; this CEP adopts those policies.[158]

Recommendations of the 2020 Vermont Public Transit Policy Plan:

- Address aging populations
- Expand transit access
- Improve outreach to raise awareness
- Use technology to improve scheduling and rider experience
- Support land use planning and investments.

These recommendations are designed to increase ridership and access, and if successful, may contribute to a reduction in associated vehicles miles traveled.

The recommendation for smart-growth and community development has the most potential impact for the transit system to contribute to the CEPs goals, as the resulting land use designs would lead to more dense communities, enabling transit to more efficiently address residents' transportation needs. However, it is important to recognize the challenges associated with public transit as an energy reduction strategy. Benefit-cost analysis for public transit should consider all the co-benefits associated with public transit programs, including environmental, socioeconomic, equity, and other co-benefits. Even so, the PTPP cannot be expected to solve all the challenges of rural public transit, because a comprehensive solution would not be economically or environmentally effective. Public transit and population density go hand in hand. Over 60% of Vermonters live in areas with low population densities, where bus routes would not attract many riders and would be expensive to operate; and empty buses are not fuel-efficient transport.

[158] https://vtrans.vermont.gov/sites/aot/files/publictransit/documents/PTPP%20Final.pdf

To increase the contribution of public transit, as well as walking and biking, to GHG reduction, a greater share of the state's housing and non-residential development needs to occur in Vermont's compact centers, consistent with smart-growth principles. To help encourage development in compact centers, supportive land use policies and regulations are needed, along with investments in transportation, water, and wastewater infrastructure to accommodate higher-density growth. The synergies between smart growth and transit will help increase ridership incrementally; significant energy and GHG reductions may not be realized from public transit until the long term. But for those reductions to be realized, investments and efforts continue to be needed today.

5.8.1.2 Park & Rides

Park and rides support carpooling, and many also provide connections to public transit and bike lanes. These facilities provide safe, no-cost parking spaces. The state now operates 31 park-and-ride sites with approximately 1,639 total spaces. Municipalities maintain an additional 69 sites, with a total of approximately 1,362 spaces. Overall, the number of park-and-ride parking spaces has increased by 78% since 2012. To encourage carpooling and mixed-modal commutes, park and rides should continue to be funded at an adequate level.

5.8.1.3 Rideshare

According to American Community Survey data, carpooling rates in Vermont declined steadily from 2009 through 2017. This may be attributable to several factors, such as rising rates of vehicle ownership, declining household size, sustained low fuel prices, and an increase in dispersed residential settlement patterns. In 2008, the state created Go! Vermont, a carpooling initiative designed to reduce SOV trips by encouraging higher rates of carpooling, transit use, biking, and walking. This initiative includes a website to link potential carpool participants and provide information for those seeking to share rides to work, meetings, and conferences.[159] VTrans should continue to support rideshare/carshare programs.

5.8.1.4 Telecommuting

The pandemic clearly showed that many Vermonters could transition to conducting many activities remotely, including work, education, and healthcare. Along with reducing exposure to the virus, this shift is expected to have resulted in a significant reduction in vehicle miles traveled. It is unclear at this time how lasting these changes will be, although it seems safe to assume that at least some employment will continue remotely, at least some of the time, again reducing Vermont's VMT. Telehealth, online learning, and other activities may also continue remotely, at least to some extent.

The pandemic also highlighted that a large number of Vermonters do not have adequate access to broadband, and need improved infrastructure. Broadband supports equitable access to remote work, online learning, and telehealth services, and also helps maximize reduction in transportation energy use. **Reliable internet access is both a public health matter and a pathway toward transportation**

[159] https://vtrans.vermont.gov/sites/aot/files/planning/documents/planning/The%20Vermont%20Transportation%20Energy%20Profile_2019_Final.pdf

consumption and emissions reductions. The Federal Highway Administration's 2012 modeling concluded that each teleworker reduces annual CO_2 emissions by approximately 0.5 metric tons.[160]

5.8.1.5 Biking & Walking

Based on the 2009 Vermont NHTS data set, 39% of all trips taken in the state are less than two miles, and 28% are less than one mile. Roughly 87% of the trips shorter than two miles were made by motor vehicle, suggesting an opportunity for increasing active transportation trips. The 2016 CEP includes an objective of increasing the share of commute trips completed by walking or biking, to 15.6% of all commute trips. VTrans and the University of Vermont Transportation Research Center have collaborated to better understand the role of active transportation, and to create a data portal to facilitate sharing bicycle and pedestrian counts among local, regional, and state agencies.

Active transportation rates in Vermont resemble those found nationally. Approximately 14% of Vermonters in the data set had taken at least one bike trip within the previous week, and 75% had taken at least one walking trip.[161] Safety concerns present a major challenge in encouraging more Vermonters to walk or bicycle. Many roads in Vermont do not have bike lanes, adequate shoulders, sidewalks, or safe crossing opportunities. Even where these facilities do exist, pedestrians and bicyclists may not feel safe sharing roads with motor vehicles, especially where those are traveling at high speeds.. The absence of secure, covered bike parking at destinations also discourages bike use.

VTrans has a Bicycle and Pedestrian Grant Program that aims to provide safe and convenient facilities for Vermonters who desire alternative transportation opportunities. The program funds projects that complete critical gaps in local pedestrian or bicycle networks, add municipal sidewalks, and solve critical safety problems. Although the required local match may take the form of cash, in-kind labor, or materials, the match can act as a barrier to municipalities without resources. This program was allocated $17 million in funding for FY21, including $3.6 million for the Lamoille Valley Rail Trail.[162]

The Complete Streets Program aims to do the same. Complete Streets principles call for transportation planning and design to safely accommodate motorists, bicyclists, public transportation users, and pedestrians of all ages and abilities. Complete Streets legislation, passed in 2011, requires that the planning and construction of state and local transportation projects either consider Complete Streets principles or document why it is not feasible to do so. By incorporating the needs of all users, VTrans can better serve the needs of all Vermonters while improving safety and connectivity when all users are invited to actively participate.[163]

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[160] https://ops.fhwa.dot.gov/publications/fhwahop18089/index.htm#fn6

[161] https://vtrans.vermont.gov/sites/aot/files/planning/documents/planning/The%20Vermont%20Transportation%20Energy%20Profile_2019_Final.pdf

[162] https://vtrans.vermont.gov/highway/local-projects/bike-ped

[163] https://vtrans.vermont.gov/sites/aot/files/highway/documents/publications/Complete%20Streets%20Guidance%20Document.pdf

Complete Streets incorporates equity concerns by ensuring ADA-compliant curb ramps for wheelchair users, crosswalks, pedestrian signals and timing (with buttons accessible for all users), street furniture along walkways, street lighting, and more.[164] The rural nature of Vermont can make biking and walking more difficult — but it also presents an opportunity, as the state's beauty inspires many to take advantage of the safe, well-maintained biking and walking paths. The Complete Streets program is an important part of ensuring this infrastructure is planned, built, and well maintained.

Recommendations

- *AOT should evaluate the impact, including benefits and challenges, of the Complete Streets program to ensure that it is working as intended. This could include auditing or compliance inspections of municipally managed sidewalk and sidepath projects within VTrans rights of way, and an understanding of how accessible, useful, and transparent the Complete Streets program is to municipalities, VTrans, and partners.*

5.8.1.6 Passenger & Freight Rail

Passenger trips by rail emit less than one-third the volume of GHGs, on a pounds-per-passenger basis, than passenger trips by gasoline-fueled automobile. Passenger rail service in Vermont is provided on two Amtrak lines: the Vermonter, running from St. Albans to Washington DC, and the Ethan Allen Express, from Rutland to New York City via Albany. Plans are underway to extend the Ethan Allen Express to Burlington and the Vermonter to Montreal. Once completed, these extended services are anticipated to double current Amtrak ridership in Vermont.

Ridership, measured by tracking the number of passengers who board and disembark at rail stations in Vermont,[165] had been relatively steady before 2020 and the onset of the pandemic, with around 95,000 passengers boarding or detraining at a Vermont station annually from FY16 to 2019. This number is a decrease from a 2014 high of more than 105,000 passengers. About 80% of the total number of rides have been on the Vermonter.[166]

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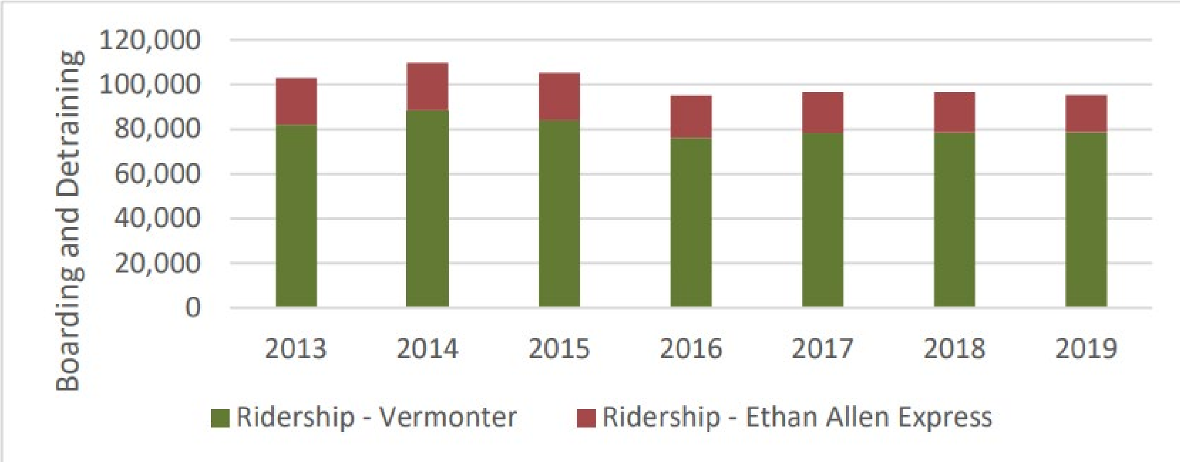
164 https://vtrans.vermont.gov/sites/aot/files/highway/documents/highway/Complete%20Streets%20Summary%202020.pdf

165 https://vtrans.vermont.gov/sites/aot/files/planning/documents/planning/The%20Vermont%20Transportation%20Energy%20Profile_2019_Final.pdf

166 https://vtrans.vermont.gov/sites/aot/files/planning/documents/Vermont%20Rail%20Plan%205-20-2021%20Final.pdf

Exhibit 5-10. Rail Ridership at Vermont Stations, Fiscal Years 2013-2019



Source: 2021 Vermont Rail Plan

The reinstatement of Amtrak options is exciting for Vermont, and Amtrak has adopted operating and policy initiatives to make its system more resilient and sustainable.[167] For passenger rail to be a feasible transportation choice for many Vermonters who commute long distances, efforts to decrease the overall travel time would be a worthwhile investment.

Rutland to New York City by car is a 255-mile trip. At present, it takes approximately six hours to get from Rutland to New York City by train, and only four and a half by car.[168] For comparison, traveling from London to York, England is a 200-mile journey that can be done in less than two hours by train (four hours by car).[169]

Work is currently underway in both New York and Connecticut to increase operating speeds to 100 MPH along major sections of rail corridors, which will benefit both the Ethan Allen Express and the Vermonter. While there are many other advantages to train travel that may influence a traveler's decision to choose one option over the other, Vermont would need to continue to invest significantly in rail infrastructure in order to overcome the prevalence of SOV use and make passenger rail a more convenient option.

Freight rail is on average four times more fuel-efficient than truck transport: trains can move a ton of freight more than 470 miles (the distance from Burlington to Baltimore) on a single gallon of fuel. Moving goods by rail instead of truck lowers GHG emissions by up to 75%.[170] Freight rail should be a continued state priority, as it allows for safe and efficient movement of goods around the region and reduces heavy-

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[167] https://www.amtrak.com/sustainability-report

[168] https://amtrakguide.com/routes/ethan-allen-express/

[169] As an additional example: Burlington to Baltimore, a trip of 474 miles takes 8 hours by car and 12 hours on the Vermonter. In the UK, a trip from London, England to Edinburg, Scotland of 410 miles takes less than five and a half hours by train.

[170] https://vtrans.vermont.gov/sites/aot/files/planning/documents/Vermont%20Rail%20Plan%205-20-2021%20Final.pdf

duty travel that negatively impacts our roadway infrastructure, while also reducing the urgent need for zero-emission heavy-duty trucks, which are currently not widely available in the U.S. market.

Recommendations

- *Carry out the policies recommended in the Vermont Rail Plan for both freight and passenger rail.*
- *Encourage ridership on Amtrak service through continued marketing.*
- *Continue to improve rail infrastructure to reduce rail travel times.*

6 Thermal and Process Energy Use

6.1 Introduction and Goals

The heating of Vermont's residential, commercial, and industrial buildings and the fueling of our industrial processes are responsible for nearly 50% of Vermont's total site energy consumption, and 34% of the state's greenhouse gas emissions.[171] At the time of the 2016 Comprehensive Energy Plan, about 20% of the energy used to heat buildings and provide process heat in industrial applications came from renewable sources, primarily wood, and the 2016 CEP set a target to increase that number to 30% by 2025. In 2019, approximately 25% of thermal sector energy consumption came from renewable supply — significant progress toward meeting the 2016 CEP's target.

This Comprehensive Energy Plan expands the target of increasing renewable thermal and process supply to 30% by 2025, increasing to 45% by 2032 and 70% by 2042. Creating aggressive 10- and 20-year targets will not only help emphasize the needed short-term changes but will also allow the state to keep an eye on the broad market transformation necessary for making substantial long-term progress toward energy and climate goals. Over 10,000 Vermont homes have been weatherized since the 2016 plan; over 10,000 heat pumps have been installed in 2020, and even more are expected to be installed in 2021, continuing the trajectory to heating more and more of our buildings with renewable electricity. But more needs to be done. Meeting these ambitious targets will require significant increases in the penetration of renewable supplies from heat pumps and biofuels, as well as significant investment in the weatherization of Vermont's buildings.

The residential weatherization goal, set in 10 V.S.A. §581 to comprehensively improve the fitness of 80,000 households by 2020, was not reached. The efforts to reach it have, however, highlighted key barriers to addressing the thermal efficiency of Vermont's building stock — including lack of information, access to capital, tenant/landlord investment priorities, and a qualified workforce not currently large enough to tackle the problem. Low-income Vermonters are particularly sensitive to these challenges, even if they may benefit the most from tighter buildings. As this chapter explains, weatherization programs have numerous co-benefits that improve Vermont's affordability, economic vitality, and greenhouse gas emissions, while equitably distributing the benefits of the program to those most in need.

This Comprehensive Energy Plan sets a new target of comprehensively weatherizing 120,000 households by 2030. Consistent with the Climate Action Plan, this target will include 90,000 new weatherized households from 2022 to 2030, and is structured to be sufficient, together with other strategies and actions, to meet our 2030 greenhouse gas targets. The GHG targets could be reached either through weatherizing this number of households *or* by increasing the average savings per household. Because of the highly variable Vermont housing stock, rather than set a target for average savings per household, the CEP emphasizes comprehensiveness: i.e., making all cost-effective improvements at each home when possible. Depending on the owner's circumstances, this could entail completing measures all

[171] For purposes of this chapter, thermal and process energy can generally be assumed to consider water heat as well.

at once, or sequentially over time as resources allow. The new weatherization target is intended to be aggressive but technically feasible, given the need to ramp up the workforce necessary to achieve it. It is over 60,000 homes faster than the pace we are currently on track to achieve. Progress will not happen overnight: significant public and private investments will be necessary, to ramp programs and services that can help Vermonters help make this transition.

Addressing thermal energy use will require not only improvements to our building shells, but also changes to the fuels with which we heat our homes and businesses. There are many options available to fuel Vermont's homes, and many can reduce Vermont's dependence on imported fossil fuels. Often multiple options need to work together to serve a building, provide heat to different spaces, or serve as a redundancy in case of a single fuel outage. Together, these options save Vermonters and Vermont businesses money in the long-term.

This chapter will start by describing current energy use in the thermal sector. Then it will focus on two core pathways: first, reducing energy consumption, and second, enhancing technology and fuel choices. Strategies presented within each pathway describe new initiatives and/or improvements to or continuation of existing initiatives, to chart a path for our thermal energy future.

Buildings and the energy technologies that heat them are complex systems; there is no one silver bullet that can reduce greenhouse gas emissions, maintain Vermont's affordability, protect the most vulnerable Vermonters, address existing inequities, improve the health of Vermonters, and spur Vermont's economy. But together, the pathways and strategies presented here can make significant progress toward meeting Vermont's goals for energy demand and greenhouse gas reduction.

6.2 Current Thermal and Process Energy Demand and Resources

Thermal and process energy use in residential, commercial, and industrial buildings accounts for nearly 50% of Vermont's total site energy consumption, and 34% of its greenhouse gas emissions. This energy is largely provided by burning fossil fuels: fuel oil, kerosene, natural gas, and propane. Biomass (cordwood and pellets, and wood chips in some commercial applications), biomass-based diesel, and renewable natural gas fuel a smaller portion of Vermont's thermal and process energy usage.

Exhibit 6-1. Renewable and Fossil Fuel Heating in 2019[172]

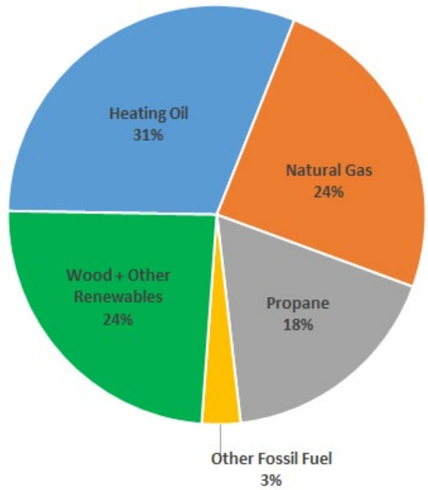
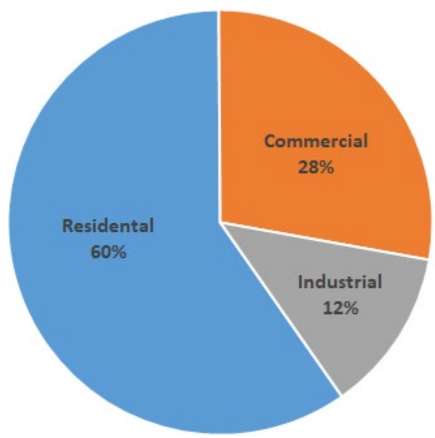


Exhibit 6-2. Thermal Energy Use by Sector[173]



The residential sector accounts for 60% of Vermont's thermal fuel consumption, commercial 28%, and industrial 12%.[174] Propane, also called liquefied petroleum gas (LPG), is used in space heating, water heating, and cooking. Wood is widely used for residential heating: an estimated 47% of Vermont homes

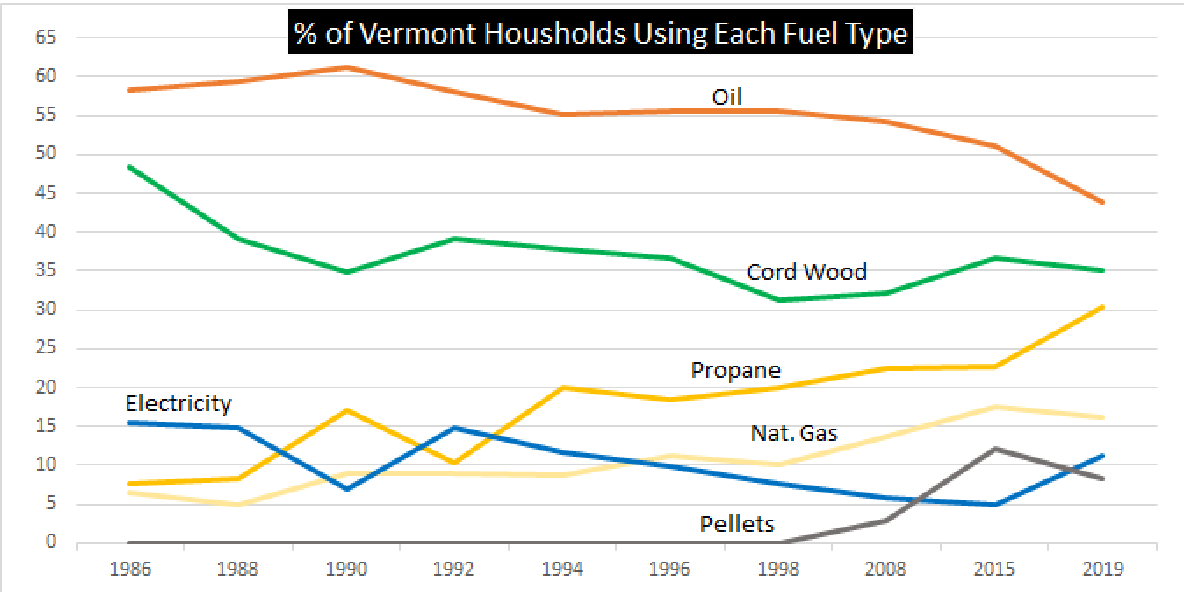
[172] Based primarily on U.S. Energy Information Administration data from 2019 with some adjustments of the wood data based on the 2018-19 Vermont Residential Fuel Wood Assessment. Data on the use of electricity for heating was from the 2019 American Community Survey, 2018 data from Efficiency Vermont, and Energy Action Network's 2021 Emissions Reductions Pathways Model.

[173] 2019 EIA data with adjustments made using Vermont data for the thermal energy generated by wood and electricity.

[174] U.S. Energy Information Administration, 2019, with thermal energy generated by wood fuels and electricity based on Vermont data.

use it as a primary or secondary heat source[175]. Wood heat has also increased in popularity in schools as a replacement for fuel oil, and pellet use has jumped as small commercial and residential buildings convert to pellet boilers and many homes add pellet stoves as a supplemental heat source.

Exhibit 6-3. Percent of Vermont Households Using Different Fuel Types as a Primary and/or Secondary Heat Source[176]



The energy required to meet thermal needs can vary widely depending on the weather in any given year, with usage higher during particularly cold winters (or, increasingly, warm summers) and more moderate during mild winters. Exhibit 6-4 illustrates the per-year correlation between heating degree days and heating fuel sales, as the years with the highest number of heating degree days also record higher volumes of fossil fuel sales. Exhibit 6-5 shows the rising trend of cooling degree days in New England; this suggests that the state will likely see growing demand for thermal energy to meet our needs for cooling.

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175 VT Dept. of Forests, Parks, and Recreation. 2018-19 heating season residential fuel assessment report/survey: https://fpr.vermont.gov/sites/fpr/files/Forest_and_Forestry/Wood_Biomass_Energy/Library/2019%20VT%20Residential%20Fuel%20Assessment%20Report%20FINAL.pdf

176 This graph represents both primary and secondary uses and thus totals are greater than 100%. https://fpr.vermont.gov/sites/fpr/files/Forest_and_Forestry/Wood_Biomass_Energy/Library/2019%20VT%20Residential%20Fuel%20Assessment%20Report%20FINAL.pdf

Exhibit 6-4. Correlation of Heating Degree Days and Heating Fuel Sales by Year[177]

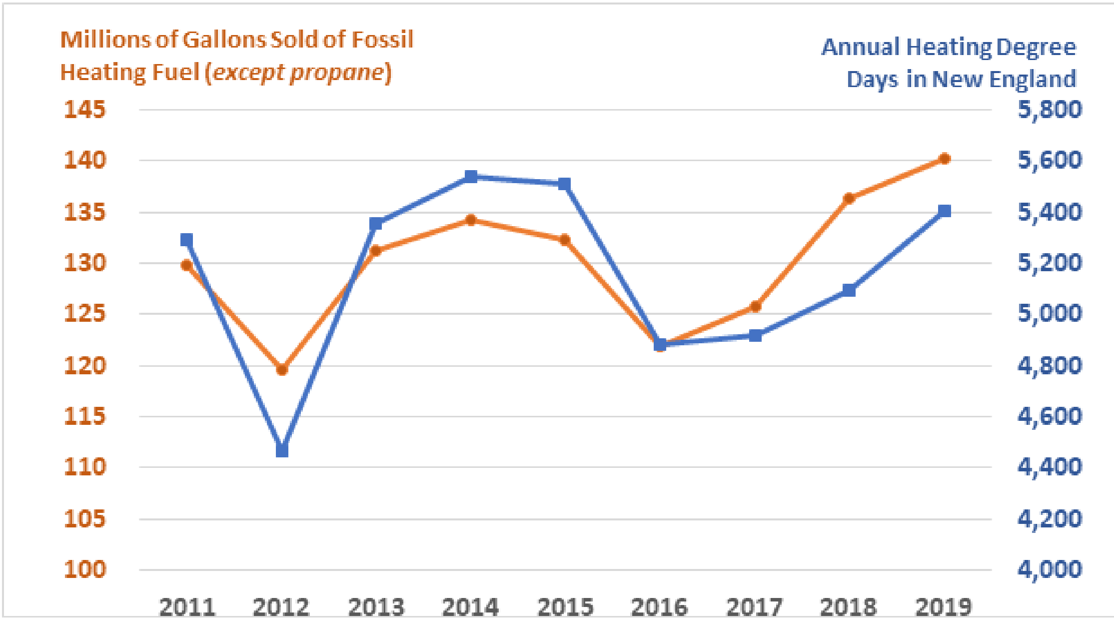
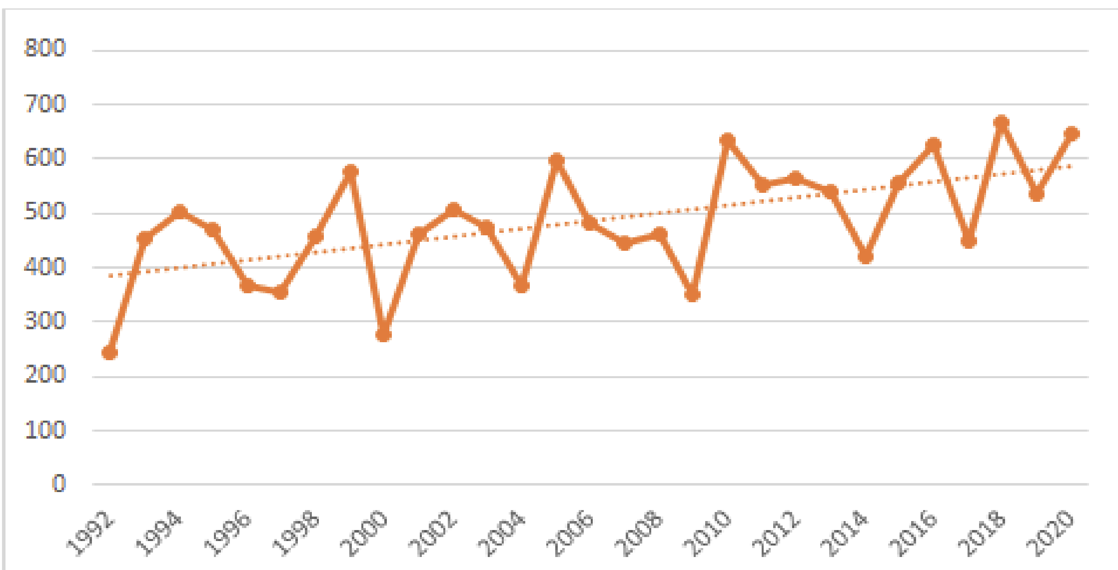


Exhibit 6-5.[178] **Cooling Degree Days in New England**

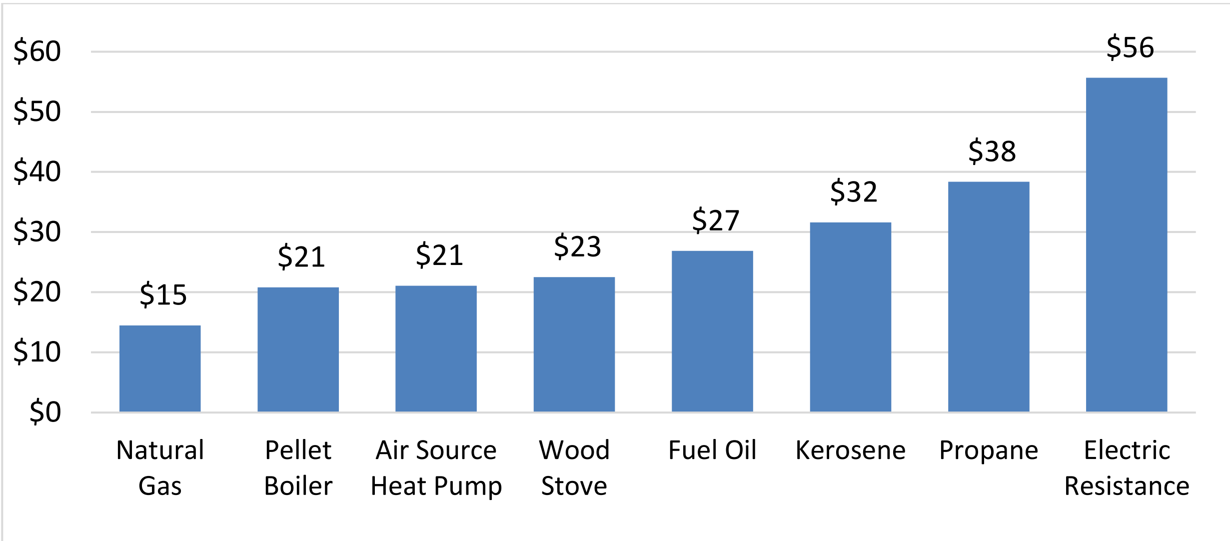


As illustrated Exhibit 6-6, natural gas and many renewable energy resources are less expensive than — or at least cost competitive with — petroleum products on a dollar-per-MMBTU-delivered basis. However,

[177] Heating degree days from EIA's US Regional Weather Data. Fossil fuels sold for heating from VT Tax Department.
[178] EIA Short Term Energy Outlook data.

in addition to ongoing fuel costs, up-front investments in heating systems can be a considerable barrier to switching to renewable fuels.

Exhibit 6-6. Residential Average Price per MMBtu Delivered by Heating Technology[179]

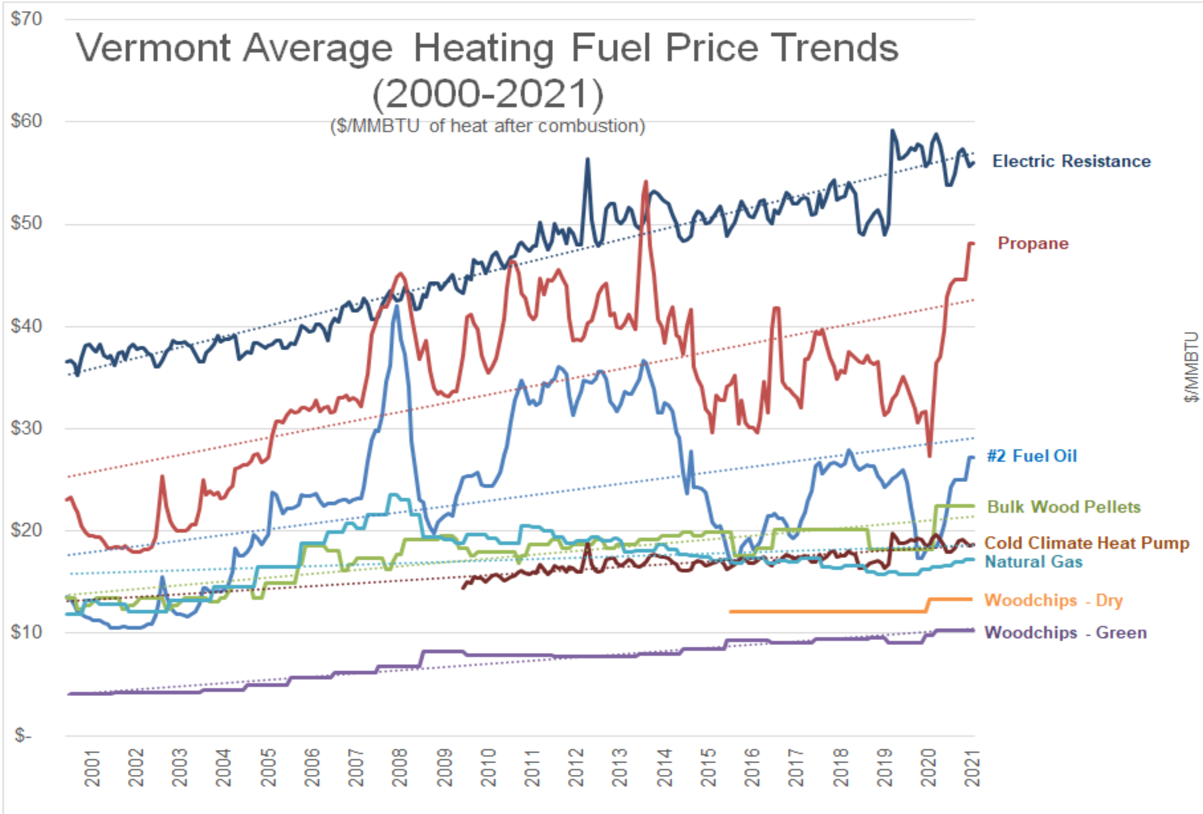


Commercial enterprises primarily use heating oil and propane for space heating, cooking, and a wide variety of other purposes. Industrial enterprises typically use heating oil and propane for manufacturing, and in some instances for space heating.

In 2018, Vermonters paid over $750 million to import and use fossil-based heating fuels.[180] Two thirds of this money left the Vermont economy. Moreover, fossil fuel prices can be extremely volatile, leaving Vermonters and Vermont businesses vulnerable to large swings in the price of fuel.

[179] PSD data from the VT and NH Fuel Price Reports and Vermont Gas.
[180] EAN 2021 Annual program report

Exhibit 6-7. Vermont Average Heating Fuel Price Trends[181]



A typical Vermont residence heated with no. 2 heating oil will spend between $2,100 and $2,700 annually to meet a winter heating load of between 80 and 100 MMBtu.[182] Average commercial building heating loads are somewhat larger, around 120 to 150 MMBtu, and annual fuel oil costs for businesses can be substantially higher. If cold-climate heat pumps are used as the primary source of residential heat, that same level of demand (80 to 100 MMBtu) can be met with about $1,800 to $2,300 in annual fuel costs, $600 to $800 of which might be spent on backup fossil-fuel heat sources.[183] Advanced wood stoves and central pellet systems can serve this same heating load at annual fuel costs of $2,000 to $2,600. An investment in weatherization can further reduce annual heating fuel costs by $500 to $700, assuming a 20% to 30% reduction in heating load — and when done together with the replacement of heating equipment, this investment can also reduce overall system capacity needs.

Considering these costs, Vermonters today face an average thermal energy burden of roughly 4%, meaning that a household tends to spend about 4% of total income on thermal-energy related

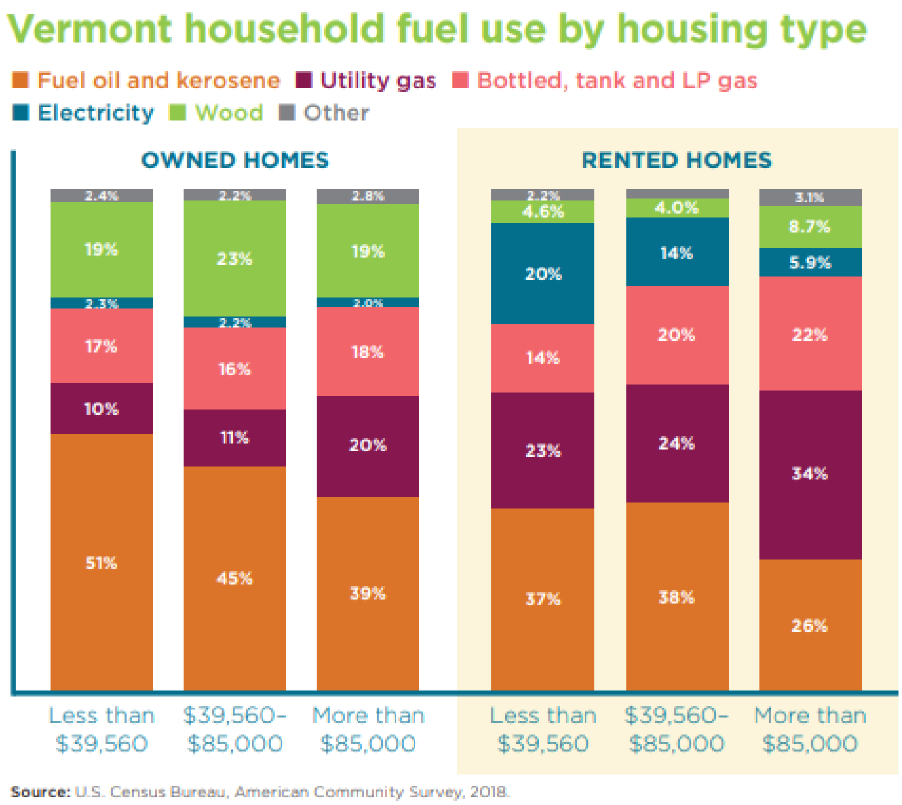
[181] Fuel price data collected in November of 2021 from PSD data, the VT Fuel Price Report, and the U.S. EIA. This exhibit has some different $/MMBTU than exhibit 6-6 mainly due to the differences in fuel prices between October and November 2021.

[182] Calculation assumes a fuel oil price range of $2.50 to $3.00 per gallon.

[183] Calculation assumes heat pump serves between 70% of an 80 MMBTU to 100 MMBTU heating load with a coefficient of performance 2.6. Electricity price is assumed to be $0.1899 cents per kilowatt-hour. It is likely two ductless mini-split heat pump heads would be necessary to meet this amount of space heat demand.

expenditures. Certain communities face even higher thermal energy burdens, upwards of 6-7%,[184] with individual Vermonters potentially facing significantly greater burdens. Research by Efficiency Vermont has shown that towns identified as the most severely burdened by thermal costs tend to show low overall thermal spending, but have household incomes well below the statewide median. Along these lines, data also shows that household fuel use is correlated with income and whether a home is owned or rented, with lower-income households disproportionately using fuel oil and inefficient resistance heating systems. Compared to rental properties, owned homes are more likely to heat with wood and less likely to heat with electricity.[185] (Exhibit 6-8)

Exhibit 6-8. Vermont Household Fuel Use



Despite Vermont having made the most significant progress toward reducing GHG emissions in the electricity sector (see chapter 7), electric ratepayers and utilities currently pay the most to advance clean energy solutions.[186] This is illustrated in Exhibit 6-9**,** which shows the relative carbon emissions of different heating fuels compared to their level of taxation as a percentage of unit cost.

[184] 2019 Vermont Energy Burden Report. https://www.efficiencyvermont.com/news-blog/whitepapers/vermont-energy-burden
[185] Energy Action Network Annual Progress Report for Vermont 2020/2021. https://www.eanvt.org/wp-content/uploads/2021/05/EAN-APR2020-21_web-1.pdf
[186] Report to the Vermont State Legislature: Act 62 — Final Report on All-Fuels Energy Efficiency. January 15, 2021.

Exhibit 6-9. Thermal Fuels by CO_2 Emissions and Percent Taxed as a Percent of Unit Price

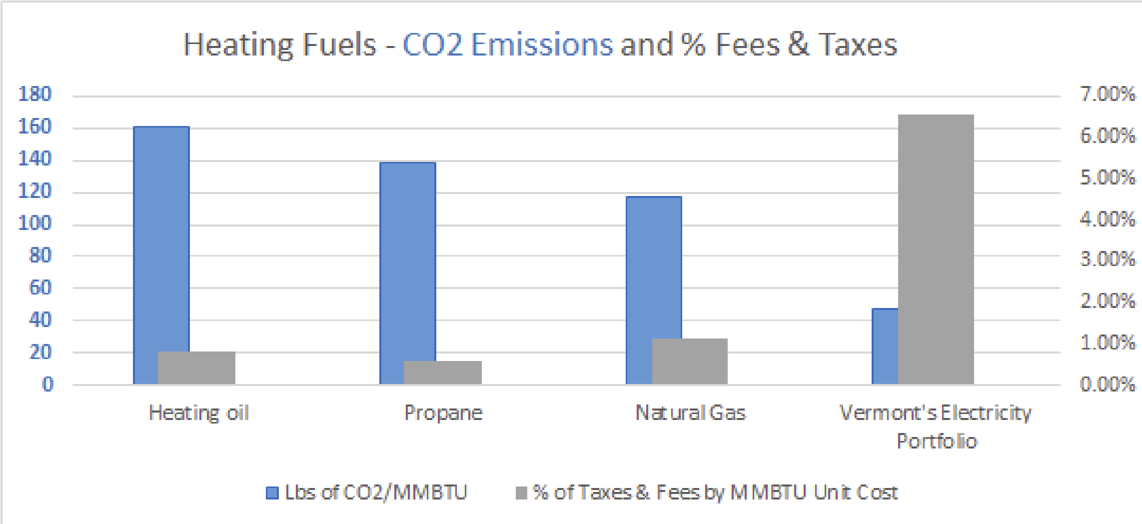


Exhibit 6-9 illustrates the high cost relative to other fuels that Vermont electric ratepayers have contributed to advance renewable energy and emissions reductions, through programs such as the RES, net-metering, standard offer, and other electric efficiency initiatives. This has contributed in part to upward pressure on electricity rates, which sends a conflicting message regarding support for electrification, one of the least-polluting heating options, as higher electric rates tend to discourage customers from choosing electricity to meet their thermal demands. There is a need for clean energy programs that limit the future cost burden on electric ratepayers while driving the move toward cleaner heating solutions.

6.3 Thermal Energy Use Pathway: Reduce Thermal Energy Demand

Further reducing thermal energy use in buildings to achieve goals for energy and greenhouse gas reduction will require significant additional effort. The two dominant areas of strategic focus for reducing demand include rapidly scaling up weatherization activities to new levels not previously thought possible, through new and innovative approaches, and making buildings as efficient as possible to substantially reduce thermal energy demand.

The Weatherization Assistance Program and the energy efficiency utilities have steadily worked to reduce thermal energy demand, consistent with their missions and statutory directives and commensurate with the funding provided to them. Regulatory tools such as appliance and building energy standards continue their long history of driving toward greater efficiency. These tried-and-true elements of the state’s thermal energy demand reduction mix should be continued and expanded upon.

But achieving Vermont’s energy and climate-related goals will also require new strategies for further reducing thermal energy consumption across all the market segments — residential, commercial, industrial, and institutional. Pursuing the strategies in this section will help to accelerate progress within the state’s thermal energy use sector. Some of the work envisioned here builds on the successes of traditional programs and policies; other strategic activities will seek synergies between different domains, such as energy and health care, to pursue mutually agreed-upon goals.

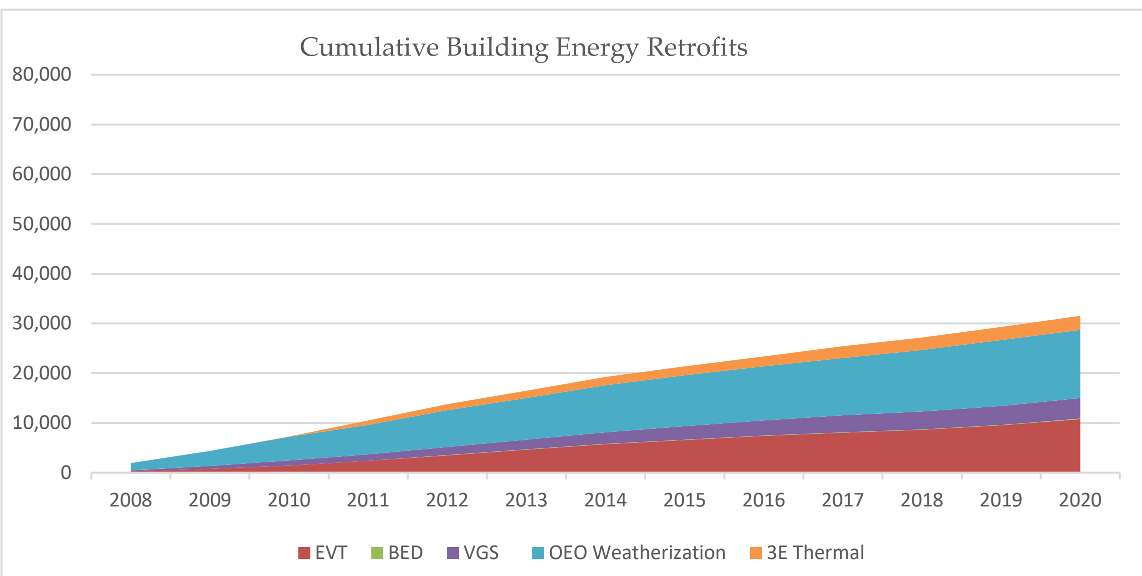
6.3.1 Strategy: Weatherization at Scale — Driving Building Energy Efficiency Through Innovative Partnerships and Sustainable Funding Mechanisms

Investing in thermal efficiency improvements — primarily air sealing, insulation, and heating system replacements — can dramatically reduce a building's thermal fuel requirements while increasing its affordability, health, and comfort, and at the same time preserving the character of Vermont. Investments in thermal demand reductions through weatherization programs are good for Vermont's economy, and perhaps more importantly, for Vermonters' health.

In 2020, the Department of Public Service and the Agency of Commerce and Community Development summarized the broad economic impact to the Vermont economy of the state's core weatherization efforts. The agencies estimate that from 2020 to 2030, sustained investments in low-income and market-rate programs will increase total personal income by $27-$39 million per year, increase GDP by $20-$21 million per year, and employ 390 to 440 people throughout the analysis period.[187] In 2018, the Vermont Department of Health summarized published and local evidence on the co-benefits of building weatherization, finding significant health value associated with reduced asthma and reduced cold- and heat-related thermal stress.[188] Housing conditions affect the health of occupants, and weatherization often improves housing conditions by providing mold remediation, appropriate temperature control, adequate ventilation, and trip hazard mitigation. The benefits of healthy, efficient homes are clear.

10 V.S.A. §581 set energy efficiency goals for residential buildings, including the goal of weatherizing 80,000 households by 2020. As shown in Exhibit 6-10, Vermont fell far short.

Exhibit 6-10. Cumulative Building Energy Retrofits, 2008-2020



[187] The Agencies' summary was originally filed in Public Utility Commission Case 19-2956, the Commission's investigation pursuant to Act 62 of 2019 on the best way to deliver holistic efficiency services to Vermonters.
[188] Weatherization + Health: Health and Climate Change Co-Benefits of Home Weatherization in Vermont. VT Department of Health. December 2018.
https://www.healthvermont.gov/sites/default/files/documents/pdf/ENV_CH_WxHealthReport.pdf

There are several primary barriers to efficiency improvements, including:

- **Up-front costs, and financing access and aversion.** Efficiency investments have up-front initial costs, with payback occurring through fuel savings over the life of the measure, often many years. Efficiency retrofits are often cost-effective for the customer over a period of time, and can provide additional health, safety, and comfort benefits — but many Vermonters simply cannot afford to make the up-front investment. What's more, customer confidence that energy savings will actually be realized remains uncertain, despite significant improvements in estimating those savings through program experience and improved modeling. Financing options do exist (see chapter 8), but consumers may not be able or willing to access the option that would be most advantageous for them, such as a long-term loan. The path to securing a loan can also be a barrier for many Vermonters; reliance on traditional financing often leaves out frontline and low-income communities. Access to credit is not equal across income, culture, and race.

- **Split incentives**. This refers to situations in which the benefits and costs of efficiency measures are divided, or believed to be divided, between two different market actors: for example, a tenant pays the energy bills but the landlord is responsible for building upgrades. The landlord may not be motivated to invest in the improvements, because they will not directly benefit from them; but for the renter, those improvements would directly affect the unit's energy cost. Also, energy costs may not be disclosed up front to potential tenants, or if they are disclosed it may not be in a format that is easily comparable to other rental property options. That hinders the renter's ability to make an informed decision on choosing a particular property based on the total cost of living there, versus just a comparison of rent charged. A second split incentive develops when building owners are not sure they will remain in the building long enough to earn a payback on their investment, leading to uncertainty as to whether they will receive adequate return on their investment if they sell their building; so they choose not to invest. Finally, builders often do not occupy the buildings they construct, so they do not see a direct benefit from installing energy efficiency improvements. The short-term outlook of these market actors often works to the detriment of long-term efficiency investments.

  About 25% of Vermont households (80,000) are renters.[189] About 80% of those are considered low-income, paying a significant share of their income for housing. BIPOC community members are more likely to be renters than white Vermonters.[190] This underscores the need to fully tackle not only single-family owner-occupied homes, but all types of rental units. (See the discussion on the Weatherization Repayment Assistance Pilot in Section 6.3.1.5 below.)

- **Old Building Stock**. Vermont's building stock is old, with about 60% built over 40 years ago, and 25% built more than 80 years ago. [191] Many of these buildings need efficiency improvements. One challenge when implementing efficiency upgrades is the presence of vermiculite insulation with

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[189] Vermont Housing Needs Assessment https://www.vhfa.org/documents/publications/vt_hna_2020_report.pdf
[190] 2019 Vermont Energy Burden Report. https://www.efficiencyvermont.com/news-blog/whitepapers/vermont-energy-burden
[191] Vermont Housing Needs Assessment, Vermont Housing Finance Agency ("VHFA Housing Needs Assessment"), February 2020. https://www.vhfa.org/documents/publications/vt_hna_2020_report.pdf

asbestos (almost all vermiculite insulation used in buildings between 1919 and 1990 contained asbestos, which can cause significant health risks if it becomes airborne). Improving a home for energy efficiency may result in the need for lead or asbestos abatement, and/or other significant structural repairs. These types of issues can ultimately prevent weatherization or defer it. A whole-building approach is critical to serving Vermonters equitably.

Some older buildings have significant historical value, helping tell the story of Vermont's past through architecture and design — how buildings were used, communities developed, and times changed. The key to a successful efficiency retrofit is to understand and identify the character-defining features that tell the building's story and ensure they are preserved, while also understanding the energy-efficient aspects of the historic building and how they function.

Workforce

In addition to the customer barriers identified above, a robust and well-trained workforce is necessary to scale the amount of building weatherization retrofits necessary to meet Vermont's targets. Amidst the broad workforce challenges associated with the fallout from the COVID-19 pandemic, Vermont's qualified weatherization workforce would need to grow to many times its current size to meet this CEP's targets.[192] Efficiency Vermont recently identified several significant barriers to developing the weatherization workforce:[193]

- A "four-year college-or-bust" mindset promoted to the state's young people preparing to graduate from high school, and unclear career pathways in Vermont's construction trades;
- A shortage of workers in general—and specifically, a shortage of skilled workers willing to undertake weatherization projects under uncomfortable conditions (hot attics and damp crawlspaces, for example);
- Wage competition with jobs requiring less-strenuous working conditions, and current low unemployment rates;
- Historical volatility in funding and the availability of incentives supporting weatherization; this drives market fluctuation, which creates instability for local construction contractors and affiliated businesses; and
- A shortage of affordable housing for construction workers.

The General Assembly directed funds in 2021 for Efficiency Vermont to begin to specifically address workforce issues that relate to weatherization. Once workers are available, they must be properly trained;

[192] Smith, Raquel, 2021. "Workforce Development in Vermont's Thermal Sector: Challenges and Opportunities for Meeting Vermont's 2030 Climate Goals." Internship presentation. Montpelier, VT: EAN. https://www.eanvt.org/ean-interns/ean-summer-2021-interns/workforce-development-thermal-sector/

[193] Weatherization Workforce Plan: Workgroup Report to the Vermont General Assembly on the Coordinated Delivery of a Standardized Statewide Building Sciences Curriculum. October 1, 2021 https://drive.google.com/file/d/1JNG4qK7h-y3hxn62KFTFGqpEyAbHiJ7Y/view

if the weatherization is not done properly, energy savings will not materialize. For example, the Weatherization Assistance Program subsidizes the first three months of employment in recognition of the initial training needs. Resolving the shortage of workers will be critical to achieving our goals.

Vermont has a once-in-a-lifetime opportunity with potential federal American Rescue Plan Act (ARPA) and other federal funds available to assist with weatherization projects. Investments already made pursuant to ARPA, as well as those that could be made, could kickstart the pace of weatherization in Vermont, leveraging the current suite of weatherization program providers that are contributing to meeting the state's building energy goals: Efficiency Vermont's Home Performance with ENERGY STAR program, Vermont Gas Systems' Home Retrofit program, the City of Burlington Electric Department, the Weatherization Assistance Program of the Office of Economic Opportunity (OEO), and 3E Thermal, which partners with these entities, mainly to deliver efficiency in multi-family buildings. Critically, these investments will need to seed more sustainable funding sources that continue to facilitate Vermont's tightening of its buildings, to deliver the broad benefits of weatherization to all Vermonters.

Weatherization at Scale

As noted above, Vermont has not made sufficient progress toward reaching its building efficiency targets; the state has not sufficiently invested in weatherization to deliver benefits at scale. At its core, weatherization reduces energy demand and greenhouse gas emissions. It also improves health of Vermonters and the Vermont economy. In 2021, the Scott Administration proposed, and the Legislature funded, over $20 million in new funding for weatherization, mainly aimed at serving the underserved — low- to moderate-income Vermonters. But to achieve weatherization at scale, significantly more public and private investment will be necessary. Continued efforts can come in a variety of forms but will require continued partnership between program implementers and other partners.

Over the course of 2021, the Energy Action Network has convened a group of dedicated stakeholders to promote weatherization at scale.[194] The team made a series of recommendations, summarized here:

- Increase funding with a mix of state and federal funds. Use a mix of federal and state funds to support current programs and increase their reach over the next four years, funding a 40% increase in annual households served above current levels.
- Allow a Clean Heat Standard carve-out for weatherization. If a Clean Heat Standard (a performance-based obligation on fuel providers; see Section 6.4.1) is implemented, weatherization could be an eligible investment by which obligated entities could meet their requirements. But in view of the long payback period for weatherization investments, entities may choose other options to meet their requirements. Because weatherization achieves so many co-benefits that are often equitably distributed, a carve out for weatherization is likely warranted, perhaps specifically directed to savings for low- and moderate-income Vermonters.
- Support for on-bill repayment. As described above, the barriers to weatherization for Vermonters may include split incentives, or the inability to secure or aversion to financing. As described

[194] https://www.eanvt.org/events-and-initiatives/weatherization-action-team/#:~:text=Goal%3A%20By%202030%2C%20weatherize%20every,average%20median%20income%20%E2%80%93%20including%20renters.

further in Section 6.3.1.5, a "to-the-meter" financing mechanism is expected to be filed by distribution utilities in 2022, in partnership with the Vermont Housing Finance Agency. The pilot is intended, if successful and fully funded, to become self-supporting with funding from private sources of capital eventually harnessed to fund weatherization.

- Sustainable weatherization funding. Longer-term sustained funding is necessary to continue to meet the state's building energy objectives. See sections 6.3.1.3-6.3.1.5 for descriptions of efforts aimed to develop sustainable funding sources.

These recommendations, developed by a broad coalition of stakeholders, can kickstart weatherization programs, and are meaningful first steps to support them in the near-term; but without exploration of sustainable funding, they will likely continue to leave a significant gap in the number of households that could benefit from weatherization, and in Vermont's ability to meet our energy and climate goals.

Recommendations

- *Support the recommendations outlined above, determining the appropriate near-term funding to dedicate toward weatherization in the 2022 Legislative session, and continuing to explore sustainable funding sources for weatherization.*

The subsections that follow explore specific programs and tactics that can be used to further weatherization at scale. While these programs are distinct from each other, each administrator has worked diligently to coordinate and deliver seamless service to customers.

6.3.1.1 Weatherization Assistance Program

Vermont's Weatherization Assistance Program (WAP) was created by 33 V.S.A. § 2502 and is administered by the Office of Economic Opportunity (OEO). Its mission is "to help low-income Vermonters save energy, thus money, by improving the energy efficiency and health and safety of their homes." The Weatherization Assistance Program was started in 1976, with funding initially provided by the U.S. DOE. This federal funding was augmented in 1990 when Vermont established a permanent source of state funding through the creation of the Vermont Weatherization Trust Fund, now called the Vermont Home Weatherization Assistance Program Fund (HWAP).

Title 33, § 2503 establishes a fuel tax that currently yields about $10.2 million in annual revenue. All funds are statutorily committed to the Home Weatherization Assistance Program Fund, although the Legislature has approved a 1:1 swap with the Vermont LIHEAP (Seasonal Fuel Assistance Program) funds to meet the policy goals of the Fuel Assistance Program without additional financial obligation. The program also receives approximately $1.5 million per year in formula funding from the U.S. DOE Weatherization Assistance Program. Additionally, in 2021 the General Assembly appropriated $4 million in ARPA SRF funds for the program; 15% of Vermont's LIHEAP ARPA Award ($3.9 million) for weatherization assistance, as allowed by the federal LIHEAP office; and up to $5 million (of which this year approximately $2 million will be spent) for emergency heating system or tank repair and replacement.

Services, which are 100% funded by the program, include:

- Comprehensive "whole house" assessment of homes for energy efficiency improvements, combustion appliance issues and indoor air quality;
- Efficiency coaching at every home, to provide enhanced client education and refer clients to all other relevant energy, health, and human service programs via the ONE TOUCH electronic referral program;
- State-of-the-art building diagnostics, including blower door testing, carbon monoxide and worst-case draft testing, and heating system testing and evaluation and infrared scans; and
- "Full-service" cost-effective energy-efficient retrofits, including dense-pack sidewall insulation, comprehensive air sealing, attic insulation, heating system repairs, upgrades and replacements, installation of bathroom and kitchen ventilation to ASHRAE standards, furnace duct work modifications and improvements, and assurance of safely operating combustion appliances in the home.

To participate, households must meet income eligibility guidelines listed by the OEO. These are currently 200% of the federal poverty level or less (DOE guidelines), or 80% of the state's median income or less (HWAP guidelines). Eligibility is determined at each regional WAP office.

One of OEO's current partners, 3E Thermal, delivers weatherization services targeted to multifamily buildings, designed to achieve comprehensive, deep energy savings. 3E is contracted with OEO to use HWAP funds, and is also funded by Efficiency Vermont, as described below.

6.3.1.2 Energy Efficiency Utilities

Efficiency Vermont and Burlington Electric Department

Beginning in 2010, revenues from the Regional Greenhouse Gas Initiative and Vermont's participation through its electric efficiency savings portfolio in the Forward Capacity Market have been directed to Efficiency Vermont (EVT) and Burlington Electric Department (BED) for the purpose of developing unregulated fuel energy efficiency services. Thermal efficiency (weatherization) services are offered to owners of existing homes, and to owners of small businesses, multifamily residences, residential rental properties, and mixed-use buildings. EVT and BED coordinate these programs with activities funded through the electric energy efficiency charge; these have included residential and commercial new construction programs and heating system incentives. EVT also provides training, quality assurance, and marketing assistance for contractors, and maintains a statewide network of certified energy-efficiency service contractors on its website.

In addition to the building weatherization services described above, some of the Thermal Energy and Process Fuel (TEPF) funds are directed to non-weatherization services. EVT's Business Existing Facilities programs may include snowmaking upgrades, maple sap reverse osmosis, heat recovery and space heating controls, ventilation improvements, HVAC system optimization, burner controls, industrial process heat recovery, and steam trap repair and replacement. Efficient Products programs may include heat pump water heaters, smart thermostats, and low-E storm windows, as well as do-it-yourself home weatherization products for insulating and air sealing. BED has little potential in this space because its territory significantly overlaps with Vermont Gas Systems territory, and TEPF funds are prohibited from being used for regulated fuel customers; however, a recent statutory change enables BED to use TEPF funds for district heating if possible.

Funding for EVT and BED for acquisition of thermal and process fuel efficiencies totals about $7.5 million per year through 2023, but then is expected to decline significantly with reductions in Forward Capacity Market revenues.

Natural Gas Efficiency

Vermont Gas Systems, Inc. (VGS) is an appointed Energy Efficiency Utility (EEU), providing efficiency services within its service territory. Vermont's electric EEUs have offered energy efficiency programs for several years; but natural gas energy efficiency offers more future savings opportunities, due to relatively smaller historic investments and continued greater opportunity for cost-effective thermal shell savings.

Natural gas efficiency investments throughout the 2021-2023 performance period will acquire energy and peak day resources at a lower lifetime price to ratepayers than most supply alternatives. The VGS territory energy efficiency budget increases from $3.6 million in 2020 to $4.6 million, $5.3 million, and $5.8 million in 2021-2023, respectively. [195] This level of investment is consistent with available potential and a reasonable program ramp rate.

This increased investment will not proportionally increase the efficiency charge, however, as the Public Utility Commission approved a strategy for VGS to invest its own capital in efficiency, in exchange for a return over time — a payment structure that more closely matches savings with cost (and is more similar to other infrastructure investments the utility may make). This new structure is another example of innovation and responsiveness in regulatory policy, allowing for greater investment sooner without undue short-term burden on ratepayers.

If VGS achieves its savings targets, the 2021-2023 total budgets of approximately $15.6 million will result in more than $41 million in lifetime natural gas savings, from 239,650 Mcf of incremental annual Mcf savings and 1,356 Mcf of peak day savings; and will reduce annual greenhouse gas emissions by more than 13,000 metric tons.

6.3.1.3 Weatherization + Health Initiative

The Department of Public Service, in coordination with the Vermont Health Department (VDH), the Office for Economic Opportunity (OEO), and Efficiency Vermont, has convened the Weatherization + Health Initiative (WHI), which intends to leverage current resources to increase healthcare sector investment in energy-saving weatherization improvements, leading to more weatherized homes and better health outcomes. To support this initiative over the next two years, the Public Utility Commission

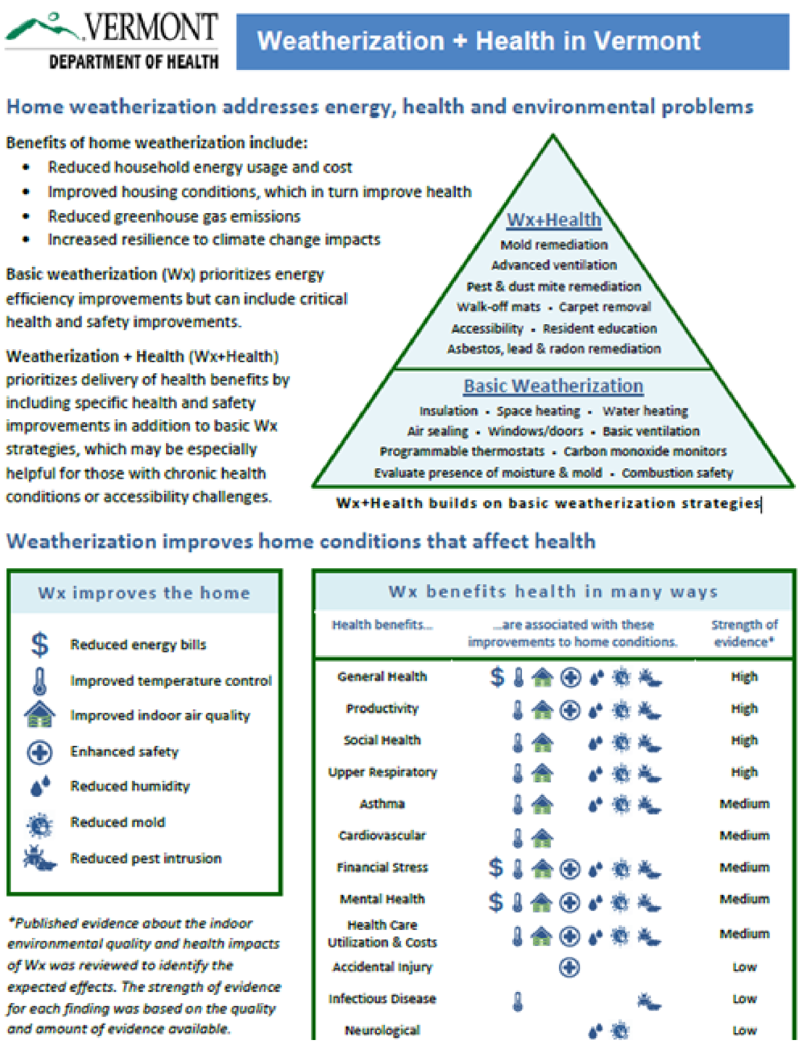
[195] See, Case No. 19-3272-PET.

has approved initial seed funding of $500,000 from the Thermal Energy and Process Fuel budgets of EVT and BED directed to the Department of Public Service.

Poorly insulated and ventilated buildings increase the incidence and severity of asthma, heat-related stress, viral transmission, and other conditions. Along with the economic costs associated with inefficient buildings, these health impacts also pose increased costs to the state's health care systems. Applying a strategic approach to improving home energy performance and indoor air quality can help achieve state energy goals while relieving associated health concerns.

To build the case for mutual collaborative action, OEO, EVT, VDH, and multiple hospitals across the state delivered several pilot projects over the last few years that demonstrated the nexus between health and energy outcomes (Exhibit 6-11). Good progress has been made to date — but the energy-plus-health focus must scale to larger levels, to generate leverage sufficient to optimize positive outcomes in both sectors.

Exhibit 6-11. Weatherization + Health in Vermont



Source: VT Department of Health, *Weatherization + Health Report*, December 2018

The WHI will explore and further demonstrate potential successful models for co-funding of weatherization efforts, providing the opportunity for private health care partners (e.g., health care providers such as hospitals, or payers such as Medicaid and private insurers) to invest in upstream preventative and acute health improvement through home weatherization and energy efficiency projects.

Through cooperation between health care and weatherization partners, the WHI will coordinate additional pilot projects, collect and analyze evaluation data, and increase education and information dissemination. The initial objective of these efforts will be to demonstrate the health value that can be achieved through health sector investments in weatherization, and to reduce risks for healthcare providers that invest in this new initiative. Ultimately, continued healthcare sector funding for weatherization projects would supplement costs and decrease taxpayer or electric ratepayer subsidies required on a per-project basis, thereby increasing the number of weatherization projects that could be completed using existing funding sources. In turn, increasing the number of weatherized homes per year will further improve population health by increasing the opportunities for households to receive weatherization-related health benefits.

6.3.1.4 Impact of Climate Change on Vermont's Insurance Industry

In June 2021, the Vermont Department of Financial Regulation (DFR) issued a report focusing attention on the impact of climate change on the state's insurance industry. Citing global climate change as a fundamental threat to Vermont's economy, environment, and way of life, DFR observes that climate change presents unique challenges for the property and casualty insurance industry. Severe weather events and extremes have resulted — and will continue to result — in increased residential and commercial property losses, including structural damage, relocation expenses, and loss of income. Climate risk, the report says, "may lead to underinsurance — or to no insurance at all. The result, substantial market dislocation, will include premium loss, higher rates of self-insurance, and an increased demand for disaster relief from the public sector."[196]

Responding to climate change may also present opportunities, where development of clean energy resources has produced new markets and products to insure. Insurers are well-positioned, DFR observes, to incentivize businesses, farms, and consumers to use energy efficient building methods in new construction and retrofitting existing structures; to install energy-efficient appliances and air-handling systems; and to transition to renewable energy. They can also help develop and market innovative products and services that support a reduction in greenhouse gas emissions, and partner with municipal, state, and federal agencies on policy matters such as improving building standards.[197]

The Department of Financial Regulation regards climate change as a critical issue that requires immediate action by individuals, businesses, and government alike, to reduce GHG emissions and climate-related vulnerabilities and improve resilience. DFR cites the financial impacts of climate change as an area of particular concern. Its report says Vermont insurance companies must "adequately assess climate-related risk and take the appropriate steps to ensure their continuing ability to cover claims and remain solvent. To prudently manage their reserves, insurers must evaluate the implications of climate-related trends for the companies and sectors in which they invest, including recent shifts from fossil fuels and coal to more renewable sources of energy."[198]

DFR notes that other states have taken steps to address climate-related financial risk in insurance markets. For example, the California Department of Insurance instituted a requirement for insurance companies to publicly disclose carbon-related investments. New York's Department of Financial Services

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[196] The Impact of Climate Change on Vermont's Insurance Industry. VT Department of Financial Regulation in coordination with Northview Weather, LLC. June 2021. https://dfr.vermont.gov/document/dfr-releases-report-examining-impacts-climate-change-vermont%E2%80%99s-insurance-industry

[197] Ibid, Impact of Climate Change, DFR

[198] Ibid, Impact of Climate Change, DFR

took a step toward adopting international best practices on climate-related financial supervision, setting forth an expectation that all regulated insurers "start integrating the consideration of the financial risks from climate change into their governance frameworks, risk management processes, and business strategies." [199]

As Vermont's financial regulator, DFR has committed to actions and initial steps to help reduce and mitigate the impact of climate change. Examples include these:

- Continue to advocate to the U.S. Securities & Exchange Commission in support of mandatory climate risk disclosures for publicly traded companies, which will assist traditional insurers in prudent reserve management and assist the Department in regulating captive-insurance entities.

- Develop guidance to address climate-related financial risks. In its guidance, the Department expects to encourage or require regulated insurance companies to evaluate potential climate-related financial exposure by conducting stress tests and scenario analyses, incorporate climate change into enterprise risk management processes, and assess and manage climate risk exposure in investments. In addition, the Department expects to encourage companies to assess their investments in carbon-intensive sectors and to evaluate whether such investments are consistent with their risk management goals.

- Support the development and marketing of innovative insurance products and services that support a reduction in greenhouse gas emissions.

- Encourage and promote the use of incentives for businesses, farms, and consumers to utilize energy efficient building methods in both new construction and retrofitting existing structures, install energy-efficient appliances and air-handling systems, and transition to renewable energy.[200]

Among DFR's action commitments was applying to join the Sustainable Insurance Forum, an international group of insurance regulators "working together to strengthen understanding and responses to sustainability issues" related to climate change. In October 2021, Vermont officially became a member of the Forum.

Recommendations

- *PSD, DFR, and insurance industry stakeholders should explore opportunities for collaboration on programs, such as weatherization, that reduce energy use and reduce risk.*

6.3.1.5 Weatherization Repayment Assistance Pilot

Governor Scott's proposed 2021 budget included provisions to make Vermont's homes and municipal buildings more affordable through investments in weatherization projects and efficiency upgrades.[201] The

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[199] California and New York examples cited in Impact of Climate Change, DFR
[200] Ibid, Impact of Climate Change, DFR
[201] Annual Budget Address, Governor Phil Scott. January 26, 2021.

Legislature shared this priority and dedicated significant funding for the purpose. One part of the funding supports what is now called the Weatherization Repayment Assistance Pilot. WRAP is focusing on the state's successful weatherization-related programs that need additional resources for scaling up to reach state carbon reduction and energy goals and is mobilizing the Vermont Housing Finance Agency (VHFA) to develop programs that leverage private capital for low-to-moderate income Vermonters through innovative, tariff-based programs.

Financing the technologies and services needed to reduce carbon and save energy has been a focus of PSD since the 2016 CEP, which identified tariffed on-bill finance (and on-bill repayment) as an option that allows local utilities to be an administrative mechanism to recover the cost of efficiency improvements through charges tied to the meter instead of the customer. Doing so would allow a utility's customers to install efficiency measures without the upfront capital or debt obligation.

In 2021, with funding allocated in Act 74 of 2021, and with support from the Department of Public Service and funds from Vermont Low Income Trust for Electricity (VLITE), VHFA initiated work on a pilot weatherization program for low- and moderate-income Vermonters that will use a financial arrangement to allow for on-bill repayment of weatherization investments, financed by VHFA and collected by utilities. If successful, this pilot will create the opportunity for VHFA to harness its bonding authority to leverage private capital, ultimately increasing the available funding for greater numbers of Vermonters to participate in energy savings programs. This initiative will test the scalability of the approach to drive capital into underserved segments of the energy efficiency landscape.

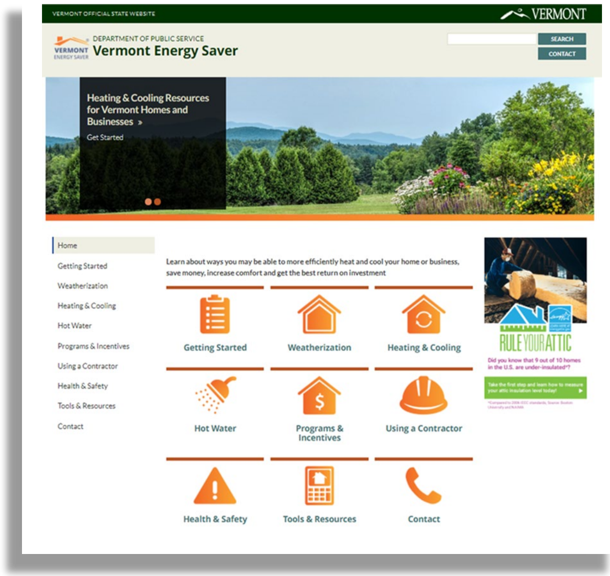
The WRAP is designed to complement existing programs and services such as the Weatherization Assistance Program by bringing energy efficiency improvements to more Vermonters who cannot currently access these programs. It will be important, when extending this new pilot to the rental market, to caution against tenants incurring increased costs due to weatherization.

VHFA engaged a wide range of stakeholders in considering the design and implementation of the pilot and explored the experiences of similar models in other states. Upon finalization of the program design, VHFA intends to implement the program in 2022, working with the Department of Public Service and within the Public Utility Commission process to create a standardized tariff that each natural gas or electrical distribution utility could opt into, so that program funds could be repaid through utility bills.

What makes this approach unique is that in it, the resources for energy improvement are not considered loans that are subject to traditional underwriting. This could make access to capital available for those to whom traditional financing mechanisms are unavailable or unwanted. The program will need to be carefully designed to address repercussions from potential non-payment, and to ensure that basic electric or natural gas service — increasingly a fundamental base necessity — is disconnected only in the most extreme circumstances, if at all. In addition, certain requirements such as the need to disclose the financing obligation when a home changes hands (e.g., when a renter moves out or when a home is sold) will need to be carefully outlined. Consumer protections that ensure no harm is done to frontline communities remain paramount in program delivery.

6.3.1.6 Thermal Energy Clearinghouse

Exhibit 6-12. Vermont Energy Saver Website



Building owners often have a limited understanding of the connections between energy use and potential building problems such as drafts, discomfort, air quality, and ice dams. In deciding whether to proceed with improvement projects, they also frequently do not realize or factor in non-energy benefits, such as increased comfort and safety, that result from energy efficiency improvements.

Building owners are also often unsure about how to start the process of improving the efficiency of their building, and where to get objective information. If this information is too difficult to find or understand, frustrated owners can give up. Some also view higher-cost energy audits as a barrier to starting the process toward energy efficiency upgrades. Yet receiving information — including a comprehensive roadmap to building energy improvements — is a crucial first step.

To help address this need, in 2019 the Department of Public Service launched the **Vermont Energy Saver** website.[202] It serves as a portal where consumers can access information about ways they can more efficiently heat and cool a home or business, save money, increase comfort, improve health and safety, and get the best return on investment. The website includes definitions and information about building efficiency and efficient thermal technologies, links and access to programs and services available to help facilitate, tips about helping find the right contractor, and many other resources. (Exhibit 6-12)

6.3.1.7 Energy Counseling Services

In 2021, the Energy Counseling Savings Group convened to meet the requirements in the Appropriations Act for SFY 2021 (Act 74). This group generated a plan for coordinated and effective delivery of counseling services that are designed to enroll and deliver energy savings programs to their target service populations. In October 2021, the Office of Economic Opportunity in the Department for Children and Families (DCF) submitted the report to the Legislature,[203] which in 2021 appropriated $1.5 million to DCF to launch a new three-year statewide energy and financial coach initiative through the state's community action agencies.

The report provides a definition for *energy saving counselor*, a term used interchangeably with *energy coach* to describe someone who helps people make decisions about energy, access resources to save energy, or use cleaner energy. This service focuses on both energy and financial savings. Energy counselors or

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[202] https://energysaver.vermont.gov/

[203] Energy Savings Counseling Report in Accordance with Act 74. Sec. E.234.3(b). Sarah Phillips, Office of Economic Opportunity. October 15, 2021.

coaches help people navigate toward achieving a goal, not just the initial steps, so that people increase their participation in energy saving and emission reduction programs leading to tangible results. Energy counseling services are intended to help people navigate a range of resources and are potentially an important equity investment for empowering typically marginalized Vermonters to be able to access resources and take action.

Efficiency Vermont and the Home Weatherization Assistance Program already have defined energy coaching programs. Other energy counseling-like services appear linked to specific sectors such as utilities, home heating, finance, or transportation, rather than taking a whole-budget or whole-household energy approach. Vermont's diverse communities will likely have different experiences with energy savings programs, different energy needs, and different approaches to decision-making. In keeping with the theme of equity in this CEP is the premise that energy counseling services will better achieve their desired results when informed by rural Vermonters, Vermonters with limited English, Vermonters with very low incomes, BIPOC Vermonters, and members of other traditionally marginalized groups.

The report outlines important opportunities to enhance and coordinate energy counseling services. An important next step is to implement and evaluate the new Energy & Financial Coach initiative led by Vermont's community action agencies, which will launch in early 2022.

6.3.2 Strategy: Encourage Efficient Buildings and Equipment

6.3.2.1 Building Energy Standards

Around 1,000 single-family homes are built every year in Vermont, as well as hundreds of commercial buildings. Once built, these structures can last 75 years or more, so it is critical to make sure they are durable, efficient, and use the best-available technology to avoid lost opportunities. Retrofits are often much more expensive than if those features were included during the original construction.

To this end, Vermont has instituted both residential (RBES) and commercial (CBES) building energy standards, which set minimum efficiency requirements for all new and renovated buildings, including additions and repairs. Building energy standards serve to avoid lost efficiency opportunities in long-lived infrastructure. The RBES have been in place since July 1, 1998, and pertain to all residential buildings three stories or less. The first CBES took effect January 1, 2007, covering all commercial buildings as well as residential buildings four stories or greater. Act 89 of 2013 gave the Department of Public Service the authority to develop residential "stretch" codes, which apply to all Act 250 projects and which municipalities also have the option to adopt. The residential stretch codes also now apply to all priority housing projects as defined in 10 V.S.A. § 6001 (30 V.S.A. § 55). The current RBES and CBES also address solar-ready requirements and EV charging infrastructure.

The standards are updated every three years through a state rulemaking process and are based on the International Energy Conservation Code (IECC) and American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) Standard (for CBES), with Vermont-specific amendments. Each update is designed to provide reductions in energy use and emissions over the life of a building, when compared with a similar building constructed under the previous standard. Any amendments to the energy standards must be consistent with state energy and housing policies; they must be evaluated relative to their technical applicability and reliability and be cost-effective and affordable from the consumer's perspective.

The most recent standards went into effect in September 2020.[204] The 2020 RBES includes all of the 2018 IECC energy efficiency requirements as well as additional, more stringent Vermont requirements, including: improved insulation levels and window U-values, required EV charging infrastructure for multifamily buildings of 10 or more units, EV charging infrastructure encouraged for all buildings, solar-ready design encouraged, more high efficiency lighting, and more efficient ventilation fans. The 2020 CBES is based on the 2018 IECC and the ASHRAE Standard 90.1-2016, and includes Vermont-specific additions such as more stringent envelope, mechanical, and lighting requirements as well as solar and electric vehicle infrastructure requirements.

One challenge in heating a building is the construction of a thermally efficient building shell, and the installation of an appropriately sized heating system to meet the structure's demands. The major components of an efficient building shell are sufficient insulation and minimizing the amount of air that escapes, while maintaining adequate ventilation to keep the building habitable. A well-constructed thermal envelope benefits both heating and cooling energy usage. For heating systems, the challenge is to install an efficient system that will meet the maximum heat load required for a building yet not be oversized. Also, the more efficient a heating system, the more it costs to purchase. Generally, gas boilers and furnaces are more efficient than fuel oil. Water heating presents a number of challenges that stem from fuel availability, size of anticipated hot water demand, and space to install equipment.

Compliance with the energy standards is currently self-certified after construction is completed, per statute. For residential buildings, certification may be issued by a builder, a licensed professional engineer, a licensed architect, or an accredited home energy rating organization. For commercial buildings, the design must be certified by the primary designer as meeting energy standard requirements, and the builder must certify that the building was constructed to the certified design. There is no requirement for review of the design of the building or inspection of the construction for compliance with the energy standards, although there may be oversight in municipalities that have their own code officials.[205] Statute currently dictates that the lack of a RBES or CBES certificate does not create a defect in marketable title[206] While one option to compel compliance would be to create such a title defect, it is unclear what impact this would have on builders or on the real estate market.

Lack of compliance undermines the objective of the building energy standards, particularly in the residential sector. Evaluations have found that in 2015 and 2016, compliance with the residential code was 66%, with 90% compliance reported for commercial projects. It is likely that code compliance is high

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[204] The VT Building Energy Standards are available on the PSD website at: https://publicservice.vermont.gov/content/building-energy-standards.

[205] As of July, 2013 municipalities must provide land use permit applicants that seek approval of a structure with information on the energy standards. Additionally, if the municipality requires a certificate of occupancy (COO) then receiving a Building Energy Standard certificate is a condition precedent to issuance of a COO. However, statute does dictate that a municipality have a COO requirement.

[206] See 30 V.S.A. § 51 and 30 V.S.A. § 53.

for commercial projects because they typically involve licensed architects and engineers, whose license is at stake if they design buildings that don't comply with the standards. There are currently no licensing requirements for builders of residential or commercial buildings in Vermont. Many other states have statewide building code officials, but that is costly infrastructure to develop, and often those code officials focus on health and safety issues rather than address energy standards . One of the reasons for poor compliance in the residential sector could be that not all builders are aware of the building energy standards. A statewide registry of builders and contractors would help raise awareness and keep builders informed of updates to the requirements.

Statute requires the building energy standards to be "cost-effective and affordable from the consumer's perspective,[207] although there is no guidance (e.g., the payback period) as to how cost-effectiveness is measured. As noted above, builders are inclined to keep upfront costs low enough that buildings are affordable, while maintaining quality. However, long-term operational costs and efficiency may not be emphasized in order to get a project built within a particular price range. Additionally, only looking at cost-effectiveness from a consumer perspective ignores benefits such as health improvements and carbon emission reductions. Without considering these benefits, building shell upgrades for efficiency, for example may not seem cost-effective.

A cost-effectiveness criterion that is customer-focused is a key component of any review of revisions to the energy standards that aim to keep building ownership and leasing in Vermont affordable, particularly at a time when the state does not have sufficient available housing and affordable housing. As the stringency of the energy standards increases, so will upfront building costs, which may cause affordability issues even if those upfront costs are offset by decreased operating costs. (Higher upfront costs may be a barrier to building ownership for some, and may cause increases to leasing costs.) For these reasons, multiple perspectives must be considered when implementing standards. Even though these may at times be in conflict, understanding differing perspectives can help in designing standards that can mitigate the issues of cost affordability.

In 2021, the Department held a series of Building Energy Code Collaborative meetings to provide an opportunity for stakeholders to discuss issues that arose during the last building energy code update process, along with other issues that aren't directly related to the update process but are code-related. The goal was to gather feedback and input to inform future decisions regarding RBES and CBES.

The Code Collaborative team reached out to 340 Vermont building stakeholders, who were invited to fill out a survey to identify issues they would like to see discussed at meetings and to answer questions about previously identified issues. Survey results were compiled and shared at the meetings, which included discussions on net zero buildings (including defining "net zero," "net zero ready," and consideration of energy code progression to meet a net-zero ready goal); code compliance; embodied carbon in building materials; cost-effectiveness and balancing affordable housing priorities with climate and energy efficiency goals; historic preservation; and other technical issues related to the energy codes.

[207] 30 V.S.A. § 51

The Code Collaborative process will inform the next energy code update, which should begin in late 2021. Informed by this process, several select opportunities related to Building Energy Standards are described below.

Net-Zero Ready by 2030

Net-zero buildings have zero net energy consumption: all their consumption needs are met through renewable energy systems and energy efficiency. The Department of Public Service defines a net-zero ready building as "a highly efficient and cost-effective building, designed and constructed so that renewable energy could offset all or most of its annual energy consumption."[208] **This Comprehensive Energy Plan sets a target to achieve net-zero ready construction for all newly constructed buildings by 2030**.

The Department proposes defining a "highly efficient" building as one that achieves a certain energy use intensity (EUI), to be determined but varying by at least building type, and perhaps also by building size. The upcoming building energy standard updates should then be focused on reaching these targets by 2030. During the upcoming updates, the Department will also consider with stakeholders whether and how to address building embodied carbon emissions. It will be important to consider whether to include embodied carbon codes in the context of broader emissions accounting across all energy policy. In other words, energy policy should be consistent in its consideration of carbon impacts.

Setting a target for net-zero ready buildings by 2030 would provide a pathway for the next energy standard updates to follow and would let the market and stakeholders know the direction the energy standards will be headed. This will allow time for the workforce to be trained in any new building techniques that will be required to achieve net-zero ready construction. A rampup will also allow for careful consideration of the cost impacts and potential solutions for keeping housing in Vermont affordable and attainable. This goal will also ensure a certain level of increased stringency on efficiency, regardless of what is proposed in the IECC or ASHRAE, and will allow for the smallest-sized renewable energy system possible if the building owner decides to go to a fully net-zero building.

Commercial Stretch Code

The General Assembly should provide the Department of Public Service with the authority to adopt a commercial stretch energy code that will apply to all Act 250 and priority housing projects and can be adopted by municipalities, similar to the residential stretch energy code. Having the PSD adopt a commercial stretch building energy standard would provide a consistent standard if municipalities choose to set requirements beyond the base energy standard — which is important to send clear signals to builders and contracts. It also primes the market for the next code revisions (often the base code is moved up to the previous stretch code requirements). One challenge is that it could cause some confusion

[208] This definition is very similar to the U.S. Dept. of Energy definition for a Zero Energy Ready Home, which is described 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."

and angst amongst builders and architects regarding which standard is required for a given project; it could also cause inequities and cost differences among buildings for which they are required.

Builder Registration

Vermont should require registration of all builders with the VT Office of Professional Regulation (OPR), and research the potential for certification and/or licensure requirements in the future.209 A builder registration would provide an avenue for the PSD to contact all builders regarding new updates and training opportunities. More progressive steps, such as certification requirements, would ensure that all builders have a sufficient understanding of building science and have acquired certain skills.

Licensing requirements would likely boost compliance with energy standards, as it could jeopardize a builder's license and therefore livelihood if they didn't meet energy standards or other requirements, similar to other professions such as electricians and plumbers. This would also increase compliance for a much lower cost than developing a statewide building code official infrastructure to enforce the energy standards. However, these steps could be barriers to market entry, or could cause builders to avoid acquiring licensure (and operate without a license), where increased access to information alone could improve compliance rates. These impacts must be better understood before any more progressive steps can be taken.

Cost Effectiveness Evaluation

As described above, the energy standard updates must be "cost-effective and affordable from the consumer's perspective."F210 To determine cost-effectiveness, the PSD has in the past used simple payback, return on investment, savings to investment ratio, and cash flow. Because current fossil fuel prices remain relatively moderate, particularly for natural gas, many efficiency upgrades to the highest-performing buildings are not cost-effective, even if they would be if considering health benefits were considered, along with a social cost of carbon. Evaluating cost-effectiveness from multiple perspectives will allow for a more transparent consideration of proposed standards.

Mandatory 200-Amp Service for Residential New Construction

The Department of Public Service should consider requiring residential new construction to install a minimum of 200-amp service to a home. A 200-amp service installed during the initial construction of a home would allow reasonable capacity within the electric distribution panel to allow for electrification of heating loads traditionally served by fossil fuels, along with the capacity to charge an electric vehicle. If this isn't installed during initial construction, building owners will incur additional costs later to retrofit existing systems. But because a 200-amp service will be incrementally more expensive than a 100- or 150-amp service, due to the cost of the higher-capacity wire required, it would increase upfront new-

[209] H. 157, which included this type of registry requirement, was passed by the Vermont House of Representatives in the 2020-2021 session, but it didn't pass the Vermont Senate.
[210] 30 V.S.A. § 51 for RBES and 30 V.S.A. § 53 for CBES

construction costs. Support should also be provided to assist developers of building in meeting this requirement.

Recommendations

- *The Department of Public Service's energy code updates should put Vermont on a path so that all newly constructed buildings are net-zero ready by 2030.*
- *The Department should consider both societal and customer cost effectiveness in analysis of code updates, starting immediately.*
- *The Legislature should authorize the Department to adopt the CBES stretch code by 2023 and authorize municipalities to adopt it.*
- *The Legislature should pass a builder registry requirement, with a goal that 100% of builders are registered with VT OPR and aware of the building energy standards and training opportunities by 2025.*
- *The Department of Public Service should, in the next code update process, consider requiring that all new constructed homes have a 200-amp service.*
- *Municipalities should consider requiring permitting and certificate of occupancy for building construction. They should also provide information on the RBES and CBES when these types of permits are being applied for per statue requirement.*
- *Municipalities should consider hiring a code official to review construction documents, receive RBES and CBES certificates, and enforce the building energy standards. If there isn't enough construction to justify a municipal code official, perhaps a regional official could be paid by multiple municipalities.*
- *Municipalities should consider adopting beyond base code standards and adopt the stretch code versus other standards, to maintain consistency across the state.*

6.3.2.2 Appliance Standards

Appliance efficiency standards are a highly cost-effective policy for reducing energy and water costs for Vermont residents and businesses, as they set minimum efficiency standards for household and commercial appliances and equipment that lock in savings for customers. Generally, appliance standards are the domain of the federal government, since federal regulations preempt state standards for a given type of equipment or appliance — but the Vermont Legislature has passed two bills that establish appliance and equipment efficiency standards for products sold or installed here.

Act 42 of 2017 adopted the federal efficiency standards in effect on January 19, 2017, for several products in the event that the federal standards are repealed or voided. Those products include boilers, ceiling fans, clothes dryers, clothes washers, dehumidifiers, dishwashers, furnaces and furnace fans, pool heaters, refrigerators and freezers, room air conditioners, set-top boxes, televisions, and water heaters. Act 139 of 2018 sets Vermont standards for products that are not covered by federal standards — such as computers, computer monitors, air compressors, commercial dishwashers, commercial fryers, commercial hot-food holding cabinets, commercial steam cookers, faucets, showerheads, portable air conditioners, portable electric spas, residential ventilating fans, uninterruptible power supplies, and water coolers.

Vermont statute does not grant any explicit enforcement authority over appliance standards, so compliance is effectively based on the honor system. The motivation to enact these standards was in part to help implement appliance standards in a "critical mass" of states, to force manufacturers and the U.S. EPA to cooperate in creating uniform national standards rather than try to comply with a patchwork of different state standards. One challenge of this approach is that without a critical mass of states or strong enforcement, the standards could be ineffective. Also, compliance may be a challenge for retailers and distributors without reliable and easy to access database of qualifying equipment. Without enforcement, retailers and distributors who comply with the standard may be at a competitive disadvantage to those that do not comply.

More efficient appliances are often higher-priced than present-day baseline equipment, which presents a barrier to low- and moderate-income households and could drive customers to the used appliance market. In rental housing, appliance standards could increase equipment costs without providing benefits to the purchaser. The legislation that established Vermont's appliance standards did not provide for implementation or enforcement costs. There have been no studies done to gauge awareness of the standards, let alone compliance.

Awareness and compliance can be improved by providing an online database of qualifying models of the various appliances covered. Since the Vermont standards are based on the model bill promoted by the Appliance Standards Assistance Project (ASAP), online databases can be implemented as a collaborative effort among the states that have adopted similar appliance standards. Awareness and compliance can be improved by establishing an online database of qualifying models of the various appliances covered. Since the Vermont standards are based on the model bill promoted by ASAP, online databases can be implemented as a collaborative effort among the states that have adopted similar appliance standards. Once they are fully implemented, appliance and equipment efficiency standards are opaque to the consumer and require no additional effort to comply at the retail level.

Recommendations

- *Collaborate with other states with similar appliance standards to create a publicly accessible online database of qualifying equipment.*

6.3.2.3 Building Energy Labeling

Building owners sometimes lack awareness of or information about the energy performance of their properties, making energy efficiency hard to prioritize when making buying and retrofit decisions. Energy ratings and labeling can be used to provide information on a building's energy use, where owners or potential buyers can compare different buildings' efficiency levels, similarly to the MPG sticker on new cars. This information may also encourage investments in efficiency by either a prospective buyer or a property seller. For home buyers, this also presents an opportunity to include any needed efficiency improvements in an energy-efficient mortgage.

Act 62 of 2019 reestablished the Residential and Commercial Building Energy Labeling Working Groups that originally were convened under Act 89 of 2013 to discuss building energy disclosure initiatives for Vermont. The working groups' January 15, 2021 report to the General Assembly[211] recommended voluntary building-energy disclosure initiatives; a tool for gathering energy data and creating a label for residential and commercial buildings; and a presentation format for the labels that would provide a simplified overview of the home or building energy use. The working groups also recommended that the selected tools and labels be used by any municipalities that choose to require building energy disclosure, to create consistency throughout the state on what information is included and displayed on a Vermont label.

6.3.2.4 Act 250

Building energy codes in Vermont are supplemented by Act 250, Vermont's land use and development statute that requires review of proposed major development and subdivisions prior to construction. Before a project that falls under Act 250 is permitted, the developer must satisfy a number of environmental, social, and fiscal impact criteria — including criterion 9F, which applies to energy conservation. The statute states that a permit will be granted only if "the planning and design of the subdivision or development reflect the principles of energy conservation and incorporate the best available technology for efficient use or recovery of energy." Approximately one quarter to one third of all commercial new construction projects go through Act 250 review.

As it relates to criterion 9F for commercial construction applications, *best available technology* has been interpreted by the Natural Resource Board to mean compliance with the statewide version of the Commercial Building Energy Standards that is effective at the time an application is submitted. For commercial buildings, the current baseline to satisfy 9F is the Vermont Commercial Building Energy Standards, enacted on September 1, 2020, which superseded the version enacted on March 1, 2015. For residential buildings, meeting the stretch code requirements contained within the Residential Building Energy Standards, enacted on September 1, 2020, is required for compliance with criterion 9F.

[211] "Residential Building Energy Labeling Working Group & Commercial and Multiunit Building Energy Labeling Working Group: Report to the Vermont House Committee on Energy and Technology and the Senate Committees on Finance and on Natural Resources and Energy" is available at: https://publicservice.vermont.gov/energy_efficiency/buildingenergy_labeling

6.3.3 Strategy: Continue to Enhance the State Energy Management Program

The State Energy Management Program (SEMP) operates within the Vermont Department of Buildings and General Services (BGS) to administer the interest of the state in all energy management measures, the implementation of energy efficiency and conservation measures, and the use of renewable resources in state-owned and -operated buildings and facilities, and in space leased to the state. Authorized by Act 58 of 2015, BGS has leveraged services from Efficiency Vermont to develop and deploy an internalized energy saving performance contracting model for taxpayer benefit through the SEMP. The SEMP is managed by BGS in accordance with statute, to help achieve state energy goals; the program's intent is to accelerate energy management measures, implementation of efficiency and conservation, and the use of renewable energy resources for state buildings and facilities.

In FY21, BGS successfully audited over 376,000 sq. ft. of building space, up from around 246,000 sq. ft. in FY20. Program results for FY21 showed first-year savings of $158,367 and lifetime savings of $1.3 million for energy savings of 284,134 kWh and 15,510 MMBtu. While the program saw a decrease in project savings because of difficulties during the pandemic in initiating and completing construction projects, this base of audits has provided a robust pipeline of potential projects to be implemented in the future.[212]

In 2021, BGS worked with the PSD, Efficiency Vermont, and the Vermont League of Cities and Towns to build on the successes of the SEMP in helping municipalities and schools in Vermont to reduce their energy consumption, save taxpayer funds, and accelerate the rate of building-efficiency project completion. Starting in 2022, BGS will pilot the expansion of SEMP into the municipal market segment, which could include schools. The intent of the expanded program is to create a mechanism for helping to advance the goals established in the CEP, and to support implementation of the Vermont Climate Action Plan. This initiative will leverage a successful government program to fill a gap in Vermont's municipal energy sector, by providing energy performance-contracting services to locations that have traditionally been underserved due to the complexity of financing and contracting associated with these types of construction projects. As the expansion to the SEMP incorporates schools in the coming years, the program would benefit from maintaining updated inventories of school facilities and ensuring that schools have access to training for facilities managers.

6.4 Thermal Energy Use Pathway: Enhance Low-Carbon Technology and Fuel Choices

Energy consumption serves a variety of end uses in different types of processes and buildings — and the choice of energy fuel and enabling technologies should match end-use application and space with the most efficient, renewable, affordable, stably priced option that fully serves the end use. Vermont home and business owners are often limited, however, in the types of fuel they can choose from to meet their energy needs, due to factors such as capital investments and limitations in delivery infrastructure. Many homes and businesses heat with petroleum products in part because of substantial investments in oil or propane heating systems.

[212] Annual Report: State Energy Management Program. July 1, 2020 to June 30, 2021. Vermont Department of Buildings and General Services. Pg. 4

Once owners invest in equipment to heat a space or manufacture a good, they will generally use that equipment until the end of its life. Even if the fuel that powers that technology becomes more expensive or the price becomes volatile, making business planning difficult, an investment in equipment "locks" the user into a certain fuel type for the life of that equipment. Similarly, the infrastructure for pipeline-delivered natural gas only covers a small portion of the state; so despite that fuel's price stability and lower carbon content, many Vermont homes and businesses do not have access to this option.

Moving toward renewable sources in building heat and manufacturing is a high priority for the state as it strives to meet the targets established in this CEP and the GWSA; and boosting access to low-carbon fuels such as electricity, renewable natural gas, advanced wood heat, and biofuels will take substantial efforts by national, state, local, and private stakeholders. While the state strives to achieve these goals, it must also acknowledge that renewable fuel sources face challenges in adequately meeting the demands of some large industrial and commercial users, and that adoption of many low-carbon fuels has not been equitably distributed among Vermont communities. For example, the adoption of cold-climate heat pumps has so far occurred primarily within towns with moderate to the lowest energy burden, instead of those with high or the highest burden.[213] In addition, particularly in manufacturing, few renewable sources can provide large amounts of heat energy, on demand, at an affordable and stable price. Renewable natural gas is one option, but it is not currently available in necessary quantities, nor is the infrastructure available across the state. Similarly, biofuels offer another pathway to meet such demands, but local markets and supply chains for these fuels are still in development.

It is critical that energy needs for end users be met adequately and equitably with low- or no- carbon fuels — and providing Vermont homes and businesses access to a wide variety of fuel choices will allow them to select the most effective fuel for their application. In this light, the following sections discuss strategies to advance access to low-carbon fuels and enabling technologies. The strategies discussed include a Clean Heat Standard, a "performance-based" obligation to reduce emissions from this sector, future Tier III programs for energy transformation, and the promotion of the use of low-carbon fuels such as electricity, advanced wood heat, biodiesel, and renewable natural gas, among others.

6.4.1 Strategy: Consider a Clean Heat Standard

While Vermont currently has a variety of programs that seek to promote low-carbon fuel choices in various ways, the state does not currently have a unifying mechanism to ensure reduced emissions from this sector, similar to the Renewable Energy Standard (RES) in the electric sector. The Energy Action Network has over the last year convened a "Network Action Team" to evaluate and design a Clean Heat Standard (CHS) that would create a market for a range of clean fuel choices.[214] As the RES does for electricity, a CHS would seek to create a performance-based, technology- and fuel-neutral obligation on the heating fuel providers that it covers, whether wholesale or retail, to procure an increasing percentage of their retail sales from low-carbon thermal solutions, at a pace set by the Legislature.

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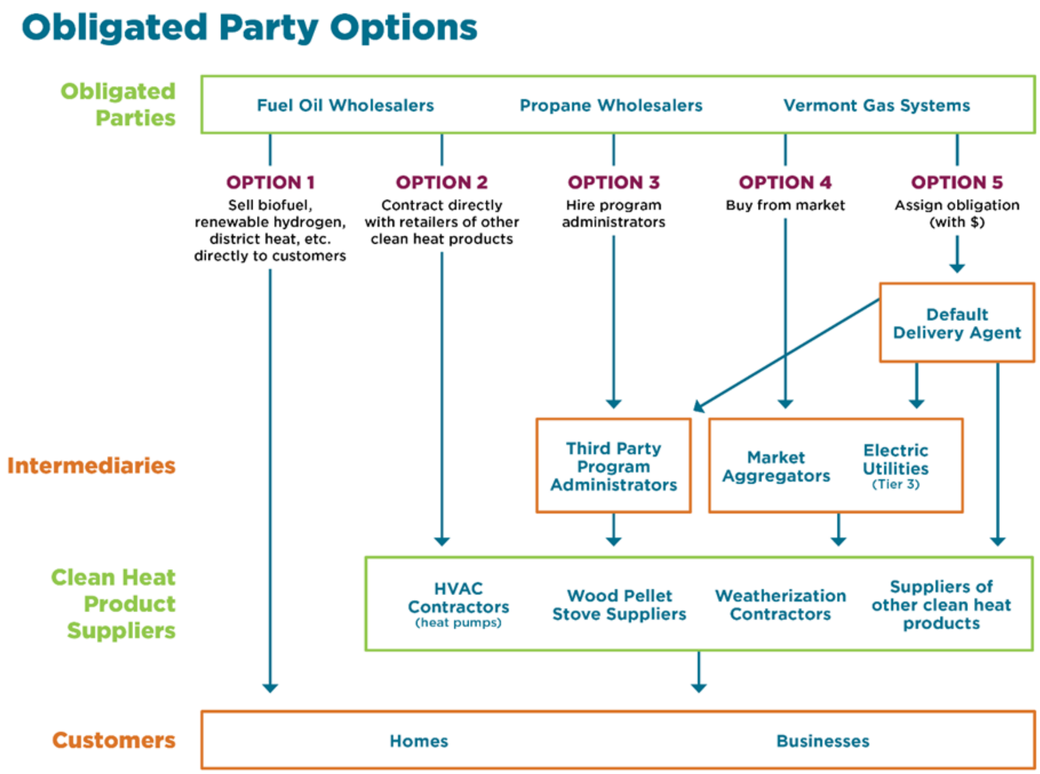
[213] 2019 Energy Burden Report. https://www.efficiencyvermont.com/news-blog/whitepapers/vermont-energy-burden

[214] Cowart, R. & Neme, C. (December, 2021). Energy Action Network White Paper: Clean Heat for a Cooler Planet . https://www.eanvt.org/wp-content/uploads/2021/12/CHS-Final-December-16-2021-copy.pdf

Obligated entities could comply with the requirement through an array of supply- or demand-side opportunities, such as increasing the supply of renewable fuels (e.g., biomass-based diesel or renewable natural gas) or by installing clean heat measures (e.g., weatherization. advanced wood heat, or cold-climate heat pumps). Compliance would be demonstrated by retiring clean heat credits, like RECs, associated with emissions reductions from clean heat measures as established by a Technical Advisory Group (TAG), as is used in the EEU and Tier III programs. Obligated entities would be required to acquire clean heat credits on an annual basis, either through creating their own credits or by contracting/purchasing them from entities such as energy service providers or retail fuel dealers. Exhibit 6-13 shows the potential options for obligated parties to acquire credits.[215]

Exhibit 6-13. Clean Heat Standard Design Options



There would be many potential benefits of pursuing a CHS in Vermont. Unlike other programs, through a calibrated obligation schedule a CHS would provide a mechanism to deliver GHG emissions reductions on a scale projected to meet requirements under GWSA in a technology- and fuel-neutral way. The competitive market design for clean heat credits could drive innovation and entrepreneurship in the clean heat space, both working to deliver least-cost solutions and providing opportunities for economic development in Vermont. Obligating wholesale providers would further provide a high degree of flexibility in how to best meet the obligation.

The structure would build off policy strategies and lessons learned from implementation of the Vermont RES and EEU programs (as well as national renewable portfolio standards), while allowing participation by wide variety of stakeholders: wholesalers, energy service providers, utilities, fuel dealers, and potential new market entrants. Finally, creating a market for clean heat credits would enable revenue streams to help finance projects (as REC markets currently do in the electricity space) that might not otherwise occur, addressing a concern highlighted in the PUC's Act 62 final report.[216] By allowing flexibility and innovation, this market for clean heat credits is likely to drive toward least-cost solutions, consistent with policy principles of §30 V.S.A. 202a and this plan, although policy design details would be critical to ensuring that least-cost solutions are borne out in practice.

While presenting many possible benefits, a CHS is not without uncertainties or challenges. While the CHS structure creates an emission reduction obligation to drive down pollution, it does not specifically cap emissions, so does not guarantee that requirements for GHG emissions reductions pursuant to GWSA would be met. There would also be a remaining uncertainty about the feasibility and legality of placing obligation on wholesale fuel providers. Although a potential alternative structure could place the obligation on retail sellers of fossil fuels, such an approach would likely be more complex to implement, administer, and evaluate compliance, requiring enhanced capacity of state agencies (like the PSD and PUC) to oversee. Further questions remain regarding how such a standard would work collaboratively with the existing programs and policies, such as the RES Tier III program and thermal efficiency efforts.

Several equity considerations are associated with a potential CHS, including the need for mechanisms to address inequities in the distribution of the benefits of clean heat solutions across Vermont communities — such as those that currently experience high thermal energy burden — and to ensure equitable access moving forward for communities such as renters, low-income, small businesses, and BIPOC Vermonters, among others. This could be done through carve-out of obligations specifically focused on different communities, credit multipliers for measures implemented in these communities, and/or the promotion of other complementary programs. The policy design would need to ensure the collection of adequate data to help identify communities in need of support, and to measure progress toward delivering that assistance.

It is also necessary to ensure that low-income natural gas customers are not left paying for a higher fraction of fixed system costs (e.g., a cost-shift for customers unable to participate in other CHS alternatives). As the state moves away from fossil fuels, a CHS would also need to provide an avenue for transitions that support fuel dealers and others who rely on fossil fuels to make a living. This highlights the need for consultation during the design phase with impacted communities — both those adopting clean heat solutions and current providers of fossil fuels — regarding the structure of the policy, along with avenues to hold the policy accountable for reaching equity objectives.

Recommendations

- *Consider the adoption of a Clean Heat Standard for Vermont. The Public Utility Commission should consider, by January of 2023, completing a study of the potential cost and equity implications of a Clean Heat Standard under different design parameters and expected measures, including the expected resources necessary to administer such a program. Following review of the*

[216] Vermont Public Utility Commission (Jan 15, 2021). Report to the Vermont State Legislature: Act 62 — Final Report on All-Fuels Energy Efficiency. https://puc.vermont.gov/document/act-62-final-report-legislature-all-fuels-energy-efficiency

PUC's CHS study, the Legislature should determine whether to authorize the Commission to adopt a CHS, provided it can be structured to equitably meet GHG requirements at a reasonable cost to Vermont consumers.

6.4.1.1 Tier III of the Renewable Energy Standard

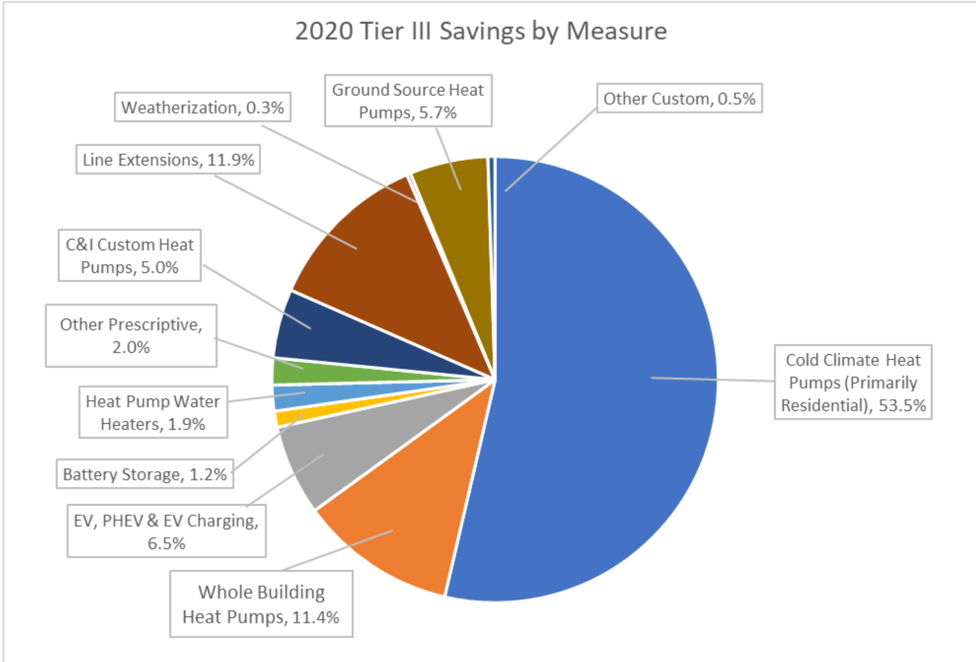
Act 56 of 2015 created Vermont's Renewable Energy Standard (RES). Tiers I and II of the RES are traditional performance standards for distribution utilities, requiring that they procure renewable power with different characteristics. Tier III of the RES was the first standard that required distribution utilities to achieve fossil-fuel savings from their customers through "energy transformation" projects (or by retiring additional Tier II Renewable Energy Credits). Tier III obligations required most utilities to acquire MWhe (megawatt hour-equivalent) savings of 2% of retail sales in 2017, with that requirement increasing by an additional two-thirds of a percent each subsequent year. (Some smaller municipal utilities obligation began in 2019.) The obligation provides utilities with flexibility to acquire savings at the least possible cost.

As it was envisioned, Tier III measures have focused to date on electrification measures, both custom and prescriptive. If new demand is managed well (See Chapter 4 on Grid Evolution), these electrification measures can help increase utility revenue and contribute to embedded utility costs, putting downward pressure on rates. Like Tiers I and II, the costs of Tier III of the RES are embedded in rates; but Tier III brings the potential benefit of additional customer revenues.

Exhibit 6-14 shows that in 2020, nearly 74% of fossil fuel savings came from cold-climate heat pumps (residential ductless mini-split, whole-building, or C&I custom projects). Utilities have also reduced fossil fuel usage through various means, including line extensions,[217] weatherization, industrial compressed natural gas burners, and electric boilers.

[217] Many of these line extensions are related to providing sufficient electric service for a sugaring or sawmill operation to switch away from diesel generators.

Exhibit 6-14. Renewable Energy Standard 2020 Tier III Savings by Measure



As noted in Section 6.4.1.1, Tier III effectively requires electric ratepayers to fund not only reducing fossil fuels from the electric mix, but also cleaning up fossil fuels. A Clean Heat Standard, or other policies directed at unregulated fuels, would better align the costs and benefits of state programs. One design option for the Clean Heat Standard is to incorporate Tier III, allowing Tier III measures to qualify for credits under the CHS. This comes with pros and cons. It could provide a revenue source to further support electrification; but if managed improperly, it could also lead to double counting or create confusion in the marketplace, with different providers offering similar services.

While several improvements to the Tier III program could be made (and are being considered, such as better tracking the distribution of benefits of energy transformation measures and evaluating specific measures to better understand their impact), the program itself has helped to kickstart electrification of thermal and some process fuel use.

Recommendations

- *The Department of Public Service should continue to evaluate equity and cost-effectiveness while verifying measure savings of Tier III programs in its RES reports.*
- *Consider whether Tier III should become a part of any Clean Heat Standard. If Tier III is part of a CHS, ensure that CHS targets are set to achieve incremental savings beyond Tier III programs.*

6.4.2 Strategy: Continue to Encourage Cleaner Technologies and Fuels

Regardless of whether a Clean Heat Standard is adopted, cleaner technologies and fuels are available for Vermonters, and they should continue to be pursued equitably. This CEP calls for a strategy to continue to expand low-carbon and renewable supply to meet demand, including electrification as well as developing sufficient sustainable biofuels to supply difficult-to-convert segments of the fossil fuel market. To respond to this challenge and improve access to fuel choice, the state plans to encourage use of the most efficient, renewable, cost-effective technology that will meet users' end needs. This supports the "all of the above" approach to meeting our energy needs, in accordance with the principles of 30 V.S.A. §202a and this plan.

Builders and building managers must balance a variety of objectives and limitations when making capital investment and design decisions that affect fuel type. For all fuel types, builders and building managers should, when possible, choose the most efficient system to deliver heating and cooling. In most cases, a life-cycle cost analysis will point to the most efficient system — but short-term decision-making that is often focused on upfront costs may suggest a less efficient system.

Policies that encourage the communication of long-term energy costs will lead to developers being able to decide on efficiency. However, non-market factors, such as environmental damages, are not always considered by builders or building owners, and are an important consideration in making the decision for more efficient heating systems. In these cases, state intervention, including incentives and possibly regulation, may be appropriate.

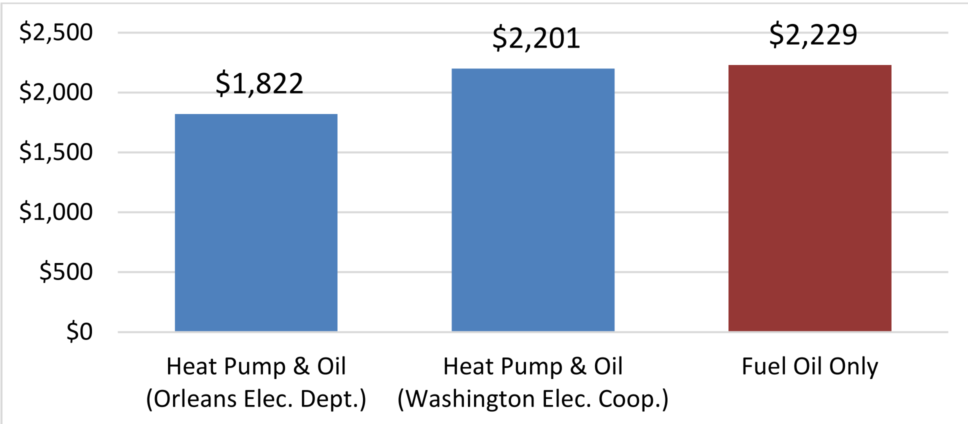
6.4.2.1 Promote Electrification of Thermal Loads

Advances in technologies such as air-source and ground-source heat pumps provide promising opportunities for increasingly electrifying thermal loads. Heat pumps have the potential to meet a significant portion, if not all, of a home's thermal demands. When powered with renewable or low-carbon electricity, heat pumps can significantly reduce emissions from any fossil fuel-served heat system that they displace. Heat pumps also provide air-conditioning; anecdotal evidence suggests that one of the reasons customers are installing heat pumps are for the cooling capability. If they replace window air conditioners, that can mean energy and cost savings for customers — but if the heat pump provides a customer with new cooling service, that will add load to the grid, and operating cost for the customer.

Air-source heat pumps use electricity to transfer thermal energy from the outside air into a home, or in the case of cooling to remove it from a home. The seasonal heating performance factor is approximately 240%, but the time-specific efficiency varies due to temperature, and could drop to as low as 80% in extreme cold. The costs for these systems range for $3,000 to $12,000, installed, depending on the size of the system and number of internal heads — whether it is a single ductless heat pump, a multi-head ductless system, or a whole home system (useful for buildings that currently rely on forced hot air). Both Efficiency Vermont and electricity distribution utilities support incentives for the purchase of heat pumps (through Tier III; see Section 6.4.1.1).

While cold-climate heat pumps come with great advantages for the climate, customer costs remain a concern. Exhibit 15 shows a sample customer operating cost for a single mini-split ductless heat pump that displaces approximately 40% of fuel oil demand, with fuel oil prices at $3.11. As shown, in some utility service territories, the operating cost of the heat pump is approximately equal that of to the existing unit. This underscores the need to keep electricity rates low and continue to investigate options that will provide more value to the customer and the grid, such as trading grid controllability for a monthly payment stream. In addition, continuing to support incentives for upfront costs, as currently provided by both distribution utilities and Efficiency Vermont, will help encourage customers to make the switch. Additional revenues from the kWh sales associated with heat pumps — to the extent they do not require infrastructure upgrades — can help put downward pressure on electric rates.

Exhibit 6-15. Heating Cost Comparison



While air-source heat pumps offer great promise for reducing overall energy consumption and emissions and are supported by this plan, the installation of heat pumps to electrify Vermont's heat load raises some concerns that must be addressed over the coming years. First, heat pumps will be operating in cold winter hours, and in hot summer hours for air conditioning. This is expected to drive up Vermont's peak electric demand. Some of the most expensive hours in the year for electricity occur during the winter when units are expected to be operating, and during monthly peak hours on which regional transmission costs are charged. Second, reliance on electricity for heating underscores the need for reliability and resilience of the electric grid. As highlighted in Chapter 4 on Grid Evolution, increased demand from these resources will need to be carefully managed.

Third, most heat pumps leak some of their refrigerant during their operational lifetime [218] [219] [220]. Refrigerants used in heat pumps have a global warming potential 2,088 times that of carbon (the refrigerant typically used is R-410A). It is critical that Efficiency Vermont, which has a voluntary refrigerant management program supported by the Department of Public Service and approved by the Public Utility Commission, continue to partner with U.S. DOE to encourage natural replacements for current high global warming potential (GWP) refrigerants. Even with current refrigerants and leakage, emissions benefits of heat pumps are significant; but if refrigerant leakage is not managed, progress toward Vermont's climate goals will be reduced.

Ground-source heat pumps (GSHP) rely on the same thermodynamic principles as air-source heat pumps but take thermal heating and cooling energy from the ground, which maintains a steady average year-round temperature in comparison to outside air. As a result, these systems maintain a high level of efficiency year-round. These are extremely efficient systems for heating a whole building and will operate

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[218] 'Impacts of Leakage from Refrigerants in Heat Pumps' Eunomia Research & Consulting Ltd, March 2014
[219] 'Intergovernmental Panel on Climate Change' UNEP 2003. Chapter 5
[220] 'Future of Air conditioning for Buildings' USDOE. July 2016 Page 62

in all the extremes of Vermont's weather. GSHPs are designed to link to central heat distribution systems, much as furnaces do — but they provide a lower-temperature heat, so they work best with forced air or radiant heat. They can be difficult to retrofit into buildings, and need outdoor space for ground loops or wells to access the latent heat underground.

In applicable new construction, GSHPs work extremely well and can provide heating and cooling consistently and highly efficiently year-round without being impacted by outdoor air temperature. The system requires significant upfront capital investment, either to install the requisite closed-loop piping or for drilling additional wells to provide the water an open-loop system needs to operate. These systems cost $15,000 to $25,000 to install but have a long operational lifetime. They can offer significant savings on annual heating and cooling costs.

Burlington Electric Department and Vermont Gas Systems, in particular, are exploring the opportunity for GSHP applications in their service territories. Although the application may be limited, Vermont should continue to explore and encourage the appropriate use of this technology.

Recommendations

- *Continue to encourage the installation of heat pumps, particularly in weatherized or already high-performing buildings, in partnership with weatherization efforts.*
- *Encourage innovative rate designs that encourage heat pumps and manage their operation consistent with requirements of the grid.*
- *Enable Efficiency Vermont to continue to pursue refrigeration management alternatives for the heat pump market in Vermont, to lower GWP refrigerants.*

6.4.2.2 Developing the Advanced Wood Heat Market

The use of wood energy for space heating and process heat in Vermont presents a valuable opportunity to replace fossil fuels for space heating and process heat. Approximately 21% to 22% of total heating demand in Vermont is currently met by wood heat, with cordwood alone supplying almost 18% of all heating.[221, 222]

Not all buildings or industrial uses can easily be converted from fossil fuels to electricity — and for those building and process-heat applications where efficient electric heat is not likely, advanced wood heating (AWH) is a recommended renewable energy source. AWH is different than other wood heating, in that it utilizes highly efficient combustion technology; produces low levels of emissions; supports healthy forest ecosystems; and consumes local wood. What is considered "highly efficient" and a "low level of emissions" evolves with technology improvements, and "local wood" could fluctuate with changes in the

221 https://publicservice.vermont.gov/sites/dps/files/documents/Renewable_Energy/CEDF/Reports/AWH%20Baseline%20Report%20FINAL.pdf

222 Using 2019 EIA data together with data from the Agency of Natural Resources and the American Community Survey

local and regional wood markets. Accordingly, support of AWH should be adaptive to ensure that it moves the wood heating market toward the state's goals for energy, forest ecology, carbon, and air quality.

Supporting AWH provides several benefits.

First, Vermont's long history of using wood for buildings and heat has created deep cultural and economic connections with the forests and wood as a warming fuel and building material. These connections have developed an able workforce, sustainable silviculture and forest ecology knowledge, forest-products businesses, and related value-chain infrastructure that together allow us to manage our forests to remain as forests, with their myriad of benefits, while also harvesting wood for fuel and timber. Vermont's strong forest-economy sector provides an opportunity, not available to many other states, to use wood as a significant partial solution to our carbon emission, energy, and economic challenges.

Second, Vermont, together with the neighboring Northern Forests of the region, contains a sustainable amount of new wood growth, enough to increase the use of wood as a heating fuel so that it meets 35% of our thermal needs by the year 2030 and beyond. Across the Northeast, wood-fueled power plants are being closed or phased out as more efficient and cheaper forms of renewable energy come online. This, combined with a long-term decline in the demand for wood pulp for paper, increases the supply of wood available as a heating fuel. In 2021, to help ensure the sustainability of the wood harvested for heating, the Department of Forests, Parks and Recreation proposed a new rule for the renewability of wood heat projects.[223] By following these guidelines, wood harvesting can be done sustainably in an environmentally sound manner.

Third, AWH provides many economic benefits to Vermonters. The use of AWH keeps heating dollars in the local economy, supporting local forest-product jobs and businesses. AWH allows Vermont to take advantage of the many economic and environmental benefits of keeping forests as forests. The economic viability of Vermont's working lands is challenged by changing land use, development pressure, and macroeconomic trends in the forest product economy; Vermont is losing an estimated 2,123 acres of forestland a year to rural and suburban development.[224] Healthy markets for low-grade wood, as is used for wood heat, help to keep managed forests in commercial operation, lessening the economic pressures on forest landowners to subdivide and develop their land. Along with less fragmentation, a healthy forest economy can provide healthy wildlife habitat, improved water and air quality, and other ecosystem services.

Fourth, peak winter electrical loads could be managed or reduced with use of wood heat and/or the combination of wood heat and heat pumps. During cold snaps, advanced wood heating technologies, including wood stoves, provide opportunities for homes and buildings to rely less on electric technologies that can exacerbate peak electric costs. In this way, AWH provides resiliency benefits to customers who use heat pumps as their primary source of warmth. Also, a much smaller and affordable battery system could provide power to an AWH system during a winter power outage than would be necessary to power heat pumps. Thermal storage of AWH could be part of utility demand-response

[223] https://fpr.vermont.gov/biomass-renewable-energy-standard
[224] Average Acres of Forest Loss Per Day and Per Year In New England and Vermont, 1990—2010: https://masswoods.org/sites/masswoods.org/files/Forest-Carbon-web_1.pdf

programs to further reduce electric load from electric heat, especially during periods when wholesale electricity prices and GHG emissions are at peak levels.

And fifth, even though wood heat is common in Vermont, much of it is produced by very inefficient wood stoves. Converting these to advanced wood heat stoves will reduced air pollution emissions greatly, while also reducing heating costs and the needed amount of wood fuel.

Opportunities exist to target AWH and its economic benefits to low-income Vermonters as well as schools and municipalities in under-resourced communities. Woodstove change-out programs would be a particularly effective strategy to reach underserved Vermonters and could provide both economic and health benefits, especially in areas with high levels of particulate pollution. Economic development of the rural forest economy would help spread economic growth to rural forested areas of the state that have not seen the same economic development as more populated areas of the state.

Wood Supply

The 2010 Wood Fuel Supply study established a goal of supplying 35% of our thermal energy from wood heat by 2030. That study looked at the amount of net available low-grade wood growth (NALG) in the forest, to determine a conservative estimate of how much thermal energy could be met with wood from Vermont's forests without negatively impacting forest health. An update of the study in 2018 found 5% more NALG in the forest now than was estimated in 2010.[225] From a wood energy perspective, Vermont has sufficient material available to keep adding to its existing portfolio of wood energy systems without risking forest health or sustainability.

Vermont has one of the best developed markets in the U.S. for wood heat — maybe the best for advanced wood heat —with a small but established base of businesses and demand to build on that many states don't have. Vermont's operating and diverse forest-product sector can provide the specialized equipment and skills to harvest, transport, and process the wood into usable fuel. (This is not the case in all forested regions.)

Vermont is approximately 74% forested. Eighty percent of that forestland is privately owned, and more than half of that is enrolled in Vermont's Use Value Appraisal (UVA) program, also known as Current Use. To be enrolled in UVA, a landowner must develop a forest management plan with the assistance of a Vermont licensed forester, which ensures that the land is being managed according to accepted forestry standards.

Current programs

The state supports the use of AWH though incentives for new heating systems for residential and commercial use. Incentives for AWH come from Efficiency Vermont and the Clean Energy Development

225 https://fpr.vermont.gov/sites/fpr/files/Forest_and_Forestry/Wood_Biomass_Energy/Library/2018%20VWFSS%20Final%20Report%20with%20Letter.pdf

Fund. Efficiency Vermont is also providing incentives for the change-out of woodstoves. The state has exempted AWH equipment from the 6% sales tax until June 2023. Vermont also supports the use of AWH by prioritizing the installation of AWH in state buildings and courthouses. Schools and municipalities throughout the state have installed AWH systems.

The federal government provides support for AWH with a residential investment tax credit. Beginning January 1, 2021, residential customers could use a 26% federal tax credit on wood fired appliances that have a minimum efficiency of 75%. This includes cordwood and pellet stoves, and boilers/furnaces.[226]

Challenges

Advanced wood heating is not without its challenges. Burning wood emits harmful particulates, greenhouse gases, and other emissions that need to be reduced and considered in comparison with other heating options. The state works to limit air pollution as part of efforts to continually improve Vermont's air quality; wood heat can have negative impacts on air quality, which limits the amount and type of wood heating and wood fuel manufacturing plants we can have in Vermont. While AWH does emit GHG gases, when wood fuels are sourced locally from well-managed forests and used to directly replace fossil fuels in high-efficiency applications like space heating, they can play a meaningful role in a robust long-term carbon emission reduction strategy for Vermont.

Although wood fuels emit slightly higher amounts of total carbon dioxide per unit of energy than fossil fuels, burning wood releases carbon dioxide that was already absorbed from the atmosphere by the trees as they grew. Burning fossil fuels, on the other hand, extracts geologic carbon stored below the surface of the earth for millions of years, and directly emits additional CO2 into the atmosphere. As a result, burning wood does not lead to long-term increases in atmospheric carbon dioxide levels when equal amounts of carbon are recaptured with the re-growth of well-managed forests.

Currently, Vermont's GHG Inventory views biomass as having no carbon emissions. That said, the Climate Council has recommended considering supplemental analysis that examines both the current methodology and the lifecycle emissions from all resources. Wood is no different; GHG emission impacts of replacing fossil fuels with wood should be considered, both in light of the current inventory and by taking into account the lifecycle of the fuel's GHG emissions.[227]

On a dollar-per-BTU basis, cordwood, wood chips, and wood pellets are cost-competitive with current propane and heating oil prices and are much more stably priced (see Exhibit 6-7 above). But without incentives or tax credits, the upfront cost of AWH equipment is higher than fossil fuel equipment. The current federal renewable energy tax credit (26%) brings the upfront cost closer to parity with fossil systems, for those that can take full advantage of the tax credit.

The AWH market is not as mature in the United States as it is in Europe. Vermonters are largely not aware of it as a viable option, and the above-noted valid concerns about carbon and particulate emissions have been a drag on adoption of, and support for, advanced wood heating. There are Vermonters whose

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[226] For a current list of AWH incentives and rebates in Vermont go to: https://fpr.vermont.gov/woodenergy/rebates

[227] https://northernforest.org/wp-content/uploads/2021/03/GHG_Final_10-14_new_logo.pdf

concerns about the sustainability of forest harvesting (both locally and for imported pellets) limit their interest in wood as a heating fuel. Providing transparent, robust information regarding AWH is essential to ensure that customer choices are being made knowledgably.

Overall, the forest products industry is shrinking, and its workforce is aging into retirement. Wood harvests for heat alone cannot sustain the sector. If current trends of decreased demand for low-grade wood continue, the lack of a skilled workforce or local wood fuel processing equipment will make it difficult to provide wood fuel locally.

Recommendations

This Comprehensive Energy Plan adopts a goal of meeting at least 35% of Vermont's total thermal demand with wood heat by 2030.

To meet this target, this CEP recommends:

- *The state, as well as municipalities, when replacing end-of-life fossil fuel systems or building new buildings, should prepare a full cost-benefit analysis of replacement sources, including advanced wood heat. Such analysis should consider all environmental impacts. Separately from the benefit-cost analysis, the state should also consider the health of the forest products industry in its decision making.*

- *To help reach the goal of 35% of total thermal demand to come from wood heat by 2030, the state should support the conversion of as many of our schools as feasible to Advanced Wood Heat systems. Schools are good candidates for conversion to advanced wood heating, because they benefit from on-site professional maintenance staff, and larger schools are difficult to transition to efficient renewable electricity for heating. To help address upfront costs of AWH systems, continue the sales tax exemption for advanced wood heat equipment that expires in June of 2023.*

- *The Clean Energy Development Fund should encourage local manufacturing and processing of advanced wood heat fuels and other products in the wood heat supply chain, including all forms of wood fuel including cord firewood, pellets, green chips, and dry precision chips; and it should support development of wood delivery infrastructure such as bulk pellet/chip trucks and wood fuel depots/silos.*

- *To develop the advanced wood heating workforce, training and education should be provided on AWH systems for HVAC professionals.*

- *To promote the most efficient, clean, and cost-effective use of technology while protecting human and environmental health, the Clean Energy Development Fund should continue to operate, and municipalities should avail themselves of, advanced wood heating programs to promote efficiency, decrease emissions, and avoid impacts on vulnerable populations or places. An education* *campaign on best practices in selecting cordwood and wood pellet fuel, stove, and boiler/furnaces; storing wood fuel; and operating and maintaining wood-burning appliances should also be considered.*

- *The Clean Energy Development Fund should continue to support wood stove change-out programs, including supporting the substitution of fossil-fueled heating equipment with advanced wood heating equipment.*

- *Municipalities should consider inclusion of the change-out of old wood heating systems for advanced wood heating as part of their Act 174 energy plans.*

6.4.2.3 Support District Heat

District heat allows residential, commercial, and institutional buildings that are in close proximity with each other to be supplied with heat from a central heat plant via an underground thermal distribution system. District heat networks remove the need for heating systems in every building, freeing up space and saving building owners on the costs of operating and maintaining their own heating system.

With increased flooding due to climate change, district heating can help incentivize the removal of fuel tanks and heating systems from basements and flood-prone areas. In addition, district heating systems can still provide heat to customers when there is a power outage, or when power is cut to buildings in a flood.

District heating can operate on renewable fuels and can incorporate combined heat and power systems through thermal storage. It can also supply thermal cooling to its customers.

To be cost-effective, district systems require sufficient demand and user density, to spread the cost of the distribution system. The cost-effectiveness of district heat is directly proportional to the length and difficulty of installing the insulated piping required to deliver the thermal energy, as well as the number and energy demand of the customers.

In Montpelier, a district heating plant has provided reliable, cost-effective heat to a relatively small number of buildings (about 20) since 2015.

The city of Burlington has been studying a district heating system for over 30 years. A district heating system could be supplied by the waste heat from the McNeil Power Plant. In 2021, the district heating project was elevated with new support from the city, Vermont Gas Systems, and the University of Vermont Medical Center.

Recommendations

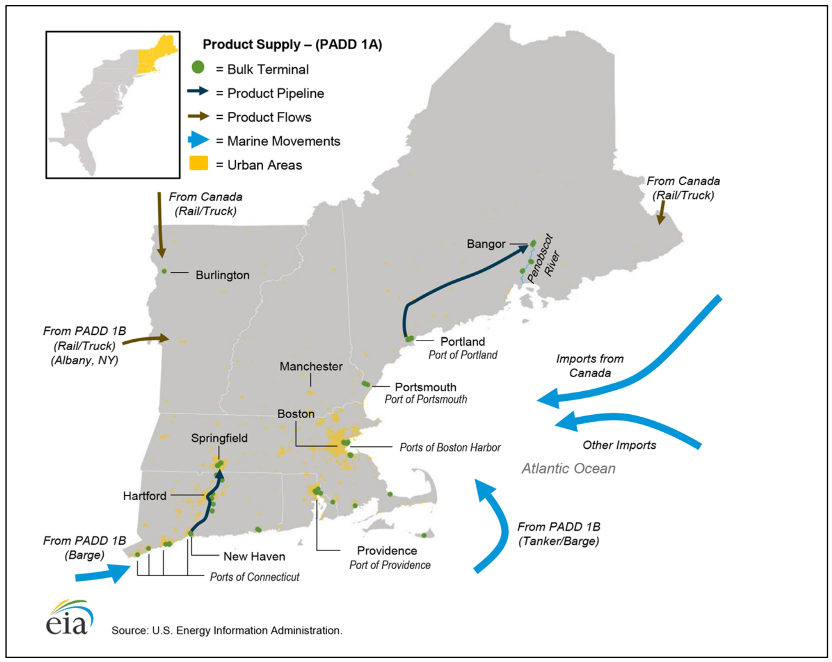
- *Vermont should continue to support the development of cost-effective district heating systems that are supplied by sustainably harvested biomass, to equitably distribute the benefits of district heating as well as the costs.*

6.4.2.4 Petroleum Products

Petroleum is processed into jet fuel and residual fuel oil, with the main uses as gasoline, distillate fuel oil (which is used as both diesel fuel and home heating oil), and propane. Transportation, space heating, and water heating are the state's primary drivers of petroleum consumption. Section 6.2 discusses the amount of petroleum products used in Vermont.

All petroleum products consumed in Vermont are imported; the state has no known petroleum reserves. In 2019, the state spent over $1.7 billion annually, about 6% of its GDP, on petroleum products that were extracted and refined elsewhere. Some small percentage of these expenditures remain in the state, with retailers that are often small-business franchise owners.; the rest of these financial resources flow away from the state's economy.

Exhibit 6-16. New England Petroleum Supply Lines



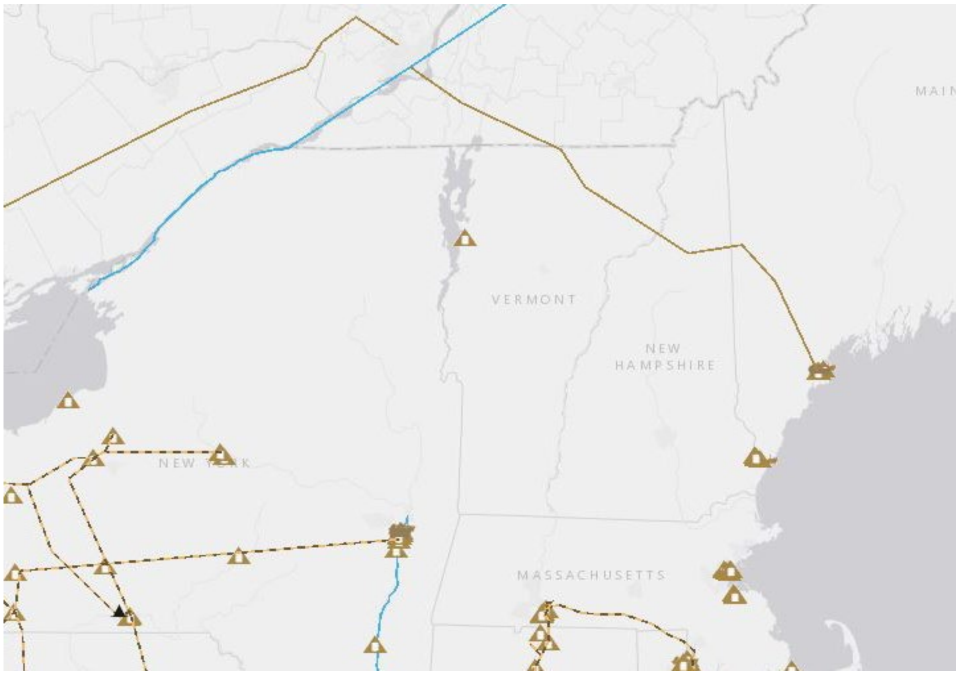
Petroleum products continue to be imported to Vermont through a variety of mechanisms. The state is relatively isolated from major supply lines and pipelines. Albany, N.Y., Montreal, Portsmouth, N.H., and Portland, Maine are major hubs for petroleum products in the Northeastern region, providing heating oil, gasoline, and other refined products to Vermont via rail and tanker truck. (Exhibits 6-16 and 6-17) Most of the products consumed here are refined at major East Coast refineries in New York and New Jersey, or at refineries in St. John, New Brunswick, Canada. Some refined products, imported via rail from Albany and Montreal, are stored and distributed from facilities on the Burlington waterfront.

Major supply disruptions can occur if rail or truck traffic is interrupted between those "hub" cities and Vermont, or if East Coast refineries go offline. Disruptions no longer stem just from historical disturbances such as weather events: in April 2021 the Colonial Pipeline, Inc.—the largest source of gasoline coming into the Northeast—was subject to a cyberattack that shut down operations on the East Coast for days. The removal of about 2.5 million barrels of fuel per day created disruptions along the Eastern seaboard that led to long lines at gas stations and higher fuel prices.[228] Because many Vermont homes and businesses rely on petroleum products for heating, transportation, and production, such disruption of supply can cause serious effects, especially during winter. As Vermonters migrate to non-

[228] Hackers Breach Colonial Pipeline Using Compromised Password. Bloomberg. June 4, 2021 https://www.bloomberg.com/news/articles/2021-06-04/hackers-breached-colonial-pipeline-using-compromised-password

petroleum energy sources, this concern should diminish over time, but in the meantime still warrants vigilance and preparedness.

Exhibit 6-17. Petroleum Delivery Infrastructure in the Northeast



Triangles indicate terminals. Brown lines indicate liquid oil pipelines. Blue lines show waterborne transport routes on the Hudson and St. Lawrence Rivers. Source: EIA U.S. EIA, *U.S. Energy Mapping System*, www.eia.gov/state/maps.cfm

Heating oil supply disruptions are slightly buffered by the Northeast Home Heating Oil Reserve (NHHOR), through which the federal government stores heating oil in Groton, Ct., Revere, Mass., and New York City, then sells it to private suppliers in the event of major supply disruptions or price spikes. The NHHOR stocks one million barrels of ultra-low sulfur distillate (diesel). The federal government also maintains the Northeast Gasoline Reserve, established in 2014 in response to disruptions that left many without access to gasoline for more than 30 days during Superstorm Sandy in 2012. The gasoline reserve holds one million gallons in South Portland, Maine, New York City, and Boston. DOE has developed an online bidding system for sales of gasoline and heating fuel from the reserves. Users may register to practice or to participate in actual emergency sales.

The heating oil and gasoline storage locations are further away from Vermont than Albany and Montreal, where current supplies are usually procured. In the event that these reserve supplies are needed, prices would likely rise in the state, and fuel dealers would be forced to travel further to obtain supplies. There are no nationally maintained propane reserves in the Northeast.

As referenced in the 2016 CEP, historical decisions about petroleum infrastructure have been supported by relatively inexpensive prices for petroleum products. Capital investments in petroleum-dependent equipment and infrastructure represent a significant sunk cost in Vermont. These investments "lock in" users to a specific fuel source. As systems reach the end of their useful life, it is important to consider replacing them with systems that can use renewable fuel types, such as electricity, wood, or higher blends of biofuels. In the meantime, adding renewable fuels, such as biodiesel, to petroleum supplies can reduce the negative impacts of transportation and heating on the environment.

6.4.2.5 Foster Greater Use of Biodiesel as Transitional Renewable Fuel

Biodiesel can readily replace fuel oil to reduce greenhouse gas emissions with up to 100% of the fuel derived from renewable resources, or in smaller amounts blended with fossil fuels, as an interim step and an immediate means of reducing greenhouse gas emissions.

GHG reductions from biofuels, can be calculated using lifecycle assessments, which follow the fuel from production to the tailpipe. (The Vermont GHG Inventory assumes zero emissions from biofuels, but analysis should estimate emissions using sensitivities associated with varying emissions levels from the resource. [229]) There are concerns regarding long-term impacts for the use of biodiesel (and other biofuels) on agricultural systems, where the supplies of biodiesel will come from (local, national, or global commodity markets), and whether policies will lead to continued dependence on imports.

Biomass-based diesel (BBD)[230] containing up to 5% biodiesel mixed with fuel oil, or B5, is already used in Vermont and has no required governmental

Liquid Biofuel Terms

- **Biofuel:** a broad term meaning any liquid fuel made from renewable biomass. The most common types of biofuels today are ethanol, biodiesel, and renewable diesel.
- **Biodiesel:** a clean-burning fuel produced from renewable resources that contains no petroleum, but can be blended at any level with petroleum diesel to create a biodiesel blend. (May be known by its branded name of Bioheat®.)
- **Renewable Diesel:** a liquid fuel produced from renewable biomass that meets the same specifications as diesel fuel and/or heating oil. It Is similar to biodiesel in feedstock and end use, but goes through a different refining process.
- **Biomass-Based Diesel:** a category of diesel fuel derived from biological feedstocks, including soybean oil, rendered animal fats and cooking oils, that can be used to comply with the federal Renewable Fuel Standard program. BBD includes both biodiesel and renewable diesel, which are made from different production processes. BBD can be used in diesel engines or as a heating fuel.

Adapted from the National Biodiesel Board

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[229] Studies supported by US DOE at the Argonne National Laboratory found that greenhouse gas emissions for B100 are 74 percent lower than those from petroleum diesel, and that soy biodiesel has the potential to achieve 80 percent reduction in fossil fuel consumption and between 66 and 72 percent reduction in overall greenhouse gas emissions relative to its petroleum counterpart. The California Air Resources Board (CARB) Low Carbon Fuel Standard program has developed life cycle carbon intensity values for over 1,100 fuel/feedstock pathways, including 192 for biodiesel. CARB biodiesel values range from 34 to 90 percent lower than for fossil diesel. *Biodiesel Handling and Use Guide, 5th Edition*, US Department of Energy. https://afdc.energy.gov/files/u/publication/biodiesel_handling_use_guide.pdf *Pg. 5; Life cycle energy and greenhouse gas emission effects of biodiesel in the United States with induced land use change impacts. Chen, Rui, et.al., Bioresource Technology, Volume 251, March 2018.* Pg. 258; www.sciencedirect.com/science/article/pii/S0960852417321648?via%3Dihub; California Air Resources Board. https://ww2.arb.ca.gov/resources/documents/lcfs-pathway-certified-carbon-intensities

[230] The term biomass-based biodiesel includes both biodiesel and renewable diesel, both of which can be used to comply with the federal Renewable Fuels Standard. Biodiesel and BBD will be used hereafter in recognition that both fuels may show up in the Vermont heating fuel mix. For more information, see: Biofuels Explained, US EIA. https://www.eia.gov/energyexplained/biofuels/biodiesel.php

disclosure.[231] One local fuel dealer offered a biodiesel heating product for $3.18 per gallon delivered, containing up to B5, with a B99 product at $3.37 per gallon as of September 2021.[232] At the same time, No. 2 fuel oil came in at $2.77 per gallon.[233] At the time of this report, some customers were paying more for B99 for heating purposes, while B99 for transportation, essentially the same fuel, showed an average retail price of $3.06 per gallon on an energy-equivalent basis.[234] At least for the one dealer surveyed by telephone, there was a price premium associated with the infrastructure necessary to supply biofuels.

More broadly, Vermont's biofuels landscape is largely influenced by federal policy and unregulated heating fuel market dynamics.[235] The state has a biodiesel policy that was established in 2011 via Act 47. Under the statute, Vermont requires all heating oil sold within the state to contain at least 7% biodiesel if other surrounding states (New York, Massachusetts, New Hampshire) have "adopted requirements that are substantially similar to or more stringent."[236] Massachusetts retains a blending policy for state agencies via executive order. As of December 2021, New York has a blending requirement. New Hampshire has no blending requirement. Because these policies do not fulfill the requirements of Vermont statute, the policy remains unimplemented. Biofuel blending would be an eligible measure under Tier III of Vermont's Renewable Energy Standard as well, but no measures have been implemented.

Regional support for biodiesel has been growing. In September of 2019, the liquid fuels industry in the Northeast adopted the Providence Resolution, which incorporates the goal of using renewable liquid fuels for heating at a B20 blend level (15% life cycle carbon reduction) by the year 2023, a B50 level (40 percent life cycle carbon reduction) by 2030, and net carbon neutrality by 2050. Recent legislation in Rhode Island and Connecticut. requires increasing amounts of biodiesel from B5 to B50, by 2030 and 2035 respectively.[237] Connecticut's law contains a provision regarding the lifecycle GHG emissions of the fuel.

With the new legislation in 2021, New York now requires an increase from B5 in 2022 to B20 in 2030,[238] joining previous requirements for biodiesel in the New York City Metropolitan Area for thermal

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[231] With no reporting requirements in place, quantities of BBD in use can only be estimated. Total distillate (oil heat, diesel, off-road) is approximately 200 million gallons per year in the state. A B5 blend for the 140 million gallons of heating oil would translate to about 7 million gallons per year of biodiesel usage for thermal purposes.
[232] PSD Phone survey. September 27, 2021.
[233] Retail Prices of Heating Fuels. Vermont Department of Public Service. September 27, 2021. https://publicservice.vermont.gov/content/retail-prices-heating-fuels
[234] Clean Cities Alternative Fuel Price Report, Tables 17c and 17d. US DOE. July 2021. https://afdc.energy.gov/files/u/publication/alternative_fuel_price_report_july_2021.pdf. Pg. 27
[235] The primary policies that govern biodiesel and renewable diesel production in the country are the U.S. Renewable Fuels Standard and California Low Carbon Fuel Standard, which target biofuels for transportation and are beyond the scope of this section. Please refer to the Chapter 5 section on clean vehicles and fuels for additional information.
[236] 10 V.S.A § 585; See also Act 47 of 2011, Section 21 (D)(1)(b)
[237] Connecticut and Rhode Island governors sign laws boosting bioheat use. Biofuels Digest. July 15, 2021. www.biofuelsdigest.com/bdigest/2021/07/15/connecticut-and-rhode-island-governors-sign-laws-boosting-bioheat-use/
[238] New York implements biodiesel mandate. Biodiesel Magazine. December 28, 2021. http://www.biodieselmagazine.com/articles/2517919/new-york-implements-bioheat-mandate

heating.[239] New York City has a biodiesel/renewable diesel blending law for thermal heating that will increase blending requirements to 20% by 2034.[240]

States such as New York and Massachusetts provide incentives via either tax credits or, as in Massachusetts, include biofuels as an eligible measure toward meeting the Alternative Energy Portfolio Standard. Most recently, Massachusetts Governor Charlie Baker signed an executive order establishing a Commission on Clean Heat, to advise on the framework for long-term greenhouse gas emissions reductions from heating fuels.[241] Taken together, there has been progress with development of the liquid biofuel markets in the region.

Vermont can participate in this evolving market, but there are some challenges to consider. First, there is currently no clear way to understand the amount of biomass-based diesel used for heating in the state and therefore no accurate way to calculate emissions reductions from biomass-based diesel usage and thus no accurate way to know how much biomass-based diesel is helping reduce Vermont's GHG emissions.

This gap means that customers do not know how much BBD they are consuming, nor does the state have a clear baseline to calculate emissions reductions as more BBD enters the supply.

Second, access to biomass-based diesel and its price are both uncertain because all relevant markets and policies exist outside Vermont. The market for BBD is primarily driven by federal tax credits and the Renewable Fuels Standard (RFS) created under the Federal Energy Policy Act of 2005, which amended the Clean Air Act. The RFS requires a certain amount of renewable fuel to replace or reduce the quantity of petroleum-based fuel used for transportation, heating, or jet fuel.[242] The RFS affects the market upstream from consumers, where the obligation to obtain qualified renewable fuels impacts refiners and wholesalers. Qualified biodiesel in this market can be used in the unregulated heating oil market. There is no quick way to determine the average price for biomass-based diesel used for heating in Vermont.

Relatedly, given Vermont's small market, any change to renewable content of heating fuels in Vermont depends on federal policies like the RFS and state policies such as the biodiesel mandates in New York, Connecticut, and Rhode Island. Access to affordable biomass-based diesel may depend on the size of markets in adjoining states and in the region. In addition, potential changes to federal policy (e.g., the Renewable Fuels Standard) contemplated by US EPA to address COVID-related impacts could disrupt this market and affect biofuel supplies, in turn raising prices for renewable fuels.

Finally, up to B20 can be blended with little concern in most new equipment. Like regular heating oil, biodiesel tends to gel in very cold weather. In winter, fuel suppliers may address this by adding a cold flow improver, using fuel line heaters, or customers can store fuel indoors, all of which may have an

[239] Chapter 315 of New York State 2017 Chapter Laws.
[240] New York City Local Law 119-2016.
[241] Executive Order No. 596: Establishing the Commission on Clean Heat. https://www.mass.gov/executive-orders/no-596-establishing-the-commission-on-clean-heat
[242] Overview for Renewable Fuel Standard. US EPA. https://www.epa.gov/renewable-fuel-standard-program/overview-renewable-fuel-standard

impact on cost.[243] At levels above B20, customers may need to have their equipment inspected to ensure proper operations. Some customers may lack resources to upgrade the seals and pumps in their heating systems to allow for higher percentage blends.

There are two common policies that could increase the amounts of liquid biofuels in the fuel supply:[244]

- **Align Vermont's requirement for biomass-based diesel with similar states**. Blending mandates are now in place in Rhode Island, Connecticut, and New York, with similar policies in Massachusetts. Vermont could remove the statutory trigger mechanism for biodiesel heating that requires "surrounding states" to have adopted a "substantially similar" requirement.[245] Vermont's policy could be lined up with other state policies in the region to amplify the market signal needed to secure updated UL listings, ASTM standards, to give fuel dealers, technicians, and fuel wholesalers time to plan for any needed equipment, and to nudge OEM support for biomass-based diesel.
- **Include an increasing volume of biomass-based diesel in a Clean Heat Standard**. This policy would focus on reduction of fossil fuels in the heating sector through a performance-based program and could cover a range of thermal fuels and applications (e.g., biomass-based diesel, woody biomass, and cold climate heat pumps for heating). Section 6.4.1. covers this policy.

Increasing the volume of liquid biofuels such as biomass-based diesel could help the state during the transition to renewables and reduce carbon dioxide emissions.

Benefits

As described above, at low blending ratios BBD for heating can be used in existing infrastructure, with little to no additional maintenance or preparation. Transitioning to increased volumes of blended biofuels, if done using lifecycle assessment criteria, could reduce both carbon emissions in the environment and air pollutants that affect human health. Consideration of policies that support biodiesel should include both the short- and long-term impacts to carbon and other pollutants, consistent with societal level analysis.

Requiring heating fuels supplied to customers in Vermont to include BBD would signal the potential scale of demand from Vermont's heating oil customers. The Department of Public Service estimates that the volume of liquid biodiesel for heating could conservatively rise to over 10 million gallons per year at

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[243] Biodiesel buying in cold weather. Biodiesel Fact Sheets, National Biodiesel Board. https://www.biodiesel.org/docs/default-source/fact-sheets/biodiesel-buying-in-cold-weather.pdf?sfvrsn=a603d82_10

[244] The biofuels policy arena shares commonalities with other transitional biofuels. There may be individual policies such as a Renewable Gas Standard that could come into play for decarbonizing the natural gas supply. These are covered under the CEP chapter on Natural Gas. Similarly, there are policies that address solid biomass, which are covered under the CEP chapter on Renewable Energy. Finally, some policies are cross-cutting and could apply to a range of fuel supplies (e.g., biodiesel can be used for heating and transportation) and sectors (e.g., Low Carbon Fuel Standard could apply to heating and/or transportation). See Transportation Section III for recommendations.

[245] Act 47 of 2011 Section 21 (d)(2) https://legislature.vermont.gov/Documents/2012/Docs/ACTS/ACT047/ACT047%20As%20Enacted.pdf

B20. Including ASTM standards for biodiesel would help ensure that fuels distributed into the state are of sufficient quality. An update to the statute for biodiesel to calibrate with New York and other New England state policies could help mitigate regional market challenges. Inclusion of a reporting requirement on the content of biodiesel in the fuel mix and volumes sold in state from fuel suppliers would help provide the data needed to evaluate progress toward meeting renewable energy and GHG reduction goals.

Increasing BBD in heating fuel would provide economic opportunities for fuel dealers to supply a renewable fuel in their mix, and potentially to innovate in how they do so. Additional support for locally produced biodiesel could potentially translate into agriculture jobs, as well as retaining jobs in the fuels market.

Many customers seeking alternatives to fossil fuels for heating might struggle with the upfront costs such a transition would require, for example the cost of advanced wood heat equipment or electric heat pumps, and access to affordable financing for the equipment). Since BBD presents the opportunity to retain existing heating systems, transitioning to this form of biofuel may offer the customer a cost-effective alternative to electrification that requires little to no substantial capital outlays.

Challenges and Opportunities

Technology Lock-In. Continued use of fossil fuels may be needed as a bridge fuel, but concern remains about technology lock-in with heating equipment that lasts 10 years or more. If access to BBD decreases due to regional competition or other supply disruptions, prices for BBD could increase. This could, in turn, lead to reverting to existing systems burning higher percentages of fossil fuel. Low blending of fossil fuels could help make some progress to emissions requirements but could create a barrier by locking-in fossil infrastructure and inhibiting progress towards renewable and sustainably produced fuels and electrification of heating loads.

Resilience. If some portion of building owners with oil heat systems add heat pumps or pellet systems as primary heat sources, then existing systems using BBD as backup could provide the winter-time security that many families and businesses need.

Economic/Job Impacts. As demand for BBD grows, it is possible that some portion of the biofuel supply could be derived locally. Previous work demonstrated this potential, but the current economics do not favor such an approach.[246] Most of the Northeast's biofuels come from the Midwest. Increased demand in Vermont would potentially spur additional supply, but other states such as Rhode Island, New York, and Connecticut could tap that same supply to meet their new blending mandates. However, a demand signal stimulated by a blending requirement or other policy would demonstrate the potential size of the market in Vermont and the region, with a portion of the biofuels to be manufactured locally when economics favor such and the rest obtained where economics and policy dictate. Alternatively, Vermont's policy

[246] For more information, see Vermont Bioenergy Initiative, http://vermontbioenergy.com/wp-content/uploads/2016/12/VBI_FINAL-REPORT-2016_FULL_web.pdf

could require some in-state production as part of a requirement to include biomass-based diesel in the fuel supply.

Transitioning toward BBD will retain employment of workers from the petroleum industry while new jobs emerge in the clean energy industry. Some fuel dealers around New England are experiencing forces that have driven about 3.5 million homes to convert from heating oil to other fuels, primarily natural gas and electricity.[247] Shifting to BBD will help retain current jobs in the heating fuels sector. Recent market changes have encouraged some fuel dealerships to offer advanced wood heating systems and cold-climate heat pumps along with legacy fuels.

*Equity***.** Vermonters making less than $27,800 spend about 18% of their average monthly income on combined heating and electricity expenses, compared with 2.7% of income spent on the same energy expenses by those in the top earnings quintile.[248] An option to substitute biomass-based diesel into existing heating systems would allow participation in the energy transition and carbon reduction efforts at a more affordable cost than options that require replacement of heating equipment. Such measures would support a just and equitable energy transition by offering a less costly option to residents from impacted or underserved communities that currently experience high energy burdens.

Environmental Impacts. Increasing the use of BBD for heating has the potential to improve air quality, since the particulate and other emissions from biodiesel for heating are lower than comparable petroleum distillate emissions. Actual pollution loads for BBD depend on the fuel type, where and how it is produced, distance traveled from fuel source to usage location, efficiency of equipment, and government policies. The Agency of Natural Resources currently considers the biofuel component (i.e., biodiesel and ethanol) of fuels, at least in the transportation sector, to have no carbon dioxide emissions. The Climate Council will issue a Request for Information that will support consideration of a supplemental GHG Inventory analysis, which could examine upstream and lifecycle emissions from biofuels.

Demand for biodiesel has the potential to create negative impacts at the source — for example, if produced through conversion of carbon-sequestering rainforests to palm oil plantations outside the United States. The U.S. Renewable Fuels Standard contains provisions under which palm oil does not qualify as biodiesel, as do some state policies (e.g., Massachusetts and California). An effective policy should include provisions to guard against such prospects. California's Low Carbon Fuel Standard requires a lifecycle assessment that tracks emissions of carbon dioxide and other greenhouse gases throughout the full life cycle of a product, rather than just accounting for the carbon contained in the product alone. This includes direct emissions from the fuel and indirect emissions from the production cycle, including land use change.[249]

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[247] NEFI Proposes Industry Survival Fund, Sean Cota and Tom Tubman. Oil & Energy Online. https://oilandenergyonline.com/articles/all/nefi-proposes-industry-survival-fund/

[248] For details on energy cost burdens of energy, see: Annual Progress Report for Vermont 2020/2021, Energy Action Network. www.eanvt.org/wp-content/uploads/2021/05/EAN-APR2020-21_web-1.pdf. Pg. 5

[249] Biomass-Based Diesel: A Market and Performance Analysis. Fuels Institute. March 2020. Pg. 100 https://www.fuelsinstitute.org/getattachment/ed72f475-8038-415c-b1fd-591b213d4815/Biomass-Based-Diesel_Report.pdf

While federal and some state policies address potential environmental and community risks associated with BBD production, Vermont legislation does not. This gap could potentially be addressed by stating that any biofuel used in the state must qualify for Renewable Identification Number credits (RINs) under the U.S. Renewable Fuel Standard.

Making a commitment to increased use of BBD in Vermont now would potentially have immediate climate-related impacts. Recently, the State University of New York College of Environmental Science and Forestry (SUNY-ESF) published research supported by the National Biodiesel Board highlighting the value of early GHG reduction, limiting the cumulative heating impact of carbon emissions. This study compared the cumulative emissions reductions and associated societal value of using biodiesel today to waiting for a future, potentially lower-carbon solution to be deployed later. These results demonstrated that when a technology with a lower or even zero lifecycle GHG emission profile was deployed even five years later, it would generate fewer societal benefits arising from a reduction in GHG emissions than a low carbon-liquid alternative technology deployed sooner. While the report focused on transportation, the analysis is being replicated with heating fuels.[250]

Human Health Risks. Petroleum distillates have a range of associated human health impacts. Researchers have evidence that BBD may lower health risks compared with petroleum diesel[251]; but like other fuels, BBD could create impacts at the point of production.

Upon enactment of a new BBD policy for liquid heating fuel or removal of the triggering mechanism in statute, progress toward achieving the biofuels portion of state energy goals must be monitored. To do so, an accurate baseline for BBD must be established. Government leaders are encouraged to provide for a baseline study and recommend mechanisms to monitor the supplies of BBD consumed in the state for heating, informing carbon savings, energy targets, environmental protections, cost effectiveness, and equity impacts.

Recommendations:

- *Compare a biomass-based diesel blending requirement to a clean energy heat standard or other sector-wide requirement, to determine whether one of these would be practical and effective. Such comparison should include a regional fuel market impact analysis.*

- *Advocate for reporting requirements for percentages of BBD in heating fuels, to allow measurement of progress toward any implemented requirements and state renewable energy goals.*

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250 Quantifying the comparative value of carbon abatement scenarios over different investment timing scenarios, J. Frank et. al., Fuel Communications, Volume 8, September 2021. https://www.sciencedirect.com/science/article/pii/S2666052021000108; cited in comments by National Biodiesel Board, December 20, 2021.

251 *Air Quality and Health Cobenefits of different deep decarbonization pathways in California.* B. Zhao, et. al., Environ. Sci. Technology. May 22, 2019, 53, 12, 7163-7171. https://pubs.acs.org/doi/10.1021/acs.est.9b02385

- *In partnership with fuel dealers and others, transition heating fuel supplies to an appropriate level of renewable fuels, particularly for customers that will have difficulty transitioning to electric sources or lack access to capital to make an energy transition.*

- *Support fossil fuel dealers in a diversification and eventual transition of their businesses into energy service providers that sell a range of energy efficiency services and products.*

- *Consider linking incentives to consumers for purchase of BBD with potential state resources that offset a portion of fuel dealer investments in BBD infrastructure and some form of performance-based policy, such as a Clean Heat Standard.*

6.4.2.6 Natural Gas and Support for Natural Gas Alternatives such as Renewable Natural Gas

Natural gas, which accounts for about 25% of Vermont's thermal site energy use, is an odorless, colorless gas that consists mostly of methane with a small amount of other volatile hydrocarbons. Most natural gas contains added mercaptan, to give it a characteristic smell that allows for the easy detection of leaks. Vermont Gas Systems (VGS), Vermont's only regulated natural gas distribution utility, supplies approximately 13,500 million cubic feet of natural gas per year to approximately 55,000 Vermont customers, who are split approximately a quarter each between residential, commercial, interruptible, and wholesale customers (some out of state).

Unlike in other parts of the country, the use of natural gas is limited in Vermont by distribution to only the northwestern corner of the state. Compressed natural gas, sold at wholesale by VGS, is being used as a fuel for commercial and industrial facilities, and there has been a small increase in its use for transportation, especially for fleet vehicles.

VGS obtains gas from Ontario markets, which procure supply from various sources in the US and Canada, so price volatility and supply constraints in the southern New England market do not affect wholesale prices paid by VGS, or retail prices paid by its customers in Vermont. Residential consumers in Vermont are insulated from winter price spikes because, as a regulated utility, VGS maintains a supply of propane that can be injected into the system in the event of supply disruptions and during peak usage periods. Some larger VGS customers have interruptible contracts, so capacity can be directed to residential customers when capacity is tight. Although market prices can be volatile, VGS engages in a comprehensive hedging program and contracts for storage supply in Ontario, which limits customers' exposure to short-term price volatility. Storage supply is replenished in the summer and is not impacted by winter pricing.

In the New England region, natural gas is a major fuel source for the shared electrical grid. Vermont relies on natural gas at the regional level to provide electric power in the short-term marketplace, especially when renewable intermittent sources are not generating. Natural gas for heating can often compete with natural gas for electricity in the region; but because Vermont's gas supply is not connected with the rest of New England, this does not affect reliability of supply.

Natural gas produces lower burner tip emissions than other fossil fuels, and it is currently less expensive. It can also be used in many applications where renewable sources cannot. Prices are expected to remain low. In strategic sectors where electrification and/or renewable energy is difficult or costly, market conditions will continue to lead customers to choose natural gas, where available, to replace oil and propane. The recent growth of compressed natural gas is an example of these opportunities. More opportunities are available with renewable natural gas and other gas alternatives that have the same chemical composition as natural gas, but are produced renewably and have far less emissions.

Renewable natural gas (RNG), also known as biomethane or biogas, is produced naturally by the anaerobic breakdown of organic waste from farms, landfills, and wastewater treatment plants, among other sources. If these emissions are not captured, methane is released into the atmosphere, where it becomes a greenhouse gas approximately 30 times more potent than CO_2. While RNG, like other biofuels, has burner tip emissions like the fossil fuels it displaces, capturing and utilizing RNG can also displace traditional natural gas in carbon-intensive sectors such as space heating, process heating, and transportation. Or it can be used to generate electricity. There are other low- or no-carbon alternatives, such as syngas (methane made from captured carbon and hydrogen) and hydrogen (made through a process of electrolysis using renewable electricity), that can be integrated in the current infrastructure with traditional or renewable natural gas.

In 2017, VGS received approval from the Public Utility Commission to offer RNG to its customers voluntarily and at a price premium.[252] Customers who choose to purchase a portion of their gas usage as RNG are charged an additional amount per Ccf (hundred cubic feet) used, based on the percentage of RNG they wish to purchase. VGS is also authorized to feather in up to 2% RNG into its distribution system under the Purchased Gas Adjustments section of the Alternative Regulation Plan. VGS currently purchases RNG from suppliers in Quebec and Iowa, and as of July 2021 from a farm-based anaerobic digester in Salisbury, Vermont. In late 2020, VGS had roughly 100 customers enrolled in the RNG program. The Salisbury project is connected to the VGS distribution pipeline and will supply nearby Middlebury College with 100% RNG; the digester is expected to produce enough excess capacity to also supply around 400 homes. Since it is impossible to physically supply a specified percentage of RNG to individual customers, VGS customers in essence are purchasing RNG "attributes," similar to how electric utility customers purchase electricity under renewable energy riders.

In November 2019, VGS announced plans to increase its levels of RNG so that by 2030, 20% of its supply mix for retail customers will come from RNG.[11] VGS has also initiated a climate action plan that sets a goal of carbon neutrality by 2050; as part of its recently approved Alternative Regulation Plan, VGS has initiated a Climate & Innovation budget to support its Climate Action Plan.[253] RNG, syngas, and hydrogen will contribute to the mixture of gaseous fuels that will be part of the future mix in the VGS pipeline network. These fuels have the advantage of being an in-kind replacement for natural gas: they can be used in the same customer equipment as traditional natural gas without any significant difference in equipment performance. They also can provide significant co-benefits. For instance, RNG produced

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[252] Public Utility Commission, Final Order of September 6, 2017 in Docket 8667, establishing the RNG program.

[253] Public Utility Commission, "Order Approving Alternative Regulation Plan" in case 19-3529, August 11, 2021. See also Public Utility Commission Case 21-0167-PET" Final Order Approving Integrated Resource Plan," October 13,2021

through the anaerobic digestion process allows farms to capture phosphorus that might otherwise pollute Vermont's waterways. This can improve farm economics, divert waste streams into productive energy, and provide local gas supply.

There are a number of challenges, however, with RNG and other alternatives to natural gas. RNG is expensive, currently about three times the cost of traditional natural gas. As demand for RNG grows in-state and elsewhere, that could put further upward pressure on prices. The technical, achievable, and cost-effective potential for RNG sourced in Vermont is unknown (although Vermont Gas will be completing a study of its potential as part of its Integrated Resource Plan requirements). While increases in the quantity of RNG and natural gas alternatives serving ratepayers is desirable, Vermont should be aware — just as it needs to be with unregulated fuels — of locking customers into existing combustion-based thermal energy infrastructure, particularly if it delays or dissuades electrification of thermal loads.

Finally, adding more RNG into the system currently significantly increases costs. While voluntary programs allocate those costs to those who can and are willing to pay, allocation of costs associated with more significant increases in RNG supply will need to be shared equitably. Increasing supply of RNG now, however, allows a broad array of customers to begin a transition to renewable fuels, while the long term should focus on bigger commercial and industrial users who have processes for which electric energy supply will not be as productive.

The VGS Climate plan sets targets for RNG blending on its way to becoming carbon-neutral by 2050; but it is not required to do so. Codifying RNG blending into a requirement could ensure that renewability of the system is increased but could inequitably distribute the added cost of such a shift among natural gas ratepayers. Voluntary programs, such as what VGS current offers, will allow those who choose to pay more to do so, but penetration of RNG in that scenario will be limited.

The Vermont gas pipeline system is one of the most updated in the country and is well-suited to increasing the proportion of hydrogen (to approximately 20%) without expensive changes to the pipeline and end-use combustion equipment. Hydrogen can be produced from renewable electricity, which could make it a good fit in areas of Vermont where renewable generation exceeds consumer demand. Initial modeling shows that without managed electric loads or significant battery storage, a large amount of renewable energy generation will need to be either exported or curtailed if grid infrastructure is more costly to build (see Sections 4.4 and 9.7). This could create a long-term market for hydrogen plants sited in transmission-constrained portions of the electric grid (such as the currently transmission-constrained Sheffield Highgate Export Interface zone), where it can act as a form of energy storage for excess generation and reduce the need for curtailments to renewable electric generation.

Several projects are under consideration at industrial sites in Vermont where green hydrogen could be blended on site with the business's natural gas supply and combusted at the facility. These types of projects are gaining interest at the federal level, as a first step to building a pathway for the use of green hydrogen in the thermal sector.

Hydrogen technology is in its infancy and is not significantly factored into this CEP. But the goal of commercial-scale hydrogen produced with renewable electricity should remain a priority, particularly as costs of hydrogen plants decline.

Recommendations

- *Complete the study of Vermont potential for renewable natural gas, as required by Public Utility Commission Order in Case 21-0167-PET. Based on results of that study, consider ways to support cost-effective RNG development.*

- *Consider RNG or cleaner fuel requirements for Vermont Gas, first in the context of a Clean Heat Standard, or independent of such a standard if a CHS is not pursued. Any RNG design should consider the benefits and burdens of RNG to all ratepayers.*

7 Electric Resources

7.1 Overview

As Chapters 5 and 6 describe, the transformation to a clean and renewable future in the transportation and thermal sectors relies heavily on the electric sector to supply the energy needed for heat pumps, electric vehicles, and other electro-technologies. This is in part because according to Vermont's Greenhouse Gas Inventory (see Chapter 2.2.1), the electric sector is a relatively small contributor to overall GHG emissions. Even so, eliminating the remaining emissions from the electric sector will help with deeper decarbonization of heating and transportation, and will likely require Vermont to consider even more ambitious renewable or carbon-free power supply requirements.

At the same time, as Chapter 4 (Grid Evolution) more fully explores, the electric sector is in a state of considerable change, continuing a shift to an integrated electric grid where both demand and supply play an active role in meeting electricity needs. This creates new challenges, and opportunities to ensure that electricity — ever more a basic need of modern life — is reliable, affordable, and delivered in an environmentally sound manner.

Regulated utilities in the electric sector have long operated under the principles of 30 V.S.A. 218c, which requires least-cost planning that includes consideration of environmental and economic costs. With this and the other guiding statutory and planning principles described in Chapter 2, this chapter starts by presenting the regional and national context within which Vermont operates. It then discusses current electric demand, including programs for reducing and managing that demand. A discussion of Vermont's electric supply follows, including energy policies and programs that drive power supply choices and deployments, electric resources deployed, electric-sector emissions, and siting considerations.

Lastly, the chapter describes a core pathway for considering mechanisms to further decarbonize the electric sector (and, through electrification, the thermal and transportation sectors) by moving to a 100% carbon-free or 100% renewable energy standard. This is consistent with a recommendation of Vermont's initial Climate Action Plan, adopted in December 2021; the CEP explores potential design considerations of such a standard in detail, including vintage, location, size, diversity, and time- and locational attributes of resources. The chapter closes by describing key recommendations for the sector, including the recommendation of a Public Utility Commission proceeding for consideration of a potential 100% carbon-free or 100% renewable energy standard that, if created well, could help Vermont decarbonize while maintaining reliability, affordability, and sustainability, consistent with the state's statutory energy policy.

7.2 Regional and National Context

It is important to understand the regional and national context for electricity, because it heavily informs available policy options. Vermont is part of a federally regulated New England-wide electric grid, which — compared to having an isolated, Vermont-only grid — allows for a more reliable, resilient, and cost-effective delivery of electricity to customers.

The first electric systems were mostly small, isolated generation resources that served local demand, such as a small hydroelectric facility that provided electricity for homes and businesses in its immediate area. As efforts to provide electricity to all Vermonters grew, those systems were connected, and generation in one town began to serve load in other areas. As the interconnections grew, so did the size of the generation sources providing energy, from kW-scale hydroelectric facilities in the late 1800s to gigawatt-scale nuclear facilities in the 1970s. The creation of larger generating facilities increased the need for transmission that could enable significant amounts of electricity to flow from one area to another. To formalize the process for coordinating generation and transmission planning, in 1971 the New England electric utilities created the New England Power Pool, or NEPOOL.

The federal government regulates these interconnections between utilities through the Federal Power Act, which grants to the Federal Energy Regulatory Commission (FERC) authority over the "transmission of electric energy in interstate commerce" and the "sale of electric energy at wholesale in interstate commerce."[254] The term *interstate commerce* does not limit federal jurisdiction to transactions that happen outside Vermont borders: it covers any transmission of energy from one utility to another, and any sale of energy that does not involve the ultimate end user. FERC reviews these transactions to ensure that they result in just, reasonable, and non-discriminatory rates.

In 1999, in response to FERC directives to transmission companies regarding open-access principles, NEPOOL formed ISO New England, Inc. (ISO-NE). This entity was designed to operate the New England electric system. Over time, its responsibilities grew to include comprehensive planning of the transmission system, and designing and administering the wholesale electricity markets. Under the Federal Power Act, ISO-NE has the authority to file proposed changes to wholesale markets and transmission tariffs, while FERC ensures that market rules and transmission tariffs are just, reasonable, and not unduly discriminatory.

As other entities in New England and further afield contend with many of the same issues that face Vermont, it will be important for our state and region to learn from the examples of our neighbors. Accommodating the penetration of distributed, renewable generation, and accounting for the impending electrification of the heating and transportation sectors, while simultaneously ensuring that the grid is capable of handling the system stresses that will be induced with these growing elements, poses a difficult challenge. Communication and coordination between state agencies, utilities, regional transmission organizations, and other parties involved in the clean energy transition will prove invaluable in enabling that transition here in Vermont.

7.2.1 Transmission Planning

ISO-NE is responsible for ensuring that the New England transmission system can handle peak loads and meet federal reliability standards. To do this, it examines forecasted loads and generation capabilities over a ten-year planning timeline, and also tests certain areas of the region by modeling energy flows over the transmission lines during stressed conditions. If the modeling demonstrates that the present-day

[254] Federal Power Act § 201(b)(1)

transmission system is not expected to perform reliably, ISO-NE initiates a process to ensure that needed facilities are constructed or that non-transmission alternatives are implemented.

Vermont Electric Power Company (VELCO), owned by the Vermont distribution utilities and VLITE, is the transmission company for Vermont. Using input data from ISO-NE, the distribution utilities, Efficiency Vermont, and others, VELCO performs studies examining the Vermont transmission system, as well the sub-transmission system, to a 20-year horizon in order to ensure local reliability. The VELCO long-term planning process is described in more detail in section 7.4 below.

Transmission facilities that provide reliability to the bulk power system are funded on a regional basis, with each state paying roughly its share of the New England load. Vermont accounts for roughly 4% of the region-wide load, with costs apportioned based on each utility's monthly peak load. To be eligible for regional funding, the purpose of transmission upgrades must be to ensure that *load* can be served reliably; if system upgrades are necessary to interconnect *generation*, those resources must pay for the necessary upgrades.

In addition, generation resources can choose to interconnect to the transmission system in a manner that doesn't always allow for full production. Depending on other generation resources and the topology of the transmission system at any given time, generation resources are sometimes required to scale back production to ensure reliable performance of the transmission system.

7.2.2 Wholesale Electricity Markets

The wholesale price of electricity in New England is set through competitive wholesale markets, in which resources (primarily generation, energy efficiency, and demand response) bid to be able to provide power or other services. An individual resource may be able to provide the electric system with multiple benefits:

- *Energy*, measured in MWh, which is the electrical energy used to power electrical appliances, and is produced by movement of electrons in a line;
- *Capacity*, measured in New England as kW-month, which is the ability of a resource to be able to provide energy when called upon, considered over the period of time in which it is available to provide that energy; and
- *Ancillary services*, or the ability to operate the resource in a way that ensures the maintenance of system stability.

To determine the appropriate price paid for each of the attributes listed above, ISO-NE administers the following competitive wholesale markets.

7.2.2.1 Energy Market

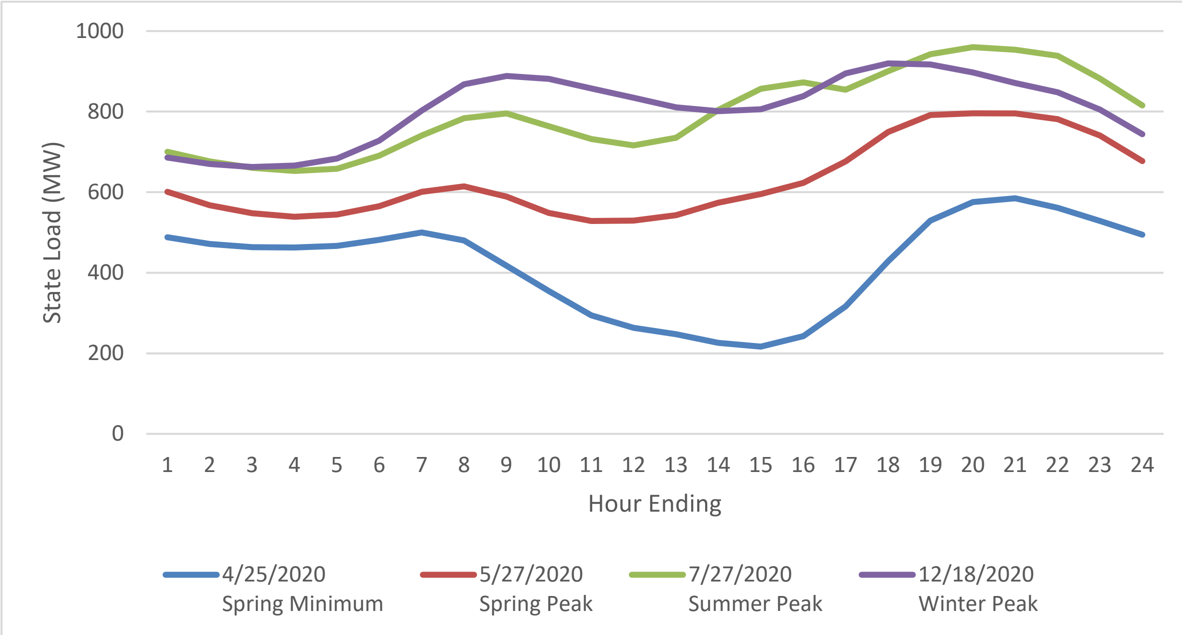
The energy market is composed of two markets: a *day-ahead market,* which is used for short-term planning purposes, and creates financially binding obligations on generators to provide power; and a *real-time* *market,* which recognizes that fluctuations will occur in consumer demand or in energy supply, either as a result of an incorrect weather forecast (for example, a day that was forecast as mild turns out to be hot and muggy, causing people to turn on air conditioners), or because of an unplanned outage (or variances from forecasted availability) at a generator or a transmission line that prevents a resource from providing energy into the grid.

In the day-ahead market, load-serving entities such as electric utilities submit demand bids, which are statements that the utility needs a certain number of MWh at any given instance, over one-hour periods throughout the day. Generators submit supply bids, stating that they will provide a certain number of MWh in five-minute increments at a certain price. ISO-NE selects the least expensive resources to supply the total number of MWh needed. The last unit selected, the one at the margin, is called the *marginal unit,* and the price that it bids is called the marginal price. All generators that produce energy are paid this marginal price for every MWh bid.

Any generator that is smaller than 5 MW may act to reduce the load within the interconnection utility, rather than participate in the energy market. For example, a 4 MW solar facility in Vermont may have a contract with the Vermont utility by which it is interconnected. In this instance, the generator is paid directly by the utility; ISO-NE does not account for the generation in its dispatch, but instead sees a reduction in the utility's load. In other words, the utility does not need to buy the number of MWh produced by the solar facility when it is producing power. The ratepayer value of these resources corresponds to the cost of the energy, capacity, and ancillary services that would otherwise be purchased by the utility.

The amount of power needed shifts throughout the day; the demand in each hour throughout the day is commonly referred to as a *load curve* or *load shape.* Historically, there is limited power needed during the early morning hours, with a steep curve upward from 5 a.m. to 8 a.m., as people are getting ready for work (often referred to as the morning ramp), and then relatively steady load until peak demand is hit around 6 p.m., as people arrive home, with load dropping off again as people begin to go to bed around 10 p.m. This changes considerably through the year, and the rapid growth of small-scale solar resources has modified these historic load curves: because of behind-the-meter solar PV production, even when it is mostly cloudy, utility load is lower during the day and the peak hour occurs after dark. Exhibit 7-1 shows sample load curves from different seasons in 2020 in Vermont.

Exhibit 7-1. Selected Vermont Load Shapes[255]



The cost of power during the day typically corresponds to the need for energy. There is less need for power in the early morning hours, so only the least expensive units are typically online. During the morning ramp, ISO-NE will need to call upon (dispatch) an increasing number of units, climbing up the cost curve for resources, with these units kept online during the day. ISO-NE will then need to dispatch even higher-priced units for the day's peak hour.

7.2.2.2 Capacity Market

The New England electric system is designed to provide power whenever called on. To do so, ISO-NE must plan for all load levels, including very cold days in the future when heat pumps will be drawing significant power. Depending on the season, the seasonal peak demand can typically range from 15,000 MW in the spring or fall to 20,000 MW during the winter, and 24,000 MW during the summer. The particular hour of the particular day with the highest load level is called *peak demand*, and ISO-NE ensures that the system can meet that need.

ISO-NE predicts the peak demand three years into the future, and adds a reserve margin. Called the *installed capacity requirement*, this amount includes how many resources are needed to meet the peak requirement, plus a buffer to account for unplanned outages and uncertainty in the load forecasts. *Generation* can provide power when called on (although many generators can take hours to ramp up to full production, and others can only run when their fuel, like wind or streamflow, is sufficient). *Energy efficiency* is a resource that is considered to be always "on" during certain hours, and *demand response* is the active short-term reduction of load, typically in response to high energy prices.

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[255] Source: VELCO load data.

After determining the installed capacity requirement, ISO-NE conducts a *forward capacity auction* to purchase the amount of capacity required three years hence. ISO-NE selects resources based on the lowest price first, and then selects the next least expensive resource, and the next, up the "supply stack" until the requirement is met. Those resources that clear in the auction receive a *capacity supply obligation*, in which the resource agrees to provide power (or reduce load) when called upon. A resource will incur financial penalties to the extent that it does not meet its capacity supply obligation. Once the last resource is selected that cumulatively, with the others, meets the installed capacity requirement, then the price of that last resource is paid to all of the resources that were selected. That price is called the *clearing price*.

7.2.2.3 Ancillary Services Markets

To account for potential contingencies such as a generator or transmission outage, ISO-NE maintains *reserve resources*. There are three types of reserves:

- *Ten-minute spinning reserves* are generators that are already operating but not producing at full power. These resources can ramp up power production within ten minutes to provide power as needed.

- *Ten-minute non-spinning reserves* are generators that are not online, but have demonstrated that they are able to start and to produce a certain amount of power within ten minutes.

- *Thirty-minute non-spinning reserves* are generators that are not online, but have demonstrated that they are able to start and to produce a certain amount of power within 30 minutes.

ISO-NE requires that, at all times, there are sufficient ten-minute reserves to meet the largest single contingency (for example, an outage by the largest generator operating within, or resource importing into, New England), and that between a quarter and half of the ten-minute reserves consist of spinning reserves. The rationale for having spinning reserves is that the a generator is most likely to experience failure during startup; since these generators are already producing power, they are much more likely to be able to increase production within ten minutes and provide the necessary reserves. The amount of 30-minute reserves must be equal to the amount needed to meet one-half of the second largest contingency.

In addition to the reserve markets, ISO-NE manages a *regulation market*. In this context, *regulation* means the ability of generators to increase or decrease output every four seconds to respond to small changes in the balance of the electric system.

7.2.2.4 Participation in the Wholesale Markets

Each of Vermont's distribution utilities is required under the ISO-NE tariffs and market rules to participate in the wholesale markets described above. To protect against market volatility, utilities can enter into bilateral contracts with resources for energy and capacity needs. These resources are still entered into the markets; however, the utility will pay only the contract price to the resource, rather than the market price. For example, if a utility has a long-term contract for energy from a generator for $60/MWh, the generator will earn that price for every unit of energy produced, providing a guarantee of revenue stability that allows the developer to finance the project. When the generating unit then participates in the energy market, the utility receives payment for each MW in the amount of the clearing price in the relevant hour. (As described above, the utility also is bidding load into the energy market, paying the clearing price hourly for load.) In this example, if the market price were $60/MWh, then the contract was set appropriately. If the price was $70/MWh, the utility would benefit (resulting in downward rate pressure). If the price was $50/MWh, the utility is required to make up the difference.

Although the utility will likely be paying higher-than-market prices at some times during the year and lower prices in others, it will have estimated the long-range market price of energy and estimated that the contract price is an appropriate hedge against market volatility. In other instances, the utility may shape the contract price to better aligned with expected variability in price or shape the amount of energy delivered in order to better align with demand at different times of day, month, or year. Overall, Vermont utilities are typically more heavily hedged against market price volatility, through bilateral contracts, than utilities in other states.

The Vermont regulatory role in the wholesale market process is typically an after-the-fact review of a utility's long-term contracts during a rate case — or, for larger contracts, a before-the-fact review in a proceeding under 30 V.S.A. § 248. During these reviews, the PUC can examine whether the utility was prudent in entering into the contract. This would involve testing the reasonableness of the utility's estimates of future wholesale prices, along with the efforts the utility undertook in pursuing alternative resource options. Utilities are also required to prepare and submit Integrated Resource Plans to the PUC, setting forth the utility's plan for serving customers in a reliable and least-cost manner while meeting sustainability requirements.

7.2.3 Winter Reliability

As reliance on electricity for essential services grows, the risk and potential impact of loss of electricity increases, and remains a primary concern in the design and operation of the grid. ISO-NE has identified the winter season as having the highest likelihood for such an event. A "severe prolonged cold snap" lasting multiple days, paired inherently with high demand for electricity, could bring about inadequacy in available generation resources such that not all electric load can be served reliably. Procurement of a portfolio of resources, and the transition to a more renewable and clean future, must consider overall reliability of the grid.

Increasingly, the New England electric system has become reliant on natural gas for power generation year-round. Available pipeline capacity limits the amount of natural gas that it is possible to procure from our neighboring regions and, during a cold snap, some natural gas plants would find their fuel supply restricted by the competing demand of residential heating. While it is possible for some generating stations to utilize liquid natural gas (LNG) in place of the gas piped in from neighboring regions, it may still be difficult for these plants to obtain fuel given supply chain challenges and competing demand from foreign markets.

Over the past years, some generating plants in New England that were fueled by coal and oil have retired, largely to be replaced by natural gas plants. This has increased reliance on the remaining coal and oil units during cold snaps. Concerning to ISO-NE, though, are the fuel reserves of these remaining units — there may be sufficient fuel to generate electricity for a day or more, but a prolonged cold weather event, especially paired with global oil supply chain limitations due to the pandemic, could prevent delivery or utilization of additional fuel shipments.

The growth of renewable, intermittent resources in Vermont and elsewhere in the region has begun to decrease the demand for electricity from fossil fuel generators, and indications are that this essential process will continue. However, the efficacy and availability of these resources can be severely hampered by extreme weather conditions. It is expected that, in a winter weather event, wind turbines may be shut down due to blade icing or high wind, solar panels may be covered by snow or ice, and that small-scale hydro turbines could suffer from deficient water flow. Reduction of this risk will require the diversification of renewable resources with regard to technology type and geographical location across Vermont and, expressly, across New England.

In preparation for a cold snap, it is possible to charge battery energy storage systems co-located with a generation resource or connected individually. However, at the present, most batteries are designed to output stored energy over the course of a few hours, rather than the duration of the few days that may be needed in a prolonged weather event. It is possible to stagger or ration the output of multiple batteries in concert, but to store an amount of energy fitting of the problem at hand would require the installation of many more batteries than may otherwise be economically feasible based on current market structures.

Research and development is underway for other resource types, like green hydrogen production via electrolysis and storage for later use in a fuel cell; low-impact run-of-river hydro, utilizing technology similar to tidal generators; small, modular, next-generation nuclear fission, such as could use thorium fuel; and inertial or magnetic confinement nuclear fusion. These types of generation may be able to provide services that are expected to be in increasing demand. Hydrogen fuel cells could account for the instantaneous differences in load and generation by injecting power on a sub-second basis in a process called frequency regulation, acting as a kind of spinning reserve. Fusion plants could provide reliable, sustainable baseload power.

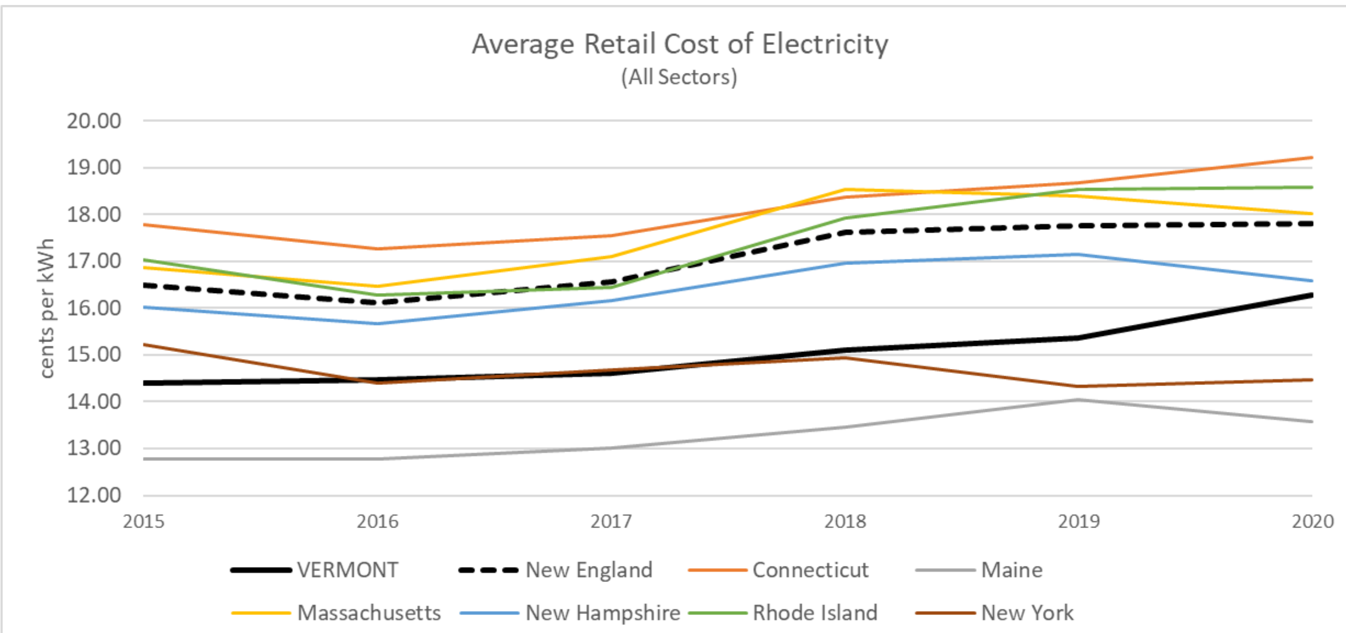
However, it remains to be seen whether these kinds of resources will become accessible, affordable, safe, and sustainable. Until such time, and until thorough cost, safety, and environmental vetting procedures have taken place, it is premature to recommend these resources as solutions to the problems of energy supply and winter reliability in the region. Existing nuclear fission generators, like the Seabrook plant in New Hampshire, presently serve as a reliable source of carbon-free electricity and are especially important under such weather conditions as described here.

Other types of resources for generating electricity that are already connected to Vermont's grid, such as biomass and large-scale hydro, can operate efficiently even during periods of extreme cold. It is possible to store biomass fuel like wood chips at quantities that allow several consecutive days of operation, and large hydro facilities do not incur the same fuel transport concerns of other resource types. It is important to recognize that these resources provide unique reliability advantages.

7.3 Paying for Electricity

Vermonters paid approximately $900 million in electricity costs in 2020, with the power supply component accounting for more than half of that total. This translates to average annual electricity expenditures of roughly $1150, within individual average household electric expenditures ranging from $302 to as much as $1777, accounting for approximately 20% of a household's energy-related costs[256]. Exhibit 7-2 shows a snapshot of recent New England and Vermont electric costs per customer. Vermont currently maintains a modest price advantage compared with the region on average, lower than all other states except Maine, although rates vary by end-use sector and by utility. Since 2012, Vermont's electric costs have risen modestly, but remain lower than most of New England.

Exhibit 7-2. Average Retail Cost of Electricity (Cents per kWh)[257]



Source: U.S. Energy Information Administration

Electric prices are influenced by commodity prices; however, Vermont utilities continue to favor long-term contracts for the bulk of their supply. While other states in the region have restructured their electric utilities to separate ownership and operation of generation, transmission, and distribution of electricity, Vermont has remained "vertically integrated": electric utilities can maintain ownership of all three components of electricity generation and delivery. Restructured states often don't allow retail providers

[256] Efficiency Vermont, Vermont Energy Burden Report, October 2019, available at:: 2019 Vermont Energy Burden Report.pdf (efficiencyvermont.com).

[257] Note, to compare Vermont electric rates with the New England states and New York, we use EIA data on average retail price of electricity as a proxy. EIA calculates the average price of electricity to customers by taking the ratio of electric revenue divided by sales, so provide an estimate for "cost per unit of electricity sold". EIA uses information on the weighted average of consumer revenue and sales within and across sectors. While this data does not represent actual rates, it provides the best way to compare costs across states.

to enter into long-term contracts, which has introduced significant volatility to customers, year over year (or in shorter time periods).

Vermont's vertically integrated structure, with long-term contracting or ownership of resources, has limited exposure to short-term variations in wholesale market prices — and as a result, customer prices tend to remain much more stable than prices in other sectors. Generally, this has also facilitated entering into long-term agreements at favorable times, which has helped lead to favorable electric rates.

However, while Vermont has generally experienced some of the lowest rates in New England to date, policies and programs seeking to achieve renewable energy goals, such as the Renewable Energy Standard, are expected to produce moderate upward rate pressure in the future (continuing the trend illustrated in Exhibit 7-2). As a result, as the state seeks to pursue electrification strategies in the thermal and transportation sectors to achieve GWSA requirements, it is important to understand core components of electricity costs and the associated drivers of that rate pressure. Such an understanding will allow for consideration of how to structure programs and policies to mitigate increases in rates where possible, keeping rates affordable for all Vermonters as electricity becomes an increasing share of energy-related costs.

In doing so, it will be particularly important to consider how rate pressure impacts different communities within the state with an understanding of the relative energy burden that Vermonters face. Electricity costs represent a higher percentage of expenses for low-income Vermonters than for those whose incomes are significantly higher than the Vermont median household income of $63,000.[258] The COVID-19 pandemic has further illustrated how vulnerable certain communities within Vermont are to experiencing energy insecurity. At times during the pandemic, some utilities had over 20 percent of customers within certain classes (e.g., residential, commercial) with past-due bills of over 30 days, experiencing dramatic increases in arrearages compared to pre-pandemic levels. Together, these data showcase how electricity costs and rate pressure are felt very differently, depending on who is bearing these costs. In efforts to better understand cost drivers, the following sections describe key components of electricity costs and how they flow through to customer rates.

7.3.1 Least-Cost Planning

The concept of least-cost planning is a central component to the decision making of Vermont's electric utilities and regulatory policies. By statute,[259] electric utilities are required to develop least-cost integrated resource plans (IRPs) that set forth the approach the utility takes for providing reliable, least-cost service to customers while meeting Vermont's renewable and environmental requirements and goals.

The underlying principles of least-cost planning have been embedded in Vermont law since 1991, and represent a key regulatory concept in the state. Least-cost planning does not mean that only the lowest-cost resources are selected. As with a portfolio approach to retirement planning, a portfolio approach to electric resources minimizes risk; and the resources must further GHG reduction and other requirements.

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[258] Ibid.
[259] 30 V.S.A. § 218c.

7.3.2 Cost Drivers

There are several components to electric costs, and an increase in one area can be offset, in full or in part, by a decrease in another. The electric rates and bills that customers pay are a sum of these component parts. Consequently, even if electric rates are holding steady, it's possible that Vermonters would have seen an increase or a decrease in their electric rates if not for the cost driver in one area.

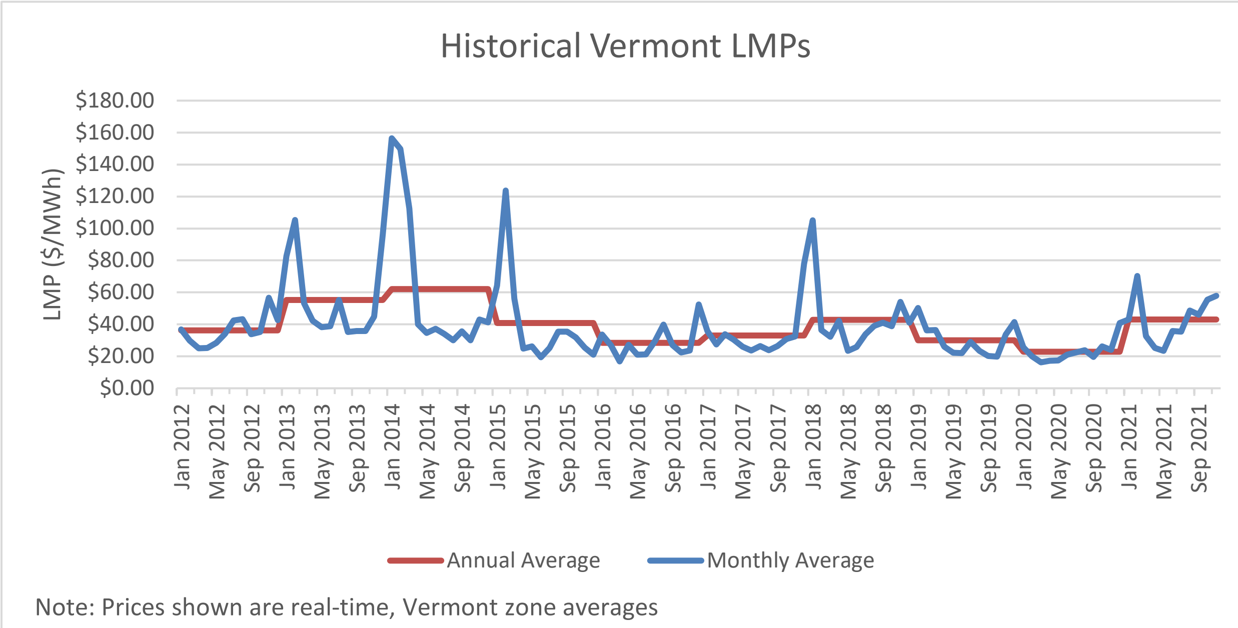
7.3.2.1 Wholesale Energy Prices

Wholesale energy prices represent the "avoided cost" of energy for Vermont utilities — in other words, the amount that Vermonters could be paying if they procured energy directly through the wholesale market (keeping in mind that energy is just one component of a consumer's electric bill). The average 2020 wholesale energy price in New England was $23.38/MWh ($0.02338/kWh)[260], which is among the lowest prices since the introduction of the wholesale markets in 2003.

New England wholesale energy prices have been trending down as the price of natural gas has fallen. Natural gas-fired units are typically the marginal units in the region, and therefore set the price; natural gas prices and wholesale energy prices correlate extremely well. Given constraints on the gas pipelines in the winter (due to natural gas being prioritized for heating in the winter), this means that annual average energy prices have become primarily dependent on winter temperatures. For example, the average wholesale energy price for the month of December 2020 was $60/MWh, while the price in March 2020 was $28/MWh. This seasonal variation impacts the relative value of different intermittent resources as well, with resources that generally produce more energy in the winter having significantly more value than resources that produce in the spring and summer.

[260] https://www.iso-ne.com/about/key-stats/markets/

Exhibit 7-3. Locational Marginal Prices for Vermont



Source: ISO New England. Available at: https://www.iso-ne.com/isoexpress/web/reports/pricing/-/tree/monthly-lmp-indices

The wholesale prices are indicative of what Vermont's utilities could be paying for power supply if they procured all energy needs through the ISO-NE market. However, Vermont electric utilities are significantly hedged against short-term wholesale market prices (through mandated power procurements, voluntary long-term contracts, or utility-owned generation resources). This means that utilities purchase relatively little energy from the wholesale day-ahead and real-time energy markets, and therefore the benefits of these current and historically low wholesale prices are muted for Vermont ratepayers. Conversely, Vermont ratepayers do not immediately bear the significant market price increases that occur when cold weather drives up wholesale prices. Rather, market price trends are reflected in future long-term contracting arrangements.

Wholesale prices also have an important role in reviews by the Department of Public Service and the Public Utility Commission of additions to an electric utility's power supply portfolio. The cost of any new resource is compared against wholesale market prices (and other value streams that the resource provides). To the extent that there are significantly lower wholesale prices projected over the term of the contract for a resource with similar characteristics, it becomes more difficult for a utility to demonstrate that a particular new resource provides an economic benefit to Vermonters.

7.3.2.2 Wholesale Capacity Costs

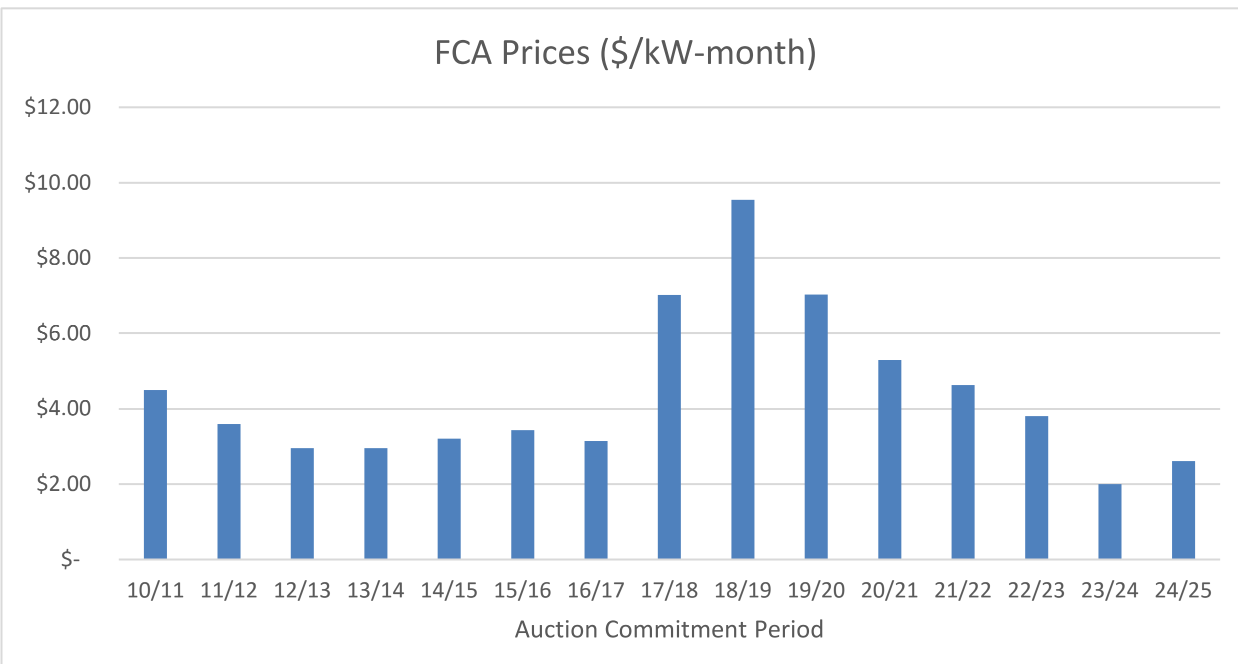
In addition to energy delivered on an hourly basis to customers, ISO-NE operates a Forward Capacity Market to ensure that there are sufficient resources to meet the region's annual peak load, which has typically occurred during mid- to late-afternoon during the summer. In recent years, this regional peak has been trending later and later in the day. The Forward Capacity Market procures capacity from generation, efficiency, and demand response providers (including Vermont utilities) three years prior to the delivery of the capacity.

Costs are collected from ratepayers based on each utility's share of the annual regional system peak. For example, if the New England-wide peak load for 2022 was 24,000 MW, and a Vermont utility's load during that same hour when the New England-wide peak occurred was 600 MW, that utility would pay 2.5% of the total cost of the Forward Capacity Market costs for the year. The costs are collected and paid out a monthly basis.

With respect to capacity resources (which can be generation, energy efficiency, or demand response), the compensation those resources receive from the capacity market depends on the likelihood that they will be providing energy during the peak hour. For example, assuming that peak hours happen on calm, humid days during the summer, a 100 MW wind project may only be producing 25% of its nameplate capacity, and therefore the wind project would be paid for providing 25 MW as a capacity resource.

Exhibit 7-4 shows the capacity prices since the inception of the ISO-NE Forward Capacity Market. Over the last several years, capacity prices have been declining, reflecting a combination of lower demand as well as continued installation of state policy supported renewable resources.

Exhibit 7-4. ISO-NE Forward Capacity Auction Prices by Winter Season[261]



Source: ISO New England.

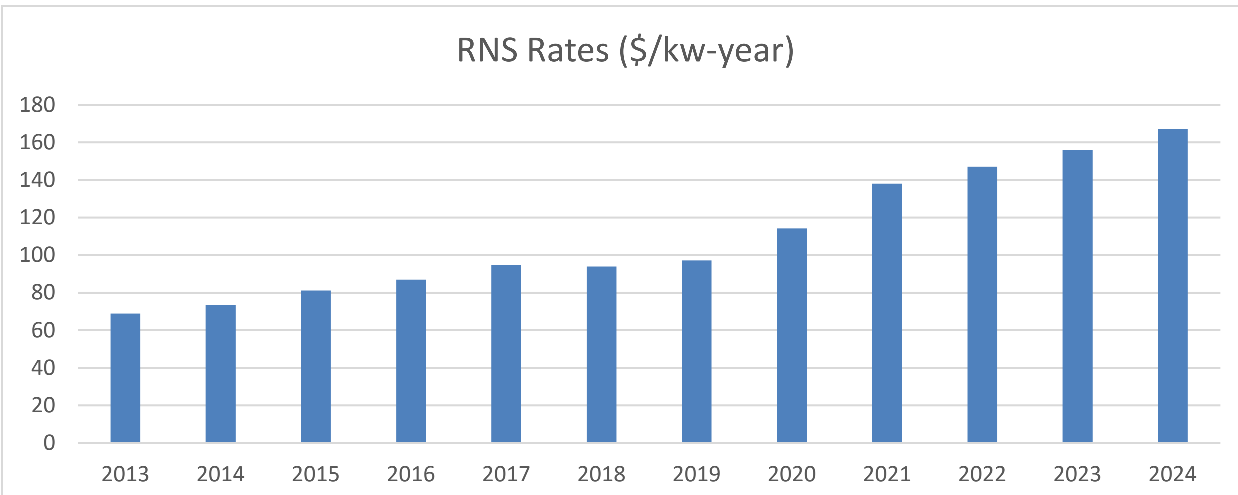
[261] ISO New England: Results of the Annual Forward Capacity Auction. Available from: https://www.iso-ne.com/about/key-stats/markets#fcaresults

7.3.2.3 Transmission Costs

As a result of increased federal reliability standards, a significant amount of transmission has been built in New England over the past two decades. New England customers pay approximately $2 billion per year in regional transmission costs, with Vermonters responsible for approximately 4% of that amount. These costs are collected through monthly payments of the Regional Network Service (RNS) charge. These RNS charges are collected based on each utility's percentage load as recognized by ISO-NE at the time of their transmission provider's peak for each month. If a utility can reduce its demand at the time of this peak, it avoids significant costs for its ratepayers by shifting those costs to other utility ratepayers in New England.

Exhibit 7-5 shows actual and projected RNS rates, projecting to continue to increase over time:

Exhibit 7-5. ISO-NE Regional Network Service Rates



Source: ISO New England.

In addition to regional transmission costs, Vermonters also pay for local transmission, or *sub-transmission*. This includes high-voltage infrastructure that does not provide a regional benefit, so the costs are borne by Vermonters. There are several instances where one Vermont utility receives sub-transmission service from another Vermont utility (e.g., Northfield Electric Department receives transmission service from Green Mountain Power), or where generation is "wheeled" out of one electric utility's service territory to another utility (e.g., power from some Standard Offer generation is wheeled out of Washington Electric Cooperative's service territory to be allocated to other Vermont utilities).

7.3.2.4 Renewable Energy Certificate Prices

Renewable Energy Certificates (RECs) represent the renewable attributes of energy, and can be sold bundled with or separate from that underlying energy as a commodity unto themselves. REC prices can vary considerably over time, and are largely driven by state renewable energy requirements within the region, for which utility compliance is usually measured in terms of retired RECs. In order to understand

Vermont REC price forecasts, it is important to first understand the relationships among the different regional REC markets.

Vermont Tier I RECs are generally equivalent to regional Class II — or existing-resource — RECs in neighboring states, with the exception that imports from Hydro-Québec (HQ) and New York Power Supply Authority (NYPA) are considered renewable in Vermont but are instead considered "carbon-free" in other states. It follows that Vermont Tier I prices tend to be very similar to Class II prices in neighboring states. Over time, Tier I prices have been relatively low, given the relatively low demand in the region for these RECs and the ability of Vermont utilities to use HQ and NYPA attributes to satisfy the Tier I requirement. However, other states have recently shown an interest in expanding their requirements related to existing renewable resources, which would drive up Tier I prices (these are also subject to a cap set by Vermont law and adjusted for inflation; if prices go above this cap, utilities can make an Alternative Compliance Payment into the Clean Energy Development Fund). In addition, significant voluntary purchases appear to have contributed to a recent reduced supply of Tier I RECs. This may be reflected in more recent prices in 2021 being up to 7-8 times as expensive as previously traded. It is difficult to say whether higher prices are here to stay, but the relatively sudden increase in costs reflects the variability of Tier I REC prices and highlights the potential impact on rates.

Vermont Tier II resources are a small subset of regional Class I, or premium, resources in other states. When there is sufficient Tier II supply in Vermont, excess RECs will be sold as Class I to neighboring states, which results in Tier II prices that are very similar to Class I prices. However, if there was a shortage of Vermont Tier II resources — for example, if constraints on the transmission or distribution system were to make new interconnections prohibitively expensive — then prices would diverge, with Tier II prices approaching the Alternative Compliance Payment while Class I prices trade at a different market price.

Tier I requirements are generally satisfied with RECs from existing, utility-owned resources or purchases of unbundled RECs from existing renewable resources that are physically located in New England or imported into the region. Tier II requirements are generally satisfied with RECs from utility-owned resources as well as resources from Vermont's net-metering and Standard Offer programs. Vermont statute requires electric utilities to retire RECs assigned to them from net-metered systems; these RECs can be counted toward Tier II of RES. RECs and the impact on the characterization of Vermont's energy supply portfolio and its costs are discussed in Section 7.6.

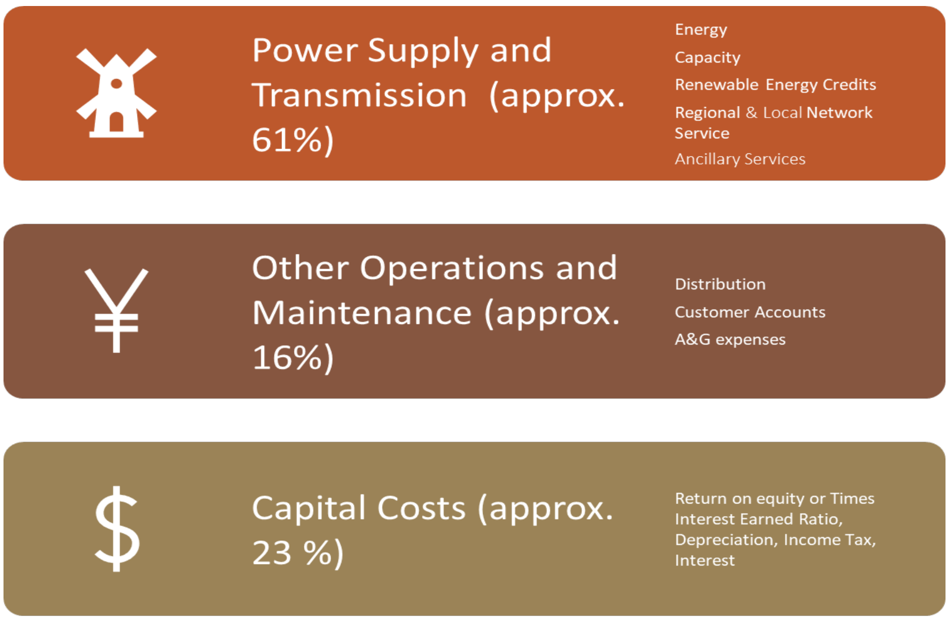
7.3.2.5 Retail Prices

Retail rates are what end-use customers pay. These rates reflect not just the power supply portfolio but also other regional costs to secure and deliver wholesale electricity (e.g., ISO-NE capacity and transmission), the costs of maintaining the distribution system (tree trimming, upgrading lines and transformers, etc.), and administrative costs (billing, customer service, etc.). The power supply component, along with regional capacity and transmission costs, generally accounts for 50% to 60% of retail rates.

Vermont's retail prices tend to be relatively stable, compared to retail prices in other states. This is in part because Vermont remains the only state in the Northeast with vertically integrated electric utilities,[25] and also because of statutory policy regarding stably priced contracts, and the resulting hedging strategy that Vermont's utilities employ. The retail rates across Vermont's utilities vary considerably and are dependent on a number of factors, including power supply commitments and whether the utility's service territory is urban or rural.

Exhibit 7-6 details the composition of retail costs:

Exhibit 7-6. Retail Electricity Costs by Component



7.3.3 Components of an Electric Bill

Vermonters' electric bills are made up of a number of components that reflect the fixed and variable components of the cost to supply them with electricity on demand.

- *Customer charge:* This set amount per billing period is designed to collect some portion of the fixed costs of the utility's service (e.g., delivery infrastructure such as poles and wires, vegetation management, operational software, administrative functions).

- *Energy:* A per-kWh charge is designed to reflect non-fixed energy costs and some portion of the fixed costs. Vermonters pay an average of $0.164/kWh for electricity, although this amount can vary considerably. Some utilities include "inclining block rates," where the initial block of kWh is at a lower cost and the second block is at a significantly higher cost.

- *Demand charge:* This per-kW charge reflects the fact that customers with very high peaks are more expensive to serve, as the utility must maintain higher-capacity infrastructure and pay greater transmission and capacity costs. This charge does not apply to most customers.

- *Energy efficiency charge (EEC):* This is the only item specifically noted on all Vermonters' electric bills. The EEC is used to fund Efficiency Vermont and Burlington Electric's efficiency programs, the portfolio of which costs less than alternative supply.

- *Other:* Subject to PUC approval, utilities can also add line-item charges for other services such as major storm cost recovery, proactive ash tree removal to address the emerald ash borer threat, etc.

Exhibit 7-7 demonstrates the variability in electric rates and customer charges paid by residential Vermonters.

Exhibit 7-7. Electric Rate Key Components for Select Utilities

Ludlow		WEC		GMP	
Customer Charge:	$8.56	Customer Charge:	$22.25	Customer Charge:	$15.45
First 100 kWh:	$0.0523	First 100 kWh:	$0.08746	kWh:	$0.17650
Above 100 kWh:	$0.1179	Above 100 kWh:	$0.22220		

Rate design is an art as well as a science. In theory, the fixed costs of providing service would be recovered entirely through the customer charge; however, this approach reduces Vermonters' ability to control electric costs and would likely disproportionately impact low-income Vermonters. As a result, some fixed costs of the electric system are included in the volumetric energy charge in addition to the customer charge. Seeking to support low-income Vermonters, one of Vermont's electric distribution utilities (Green Mountain Power) currently offers an Energy Assistance Program (EAP), which offers a 25 percent discount on the customer and energy charge portions of their electric bill each month and includes 100% arrearage forgiveness at the time of enrollment[262] (Vermont Gas Systems has a similar program). This rate is available to customers at or below 150% of the federal poverty line. The Public Utility Commission, under case 20-0203-INV, is currently investigating the potential to establish a program for reduced rates for low-income residential ratepayers across Vermont electric utilities.

The electric rates paid by Vermonters have implications for the customer cost-effectiveness of energy services and decarbonization strategies, as discussed in Chapter 4 (Grid Evolution), Chapter 5 (Transportation and Land Use), and Chapter 6 (Thermal and Process Energy Use).

7.4 Electricity Demand

Exhibit 7-8 shows the state's annual electric energy consumption for the last two decades. Annual electricity consumption has declined since 2005, largely due to increased investments in electric efficiency (see Section 7.5) and also small-scale solar projects.

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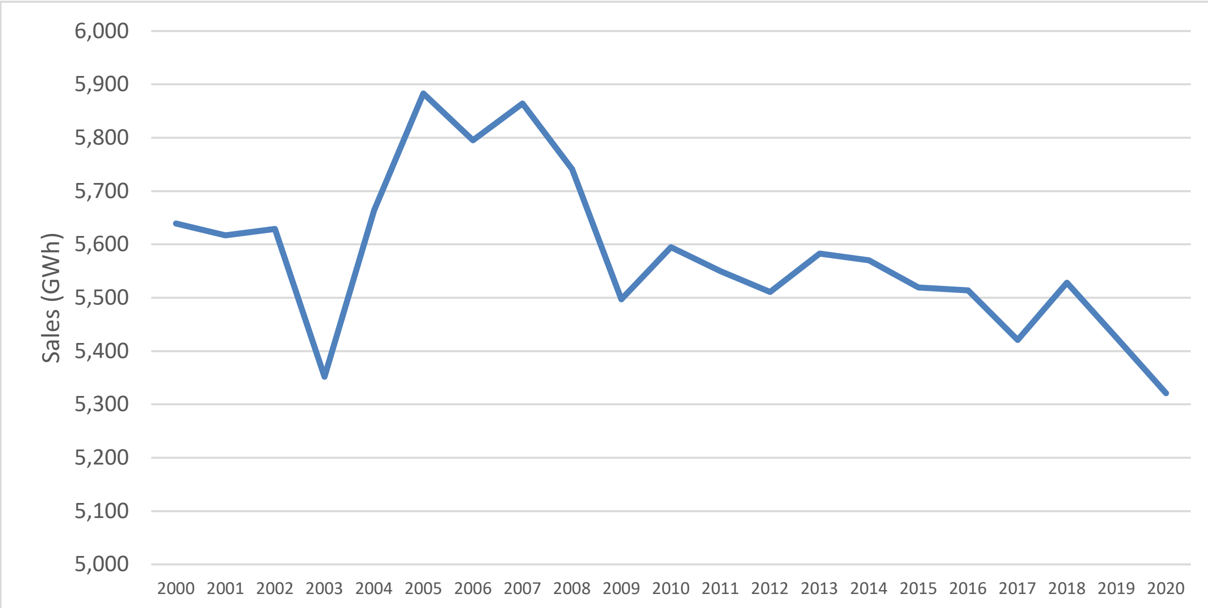
[262] The EAP was approved by the PUC in 2012 and began enrolling customers in 2014. More information is available from: https://dcf.vermont.gov/benefits/eap/gmp and the "Workshop Presentation Materials" filed on July 6, 2021 under PUC case 20-2003-INV.

Exhibit 7-8. Annual Electric Energy Retail Sales, in Gigawatt-hours (GWh)



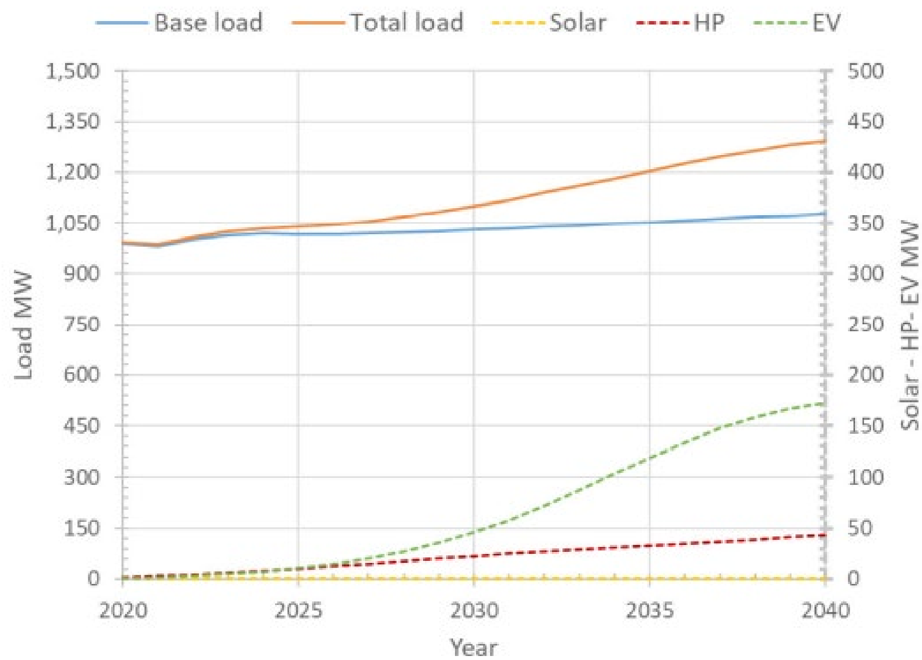
Source: U.S. Energy Information Administration. Available at: https://www.eia.gov/electricity/sales_revenue_price/

Vermont Electric Power Company (VELCO) is the state's transmission company. VELCO is required to periodically complete a long-range transmission plan[263] that is vetted through a stakeholder group called the Vermont System Planning Committee (VSPC). The VSPC is made up of VELCO, electric distribution utilities, the Department of Public Service, representatives of demand and supply resources, and representatives of the general public. The long-term VELCO demand forecast is based on forecasts by customer class and energy end uses. That is, the forecast captures changes in customer class and end-use sales trends that are driven by long-term structural changes — such as changes in housing size, improvements in thermal efficiency, and changes in end-use saturation and end-use efficiency trends. The forecast is weather-normalized (adjusted for year-to-year weather variability), and it incorporates expected effects from the most recent appliance efficiency standards. In addition, the VELCO forecast reflects a projection of program efficiency savings as completed by Efficiency Vermont, behind-the-meter solar, heat pumps, and electric vehicles.

Overall, the most recent VELCO summer forecast (Exhibit 7-9) projects a relatively modest increase in peak load over the next ten years, to 1,119 MW in 2030 (from a historical five-year average of 950 MW), and then a more significant increase thereafter (to 1,294 MW in 2040), primarily driven by electrification of heating and transportation. The VELCO winter forecast (Exhibit 7-10) shows a much more significant increase, given the expected load from electric vehicles and heat pumps. The 2030 winter peak forecast is 1219 MW (from a historical five-year average of 970 MW), increasing to a forecasted 1499 MW in 2040. For both forecasts, solar is shown as not impacting peak load, as the peak hours are expected to be after dark, consistent with experience over the past several years.

[263] The 2021 Long Range Transmission Plan is available at 2021 VLRTP to PUC_FINAL.pdf (velco.com).

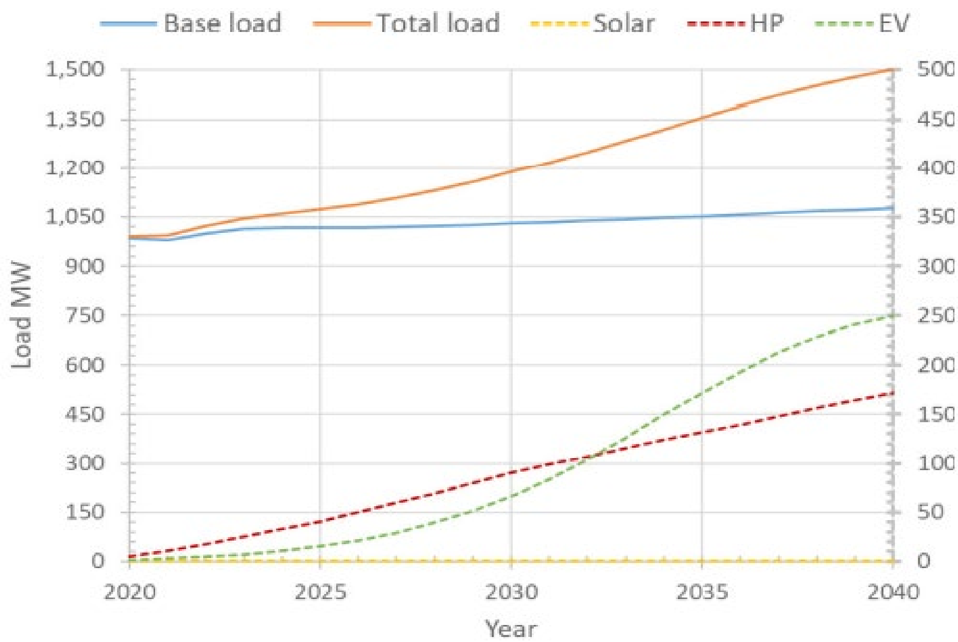
Exhibit 7-9. Projected Vermont Summer Peak Load and Component Forecasts



Source: VELCO 2021 Long-Range Transmission Plan at 21. Available at: [2021 VLRTP to PUC_FINAL.pdf (velco.com)](). The base and total load lines use the scale to the left. The dashed lines for solar photovoltaics (PV), heat pumps (HP), and electric vehicles (EV) use the scale to the right.

VELCO's system has been winter-peaking for the past several years, due in part to long-term growth in electric efficiency and behind-the-meter solar. Going forward, Vermont will see higher growth in the winter peak load than in the summer peak, as a result of increased adoption of heat pumps and electric vehicles. Although heat pumps will be used for air conditioning in the summer, these devices use significantly more electricity to provide heat; in addition, electric vehicles are much less efficient in cold weather, and therefore more charging is needed to provide the same amount of mobility.

Exhibit 7-10. Projected Vermont Winter Peak Load and Component Forecasts



Source: VELCO 2021 Long-Range Transmission Plan at 21. Available at: [2021 VLRTP to PUC_FINAL.pdf (velco.com)](). *The base and total load lines use the scale to the left. The dashed lines for solar photovoltaics (PV), heat pumps (HP), and electric vehicles (EV) use the scale to the right.*

The above VELCO forecasts can generally be considered a "Business-as-Usual" or "Baseline" forecast of what might occur without significant action to meet our climate and energy policy needs. Before the completion of the pathways modeled for the Climate Action Plan, VELCO created a high load scenario to examine load growth that might be expected to occur if Vermont were to meet its energy and greenhouse gas emission goals. Without load management, it was observed that the winter peak load could reach as high as 1,800 MW. In order to limit system impacts, VELCO implemented load management measures for electric vehicles in line with present and expected utility practices. Doing so reduced the winter peak to 1,471 MW; it was found that this load level could generally be served reliably from a transmission perspective, with minimal modifications to transmission equipment. Further analysis by the distribution utilities would be needed to ascertain what degree of impact there would be to distribution equipment at this load level.[264]

As described in Section 2.2.1.1, the Department of Public Service in coordination with the Climate Action Plan and stakeholders modeled pathways toward meeting state energy and greenhouse gas emission goals. Because of the reliance on electrification to move away from fossil fuels as articulated in Chapters 5 and 6, modeling shows significant increases in annual and peak (if unmitigated) electricity consumption are necessary to meet our targets. Initial modeling shows that unless well managed, electrification

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[264] It is important to distinguish the load serving capacity of the system and the generation hosting capacity of the system. Because the system is expected to be able to accommodate a certain amount of load does not guarantee that it could accommodate a commensurate amount of generation, and vice versa.

necessary to meet our goals will increase electricity consumption approximately 16% by 2025 and over double by 2050 (See Exhibit 7-23 further below).

This highlights significant opportunities to manage demand and meet remaining needs with efficient, affordable, and cleaner supply. Demand and Supply are discussed in the following two sections.

7.5 Managing Demand

7.5.1 Energy Efficiency Utilities

The Vermont Legislature has long required that regulated utilities include "comprehensive energy efficiency programs" as part of their responsibility to deliver services to their customers at least cost, under 30 V.S.A. § 218c. Electric efficiency programs and services are delivered primarily through *energy efficiency utilities* (EEUs) that have been appointed by the PUC. The EEUs are funded to design and deliver technical, financial, and educational services that help Vermonters overcome barriers to improving the energy efficiency of their homes, businesses, institutions, and municipal facilities. The EEUs provide financial support to retail customers, distributors, and wholesalers, as well as technical assistance across a wide variety of electric technologies, to improve the efficiency of electric consumption across sectors. The EEUs are authorized by 30 V.S.A § 209(d).

Title 30, § 209(d)(3)(B) requires the PUC to establish and adjust energy efficiency charges (EEC) in order to realize all reasonably available, cost-effective energy efficiency savings, with due consideration to rate impacts and several policy priorities. It requires that the PUC balance a number of objectives when setting an energy efficiency charge; provided that particular emphasis be on the first four of the following objectives:

1. Reducing the size of future power purchases;
2. reducing the generation of greenhouse gases;
3. limiting the need to upgrade the State's transmission and distribution infrastructure;
4. minimizing the costs of electricity; reducing Vermont's total energy demand, consumption, and expenditures;
5. providing efficiency and conservation as a part of a comprehensive resource supply strategy;
6. providing the opportunity for all Vermonters to participate in efficiency and conservation programs; and
7. targeting efficiency and conservation efforts to locations, markets, or customers where they may provide the greatest value.

The City of Burlington Electric Department (BED) is appointed to provide electric energy efficiency services in its own electric service territory, while for the remainder of the state, VEIC is appointed to operate to provide services as Efficiency Vermont (EVT). The PSD provides evaluation, measurement, and verification services to ensure that claimed savings materialize.

Over the past 20 years, the EEUs have managed electric energy demand to a level lower than it otherwise would be, while also delivering peak demand reductions and producing non-energy health, climate, and economic benefits. Exhibit 7-11 shows EVT's cumulative savings over time, and Exhibit 7-12 shows the results of BED's efforts, illustrating how investments in electric energy efficiency have mitigated increases in load and reduced the size of distribution utility power purchases to a level lower than they otherwise would be.

Exhibit 7-11. EVT's Electric Energy Efficiency Impacts

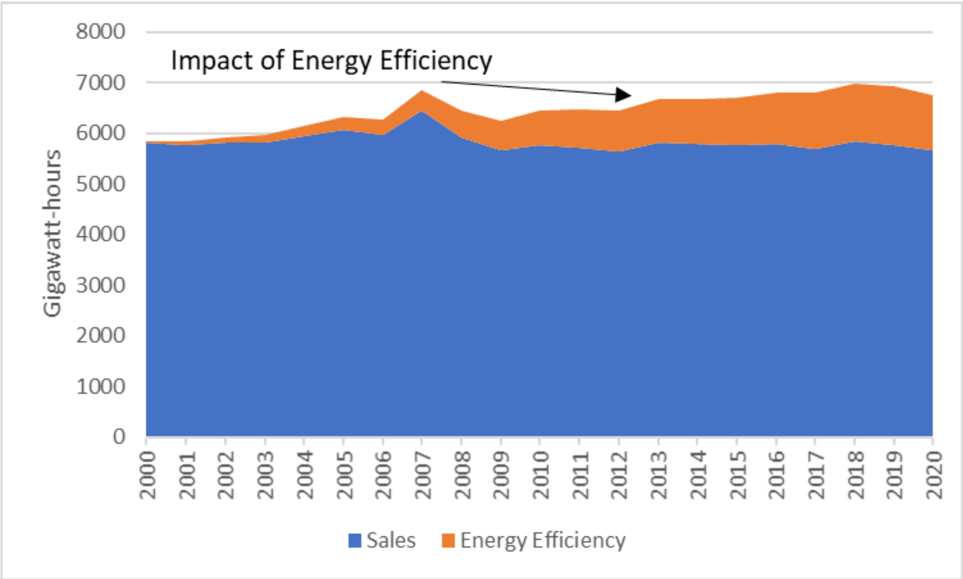
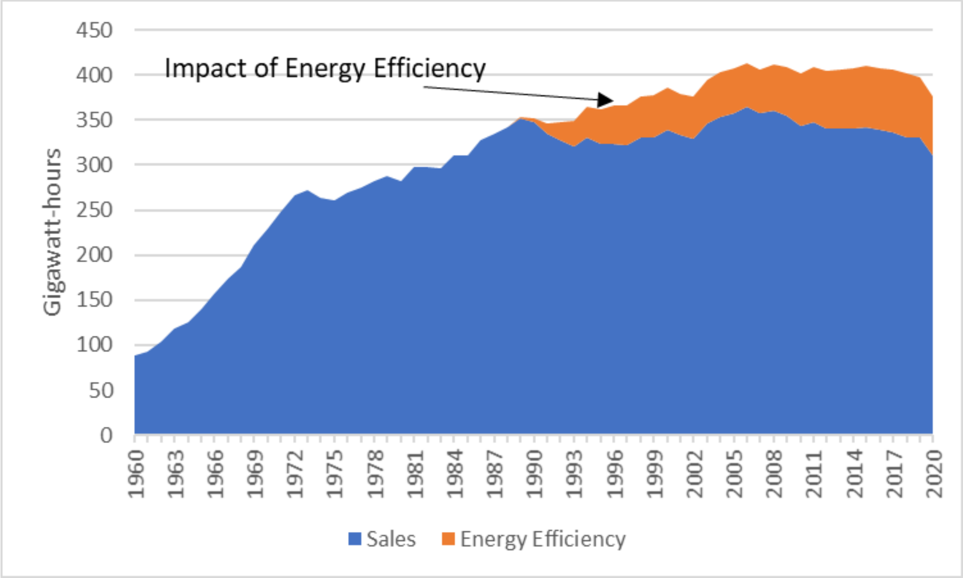


Exhibit 7-12. BED's Electric Energy Efficiency Impacts



The EEUs' three-year budgets are adopted by the PUC following the Demand Resource Plan (DRP) Proceeding, and an annual charge on utility bills, called the Energy Efficiency Charge (EEC), is set based on the approved budgets. Exhibit 7-13 identifies the 2021-2023 approved budgets for efficiency resource acquisition, development, and support services, PSD evaluation funds, and items such as fund audit expenses. For long-term planning purposes the DRP includes an assessment of potential as well as EEU modeling of both 3- and 20-year forecasts of electric savings. The EEU investments in energy efficiency are approved in the DRP every three years and remain less costly than alternative investments that could be made to procure the equivalent energy, capacity, and ancillary products, as well as the "non-energy benefits" such as greenhouse gas externalities or health benefits. In turn, with energy efficient equipment in place, participant customer bills are significantly reduced the over the lifetime of the investments. The budgets below are expected to produce more than 277,900 annual incremental MWh savings, 30 and 37 summer and winter MW of peak demand savings, respectively, and 140,200 metric tons of CO_2 energy and non-energy related GHG reductions.

Exhibit 7-13. Electric Energy Efficiency Charge Budgets as Approved by the PUC

2021-2023 Electric Energy Efficiency Charge Budgets			
EEU EEC Budgets	**2021**	**2022**	**2023**
EVT	$46,762,300	$46,814,856	$46,853,902
BED	$2,661,737	$2,336,530	$2,401,882
Total	**$49,184,037**	**$49,151,386**	**$49,255,784**

The DRP also sets Quantifiable Performance Indicators (QPIs) for each EEU. The QPI structure sets out a framework of targets that effectively aims to balance priorities, encouraging the placement of efforts where they are provide value to ratepayers. Each EEU QPI framework also includes a comprehensive suite of minimum performance requirements, ensuring equity of EEU services across ratepayer incomes, service classes, geographic regions, and utility territories.

The mix of measures and programs analyzed in the DRP aim to optimize rate and bill impacts, sector equity, and targeted areas for market transformation. Recently approved new pilot program areas pair energy savings with other benefits in an attempt to optimize investments and avoid lost opportunities. For example, the EEC was recently approved to support installation of end uses that are capable of being controlled by the area distribution utility, through "Flexible Load Management" (FLM) programs. Load control is overseen by the area distribution utility, which flexes loads away from times of peak demand. This saves energy and capacity and also avoids emissions from fossil generators. As articulated in Chapter 4, it is critical that the state continue to capture opportunities to increase load resource capability of matching the time when supply resources are operating. To the extent they are cost-effective over time, these types of pilots and programs can effectively leverage the statewide presence of EVT to help enable transitions away from fossil fuels.

The EEC was also recently approved to be used for a refrigeration management pilot, to support measures that both save energy and reduce fugitive refrigeration GHG emissions, which have a much greater global warming potential (GWP) than CO_2. Finally, through the passage of Act 151, a limited amount of electric ratepayer EEC funds are eligible to be used to support GHG emission reductions in the transportation and thermal sectors through market transformation efforts in coordination with the distribution utility Tier III programs. Evaluation of each of these newer programs will help determine their place and magnitude in future portfolios.

Over the strong 20-year history of electric energy efficiency programs, and due to the success of these programs, the amount of available electric energy efficiency potential has moderated. Exhibits 7-14 and 7.15 identify the forecast of electric energy efficiency potential for EVT's and BED's service territories.

Exhibit 7-14. EVT's Electric Energy Efficiency Potential (Incremental Annual MWh)

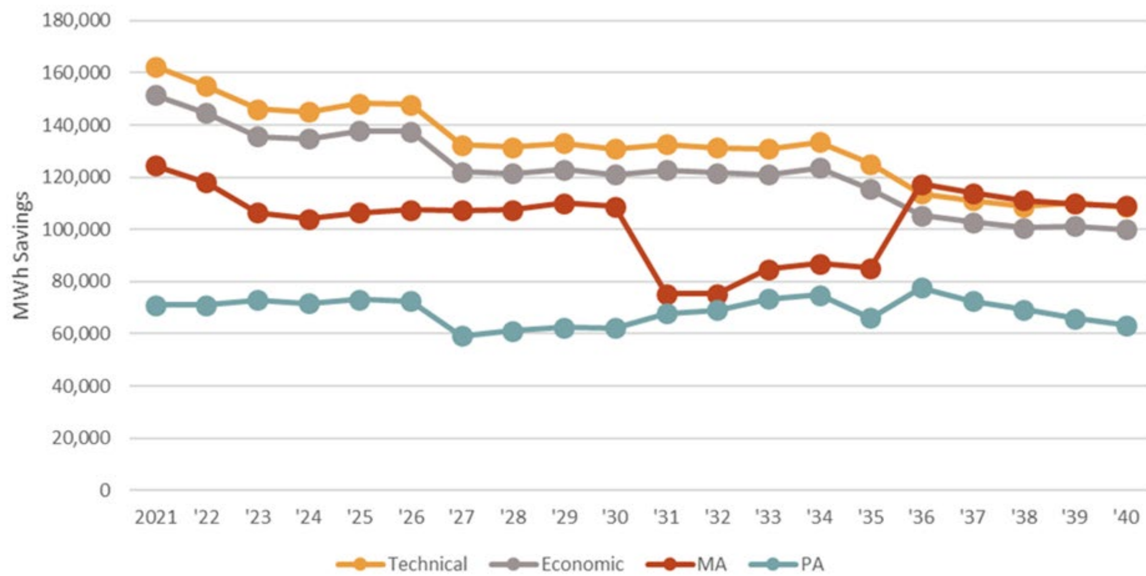
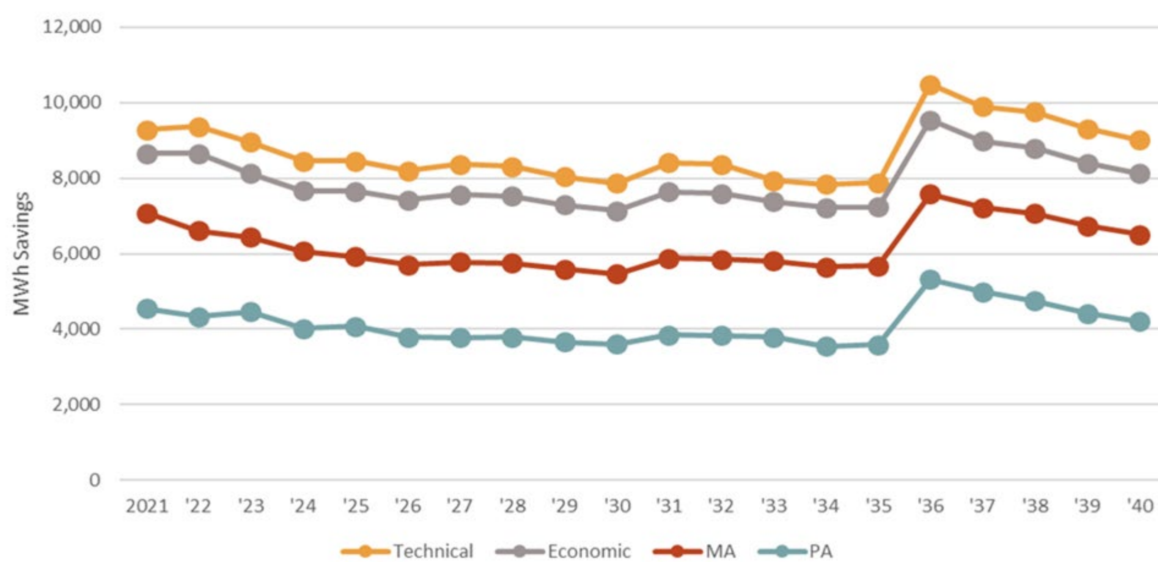


Exhibit 7-15. BED's Electric Energy Efficiency Potential (Incremental Annual MWh)



In these charts, *Maximum achievable* (MA) is the amount of energy use that efficiency can realistically be expected to displace, assuming the most aggressive programs and incentives for the entire incremental cost of the more efficient equipment. *Program achievable* (PA) estimates potential with incentive levels calibrated to historic levels, which are a fraction of the full incremental cost intended to reflect realistic barriers as well as sector equity constraints. Recent approved 2021-2023 performance targets for EVT and BED are set approximately between MA and PA levels. *Technical potential* and *economic potential* are theoretical. Technical potential is the amount of energy use that *could* be displaced by efficiency, disregarding non-engineering constraints such as cost effectiveness and willingness of end users to adopt. Economic potential is a subset of technical potential that is economically cost-effective but assumes no market barriers and programmatic costs.

Going forward, the confluence of a strong history, lower-trending avoided costs, and ongoing need to better support equitable investment for low-income and BIPOC (black, indigenous and people of color) communities may put pressure on overall portfolio cost effectiveness. This means that innovating non-traditional forms of demand management will be of continued importance. Further, initiatives with a higher cost of energy saved or no savings at all may need to be buoyed by other initiatives with a lower cost of energy saved — and continuing innovation in program design and delivery will be required to strike the right balance of overall portfolio cost-effectiveness. As Vermont meets more of its energy needs with electricity, more electric efficiency may become available than what the above Exhibits show. The amount of reasonably available cost-effective efficiency will need to continue to be evaluated, and acquired pursuant to the parameters of enabling statutes. A number of specific considerations and opportunities for the future are discussed below. Some are specific to the electric sector, and others are cross-cutting.

As discussed above, low-income customers have benefitted from EEU performance requirements ensuring that a minimum level of EEC collections (currently 85%) are reinvested back into low-income programs. To ensure equity for low-income and BIPOC communities, the current method of defining and pursuing equity for income-eligible and underserved Vermonters may need to be revisited. This will help ensure that benefits from EEC-funded programs are distributed inclusively and equitably. Efficiency Vermont and BED should evaluate diversity, equity, and inclusion metrics and indicators as well as the best methods for gathering participation data to ensure the benefits and burdens of the program are equitably distributed, without discouraging participation.

Refrigeration management and FLM programs will require further evaluation and scaling to ensure they are cost-effective and appropriately balance the priorities of electric EEC funding. Electric ratepayers are not intended to be the sole source of GHG reduction funding, so these programs should continue to be structured to provide benefit back to ratepayers in addition to acquiring societal GHG benefits. Any refrigerant management programs should include safeguards against improper disposal of refrigerants to ensure that harmful GHGs removed from old systems are contained, and do not leak back into the atmosphere after the project is complete. Caution should also be taken to account for fugitive refrigerants from old and new systems alike. For example, accounting for high-GWP refrigerants should include reduced leaks from old systems as well as the impact from the occasional leaks from new cold-climate heat pump systems (this is true for efficiency programs as well as fuel switching programs). In other words, high GWP refrigerant reductions should be accounted for on a net total portfolio basis.

Several areas of EEU efforts cut across sectors. They are discussed briefly here to highlight the need to clarify roles for efficiency programs in the future:

- Connected devices and controllable loads are made possible via internet connectivity. The broadband expansion to new and unserved areas of the state creates an opportunity to offer a suite of new services, including connected devices and controllable loads. For example, bundling smart appliance upgrades and connected energy-saving devices with incentives and federal dollars to improve broadband service and/or reduce the monthly cost of broadband service could create benefits for long-term adoption of FLM technologies and the utility's ability to manage load growth. These programs could be especially complementary to target markets including low-income residents, hospitals, nonprofits, agricultural businesses, and healthy home initiatives as a means for reducing costs and enrolling participants. However, while the electric EEUs can support putting energy-efficient end uses into service that are controllable by area distribution utilities, not all utilities may be capable of flexing loads at the same time or in the same way. Further, as broadband access is expanded, there is an opportunity to safeguard against stranded assets and potential inequitable distribution of FLM benefits across jurisdictions, through coordinated planning and common standards for connecting to and controlling loads. There is also an opportunity to establish regulatory performance incentives for coordinated solutions to controlling loads, with connected devices that cut across regulated utility services. Energy Efficiency Utilities should be fully engaged in the evolution of the grid (see Chapter 4) in order to determine the best manner in which to cost-effectively leverage the significant investments in efficiency delivery infrastructure to help facilitate broadband deployment, if possible.

- Workforce development is an important part of ensuring the ability to deliver energy services to Vermonters. The EEUs have made significant progress in this area — for example, they maintain a network of qualified contractors, trade, and workforce allies to aid in the design and installation of efficient equipment and continually offer trainings to ensure high-quality installations. To meet the demands of aggressive goals, the workforce may need additional support. See chapter 6 for further discussion on workforce issues.

- At present, EEC collections from Electric and Plug-in Electric Vehicle charging are not separately collected, or routinely quantified. While a relatively small total at this time, as EV and PHEV adoption increases the portion of EEC collections associated with transportation charging will increase. There is an opportunity to forecast and quantify estimates of future EEC collections from charging, in order to examine and establish policies that direct this revenue to the programs that deliver the greatest benefits to the sector.

7.5.2 Customer Programs

The PUC has established three types of programs that qualifying customers can use to manage energy efficiency projects on their own, without going through EVT. Participation criteria vary, and customers wishing to self-administer energy efficiency must submit an application to the PUC for approval.

- Energy Savings Accounts (ESA) and Energy Savings Accounts Pilot: Customers paying an average annual EEC of at least $5,000 may apply to the PUC to self-administer energy efficiency through an energy savings account. In addition, Act 150 of 2018 authorized the PUC to create an ESA Pilot. Participants continue to pay their EEC, and may receive that total amount back to cover the costs of energy projects, including technical support, evaluation, measurement, and verification. This is a three-year pilot, not to exceed $2 million in diverted EEC contributions. Eligible projects include electric and thermal efficiency, energy productivity, demand reduction, and storage.

- Commercial and Industrial Customer Credit Program: This program specifically targets large commercial and industrial electric customers who desire greater control over energy-efficiency expenditures at their facilities. This program recognizes that certain commercial and industrial customers in Vermont are committed to energy efficiency, and have considerable expertise in it. Currently there are no participants. To be eligible to participate, the customer must have:

  - Never accepted financial incentives from a Vermont utility-sponsored efficiency program, and

  - Demonstrated a commitment to pursuing cost-effective energy efficiency on their own.

- Self-Managed Energy Efficiency Program (SMEEP): Transmission and industrial electric ratepayers[2] may apply to implement electric and thermal energy efficiency measures on their own, if certain conditions are met. The ratepayer must have (1) at least $1.5 million in energy efficiency charges during calendar year 2008 or 2017; (2) a comprehensive management program, with annual objectives or achievement of certification under ISO standard 14001; and (3) commitment to an annual average investment in energy efficiency and energy productivity programs of $500,000 if using 2017 as a baseline for EEC charges, or $1,000,000 if using 2008. An eligible ratepayer may participate in SMEEP instead of participating in services or initiatives offered by Vermont energy efficiency utilities, and would be exempt from the EEC on its bills. There are currently two SMEEP participants.

7.6 Energy Supply

Vermont electric utilities have an obligation to provide reliable and sustainable power to customers, consistent with the principles of least-cost planning. Least-cost planning is conducted with full consideration of the GHG reduction and renewable requirements, and with the renewable goals contained in Section 8001 of Title 30. Further, utilities must provide customers with power during all hours of the year, and the selection of power supply resources must reflect the existing and forecasted load shapes.

Vermont's power supply requirements and policies have changed over time, and the characteristics and costs of electricity are heavily influenced by these requirements. The primary statutes from the last two decades that have shaped Vermont's power supply portfolios include:

- Sustainably Priced Energy Enterprise Development Program (SPEED) (30 V.S.A. § 8005 — from 2005 to 2015);
- Renewable Energy Standard (30 V.S.A. § 8005 — from 2015 to present);
- Net-metering (30 V.S.A. § 219a — from 1999 to 2017; 30 V.S.A. § 8010 — from 2015 to present);
- Standard Offer Program (30 V.S.A. § 8005a — from 2009 to present); and
- Renewable Energy Goals (30 V.S.A. § 8001 — from 2003 to present).

The SPEED program required Vermont utilities to collectively enter into long-term, stably priced contracts for at least 5% of statewide load in 2012 and 20% of statewide load in 2017. SPEED explicitly did not require Vermont utilities to retain renewable energy certificates (RECs) associated with the energy from SPEED projects. This provision allowed the Vermont utilities to encourage the development of renewable projects while offsetting some of the costs of the program. By 2014, approximately 230 MW of resources were included in the program, representing about 13% of kWh sales in Vermont.[265]

In 2015, the Vermont Legislature removed the SPEED requirement and brought Vermont into line with the majority of other states in the U.S. and every other state in the Northeast, by establishing a renewable standard that requires each Vermont utility to retire an amount of RECs equal to a certain percentage of its annual MWh sales.

- Tier I of the RES requires that each Vermont utility retire RECs associated with 55% of its annual MWh sales in 2017, rising to 75% in 2032. There are no size, age, or geographic limitations on the renewable resources that are eligible to produce RECs for this tier, provided that these resources deliver energy into New England.

- Tier II of the RES requires retirement of RECs from renewable resources with a nameplate capacity of less than 5 MW, commissioned after June 30, 2015, and located in Vermont. The Tier 2 requirement is a carve-out of the Tier 1 amounts and starts at 1% of annual MWh sales in 2017, rising to 10% in 2032.

- Tier III of the RES is not directly related to power supply purchases but instead directs utilities to pursue energy transformation projects such as building weatherization, increased electric vehicle adoption, and fuel switching of thermal sources. (Tier III is discussed further in Chapter 6).

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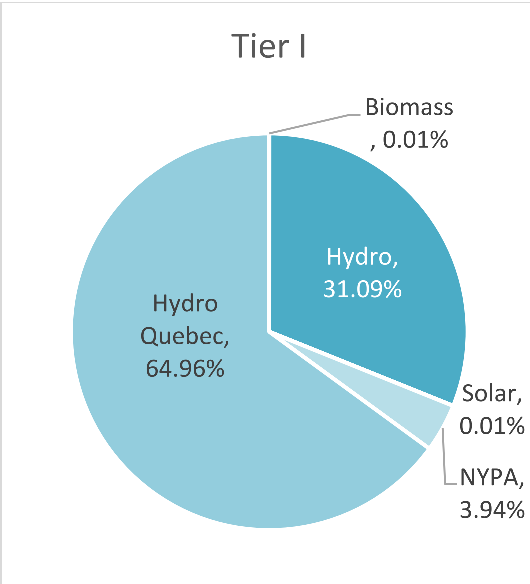
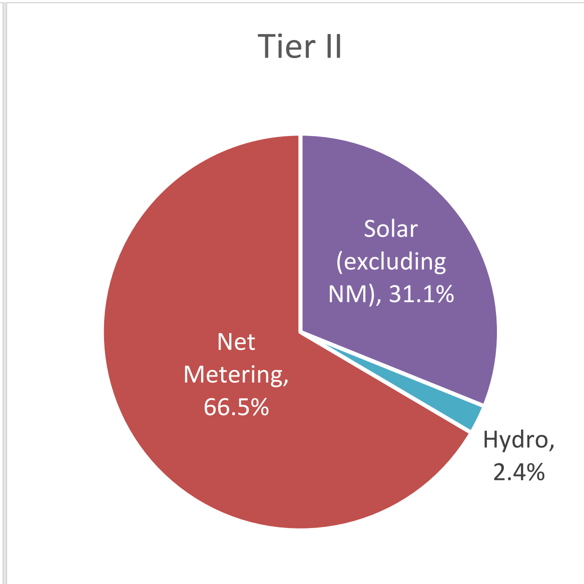
[265] Vermont Public Service Board, Biennial Report to the Vermont General Assembly Pursuant to 30 V.S.A. § 8005b, at 6-7. Available at: final-report.pdf (vermont.gov).

Exhibit 7-15 details the resources for which utilities retired RECs in compliance with Tiers I and II. The RES does not require the attributes that are retired to be associated with the purchase or ownership of other resource products such as energy or capacity.

Exhibit 7-15. Compliance with the Renewable Energy Standard by Resource REC Retirement, 2020





The RES did not incorporate the requirements of the SPEED program that rewarded the development of new resources, nor do those SPEED resources have an effective path to count under the RES. Technically, RECs from SPEED projects are eligible for Tier I; however, Tier I was specifically designed to be low-cost, recognizing that Tier II resources would be more expensive given the requirement that they be small and in-state. Since Tier I compliance can be achieved through the retirement of relatively low-priced RECs from older hydroelectric units or other imported hydroelectric resources and RECs from SPEED projects are not eligible for higher-value Tier II, the RES incentivizes the sale of higher-value RECs from the projects built under SPEED to utilities outside of Vermont.

Meeting the RES requirements comes at a cost to Vermont ratepayers: purchasing the energy, capacity, and environmental attributes is more expensive than just purchasing the energy and capacity needed to serve demand. The PSD is required to report on the costs of the RES annually. Exhibit 7-16 describes the cost of the three Tiers for the 2020 compliance year.

Exhibit 7-16. 2020 Renewable Energy Standard Performance by Tier

2020 RES Performance			
	REC Retirements		*Compliance Cost*
Tier I	3,682,870	RECs	$2,320,000
Tier II[266]	138,690	RECs	$6,010,000
Tier III [267]	248,953	MWhe[268]	$12,640,000
Total Cost of Compliance			$20,970,000
Total Retail Sales	5,300,757	MWh	
Rate Pressure of RES Compliance[269]	2.3%		
CO_2 Reduction from RES[270]	632,753*	tons of CO_2	
Vermont Emissions Profile	23.8	lbs per MWh	

**The CO_2 reduction value is preliminary and subject to revision.*

Statutory Renewable Energy Goals

The renewable energy goals contained in Section 8001 are not specific requirements; they provide guidance to Vermont utilities, the PSD, and the PUCwith respect to the policies that the state supports. There are eight enumerated goals, of which the following are most relevant to the power supply portfolios of Vermont's electric utilities:

(a)(3) Providing an incentive for the state's retail electricity providers to enter into affordable, long-term, stably priced renewable energy contracts that mitigate market price fluctuations for Vermonters;

(a)(7) Providing support and incentives to locate renewable energy plants of small and moderate size in a manner that is distributed across the state's electric grid, including locating such plants in areas that will provide benefit to the operation and management of that grid through such means as reducing line losses and addressing transmission and distribution constraints; and

[266] The 138,690 2020 Tier II REC retirements include 329 RECs retired for Tier III compliance.
[267] Tier III costs reported here are gross costs. They do not include the revenues from retail electric sales above the additional costs from those sales.
[268] MWhe is the nomenclature for MWh equivalent for Tier III savings claims.
[269] The rate impact is based on the 2019 total gross receipts of $918,806,869.
[270] Emissions reductions for 2020 are based on the change in Vermont's power supply portfolio from renewables, which increased from 35% in 2016 to 69.5% in 2020, resulting in a reduction in the amount of energy from the NEPOOL GIS residual mix, which in 2020 had an emissions factor of 736 lbs/MWh. Emission reductions associated with Tier III measures are also included. Tier III credits are based on lifetime savings. Based on average 13-year life of Tier III measures and applied to all installed Tier III measures in the first 3 years of RES. The total annual MWh savings was calculated to be 30,828 MWh, resulting in the equivalent of 11,035 tons of CO2 avoided in 2019.

(a)(8) Promoting the inclusion, in Vermont's electric supply portfolio, of renewable energy plants that are diverse in plant capacity and type of renewable energy technology.

The renewable energy goals are not mandatory and do not override other important policy considerations, such as the need to provide sustainable, affordable, and reliable service pursuant to 30 V.S.A. § 202a. Instead, they are complimentary. As described in Chapter 3, this CEP proposes that alongside §202a and §8001, the distribution of benefits and burdens of the project must be considered when evaluating renewable energy related policy and decisions.

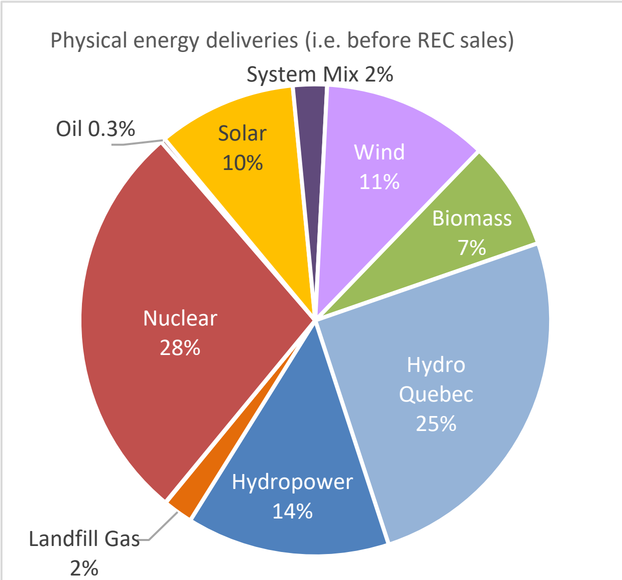
The renewable energy goals described above are policy expressions of the state of Vermont, and the impacts of renewable energy deployment to ratepayers and Vermont must also be weighed. Each individual project or program will create varying tradeoffs that impact cost, the environment, and equity differently. For example, if a relatively new type of resource is high-cost, it may still be in the general good of the state if the project clearly fits within the renewable energy goals, represents a pilot project from which a utility could gain operational and economic experience that would inform subsequent resource choices, and is funded voluntarily by participants who have the means to pay. (It is not necessary that all three of these example benefits are achieved, and other tradeoffs such as economic development or natural resources impact may impact the final decision as well.)

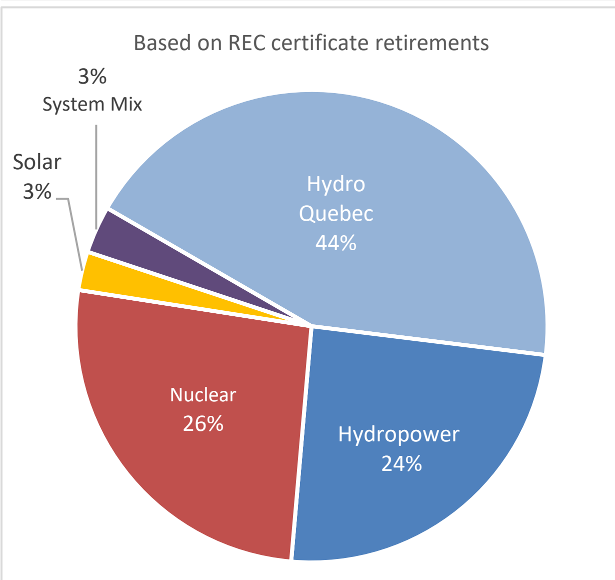
7.6.1 Current Electric Supply

Vermont utilities have multiple options for procuring supply: owned generation, power purchase agreements, and through the ISO-NE energy market. In addition, a significant portion of utilities' power supply is the result of legislatively mandated purchases of specific types of resources.

Although the composition of portfolios for any one utility can vary, the aggregate supply of committed contracts or generation units (as opposed to open-market purchases) has met 85% to 90% of Vermont's energy needs over the last several years, of which approximately 20% has been from Vermont-based resources. Exhibit 7-17 shows the mix of sources that were purchased by utilities to meet electric energy needs of end users in 2020. The data is presented both before and after any sales and purchases of renewable energy certificates (RECs). The "before" data is termed "physical" energy deliveries, consistent with terminology utilized in the ISO-NE wholesale markets — even if the electrons from a physical resource out of state don't travel through transmission and distribution infrastructure to make it to a Vermont end user, the utility purchase or ownership has caused the electrons to "physically" be generated, and thus is counted. The "after" is based on the disposition of RECs after the attributes are "retired" in the multi-state accounting system for generating resource attributes, called "NEPOOL GIS." Once retired, a REC cannot be used for any other purpose or by any other entity, and the utility has a legal right to claim that they own that renewable attribute for the MWh retired.

Exhibit 7-17. Vermont Electric Energy Supply, 2020, Before and After REC Sales and Purchases[271]



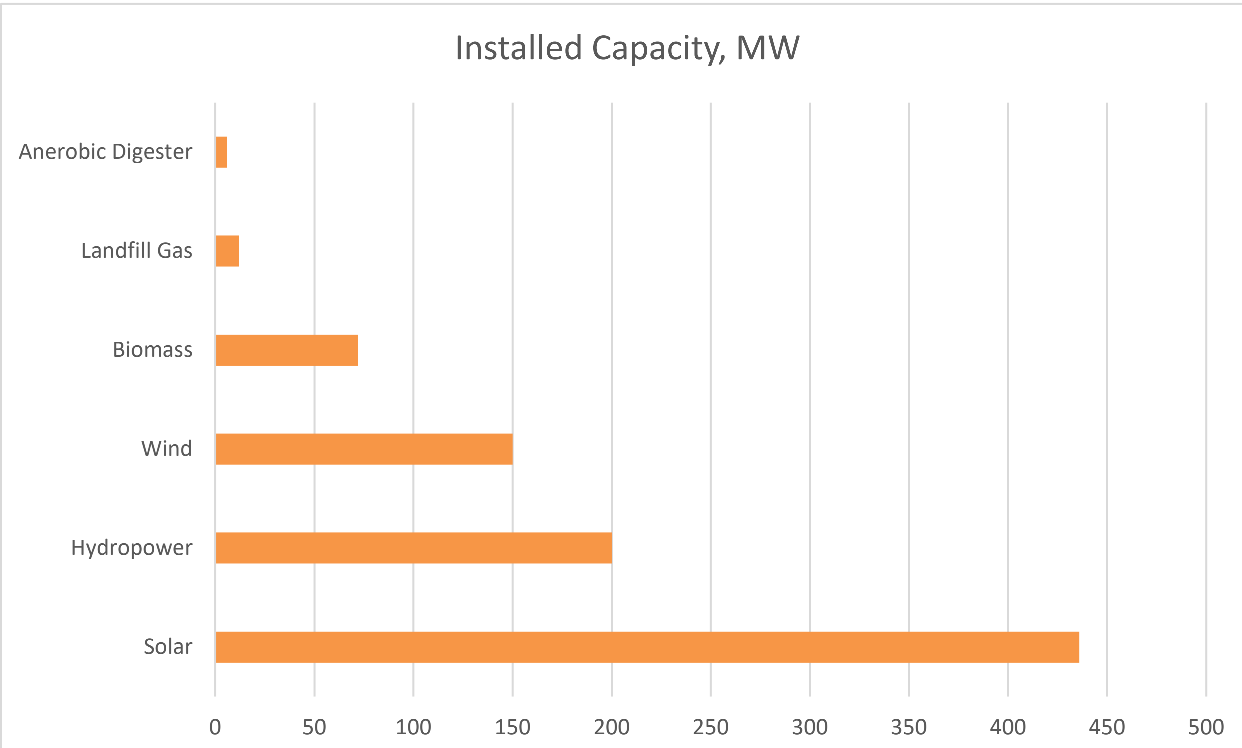


As shown in Exhibit 7-17, the mix of resources in the Vermont portfolio is different based on retired attributes than physical attributes. While nuclear (which also has legal attributes that can be retired, even though it isn't renewable) remains relatively constant in the "before" and "after," the total amount of renewable resources account for a majority of supply in both cases. Within that total, some physical resources such as biomass and solar are sold into regional markets where their value is higher to relieve upward pressure on Vermont rates. They are replaced with lower cost renewable attributes, largely from Hydro-Québec or other hydroelectric units in the region, consistent with the current parameters of the RES.

[271] Source: Data provided to the Department by the electric distribution utilities.

Exhibit 7-18 below depicts the nameplate capacity of in-state renewable generation. As the graph shows, solar is the single largest renewable generation type in Vermont. Solar has the lowest capacity factor of the resources listed, and therefore provides a relatively small portion of the state's energy, but during peak solar production hours the total amount of solar has a significant impact on the electric system (see text box below Exhibit 7-18 for more description). In addition, peak solar production occurs in late spring, often overlapping with small-scale hydro, another significant energy source in Vermont.

Exhibit 7-18. Vermont In-State Renewable Generation, By Fuel Type[272]



[272] Source: Data compiled by the Department from VELCO (Presentation of Kerrick Johnson to Senate Natural Resources Committee, available at: Kerrick Johonson VELCO Long Range Transmission Plan~4-6-2021.pdf), the ISO-New England distributed generation survey, Standard Offer program, and EAN Community Energy Dashboard (https://www.vtenergydashboard.org/statistics)

Electric Equivalents for Renewable Generators

Electric generators are often compared on the basis of their generation capacity, expressed in megawatts (MW) or kilowatts (kW). But different kinds of generators operate differently and produce different amounts of energy per unit of capacity. A generator that runs at its maximum all the time is said to have a capacity factor of 1. A generator with the same capacity, but which outputs only 20% as much energy over the course of the year, has a capacity factor of 0.2. This table shows illustrative capacity factors for different kinds of renewable electric generators.

Illustrative Capacity Factors for Renewable Electric Generators

Fuel	Capacity Factor
Residential Solar	0.15
Wind	0.33
Methane	0.95
Biomass	0.75
Small Hydro	0.45

Using these capacity factors, one can determine the electric energy equivalence of different generators. For example, each of the follow generators might be expected to generate approximately the same amount of annual electric energy (about 60 GWh, or 1% of Vermont's annual electricity use):

- A 20 MW wind project, consisting of eight 2.5 MW turbines, or half the size of the Sheffield wind project.
- 44 MW of solar PV, using a land area of approximately 300 acres if ground-mounted, or roughly equivalent to the cumulative capacity of all the solar PV deployed to date under the Standard Offer program.
- 15 MW of run-of-river hydroelectric generation, or approximately three times the size of GMP's Waterbury Dam hydroelectric generator.
- 9 MW of woody biomass electric generation, or slightly less than 1/5 the size of the McNeill generating station.
- 7 MW of anaerobic digestion, or somewhat more than all of the currently operating anaerobic digesters in Vermont.

7.6.1.1 State-Directed Resources

There are different ways for the Legislature to direct the power supply portfolio of Vermont's utilities. The most general approach is to set statutory goals, such as indicating a preference for stably priced long-term contracts to minimize volatile wholesale market exposure. A second method is to provide general guidance by requiring that utilities procure resources of a certain type, while leaving utilities to determine the best way to procure these resources. The RES is an example of this latter strategy, and is a method that is used throughout the U.S. The greater the specificity regarding resource type, the more constrained the utility procurement process; however, generally this approach provides sufficient flexibility for utilities to make decisions within a least-cost planning framework.

The most direct means of influencing the power supply portfolio is to mandate the procurement process. Net-metering is an example of this approach that is widely employed around the country. Examples that are specific to Vermont include the Standard Offer program and the requirement that utilities purchase power from the Ryegate biomass facility.

Net-Metering

Net-metering provides an incentive for customers to self-generate power and *net* this generation against their electric bill, either directly or as a monetary credit. The net-metering program has been in place since 1999 but had relatively low adoption rates until 2009, when the Legislature required that solar net-metered projects receive an adder for each kWh generated, on top of retail rates. This requirement, combined with a dramatic decrease in installed costs for solar projects, resulted in significant growth in the number of net-metered customers. A second component of the growth in net-metering is the ability for customers to subscribe to group net-metered systems, which do not need to be located anywhere near the customer. Instead, the customer essentially buys a share of the output of a project.

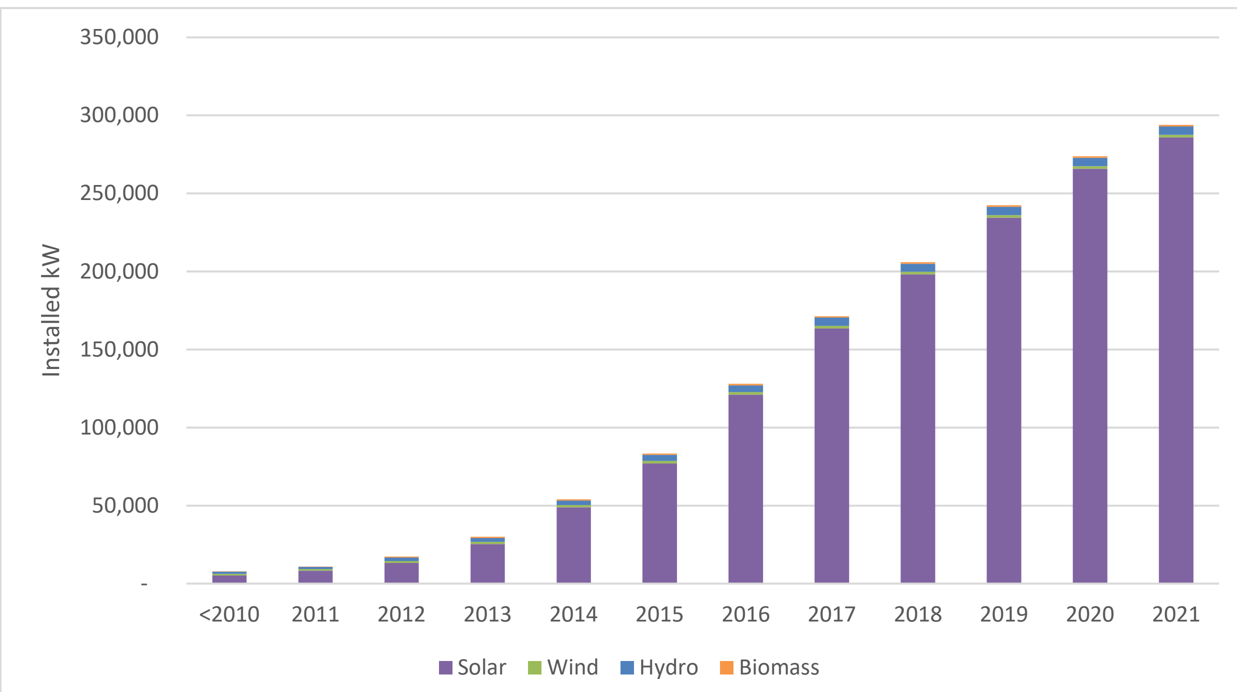
The Legislature enabled the PUC, starting in 2017, to determine rates paid for net-metered production and to make modifications to those rates every two years (see 30 V.S.A. § 8010). Adjustors are applied to the base compensation, which is based on retail rates, depending on whether the RECs are assigned to the utility for its RES compliance and the category of the system (size and type of site). This mechanism has enabled better fine-tuning of the net-metering program's rates. Excess generation from a new residential rooftop solar system is currently compensated at about two-thirds the 2016 rate for the same system (generation that offsets on-site load in a month is valued at retail rate), while all generation from new large, remote system is currently compensated at 60%-80% of the 2016 rate for the same system (though a 500 kW net-metering project is still 30% more expensive than the most expensive Standard Offer project selected in the most recent solicitation).

The net-metering program has seen rapid growth in the past few years, as a result of the technology costs significantly decreasing while the rate paid for net-metering production decreased much more gradually. As the number of net-metering systems increased exponentially, it changed the characteristics of the electric system —for example, it reduced load during midday, during what were typically times of higher prices, thus pushing the net peak hour to later in the day or into the evening when solar production is less effective or non-existent. In turn, value of a new net-metering resource has declined, in part because new solar-only net-metering systems only produce energy during daylight and therefore cannot reduce customers' load during the new evening peaks that are new utility cost drivers.

The fact that solar output no longer coincides with the most expensive hours for utilities to purchase energy, capacity, and transmission to serve customers, combined with alternative mechanisms through which utilities can purchase distributed solar at significantly lower costs than the current net-metering rates, means there is now a cost shift; non-net-metered customers are subsidizing those customers who have the means to net-meter. In 2019, Vermonters paid more than $40 million more for net-metering than if this solar generation had been procured through bilateral contracts between solar developers and utilities. This amount reflects the higher compensation that was paid in prior years. While compensation rates for net-metering have more recently declined slightly, the compensation currently paid to net-metering systems continues to significantly exceed the wholesale energy price and market-based Class I REC prices combined, and therefore results in a higher cost of compliance for meeting the RES and serving Vermont customers with electricity than would alternative resources.

While the net-metering program is open to a variety of technologies and fuel sources, as illustrated in the chart below, actual installations have been dominated by solar. Of the roughly 290 MW of currently installed net-metering, about 285 MW, or 97%, is solar, nearly 2% is hydro (primarily pre-existing resources), and the remaining 1% is split between wind and biomass.

Exhibit 7-19. Cumulative Net-Metering Installations by Technology[273]



[273] Data provided to the Department by Vermont distribution utilities via the ISO-NE monthly distributed generation survey. This figure includes updates through November 2021 for the majority of distribution utilities in Vermont.

All Vermont utilities host net-metering projects. Green Mountain Power has the greatest share of projects, with more than 83% of Vermont's total capacity, exceeding its 76% share of the state's retail sales. Burlington Electric Department, in Vermont's mostly densely populated service territory, hosts just 1.8% of the state's net-metering capacity while serving 6% of the load. Exhibit 7-20 shows the distribution of net-metering installations among utilities.

Exhibit 7-20. Installed Net-Metering Resources, 2020[274]

Utility	Total Installed NM (kW)	2020 Non-Coincident Peak	NM as % of 2020 Peak Load	Percent of NM Capacity	Utility Share of 2020 Retail Sales
Barton	247	2833	9%	0.08%	0.26%
Burlington Electric	5,267	57,600	9%	1.79%	5.87%
Enosburg	1,306	4858	27%	0.44%	0.50%
Green Mountain Power	243,918	686,088	36%	82.97%	76.20%
Hardwick	2,452	6910	35%	0.83%	0.65%
Hyde Park Electric	530	2,570	21%	0.18%	0.23%
Jacksonville	159	1066	15%	0.05%	0.09%
Johnson	567	2318	24%	0.19%	0.22%
Ludlow	222	13388	2%	0.08%	0.95%
Lyndonville	2,282	12920	18%	0.78%	1.13%
Morrisville	4,216	9087	46%	1.43%	0.87%
Northfield	736	4779	15%	0.25%	0.51%
Orleans	35	3240	1%	0.01%	0.22%
Stowe Electric Department	1,700	18,677	9%	0.58%	1.32%
Swanton	1,242	11053	11%	0.42%	1.01%
Vermont Electric Cooperative	23,364	80,082	29%	7.95%	8.55%
Washington Electric Cooperative	5,724	16,037	36%	1.95%	1.38%
VERMONT	**293,967**	**960,086**	**31%**	**100%**	**100%**

Standard Offer

The Standard Offer program was designed to provide a financing mechanism for small-scale renewable projects, by requiring that the electric utilities, through a centralized procurement process, enter into long-term contracts with new renewable resources that have a nameplate capacity of 2.2 MW or less. There is a statutory exemption for utilities that procure 100% of their energy from renewable resources; at

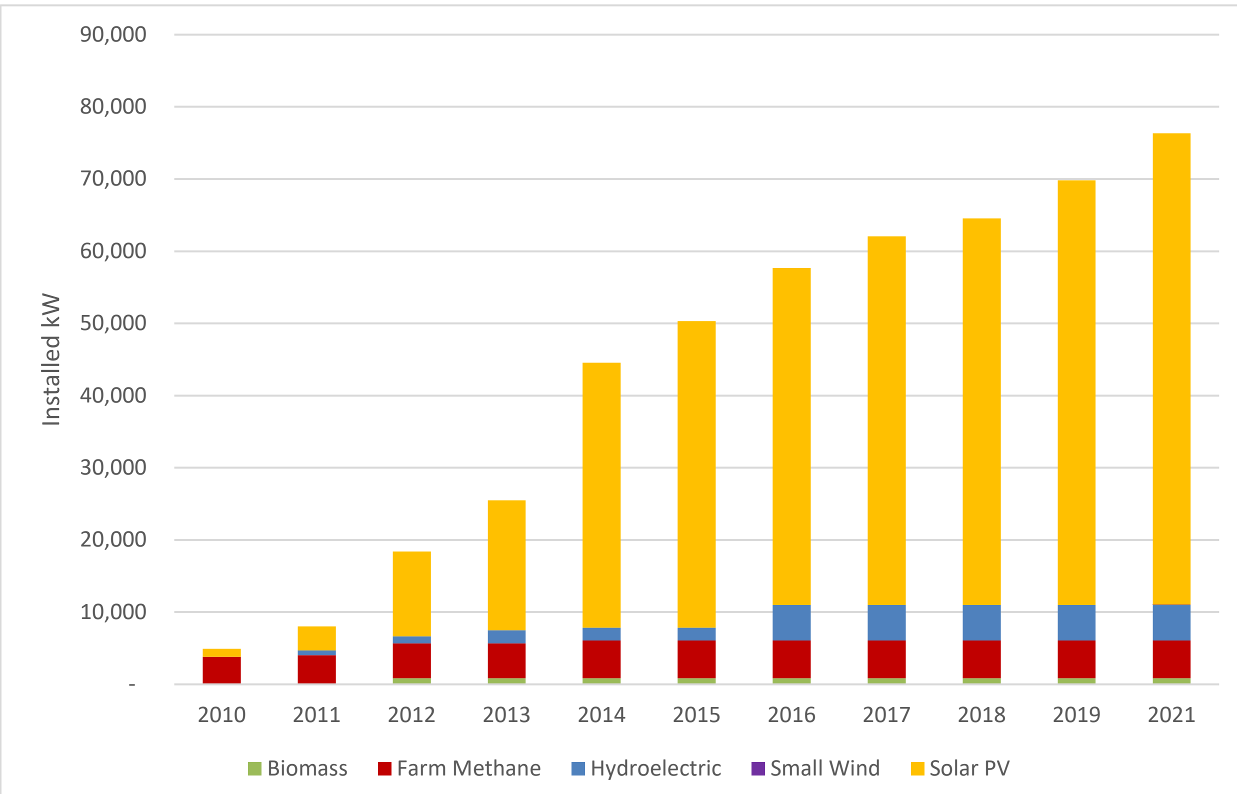
[274] Source: Data provided to the Department by the distribution and transmission utilities through an annual resource survey, monthly ISO-NE distributed generation survey, and ad hoc requests.

present, these are Burlington Electric Department, Swanton Electric Department, and Washington Electric Cooperative.

When Standard Offer was originally enacted in 2009, the PUC established a set price for each eligible technology: all resources utilizing that technology received the same price. The second iteration of the program required developers to participate in a competitive selection process, through which the lowest priced resources were selected. This process has significantly decreased the cost of the program. For example, the price paid to solar projects is more than two-thirds lower in 2021 than it was in 2009.

Like net-metering, the majority of the resources procured under the Standard Offer program have been solar resources. The second largest category is farm methane projects; however, the majority of these projects were built under the former Central Vermont Public Service Cow Power program and transitioned to the Standard Offer program.

Exhibit 7-21. Installed Standard Offer Projects by Technology[275]



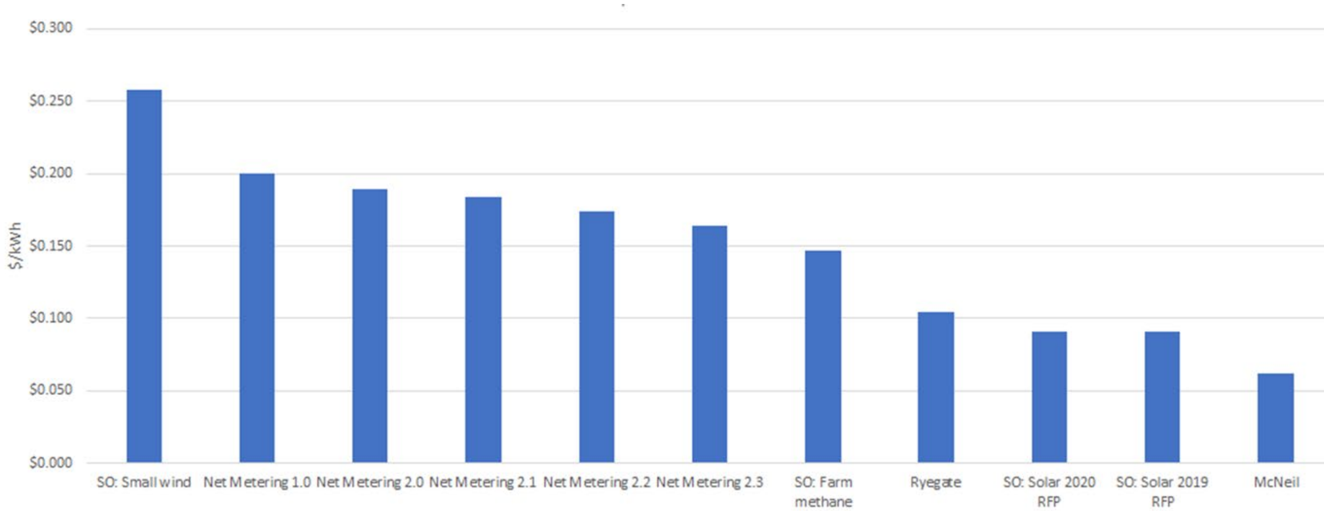
[275] Source: VEPP Inc. Data Portal — Program Overview: Projects in Program 10/19/09-12/20/21. Available from: https://vermontstandardoffer.com/data-portal/

Ryegate

In 2011, the Legislature mandated that Vermont utilities collectively purchase the output of an "in-state woody biomass plant that was commissioned prior to September 30, 2009, has a nominal capacity of 20.5 MW, and was in service as of January 1, 2011."[276] The only resource to match this description was the Ryegate biomass facility. The statute requires the PUC to set the rate paid to Ryegate, and each utility pays based on the utility's pro rata share of load.[277]

Generally, legislatively mandated procurements, such as net-metering, tend to be more expensive than other forms of procurement, as can be seen in Exhibit 7-22. The net-metering rates shown are for small residential systems, and do not reflect the lower compensation for larger projects.

Exhibit 7-22. Illustrative Cost Comparison of Renewable Resources[278]



7.6.1.2 Voluntary Power Purchase Agreements

The largest share of utilities' power supply portfolios is composed of long-term Power Purchase Agreements (PPAs), with Seabrook nuclear and Hydro-Québec representing approximately half the electricity supplied to Vermonters. These arrangements can vary depending on the term of the contract and the timing of delivery (e.g., peak hours during the week). A key feature of long-term voluntary PPAs is that the risk of changes to the market are shifted to the owners of the generation rather than Vermonters.

7.6.1.3 Utility-Owned Resources

There are numerous resources owned directly by electric utilities. The majority of these are hydro resources that have been owned by utilities for decades, in some cases more than a hundred years. Some

[276] 30 V.S.A. § 8009(a)(2).
[277] The statute exempts any electric utility that already meets one-third of its load through biomass generation, which is limited to the City of Burlington Electric Department. See, Section 8009(g).
[278] Source: Department of Public Service collection of program rates over time, and data from McNeil owners.

electric utilities still have ownership shares in plants outside Vermont, when utilities throughout New England would work collaboratively to build large baseload plants, like the Millstone nuclear plant in Connecticut. The McNeil biomass plant in Burlington is owned by Burlington Electric Department, Green Mountain Power, and Vermont Public Power Supply Authority, with BED owning the majority of the plant. In addition, several more recent power supply additions, including Kingdom Community Wind and the Coventry Landfill plant, are directly owned by utilities.

7.7 Siting Energy Resources

As Vermont continues to deploy new in-state generation facilities to meet renewable energy requirements, these facilities are increasingly becoming a part of the state's landscape. When accounting for all net-metering projects, thousands of generation facilities have been permitted in the past 15 years. Examining only those projects that impact a land area greater than one acre, the PUC gave siting approval to the vast majority of projects. The current siting process allows well-sited generation projects to be built in Vermont. Moving forward, it is important that the process continue to maintain or enhance Vermont's natural resource protections. The ecosystem services provided by the natural environment are vital to climate resilience and to Vermonters' sense of place.

The process of determining where to site these facilities requires answering a multitude of questions and weighing trade-offs between them. Where do communities wish to see new facilities sited within their jurisdiction? What locations will optimize renewable resource potential and grid infrastructure to support the delivery of least-cost, reliable power, and economic benefit to Vermont ratepayers? How will the siting of new facilities impact our natural resources and their ability to provide critical ecosystem services, such as carbon sequestration and climate resilience? How will the benefits and burdens of the siting decision be distributed?

As communities in Vermont navigate competing uses for land, it will be critical to name the various values and priorities for different land parcels and use transparent frameworks to holistically weigh competing needs. Decisions made today may impact the character, energy use and generation potential for many years into the future, along with the climate resilience of the landscape. This will require increased coordination among numerous stakeholders, including utilities, communities, local and regional planners, developers, and various state agencies, among others.

In Vermont, permitting for land use development is primarily governed by 24 VSA § 4414 (municipal zoning) and 10 VSA § 6086 (Act 250), while energy siting is governed by 30 VSA § 248 (Section 248). Act 250, Vermont's Land Use and Development Act, regulates non-energy generation and transmission development, while Section 248 regulates electric generation and transmission and natural gas facilities, now including storage. Projects are evaluated against the statutory criteria included in Section 248 by the PUC, to determine whether a Certificate of Public Good (CPG) should be granted to allow the project to proceed. The Section 248 criteria include consideration of issues such as need for the generation facility, economic benefit, reliability impacts, and consistency with the state electric plan; since 1988, they also include many of the Act 250 criteria, which provide a framework for reviewing the potential environmental impacts of energy projects. Parties to Section 248 siting proceedings include the PSD, the Agency of Natural Resources (ANR), Vermont Division of Historic Preservation, the Agency of

Agriculture, Food, and Markets, and town and regional planners, among others. ANR has concurrent jurisdiction over several of the environmental issues that are considered under the PUC's Section 248 review.

To promote greater participation by communities in the siting process, Act 174 of 2016 established standards for regional planning commissions and municipalities. The Act 174 standards flow from state energy policy; they include provisions that help regions and municipalities set appropriate targets for renewable energy siting and deployment, for conservation of energy and reduction of fossil fuel use in the electric, thermal, and transportation sectors, and for establishing implementation pathways to meet those targets. The enhanced energy plans developed by regions and municipalities also include geographic analyses that assess renewable energy potential (e.g., from solar and wind) and identify preferred and unsuitable locations for future development given constraints on development (such a grid infrastructure, natural resource impacts, and community priorities).

If regions and municipalities demonstrate compliance with the standards, which are voluntary, their plans receive substantial deference[279] in Section 248 proceedings regarding siting of new generation facilities. Since Act 174 went into effect, all 11 regional planning commissions have applied for and received affirmative determinations of compliance for their current enhanced energy plans. Roughly 30% of municipalities in the state (69 in all[280]) also have enhanced energy plans.

The net-metering program, governed by 30 V.S.A. § 8010 and PUC Rule 5.100, guides construction of new projects toward sites that reduce environmental impacts through the identification of *preferred sites*, a revision made to the net-metering rule in 2017. Net-metering systems between 150-500 kW must be located on a preferred site to be eligible for net-metering compensation. Systems between 15-150 kW receive higher compensation via siting adjustors if they are located on one of these sites. Rule 5.100 designates nine categories of preferred site, which include existing or new structures (such as rooftops), parking lot canopies, previously developed parcels, brownfields, landfills, and gravel pits.

Preferred site categories also include specific locations that are designated in a duly adopted municipal plan under 24 VSA chapter 117, or a through joint letter of support from the municipal legislative body and municipal and regional planning commission in the community where the facility will be located; and sites that are on the same parcel as or are directly adjacent to the majority offtaker, or consumer, of the system's output. Generally, preferred siting requirements and incentives have steered net-metering development away from undeveloped "greenfields," and have helped facilitate the reuse of previously developed lands. Even so, greenfield development still occurs, especially in connection with the municipal plan, joint letter, and majority offtaker preferred-site categories.

In addition, the joint letter approach — while providing flexibility for project developers and local and regional planners — also bypasses the enhanced energy planning process, which involves clear criteria and process. This approach was intended as a temporary measure, to be supplanted by the identification

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[279] Pursuant to 30 V.S.A. § 248(b)(1)(C), "'substantial deference' means that a land conservation measure or specific policy shall be applied in accordance with its terms unless there is a clear and convincing demonstration that other factors affecting the general good of the State outweigh the application of the measure or policy."
[280] A list of municipalities with affirmative determinations of enhanced energy planning is available at vapda.org.

of specific preferred sites in municipal plans. In reality, such parcel-level review has proven impractical, so the joint letter continues to be a valuable tool for municipalities to use in endorsing specific sites for development. Further work may be necessary, though, to ensure that joint-letter sites also receive adequate environmental screening before being proposed for development.

As renewable energy development has increased across the state, numerous challenges and concerns have been raised — and to some extent, addressed — regarding the policies and programs that govern the siting process, particularly with regard to the protection of natural resources, consideration of grid constraints, and community participation in siting decisions.

Grid Constraints and Siting: In Vermont, incentives and policies regarding renewable resources have focused to date on developing new generation without explicitly reflecting grid impacts in the incentive structure. However, as an increasing number of renewable generation facilities and other distributed energy resources (DERs) have interconnected in Vermont, the need to consider locational as well as cumulative impacts on system reliability and ratepayer value has been highlighted.

As DERs deploy, the grid is already beginning to see areas of constraint on the transmission and distribution systems, as discussed in Chapter 4 on Grid Evolution. These constraints appear in a variety of ways, such as limits to hosting capacity for new solar on certain circuits of the distribution grid,[281] which limit additional deployment of systems without costly upgrades to grid infrastructure, and create transmission constraints in areas where renewable generation far exceeds local load (e.g., the Sheffield Highgate Export Interface in northern Vermont[282]). The latter of these scenarios has resulted in curtailments of existing renewable generation, to maintain system reliability, that are exacerbated as new generation is added. These curtailments have cost implications for the ratepayers paying for those resources. To date, the Section 248 criteria have proven flexible enough to highlight such considerations on a project-by-project basis, and the PSD has recommended a mechanism that would require generation projects interconnected in SHEI to mitigate the economic impacts.[283] However, grid constraint issues are not consistently reflected in the siting procedures or compensation mechanisms for renewable resources, such as within the net-metering program.

To address issues around siting new generation in relation to grid conditions, there are new opportunities to better align compensation structures for distributed generation. Inclusion of locational adjustors would accurately reflect the reality that the value of distributed generation to Vermonters depends, in part, on the characteristics of the grid where the generation is interconnected. The Department has proposed to the PUC[284] that any revision to the net-metering rule reflect the locational value of distributed generation.

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[281] See Department of Public Service, IDENTIFYING AND ADDRESSING ELECTRIC GENERATION CONSTRAINTS IN VERMONT, January, 2018; available at: Identifying and addressing Electric generation constraints in Vermont, A Report Submitted Pursuant to Act 139 of 2018.

[282] For additional information on SHEI constraints, see: Grid Planning, Vermont System Planning Committee (vermontspc.com).

[283] See, Department Petition for investigation re: a net-metering SHEI constraint mitigation grid adjustor, 10/30/20, Case No. 20-3304-PET.

[284] Vermont Department of Public Service Comments on Revising Rule 5.100 to Address Sheffield Highgate Export Interface ("SHEI") Impacts, 8/27/21, Case No. 19-0855-RULE.

This adjustor would be based on expected growth of load and distributed generation in the area, and would be set to provide a signal that encourages new distributed generation in areas with existing and expected capacity. These issues are further discussed in Section 7.9.1.2.

Protection of Natural Resources: In addition to issues around grid constraints, concerns have been raised regarding whether existing policies and programs appropriately protect natural resources when assessing the environmental impact of a potential new generation facility. This has been raised particularly as relates to forest conversion for energy development. Recent data compiled by ANR[285] indicates that, between July 1, 2017, and July 31, 2021, 46% of net-metering applications reviewed by ANR have required some amount of forest conversion, even with the preferred site incentives intended to steer generation facilities away from undeveloped fields and forests. Over 25% of these projects have included forest conversion of more than one acre, and 5% have required conversion of more than five acres. Larger, non-net-metered generation facilities can also involve significant forest conversion.

Forest conversion is particularly concerning given the variety of roles that forests play in maintaining Vermont's biodiversity and providing critical resources to combating climate change, such as carbon storage and sequestration. ANR has recommended that the PUC's preferred-site incentive structure for Category II and III net-metering systems should be modified to reduce forest conversion, in part because non-forested land for net-metering appears sufficiently available in Vermont.

Policies that limit utilization of forested sites may inadvertently redirect some development to fields and pastures, raising concerns that range from interfering with breeding bird habitat and marring viewsheds to disturbing prime agricultural soils, or otherwise removing them from agricultural use; but there are proven strategies in Vermont for minimizing, mitigating, or otherwise managing those impacts. Innovative examples of shared use that have been deployed in Vermont — such as panels raised above the ground enough to allow for grazing — may become more widespread as more instances of competing uses arise, and should be considered by participants in the facility siting process.

As Vermont continues to deploy renewable resources, it will be critical to make sure they are sited in a way that maximizes both renewable energy production and reductions in greenhouse gas emissions. It's especially vital that deployment of renewable resources in the name of reducing greenhouse gases doesn't have an overall impact that is counterproductive to that goal, or detrimental to the ecological functioning of Vermont's natural landscapes. As acknowledged in the Climate Action Plan, if alternative sites are reasonably available, new renewable generation infrastructure, like other land development, should avoid and minimize to the greatest extent possible impacts on Vermont's forests, which support a range of ecological services critical for climate resilience and adaptation and provide the single largest source of carbon sequestration and storage in the state. Policies should continue to favor energy

[285] See Vermont Agency of Natural Resources, *Forest Conversion for Net-Metering: Trends & Options to Reduce,* August 24, 2021; available at: https://epuc.vermont.gov/?q=downloadfile/503532/139251

development that avoids and minimizes conversion of natural lands[286], and reuses or adds new compatible uses to previously developed lands.

Community Participation in Siting: During the initial rounds of regional and municipal enhanced energy planning, numerous questions have been raised about how to better support the process and enhance the agency of communities in making decisions regarding siting in their regions. While all RPCs and roughly 30% of towns have completed the process, many towns, though supported in large part by their RPC, have volunteer committees that struggle to find the capacity to meaningfully engage with either the planning process or, especially, the Section 248 process. There is also continuing uncertainty about how these planning efforts have influenced the siting of projects, such as the extent to which the maps and policies included in the plans are proactively used by developers to identify preferred sites for development; and if the language used in plans, particularly at the town level, is strong or specific enough to prevent development where communities do not want it.

The need for greater collaboration between regional and local planners and distribution and transmission utilities has emerged from these planning processes. This has been particularly highlighted in the recent 2021 VELCO Long-Range Transmission Plan (LRTP), which compared the RPC renewable generation targets and remaining capacity on the transmission and sub-transmission system, ultimately illustrating that many regional targets exceed current capacity. To ensure that new renewable generation serves Vermonters well, additional and evolving consideration of grid constraints, natural resources, and emissions impacts — along with land use and community considerations — will be necessary in the energy and land use planning and siting processes, as well as in the state's energy policies and programs.

7.8 Pathway: Further Decarbonization of the Electric Sector

Vermont has a highly renewable electricity system. In 2020, Vermont's power supply was 69.5% renewable,[287] and 94% carbon-free when including nuclear power, while three utilities provided their customers with 100% renewable electricity.[288] As a result, the electric sector currently contributes only a small share of the state's total GHG emissions, roughly 5.7% (0.49 MMTCO_2e) of Vermont's total in 2017.[289]

While Vermont has one of the nation's cleanest power supply portfolios, removing GHG emissions from the remaining percentage will be critical to supporting the deep decarbonization of buildings and transportation, Vermont's highest GHG-emitting sectors. To achieve state GHG requirements, these sectors will rely heavily on electrification opportunities to shift away from GHG-emitting fossil fuels. As electricity use increases to accommodate these shifts, it will prove critical to ensure that Vermont utilities are supplying low-carbon and renewable electricity resources for maximum emissions reductions. In addition, as heating and transportation costs shift to Vermonters' electricity bills, it becomes increasingly

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[286] Here, natural lands means undeveloped, uncultivated, non-agricultural land, including forests, wetlands, certain grasslands and shrublands, and water over such land.
[287] Based on 2020 Renewable Energy Standard Compliance Filings.
[288] Burlington Electric Department, Washington Electric Cooperative, Swanton Electric Department.
[289] Vermont Greenhouse Gas Emissions Inventory and Forecast: 1990 — 2017. Available at: _Vermont_Greenhouse_Gas_Emissions_Inventory_Update_1990-2017_Final.pdf.

important to ensure that the GHG reduction requirements contained in statute are achieved both equitably and at a reasonable cost.

While the current RES is effective at consistently increasing the renewability of Vermont's electric sector, several challenges remain with regard to meeting state renewable energy goals and GHG reduction requirements. The existing RES requires 75% renewable electricity by 2032 — and while several utilities have publicly committed to 100% decarbonization and renewable goals,[290] currently no mechanism exists to ensure whether and how this occurs.

The RES as currently structured, with current market dynamics, effectively encourages the retirement of RECs from two categories of resources: new distributed solar (under Tier II of the RES) and existing hydro (under Tier I of the RES). Under statute, utilities can also retire RECs from owned or contracted wind, biomass, and other renewable resources to meet their obligations under Tier I of the RES; however, given the significant REC price premium for these resources compared to existing hydroelectric resources, there is a disincentive to retire these RECs instead of selling them out of state, to reduce the overall costs of RES.

Given the significant work necessary to meet Vermont's GHG reduction requirements — which were established subsequent to enactment of the RES requirements but with a consistent framework for GHG accounting — it is reasonable to now reassess RES design options to determine how to best wield this tool in order to meet the GWSA goals of reducing GHG emissions in a cost-effective and equitable manner.

7.8.1 Strategy: Consider Design Options for a Carbon-Free or 100% Renewable Energy Standard

Numerous ways exist to decarbonize, or make fully renewable, Vermont's electric power supply, potentially informed by examples from other states. Some have moved to a 100% renewable requirement, while others focus on decarbonization, depending on priorities. Often, in practice, the primary differences in the two approaches is the treatment of nuclear energy. In addition, large-scale hydroelectric resources are treated differently depending on the state: some include it in the definition of renewable, while others impose a size limit on hydro, beyond which it is considered low- or zero-carbon but not renewable. Cost and economic development benefits are also typically considered in determining eligibility for inclusion in a portfolio standard.

Vermont's existing RES defines renewable energy as "energy produced using a technology that relies on a resource that is being consumed at a harvest rate at or below its natural regeneration rate." The impact of the RES on GHG emissions depends on the relative energy contribution from each resource and the emissions profile of that resource. Utilities can achieve compliance through numerous resources considered renewable and zero-GHG-emitting including wind, solar PV, and hydropower, and through resources considered renewable but not zero-carbon, such as biomass, which the current GHG inventory considers zero-emitting of carbon dioxide, but emitting of other GHG (e.g., CH_4 and N_2O). The RES

[290] See, for example, GMP's 2021 Integrated Resource Plan: https://greenmountainpower.com/wp-content/uploads/2021/12/2021-Integrated-Resource-Plan.pdf at 6-27, and https://vermontelectric.coop/latest-news/vec-commits-to-carbon-free-power-supply-by-2023-04-06-21

excludes nuclear, which is not considered renewable but is currently considered zero-GHG-emitting by the Greenhouse Gas Inventory.[291] As described in Section 7.7 above, outstanding questions remain regarding what resources should be defined as renewable and/or zero-emitting and how best to account for those emissions (e.g., through consumption-based or lifecycle analyses) and these questions are currently under consideration by Science and Data Subcommittee of the Vermont Climate Council.

As Vermont seeks to further decarbonize and meet GWSA requirements, the state could look to expand the existing RES obligations to require distribution utilities to procure 100 percent of electric retail sales from renewable energy resources and/or develop complementary policies or additional RES Tiers to address emissions reductions from the electric sector. Such policies could include the establishment of a Clean Energy Standard or Emissions Reduction Standard to work in concert with the existing RES.

In recent years, numerous states have established mandates that require 100% carbon-free electricity. States like Massachusetts and California have adopted a layered policy approach, considering both clean and renewable energy goals. For example, Massachusetts has three policies: a Clean Energy Standard (CES), Clean Energy Standard-Existing (CES-E), and a Renewable Portfolio Standard (RPS). Under the Massachusetts RPS, utilities and competitive suppliers must acquire a minimum percentage of electric retail sales from renewable energy sources, such as solar PV, wind, small hydropower, eligible biomass, and landfill methane, among others. The RPS includes several classes of resources and carve-outs for qualifying resources such as existing resources and solar PV. The Massachusetts CES adds additional clean energy obligations beyond those of the RPS and further sets a minimum percentage of electric retail sales that the same entities (electric utilities and completive suppliers) are required to procure from clean energy sources, which include RPS Class I resources, those procured through a specific clean energy procurement, or those with a net lifecycle GHG emissions of less than a specified amount. While the CES seeks to increase procurement of new clean energy resources over time, the CES-E aims to maintain a consistent level of existing clean energy generation (such as nuclear and large hydropower), accounting for load growth, over time[292]. California's SB 100 requires the state to reach 60% renewable electricity by 2030 and 100% of electricity from any zero-carbon energy source by 2045. Under SB 100, eligible renewable energy resources include solar, wind, geothermal, biomass, small hydropower, renewable methane, ocean wave or thermal, or fuel cells using renewable fuels, and zero-carbon energy resources include all eligible renewable sources plus resources that generate zero GHG emissions on site.[293]

Vermont's RES design also includes an existing, unique mechanism to help achieve emissions reductions *beyond* the electric sector via Tier III, which requires utilities to help their customers reduce fossil fuel use, in large part through electrification of heating and transportation. Importantly, a portfolio standard that

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[291] Vermont Greenhouse Gas Emissions Inventory and Forecast: 1990 — 2017. Available at: _Vermont_Greenhouse_Gas_Emissions_Inventory_Update_1990-2017_Final.pdf.

[292] Presentation by Massachusetts DOER Commissioner Patrick Woodcock at the Electric Sector Workshop on 8/10/2021. Slides available at: Comprehensive Energy Plan / Vermont Climate Council Electric Sector Workshop 8-10-21 and Massachusetts Department of Environmental Protection 310 CMR 7.75: Clean Energy Standard (CES) Frequently Asked Questions (FAQ) Version 2.0 (August 2021), available from: frequently-asked-questions-massdep-clean-energy-standard/download

[293] 2021 SB 100 Joint Agency Report: Achieving 100 Percent Clean Electricity in California: An Initial Assessment. Available at: 2021 SB 100 Joint Agency Report

requires procurement of renewable energy resources based on percentage of a utility's load or sales — as the current RES is structured — will by design keep pace with the added load from this electrification.

Also important to consider is the transition period for any design changes to the RES. Power supply procurement does not happen overnight, and any changes to the existing RES must be mindful of the committed resources in the utilities' power supply mix and must provide sufficient time for utilities to meet any new requirements. Returning to the Massachusetts CES and CES-E examples, certain existing contracts were allowed to be used as compliance.[294]

A number of criteria and tradeoffs will need to be assessed when considering whether, and how, to redesign the RES. Modification of the RES to supply 100% carbon-free, or 100% renewable, energy is one consideration, and either would greatly support deep decarbonization of the transportation and thermal sectors as they electrify. The existing feature of the RES that scales requirements with load is beneficial and would ensure that a portion of new load is met with either renewable or zero-carbon resources based on attributes retired by utilities and verified by annual compliance reviews. Depending on the design, these attributes could create the revenue stream for new resources to develop, or existing ones to stay in operation.

Another essential consideration is cost. As emphasized throughout the CEP, it is essential to keep electricity affordable to make progress in decarbonizing the emissions-heavy thermal and transportation sectors. Currently, PUC Rule 4.400, which governs implementation of the RES, does not include a specific mechanism to measure the cost-effectiveness of the RES. The Department estimates RES compliance costs in a legislative report each year. As described above, Vermont has historically encouraged its utilities to procure long-term resources (which support ratepayers by reducing price volatility) and as a result, some utilities have long-term contracts (e.g., with nuclear resources). Any RES design changes must take these existing obligations, and the potential costs of early retirement/contract termination, into consideration.

As Vermont considers the next steps for the RES, it will be critical to consider such changes through a lens of equity. As previously noted, the RES even under its current design is anticipated to produce moderate upward rate pressure for Vermonters. As a result, it will be imperative to consider how such rate pressures might impact different communities in Vermont, and deploy mechanisms to mitigate those impacts as future policies strive to reduce, and not exacerbate, existing energy burdens within the state. This includes cost shifts created by renewable energy programs and other design parameters associated with electricity policy. Given the potential impacts of a redesign of the RES, such efforts should be informed by robust stakeholder engagement to understand the needs of and implications for a wide array of stakeholders, and to consider the inclusion of accountability mechanisms for ensuring that the RES advances equitable access to affordable renewable or carbon-free electricity for all Vermonters.

Several design considerations could have important implications for the equitable distribution of the benefits and cost-effectiveness of future policy. These include:

[294] Massachusetts Department of Environmental Protection 310 CMR 7.75: Clean Energy Standard (CES) Frequently Asked Questions (FAQ) Version 2.0 (August 2021), available from: frequently-asked-questions-massdep-clean-energy-standard/download

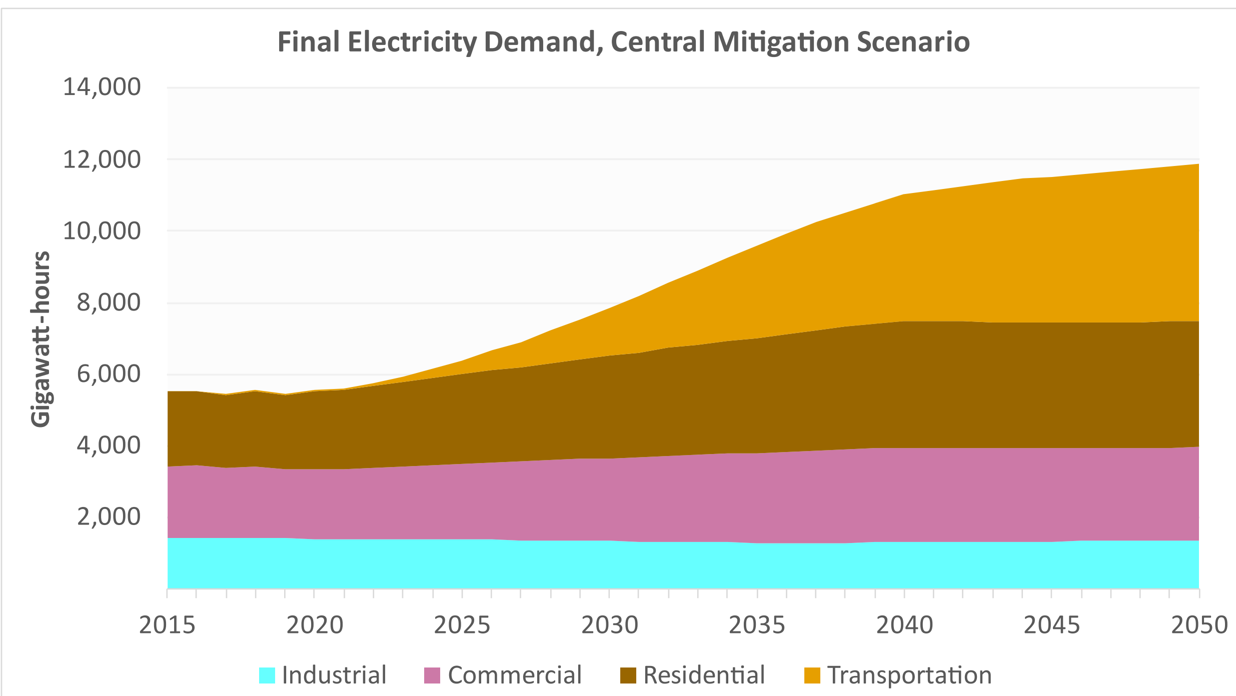
- Extent of support for new vs. existing resources,
- In-state vs. regional resources and the need for regional coordination,
- Support for different sizes and types of distributed generation resources, and
- Valuing resources based on time and locational considerations.

Each of these variables is discussed in further detail in the remainder of this chapter.

7.8.1.1 New and Existing Resources

As Vermont strives to meet renewable energy and decarbonization requirements, the state will need to deploy or support the deployment of considerable new renewable resources (see Exhibit 7-23 below). The modeling completed for this CEP and the Climate Action Plan estimates that without rate design and load management strategies, a pathway to meet greenhouse gas requirements could require 16% more electricity in 2025 and over twice as much by 2050. While the exact amount of additional load may not reach these levels, if implemented the recommendations in both this CEP and the Climate Action Plan will add electric demand. Thus, it will be important that cost-effective renewable and/or clean resources are added to the Vermont portfolio in an equitable manner that limits rate pressure and supports the energy policy goals of 30 V.S.A. § 202a.

Exhibit 7-23. Mitigation Scenario Estimated Electricity Demand by Sector (GWh)



Source: SEI and NESCAUM, LEAP Model. See Appendix D.

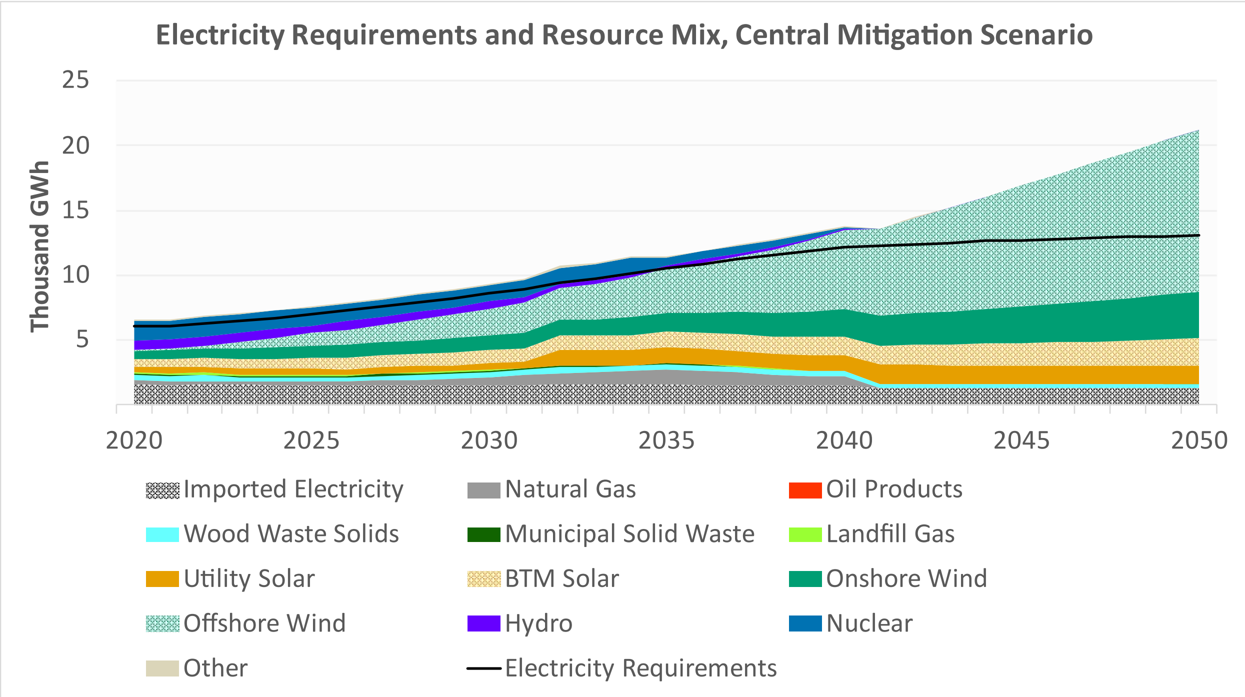
Vermont operates as part of a regional grid, through ISO-NE. This provides opportunities to pursue resources from both within Vermont as well as neighboring states and control areas. As shown above in Exhibit 7-18, Vermont has well over 800 MW of installed renewable capacity Of course, those resources don't all provide supply that meets demand at the time it is needed. Some of these resources supply products (energy, capacity, renewable attributes) to counterparties outside of Vermont; conversely, Vermont's utilities have contracts with or ownership of renewable resources outside the state, including Hydro-Québec. Vermont's interconnectedness with its neighbors offers opportunities to access supply from a diversity of resources not otherwise available within Vermont's own borders (e.g., offshore wind) with production shapes that could prove highly valuable in meeting decarbonization goals (see next section on time and locational considerations, as well as Chapter 4, generally). At the same time, in-state resources may offer the chance to co-locate distributed generation with load to — potentially — reduce system costs, offer economic development benefits, and seed resilience opportunities at various scales.

It is important that while Vermont strives to reach its short- and long-term emissions goals, reliable electric service is not compromised. Section 7.2.3 above detailed some of these regional concerns during critical periods, such as extended winter cold snaps. Meeting Vermont's short-term electric supply needs will be challenging without existing resources such as hydroelectric power and nuclear and could have unintended consequences such as increasing pressure to build new long-lived fossil generation.

Determining which resources to support will require careful weighing of criteria such as cost-effectiveness, equity, reliability, emissions impact, and resilience. Exhibit 7-24 provides one example of a potential portfolio for meeting the state's greenhouse gas requirements and renewable requirements (note, load management and energy storage potential are not fully captured in this example). It shows significant penetrations of offshore wind, which is selected to meet demand because it is the most cost-effective resource modeled. Solar — both utility scale and behind the meter[295] — increase in this model example only modestly because they are a higher-cost resource than offshore wind (note that in Exhibits 7-24 and 7-25, annual supply exceeds demand in order to ensure sufficient supply at peak times. Excess supply is assumed to be sold into the regional market or curtailed).

[295] For modeling purposes, "behind-the-meter" solar is assumed to be solar with generating capacity of 1 MW and less while utility scale is anything larger. This may differ from definitions used elsewhere in the Comprehensive Energy Plan. For example, in the context of ISO-NE market rules, 'behind-the-meter' includes any resource smaller than 5 MW. At a more granular level, "behind-the-meter" at times means generation that is directly serving load before exporting to the grid. The modeling provides indicative results and the size distinction is less important than overall results.

Exhibit 7-24. Mitigation Scenario Example Electric Supply Resources



As noted earlier in this chapter, utility compliance with obligations under the current RES Tier I are met heavily with existing hydropower resources, whether they are bundled with other products such as energy and capacity or separately purchased. Tier II is effectively a tranche of Tier I requirements requiring utilities to procure an increasing percentage of new distributed generation, where the resources must be connected to Vermont distribution or sub-transmission lines.

Within the current structure of the RES, Tier II sets the pace for development of distributed generation within the state, requiring the distribution utilities to procure a defined percentage of their retail electric sales from new distributed renewable generation.[296] The Department estimates that with relatively stable demand, each year 25-30 MW of new distributed generation will be needed to meet Tier II, if Tier II continues to be met primarily with solar resources, and greater amounts if load increases to accommodate electrified transportation and thermal energy end uses.[297] Under the existing net-metering program, the scale of deployment for net-metered solar alone has consistently exceed the pace required to meeting Tier II of the RES — with 36 MW and 31 MW of net metered solar PV being deployed in 2019 and 2020, respectively.

[296] Statute defines new distributed renewable generation as electric generation facilities that have a plant capacity of 5MW or less, commenced operation after June 30, 2015, and are directly connected to a distribution utility's sub transmission or distribution system, or have been identified in an approved plan to defer transmission upgrades, or net-metering systems, provided the distribution utility owns the environmental attributes associated with the system.

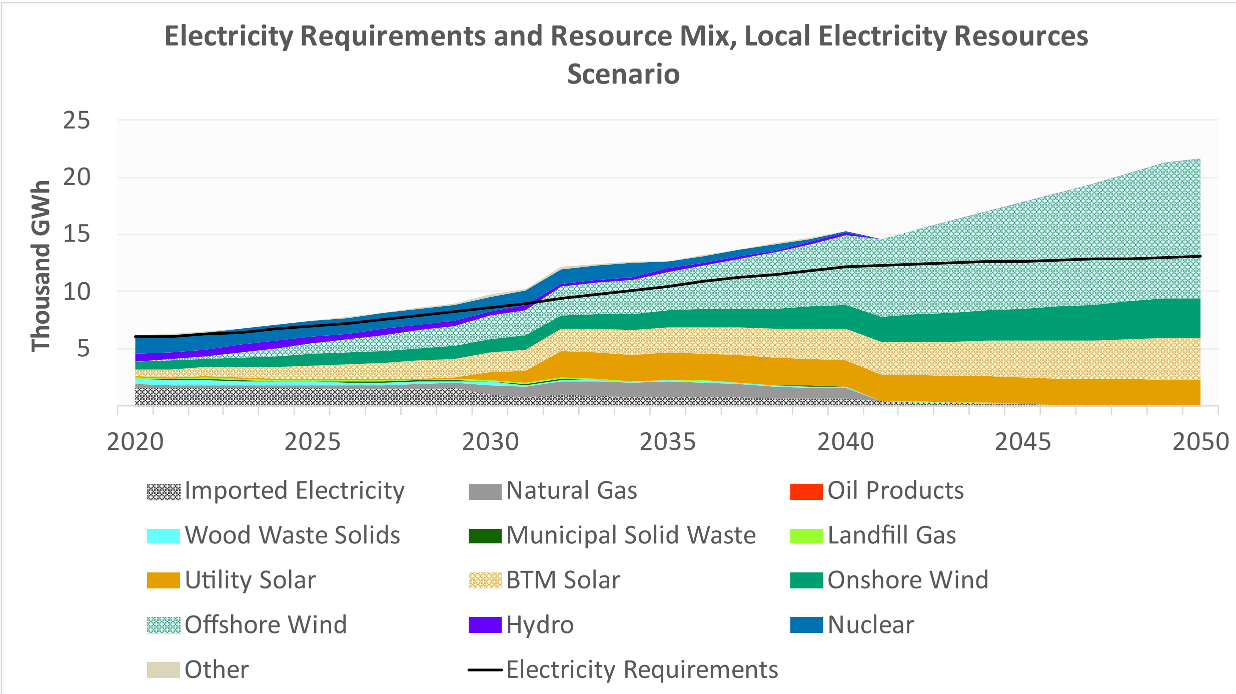
The Standard Offer (and previously SPEED) and net-metering programs, in addition to utility-owned or procured resources, are the primary mechanisms to support Tier II resource deployment in Vermont. These procurement mechanisms come at varying costs to Vermont ratepayers. Growing EV and heat pump deployment will grow load, which — even assuming deployment of load management mechanisms — will necessitate deployment of additional renewable and carbon-free resources to support those additions without adding emissions.

At the same time, meeting long-term renewable electricity and energy goals will require attention to the maintenance of existing renewable electric generation, especially in the short term. Vermont hosts a variety of existing generators that can be cost-effectively operated at or below the cost of new generation given they have either fully depreciated or paid off construction loans. Such resources, many of which are hydroelectric facilities with production supply curves that often complement those of other renewable resources, such as solar, will play a critical role in meeting the Vermont's renewable energy needs. Many of these generating plants were the centerpiece of communities over a 100 years ago, and continue to serve those communities with clean, renewable power. Other larger existing resources, whether in New England, New York, or Quebec, have served Vermonters for decades, and can also play a continued role in meeting our renewable energy needs to the extent they cost effectively meet demand and equity implications are addressed.

For example, Hydro-Québec, which offers large hydropower, currently provides a significant source of low-cost and consistent power to Vermonters during all hours of the day through a long-term contract. In addition, Vermont utilities have separately purchased attributes from Hydro-Québec's power supply in order to meet Tier I RES requirements. However, questions have been raised regarding the appropriate accounting of emissions from large hydropower (See section 7.7), generally, and concerns about the significant inequitable burdens experienced by Indigenous Peoples in Quebec and environmental impacts, specifically, due to use and destruction of lands to develop such hydropower resources. Moving forward, such considerations will need to be transparently acknowledged as the state weighs tradeoffs in decisions regarding electric power supply procurement.

The collection of these in-state and out-of-state resources have informed long-term contract decisions and should continue to be considered going forward. The CEP and Climate Action Plan modeling effort included a sensitivity on the amount of local electricity resources that are used to meet our targets. In this example scenario (Exhibit 7-25), behind-the-meter and utility-scale solar both grow more substantially than the initial mitigation scenario.

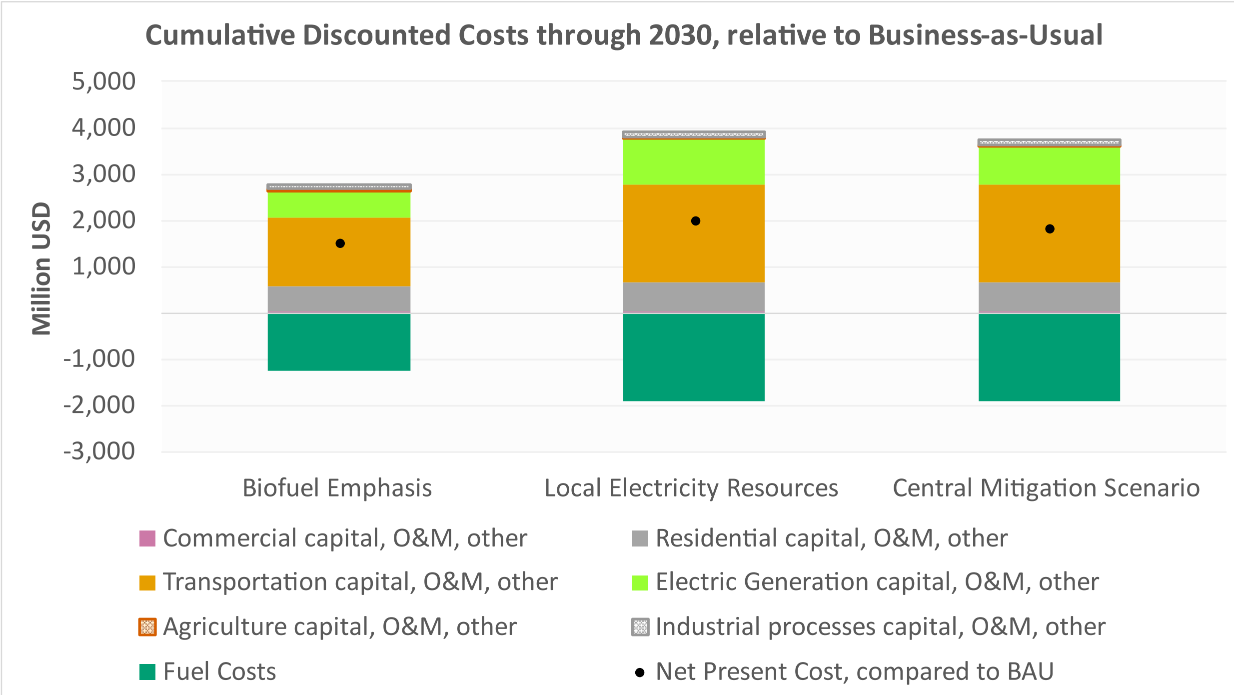
Exhibit 7-25. "Local Electricity" Mitigation Scenario Example Electric Supply Resources



Source: SEI and NESCAUM, LEAP Model. See Appendix D.

There are significant siting and cost implications of a substantial increase in Vermont-sited generation. As shown in Exhibit 7-26, the local pathway example was estimated to cost $169 million more in net costs than the general mitigation scenario.

Exhibit 7-26. Economic Values of Pathways



Source: SEI and NESCAUM, LEAP Model. See Appendix D.

Ultimately, it is likely that new and existing resources from both in-state and out-of-state will be needed to meet the expected growing demand. There are numerous tradeoffs between each type of resource in terms of the power it delivers and the impact (cost, equity, reliability, sustainability, etc.) to Vermont. Designing a 100% carbon-free or renewable energy standard will require weighing these considerations and tradeoffs carefully and transparently. This CEP encourages the continued deployment of cost-effective, well sited in-state generation. The pace of deployment of in-state generation could feasibly be increased if current programs supporting in-state resources, such as net-metering, are restructured to mitigate costs and to distribute the benefits and burdens of remaining costs more equitably. Where cost-effective, new out-of-state generation such as contracts with or ownership of potential offshore wind resources, should be encouraged as well, especially where those resources are aligned with the timing of demand, enhance reliability, or offer other co-benefits, as discussed below. At the same time, existing resources continue to have an important role to play to ensure the system remains reliable and the cost of electricity remains affordable.

7.8.1.2 Time and Locational Considerations

As Vermont seeks to meet renewable and decarbonization requirements, it will be increasingly critical to recognize time and locational values in policies, programs, and related compensation structures to ensure the procurement of resources that can deliver power when and where it is needed most. Such valuation will encourage the development of resources capable of delivering energy during daily peak demand hours and/or whose shape will specifically match seasonal needs (particularly winter loads), operating in ways that deliver the greatest GHG emissions reductions. The addition of substantial electric vehicle and heat pump load will change not just the amount but also the timing of demand that must be served by utilities. EVs and heat pumps use considerably more electricity in the winter than the summer; these devices will predominantly draw power in the overnight hours during the coldest part of the day. This will not be unique to Vermont; the entire New England region is expected to experience this dynamic. It is important to match the supply curves (times of production) for generation resources to the expected load, and vice versa, especially when load-shifting is impractical or has already been maximized.

As noted above, both in-state and out-of-state resources will likely be necessary for Vermont's portfolio in order to best balance supply and demand. To this end regionally, offshore wind and other resources that generally produce during times of high winter loads are expected to become increasingly available. Battery storage can help alter supply curves for some more local generation resources, however over-reliance on storage could increase costs compared to matching supply and load shapes as closely as possible from any resource, local or regional.

In meeting renewable energy goals and GHG requirements, renewable policies and programs in Vermont at all scales should evaluate whether and how to appropriately incentivize procurement of resources with complementary delivery shapes and/or operational capabilities that explicitly meet needs of the grid and that are intelligently sited to deliver to maximum value to Vermonters. A variety of opportunities exist to address such concerns. Vermont could modify the RES to specifically incentivize delivery of renewable electricity based on time-based needs to match renewable supply more closely with demand for resources. This could be achieved through, for example, establishing a carveout of Tier I that requires delivery of a certain percentage of renewable energy resources during specific time periods (such as during daily or seasonal peak periods). Alternatively, Vermont could opt to adopt a complementary policy, such as in Massachusetts, which has both a Clean Energy Standard and Renewable Portfolio Standard (as previously discussed), in addition to a Clean Peak Standard (CPS), to specifically incentivize delivery of resources given time-based needs. Under the CPS in Massachusetts, clean energy resources that can either supply electricity or reduce demand during seasonal peak periods, as defined by the MA Department of Energy Resources, receive incentives.[298]

An alternative (or complement) to broad changes to the structure of the RES is to consider a redesign of distributed generation programs to include locational and time adjustors to more accurately reflect that the value of distributed generators to Vermont ratepayers depends, in part, on the time and location of their generation. The Department has proposed to the PUC[299] that any revision to the net-metering rule reflect the time value of distributed generation, especially for generation exported to the grid (rather than used on site). In the Department's proposal, this exported generation would be compensated based on its actual value to the system, rather than based on retail rates. By enabling annual netting of credits, the current framework encourages overgeneration during summer, with those exports to the grid credited to net-metering customers at much more than their system value at the expense of all ratepayers. Moreover, net-metering customers are able to claim those summer credits to offset their winter bills, when all

[298] See Massachusetts Department of Energy Resources: https://www.mass.gov/clean-peak-energy-standard

[299] See Department of Public Service Report on Public Utility Commission Net-Metering Information Requests in Case No. 19-0855-RULE, filed 11/1/19: https://epuc.vermont.gov/?q=downloadfile/384059/139251

ratepayers are in fact paying a premium for energy required to serve their load (including the load of net-metering customers) in real time. Aligning compensation with value (including renewable and emissions values) will stimulate resources that serve Vermont's renewable and emissions requirements at the lowest cost to ratepayers, thus helping contain the cost of electricity and facilitating the carbon imperative to electrify heating and transportation.

The Department also recommended that locational adjustments to net-metering compensation be considered to encourage distributed generation to locate in areas that have transmission and distribution "headroom" to accommodate resources. In relation to the export-constrained SHEI area of the transmission system, the Department recommended a per-kW fee adjustor commensurate with the impact the net-metering system's production would have on production from existing renewable generation in the area.[300] The Department's comments also articulated the need for broader consideration of location value than just in the SHEI, which could potentially be implemented through utility net-metering tariffs, giving ample opportunities for stakeholder engagement.

Other examples of mechanisms that better match distributed resource supply with demand and/or system value include dynamic rate structures for load such as time-of-use or critical-peak-pricing (instead of providing flat rate compensation) and narrowing the amount of time within which credits associated with excess generation can be used (e.g., credits apply only within the month they are generated). These options would all better reflect the time-based value such resources offer; the mechanisms discussed are becoming increasingly feasible with the continuing technology advancements and cost reductions of energy storage. Storage can help time-shift demand and supply to help customers, for example, use more of their net-metering production on-site or time-shift exports (in the example where on-site use is valued based on retail rates while exports are based on system value), or time-shift demand (in the example of time-of-use rates).

Part of aligning compensation for resources with the value that they provide should include encouraging intelligent siting of distributed generation — in other words development should be steered toward areas of the grid where distributed generation will provide benefit, or at least not increase costs.

Depending on where renewable resources are located, limited system capacity to accommodate their output can be one of the largest cost drivers to the project. If there is not room on the grid, an upgrade is needed, the costs of which are borne by the developer of the resource. In some areas, this effectively prevents further development. As much as possible, considerations should be taken to limit this effect by low- and no-cost options in planning and operation of the grid. However, it must also be recognized that there are real, physical limits to Vermont's electric system, and that to reliably host generation far in excess of that capacity may require significant investment.

As a part of the 2021 Long-Range Transmission Plan, VELCO examined multiple high generation scenarios, each with varying statewide generation siting assumptions, in order to calculate transmission capacity and to evaluate distribution capacity. It was determined that, should generation be sited exactly

[300] See Department of Public Service Comments on Revising Rule 5.100 to Address Sheffield Highgate Export Interface ("SHEI") Impacts, filed 8/27/21: https://epuc.vermont.gov/?q=downloadfile/505104/139251

where there is presently grid capacity, approximately 950 MW of distributed renewables could be reliably accommodated without system upgrades. However, given the extreme unlikelihood of such an outcome given economic, land use, and equity considerations, evaluation was undertaken of transmission upgrades that could be needed to accommodate 1000 MW of in-state, distributed generation. These projects range from the upgrade of sub-transmission lines to the construction of new transmission lines and sum near to $1 billion in estimated cost.

Locational adjustors within distributed generation programs would incentivize new, distributed generation to be sited in areas of the grid where it will generate the most economic benefit for Vermonters and make the most efficient use of existing T&D systems (see additional discussion in Chapter 4). If set appropriately, the compensation mechanisms could provide a flexible tool capable of evolving as grid constraints emerge or are mitigated (e.g., through load growth, co-location with load, or strategic addition of storage) or prevent them from forming altogether.

Modifications to the RES or specific programs need to be closely examined, preferably by a transparent stakeholder process such as a PUC workshop process or study. Valuing resources based on a more granular accounting of when they produce and where they are located would more accurately reflect their value, and target procurement to be most cost-effective. These resources have good potential to align with short-term emissions reductions. That said, time-based compensation could be complex to both the customer and to implement for the utilities, particularly if they have less advanced billing or metering systems. Any broad-based accounting must take into account regional context as well — both market pricing and REC accounting (which is currently done on an annual basis). Finally, the distribution of the benefits and costs of such programs need to be examined to ensure they are equitable.

7.8.1.3 Resource Size and Diversity

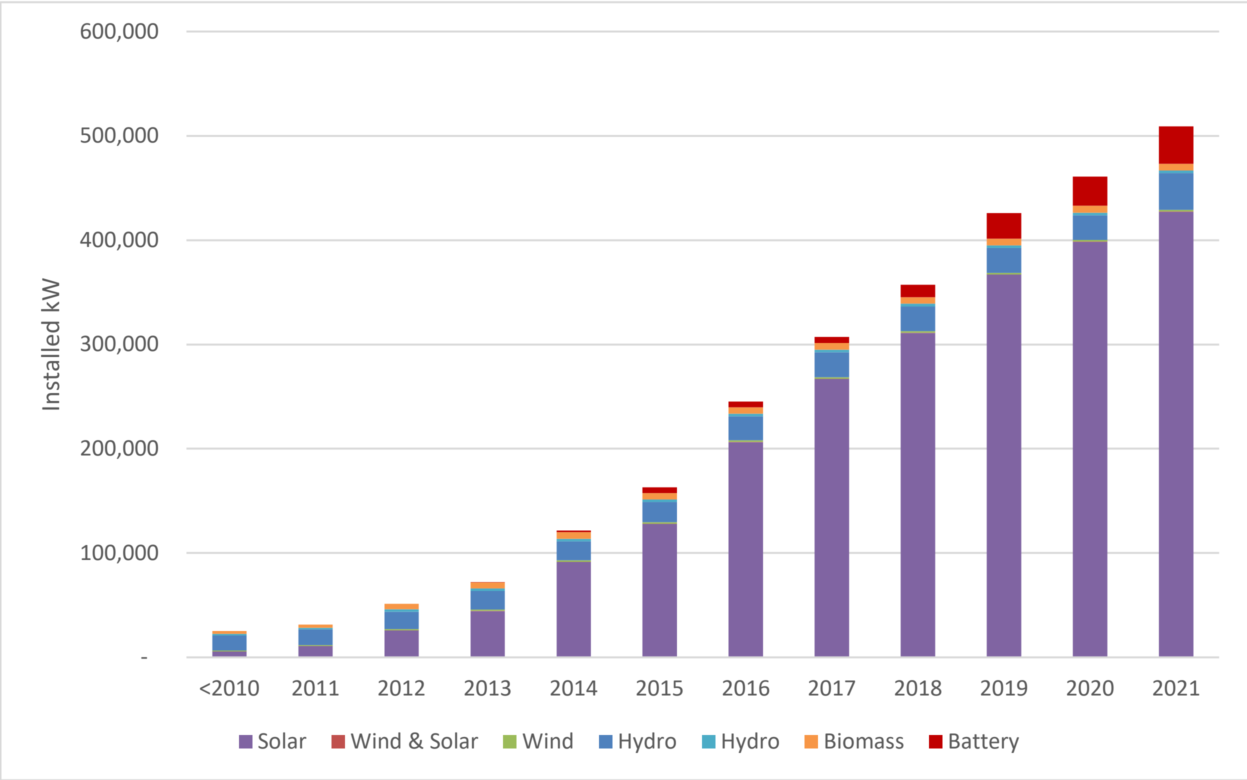
Since the 2016 CEP, the deployment of distributed generation (DG) in Vermont — largely distributed solar — has advanced considerably. As illustrated in Exhibit 7-27, approximately 345 additional MW of DG has been deployed over the past six years, and this increase has been dominated by solar, which saw almost 300 MW of additional installed capacity (over 200% increase).

The value proposition for DG has also changed since 2016. Currently, distributed solar corresponds to roughly 44% of the magnitude of Vermont peak load[301], with net-metered solar representing 31% of the magnitude of peak load. This substantial rollout of distributed solar has changed the Vermont electric system, in part by shifting Vermont's peak demand into the evening — meaning new solar no longer provides the benefit of reducing peak-related costs. Now, Vermont must address the necessary evolution of programs to keep pace with changing technology, market, and system dynamics. It must also better articulate the tradeoffs associated with deploying smaller, local resources and larger resources (whether in state or out) in best meeting the competing objectives of Vermont's energy policy. At the time of drafting this CEP, next steps for RES and its supporting programs, including net-metering and Standard Offer, are under consideration. It is primarily the structure (including the compensation frameworks) of

[301] Based on 960 MW summer peak in 2020. See VELCO Long Range Transmission Plan, page 23.

these programs, however — and not "small" vs. "large" or "in-state" vs. "out-of-state" resources, per se — that should be the focus of this effort.

Exhibit 7-27. Cumulative installations of Distributed Generation Resources by Year, by Capacity (kW)[302]



Programs that incentivize renewable resources may pay very different amounts for those resources, despite the resources offering very similar system benefits to ratepayers or society more broadly. For example, the same carbon reduction benefits as those procured via net-metered solar and other small-scale resources are being achieved at significantly lower cost through the development of larger-scale projects.[303] Ratepayers pay this premium, which puts upward pressure on electric rates, counter to the objective of encouraging electrification in thermal and transportation sectors. This dynamic has become clear since the 2016 CEP and underscores the need for Vermont to create flexible policy frameworks that can evolve with this rapidly changing landscape. It is essential for policymakers and regulators to continually re-evaluate programs and resources to ensure Vermont's policies and programs continue to best serve Vermonters.

[302] Data provided to the Department by Vermont distribution utilities via the ISO-NE monthly distributed generation survey. This figure includes updates through November 2021 for the majority of distribution utilities in Vermont.

[303] See Department of Public Service's 2021 Annual Energy Report. https://publicservice.vermont.gov/sites/dps/files/documents/Pubs_Plans_Reports/Legislative_Reports/2021%20Annual%20Energy%20Report%20Final.pdf

- *One aspect of resource size and type of considerable interest to many Vermonters is "community" energy. To some, this implicates a certain size or location of system. For others, it implicates ownership or beneficiaries. A better way to examine the meaning of, and pathways for, community energy may be through the lens of equity. Concerns regarding the ability of all Vermonters to equitably access renewable energy through programs like net-metering have been raised as issues for consideration in future iterations of the program. For certain demographics (e.g., renters, low-income homeowners), net-metering may not be feasible due to lack of upfront capital or homeownership. Further, at present the state does not have a long-term, sustainable program to support community-owned or community-scale resources to serve those communities that cannot afford to net-meter on their own, given challenges with the cost-effectiveness of group net-metering projects. The cost shift that occurs within the net-metering program poses significant concerns regarding the sustainability of the program in its current form, with the benefits disproportionately accruing to those who can participate (historically those who are economically better off), while costs of the program are shifted to non-participating customers (historically marginalized or lower-income customers). Development of a community energy program as one potential successor program to the current Standard Offer program would provide an opening to address inequal access to existing clean energy technologies.*

7.8.2 Electric Sector Recommendations

Any potential changes to the RES and related renewables programs and policies will require careful consideration of the types and sizes of resources best suited to meet Vermont's energy policy needs. Vermont now has the opportunity to revisit and align the state's suite of renewable policies and programs to ensure they work together coherently. At present, the Standard Offer program is sunsetting, net-metering is under review, and discussions regarding potential modifications to the RES required to meet state decarbonization requirements are occurring. Both the net-metering and Standard Offer programs predated the RES, and while the resources from these programs do provide mechanisms for utilities to meet RES obligations, in their current form they do not always do so in a way that is most beneficial to all Vermonters. When evaluating opportunities to improve the structure of renewable energy and low-carbon electric resource programs, analysis should consider:

- Equity: Impacts of current and proposed programs on frontline communities; how the benefits and burdens of policies are distributed.
- Cost-effectiveness: Modifications to programs should closely consider costs and benefits. If there are more affordable mechanisms to meet Vermont's energy service needs, they should be closely considered. Cost-effectiveness, in terms of dollar per desired output, can be measured a number of ways (e.g., carbon, energy provided, capacity provided, etc.). Policies and programs must be aware of any upward rate pressure that could discourage the economic proposition for customers to electrify.
- Carbon reduction: The amount of carbon reduction acquired relative to alternative resources.
- Grid impact: Does the policy or program address time and locational value (or cost) of resources?

- Economic development impacts: How does the policy or program impact economic development?
- Uncertainty/flexibility: Does the policy or program stand up well to uncertainties and does it include mechanisms to react to changes over time?
- Simplicity: Is the policy/program understandable and implementable?

Recommendations

- *Consider adjustments to the Renewable Energy Standard and complementary renewable energy programs comprehensively, through a transparent an open process such as a PUC proceeding. The considerations should include:*
    - *Consideration of a low-carbon or carbon-free standard, in addition to a 100% renewable energy standard;*
    - *Consideration of a cohesive set of programs to support the standard; for example:*
        - *Modification of the net-metering program to bring program costs into better alignment with benefits to allow for more well-sited, cost-effective, and equitable distributed generation to be added to Vermont's portfolio;*
        - *Consideration of "community solar" or other programs to better enable frontline or impacted communities' access to participate in distributed generation programs;*
        - *Consideration of the sunset or continuation, modification, or replacement of the Standard Offer program, with the goal of simplifying procurement of larger distributed generation at least cost and allowing for utilities to procure resources that best fit the needs of their systems and customers;*
        - *Better reflection of the time and locational values of resources; and*
        - *Consideration of how to maintain existing cost-effective renewable generation within Vermont's portfolio.*
- *As part of the Act 174 enhanced energy planning and implementation process:*
    - *Distribution and transmission utilities should engage with regional and municipal planning commissions to ensure that their goals and targets consider projected grid hosting capacity;*
    - *Developers of potential renewable energy facilities should consult regional and municipal enhanced energy plans to identify sites highlighted as preferred for additional development;*

- *Ongoing state support should be sought for the development, revisions, and implementation of enhanced energy plans, including the initial development of such plans in the remaining municipalities yet to establish them; and*
- *Energy savings and conservation by individuals and organizations should be encouraged through educational activities and events such as convening or sponsoring weatherization workshops, supporting local energy committees as well as the use of exiting utility and other efficiency and conservation programs and funding sources.*

- *The Department should work collaboratively with other state agencies such as ANR to ensure that issues of environmental justice and equity are incorporated consistently across siting policy in Vermont (for example, Act 250, Section 248).*
- *Siting of energy infrastructure should avoid or minimize conversion of natural lands, and should seek to maintain the ecological functions of the land.*
- *Re-evaluate Energy Efficiency Charge low-income definition and seek to expand to BIPOC individuals and communities, as appropriate. Consider the tradeoffs associated with an increase to the minimum equity investment required of efficiency utilities from 85% to 100% of their estimated payments into the Energy Efficiency Charge, or more.*
- *Evaluate and build on successes of current Energy Efficiency Utility pilots for Flexible Load Management and refrigeration management. Account for refrigerant leaks from all technologies, including reductions from refrigerant management programs and increases that may occur from new systems that use refrigerants such as cold climate heat pumps. Explore feasibility of including an assessment of Flexible Load Management and refrigeration management potential prior to or as part of the next Energy Efficiency Potential Study conducted by the Department.*
- *The Department should work collaboratively with the PUC, ANR, RPCs, and other stakeholders to modify the net-metered preferred site incentive structure to discourage projects that result in excessive forest conversion, and expand enhanced energy planning requirements to consider impacts to forests, more broadly, for energy generation projects of all scales.*

8 Clean Energy and Climate Finance

Achieving affordable greenhouse gas reductions and renewable energy development that encourages Vermont's economic vitality will require the State of Vermont to enhance its suite of climate and energy-related policies with public and private financial resources that are sufficient for the necessary investments. The state has made progress toward its goals since the 2016 CEP, in part due to the financing made available for the deployment of renewable energy systems and the reduction of energy use through efficiency upgrades. This section reflects on some key challenges yet to be overcome involving finance for clean energy, as part of an integrated approach to achieving the state's climate and energy goals. The chapter includes recommendations for expanding access to development capital for clean energy and climate-related investment.

8.1 Overview

The journey from an economy largely dependent on fossil fuels toward the decarbonized economy described in this CEP and the Climate Action Plan will require speeding up transformation of the state's energy markets. The rate at which that transformation must take place will need to accelerate, with the share of renewable and low-carbon energy increasing rapidly to meet reductions of fossil fuel use through electrification. This fuel conversion will require substantial commitments of public and private financial resources, at a scale we have not witnessed to date.

In 2016, the previous CEP identified financing needs for meeting state energy goals. These financial investments would ultimately lower energy costs, reduce emissions, and create many clean energy jobs in the state. That 2016 CEP provided background on a range of finance tools and techniques available in Vermont, or capable of being developed.[304] Based on current rates of funding and financing, to make serious progress the state will need to see investments ramp up in the next few years. Given the current set of finance-related tools and resources, it is unlikely that the private market alone will fill this need.

Over the past five years, the state has seen progress in the creation of accessible financing products for customers interested in deploying clean energy technologies. Since the 2016 CEP, the Department of Public Service and many finance institutions have improved access to capital to meet key gaps in the market. For example, renewable generation in the electric sector grew significantly, as witnessed by the Vermont Economic Development Authority's financing since 2016 of 28MW of photovoltaic solar projects, altogether valued at more than $46 million. On the residential front, the Heat Saver Loan pilot program initiated and run by the Department of Public Service from 2014 to 2017 laid the foundation for the subsequent Home Energy Loan program managed by Efficiency Vermont, which through its partnerships with local credit unions has loaned out nearly $13 million for 1,444 residential energy upgrades since 2018. In 2018, the Vermont Housing Finance Agency (VHFA) sold the state's first sustainability bonds, which raised $37 million for housing projects that included energy improvements. VHFA partners with housing organizations that share energy goals with the energy and climate sectors, and through which energy improvements are made. In addition, the Office of the Treasurer has provided

[304] See the 2016 CEP Chapter 6 on Energy Financing for information on finance tools.

financing to NeighborWorks of Western Vermont, which as of 2018 had loaned over $1.9 million for 156 homeowner energy loans.[305] These are notable achievements.

But at present, with interest rates remaining near historic lows, the rates of participation in some programs do not appear driven by the availability of affordable capital. Even with the increase in financeable energy projects, the overall pace of transformation remains patchy and insufficient to meet state goals. Across different institutions, financing for renewable energy and energy efficiency is fragmented by type of property (e.g., residential vs. commercial, rental vs. owner-occupied) and by type of project (e.g., efficiency vs. generation). With numerous sources of public and private capital spanning different domains, this can cause confusion for consumers and businesses about the best options for financing and how to access them. This CEP explores what it will it take to increase deployment of clean energy technologies and services, and what role funding and finance can play.[306]

A glimpse at data for publicly funded energy efficiency activities identifies the resources dedicated to a specific state energy sector and the implications for financing. As an example, building energy upgrades through state programs generated results well below levels needed to meet the statutory goals for weatherization.[307] Between 2008 and 2020, 31,535 homes were weatherized — but that only achieved 39% of the state's goal of weatherizing 80,000 homes by 2020. In 2019 alone, these projects received over $13 million in direct financial incentives to the homeowner or building owner, toward total project costs of nearly $21 million where each participant contributed about $3,600 to total project costs. Since 2015, the average participant contribution was around $4,200. [308] It remains unknown how much of the participant cost was financed and if so, how. For the average family, a contribution of $4,200 would be a substantial commitment.

The state will likely need to weatherize many tens of thousands more homes to help achieve the 2030 emissions reductions required by the Global Warming Solutions Act (see Chapter 6). Hitting the requirements will necessitate improving five to six times the number of homes weatherized at the current pace, with many more projects requiring publicly funded incentives, but also financing at terms (e.g., interest rates, loan term) to make them economically viable. This financing barrier is formidable, especially when so many Vermonters and businesses are coping with the ongoing economic impacts of the global pandemic. The weatherization example can be translated to other energy-service needs as well.

In retrospect, successful financings of residential and commercial energy projects using public and private resources have demonstrated the movement of local energy markets beyond the earlier, higher-risk stage of development. For example, there are now many financial options for commercial solar

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[305] Local Investment Advisory Committee (LIAC) Report. State of Vermont Office of the Treasurer. January 5, 2018. https://www.vermonttreasurer.gov/sites/treasurer/files/cash-investments/local-investment-advisory-committee/supporting-materials/LIAC_FINAL2018_Report.pdf

[306] The PSD does not have access to primary data on consumer or commercial debt for clean energy upgrades provided by the state's private financial institutions. The PSD uses the information on public funding for weatherization and financings by state agencies for illustrative purposes. There is little publicly available data on private financings for the energy sector.

[307] 10 V.S.A § 581 sets residential building energy efficiency goals including the goal to weatherize 80,000 homes by 2020.

[308] 2020 Final Annual Report on Vermont's Progress Toward Building Energy Fitness Goals—. Vermont Department of Public Service. VT Public Utilities Commission Case # 21A - 5379 .

projects in the market. But new energy technologies and services continue to emerge, requiring financial institutions to keep abreast of these changes. This situation, combined with other factors described in this section, inhibits investment in potentially viable projects.

Achieving scale with investments for climate and energy will require a more concerted effort, not only to provide access to affordable capital to all customer segments, but also to drive capital into under- or unserved customer segments. While there are a few ways to approach this goal, other states appear to be addressing this through the creation or dedication of finance institutions purpose-built for driving capital into clean energy market gaps. Although Vermont has benefited from the financial products and institutions that have entered the market since the 2016 CEP, there is still a compelling need for the state to identify a pathway for accelerating the deployment of capital to complement the policy work envisioned by this CEP. Accomplishing this objective might be achieved through a formal collaboration among the state's bonding agencies (Vermont Economic Development Authority [VEDA], Vermont Housing Finance Agency [VHFA], and Vermont Bond Bank [VBB]), as opposed to creating a new entity for this purpose.

8.2 Strategy: Enhance Finance for Climate and Clean Energy

Meeting the requirements of the Global Warming Solutions Act and the CEP will require substantial commitments of new financial resources over the next three decades. The 2016 CEP identified the need for approximately $33 billion by 2050, or about $1 billion per year.[309] The implications for such a commitment can be put into the context of the state's current expenditures on energy. According to the Energy Information Agency, Vermont spent over $2.7 billion on energy in 2019 or $4,384 per capita, placing the state 12th overall on energy expenditures per capita and as a percent of current dollar GDP, even as the state ranks 50th in terms of actual expenditures. [310] Vermont ranked 43rd in actual energy consumed, at 219 million Btu per capita.[311] The $4,384 spent per capita is lower than in 2013, when Vermonters spent $5,196 per capita, but is still in the top quartile overall for the United States.

Individuals or organizations seeking to lower their annual energy costs by upgrading their buildings, purchasing new energy saving technologies, or accessing relevant services would be expected to invest such that their overall energy costs at minimum do not go up. In the optimal case, they would be seeking ways to reduce their energy expenses with cash flows that save money and pay for energy investments over time. Thus, the terms, rates, and availability of financing play a central role when those who must finance their projects are deciding whether (or not) to proceed.

[309] Vermont Comprehensive Energy Plan 2016. https://publicservice.vermont.gov/publications-resources/publications/energy_plan/2016_plan. Pg. 65.
[310] State Energy Price and Expenditure Estimates 1970 Through 2019. DOE/EIA-0376(2019). June 2021. US Energy Information Administration. https://www.eia.gov/state/seds/sep_prices/notes/pr_print.pdf.
[311] State Energy Consumption Estimates 1960 Through 2019. DOE/EIA-0214(2019). June 2021. US Energy Information Administration. https://www.eia.gov/state/seds/sep_use/notes/use_print.pdf

8.2.1 Challenges in the Market

Meeting the requirements of the GSWA and other state energy objectives will require not just investing billions of dollars into proven and emerging technologies over the coming years, but also recognizing that private investment and market forces will not necessarily by themselves create a just and equitable transition to a decarbonized economy. The need to include equity in decision making regarding climate change and the state's energy goals, as discussed previously in this CEP, also applies in the realm of financing. Equity must be at the center of how the state addresses the role of financing to decarbonize, including a focus on Vermont's marginalized, underserved, and higher-risk populations.

There are multiple barriers that impede progress on energy and climate goals related to finance. These include perceptions of project risk by lenders, credit risk of customers, marginal project economics, inefficiencies for smaller dispersed projects, first-of-a-kind projects or deal structures, technical capacity gaps at the local level, the tendency to focus on individualized solutions at the expense of collective solutions, low incentive to assist under-served low-income and BIPOC communities, workforce gaps, standardization issues for financing, lack of consumer awareness, and mismatches between project lifespans and debt terms.[312]

Vermont has a range of public and private finance institutions that are charged with supporting key aspects of the state's infrastructure, services, and economy. However, there is no single, mission-driven, outcomes-based state financing entity charged with addressing the barriers just listed and driving capital into clean energy projects or climate-related investments in an equitable way, or otherwise addressing the multiple business problems that hamper the scaling of needed clean energy technologies and climate tools.

Along with project-related financing concerns are significant business finance challenges. Consumers and commercial entities seeking clean energy products and services may tap incentives and other financial resources to implement their projects. When they have the financial resources and capacity to launch a project, they often turn to one or more of the many of the providers of clean energy goods and services in the state. Many of these are small enterprises — often with few than 10 workers — that have small balance sheets, modest marketing capacity, and limited access to growth capital. It is often difficult for smaller operations to obtain financing that would help them achieve economies of scale, which in turn would lower costs and make them more competitive in the marketplace. There is currently limited support for clean energy ventures seeking business assistance that could help them achieve greater scale or develop innovative products or services.

8.2.2 Opportunities to Advance Clean Energy Finance

Vermont has a compelling opportunity to coordinate among the state's finance institutions and private capital providers to organize a purpose-built, mission-driven finance institutional arrangement charged

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[312] Derived from: Accelerating Investment in Clean Energy & Climate Infrastructure to Create Jobs & Drive an Equitable & Just Transition: Policy Analysis of the Clean Energy and Sustainability Accelerator. Coalition for Green Capital. November 2020. Pgs. 8-11. https://coalitionforgreencapital.com/wp-content/uploads/Policy-Analysis-of-the-Clean-Energy.pdf

with promoting and propelling development capital into clean energy and climate finance markets in a deliberate and equitable way. Each of barriers listed in the previous section could be improved via an institutional arrangement tasked with such responsibilities — and the experiences of other states now provide a range of lessons and examples from which to draw.

Far larger states such as New York, Connecticut,[313] and others are actively creating purpose-built finance institutions and capacity aimed directly at overcoming the key barriers that impede growth of clean energy markets. There are currently 21 states and municipalities using similar approaches to finance projects that reduce carbon emissions, create jobs, and support their communities. These institutions drove $1.69 billion in total, using $442 million of their own funds, into clean energy investment in 2020. The cumulative investment by these institutions now stands at $7 billion, using $1.9 billion of funds to leverage $3.70 of private resources for every dollar invested. [314]

While Vermont has supported development of new tools and tactics to help increase access to affordable capital, the larger task of financial market development for clean energy remains a work in progress for the state. As other states pioneer viable approaches that resolve and overcome some of the many barriers outlined above, Vermont can learn from their experiences and design an approach that works in the context of the state's existing institutions. The task would be for the state's finance entities (VBB, VEDA, and VHFA) and intermediaries to create a new institutional arrangement, with a strategic business plan that encompasses the functions necessary for Vermont to achieve its energy and climate goals.

8.2.3 Trade-off Analysis

There are many benefits that a new institutional arrangement would provide that go beyond the services and capacities present in the state's clean energy finance market. An insightful approach would harness the skills and experiences of current market actors to design an arrangement that propels the energy transformation without creating unnecessary new organizational infrastructure or administrative redundancies.

The functions for this new institutional arrangement should focus on mobilizing private capital (primarily debt, but it may include equity as well) along with tools designed to reduce risks, generate expertise in the Vermont clean energy finance market context, facilitate a range of financial transactions, and drive equitable access to capital that yields cost-effective, technically appropriate solutions.

A plan to establish a new institutional arrangement should include a mandate to mobilize private investment in ways that create market scale through transparent, simple, replicable means, not merely reusing existing finance tools and tactics that have not generated the level of investment required or pursuing the finance tool of the day. Such an institutional arrangement should be provided with the necessary authorities to work independently, with the latitude and flexibility to design and implement

[313] In July 2021, the Connecticut legislature and Governor expanded the state's clean energy finance authority to include environmental infrastructure financing that will encompass structures; facilities; systems; improvement projects related to water, waste, and recycling; climate adaptation and resiliency; agriculture; land conservation; parks and recreation; and environmental markets. https://www.ctgreenbank.com/tenth-anniversary-marked/
[314] Green Banks in the United States: 2021 U.S. Green Bank Annual Industry Report. American Green Bank Consortium and Coalition for Green Capital. May 2021. https://greenbankconsortium.org/annual-industry-report

tested or novel solutions — either alone or in syndicate with other partners — with cost-effectiveness, performance-based outcomes, and equity as measures of effectiveness.

Risk Mitigation: Project and credit risk can limit the deployment of capital. The plan should include a means by which some of the risk is reduced for other finance market participants. Tools could include credit enhancements (e.g., loan loss reserves) or co-investing strategies.

Bundling Transactions: Inefficiencies and costs common to smaller projects can be addressed via aggregation techniques employed in other sectors of the state.

Direct Lending: The function of providing concessionary financing for clean energy projects can be used to support projects that cannot be financed by private financial institutions.

Connector: Part of the work needed to advance the state's energy and climate goals will require building and enhancing linkages between finance institutions, government agencies, and private market actors. By building a body of experience and knowledge specific to Vermont, this essential function forms the "glue" that holds new arrangements in place. [315]

Adding these functions deliberately in the context of clean energy finance market development will benefit the state by helping facilitate more projects, meeting statutory requirements, overcoming challenges, and meeting energy needs for all Vermonters.

Some potential drawbacks from pursuing new capacity to build financial markets for clean energy include the potential for disruption among existing finance institutions that continue to struggle with challenges from the pandemic, and the risk of duplicating functions that complicate rather than streamline access to finance for clean energy products and services. Both can be addressed through a thoughtful design process. It would also be important to consider how to structure any new engagements in the market so that they complement and enhance existing private market capacities, rather than compete with them. Thus, one key objective for any new institutional capacity would be to leverage private resources, not replace them. From the perspective of the finance authorities, new activity should build on existing institutional capacity rather than creating a potentially redundant and disruptive institution that may diminish the capacity of the existing public finance institutions.

8.2.4 Measuring Progress

The new institutional arrangement would need to account for the current conditions and actors in the state's renewable energy, energy efficiency, and transportation sub-sectors. Considerations for where to focus should include:

- Providing equitable access to clean energy solutions and financing by historically marginalized communities,
- Contributing to meeting targets for greenhouse gas emissions reduction,
- Mobilizing and leveraging private capital,
- Lowering the overall cost of capital through economies of scale and other means,

[315] Adapted from Accelerating Investment, Coalition for Green Capital. Pg. 58.

- Fostering markets into which new clean energy technologies may take root,
- Helping communities meet their development objectives, and
- Creating clean energy-related jobs[316].

Potential metrics may include emissions reductions, job creation or retention, various finance ratios (e.g., leverage), geographic and demographic distribution of capital, measures of economic efficiency in the marketplace, total capital deployed for clean energy by public and private institutions, and/or others as deemed appropriate.

8.2.5 Review of State-supported Clean Energy Financing Activity

Vermont has a variety of public and private providers of capital helping to meet some of the needs in the market. These institutions have specific missions designed to provide financing for municipalities, public education and health institutions, infrastructure, economic development, and housing.[317]

Vermont Bond Bank: Energy efficiency retrofit and renewable energy projects are a growing part of the Bond Bank's regular loan activity, with an average of $4 million in related projects financed annually. From 2016 to 2020, financings for seven energy efficiency and renewable energy projects totaled about $19 million. To date, this activity has been concentrated in larger retrofit projects for school districts. Less common are municipal retrofit projects that have smaller project costs, but through the Bond Bank those gain equal access to low-cost finance. Municipal projects typically take the form of new construction in buildings that benefit from efficient design. The VBB has also begun supporting climate resilience and response projects, with three such projects financed from 2019 to 2020 totaling over $2.8 million. The VBB reports that energy efficiency projects may be higher, since this kind of work may be included in a broader scope of work that was not an explicit part of a project description. The VBB reports that energy financing is an important part of the integrity of its portfolio.

Vermont Economic Development Authority: Over the past five years, VEDA has financed 97 solar projects and one hydro project, altogether totaling 28,198 kW (AC) capacity. In addition, the Authority financed two energy technology loans and two energy efficiency loans. In all, these projects tapped about $47 million of VEDA financing for total investments of over $94 million, a 2:1 leverage ratio.

VEDA reports that over the past six years, the authority leveraged $10 million of state funds loaned from the State Treasurer (2014 Act 199 — Credit Facilities for Local Investments Act) into energy projects totaling $187 million across Vermont. In addition to this significant leveraging of private capital, VEDA-financed clean energy projects have created over 1,300 FTE's, reduced greenhouse gas emissions by 54,715 tons per year, generated over 318,000 MMBtus of renewable clean energy per year, lowered the overall cost of capital for clean energy projects, financed new clean energy technologies, and provided access to clean energy solutions to communities with limited access to affordable capital.

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[316] Ibid

[317] This section reviews only public finance-related institutions as access to data from the private sector remains beyond the scope of the CEP.

VEDA reports that its energy programs have been very successful in developing solar PV arrays. As the industry has matured, other financial institutions have become less risk-averse and are now offering more lenient terms, including longer loan terms, no personal guarantees, and lower rates — all indicative of the stability of the solar industry. Other types of energy financing are not as well-developed. VEDA is also engaged with financing related to electric vehicle infrastructure, both through VEDA's Energy Loan Program and through the State Infrastructure Bank (SIB), which is authorized to support development of Level III charging stations and related technology located on state and federal highways and accessible to all. VEDA is using its energy loans in a workplace EV charging program that is being offered in conjunction with Green Mountain Power to help businesses across Vermont install Level II chargers for their employees and customers. There are opportunities to work with federal partners to make the SIB easier to use.

Vermont Housing Finance Agency: Drawing on its extensive track record with multi-family housing projects, VHFA and its partner, the Vermont Housing and Conservation Board, employ a set of building design standards that require projects to meet the Efficiency Vermont's High Performance Building Standards. The agency has a Qualified Allocation Plan (QAP) that determines how tax credits are awarded to multi-family developments. This QAP awards points to projects that are "passive house" or net-zero, both of which require a project to have solar as part of the overall energy efficiency package. As of 2021, VHFA participated in an effort with the State of Vermont to explore development of a tariffed on-bill repayment program pilot designed to facilitate residential weatherization projects by linking payments for upgrades to the utility meter rather than traditional consumer debt. VHFA acknowledges that it will be imperative to tap private market capital to achieve the goal of weatherization envisioned in the CEP. The agency has designed the Weatherization Repayment Assistance Program (WRAP) around this idea with a goal of scaling the pilot into a comprehensive program by leveraging private market capital with public subsidies to make weatherization affordable (see section 6.3.1.5 for more information).

Efficiency Vermont: EVT manages two main finance programs, the Home Energy Loan and Business Energy Loan programs, the latter of which also includes a focus on agriculture. The BEL program has supported 100 loans valued at $2.6 million since 2015. The Home Energy Loan includes weatherization, cold climate heat pumps, advanced modern wood heating systems, and other upgrades. Between 2018 and August 2021, this program financed nearly $13 million of upgrades at over 1,400 residential projects.[318]

8.2.6 Department of Public Service Clean Energy Finance Activities

In 2017, upon completion of the Heat Saver Loan pilot project, the Department convened the Clean Energy Finance Collaborative to identify additional gaps in the market that could be filled. The results of this effort led to attention on energy savings guarantees for residential home energy upgrades, to test factors that may be inhibiting participation rates. The pandemic led to a pause in a pilot that aimed to test the confidence in achieving savings behind efficiency projects.

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318 Email communication, Efficiency Vermont. October 11, 2021

Participants in the Clean Energy Finance Collaborative also identified the need to expand energy management services into the municipal, university, schools, and hospitals market segment. The Department worked closely with BGS over the next three years to extend the use of BGS's successful State Energy Management Program to municipalities and schools. This new effort is slated to launch in 2022. The PSD continues to manage finance-related grant programs that are designed to mobilize private capital for energy efficiency and renewable energy investment through risk mitigation.

In addition to its role as provider of grants and incentives that support advancements in the renewable energy sector, the Clean Energy Development Fund (CEDF) also contributes to strategic planning for clean energy financing through its role at the Department of Public Service. Between 2018 and 2020, the CEDF sponsored three Vermont Clean Energy Finance Reports to articulate financing's role in the clean energy transition, present a snapshot of the clean energy finance market in the state, and identify potential areas of expansion and future research.[319] The series of reports provided a set of directional cues regarding financing's role in support of clean energy development.

Recommendations:

- *Vermont's state finance institutions (VEDA, VHFA and VBB) should investigate the optimal structure(s) needed to deploy low-cost capital at the scale and pace needed to meet energy and greenhouse gas emission reduction goals. The investigation should at a minimum consider:*
    - *Identifying a new institutional arrangement between existing mission-driven state funding and financing agencies. The arrangement or structure would be charged with promoting and propelling development capital into clean energy and climate finance markets for low- and zero-emissions technologies and environmental infrastructure using equity/justice and geographic distribution criteria.*
    - *Examining how the new institutional arrangement would be responsible for (1) driving private capital into market gaps for low- and zero-emission goods and services, including in currently under-served communities; (2) using finance tools to mitigate climate change; (3) functioning as a non-depository institution; (4) receiving funding from government, public, private, and charitable contributions; and (5) investing alone or in conjunction with other investors or finance institutions.*
    - *Streamlining and simplifying finance products in the market, to reduce confusion and facilitate access to capital.*
- *In conjunction with the first recommendation, the slate of clean energy and climate-related finance tools and tactics used in Vermont should be reviewed to find economies of scale, cost savings, and opportunities to expand participation by marginalized and under-served*

[319] Vermont Clean Energy Finance Reports 2018, 2019 & 2020. Energy Futures Group for the Vermont Clean Energy Development Fund. https://publicservice.vermont.gov/renewable_energy/cedf/reports

communities. The state should continue using existing finance products and developing new tools, such as tariffed on-bill repayment, as vehicles to address key market problems or barriers.

- *Within the existing financial partners, the state should build the capacity to access energy financing opportunities at the federal level, with a dedication to finding and knowing how to obtain and deploy federal funds.*

9 State Agency Energy Plan

9.1 Introduction

The State of Vermont is committed to supporting Vermont's transition to a healthy and prosperous clean energy future, by reducing energy use and improving energy efficiency in its own facilities and operations, and by increasing the share of energy it gets from renewable sources.

State government is one of the largest institutional energy users in Vermont. It is the third-largest employer; state agencies occupy three million square feet of building space, and own and operate more than 2,353 vehicles. As one of Vermont's largest energy users, state government has an important role to play in demonstrating how public- and private-sector organizations from across the state can contribute to meeting Vermont's energy and climate goals, while also saving money and creating desirable workplaces well-positioned to recruit and retain top talent from Vermont and beyond.

This State Agency Energy Plan (SAEP), prepared by the Department of Buildings and General Services with support from state agency staff, lays out a road map for how state government can lead by example as we implement Vermont's Comprehensive Energy Plan and make progress toward ambitious energy goals for 2025, 2035, and 2050.

9.1.1 Purpose of the State Agency Energy Plan and Individual Agency Energy Implementation Plans

Authorized in legislation passed by the Vermont Legislature in 1992, the SAEP serves as a guiding document for Vermont state agencies when making decisions about energy in state government operations. The SAEP must be updated every sixth year, beginning in 2010. An update to the 2016 SAEP was incorporated into the 2016 Comprehensive Energy Plan. The 2021 SAEP will be published both as an integral chapter of the CEP and as a separate document.

The inclusion of the SAEP within the CEP clarifies state government's intent to demonstrate the institutional goals and actions that will contribute to a rapid transition to a clean energy future for Vermont, and allows the SAEP to become a formal state agency leadership section within the larger plan.

The 2021 SAEP includes:

- Clear and measurable energy goals for state government in three areas: a) reductions in total energy consumption across all facilities and operations; b) expansion of the share of state energy that comes from renewable sources such as solar, wind, high-efficiency biomass, and hydroelectric power; and c) reductions in state government emissions of greenhouse gases that cause climate pollution.

- A profile of Vermont state government's current energy use, highlighting improvements made in recent years.

- A road map, including recommended strategies and action steps, that state government will use to make progress in different sectors, such as building energy use, distributed generation of renewable power, and reductions in fossil fuel use for transportation.

- A recommended process for implementing this road map and making progress toward the SAEP's energy goals across state agencies, including steps for tracking, documenting, and reporting progress.

The plan focuses on near-term, actionable items that can be implemented now to meet the state's goals.

Individual agency actions to manage energy use and invest in energy improvements will be coordinated with this SAEP. Each state agency is also required to prepare a biannual Agency Energy Implementation Plan (AEIP) that aligns with the SAEP and provides more detail on agency-specific goals and recommended actions. Current plans are scheduled to be updated during 2022.

The 2021 SAEP was produced by the Department of Buildings and General Services in coordination with inter-agency staff. It is the objective of BGS and agency staff to establish a coherent and consistent plan based on the array of obligations, responsibilities, legal mandates, and authorities that have been established relative to energy in state government operations.

Established under 10 V.S.A. § 591 by the Legislature in 2020, the Climate Council is composed of state agency secretaries, commissioners, and senior officials representing a cross-section of organizations. The Council is charged with providing comprehensive leadership of the state's climate change initiatives, including initiatives to reduce greenhouse gas emissions and reliance on fossil fuels, and to improve the state's resilience to the current and future impacts of climate change. As the SAEP is implemented during the next six years, the Council’s Climate Action Plan will have a key role in the achievement of emissions targets.

Beginning in March of 2020, the State of Vermont was forced to cease non-essential in-person operations in facilities across the state in response to the onset of the COVID-19 global pandemic. This dramatic change in facility occupancy and operating procedures caused a departure from normal annual energy consumption trends for the 2020 fiscal year, leading BGS to consider fiscal year 2020 an outlier. To give readers the most accurate trend information, the state energy information provided within the SAEP is reported for the 2019 fiscal year.

9.1.2 Statutory Authorization for the Plan

The SAEP was established in Title 3 V.S.A. § 2291 — State Agency Energy Plan. Relevant language can be found in Appendix A. The statute outlines the following objectives to be accomplished by the plan:

- Conserve resources, save energy, and reduce pollution;
- Consider state policies and operations that affect energy use;
- Devise a strategy to implement or acquire all prudent opportunities and investments in as prompt and efficient a manner as possible;
- Include appropriate provisions for monitoring resource and energy use and evaluating the impact of measures undertaken;
- Identify education, management, and other relevant policy changes that are a part of the implementation strategy;
- Devise a strategy to reduce greenhouse gas emissions; and
- Provide, where feasible, for the installation of renewable energy systems.

9.2 State Government Energy Goals

This 2021 SAEP puts forth the following goals to establish state government's commitment to demonstrating leadership in Vermont's transition to clean energy and showing the diverse economic, environmental, and social benefits that this transition will yield for public and private institutions across the state. The SAEP's goals challenge state government to reduce total energy consumption by a greater percentage by 2025 than sought in the corresponding CEP goal; to expand the share of total energy the state gets from renewable sources by a greater percentage by 2025 than the corresponding CEP goal; and to achieve greenhouse gas emissions reductions relative to these goals.

The specific goals are:

- Reduce total energy consumption by 40% by 2025, and by 50% by 2035.
- Meet 35% of the remaining energy need from renewable sources by 2025, and 45% by 2035.
- 40% reduction of greenhouse gas emissions below 1990 levels by 2030.

9.2.1 Basis for the SAEP Goals

9.2.1.1 Total Energy Reduction

The Legislature asked in Act 40 of 2011 that every agency, board, department, commission, committee, branch, or authority of the state reduce its energy consumption by 5% each year, including the amount of fuel used by its employees to travel to and from meetings during the workday. The Legislature also asked that state government increase the amount of renewable energy used by the state.

The critical intent of Act 40 complements Title 3, summarized above, which requires that the energy needs of the state be met in a manner that reduces greenhouse gas emissions. Since the 2016 SAEP report, the state has remained on track to achieve a 40% reduction by 2025, sustaining the requested 5% annual reduction in energy. If state government were to continue to achieve a 5% reduction in energy consumption annually, total energy consumption would be reduced by over 50% from fiscal year 2019 to FY 2035 — but additional measures will need to be taken in order to achieve the desired 80% reduction by 2050. Given current economic conditions, technologies, and funding, it is difficult to determine if the recent annual reductions can be sustained through 2050.

With state government on track to achieve the stretch target reduction of 40% by 2025, this SAEP proposes a goal for reducing total energy use by 50% by 2035, including the energy used to power and heat state buildings as well as energy associated with transportation by employees. This goal is at approximately the same scale as the all-economy goals put forth in the Comprehensive Energy Plan, while still challenging state government to lead by example, by achieving a greater energy reduction.

9.2.1.2 Using Renewable Energy

The SAEP's renewable energy goal is also a good stretch goal, accounting for the progress made so far but also requiring considerably more investment in a transition to renewable sources of power. Vermont state government has already made good progress toward achieving the 2050 renewable energy goal adopted in the 2011 Comprehensive Energy Plan; in FY 2019, total energy consumption was 26.5% renewable. This progress has been achieved in large part through the successful implementation of the Renewable Energy Standard (which has resulted in Vermont's electric utilities supplying 69% renewable power in 2020), net-metered solar projects, and an increased use of woody biomass for heating.

Finally, the 7% ethanol component of gasohol, or gasoline with added ethanol, now delivered at fuel pumps has helped increase the state's use of renewable energy.

Without relying on renewable energy supplied by the grid, state government increased its usage of renewable energy by 11% over the last four years. In every year between FY 2015 and FY 2019, the state used more wood products than oil for heating, as a result of the two largest heat plants in state government, at the Montpelier Capitol Complex and the Waterbury State Office Complex, being primarily fueled by wood chips.

Due to this progress, state government is on track to meet 35% of its energy needs from renewable sources by 2025 and 40% by 2030.

9.2.1.3 Greenhouse Gas Emissions

Based on a simple analysis conducted with the Center for Corporate Climate Leadership's GHG emissions calculator tool, state government was responsible for over 56,000 metric tons of CO_2 equivalent emissions (MMtCO2-e) in FY 2019. If state government achieves the total energy reduction and renewable energy goals set forth in this plan, it will reduce greenhouse gas emissions associated with state government operations by at least 40% by the year 2030.

9.2.2 Sector-Specific SAEP Targets

State government should plan to make changes in all areas of operations in order to achieve these overall goals for reductions in energy consumption, improvements in energy efficiency, and increases in the share of energy consumption using renewable sources. This section provides a sector-by-sector synopsis of what state agencies can do to help meet these goals. Additional guidance on the kinds of actions that can and will be pursued to meet these goals is in the Strategies and Recommendations section.

9.2.2.1 Improving Building Energy Conservation and Efficiency

To meet the SAEP's goals for reductions in total energy consumption, state agencies must improve electric and heating efficiency within state buildings (especially those that are state-owned, but also those that are leased), in addition to conserving more energy through changes in practices. In total, these gains in efficiency and conservation should reduce fuel usage by 15% by 2030, to support progress in meeting the state's overall energy use reduction goal. Funding is available for energy retrofits through the State Energy Management Program (SEMP). The energy team of the Department of Buildings and General Services (BGS) is available, in partnership with Efficiency Vermont, to provide technical assistance to agencies that wish to implement efficiency measures in their buildings. Visit bgs.vermont.gov/energy for more information.

9.2.2.2 Heating with Renewable Fuels

Meeting state government's renewable energy goals will require using more renewable fuels to heat buildings, along with continuing to increase the use of electricity generated from renewable sources. When building new state facilities, or when replacing heating equipment that has reached the end of its useful lifespan, state agencies switching to high-efficiency advanced wood heating systems that rely on woody biomass will support progress toward our energy goals.

Since the release of the 2016 SAEP, the predicted adoption of liquid biofuels has not materialized. This remains a potential source for additional emissions reductions in heating systems.

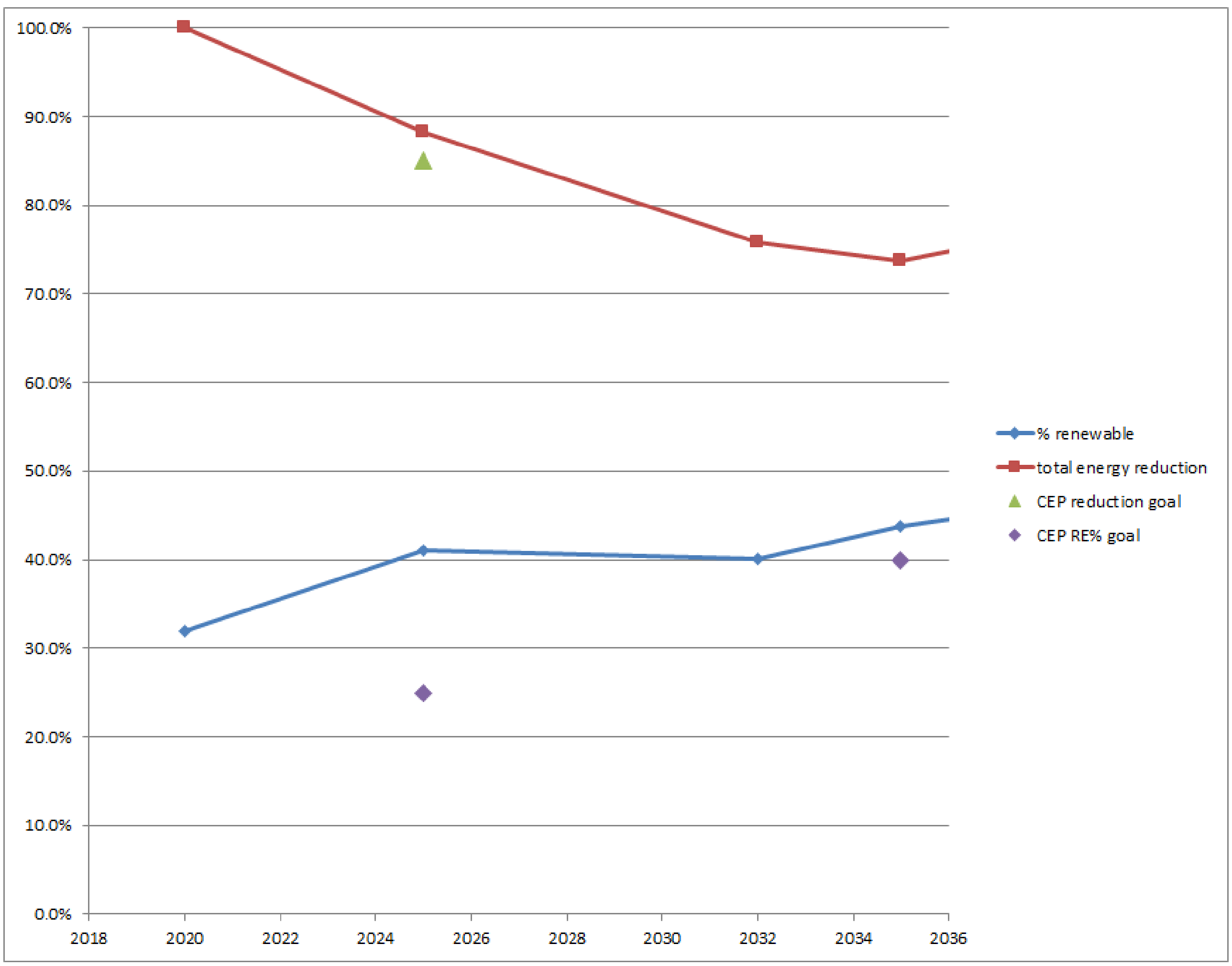
9.2.2.3 Using Alternative Fuels for Transportation

The energy that state agencies use for transportation must also continue to decarbonize if state government is to reach its near- and long-term energy goals. Specifically, the diesel fleet should increase the use of biodiesel from 0% in 2019 to 5% in 2025, and 25% by 2035. State agencies will also need to continue to meet more of their transportation needs with electric vehicles. Miles powered by electricity in plug-in hybrid vehicles and all-electric vehicles have already helped displace over 15 % of the state's gasoline use since 2015; they should achieve a level sufficient to displace 25% of the state's current gasoline use 2025, and one-third by 2032. The Go Green Fleets Initiative activated by BGS in 2015 (and described in the Recommendations section) is designed to achieve and surpass this goal.

In summary, state government must increase energy efficiency to reduce building energy usage by 15%; increase the use of biodiesel and bio-heating oil from 0% in 2019 to 5% by 2025, and 25% by 2035; and reduce state gasoline use by 25% in 2025 and one-third in 2032.

Exhibit 9-1 models a trajectory for energy reduction and renewables within state government if these changes occur. CEP goals are indicated for comparison, showing that the state is committing to lead by example.

Exhibit 9-1. SAEP Energy Reduction and Renewable Energy Trajectory



9.3 Recent Energy Improvements and Current Energy Use in State Government Operations

9.3.1 Summary of Accomplishments

Since the last SAEP was published in 2016, state government has made great strides in the reduction of electricity consumption, increases in solar photovoltaic energy projects, investments in hybrid and electric vehicles and infrastructure, approved expansion of energy services for municipalities, and through the continued use of biomass to supplement traditional heating fuels. Examples follow, with further detail in the Strategies and Recommendations section.

State agencies have improved their buildings through weatherization, lighting upgrades, heat pumps, building controls optimization, fuel switching away from fossil fuels toward alternative fuels like woody biomass, and various other energy efficiency and conservation measures.

State government has secured new grant funding and has partnered with Department of Public Service, Vermont Low Income Trust for Electricity, Vermont League of Cities and Towns, and Efficiency Vermont to expand the State Energy Management Program with dedicated staffing to provide technical and program development assistance to municipalities. This program will achieve additional energy savings by funding investment grade energy audits, and helping participating municipalities utilize those audits to generate energy conservation projects.

The Fleet Management Program continues to provide fleet vehicles to high-mileage state employees, and has decreased fossil fuel consumption and the associated air emissions within the fleet motor pool by increasing the number of plug-in hybrid electric vehicles and all-electric vehicles, and by providing additional electric vehicle supply equipment at state facilities.

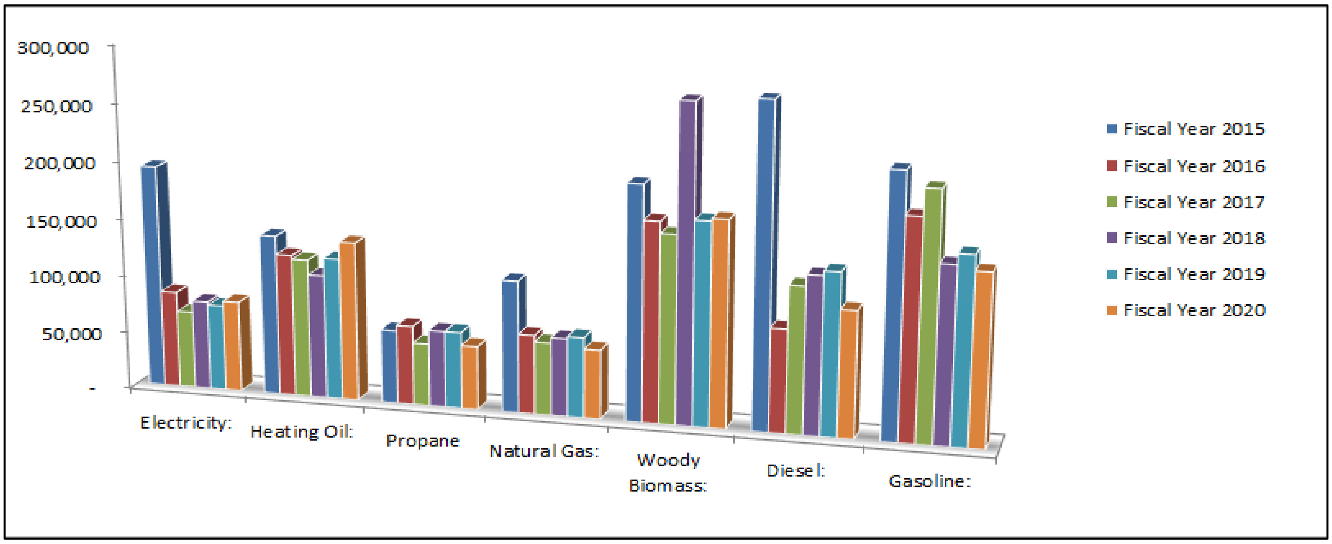
The Department of Buildings and General Services has secured funds for additional EVSE installations along key transportation corridors used by state employees.

To reduce energy consumption during peak hours of the day, the state has launched pilot programing for flexible load management in partnership with Green Mountain Power and Efficiency Vermont. To better manage state government transportation, agencies continue to utilize the WEX fuel purchasing system to aggregate transportation energy data. Agencies and departments throughout state government have increased renewable biomass and solar photovoltaic usage in state government operations.

9.3.2 Recent History of Energy Use in State Government Operations

In fiscal year 2019, state government consumed 839,222 million Btu of energy. While total energy consumption increased in fiscal year 2018, total energy consumption has decreased by over 30% since FY 2015. Reductions in total electricity consumed and transportation energy account for this decrease. In fiscal year 2015, gasoline accounted for 27% of all energy consumed by state government, more than any other energy resource consumed over the same period.

Exhibit 9-2. State Government Annual Energy Consumption by Energy Resource (MMBtu)



9.3.3 Transportation

The decrease in transportation energy is evidence of the success of recommended measures from the previous SAEP reporting period, including adoption of electric vehicle technology, incorporation of electric vehicles into the state's motor pools, and reductions in state employee mileage reimbursements. Following the adoption of teleworking during state government's response to the global pandemic, the state expects additional opportunities for reductions in transportation sector energy use.

9.3.4 Buildings

In FY 2019, energy associated with state-owned buildings made up 52.5% of the total energy consumed through state government operations. The reduction compared to the previous SAEP reporting period comes from significant decreases in the amount of electrical consumption associated with our building stock, and increases in the amount of renewable energy consumed. From FY 2015 to FY 2019, our oil and natural gas consumption also saw a drop in consumption as a result of displacement by wood biomass; however, both oil and gas have seen slight increases in recent years. Propane use has remained relatively steady during this period. Following the initial gains in biomass use, consumption has more or less leveled off over recent years. This demonstrates a need to continue the state's focus on improving electrical efficiency, while also increasing our focus on thermal energy efficiency initiatives.

9.3.4.1 Renewable Energy

In 2012, state government had no solar photovoltaic projects associated with its electric utility accounts. Starting in 2016, the state implemented over six megawatts of solar production capacity, as a result of state government projects that have generated over 33 megawatt hours (MWh) of electricity to date, offsetting electricity consumption by an average of 11% per year (Exhibit 9-3). Woody biomass consumption for state government building heating energy has continued to increase, with overall growth of over 6% since 2015. Since FY 2015 the state has consistently used more wood products than oil for heating.

Exhibit 9-3. State Government Annual Electricity Consumption (kWh)

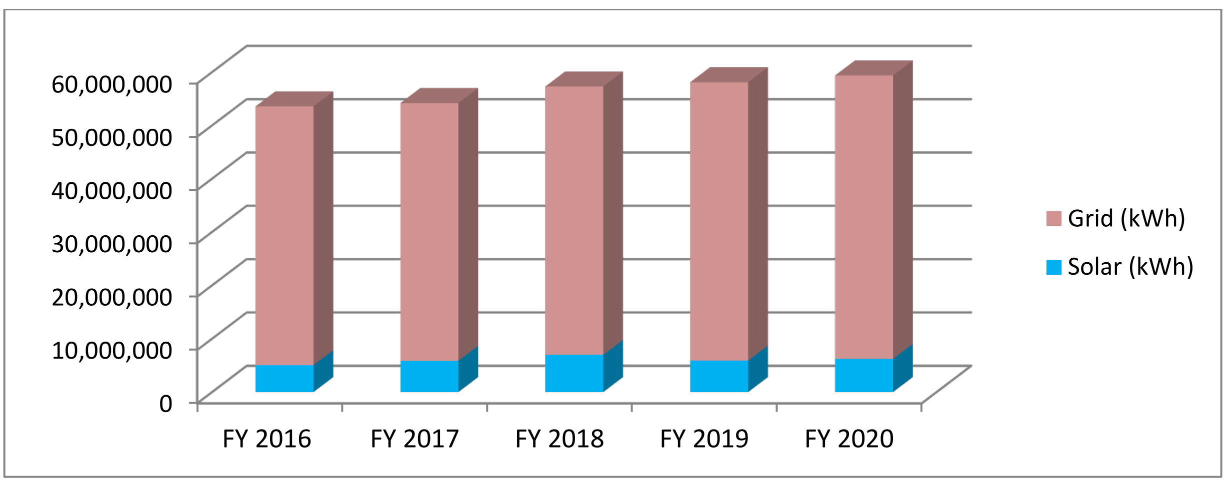
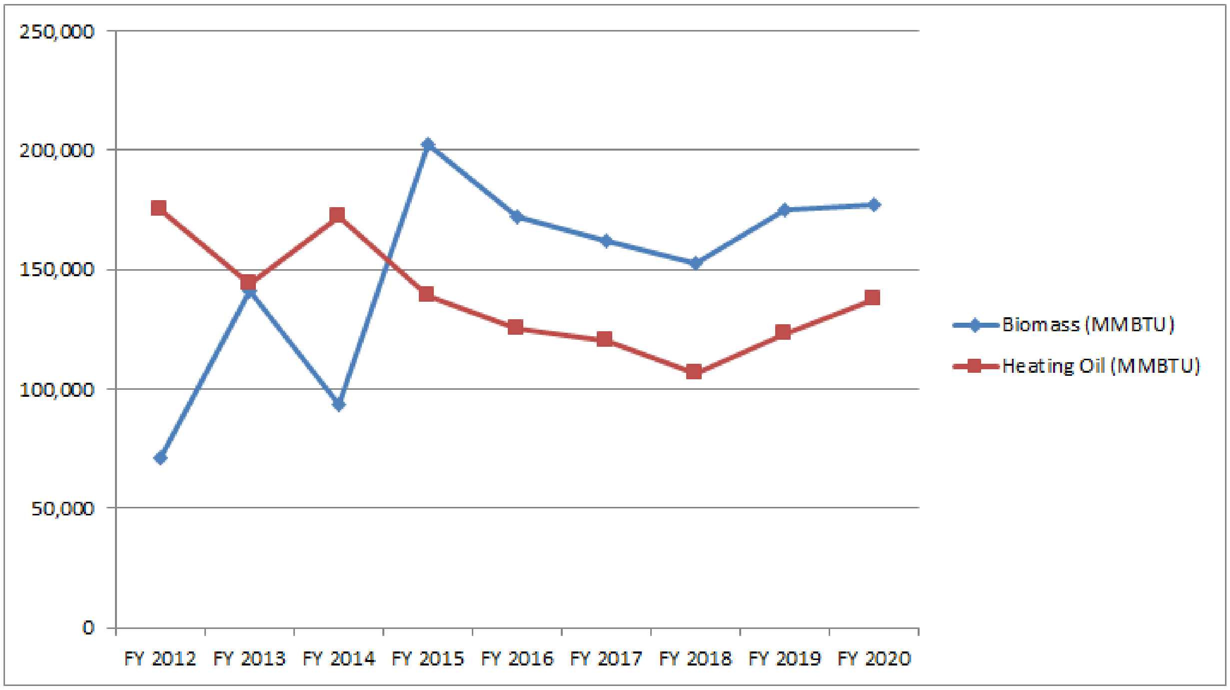


Exhibit 9-4. State Government Annual Heating Oil v. Biomass Energy Consumption (MMBTU)



9.3.4.2 Greenhouse Gas Emissions

Emissions of greenhouse gases (GHGs) associated with state government operations have decreased by an average of 11% annually since 2015, with the largest single-year drop in emissions between FY 2015 and FY 2016. In the buildings sector, GHG emissions dropped significantly between FY 2015 and FY 2017, due to an increase in renewable energy consumption and a reduction in overall electricity usage; but since FY 2017 they have risen slightly, as a result of incremental increases in natural gas and oil use. Transportation-related GHG emissions have likewise seen an overall decrease of an average of 9% annually since 2015, as a result of decreases in gasoline and diesel consumption, mileage reimbursement, and efforts to electrify the vehicle miles travelled by fleet motor pool vehicles.

The energy data used in this plan was derived from aggregated government-wide energy expenditures, which have been converted to units of energy using average electricity costs, average gasoline prices at the pump, and state fuel contract pricing. This data omits energy consumption associated with space leased to the state, because that information is not readily available. The data is meant to provide an indication of how much energy is consumed by state government, to create a baseline against which we can measure progress toward our goals.

Although data from fiscal year 2020 is available, the State of Vermont was forced to cease non-essential in-person operations in facilities across the state in response to the onset of the global pandemic. This dramatic change in facility occupancy and operating procedures caused a departure from normal annual energy consumption trends for the 2020 fiscal year, leading the State Operations Working Group to consider FY 2020 an outlier. To give readers a more accurate set of trend data, the state energy information highlighted within the SAEP is reported for the 2019 fiscal year.

9.4 Strategies and Recommendations

While development and implementation of the SAEP is the responsibility by statute of the secretary of administration through the Department of Buildings and General Services, BGS has involved all agencies in the development of the strategies and recommendations that follow.

9.4.1 Strategies and Actions for State-Owned and Operated Buildings, Construction Practices, and Leased Space

9.4.1.1 Make Use of Available Funding and Technical Assistance to Improve Energy in State Buildings and Municipalities

In 2019, the Legislature passed Acts and Resolves No. 72, amending section E.112 of 2015 Acts and Resolves No. 58 to increase the State Energy Management Program (SEMP) from four to eight years, effectively extending the duration of the program to 2023. Sec. E.112, Energy Efficiency; State Building and Facilities, requires BGS, with support from Efficiency Vermont, to continue to scale up work performed by the SEMP to deliver energy and dollar savings to state government.

During the extended four-year period, Efficiency Vermont will provide adequate funding to support the creation and maintenance of BGS's SEMP team. Over the remaining fiscal years, the program will continue to help agencies across state government to identify, fund, and manage projects that will make state buildings more efficient and power them with renewable energy. The program will also continue to focus on achieving savings through enhanced operational practices, such as the deployment of integrated building controls, that can dramatically reduce the energy consumed in state buildings.

The SEMP oversees two revolving loan funds to provide low-cost financing for energy management measures in state buildings and facilities. All state agencies and departments may apply to fund energy projects using these funds. The State Resource Management Revolving Fund (SRMRF) and the State Energy Revolving Fund (SERF) are available for resource conservation measures, energy efficiency improvements, and the use of renewable resources. These funds were created to eliminate barriers to funding to up-front costs of efficiency improvements that yield significant cost savings once completed. They will make diverse projects in state buildings fundable, and in the process will help to make progress toward the state's energy goals while also saving Vermont taxpayer funds.

Since the creation of the SRMRF in 2004, over 182,000 MMBtu and more than $2.9 million have been saved. Additional projects have received funding and will soon be constructed. If no further investments are made, the fund is projected to save over $4 million through avoided energy expenditures by 2025. The SERF has saved an additional 18,800 MMBtu and $916,000.

BGS and Efficiency Vermont have committed to collaboratively supporting and managing the SEMP and the SEMP Expansion for municipalities. By working in close partnership, BGS and Efficiency Vermont will leverage each organization's strengths, experience, and resources toward meeting the established goals. Significant work will take place during the period of this plan to identify and launch energy efficiency projects in state-owned buildings, and to provide the necessary technical and staff assistance needed to develop municipal energy conservation projects utilizing investment-grade energy audits. The partnership will also continue to find opportunities to address space that is leased by the state, through discussions with building owners about the improvements they could make for a major tenant of their buildings.

The SEMP will continue to work with agency partners to increase the number of state facility and operations managers that are actively measuring progress in reducing energy use against a measured baseline. The SEMP team and Efficiency Vermont are available to help state agencies use Energy Star Portfolio Manager, the U.S. EPA's energy tracking tool, to analyze current energy consumption and establish a baseline for assessing progress.

Agency Energy Implementation Plans

All state entities are required to produce an implementation plan with actionable items specific to their operational energy consumption. These plans and the process to develop them can create an important opportunity for analyzing current trends in agency energy use, setting agency-specific goals, and identifying good cost-effective projects that can be financed with these revolving loan funds and assisted by the SEMP team if desired. There is significant assistance available to agencies as they move forward with the highest-value energy efficiency and renewable energy improvements that can be made in state buildings.

Recommendations

- *State agencies should work with the SEMP team to gather and analyze current energy use using EPA's Energy Star Portfolio Manager for buildings, and to utilize integrated asset management systems to enhance information sharing across departments.*

- *All state agencies that occupy state-owned buildings should appoint energy liaisons to work with the SEMP staff to identify and prioritize further opportunities to improve their energy efficiency. Many projects have already been completed and are saving state taxpayer money. When needed, state agencies should utilize services provided by the SEMP to expand their capacity for planning cost-effective projects, organizing financing, and managing the construction process. For more information, go to bgs.vermont.gov/energy.*

- *State agencies should also evaluate opportunities to construct renewable energy facilities and participate in net-metering on facility sites where possible. Sites should be carefully selected to ensure the protection of natural resources, and to minimize visual impacts for site neighbors.*

SEMP staff and program partners should work with local municipal energy leadership teams to identify a list of priority buildings in need of energy improvements.

9.4.1.2 Implement Energy-Saving Construction Practices

The BGS Design Guidelines are meant to help architectural and engineering firms to better understand state government construction standards. The guidelines were last updated in 2018. BGS adheres to the commercial and residential building energy codes required by the state and works with partners to achieve higher standards when practical.

When starting new construction or renovation projects, state agencies can contact Efficiency Vermont for technical support. When technical advisors from Efficiency Vermont provide guidance during the earliest phase of a project, they can often help to ensure that opportunities are maximized to improve building energy efficiency during design and construction, and that the necessary construction work for efficiency improvements proceeds efficiently without obstacles or delays.

BGS currently considers meeting the energy standards necessary to secure the U.S. Green Building Council's LEED, or Leadership in Energy & Environmental Design certification, on all new construction projects. However, BGS does not *require* that projects meet these standards and become certified. LEED is a green building certification program that recognizes best-in-class building strategies and practices; to receive LEED certification, building projects must satisfy prerequisites that are associated with each different levels of certification, and earn the corresponding points. Prerequisites and credits differ for each rating system, and teams choose the best fit for their project. Depending on the number of points achieved, projects can receive a LEED Certified, LEED Silver, LEED Gold, or LEED Platinum certification.

State government currently has one LEED Silver-certified building, the Pittsford Training Academy, and one LEED Gold-certified building, the Bennington District Court and Office Building. The Waterbury State Office Complex is on target to become state government's first LEED Gold-certified campus.

The LEED certification process focuses on many areas of sustainability, including downtown designation. Locating state government operations in downtown areas helps to build strong local economies, and reduces transportation energy by increasing walking, cycling, and transit opportunities. The commissioner of Buildings and General Services and all other state officials have been asked by the Legislature to locate state government functions such as new buildings in downtown areas when suitable. Title 24 § 2794 (12).

BGS is statutorily required to utilize lifecycle cost analysis when considering the use of renewable energy sources, energy efficiency, and thermal energy conservation in any new building construction or major renovation project in excess of $250,000. In accordance with this procedure, the *lifecycle cost* of each new building construction or major renovation project shall mean the net total of the present-value purchase price of all items used, plus the replacement cost, plus or minus the salvage value, plus the present value of operation and maintenance costs, plus the costs or benefits of the energy and environmental externalities.

Recommendations

- *All state agencies should utilize BGS Construction Guidelines when constructing or renovating state facilities and should adopt higher standards wherever possible given project budgets.*

- *When considering new construction, all agencies should work closely with BGS and local municipalities to find a suitable downtown location for their operations if appropriate.*

- *State agencies are encouraged to assess the lifecycle costs of potential energy improvements — including long-term cost savings — during design and construction planning. The National Institute of Standards and Technologies' Building Life Cycle Cost Programs offers free calculation tools to help analyze potential capital investments in buildings. The SEMP team can offer assistance on lifecycle cost evaluation as well.*

9.4.1.3 Reduce Energy Use and Improve Efficiency in Leased Space

In 2020, state government leased 888,222 square feet of space, a 15% decrease in leased space from 2015. While this was a decline in energy opportunities for leased spaces, leased spaces still equal an additional 30% of occupied space not currently utilizing SEMP energy reduction opportunities. For this reason, state agencies need still need to advocate with building owner/operators for energy efficiency and renewable investments in buildings that the state does not own.

Many agencies occupy leased space and do not have the ability to directly implement energy conservation measures in them. There is a need to develop guidelines for state employees to follow when occupying leased space, in order to reduce the overall energy impact of state government. In response, BGS developed an Agency Energy Implementation Plan template for those agencies occupying leased space. This template consists of eight primary elements: a statement of commitment, assessment of performance, goal setting for infrastructure, purchasing, and transportation, creation of an action-oriented implementation plan, implementation of the plan, evaluation of progress, recognized achievements, and final adoption by the agency.

Recommendations

- *BGS should continue to assist state agencies in the creation of updated Agency Energy Implementation Plans, based on the template for all state agencies whose operations are housed in leased space.*

- *When considering new or additional leases, agencies should continue to work closely with BGS to find leased space in downtown areas.*

9.4.2 Strategies and Recommended Actions for Transportation

State government is committed to demonstrating fleet management and investment practices that reduce energy use and emissions from transportation. In FY 2019, state government consumed over 1.6 million gallons of gasoline, including gasoline consumption associated with state-employee mileage reimbursement, and over 1 million gallons of diesel. This was a decrease of nearly 60% in gasoline and diesel consumption since 2015, which was achieved by increases in fleet utilization of hybrid and electric vehicles, as well as reductions in mileage reimbursements.

A key initiative during the last several years has been to add full electric plug-in hybrid electric vehicles to the state motor pool. Electrifying the state fleet addresses a key priority in Vermont's Zero Emission Vehicle Action Plan, and in a Multistate Zero Emissions Vehicle Plan that Vermont has committed to help implement. These initiatives are fully described in the Comprehensive Energy Plan.

Since 2007, Fleet Management Services has been purchasing plug-in hybrid vehicles for the motor pool. As of 2019, 25% of the vehicles in the state's central motor pool were all electric or plug-in hybrid electric vehicles; 28 of the 142 vehicles were EVs. While the overall number of vehicles has increased, the total number of plug-in electric vehicles has more than doubled. The environmental and cost benefits of this transition are significant.

Additionally, as electrification of the fleet has progressed, the state has accelerated the installation of charging infrastructure needed to power these vehicles and maximize their electric miles. Five new dual-port and two single port level 2 charging stations have been installed at 134 State Street in Montpelier, allowing for 12 new plug-in electric vehicles to charge and be ready for rental by state employees requiring travel between work stations. This allows fleet to continue providing efficient fleet vehicles to high-mileage state employees, rather than paying the higher cost of mileage reimbursement.

Gasoline consumption associated with mileage reimbursement has decreased by an additional 23% from FY 2015 to FY 2019. Total gas and diesel consumption has also decreased by 40%

In the next five years, the Fleet Management Program and all state agencies must collaborate to make more progress on right-sizing fleets, continuing the transition to electric, and reducing employee travel. Following are the state's strategies and recommendations for achieving these energy improvements in state transportation.

9.4.2.1 Expand the Go Green Fleets Initiative

In 2016, the state launched a new Go Green State Fleets Initiative to formalize and demonstrate its commitment to low-carbon and clean-energy transportation. This initiative has helped agencies lead by example in the transition to greener fleets and fleet practices that save taxpayer funds and reduce energy use and greenhouse gas emissions.

Even though state government has increased the total number of electric vehicles in its fleet, at present only 4% of the total fleet of 750 light-duty vehicles (including those leased by individual agencies from BGS) are plug-in electrics, largely because of an overall increase of vehicles. This percentage rises to roughly 24% if both plug-in and conventional hybrids are counted. In order to meet the state's light-duty fleet target of 25% electric by 2025 and meet the goal in the Vermont ZEV action plan, all state agency fleets need to dramatically increase the incorporation of electric vehicles.

Converting a much larger percentage of state government's light-duty fleet to electric is an attainable goal: the technology is available, the vehicles are affordable, and the investment in vehicles and infrastructure is cost-beneficial to the state. The medium- and heavy-duty fleet engine technology is becoming more efficient, and there are some promising hybrid and all-electric options for these larger vehicles. While a serious effort should be made to consider pilot purchases of these vehicles where feasible, unfortunately the cost is often prohibitive.

Recommendations

- *All state agencies should increase efforts to meet the goal adopted in the Vermont ZEV Action Plan, to make 25% of light-duty state fleet vehicles electric by 2025. The Fleet Management Program should continue purchases of plug-in electric vehicles, while also retiring ICE vehicles at a faster rate. BGS should also work to familiarize agency leaders and employees with the new electric vehicles through Ride and Drive events, training videos, and other means as capacity allows.*

- *BGS and state agency leaders and operations staff should encourage and support the use of electric vehicles by state employees, including the siting of EVSE at workstations where possible.*

- *BGS should continue building charging infrastructure to service the state's growing EV fleet, and to promote charging access to the public after hours where possible. BGS should redouble efforts across state government to right-size fleets and make standard the replacement of ICE vehicles with plug-in electrics upon vehicle end of life.*

9.4.2.2 Increase the Use of Biodiesel in Transportation

To reach the renewable energy goals and greenhouse gas emissions goals of the SAEP, state government will have to seriously consider the use of biodiesel blends when possible. At present, 52% of state government's total transportation energy is attributable to the Vermont Transportation Agency (VTrans), including over 93% of diesel consumption. All original-equipment manufacturers warranty their engines for use with B5, a blend of 5% biodiesel and 95% petroleum diesel. Some manufacturer's warranty their engines for use with B20, a blend of 20% biodiesel and 80% petroleum diesel. The National Biodiesel Board keeps a list of manufacturer warranties on its website, biodiesel.org/using-biodiesel.

Since the previous report in 2016, almost no progress has been made toward the adoption of biofuels for transportation. With mid- to large-sized vehicles still largely priced out of large-scale EV adoption, the conversion of larger diesel vehicles to biofuels could help the state achieve its goals for transportation emissions reduction.

Recommendations

- *VTrans should increase its purchase of biodiesel from state fuel-purchasing contracts for those facilities that have diesel storage tanks.*

- *All agencies that purchase diesel fuel for transportation purposes should use the highest biodiesel blend available without compromising the manufacturer's engine warranty. All manufacturers fully warranty their engines with the use of B5, a blend of 5% biodiesel and 95% diesel.*

9.4.2.3 Reduce On-the-Job Transportation and Solo Commuting by State Employees

Since the last report was issued six years ago, the technology that allows for fast and reliable teleconference and videoconference use has continued to improve, allowing more state employees across agencies to access videoconferencing in ways they previously could not. Along with the improved technology, the forced adoption of teleconferencing as a result of the response to the pandemic, and the need to socially distance, required many state agencies to implement regular teleconferencing practices that will continue after the pandemic has ended.

Although telecommuting will not directly affect the goals stated in this plan, a considerable amount of energy is consumed by state employees commuting to and from work. Policy 11.9 — Telework, issued by the Department of Human Resources and approved by the Secretary of Administration, establishes the basic principles and conditions regarding employee requests to work remotely from an alternative worksite. Following the state lockdown executive order in March 2020, all non-essential state employees began teleworking from home. While the full measure of this impact on transportation emissions is not yet known, it is likely to have caused a significant reduction in commuter emissions.

As agencies begin to move toward the return to office work, they are encouraged to promote a hybrid telework schedule for their employees that will allow for sustained reductions in commuting-related transportation emissions.

Another way to reduce state government-related transportation is to encourage and incentivize employees to use public transit services when available to commute to work. The Go! Vermont program, administered through VTrans, provides commuting alternatives for all employees in Vermont, including state employees. Go! Vermont connects rideshare participants, administers vanpool programs, and is a convenient portal to state transit programs.

Recommendations

- *State agencies should adopt the practices of the Go Green Fleets Initiative, and implement monitoring of light-duty vehicle use and reduce unnecessary state employee travel through teleconferencing where possible.*

- *State agencies should permanently institutionalize the use of Policy 11.9 on telework as part of the hybrid work model adopted during the pandemic response. As they implement the policy, they should share the lessons they learn about how to support telework without causing significant impacts to the productivity or quality of state employee work.*

Abbreviations

ACCD: Vermont Agency of Commerce & Community Development
ACP: Alternative Compliance Payment
ACRPC: Addison County Regional Planning Commission
ADMS: Advanced Distribution Management System
AEIP: Agency Energy Implementation Plan
AEV: all-electric vehicle
AMI: advanced metering infrastructure
AMP: Acceptable Management Practice
ANR: Vermont Agency of Natural Resources
ANSI: American National Standards Institute
ASAP: Appliance Standards Assistance Project
ARPA: American Rescue Plan Act
ARRA: American Recovery and Reinvestment Act
ASHRAE: American Society of Heating, Refrigerating, and Air Conditioning Engineers
ASTM: American Society for Testing and Materials
AVL: automatic vehicle locator/location
AWH: Advanced Wood Heat
BBD: Biomass-based Biodiesel
Bcf: billion cubic feet (of natural gas)
BCRC: Bennington County Regional Commission
BED: City of Burlington Electric Department
BEL: Business Energy Loan program
BGS: Vermont Department of Buildings and General Services
BIPOC: Black, Indigenous, and People of Color
BOD: biological oxygen demand
BPI: Building Performance Institute
Btu: British thermal unit
CAFE: Corporate Average Fuel Economy
CAIDI: Customer Average Interruption Duration Index
CAP: Climate Action Plan, or Community Action Partnership
CARB: California Air Resources Board
CBES: Commercial Building Energy Standards
Ccf: hundred cubic feet (of natural gas)
CCHP: cold climate heat pump
CCRPC: Chittenden County Regional Planning Commission
CEDF: Vermont Clean Energy Development Fund
CEED: Community Energy and Efficiency Development
CEP: Comprehensive Energy Plan
CES: Clean Energy Standard
CFL: compact fluorescent lighting
CGC: Coalition for Green Capital
CHP: combined heat and power
CHS: clean heat standard
CO: carbon monoxide
CO_2: carbon dioxide
CNG: compressed natural gas
COO: Certificate of Occupancy
CPG: Certificate of Public Good
CPP: critical peak pricing, or Clean Power Plan
CUDs: Communications Union Districts
CVR: conservation voltage regulation
CVRPC: Central Vermont Regional Planning Commission
DC: direct current
DEC: Department of Environmental Conservation
DER: distributed energy resource
DEV: Drive Electric Vermont
DFR: Vermont Department of Financial Regulation
DERMS: Distributed Energy Resource Management System
DG: distributed generation
DOE: U.S. Department of Energy
DOE-OE: U.S. Dept. of Energy's Office of Electricity
DPV: distributed photovoltaics
DR: distributed resources
DRP: Demand Resource Plan
DSM: demand-side management
DU: distribution utility
DUP: distributed utility planning
EAN: Energy Action Network
EEC: energy efficiency charge
EEN: Efficiency Excellence Network
EEU: energy efficiency utility

EIA: U.S. Energy Information Administration
EISA: U.S. Energy Independence and Security Act
EPA: U.S. Environmental Protection Agency
EROEI: energy return on energy invested
ESA: Energy Savings Account
ESCO: energy service company
ESPC: energy service performance contracting
ESPM: ENERGY STAR Portfolio Manager
EVSE: Electric Vehicle Supply Equipment
EU: European Union
EUI: energy use intensity
EV: electric vehicle
EVT: Efficiency Vermont
FEMA: Federal Emergency Management Agency
FERC: Federal Energy Regulatory Commission
FCA: Forward Capacity Auction
FCEV: fuel cell electric vehicle
FCM: Forward Capacity Market
FDIR: fault detection isolation and recovery
FERC: Federal Energy Regulatory Commission
FIA: U.S. Forest Inventory and Analysis National Program
FLM: Flexible Load Management
FPR: Vermont Department of Forests, Parks & Recreation
FTE: full-time equivalent
GHG: greenhouse gas
GMP: Green Mountain Power
GSHP: Ground Source Heat Pump
GT: geotargeting
GTFS: General Transit Feed Specification
GW: gigawatt
GWh: gigawatt-hour(s)
GWP: Global Warming Potential
GWSA: Global Warming Solutions Act
HEPA: high-efficiency particulate arrestance or air (filter)
HERS: Home Energy Rating System
HHV: higher heating value
HPWH: Heat Pump Water Heater
HQ: Hydro-Quebec
HSIPR: high-speed and intercity passenger rail
HVAC: heating, ventilation, and air conditioning
HWAP: Home Weatherization Assistance Program
IECC: International Energy Conservation Code
IEEE: Institute of Electrical and Electronics Engineers
IHD: in-home display
IRB: interest rate buy-down
IRP: integrated resource plan/planning
IPP: independent power producer
ISO-NE: ISO-New England
ITC: Investment Tax Credit
kBtu: thousand Btu
kW: kilowatt
kWh: kilowatt-hour(s)
LBNL: Lawrence Berkeley National Laboratory
LCPC: Lamoille County Planning Commission
LDC: line-drop compensation
LEAP: Low Emissions Analysis Platform o
LEED: Leadership in Energy and Environmental Design
LCA: Life Cycle Assessment
LiDAR: combining "light" and "radar," a remote sensing technology
LIHEAP: Low-Income Home Energy Assistance Program
LNG: liquefied natural gas
LPG: liquefied petroleum gas
LRTP: VELCO Long-Range Transmission Plan
LTC: load tap changer
MARC: Mount Ascutney Regional Commission
Mcf: thousand cubic feet
MDMS: meter data management system
MLS: Multiple Listing Service
MMBtu: million Btu
MMcf: million cubic feet
MPG: miles per gallon, or Municipal Planning Grant
MOU: memorandum of understanding
MW: megawatt
MWh: megawatt-hour(s)
NALG: net available low-grade wood growth
NBB: National Biodiesel Board
NDA: Neighborhood Development Area
NECPUC: New England Coalition of Public Utility Commissioners
NEGECP: Northeastern Governors and Eastern Canadian Premiers
NEIL: Nuclear Electric Insurance Limited
NEPOOL: New England Power Pool
NEPOOL GIS: New England Power Pool Generator Information System
NERC: North American Electric Reliability Corporation

NESCAUM: Northeast States for Coordinated Air Use Management
NESCOE: New England States Committee on Electricity
NHTSA: National Highway Traffic Safety Administration
NICE: Northeastern International Committee on Energy
NOx: nitrous oxide
NPCC: Northeast Power Coordinating Council
NRC: Nuclear Regulatory Commission
NRCS: Natural Resources Conservation Service
NREL: National Renewable Energy Laboratory
NRG: Renewable NRG Systems, a Hinesburg, Vt. company
NRPC: Northwest Regional Planning Commission
NTA: non-transmission alternative
NVDA: Northeastern Vermont Development Association
NYPA: New York Power Authority
OATT: Open Access Transmission Tariff
OEO: Vermont Office of Economic Opportunity
OMS: Outage Management System
OPR: Vermont Office of Professional Regulation
PACE: Property Assessed Clean Energy
PAH: polycyclic aromatic hydrocarbon
PEVs: plug-in electric vehicles
PHEVS: plug-in electric hybrid vehicles
PLC: power line carrier
PM: particulate matter
PPA: power purchase agreement
PPESCO: public purpose energy service company
PSD: Vermont Department of Public Service
PTC: production tax credit
PUC: Public Utility Commission (formerly Public Service Board)
PURPA: Public Utility Regulatory Policies Act
PV: photovoltaic(s)
QA: quality assurance
QAP: Qualified Allocation Plan
QPI: quantifiable performance indicator
RBES: Residential Building Energy Standards
RDI: Rate Design Initiative
REAP: U.S. Dept. of Agriculture's Rural Energy for America Program
REC: Renewable Energy Certificate
RES: Renewable Energy Standard
REV: Renewable Energy Vermont
RF: radio frequency
RFI: request for information
RFP: request for proposals
RFS: Renewable Fuels Standard
RGGI: Regional Greenhouse Gas Initiative
RGGR: Regional Greenhouse Gas Registry
RIN: renewable identification number
RINA: rare and irreplaceable natural area
RLF: revolving loan fund
RMI: Rocky Mountain Institute
RNG: renewable natural gas
RNS: regional network service
ROI: return on investment
RPC: regional planning commission
RPS: renewable portfolio standard
RRPC: Rutland Regional Planning Commission
RSP: Regional System Plan
RTE: rare, threatened, and endangered
RTP: real-time pricing
SAEP: State Agency Energy Plan
SAIDI: System Average Interruption Duration Index
SCADA: supervisory control and data acquisition
SCFM: standard cubic feet per minute, a measure of gas flow
SEI: Stockholm Environment Institute
SEMP: State Energy Management Program
SERF: State Energy Revolving Fund
SHEI: Sheffield Highgate Export Interface
SHPO: State Historic Preservation Office
SHW: solar hot water
SMEEP: Self-Managed Energy Efficiency Program
SO_2: sulfur dioxide
SOP: single-occupancy vehicle
SOWG: State Operations Working Group
SPEED: Sustainably Priced Energy Enterprise Development
SRMRF: State Resource Management Revolving Fund
SSREI: Small Scale Renewable Energy Incentive
SSREIP: Small Scale Renewable Energy Incentive Program
SQRP: service quality reliability plan
TAG: Technical Advisory Group
TOB: Tariffed on-bill financing or payment program
TCI: Transportation Climate Initiative
T&D: transmission and distribution

TDM: transportation demand management
TES: Total Energy Study
TGFOV: Transmission Ground Fault Overvoltage
TEPF: Thermal Energy and Process Fuel
TOU: time of use
TRORC: Two Rivers-Ottauquechee Regional Planning Commission
TW: terawatt
TWh: terawatt-hour(s)
UFLS: Under Frequency Load Shedding
USDA: U.S. Department of Agriculture
UVA: Vermont Use Value Appraisal program
UVM: University of Vermont
VAAFM: Vermont Agency of Agriculture, Food & Markets
VAR: volt-ampere-reactive
VBB: Vermont Bond Bank
VCCT: Vermont Clean Cities Coalition
VDH: Vermont Health Department
VEC: Vermont Electric Cooperative
VECAN: Vermont Energy and Climate Action Network
VEDA: Vermont Economic Development Authority
VELCO: Vermont Electric Power Company
VEPP: Vermont Electric Power Producers
VFDA: Vermont Fuel Dealers Association
VFEP: Vermont Fuel Efficiency Partnership (now known as "3E Thermal")
VGS: Vermont Gas Systems
VHCB: Vermont Housing and Conservation Board
VHFA: Vermont Housing Finance Agency
VLCT: Vermont League of Cities & Towns
VMT: vehicles miles traveled
VLITE: Vermont Low Income Trust for Electricity
VPPSA: Vermont Public Power Supply Authority
V.S.A.: Vermont Statues Annotated
VSPC: Vermont System Planning Committee
VTrans: Vermont Agency of Transportation
VTWAC: Vermont Weather Analytics Center Project
VVC: volt/VAR control
WAP: Weatherization Assistance Program
WEC: Washington Electric Cooperative
WHI: Weatherization + Health Initiative
WRAP: Weatherization Repayment Assistance Pilot
WRC: Windham Regional Commission
WLEF: Working Lands Enterprise Fund
ZEV: zero emission vehicle
ZEV MOU: Zero Emission Vehicle Memorandum of Understanding

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