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

June E. Tierney
Commissioner, Department of Public Service

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.*
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> *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.*
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> *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:

- 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.

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.

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.

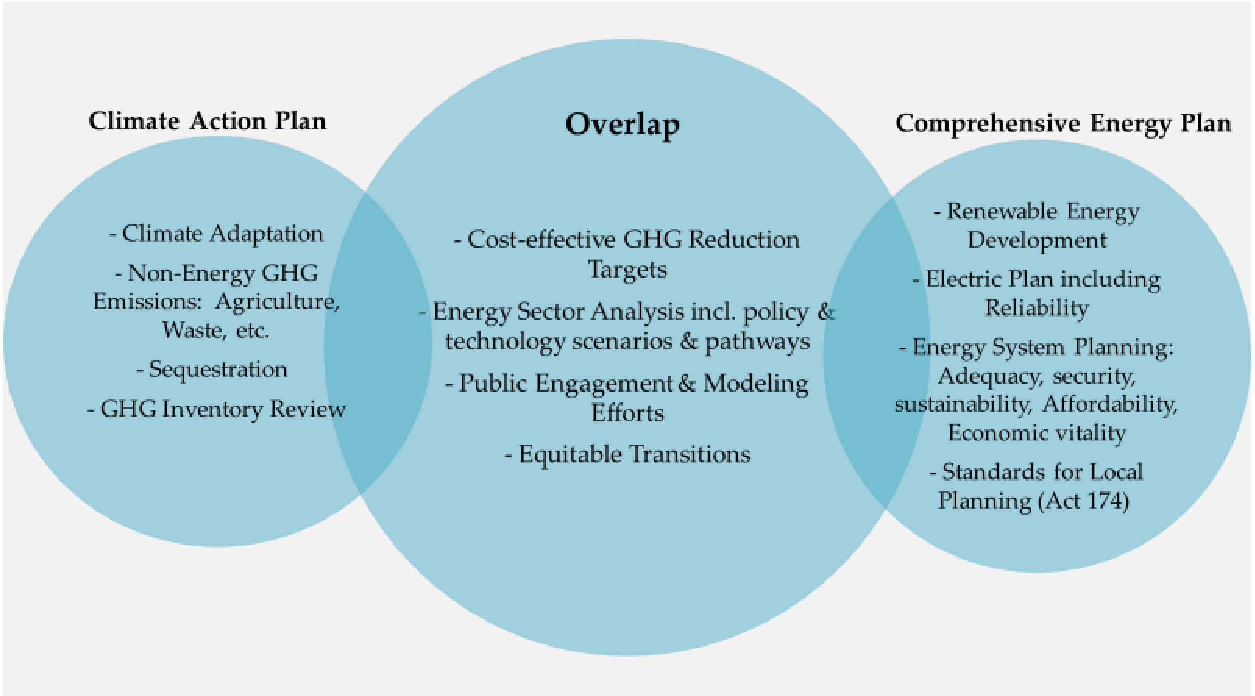
These, and many other, successes are discussed throughout the remainder of this CEP.

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.

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.

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.

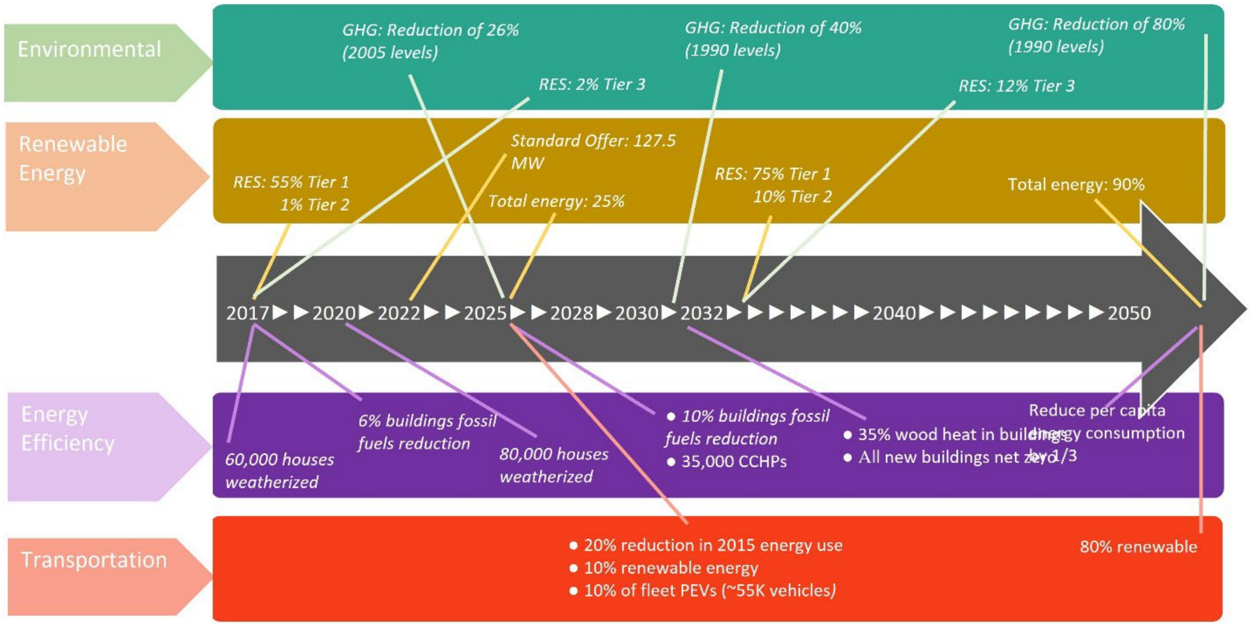
With reducing greenhouse gas emissions as our north star, we must carefully steer toward it on a path bounded by markers of affordability, security, resilience, and efficiency, as well as equity. Pursuing grid modernization without clear objectives or a mechanism for understanding and navigating tradeoffs 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."

[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-

[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.