Mapping Energy Resilience for the Grid and the Consumer

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ABSTRACT

Federal funding increases for clean energy lead to significant increases in the electrification of thermal and transportation loads. Additional load from electrification, the intermittent nature of renewable energy supply, and increasing severe weather events pose new challenges for grid reliability. To help address these challenges, forward-thinking energy efficiency programs can incorporate new performance metrics to describe reliability for both the grid *and* utility customers.

One efficiency program prioritizes equity while keeping its attention on greenhouse gas emissions reductions and mapping a statewide energy resilience strategy. This paper examines that strategy, its system-mapping, and results. The program defined *energy resilience* in terms supporting all customer types—and the region's distribution utilities—in maintaining grid stability during and after external events. By placing customer needs at the center of its consideration, the program identified critical nodes of influence in the state's energy system. The program then implemented methods for achieving beneficial system change while making customers (and the grid) more resilient in the event of disruptions.

This work demonstrates ways that program administrators and regulators can fully prioritize climate-forward efficiency and make energy resilience part of clean-energy programs' performance metrics. Well-designed policies can incentivize individual energy resilience investments, which support and maximize grid resilience. With such new priorities, the cost of energy resilience for customers can go down, while grid reliability increases.

Introduction

The energy industry is rapidly evolving to deliver decarbonized, renewable energy for all market sectors, including thermal and transportation loads. This evolution necessitates an assessment of an energy efficiency program administrator's role in supporting customer energy resilience, as customers rely more on the electric grid and customer energy use has a greater impact on grid performance.

In Vermont in particular, Efficiency Vermont, a 25-year-old statewide energy efficiency utility, seeks to deliver energy efficiency programs and services to further increase energy system benefits to ratepayers and the state. As Vermont shifts towards greater reliance on intermittent and variable sources of renewable energy and energy becomes bidirectional, Efficiency Vermont aims to identify its optimal role in support of customers' energy resilience, resulting in a successful energy decarbonization transition. Mapping Vermont's energy system from the perspective of customer energy resilience helped Efficiency Vermont identify ways to support customers and partner with distribution utilities to achieve energy resilience.

This paper explains Efficiency Vermont's process in defining energy resilience and establishing a strategy to support customers in advancing their energy resilience while meeting the customers' energy efficiency goals. The paper also makes recommendations for program administrators to recognize the benefits of energy efficiency in bolstering grid reliability and customer energy resilience.

Defining Energy Resilience

Federal funding opportunities such as American Rescue Plan Act (ARPA), the Infrastructure Investment and Jobs Act, and the Inflation Reduction Act (IRA) are poised to accelerate the energy transition. Efficiency Vermont supports customers and Vermont's energy system in this evolution through the delivery of energy efficiency and flexible load management programs, long-term resource planning, and emerging technology development. As customers electrify their thermal and transportation loads, their impact on grid stability (or instability) will increase, as will their dependence on the grid for energy resilience. Simultaneously, increased severe weather events and reliance on intermittently available renewable energy for power generation present greater risk to grid reliability.

Distribution utilities are required to meet regulated standards for quality of service, including energy reliability—the ability to keep power on. Resilience in the utility setting is the ability to recover from system failures, and often is considered the plan for ensuring reliability.

The U.S. Department of Energy (DOE) defines energy resilience as "the ability to operate building energy services, such as heating, cooling, ventilation, critical plug loads, and shelter, during and in response to a major disruption" (DOE, 2023). The DOE's definition incorporates both passive survivability—the ability to maintain safe indoor conditions during prolonged energy outage—and grid resilience—energy efficiency and grid flexibility technologies.

The Federal Energy Regulatory Commission (FERC) proposed grid resilience to be "a range of attributes, characteristics, and services that allow the grid to withstand, adapt to, and recover from both naturally occurring and manmade disruptive events. At the most basic level, ensuring resilience requires that we both (1) determine which risks to the grid we are going to protect against, and (2) identify the steps, if any, needed to ensure those risks are addressed" (FERC, 2018).

Vermont's Global Warming Solutions Act (GWSA) defines resilience as "the capacity of individuals, communities, and natural and built systems to withstand and recover from climatic events, trends, and disruptions" (No. 153, 2020). Vermont's Comprehensive Energy Plan (CEP) explains that governed grid reliability is "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," and that resilience "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'" (VT PSD, 2022). The CEP goes on to highlight the Electric Power Research Institute's three-pronged approach to resilience planning, which includes prevention, survivability, and recovery, and to make the connection between resilience and climate change adaptation (VT PSD, 2022).

Efficiency Vermont's Definition for Energy Resilience

Efficiency Vermont's current programs and services impact passive survivability and grid resilience through building weatherization, energy efficiency, and flexible load management. Efficiency Vermont therefore defines energy resilience in an all-inclusive way, as "a condition under which customers have access to affordable, reliable, low-carbon energy—with the ongoing ability to prepare for, adapt to, and recover from power disruptions."

Power disruptions can result from a wide range of potential events, such as weather events, malicious attacks, and/or planned or unplanned grid constraint or power outage events. The duration of a power reduction or outage event is intentionally absent from Efficiency

Vermont's definition of energy resilience, as the period in which a customer seeks to be able to manage their critical loads is determined at the site level based on the customer's specific goals.

Efficiency Vermont's definition of energy resilience requires energy assurance through one or more sources, which can require collaboration between multiple partners, including distribution utilities, to support critical loads that protect life and property.

Background: Current Efficiency and Resilience Standards

Efficiency Vermont reviewed applicable state policies and program requirements to identify the role of energy efficiency in supporting customer energy resilience, as discussed in the following sections.

Demand Management

Under Vermont state law, Efficiency Vermont's 2023 Order of Appointment (OoA) requires it to acquire "cost-effective demand-side electric efficiency resources as well as cost-effective opportunities associated with Thermal Energy and Process Fuels ('TEPF') efficiency. [Efficiency Vermont] may also provide assistance, general information, and financing for customer-sited renewable generation ('CSG') and combined heat and power ('CHP')" (VT PUC, 2023). Efficiency Vermont may support customers interested in renewable energy generation with general information, financing assistance, and coordination with partners. Efficiency Vermont may also support the customers in obtaining demand-response systems and upgrades and associated control measures that "result in both demand-response and energy savings capabilities." A restricted Efficiency Vermont budget exists to support utilities and ratepayers in acquiring equipment and controls that enable flexible load management.

The OoA also requires Efficiency Vermont to support electric utility distribution planning and transmission planning processes, and to work with the DUs and the statewide transmission operator, Vermont Electric Power Company (VELCO) in delivering an integrated utility service as outlined in 30 V.S.A. § 209 and 218c (VSO, 2006, 2009). 218c calls for least-cost integrated planning that meets "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" with economic costs considering renewable energy and greenhouse gas goals (VSO, 2006). In addition, the OoA requires Efficiency Vermont to participate in the forward capacity market to secure benefits for Vermont as available from demand-side measure resources implemented by Efficiency Vermont.

The requirements of the OoA enable Efficiency Vermont's role in demand management. Demand management supports customer and energy system resilience by reducing the total energy demand of the customer and the grid, reducing the potential of energy system overload through flexible load management, improving customer ability to maintain energy reliability during emergencies through load reduction and management, and increasing the ability of the customer and the system to optimize the use of clean renewable energy.

Policies and Regulations

Vermont has several policies and regulations related to customer energy resilience. Vermont's Act 153 - GWSA of 2020 is legally binding. The GWSA calls for reducing the emissions of GHGs from within the geographical boundaries of VT and emissions outside of the State caused by energy used in the state by 26% from 2005 levels by Jan. 1, 2025, 40% from 1990 levels by Jan. 1, 2030, and 80% from 1990 levels by Jan. 1, 2050 (VGA, 2020). Vermont's Climate Action Plan (CAP) was created in 2021 to provide guidance to the Vermont Legislature in setting policy that supports the GWSA. The CAP is to be updated every four years to include strategies that will reduce GHG emissions, achieve net zero emissions across all sectors by 2050, reduce energy burdens for marginalized and rural communities, and "build and encourage climate adaptation and resilience of Vermont communities and natural systems" (VCC, 2021).

Vermont's 2022 *Comprehensive Energy Plan* (CEP) sets a three-phase goal of meeting 25% of Vermont's energy needs from renewable energy sources by 2025, 45% by 2035, and 90% by 2050 (VT PSD, 2022). To align with the GWSA requirements and the recommendations embedded in the CAP, the CEP calls for 100% of the electricity sector energy needs to be met with carbon-free resources by 2032, with at least 75% from renewable energy (VT PSD, 2022).

In addition to establishing legally binding requirements for reducing Vermont's GHG emissions, the GWSA established five subcommittees, listed below, to develop the CAP and assist with other duties related to the act.

- Agriculture and Ecosystems Subcommittee
- Cross-Sector Mitigation Subcommittee
- Just Transitions Subcommittee
- Rural Resilience and Adaptation Subcommittee
- Science and Data Subcommittee

The strategies and recommendations developed by the Just Transitions Subcommittee are the first State-provided guidance to ensuring a just energy transition.

Vermont's environmental justice act passed in 2022. Beginning in 2024, Act 154 requires State agencies to direct investments proportionately in environmental justice focus populations[1] and to publicly report annually on the amount spent and resulting outcomes. The act establishes the Environmental Justice Advisory Council (Advisory Council) to advise State agencies and the General Assembly on matters relating to environmental justice, and the Interagency Environmental Justice Committee (Interagency Committee) to guide and coordinate State agency implementation of the Environmental Justice State Policy (VGA, 2022).

Vermont Act 18, the Affordable Heat Act and also referred to as the Clean Heat Standard (CHS), passed in 2023 to meet the GHG reduction requirements of the GWSA. Act 18 requires all entities selling heating fuel into or in Vermont to register annually beginning in January 2024 and earn, beginning Jan. 1, 2023, clean heat credits by reducing GHG (VGA, 2023). Minimum annual credits must be earned/retired from customers with low or moderate income. At least 50% of the credits must have measure lives of 10 years or more and lower annual energy bills. Customers qualifying for other energy efficiency program assistance may contribute towards the

[1] Act 154 defines environmental justice focus populations based on census block groups where the annual median household income is 80 percent or lower than State median household income, six percent or more of the population is indigenous or of color, or at least one percent of the households have limited English proficiency (VGA, 2022).

credits. Entities that do not retire their specified number of clean heat credits in a given year may be required to make a non-compliance payment.

Collectively, these policies and regulations shape the future of Vermont's energy production and reinforce the need for customer energy resilience. Efficiency Vermont's role in demand management and focus on equity in program delivery equips the organization to have in-depth skill sets for supporting cost-effective customer energy resilience.

Distribution and energy efficiency utility requirements. Distribution utilities (DUs) and energy efficiency utilities (EEUs) are required to meet standards and quantifiable performance indicators (QPIs) in support of Vermont's energy goals (VT PUC, 2024).

DU and EEU rates, quality of service, and financial management are regulated by the Vermont PUC and PSD. DUs earn revenue from ratepayers and some federal funds, and are required to deliver least-cost services and meet the renewable energy standard. EEUs access funding from the collected electrical efficiency charge (EEC), a cost per kilowatt-hour fee billed to ratepayers (or natural gas EEC in the case of Vermont Gas), and the thermal energy and process fuels fund – a combination of revenues from Vermont's participation in the Forward Capacity Market and the Regional Greenhouse Gas Initiative (RGGI) fund. EEUs are required to meet QPIs and minimum performance requirements (MPRs) in order to receive full compensation. Additionally, EEUs access some federal funds, which have specific rules for disbursement.

DUs and EEUs are required to conduct planning activities to demonstrate how they will meet their customers' needs, and those plans are used by VELCO to generate a long range transmission plan (LRTP) for the state.

Electric service quality and reliability. The Public Service Commission approves the service quality and reliability plans for the electric DUs and EEUs. Both the DU and EEU plans cover customer service phone answering. The DU plans also cover billing, meter reading, work completion, customer satisfaction, worker safety, and reliability of service.
Reliability of service performance measures are based on customer surveys, system average interruption frequency (SAIFI), customer average interruption duration (CAIDI), worst performing areas, and major storms. SAIFI measures the average number of times that the average customer experienced an outage. CAIDI measures the average length of time, in hours, that was required to restore service to customers who experienced and outage.

Renewable energy standard (RES). Vermont's renewable energy standard supports the State in meeting its climate goals by requiring DUs to procure 85 to 97 percent of electric retail sales from renewable energy in 2032, as follows (VSO, 2017):

- Tier I: 55% of annual retail electric sales from any source of renewable energy in 2017 and increase by 4% every three years to achieve 75% in 2032; commonly met through large-scale renewable power purchase (bundled RECs) or purchase of unbundled RECs
- Tier II: 1% of annual retail electric sales from new, distributed renewable generation[2] in 2017 and increase by 0.6% each year to achieve 10% in 2032; commonly met through net

[2] *Distributed renewable generation:* electric generation facilities with ≤5 megawatt capacity that commenced operation after June 30, 2015 (RES definition). Further, the facility must be directly connected to a DU's subtransmission or distribution system, or

metering and Standard Offer, a long-term fixed-price contract for renewable facilities up to 2.2 megawatts in size

- Tier III: 2% of annual retail electric sales from additional new distributed renewable energy meeting Tier II or fossil fuel savings through energy transformation projects in 2017, and increase by 0.67% each year to achieve 12% in 2032 with low-income spend targets assigned in 2022; commonly met through energy transformation projects that reduce fossil fuel use and typically provide revenue benefit such as electrification

DUs and EEUs develop plans documenting their strategies for meeting their performance requirements. EEUs create demand resource plans (DRPs) every six years with an opportunity to update them during the third year of implementation. The DRPs include 20-year electrical efficiency and 10-year thermal efficiency resource-acquisition models. The DRPs also include development and support services in support of resource-acquisition.

DUs create integrated resource plans (IRPs) every three years. The IRPs incorporate the DRPs and provide a 20-year load forecast for energy and peak capacity; a description and assessment of existing power supply resource mix including long- and short-term contracts; projects to meet future supply through extension of existing contractor new contracts; capacity supply obligation; plans to meet their RES requirements; transmission and distribution system evaluation including safety, reliability, resilience, end-of-life replacement, and upgrades due to load growth or backfeeding; system analysis to improve reliability and emergency preparedness and response; capital costs and requirements such as tree clearing and trimming; and automated meter infrastructure (AMI) installation and utilization.

The Department of Public Service's (PSD) draft guidance for IRPs encourages utilities to describe resilience-related efforts with a focus on "low-probability, high-impact events, typically impacting large geographic areas, lasting more than 24 hours, and classified as 'Major Events' according to IEEE 1366" (VT PSD, 2022).[3]

In meeting energy supply needs, DUs are required to follow least-cost integrative planning and meet the public's need for energy service after addressing safety at lowest present value lifecycle cost, including environmental and economic costs, through investment in energy supply, transmission, distribution, and comprehensive energy efficiency programing. EEUs are appointed to administer the comprehensive energy efficiency programming on behalf of the DUs to achieve least-cost planning.

Both the DRPs and IRPs are used by VELCO in generating their long-range transmission plan (LRTP). The LRTP is updated every 3-years and provides a 20-year forecast of future load and DER growth in the context of reliability for low, medium, and high forecast scenarios.

Influx of Funding Shaping the Energy Transition

As calculated by the author, in the next ten years, Vermont will invest in excess of $480 million in the energy transformation in addition to the traditional State investments in this sector.

listed in an approved plan as deferring transmission upgrades; or it must provide net metering where the DU owns the environmental attributes associated with the system.

[3] Efficiency Vermont acknowledges the PSD's association of resilience with "Major Events" lasting more than 24-hours may not align with Efficiency Vermont customers' association of energy resilience as the customer may risk substantial loss of property and life when undergoing shorter-term, less-sever power outage events as described in the Customer need for energy resilience section of this report.

Vermont's energy transition timeline in Figure 1 illustrates the timing of new federal funding alongside state energy transition goals and requirements.

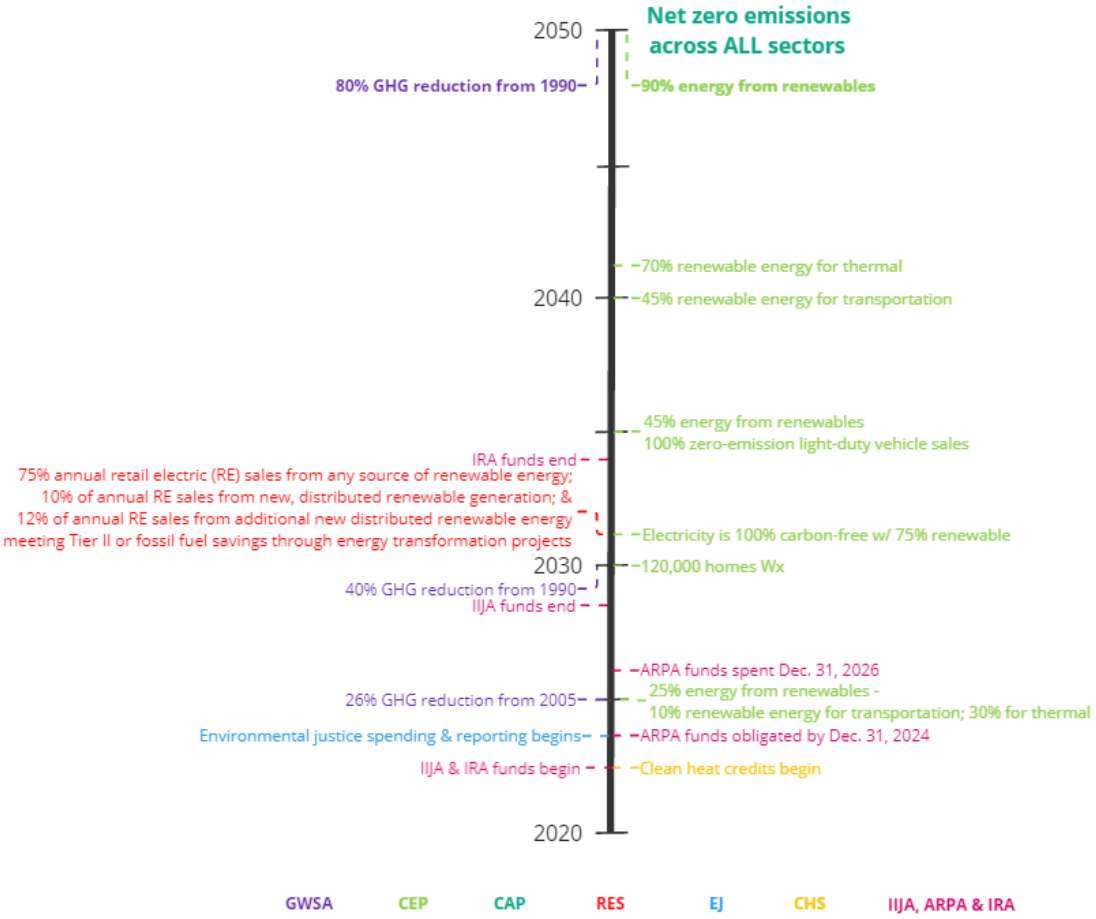

Figure 1: Vermont's energy transition timeline. *Source:* Author.

Thoughtfully supporting vulnerable customers in participating in the energy transition and through that, bolstering their energy resilience, is essential for ensuring a successful energy future for Vermonters. This scale and rate of change is similar in markets across the country, necessitating direct engagement and support from energy efficiency program administrators. Establishing the framework for the cost-benefit analysis of energy efficiency programs to recognize the impact the programs on energy resilience is necessary for those programs to optimize program design and delivery models for energy resilience benefits.

Evolving Utilities

As Vermont, and the region, transitions to full electrification of thermal and transportation loads supplied by low-carbon and intermittently renewable electricity with an emphasis on equity[4], the pricing structure and infrastructure of the energy system will change to

[4] For additional information on Efficiency Vermont's focus on equity, see "Toward More Equitable Energy Efficiency Programs for Underserved Households" by Jennifer Amann, Carolin Tolentino, and Dan York, 2023.

promote and reward flexibility and controllability in demand. Customers will be incentivized to use energy when excess renewable power is available and to minimize consumption during periods of peak demand and when energy production results in higher greenhouse gas emissions or other demand signaling events occur, as identified by the grid operator.

Pacific Northwest National Lab (PNNL) completed a study in 2022 to assess a scalable solution for integrating automated demand flexibility into everyday grid operation with customer controls and fair compensation (PNNL, 2022). The Distribution System Operator with Transactive (DSO+T) Study identified customer cost savings of 10-17% when optimizing demand flexibility programs.

To implement this level of automated demand management, California has proposed load management standards (LMS) rulemaking and designed the Market Informed Demand Automation Server (MIDAS), to provide implementation support. MIDAS serves as an example of what's to come for Vermont with a long-term vision of public-wide broadcasts with real-time automated response sequences at the customer site level (CEC, 2021).

To meet this future state, distribution and energy efficiency utilities need to evolve their programs and infrastructure. Distribution utility data collection and billing systems will require updating, and some utilities will need to install demand signaling systems. New systems enabling automated load controllability will be required at customer sites. Umbrella security platforms will be required to protect utility and customer equipment and information.

Given the cost savings potential of load flexibility, enabling and incentivizing energy efficiency programs, in partnership with distribution utilities, to support projects that provide demand flexibility without also incurring energy savings will be beneficial to best meeting ratepayer's needs for maintaining affordable energy and reducing greenhouse gases.

Example energy resilience programs. Enbridge Gas, Southern California Edison, Natural Resources Canada, NYSERDA, and Xcel Energy are several efficiency program administrators offering energy resilience pilots and programs. Their programs include poles and wire monitoring and preventative maintenance, planning for demand response to reduce grid constraints, deploying combined heat and power systems, developing microgrids, and supporting customers with electric vehicles and other battery storage systems for power backup.

Customer Needs

The following two examples highlight customer needs related to energy resilience.[5]

Low-income, elderly apartment building. Most building residents manage medical issues, some have mobility challenges, and many require home health aides. While many can travel locally on their own to stores and attractions, fewer of them can travel long distances without significant planning and additional time. Some have family in the area, but others have family at least a day's travel away, and all have low income, so they do not have the financial resources to procure the services they would need for significant travel and lodging during a prolonged power outage.

The property operator wants to ensure that during a power outage, the residents can remain safe and comfortable, to prevent any health impacts. The operator understands that elderly people can be more temperature-sensitive than younger people, and the residents require

[5] Customer descriptions developed by Allison Ross, VEIC, to represent example Efficiency Vermont customers.

access to electrical outlets to power medical equipment. Many also have medication that must be refrigerated to remain safe.

The facility buys into a community solar project and installs battery backup at the building. The operator wires the electrical panels so that apartment refrigerators and two electric outlets have backup power. For safety, they also wire the living room lighting to operate. To extend the duration of load support, they allow the heat pumps to operate only if the outage lasts more than 6 hours. During normal operations, they allow the utility to access the battery for grid support, in exchange for a bill credit that allows the facility to divert funds to support their low-income residents.

Local business. As an independently owned small business, the bakery relies on regular customers and occasional tourists to frequent the coffee and baked good offerings. The owners begin baking menu items in the early morning to prepare for opening during morning commuting hours, and they continue food prep and baking during the morning to cater to the lunch hour. A power outage of a minimum duration means they must discard batches of food that were in the process of baking but incomplete. They are also unable to process electronic payments and have to turn customers away. When power is restored, staff must clean up wasted food and restart any kitchen equipment they will continue to use.

The bakery wants to prevent the economic losses from wasted food and staff labor diverted to outage clean up. They would also like to be able to provide customers with a place to go during an outage to get hot coffee and a snack when their own homes are dark. The bakery enters into a power purchase agreement to purchase solar energy from a third party. They receive a grant toward electrochemical energy storage and add thermal storage to capture waste heat from the kitchen for water heating. They are able to keep their oven going for 45 minutes after an outage to complete any baking, and they are able to serve customers hot coffee and baked goods for 5 hours of an outage with their payment system operational. They are able to use their heat recovery to reduce their water heating energy costs during normal operations, and they participate in a utility program for their battery, further reducing their energy costs.

In each of the above scenarios, energy efficiency programs can identify their optimal role supporting the customers' energy resilience in collaboration with distribution utilities, and in doing so, identify the value of the energy efficiency program in delivering energy resilience at the customer level and the value of those benefits at the energy system level. Efficiency Vermont and DUs are working collaboratively to find ways to organize themselves around supporting customer energy resilience.

Valuing Energy Resilience[6]

Energy resilience plays a critical enabling role in the ongoing transition toward a more distributed, more renewable electric power system capable of reliably integrating new loads from heat pumps and electric vehicles. It is conceivable that sustained growth in solar, wind and other intermittent renewable generation, coupled with mass electrification of thermal and transportation loads, will not be possible without an organized deployment of weatherization, flexible load management, and storage. Efficiency Vermont customers will require support in planning to reduce the potential for energy outages through effective site load management, and

[6] Created from content included in the May 13, 2020 "Revised Work Paper for Efficiency Vermont's Support of Flexible Load Management", Case No. 19-3272-PET, Exhibit No. EVT-MJ-1

to manage critical loads during power outages to prevent the loss of life and property and maximize the performance of their energy storage devices.

The steps taken with customers to reduce and better manage energy consumption might include secondary benefits such as improving comfort, safety, and health. They will also benefit their communities, the state, and the region through:

- Firm capacity,
- Generation capacity avoidance (e.g. FCA, wholesale capacity costs),
- System peak related transmission cost avoidance (e.g. RNS costs),
- Reduced peak energy costs (e.g. wholesale energy),
- System and targeted transmission and distribution capacity deferral,
- Distribution voltage support and loss reduction,
- Power quality,
- Load-shifting & load-building,
- Ancillary services such as frequency response and operating reserves, and
- Avoided greenhouse gas emissions.

Additionally, customer energy resilience efforts can support meeting the goals of Vermont's CEP and the requirements of Vermont's GWSA and renewable energy standard.

Efficiency Vermont's Role in Supporting Customer Energy Resilience

Within this context of local policies and regulations, changing energy supply and demand, and customer values, Efficiency Vermont identified the following roles for Efficiency Vermont to provide in supporting customer energy resilience.

1. Collaborating with the State, DUs, and Vermont Electric Power Company (VELCO) for long-range energy resilience planning, such as 2024 participation in the flexible load management (FLM) working group to map out the use of long-term FLM, which could be used for energy resilience
2. Using such planning to inform ways to achieve Efficiency Vermont's goals for delivering energy efficiency (including weatherization), FLM, and energy storage that support customer and grid energy resilience
3. Co-designing systems-optimized programs and services with DUs, customers, and other stakeholders to achieve customer energy resilience
4. Reinforcing the nexus of the "voice of the customer/community," their energy resilience time scale, greenhouse gas (GHG) reduction goals, and climate adaptation needs
5. Communicating the need for customer energy resilience and the quantifiable value of Efficiency Vermont's programs and services in contributing to such resilience

Methods: Vermont Energy System Map

To best support customers in energy resilience, resulting in a successful energy decarbonization transition, Efficiency Vermont developed a map of Vermont's energy system following the systems mapping process outlined by Donella Meadows in *Thinking in Systems* and using techniques from FSG's "Systems Thinking Toolkit". The Vermont energy system map

places the customer at the center and works outward to identify the key variables in the system that influence the customer's energy resilience.

Efficiency Vermont characterized the system actors, system inputs, flows and feedback loops within the system, and system outputs. The team identified individual and societal conditions such as security, safety, climate adaptation, affordability, vulnerability, and personal and community goals as primary system drivers, with personal and community relationships influencing individual and community goals, which in turn lead to policies and regulations. Policies and regulations drive planning and determine programs. Programs heavily influence the supply chain, which establishes buildings and equipment efficiency and management practices. Buildings and equipment efficiency and management practices collectively influence grid capacity and locally drive critical loads. Critical load requirements and the system's ability to fulfill them during power outage conditions determine customer energy resilience, which ultimately drives societal and individual customer conditions.

Grid capacity is influenced by the weather and energy production, and limited grid capacity encourages grid modernization. Grid modernization is heavily influenced by long-range planning, risk management, and technological advances. Technological advancements, electricity production, and weather, represented in Figure 2 by cloud shapes, are outside the scope of this simplified map, but have a significant impact on the system. Figure 2 illustrates a highly simplified version of the energy system map from the viewpoint of customer energy resilience.

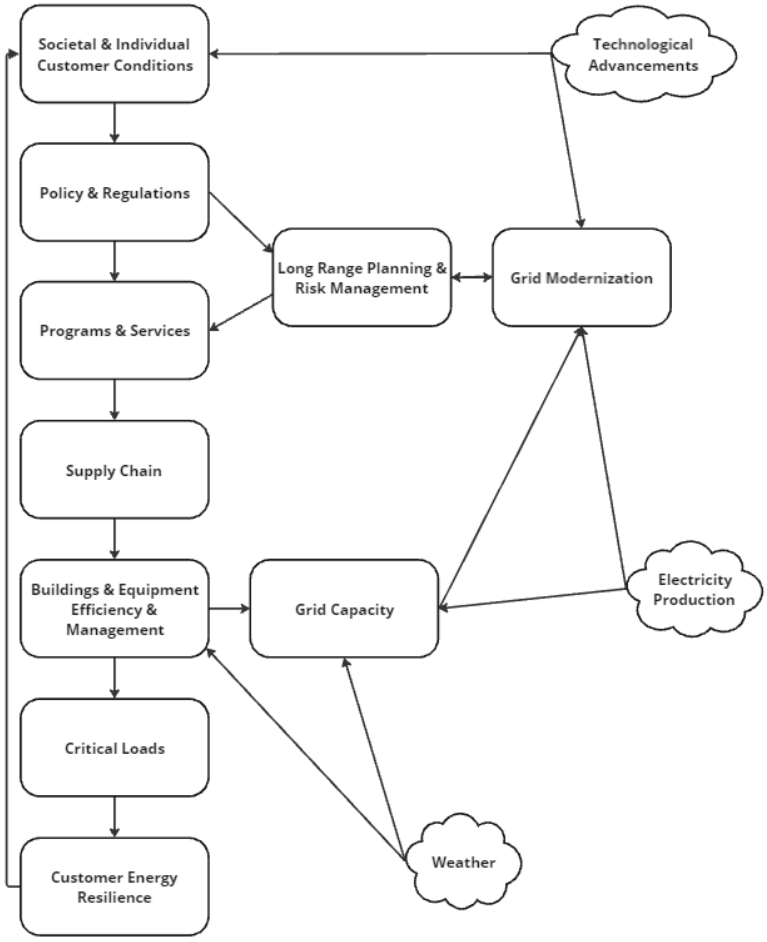

Figure 2: Simplified energy system map from the viewpoint of customer energy resilience. *Source:* Author.

Map Boundary, Assumptions and Gaps

Efficiency Vermont staff developed and reviewed this map based on their knowledge of Vermont's energy system and customer energy resilience. The map has not been reviewed by external parties and customer input into the map is limited to information from Voice of the Customer reports and feedback from customer-facing team members. Though societal and individual goals beyond decarbonization and equity, such as health, influence customer energy resilience, they are not represented on the map—nor is electricity production, beyond regional capacity. Staff developing and using the map acknowledge their bounded rationality of limited knowledge, cognitive capacity, and time limits. The map is intended for use by staff in assessing and understanding the energy system and it's impact on customer energy resilience.

According to Efficiency Vermont's research, no similar mapping from the perspective of customer energy resilience exists.

Opportunities to Support Energy Resilience

Using its mapping, Efficiency Vermont identified the following consequential nodes of influence that align with Efficiency Vermont's role, listed in order of their influence on customer energy resilience:

1. Community & individual relationships
2. Critical loads
3. Policy & regulations
4. Building operations & maintenance
5. Supply chain
6. Programs & services

For each significant node, Efficiency Vermont assessed the high-level flows, drivers, customer needs, and feedback loops, identifying the following opportunities:

- Supporting customers in establishing and strengthening energy resilience plans, grounded in energy efficiency and in collaboration with DUs
- Helping customers identify and quantify their critical loads and planning for critical load management
- Informing customers of operations and management as an energy resilience strategy
- Elevating the voices of Efficiency Vermont customers in programs that can best support those customers in equitably improving energy resilience
- Supporting the supply chain in delivering products and services that optimize operations and maintenance for energy resilience
- Supporting vulnerable customers (likely to suffer significant hardships during a power outage) in navigating the complex supply chain for energy resilience
- Understanding how current Efficiency Vermont programs are delivering customer value for energy resilience and eliminating barriers to achieving energy resilience

For each opportunity, Efficiency Vermont explored existing market efforts, the optimal role for Efficiency Vermont, probable scenarios that would change the optimal role, and tangible

programs and impacts. Efficiency Vermont's analysis resulted in the identification of potential projects that the organization could deliver in support of customer energy resilience.

Results: New Energy Resilience Efforts

Efficiency Vermont is in the process of implementing the following projects, which model ways that other program administrators can support energy resilience for both ratepayers and the grid.

Energy resilience communications strategy: Cultivating a culture of energy resilience. Efficiency Vermont reviewed customer and partner information on energy resilience goals and stakeholder needs for meeting those goals. Efficiency Vermont used this information in the publication of a program marketing and information materials to help customers make the connection between their desired energy resilience outcomes and energy efficiency projects.

Efficiency Vermont also provided foundational training for staff who directly work with customers. Well-informed staff can then support customer energy resilience planning and project implementation in collaboration with DUs.

To achieve optimal outcomes on energy resilience, Efficiency Vermont delivers clear and consistent messaging to complement the customer engagement. Clear messaging can also be directed to DU partners, who are also interested in advancing customer energy resilience to meet Tier III renewable energy targets. This messaging emphasizes weatherization, energy efficiency, and electrification in achieving energy resilience, and seeks to normalize planning for critical loads, FLM, and storage.

Sustaining energy resilience by serving customers and DUs together. In the long term, Efficiency Vermont customer support staff and engineering consultants can be trained on comprehensively supporting customers in evaluating the projects they undertake while on their total energy journey. Staff can help customers set energy resilience goals and create plans for achieving those goals. They can also collaborate with DUs and other industry stakeholders to promote resilience in targeted areas or sectors. They can support the most vulnerable customers and motivate customers to participate in Efficiency Vermont and corresponding DU programs.

Customer energy resilience demonstration projects. Efficiency Vermont is co-designing pilot projects targeting customer energy resilience. Two sites have been identified thus far for comprehensive energy resilience planning, a nonprofit family support center and a school. A third site will test and evaluate residential vehicle-to-grid integration and controls.

These projects will provide Efficiency Vermont staff with valuable experience in the dual benefits of motivating customer energy resilience and partnering on this topic with the DUs. The projects will also enable staff to identify the elements necessary for achieving energy resilience goals, determining which are the most promising, confusing, or negative for the customer. In this work, Efficiency Vermont can understand the costs and quantify the value of energy resilience for customers and DUs, measuring the outcomes of energy resilience projects in the context of Efficiency Vermont QPIs and MPRs.

Measuring impact: quantifying the value of energy resilience. Efficiency Vermont will create a framework for reflecting energy resilience in cost-benefit analysis. The framework will assess the benefits of Efficiency Vermont's role in accelerating energy resilience, quantifying those

impacts where possible with operational data and input from DUs and industry stakeholders. This framework would form the basis for a critical evaluation of the cost-effectiveness of Efficiency Vermont's energy resilience work and, if appropriate, justify potential adjustments to Efficiency Vermont's screening and compensation structure. Such information would inform continued or expanded support for energy resilience efforts.

In addition, high-value experience with the DUs on energy resilience planning and implementation will provide insights for energy efficiency program updates and future DRP, IRP, and LRTP planning.

Equity and Benefits

Customers and DU partners request help from energy efficiency program staff in planning for customer energy resilience. Vulnerable households and businesses run by vulnerable households suffer the most when the power goes out. As these households and businesses increase their reliance on electricity for thermal loads and transportation, the negative effects of a power outage add to that suffering. Supporting these community members in understanding, planning for, and implementing energy resilience aligns with Efficiency Vermont's diversity, equity, and inclusion (DEI) plan and goals.

The proposed "Measuring impact" project will evaluate Efficiency Vermont's role in energy resilience delivery and quantify the value to Efficiency Vermont and Efficiency Vermont's customers and partners. Lessons learned from this work can be applied in the development and implementation of existing and new programs.

Conclusions: Next Steps

Efficiency Vermont will continue to develop the demonstration projects in collaboration with DUs. Efficiency Vermont will also identify opportunities to increase customer awareness of energy resilience, and will investigate valuing the benefits of energy resilience to contribute to a broader analysis of existing and potential metrics for energy efficiency programs.

Energy efficiency program administrators are encouraged to evaluate their program requirements, and applicable state policies and regulations to identify opportunities to further support their customers in energy resilience through their programs and services. Sharing results across program administrators through papers such as this one will accelerate industry learning and the ability for energy efficiency program administrators and DUs to advance their role in energy resilience with recognized value for their work.

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