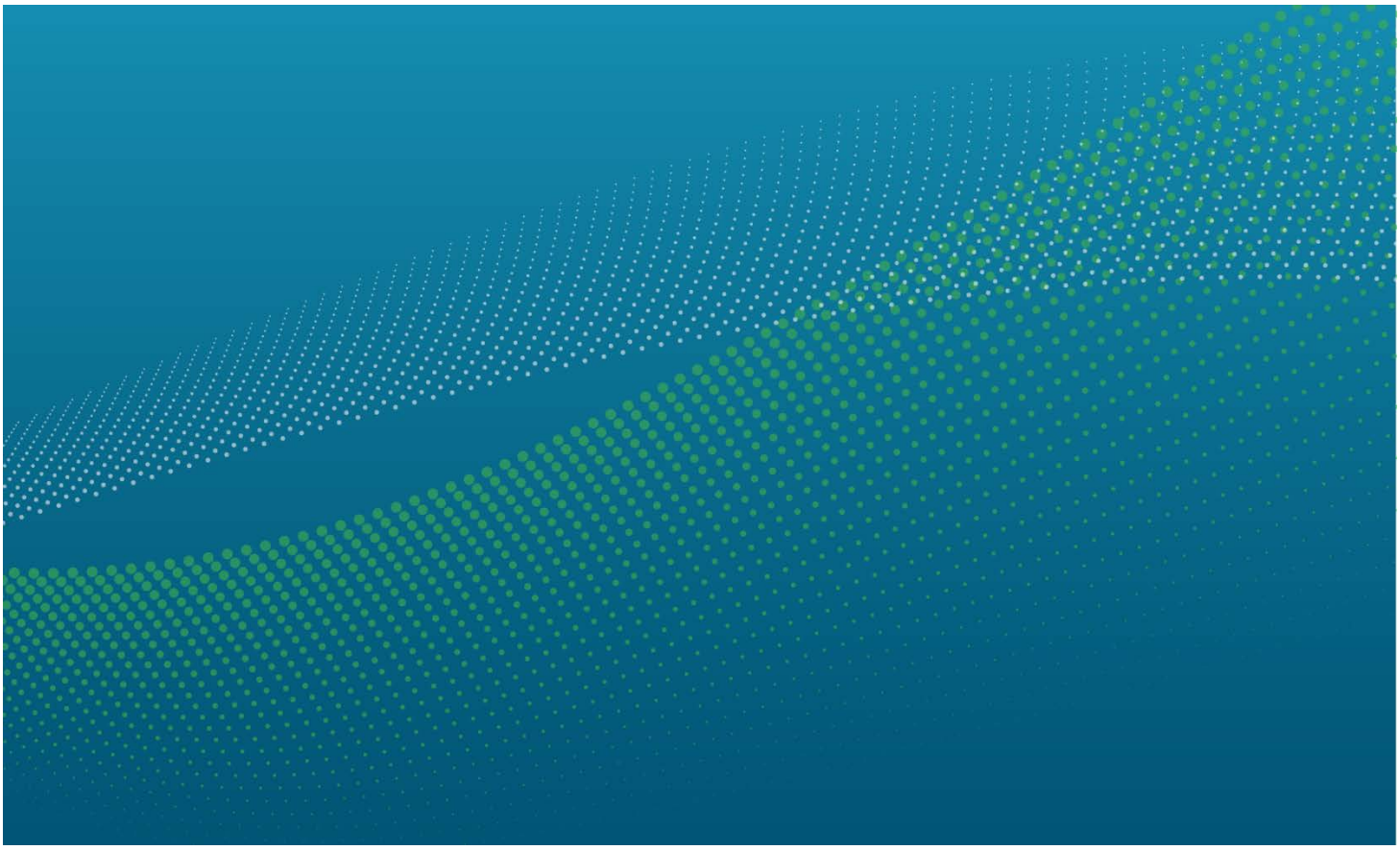

Assessment of Demand Response Capability and Effectiveness

EFFICIENCY VERMONT REPORT

JJ Vandette
Efficiency Vermont
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Efficiency Vermont

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Introduction

Changing energy systems—from the fuels that generate electricity and the ways in which utilities interact with their customers, to the role of increasingly mature energy efficiency programs—require all energy industry players to think differently about the services they offer their respective customers. Since 2000, when the statewide energy efficiency utility Efficiency Vermont began offering demand-side management (DSM) services, the primary objective of most energy efficiency programs has been to provide least-cost electric energy supply for Vermonters.

This objective has historically been met by focusing on traditional energy efficiency measures, which are passive in nature (not controlled) and have the goal of annual energy savings (kWh). Demand response (DR) is another demand-side management strategy, and has historically focused on reducing demand at specific peak periods, for which success is quantified in kW.

Vermont regulators have specified DR[1] as an allowable DSM activity. Outside of Vermont, DR, renewable energy, energy efficiency, and several other strategies have been considered valid elements of integrated DSM (iDSM) in energy utilities' portfolios of reliable power supply.[2] Each element to date has complemented reliability mandates for distribution utilities in jurisdictions offering iDSM. Together in the past decade, these elements and traditional energy supply have helped to shape what is becoming known as the *new utility.*

Is there an opportunity in mixing some of these elements together to achieve even stronger iDSM outcomes such as greater energy savings, better non-energy benefits, and higher system reliability?

With this project's exploration of DR, Efficiency Vermont investigated where existing efficiency program activities might complement existing distribution utility-led demand-response (DR) services. The investigation asked whether DR activities might bring new value to Vermont ratepayers and the grid that serves them, with special consideration given to efficient consumer products, energy management systems,

[1] This language first appeared in the 2010 Vermont Public Utility Commission Order appointing VEIC as the 12-year administrator of Efficiency Vermont work (under Docket 7466), and a subsequent renewal of that term in 2016 (under Docket 8455). The documents specify that VEIC can claim energy savings from demand response measures. https://puc.vermont.gov/sites/psbnew/files/doc_library/7466-appointment-veic.pdf, Section II, 16, at 8.

[2] The other elements are energy storage, electric vehicle technologies, and time-based rate programs to residential and commercial electric utility customers. Potter, Jennifer, Elizabeth Stuart, Peter Cappers, 2018. "Barriers and Opportunities to Broader Adoption of Integrated Demand Side Management at Electric Utilities: A Scoping Study." LBNL-2001110. Berkeley, Calif.: Lawrence Berkeley National Laboratory. https://emp.lbl.gov/publications/barriers-and-opportunities-broader

and commercial equipment. Special attention was given to products that were already being offered by Vermont's energy efficiency program administrators, and that were already DR capable. This includes commercially available energy efficiency technologies that are capable of remote communication and can be used for DR "events" the at times when the grid needs to constrain electricity demand so that distribution utilities can maintain reliable and cost-effective power supply.

The project involved the engagement of both the energy efficiency utility, Efficiency Vermont, a number of Vermont distribution utilities, and the Vermont Department of Public Service. During the first part of this project, Efficiency Vermont reviewed a list of DR measures recognized by the Vermont Department of Public Service. The objective was to move the list from the Department's draft *Demand Response Catalog* (DR Catalog) to a final version. The DR Catalog work supported the second part of the project: identifying and demonstrating where Efficiency Vermont could complement existing demand response services while bringing new value to ratepayers, distribution utilities, and the grid. Part two uncovers a new treatment of iDSM, and answers the central question: Can it be done?

Research Assumptions

From the outset of this project, Efficiency Vermont began to explore the value of demand response measures with the research assumptions shown in **Table 1.**

Topic area	Assumption
Technology	Expertise in technology, customer knowledge, and Vermont markets will add value to the assessment of technologies and their feasibility for inclusion in the DR Catalog.
Usefulness of project outcomes	Efficiency Vermont offers a sufficient number of energy efficiency measures that are already DR capable, to measure project outcomes with statistical significance.
	The values obtained from this study can be used by other traditional energy efficiency programs to increase the societal benefits of their program offerings by offering DR-capable measures.
	DR-capable technologies, when complemented by traditional energy efficiency measures, lend themselves to market transformation strategies.
Market potential for DR measures	DR-specific potential analyses would duplicate Efficiency Vermont's current market potential analyses, but using Efficiency Vermont data could streamline the conclusions.
Cost effectiveness of combining energy efficiency and demand response	Efficiency Vermont's energy efficiency programs will cost-effectively provide greater societal benefits by incorporating DR components.
Demand-side management	Vermont's distribution utilities and energy efficiency utility customer-facing DSM programs will benefit from integrated planning.
	Least-cost planning should consider flexible loads in all DSM programs.

Table 1. Research assumptions for the Efficiency Vermont demand response project

Methods

The Efficiency Vermont team divided the project into two parts: (1) reviewing the Department's draft *DR Catalog*; and (2) using the review as a basis for articulating ways in which Efficiency Vermont could support greater amounts of DR in the state's energy efficiency utility portfolios.

Efficiency Vermont reviewed and provided comments on the *DR Catalog* during the first half of the project period. Because of the assumed potential for significant value of DR in the Vermont energy efficiency utility portfolios, the project team entered the second phase with the baseline of the Catalog's demand response programs: a few legacy utility programs, a small number of rate-related demand programs, and several recent program offerings from Green Mountain Power (GMP, the state's largest electricity utility).

The project team's objective was to have sufficient information and insights to map characteristics of these demand response measures, from the perspective of their (or their successor measures') possible inclusion into an energy efficiency utility portfolio. The resulting map contained a list of DR-capable measures and associated metrics that could be incorporated into traditional energy efficiency programs.

Energy efficiency + DR programs can make a substantial, positive impact on the grid, with a relatively small cost increase to existing initiatives.

The Department later requested comments on the DR Catalog from Vermont distribution utilities and from Efficiency Vermont. Project staff analyzed the technical document and commented on it. Efficiency Vermont's comments on the Catalog related to the technical feasibility of DR measures. Some of the measures and their suggested uses were incomplete; other DR-capable measures were missing and could be incorporated to create a comprehensive catalog.

The project team suggested several next steps, notably coordinating DR considerations and energy efficiency market potential studies, and coordinating DSM planning generally across Vermont's energy efficiency utilities with any future DR programs.

Efficiency Vermont concluded the project with a high-level DR market potential study. The results of the analysis are contained in the remainder of this report.

Analysis

Efficiency Vermont's DR market potential study concluded that certain residential measures specified in the DR Catalog could create substantial and positive impact to Vermont's grid, at a small incremental cost to existing energy efficiency utility initiatives. For example, in the 2018 – 2020 Demand Resources Plan for Efficiency Vermont, a number of room air-conditioners (AC), heat pump water heaters, dehumidifiers, and pool pumps were modeled. If DR-enabled, this subset of measures alone could achieve more than 8 MW of demand reduction. Table 2 shows the relative values of the DR measures.

Residential DR measure	Forecasted measures across 3 years (2018 – 2020)	kW resources per measure (from DR Catalog)	Total resource (MW)
Room AC switch	6,687	0.500	3.344
Heat pump water heaters (Water-heating switch)	5,922	0.500	2.961
Pool pump switch	1,089	1.360	1.481
Dehumidifier	2,394	0.200	0.479
Total			**8.264**

Table 2. Demand response residential measures that can be enabled for energy efficiency utility programming, and their estimated total savings to the grid

The 8 MW of peak load reduction can result in $1.5 million in additional peak cost avoidance for Vermont. ISO-NE capacity costs are currently approximately $100 / kW-year,[3] and Vermont regional network service costs are approximately $100 / kW-year.[4] Together, these total $200 / kW-year.

$200,000 / MW X 8 MW = $1.6 million

This translates to additional peak-related avoided costs from a subset of only 5 residential energy efficiency measures that are already being implemented as part of existing energy efficiency utility programs.

During the team's investigation of current DR programs in other states, programmatic challenges common to all DSM initiatives, including energy efficiency, became evident: The ability to scale technologies (measures) is critical to meeting cost-effectiveness requirements.

Scaling many small measures to meet a collective, grid-scale impact target is central for Vermont's energy efficiency utilities, and can be achieved through coordinated market transformation practices. Vermont's energy efficiency utilities have ongoing relationships with manufacturers, supply channels, and contractors from technologies of all types, many of which are DR capable. This type of market

[3] Calculation of $9 / kW-month X 12 = $108 / kW-year drawn from: Rose, Judah, George Katsigiannakis, Josh Ghosh, and Himanshu Pande, 2017. "ISO-NE FCA 11 Auction Results and Future Expectations. Fairfax, Virginia: ICF. https://www.icf.com/-/media/5891f1ade0d34fefbb20721e5d7a87b9.ashx;

[4] ISO New England PTO AC Rates Working Group, 2018. "RNS Rate – Effective June 1, 2018." Presentation to NEPOOL Reliability Committee / Transmission Committee Summer Meeting, August 7-8. Holyoke, Mass.: ISO New England. https://www.iso-ne.com/static-assets/documents/2018/08/a2.0_2018_08_07_08_rc_tc_ptoac_rates.pptx.

transformation requires Efficiency Vermont to engage with customers about tens of thousands of measure installations annually, as modeled in Efficiency Vermont's Demand Resources Plan. **Table 3** shows measures that were identified in the DR Catalog that are also in Efficiency Vermont's Demand Resources Plan Model. As indicated in the columns on the right, Efficiency Vermont plans to encourage the installation of many of these measures (second column from the right), and Efficiency Vermont has already claimed energy efficiency savings on thousands of these measures (far right column).

DR measure	Sec-tor (Res, C&I, all)	Forecasted average annual measures installed, 2018 - 2020	Total number of installed measures incentivized by Efficiency Vermont since 2000
Measures cited in the Vermont Public Service Department's DR Catalog:			
Central AC switch	Res	0	385
Room AC switch	Res	2,229	22,342
Water-heating switch	Res	1,974	7,867
Pool pump switch	Res	363	1,013
Smart thermostat	Res	907	2,927
Dehumidifier	Res	798	11,517
Small to medium-sized business direct load control – AC	C&I	850	1,899
Small to medium-sized business direct load control – water htg.	C&I	0	0
Measures added by Efficiency Vermont, following review of DR Catalog:			
Cold-climate heat pump	Res	1,375	12,950
Cold-climate heat pump	C&I	1,350	0
Freezer	Res	890	3,660
Freezer (reach-in or chest)	C&I	36	237
Lighting	All	NA	TBD
Plug loads, major appliances	Res	NA	32,812
Refrigeration	C&I	NA	2,324
Thermal energy storage (ceramic block heater)	C&I	NA	NA

Voluntary load management	C&I	Unknown	Unknown

Table 3. DR measures in residential and commercial and industrial (C&I) sectors, in the context of overall energy efficiency value

The far-right column refers to the number of measures that Efficiency Vermont has installed already, but for which no DR capabilities have been explored either by the DR Catalog or by EVT up to this point in time. In addition, three new demand-side, end-use measures for which no values can be assigned for **Table 3** could be informed by Efficiency Vermont's existing programs and statewide market transformation activities in the future: electric thermal storage heat, battery storage, and thermal energy storage (for air-conditioning).

Efficiency Vermont recommended the new measures (in **Table 3)** to the DR Catalog. These measures are forecasted under the 2018-2020 Demand Resources Plan Model to be installed and incentivized by Efficiency Vermont. The project team deemed them valuable because they met one or more of the following criteria:

- They are forecasted to have increased penetration rates in the near term
- Their known or expected use coincides with peak demand times
- They will have minimal disruption to customer experience from load shifting
- Integrated controls for them are commercially available

To explore the extent to which Efficiency Vermont could add value with demand response resources, the project team contacted North American program implementers that work with DSM programs having dual goals of meeting energy efficiency and peak demand reduction targets via demand response.

Although the term *demand response* was once associated with an emergency, peak-shaving strategy, the project team's survey of North American implementers concluded that DR is now associated with two-way communications that enable many new grid benefits. Several manufacturers and a growing number of DR controls companies ("aggregators") are mapping where demand (behind the meter) is being flexed to avoid expensive peaks, soak up surplus or inexpensive renewable energy (via energy arbitrage), or provide ancillary services, such as frequency regulation and black start restoration.[5]

Known more accurately as *flexible demand management*, *AutoDR*, or *Demand Response 2.0*, the combined survey information about DR complemented the analysis that Efficiency Vermont was concurrently conducting with Washington Electric Cooperative (WEC). The WEC study sought to understand how DSM programs might be better used to lower WEC's growing peak-related costs.[6] Thus,

[5] Potter et al., 2018. "Barriers and Opportunities."
[6] That study is the subject of another Efficiency Vermont report on 2018 R+D projects, "'Peak Response Program': A 2018 Demand Response Capability Initiative" available at

Efficiency Vermont worked with WEC for the DR project, to outline a demonstration project to control the loads of a sample of heat pump water heaters (HPWH)[7] within WEC territory that already contained DR controls.

By targeting HPWH, both the energy efficiency utility and the distribution utility had a chance to learn more about the DR performance of a technology that has zero incremental hardware costs to enable remote control. The project team recognized that the same elements of an energy efficiency DSM program had to be in place for a "flexible demand" demonstration that would involve program planning, program design, program launch, customer engagement, supply chain and contractor engagement, measurement and verification, and reporting.

The project team also recognized that traditional DSM program design processes would require controls company "aggregators" to provide the software-as-a-service (SaaS) capability for controlling the water heaters, so that they could avoid times of expensive peak demand. A diagram from the Bonneville Power Authority (Figure 1) outlines one option for the data flow, communication pathways, and players required to implement a "flexible demand" program.[8] Using this network diagram to guide the roles and responsibilities for parties involved, the implementation of this demonstration project has been approved for a 2019 Efficiency Vermont R&D project.

https://www.efficiencyvermont.com/news-blog/whitepapers/peak-response-program-a-2018-demand-response-capability-initiative.

[7] Larger distributed demand resources such as customer-sited electric batteries and electric vehicles, which are not yet authorized for incentives under Efficiency Vermont programming, would have offered easier starting points. Instead, the project team scanned the Efficiency Vermont portfolio to derive the following targeting criteria: the measure should (1) be a "significant" demand response asset (as opposed to a single lightbulb, for example); (2) be widely available in Vermont (central AC, for example, would not be a good candidate because it is found in only 3 percent of Vermont homes); and (3) have high penetration in the market, with already built-in controls (cold-climate heat pumps, for example, require an aftermarket controller). These criteria led the project team to choose heat pump water heaters for the pilot.

[8] Bonneville Power Administration, n.d. "Regional Study of CTA-2045 Enabled Water Heaters." https://www.bpa.gov/EE/Technology/demand-response/Documents/CommDataPathSchematicAndPhotos.pdf

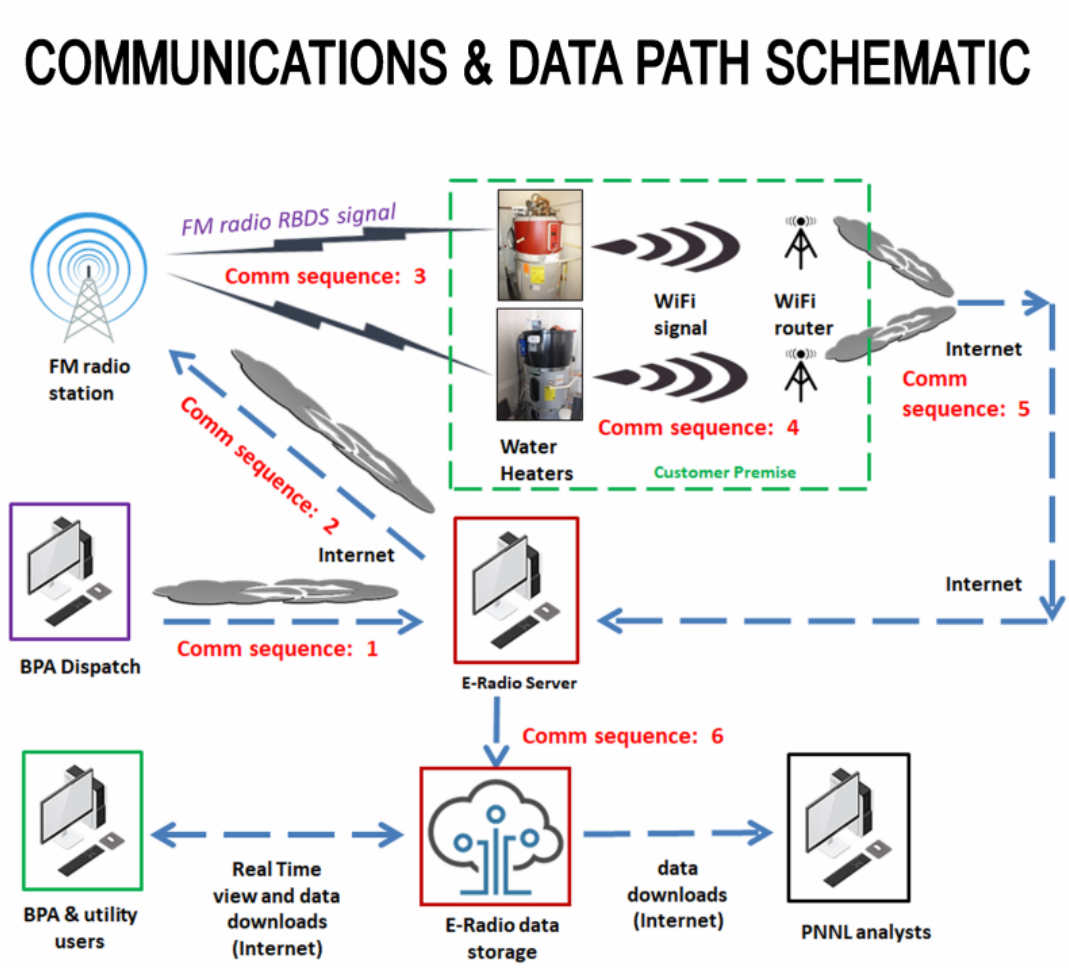

Figure 1. Example of communications pathways, demonstrating an analogy for handling flexible load management.

Source: Bonneville Power Administration. https://www.bpa.gov/EE/Technology/demand-response/Documents/CommDataPathSchematicAndPhotos.pdf

Conclusions

The incremental costs for an existing customer-facing iDSM energy efficiency project that can incorporate flexible demand capability are small, relative to total project costs. Moreover, Vermont's energy efficiency utilities have 19 years of DSM experience—and at least a decade of iDSM experience—that can reliably accrue societal benefits from an integrated efficiency + DR effort. That DSM experience also means that Efficiency Vermont is capable of adjusting any efficiency + DR programming as grid challenges and costs evolve. Efficiency Vermont's role in

demand response has been specified in the Vermont Public Utility Commission's two Orders of Appointment for VEIC, Efficiency Vermont's implementer.[9]

Controllable loads present a tremendous opportunity for bringing energy savings to Vermont ratepayers. Many of these flexible load measures can already pass today's cost-effectiveness screening. As such, these measures could be used to reflect real-world energy reductions in Efficiency Vermont's kW-related quantitative performance indicators.

Maximizing the value of DSM programs for societal benefits goes hand-in-glove with incorporating DR planning and coordination into distribution utilities' integrated resource plans and energy efficiency utilities' demand resources plans. Such incorporation is also consistent with Vermont statute requiring consideration of least-cost resources in energy planning.[10]

Future Potential Research

This study led to productive conversations between Efficiency Vermont and Vermont's distribution utilities. As a result, several new demonstration projects are now under way. The work has paved the way for possible subsequent activity via distribution utility innovation pilots and through Efficiency Vermont R+D projects. Examples include:

- Participation in Burlington Electric Department's *Defeat the Peak* initiative, which was a natural extension of the present project; a separate report will share those findings.
- Efficiency Vermont and Green Mountain Power will collaborate on the 10 projects comprising GMP's Flexible Load Pilot through 2019.
- Efficiency Vermont and WEC intend to explore this topic more deeply by demonstrating how existing heat pump water heaters might be used to further reduce WEC's peak-related costs. The objective will be to determine the extent to which , energy efficiency, and flexible load management can

[9] See Section II, 16, in *Order of Appointment for Vermont Energy Investment Corporation, Pursuant to 30 V.S.A. § 209(d)(5),* December 20, 2010: "VEIC may, as part of comprehensive treatment of customers, include demand response as an eligible demand-side resource option. The guidelines specifying eligible demand-response applications and economic screening procedures for VEIC treatment of demand response are provided as Appendix C to this Order of Appointment, as may be amended by the Board from time to time." https://puc.vermont.gov/sites/psbnew/files/doc_library/7466-appointment-veic.pdf. The demand response programming language was repeated in the February 2016 "second term" Order of Appointment to VEIC (Section II, 12: "VEIC may, as part of comprehensive treatment of customers, include demand response as an eligible demand-side resource option." https://puc.vermont.gov/sites/psbnew/files/doc_library/8455-second-term-veic.pdf).

[10] Vermont's least-cost integrated planning law is found in 30 V.S.A. § 218c, https://legislature.vermont.gov/statutes/section/30/005/00218c.

have positive effects on the state's DSM programs involving the energy efficiency utilities, the distribution utilities' Tier III efforts, and resource planning generally.[11]

When DSM program goals pivot from kWh to kW, residential customers in Vermont are unlikely to see reductions on their utility bills, because nearly all rates are volumetric and not related to time of use.

Through this DR program investigation, the project team learned that most DR program administrators managed consumer-informed consent through opt-in contract language designed to mitigate risk. These programs also made customer satisfaction a Number 1 priority. Additional investigation might be warranted on this topic.

Utility rates and rate design are an increasingly important topic for any future flexible load initiatives. Translating grid benefits to customer benefits is comparatively simple when kWh is the main objective. When DSM program goals pivot from kWh to kW, many customers, especially residential customers, are unlikely to see the direct benefits of kW reduction initiatives on their utility bills since nearly all rates are volumetric and not related to time of use. Many DSM flexible load programs reward customers in ways that go beyond reductions to their utility bills, but such rewards are likely to diminish in value. States such as California have introduced time-of-use rates statewide for residential customers. Even so, those solutions are often not dynamic enough to match the complexities of cost and benefits of flexible load management from the grid perspective. Any future demand-related projects, or other types of demonstration, should consider rates as a key variable.

[11] *Tier III* is the name given to a portion of Vermont 2015 Act 56, which established a renewable energy standard for the state. *Tier III* refers to a requirement that distribution utilities procure new renewable distributed generation via "energy transformation" projects. Energy transformation projects are "those that reduce fossil fuel consumed by DU customers." https://publicservice.vermont.gov/content/tier-iii-renewable-energy-standard.