“Peak Response Program”: 2018-2019 Demand Response Capability Initiative

EFFICIENCY VERMONT REPORT

Updated by
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Efficiency Vermont

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Introduction

Testing the Value of Combining Energy Efficiency with Demand Response
VEIC, the organization that operates Efficiency Vermont, was a next-door neighbor to and customer of the Burlington Electric Department (BED) municipal utility during the timeframe of this study. BED asked VEIC, as a customer, to participate in the Defeat the Peak[1] program. The 2018-2019 pilot would help test the efficacy of combining both "demand response" and energy efficiency practices in reducing energy use on the hottest and coldest days of the year. As part of its demand response research and development (R&D), Efficiency Vermont joined BED's pilot initiative by engaging VEIC office occupants and attempting to measure savings of peak events. Results of BED's overall Defeat the Peak program, which was partially funded through American Public Power Association (APPA), will be published separately and has stimulated academic research on the topic of altruism[2]. This report describes Efficiency Vermont's use of research and development (R&D) resources to enhance these insights.

Demand response and energy efficiency (including energy conservation) practices are classically separate domains in the regulated energy system. The practices are delivered through separate operations and are valued under separate evaluation methods. BED and Efficiency Vermont were both interested in seeing the extent to which combining these approaches in a disciplined and strategic way, could produce ratepayer, energy system, and environmental benefits. BED launched its Defeat the Peak demand response program for customers in 2017, making it relatively easy to track additional benefits from a pilot that coordinated both functions.

Given VEIC's mission to act with urgency to enhance the benefits of clean energy use, the organization welcomed the invitation. Efficiency Vermont welcomed the opportunity to assess how efficiency program technical expertise could be utilized for demand response programming. Efficiency Vermont staff wanted to utilize its staff office facility to learn about and potentially support peak reduction programming. When signaled by BED, Efficiency Vermont carried out energy conservation and peak reduction measures within its office; Efficiency Vermont also monitored performance and reported results back to VEIC staff to facilitate continuous improvement throughout each peak season.

[1] See Defeat the Peak: https://www.burlingtonelectric.com/peak.
[2] Pratt, Bonnie Wylie, and Jon D. Erickson. "Defeat the Peak: Behavioral Insights for Electricity Demand Response Program Design." *Energy Research & Social Science* 61 (March 1, 2020): 101352. https://doi.org/10.1016/j.erss.2019.101352.

Specific Aims

The primary objective of the R&D pilot was to test the extent to which a single, medium-sized customer could shed and shift load during the summer peak season. The objective of Defeat the Peak is to lower utility expenses by reducing transmission costs during periods of congestion on the regional power system (i.e., “Peak periods”).

A reported 15% of BED’s annual budget was used in 2017 to pay for the extra costs of maintaining reliability of supply during peak events in that year.[3] The regional transmission organization (grid operator) for Vermont is Independent System Operator (ISO) New England, which determines the days and hours of peak events, whether summer or winter. ISO New England’s announcements of peak events trigger distribution utilities (DUs) like BED to signal participating customers to reduce the customer’s draw (demand) on electricity supply for a set number of hours and occasionally during a sequence of days. Knowing peak hours enables utilities to base electric rates on the amount of electricity needed to supply enough power on peak demand days so that the utilities do not have to purchase additional (and costlier) supply. In Vermont, a state with a baseload supply of electricity that comes from mostly clean sources, buying additional supply at peak means purchasing from less-clean fuel sources and at higher prices.

Efficiency Vermont anticipated that it would likely learn several important lessons from the pilot. Efficiency Vermont hoped that any lessons learned could enhance BED’s Defeat the Peak program and result in a subsequent Efficiency Vermont offering for the state’s other utilities and large customers. This aspiration is based on the recognition that effective delivery of energy supply and effective delivery of energy efficiency services each has its own time and locational value—and that demand response programs can provide great additional value to ratepayers and utility programs alike.

Methods

The goal for this research was to explore how Efficiency Vermont could support and extend BED’s existing utility-led demand response effort. Efficiency Vermont created an in-house campaign at its Burlington headquarters to manage the employee experience for peak season and events. Each Burlington-based employee received a “seasonal peak” announcement, preparing the employee with a list of measures that could be undertaken during peak hours. The list described measures the employee could implement at desks, in meeting rooms, in general office spaces, and at home to conserve energy during the peak periods. This approach leveraged Efficiency Vermont’s experience implementing programs and services focused on reducing

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[3] Kanarick, Mike, 2017. “Burlington Electric Launches Defeat the Peak Program.” Burlington: Burlington Electric Department. June 22. https://www.burlingtonelectric.com/news/111

energy use through customer behavior change.[4] Efficiency Vermont used three primary pathways to respond to peak conditions including: (1) asking participants to change behaviors, as described above; (2) applying tenant building controls by changing peak lighting settings to be more energy efficient; and (3) working with property management to set back temperatures on the HVAC system during peak events.

Efficiency Vermont created periodic communications to round out the campaign. These involved "day before peak" announcements, "morning of peak event" reminders, "peak event starting" notifications, and "peak event results." To enhance awareness of the start of the peak, and to drive positive results, Efficiency Vermont facilitated early awareness through communications and events, including the 2019 additions of digital calendar events and reminders, posting flyers in the restrooms, and generating buzz around the office through interpersonal conversations. This expanded menu of communication to staff for management of peak events and increased activities incorporated feedback from employees in the VEIC office after the 2018 summer experience.

Efficiency Vermont retrieved and analyzed the Advanced Metering Infrastructure (AMI) data from the office smart meter to determine the effects of these combined efforts. Program performance analysis was designed to align with the method BED was using at the time. In 2018, the analysis began with a 24-hour baseline derived from data on similar historical days (non-weekend, non-holiday, hot days). In 2019, the baseline was derived from a slightly more elaborate method based on an approach previously used elsewhere by Enel X[5] (formerly known as EnerNOC), as follows:

Step 1. Finding the total energy consumption for the peak event hours of each day in the three weeks preceding the peak event;

Step 2. Using the top three days from Step 1 to construct a 24-hour average baseline;

Step 3. Making adjustments to the baseline for a given hour if the current peak day's usage was higher in the two hours preceding the event. To

[4] Since 2015, Efficiency Vermont has implemented residential customer behavior pilots and initiatives, and continuous energy improvement projects in the commercial and industrial sector. The results of these and earlier projects have been substantially reported in the literature. See, for example: Lange, Nicholas, 2014. "The REAL Problem with Behavioral Savings (and what we can do about it)". Presentation at the 2014 Behavior, Energy & Climate Change Conference (BECC), convened by American Council for an Energy-Efficient Economy, Berkeley Energy & Climate Institute (University of California at Berkeley), and Precourt Energy Efficiency Center (Stanford University), https://beccconference.org/wp-content/uploads/2014/12/presentation_Lange.pdf; Palchak, Elizabeth, 2017. "Casting a Wide Net: What We Know Now About Behavioral Strategies and Energy Use." Presentation at 2017 BECC; and Baker, Greg, 2019. "The Call for Energy Efficiency at Work." Blogpost athttp://www.veic.org/media-room/insights/insights/2019/05/29/the-call-for-energy-efficiency-at-work.

[5] This method was described by BED staff in analysis code documentation.

adjust the baseline, the difference between the baseline and the observed usage during the peak period was added to the original baseline.[6]

Once the baseline was established, Efficiency Vermont created data visualizations to easily communicate the extent to which the addition of demand response practices to an energy-efficient building were able to shift load from peak periods. During both summers (2018 and 2019), Efficiency Vermont adjusted the visualizations to improve the communication of performance; this process gradually made it easier to quickly turn around estimated results.

In 2019, Efficiency Vermont also participated in BED's pilot program with the blockchain energy rewards platform Omega Grid[7] to provide commensurate value to the energy saved during peak periods. Omega Grid and BED are testing a local market that uses dynamic financial incentives to motivate customers to reduce loads in response to dynamic pricing. The goal of the program is to reduce BED's peak charges on both the monthly Vermont and annual ISO New England peak load hours. Using the platform, BED rewards customers with tokens for the customer's energy reduction contributions, worth 70% of the realized benefits.

Analysis and Results

Summer weather conditions in Burlington made the building VEIC occupied—and BED's electricity supply—ripe for peak management. BED called six system peak events in spring/summer 2018, and eight system peak events in the same period for 2019 (including two weekends, which are atypical for a system peak). With each event, Efficiency Vermont observed different results in overall energy use and load, and generally was able to improve performance over the course of the two summers. Performance during each event was influenced by weather conditions, staff schedules, and the ability to interact with building systems. Savings estimates, described in Table 1 and Table 2, may be influenced by the method of estimating a baseline for each event and is discussed later in the report. In 2018, on average VEIC reduced demand during peak periods by 26 kW (38%) while overall consumption during these days increased approximately 11%. In 2019, on average during weekday events VEIC was able to reduce its demand during peak periods by 144.1 kW (25%) while overall consumption during these days also *decreased* by 5%. The following sections use a few select visualization examples from 2018 and 2019, and visualizations for all the events are presented in Appendix.

[6] For example: If one hour within the baseline set was 2kW, and that same hour on the peak day was 3kW, then 1kW was added to 2kW so the adjusted baseline was now 3kW (meaning there was no savings during this hour).
[7] The Omega Grid blockchain platform helps utilities calculate, deliver, and earn rewards for clean energy practices. See https://www.omegagrid.com/.

Table 1: Summer 2018 peak event results

2018 RESULTS			DAILY SAVINGS			PEAK SAVINGS		
EVENT	DATE	EVENT HOURS	KW	KWH	%	KW	KWH	%
1	Mon, Jul 02, 2018	4-7 PM	-25	-609.2	-43%	0	0.0	0%
2	Tue, Jul 03, 2018	4-7 PM	-3.5	-84.1	-6%	24.2	78.6	50%
3	Mon, Aug 06, 2018	4-7 PM	-18	-423.9	-30%	-1.3	-4.2	-3%
4	Tue, Aug 07, 2018	3-6 PM	2.3	54.6	4%	47.9	155.6	62%
5	Tue, Aug 28, 2018	3-7 PM	0.8	20.4	1%	36.4	154.9	57%
6	Wed, Aug 29, 2018	3-6 PM	4.3	102.2	7%	48.8	158.6	64%

Table 2: Summer 2019 peak event results

2019 RESULTS			DAILY SAVINGS			EVENT SAVINGS		
EVENT	DATE	EVENT HOURS	KW	KWH	%	KW	KWH	%
1	Thu, May 23, 2019	6-9 PM	125.5	31.4	3%	84.1	21.0	27%
2	Wed, Jun 19, 2019	6-9 PM	51.4	12.9	1%	21.8	5.4	5%
3	Wed, Jun 26, 2019	7-9 PM	63.7	15.9	1%	15.5	3.9	5%
4	Thu, Jun 27, 2019	6-10 PM	455	113.7	8%	204.1	51.0	39%
5	Fri, Jun 28, 2019	6-9 PM	313.8	78.5	6%	159.8	39.9	34%
6	Wed, Jul 17, 2019	4-7 PM	621.9	155.5	10%	379.4	94.9	40%
7	Sat, Jul 20, 2019	4-7 PM	22.4	5.6	1%	11	2.7	5%
8	Sun, Jul 21, 2019	4-7 PM	16.3	4.1	1%	0.2	0.1	0%

Figure 1 is an example of a peak event visualization from the 2018 season. The green line indicates energy use on the peak day in kWh, beginning at midnight. The black line indicates a baseline constructed from historically similar days. The gray area denotes the peak period beginning at 4 p.m. and ending at 7 p.m.

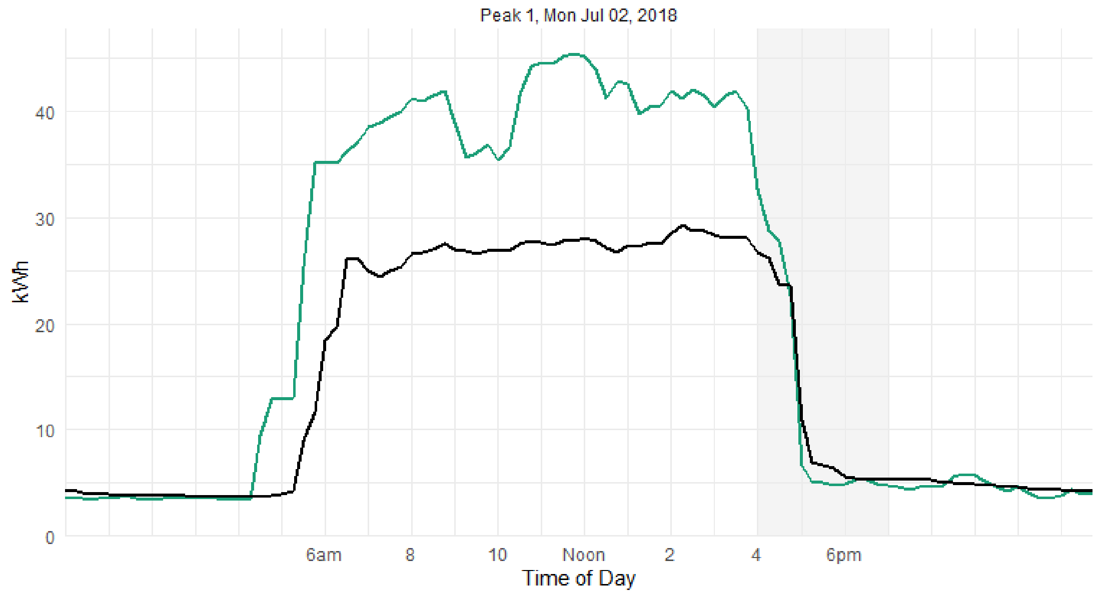


Figure 1: Summer 2018 peak event 1

It is important to note that the green line is significantly higher than the baseline, indicating greater consumption for that day in July 2018. However, there is no significant shift in the amount of energy consumed during the peak hours – while the peak event day has some lower consumption after 5pm that day, the increased consumption relative to the baseline suggests why the savings estimate shows no peak savings on that day in Table 1.

On this first peak event, the building had not been prepared to handle the peak. Further, Efficiency Vermont's peak response practices were not in place. There was a general increase in energy use on this day, and little to no shift from previous performance, especially during the 3-hour peak period. Efficiency Vermont used lighting controls but did not apply HVAC controls. Efficiency Vermont did, however, use behavior-change strategies, including communications and an office social to engage the occupants, and provide awareness of peak events and activities. This suggested that behavior change has potential as a peak response practice, and that it was critical to engage the systems that could change how HVAC was controlled.

Figure 2 is an example of how Efficiency Vermont was able to successfully execute on this approach. The yellow line indicates energy use on August 29, the sixth and final summer peak day of the 2018 season. The black line shows average historical energy use for similar days. Again, the gray area denotes the peak period on that day, beginning at 3:00 p.m. and ending at 6:00 p.m. on this day. During the peak event, the yellow line is at or below the historical energy use for similar days. The shift in the amount of energy consumed on that peak day is significant in two ways: the peak line notably begins sooner than the peak shape for average days; and drops off earlier, and more quickly and decisively, throughout the three-hour peak period. This rapid drop is largely due to the office's HVAC systems shutting down as well as staff engaging in the savings strategies that had been previously recommended. On this day, VEIC was able to reduce its demand by 64% during the peak period and reduced consumption that day by approximately 7%.

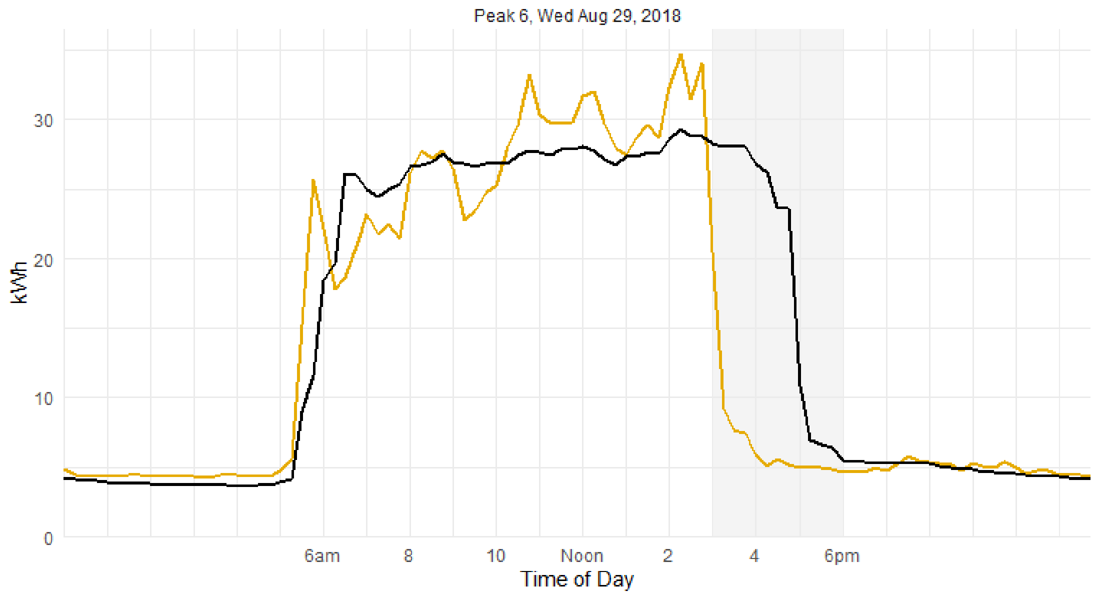


Figure 2: Data visualization of the sixth peak event, August 29, 2018, from 3:00 p.m. to 6:00 p.m., after VEIC put into place more demand response strategies.

Efficiency Vermont determined that optimal peak event management begins the night before, when an occupant needs to pull window blinds to prevent early-morning solar heating. In the summer months, blocking the sun's warming effect inside the building after business hours means less energy is required to cool the building the next day. This practice also had the added benefit of a reduced overall kWh consumption during peak days. A key finding was that the combination of behavior methods and equipment controls as demand response measures, was essential to successful peak management.

In 2019, Event 6 (Figure 4) stood out as the most successful peak performance for the season. The orange line in Figure 1 shows how on the morning of the event day, the office was operating higher than normal for the calculated baseline (in black), and around 2 PM the systems' operation in the office, as well as occupant behaviors, changed. This resulted in approximately a 40% reduction during the peak period.

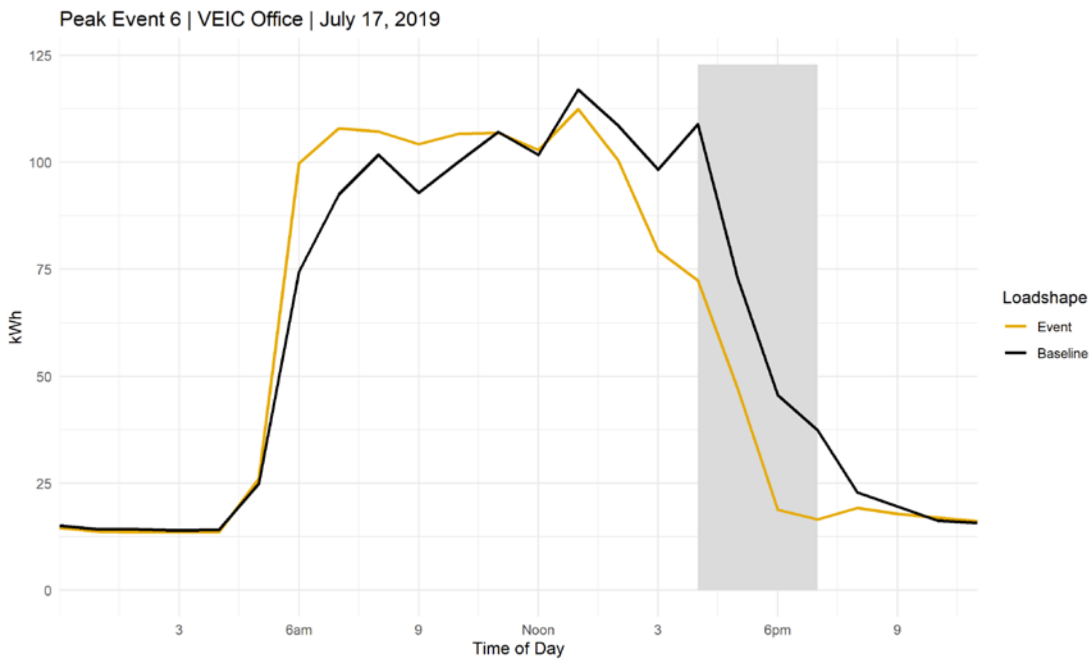


Figure 3. Summer 2019 peak event 6

Weekend peak events are an uncommon experience, but BED called two in late July 2019. The VEIC office managed to achieve some savings near the end of the peak period on this day, but the office was generally operating under the same low-usage conditions as would be the case over night. Interestingly, as Figure 5 demonstrates, for the last event of the summer energy consumption in the office spiked in the hours just before the eighth peak event on July 21, 2019, likely affecting savings performance. Program staff had intentionally come into the office over the weekend to prepare for the peak events, but it is likely that a building system was not configured properly or reacted to high temperatures that day. This speaks to both the importance of peak event participants having effective access to controls on systems that consume energy (such as HVAC systems), and also the reality that quirks in a facility’s operations may occur. Additionally, a property manager may be responsible for making these types of changes and could have other priorities around the building during the peak event or the times that require preparing systems for peak event conditions, as was the case with the building where VEIC was located.

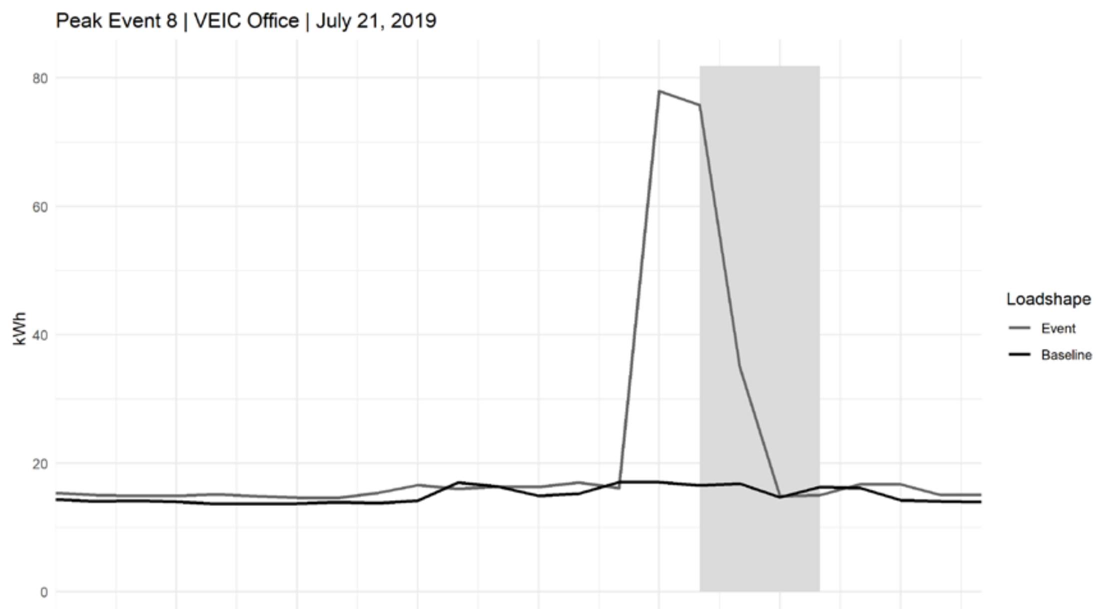


Figure 4. Summer 2019 peak event 8

Efficiency Vermont successfully changed the VEIC office occupants' behaviors to include building preparation on the evening prior to the peak day. VEIC had also fine-tuned its building energy systems to the point of being able to use less energy throughout the day, and less during the peak hours, despite the glitches mentioned previously. Efficiency Vermont successfully used lighting and HVAC controls, along with behavior changes, during the peak.

Omega Grid and DU AMI Data Challenges
Building on the experience in 2018, and to create a more refined Defeat the Peak campaign, Efficiency Vermont sought to bring a similar program experience to DU partners and large electric customers in 2019, but was delayed by the eventual timing of both the BED pilot and access to DU AMI data. At the outset, Efficiency Vermont planned to test a few customers with AMI data by the end of 2019, but myriad constraints including access to AMI data limited the ability to deeply engage with other DUs to provide a similar prototype program. As of this report's writing, Omega Grid was able to provide some details on VEIC's performance in the 2019 program, and more details of the pilot results will be shared by BED in a forthcoming APPA report. In a December 2019 communication from Omega Grid, VEIC had earned $1,864.06 in credit to its utility account based on the pilot's reward mechanism to compensate pilot participants. VEIC was ranked 2 out of 19 pilot participants in terms of savings during the pilot.

Conclusions

Shifting load effectively is possible via a combination of demand response and energy efficiency practices. This pilot project demonstrated that it is possible to manage energy consumption in commercial office buildings during peak hours and peak days, using relevant behavior change and judiciously adjusting building controls. Success with these strategies can be difficult, especially in situations when building controls are not accessible by the utility customer (as was the case with VEIC), a common occurrence in multi-occupant commercial spaces. Similar to how Continuous Energy Improvement programs engage both customer staff and facilities managers, future load-shifting programs could adopt similar program designs.

Seasonal planning is the key to achieving success. Responding effectively to peak events requires coordination and planning. Demand response also requires timely action. Because commercial building operators frequently do not have much time to react to a signal from the DU, the operators must find ways to plan ahead, both seasonally and in the event of a short-notice spike in the system. It is also important to have backup plans in place. Peaks do not typically occur on holidays, but peaks can happen while a program team member or building operator trained in reducing energy use on peak days is out of the facility (such as the weekend or during a vacation).

Enlisting the support of building occupants is important. The improved performance of the VEIC building on the sixth peak day was the result of a coordinated effort among occupants and building operators—because the occupants and operators had all been primed to get ready for peak events. However, there is a tension between frequently engaging staff to respond and burning staff out; this issue – the "False Alarm" or "Cry Wolf" effect[8] – is relevant to Demand Response as well as other climate-related events like hurricanes and floods. Research on the topic with respect to weather events[9] may also offer insights: rather than reducing 'false alarms' (in this case, calling peak events), a utility could provide estimates of uncertainty relating to when an actual peak event will likely happen.

Documenting appropriate and relevant steps takes the guesswork out of good building management practices on peak days. Creating a list of effective activities to undertake on peak days is an important element for success. Spending time *prior to* peak season to create the peak activities list is a must. It is also a good practice to solicit employee input on those activities, to ensure that energy use in all parts of the building are considered, and employees are engaged.

Testing and testing again. Planning for a peak event should include tests of operations with building operators and software managers or vendors. Even temporary failures in HVAC system settings, or lighting settings, can significantly impede energy use reductions during peak periods. Such failures can introduce or exacerbate occupant dissatisfaction if workspaces are too hot or cold, or if lighting is

[8] Lindell M.K. (2018) Communicating Imminent Risk. In: Rodríguez H., Donner W., Trainor J. (eds) Handbook of Disaster Research. Handbooks of Sociology and Social Research. Springer, Cham

[9] LeClerc, Jared, and Susan Joslyn. "The Cry Wolf Effect and Weather-Related Decision Making: Crying Wolf and Weather-Related Decision Making." *Risk Analysis* 35, no. 3 (March 2015): 385–95. https://doi.org/10.1111/risa.12336.

not working correctly. Similar to fire drills, a building team can prepare for peak events when there is low risk.

Explaining peak impacts so that everyone can understand. ISO New England peaks and the effects of reducing demand during the peak are both difficult to explain to occupants who are not familiar with energy systems. Easy-to-understand language about why peak demand management is essential. Even at VEIC, which has an energy-attuned staff, it is difficult to change behaviors. Thus, reminders of the steps to take, at a minimum, are important—especially when accompanied by a general orientation about peak management.

Sharing results reinforces future good practices. Sharing results in a timely and effective manner is important for reinforcement of peak management actions. Sharing results involves good data science systems and practices.

The time value of energy. Organizations need to understand that energy saved involves not just reducing use generally, but also deliberately timing energy use reductions. Understanding the time value of energy is important for companies, as much as it is for the regulated energy industry.[10]

The project showed value. Efficiency Vermont now knows that, in terms of effective peak management, optimal, if not maximum results are achieved when behaviors are modified, and all of the other lessons presented in this report are operationalized. Improvements to measurement and verification (M&V), including more precise and reliable baseline estimation methods, will help determine agreed-upon savings estimates and rewards.

Future Work and Program Potential

To fully utilize the emerging grid benefits from demand flexibility, new methods must serve a broad range of customer needs. Efficiency Vermont has been exploring, in strong partnership with various DUs, four demand flexibility strategies including Commercial & Industrial (C&I) automated, C&I non-automated, Residential automated, and Residential non-automated. Through the Efficiency Vermont/VEIC partnership with BED on Defeat the Peak, it was possible to test if large businesses would respond manually (i.e., non-automated) to requests for energy use reduction at specified peak hours in exchange for a non-monetary incentive. Efficiency Vermont hopes to continue the pilot and data analysis with BED in 2020 to further test and learn how this approach to demand flexibility may work.

While 2019 faced a set of limitations due to data access and the Omega Grid system's roll-out, the results remain promising for future activities and the approach

[10] To date, *investment* language for energy efficiency and other demand-side management strategies has been relevant for customers, just as is the concept of *paying for peak performance*. However, the true and positive effects of peak management have traditionally eluded comprehensive evaluation—and subsequent appropriate valuing. Demonstrating the impacts in terms of $0.15 / kWh leaves little customer incentive to reduce demand (measured in kW, not the kWh of consumption). Appropriately valuing the kW reductions can provide customer motivation to change practices, while making peak management strategies and outcomes easier to comprehend.

taken in the VEIC office clearly yielded benefits to BED and VEIC's energy costs. Efficiency Vermont can extend this experience, building partnerships with DUs to develop action plans, protocols, and support systems to prepare building occupants for peak events, similar to how Strategic Energy Management can empower C&I properties to adjust behavior with a structured, measurable method.

Should Efficiency Vermont be able to partner with DUs and build on a set of analytic tools, the following elements can bring value to Efficiency Vermont's stakeholders:

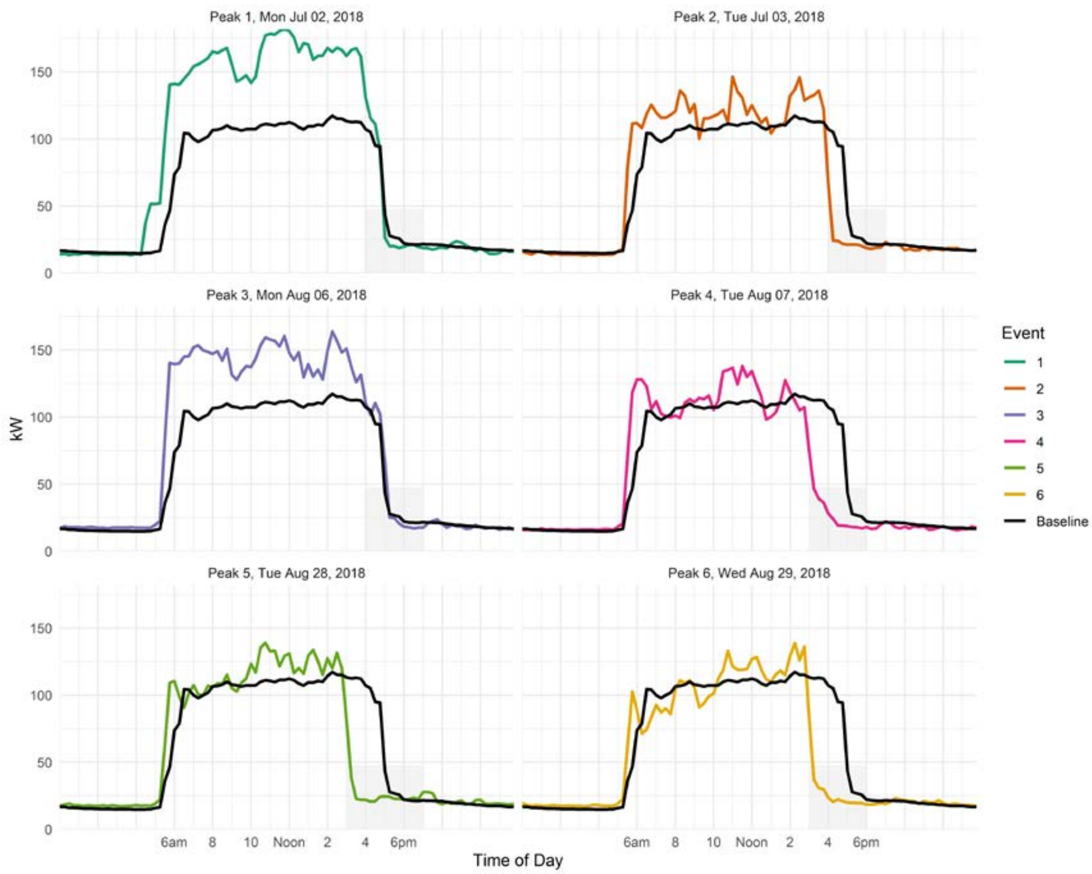
- **Creation of a seasonal peak management package** to make it easy for non-energy experts to participate and earn savings.
- **Seasonal announcements and tips** to share with coworkers in the event of a peak event being announced
- **Employee surveys / interviews** for program evaluation and success
- **Peak management activities list** (including strategies and protocols) that are in alignment with existing efficiency programs
- **A menu of communications** (day-before-peak announcements, morning-of-peak-event reminders, peak-event-starting notifications, and peak-event results) to help deploy peak management services to participating organizations.
- **Savings analysis services** aligned with agreed-upon best practices, leveraging existing in-house M&V assets.

Appendix

The following figures present ensembles of VEIC's office peak event performance compared to baselines used for each peak event during the 2018 and 2019 summer seasons.

2018 Summer Season Peak Events

The baseline used in 2018 was consistent and derived from historically hot non-holiday weekdays prior to the first event of the 2018 season.



2019 Summer Season Peak Events

Baselines for each event in 2019 were derived using BED's method (abstracted from the Enel X (formerly known as EnerNOC method) to estimate typical energy consumption for that day. In this ensemble figure, the y-axis is fixed for all events, so the disproportionately-low energy consumption on the weekends is visually suppressed.