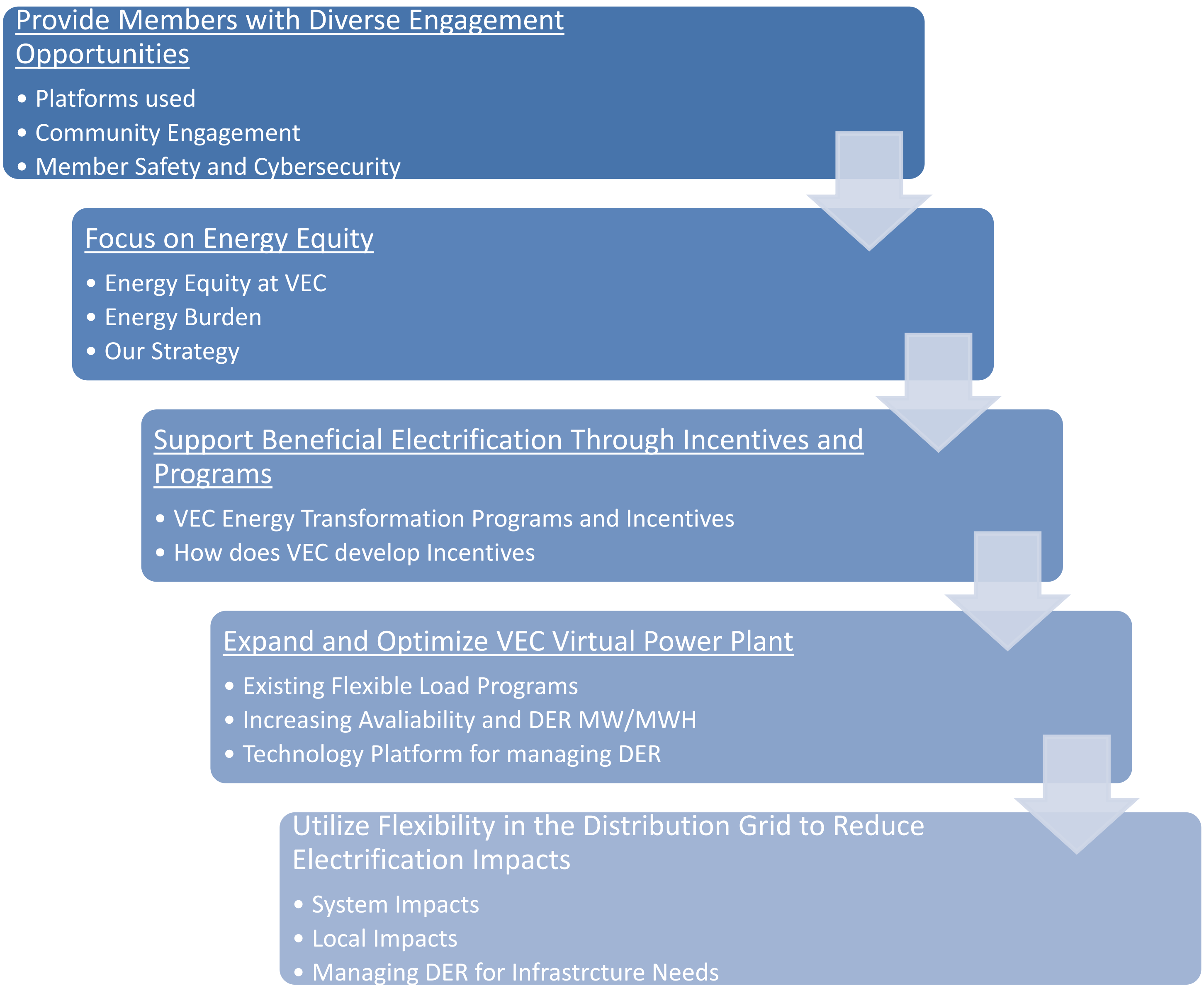
4 Engage Members

4.1 Introduction

This section of the IRP contains an overview of VEC's member engagement, energy transformation programs, energy equity focus, flexible load programs, and electrification impacts to the grid. As we act to ensure a cleaner energy future, our members continue to be at the center of everything we do. Through continued member engagement and innovation, we will create a resilient, reliable, and affordable power system.

4.1.1 Section Overview



Providing our Members with Diverse Engagement Opportunities

VEC has a proven track record of creating exceptional member service and satisfaction. Informed by various sources of data, including annual member surveys, member requested work feedback postcards, analytics of our digital communications, and direct face-to-face feedback. VEC continues to refine our practices to continuously improve the member experience. Courtesy, timeliness, clarity, and transparency are key guideposts for all our member interactions.

Broadly speaking, there are many factors that require VEC to think ahead, innovate, and implement new ways of keeping members engaged and informed. Demographic changes are increasing the proportion of our members who are involved in how they use energy, requiring a more performance-based, real-time, and digitally driven member experience. Member expectations regarding reliability continue to evolve as more people work from home and more people move to our state from less rural areas. Members expect fewer outages and more real-time information about restoration estimates. Changing regulatory requirements also translate into new programs for members. As weather continues to challenge the reliability of the grid, we will need to be anticipatory and fast-acting in our member communications. Finally, as-yet-unknown trends in the utility sector will push us to continue to be creative in seeking ways to improve the member experience.

4.1.2 Platforms Used

VEC's member experience takes many forms. We work to "meet members where they are at" which may be phone, postal mail, digital via apps, email, webinars, or in person. Members have face-to-face contact with field staff, including line workers and meter technicians, and connect with VEC staff and directors at VEC's Annual Meeting and other community events. Phone communication continues to comprise a considerable amount of our member contact, with approximately 4,700 incoming calls on average per month. Other member communication mechanisms include:

- Messages via email, SmartHub and VEC website on-line forms
- Monthly on-bill messages, bill graphics and bill inserts
- Social media channels including Facebook, X (formerly Twitter), Instagram, LinkedIn, and Front Porch Forum.
- Outgoing automated calls and text alerts
- A three times a year publication of the "Co-op Life" Newsletter distributed to all members by their chosen preference, hard copy, electronically, or both.
- Community engagement events including annual meeting
- Innovation webinars

VEC continues to encourage our members to sign up for and use our on-line portal and app, SmartHub. SmartHub allows members to check electric usage, pay bills, enroll for paperless billing, and get alerts of various types. At least 85 percent of VEC members have signed up for SmartHub. Approximately half of those are also signed up for paperless billing available through the portal. These numbers continue to grow over time.

"Convenience! 100 Percent."

That is how one member recently described SmartHub in a social media post. Another member, Patty Titus of Hinesburg, had this to say:

"We love SmartHub. It lets us see our usage so we can make changes in how we use electricity so we can lower our bills. It's also easy to pay your bill through the portal, and we love the outage feature too."

4.1.3 Community Engagement

A significant focus of VEC's member engagement involves community/field visits within our service territory. For example, VEC sets up at farmers' markets, in front of hardware stores, and other public events including fall Drive Electric events. We also visit local energy committees and public safety organizations in our member communities and host school field trips to VEC facilities. Over 200 VEC members also gather at the VEC Annual Meeting that is held every May. In addition, more than 2,500 VEC members are engaged by supporting their local communities by rounding up their bill or donating their annual member capital to the VEC Community Fund, which provides small grants to support local, non-profit organizations. Finally, approximately 400 members have signed up for VEC's voluntary Beat the Peak program. These members have agreed to be alerted to opportunities to reduce their power usage to help the Co-op save money on power and transmission costs.

As would be expected with any membership organization such as VEC, levels of member engagement vary. Most of our members have regular but basic contact with VEC. They receive and pay their bills and receive our newsletter and general email updates. Other members are more frequently engaged, following us actively on social media and inquiring more regularly about innovative projects or energy efficiency opportunities. A smaller group is engaged particularly with VEC's energy transformation projects, enrolling in innovative technological programs. And, given our demographics, we have ongoing engagement with members who struggle to pay their bills and may face disconnection. As we focus on our core mission of delivering safe, affordable and reliable electricity and at the same time embrace changes in the electric industry, VEC works hard to provide the best member service possible to all members no matter their level of engagement.

A critical element of VEC's ongoing enhancements to the member experience is continuing to focus on data as a key tool to optimize our communications. We track a range of metrics, including year-to-year answers to repeat questions on our member survey, social media followers, and the level of engagement (open rates and click rates) with our email communications. We also have enhanced our web presence and, importantly from a member experience perspective, have adopted a system of enrollment forms that has streamlined processes.

4.1.4 Community Fund

The VEC Community Fund, supported entirely by voluntary donations from VEC members, is intended to strengthen the community by awarding grants to organizations that promote community development and economic security - underscoring the basic cooperative principle of "concern for community." The fund awarded its first grant in 2015 and by the end of 2024 has awarded over 220 grants to organizations across the VEC region, totaling over $170,000. Applicants are asked to address how their funding request applies to one or more of the following Focus areas:

- Economic Security
- Emergency/Disaster Relief
- Community Support/Development

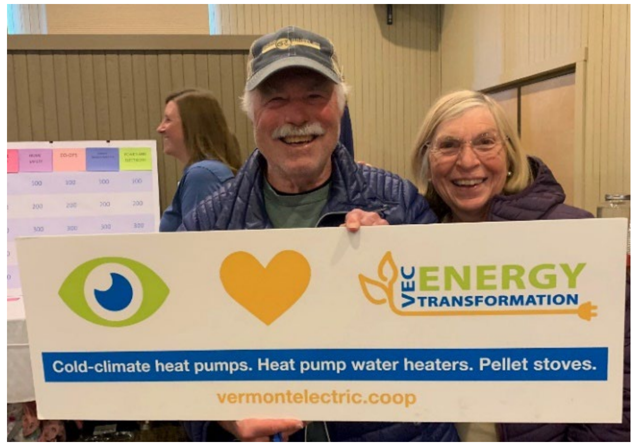
The Community Fund offers VEC an opportunity to engage with many of our low income and other disadvantaged community members. Some of the recent grant recipients include Adult & Teen Challenge Vermont, Central Vermont Council on Aging, Johnson Health Center, Age Well, Hardwick Food Pantry, Westfield Senior Meals, Wood4Good, Abenaki Nation of Missisquoi Food Pantry, and many others. All grant recipients can be viewed here: https://vermontelectric.coop/community-fund

4.1.5 Bruce Lamb Memorial Scholarship

The sponsorship which is part of the Vermont Scholarship Fund is sponsored by Vermont Electric Cooperative Employee's Fund. This scholarship was created in memory of Bruce Lamb, a first-class lineman who passed away in a fatal accident while performing his job. He was devoted not only to his job, but also to his co-workers and friends. His career as a lineworker lasted 34 years. The scholarship, funded and administered by his former co-workers, provides financial aid for students accepted to an accredited lineworker school. Applications are accepted from students in Addison, Essex, Franklin, Orleans, Caledonia, Grand Isle, Chittenden or Lamoille counties.

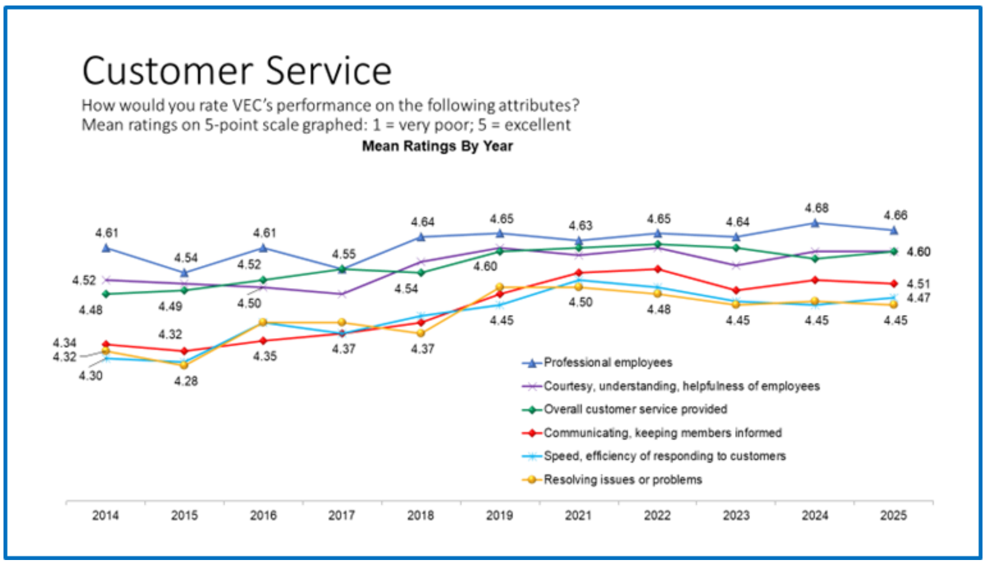
4.1.6 Annual Meeting - Fundamental to Member Experience

One of VEC's key elements of our member experience is our Annual Meeting held each May. At this half-day event, we finalize the board election, offer an update on co-op activities, highlight exciting trends and opportunities in the energy sector, and hear from members. Recent updates from VEC leaders have included the growth of electric vehicles, how VEC will handle increased load from electrification, and the changing climate and its effect on the reliability and resilience of the system. The event includes a free and lively social breakfast buffet, door prizes, and display tables covering various topics of interest, including a table dedicated to safety. In recent years, Annual Meeting has drawn approximately 200 members.



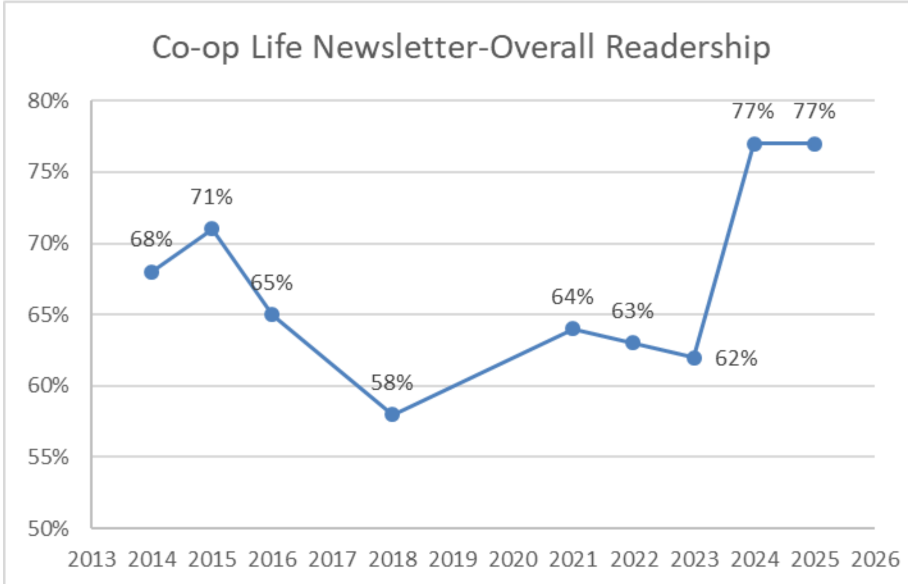
4.1.7 Annual Member Survey

VEC's Annual Member Survey is a unique opportunity for VEC to obtain valuable feedback from members about our performance and policies. The survey measures members' views on various subjects, including employees' courtesy, understanding, and helpfulness; our performance for field services and outage response, VEC's public policy priorities; and overall customer experience. We also use the survey to gauge member interest in new and innovative energy programs and technologies. Member survey results are available on our website here.



4.1.8 Coop Life

A key component of VEC communications is our Co-op Life newsletter. Co-op Life keeps members up-to-date on the latest news from the co-op. We highlight new programs and incentives, VEC Co-op Community Solar, VEC Community Fund, VEC employees, billing and rates, VEC Annual Meeting and the Board of Directors election among other topics. Co-op Life also serves as a key mechanism for VEC to provide required regulatory notices to members. Co-op Life is delivered in two ways: digitally to all members for whom we have email addresses, and in hard-copy, mailed to all members who have not opted solely for the digital version.

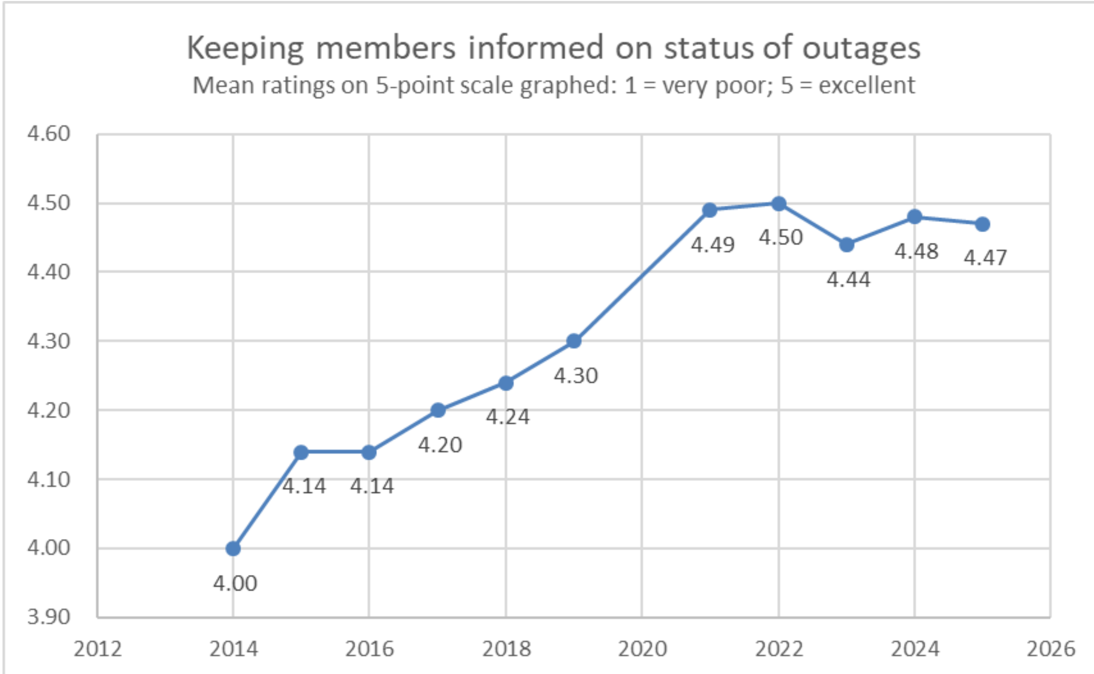


4.1.9 Commercial and Industrial Newsletter

VEC offers to our Commercial and Industrial (C&I) members a special e-newsletter tailored specifically to their needs. This newsletter is sent to just under 3,000 C&I members quarterly. Subjects include energy efficiency opportunities for businesses, reliability, safety tips, and incentive programs targeted toward commercial and industrial activities.

4.1.10 Outage Communications

Information about outages, both planned and unplanned, is the highest member communication priority. Our members need accurate and timely information. VEC deploys a variety of communication mechanisms to keep members informed which vary depending on the duration and extent of the outage. We continuously improve our online outage page and an associated phone app which provides comprehensive information on affected towns with an account lookup function that provides detailed information about their individual outage. We continue to refine our Estimated Time of Restoration (ETR) processes so that members can have a realistic expectation for their outage duration. Members also have the opportunity via the SmartHub system to sign up for text or email outage alerts. Social media, web page alerts, and customized phone messages for incoming calls also keep members up to date.



4.1.11 Member Safety and Cybersecurity

Member safety and cybersecurity are of the highest priority in our member communication activity. Safety and cybersecurity messages are delivered via video, emails, social media posts, earned media, and in Co-op Life. Topics range from outdoor do-it-yourself safety tips relating to use of ladders, lawn mowers, and chainsaws, to driving and parking tips, to outdoor recreation safety advice. VEC is proud of our certification as a VOSHA VPP site and we feel it's important to bring our strong organizational safety culture to our membership.

4.2 Focus on Energy Equity

Energy equity, the fair distribution of energy benefits and burdens, and the creation of inclusive energy systems, is a value that has been embraced by VEC since our formation. The Cooperative Principles, shared by all cooperatives, embody the key principle of not leaving the most vulnerable behind and knowing that when we work together, we are stronger. As a not-for-profit rural cooperative, VEC has always held equity as a fundamental principle. Now, and in the coming years, as we participate in a once-in-a-century power sector transition, we are as acutely aware as we ever have been of our obligation to live by this tenet.

For a co-op like VEC, the concept of working together – members, staff, our Board of Directors, our broader community – toward a common goal is central to how we operate. Many of the principles that apply to co-ops generally – things like democratic member control, member's economic participation, and concern for community – all are key guideposts for VEC. They are, ultimately, about fairness and equity.

4.2.1 VEC's Equity Challenge

The coming years will bring continued cost pressures that will test all utilities' commitment to their members/customers, particularly their low-income members who often have high energy burdens. As a cleaner and more modern energy system evolves over time, there should be long-term cost reductions for VEC members in aggregate. But in the meantime, hurdles remain for many of our members to take that step. The up-front cost of weatherizing a home, moving to heat pump heating, purchasing an electric vehicle, or participating in solar energy, can be prohibitive.

Adding to the challenge is the political and public perception that energy transformation is for more affluent people and will leave lower income and rural people behind. We need to ensure that this perception is disproven and work together to minimize cost shifts and increased energy burden on lower income Vermonters. We must ensure that the benefits of a transition to a cleaner and more efficient energy system are realized by all.

Furthermore, as the energy economy shifts, there will be labor market and employment changes as well that, while offering some positive opportunities, could bring some dislocation as well. These adjustments could have an impact on VEC members. As is suggested in the state's 2022 Draft Comprehensive Energy Plan, it is imperative that VEC and all utilities take specific steps to assure equity as the energy economy changes, to guarantee a just transition that serves all Vermont electric customers. In fact, the transition presents an opportunity to support Vermonters who have heretofore not had access or ability to participate in the building of or participation in a more inclusive energy system.

VEC is well-positioned to take on these challenges, because they are close to home.

VEC's Member Survey

As noted, VEC implements a professionally designed and statistically significant member survey annually where we collect self-reported household size and income data from a sample of VEC members In VEC's 2025-member survey of 1,255 members, 57 percent of respondents were aged 65 or older. Over 64 percent were retired or employed less than full time. We have an older and rural demographic (lower and fixed incomes) in many parts of our service territory.

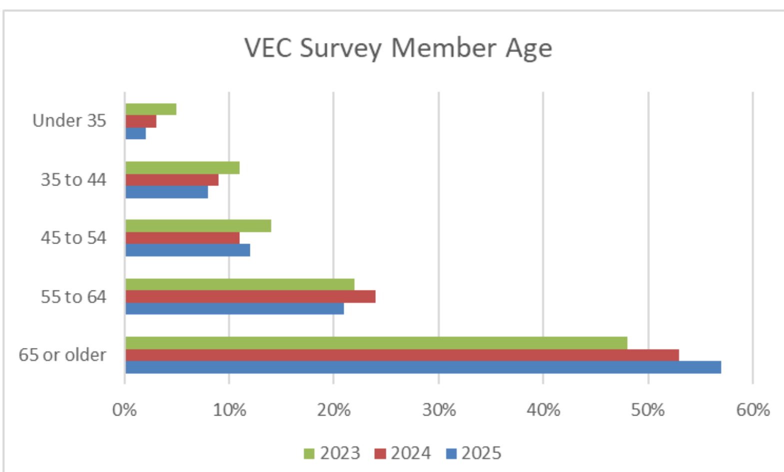


Figure 4.2.1.A Age Demographics from VEC 2025 Member Survey results

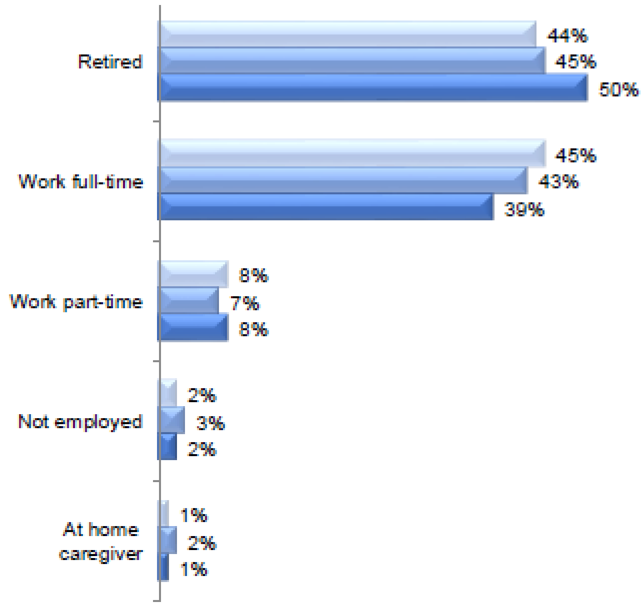


Figure 4.2.1.B Employment Status from VEC 2025 Member Survey results (Darker blue is 2025)

Efficiency Vermont 2023 Energy Burden Report

It is well understood that the cost of many necessities, including electricity, are regressive in nature. The relative burden to heat a home, or fill up a car with gas or electricity, is greater the less money one has. The burden is often compounded when there is no extra money to buy a fuel-efficient vehicle, or to invest in thermal insulation, for example.

In our daily interaction with VEC members we understand the burdens they face and we are committed to doing our part to ensure that the cost for this most essential basic service is manageable and sustainable for all VEC members.

When Efficiency Vermont published the 2023 Energy Burden report https://www.efficiencyvermont.com/news-blog/whitepapers/vermonts-2023-energy-burden-report

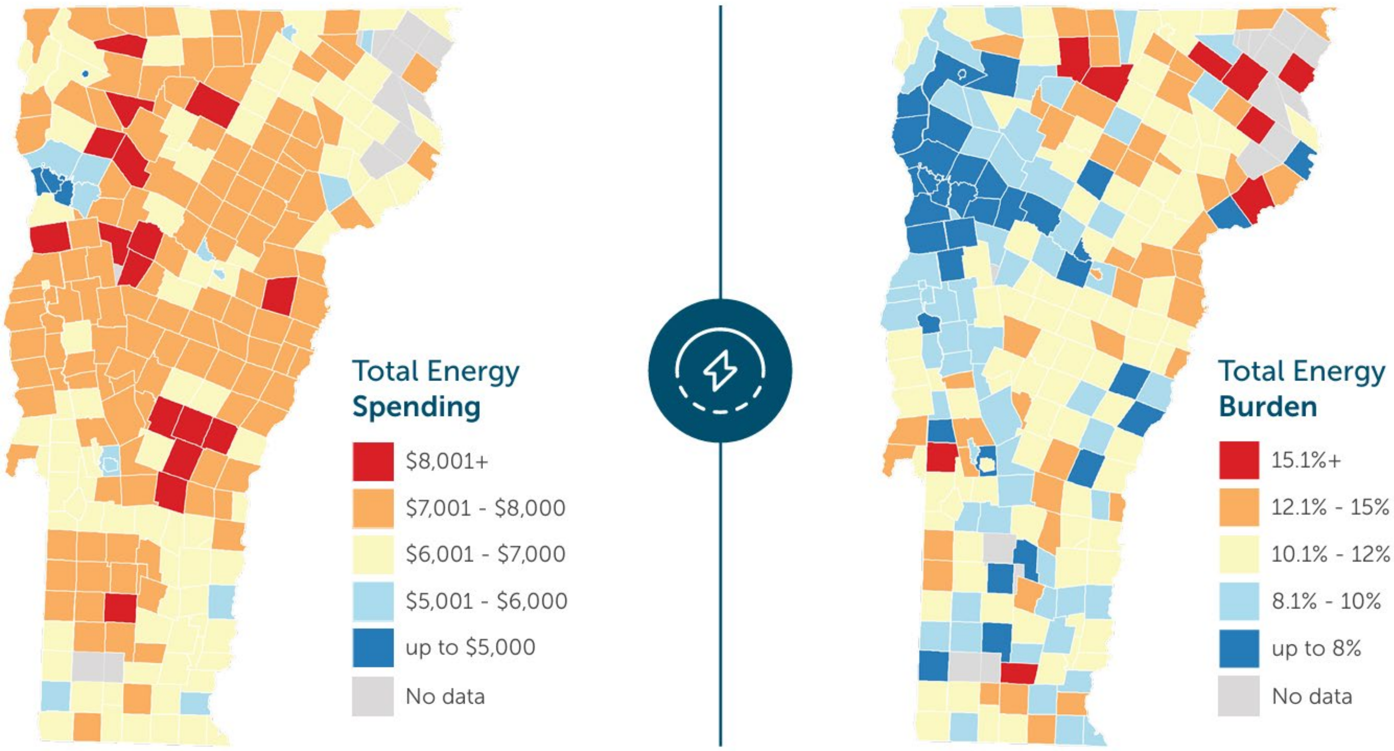
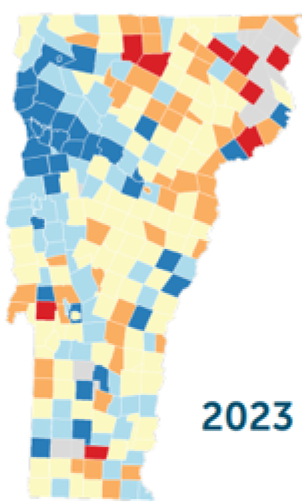


Figure 4.3.2.A Efficiency Vermont 2023 Energy Burden Report

VEC was not surprised to learn that VEC serves seven of the top 11 towns, and three of the top five counties, with the highest energy burdens in the state.

Energy Equity and Affordability



2023 Efficiency Vermont Energy Burden Report
Red areas indicate high burden and blue areas indicate low burden.

7 of top 11 Towns with largest energy burden

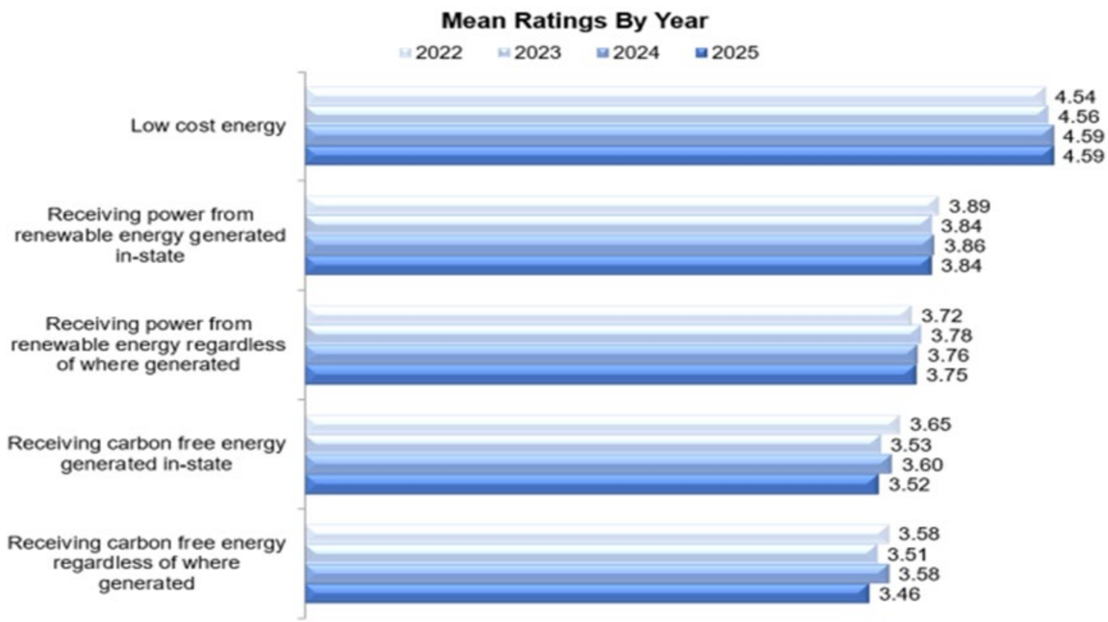
Montgomery	Franklin	23.1%
Charleston	Orleans	19.1%
East Haven	Essex	18.9%
Lowell	Orleans	17.1%
Concord	Essex	15.9%
Brighton	Essex	15.5%
Castleton	Rutland	15.2%
Dover	Windham	15.2%
Bloomfield	Essex	15.1%
Eden	Lamoille	14.8%
Jay	Orleans	14.7%
Pawlet	Rutland	14.7%
Windsor	Windsor	14.4%

4.2.2 Strategy and Programs

Rate Containment

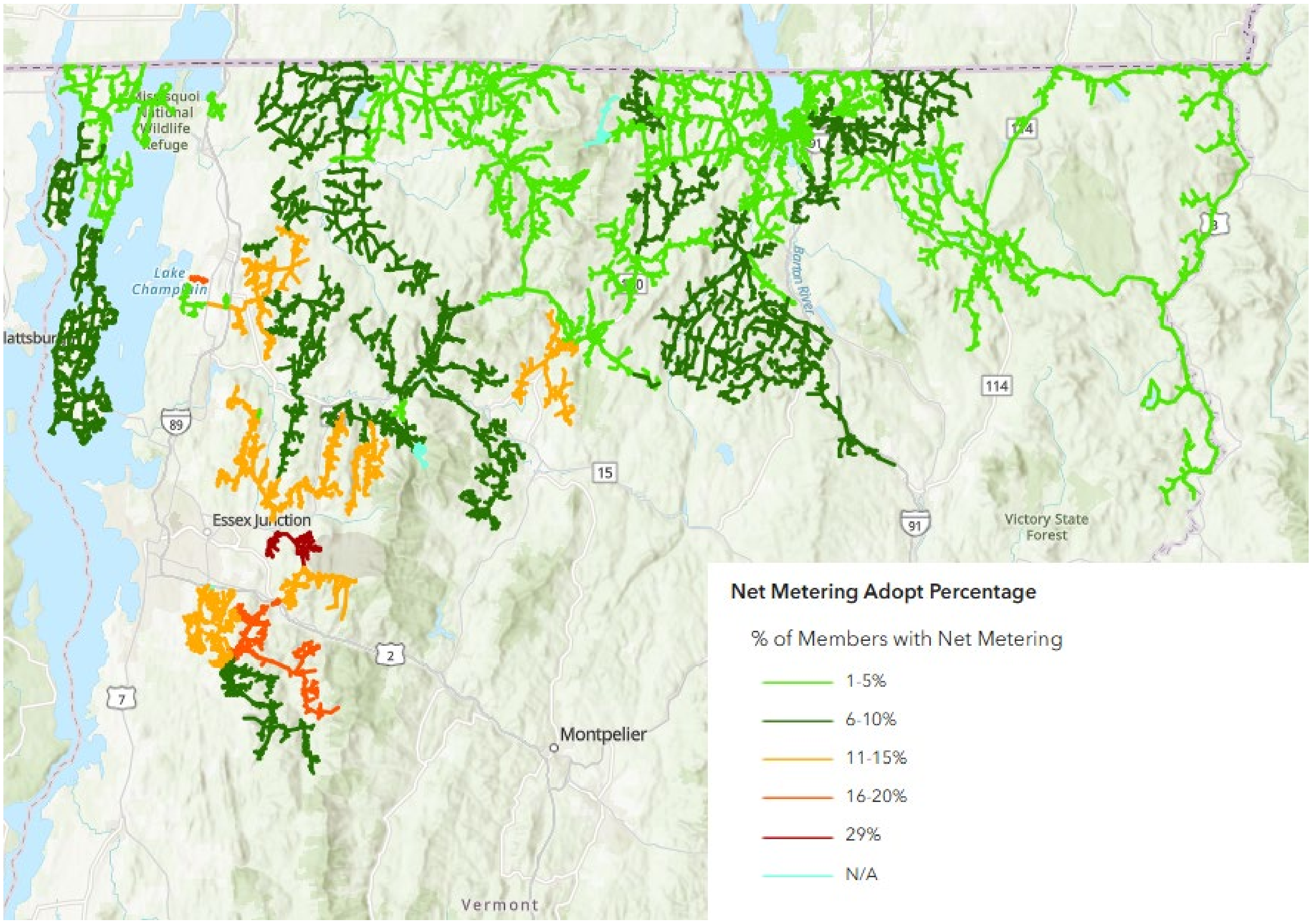
Keep rates as low as possible: A priority in promoting a just transition for our members is a simple, tried-and-true strategy: keeping rates as low as possible. If the 2025 VEC rate request is approved, VEC will have a 10-year average annual rate increase of 2.66 percent, which is below the average rate of inflation for the period. Increases in transmission costs, property taxes, and inflationary costs of wages, benefits, and interest rates are challenging our ability to contain rate increases. VEC will continue to advocate in regulatory and legislative processes to reduce unnecessary cost pressures.

In our -annual member surveys we consistently hear from members that low cost of power is the most important power supply priority, more important to the VEC respondents than carbon-free or renewable energy. This feedback informs not only our power supply decisions but also our policy advocacy at the statehouse and before the Public Utility Commission.



Affordable Clean Renewable Energy - ACRE Solar

We have found in our analysis that existing renewable energy programs such as net metering are not equitable. Uptake is higher in our higher income communities and that is not acceptable or sustainable because costs are shifted to lower income community members. VEC has mapped income and net metering adoption below, the data is also available on our website



The ACRE solar program, supported by a grant from the Department of Public Service through ARPA funds, provides meaningful reductions in electric bills for income-qualified members by sponsoring shares in community solar projects. Participants receive a fixed monthly bill credit of $45 for five years, totaling $540 annually and $2,700 over the sponsorship term. The program is a no-cost sponsorship for Vermont Electric Co-op (VEC) members who income-qualify, meaning there is no up-front payment or additional charge to these members. To be eligible, participants must be residential members of VEC and have a total gross household income at or below 185 percent of the federal poverty level.

VEC launched the program in the summer of 2024 using the Jericho Landfill solar project as the host site. Phase 1 of the program included 365 members and was fully subscribed to by the end of October 2024.

In July 2025 VEC obtained an ACRE grant amendment to provide funding for Phase 2 of the program using the Jericho Gravel Pit solar site to serve an additional 307 VEC members. When fully implemented 672 income-qualified VEC members will obtain 5 years of significant bill assistance, directly reducing their energy burden.

Another income qualified renewable energy program recently implemented is in partnership with Northeastern Vermont Development Association, where we have secured grant funding to support enrollment of 20 income qualified members in Orleans County in VEC's Cooperative Community Solar Program. This program involves the upfront payment for sponsorship of 16 program panels, resulting in a monthly bill credit of $43.52 every month for a 10-year term.

We are finding programs such as these engage income qualified members into our renewable energy future in ways that do not require upfront payments which would limit participation in these communities.

ESAP Income Qualified Storage

The Energy Storage Access Program (ESAP) is designed to provide battery storage solutions to income-qualified residential and municipal members. The primary goals of the program are to enhance resilience, support income-qualified households, and address emergency needs. By providing backup power during outages, the program ensures that essential services such as refrigeration, medical equipment, and heating remain operational. It targets low- and moderate-income households, making battery storage accessible and affordable for those who might not otherwise be able to afford it. Additionally, the program helps households manage during emergencies, reducing the impact of power outages on vulnerable populations.

The program is funded through a state grant, which enables low or moderate-income homes to receive battery storage at no or a heavily discounted cost. VEC expects to enroll approximately 55 low and moderate-income members in the initial phase, with the batteries provided being used for peak reduction in addition to resilience. VEC was unable to demonstrate a reasonable ROI for battery investment, so our existing battery storage program is "bring your own device." This grant funding bridges that gap and provides VEC with an avenue to offer batteries to members.

Energy Transformation Programs

An important goal that we continue to track, is for our energy transformation program uptake to reflect our energy equity goals. In 2024, there were 123 (self-reported) low-income member participants in VEC's energy transformation program out of 763 total participants (16%). However, spending on incentives for low-income members was 27% of the total residential spending because of enhanced and targeted incentives.

In 2022 we implemented an LMI heat pump program with financial support from VLITE and in partnership with EVT. To date, 41 low-income members who had also completed a project through the Weatherization Assistance Program have received a free heat pump installation, and 7 moderate-income members received an enhanced heat pump incentive of $2000. We increased our income-eligible electric vehicle bonus to $500, which 61 members took advantage of in 2024. Two members are also participating in the Weatherization Repayment Assistance Program, which provides low-cost, on-bill financing of weatherization projects, in partnership with VHFA. Through energy transformation programs and incentives, VEC continues to help members save money and avoid volatile fossil fuel prices.

Partnerships

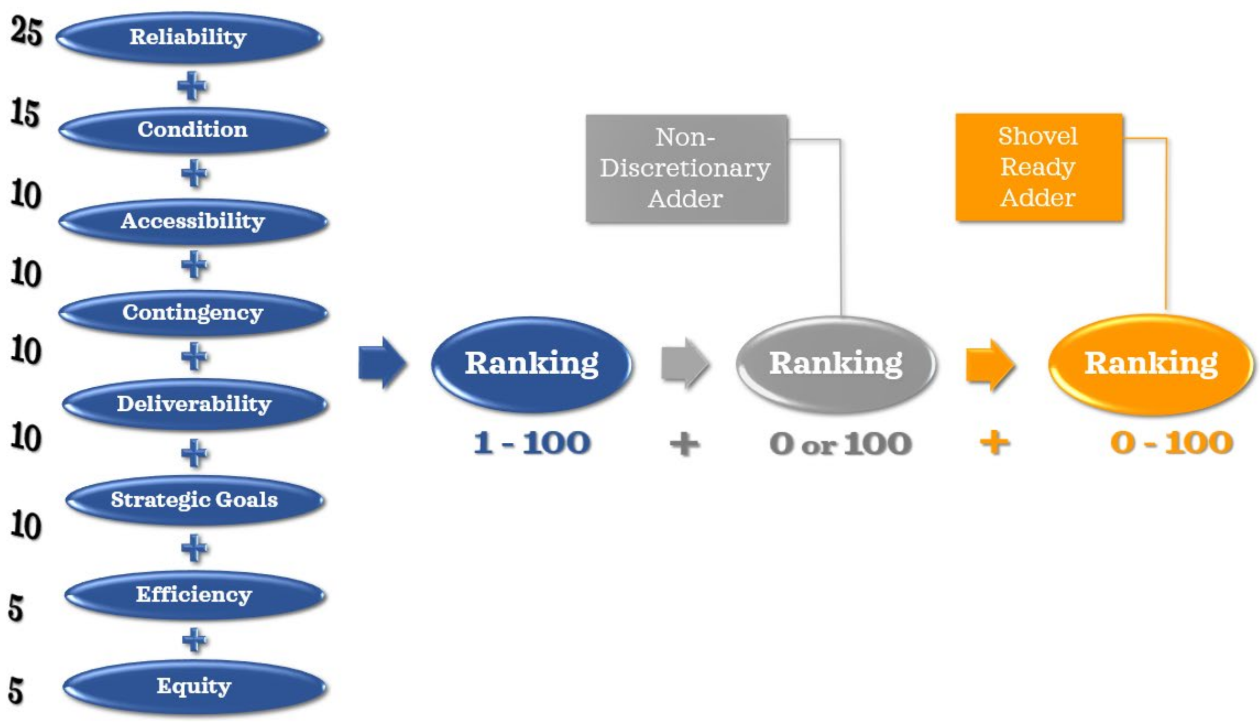
VEC collaborates, shares information and participates in a variety of programs developed and managed by community action groups such as Northeast Kingdom Community Action (NEKCA), Capstone Community Action and Champlain Valley Office of Economic Opportunity (CVOEO). These organizations provide free coaching services and assistance to low- to moderate-income individuals and families, and prioritizes BIPOC (Black, Indigenous, and People of Color) and New American communities. Coaches help to navigate the complex landscape of Vermont's services and programs provided by energy efficiency utilities, financial institutions, local utility companies, fuel providers, and others. By providing our members with higher resolution AMI data and access to more programs VEC believes that we will help accelerate the capabilities of these community action groups.

Additionally, VEC works closely with over 15 Vermont town energy committees and Vermont Energy and Climate Action Network (VECAN) , and several Regional Planning Commissions to develop and enhance town energy plans. Local energy committees are at the forefront of a robust grassroots initiative addressing the urgent imperative to enhance energy efficiency, promote in-state renewable energy generation, and curtail greenhouse gas emissions.

Under Act 174 of 2016, towns and regional planning commissions can present improved energy plans to the Vermont Public Utility Commission. Upon approval, these plans are granted "substantial deference," particularly in matters related to permitting energy projects

T&D Prioritization

As is described in more detail in Section 6, VEC uses a capital prioritization framework for all capital investments that includes a category for equity.

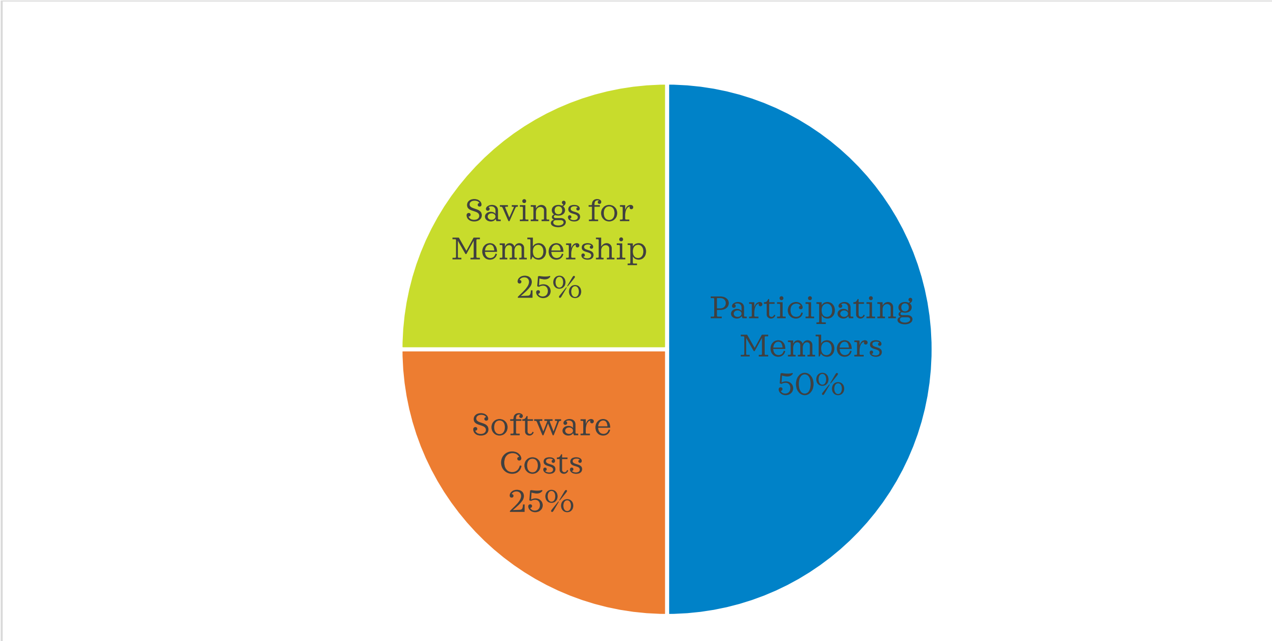


VEC ranks each project based on a variety of criteria. Projects that impact towns with higher energy burdens receive a higher ranking.

Value	Description
0	Project impacts town(s) with energy burden up to 12%.
0.5	Project impacts town (s) with energy burden between 12.1% - 15%.
1	Project town(s) with energy burden over 15%.

Flexible Load Program Design

VEC has a variety of Flexible Load programs, but all share a common goal – maximize the value to non-participating members. While most enrollees in the program are not income qualified the program design ensures that all members save when we enroll a new device into the program



For example, VEC currently sees an average kW usage across the EV fleet of a little over 1kW during peak times. VEC can save $204/kW if load is decreased during the 13 (annual ISONE FCM and monthly Vermont RNS) transmission peaks. VEC provides participating members with a $96/year ($8/month) bill credit. This leaves ~$100 to cover software costs and demonstrate savings to the entire membership.

Other Programs

VEC's annual operating plan contained special programs focused on LMI members. These include:

- **Bill pay assistance**. This includes budget billing, payment arrangement, promotion and support of state arrearage assistance programs. VEC vigorously promotes the VERAP and VEHAP arrearage assistance for income-qualified members.
- **Rural and High Energy Burden Pilot Projects**. Each year we plan on targeting one or more of our rural and lower income communities for focused project implementation. Working with community partners we will identify projects that will support energy efficiency and energy transformation and bring financial benefits to the community. Example include street light upgrades, joint grant applications for electric school buses or building weatherization, etc. As pilots are completed, we will evaluate lessons learned, transferability, and scalability.
- **Energy Equity Advocacy**. At the statehouse and at the Public Utility Commission, VEC is committed to be a voice in support of lower income and rural communities. When we see programs that will cost shift without direct benefit to these communities we weigh in as resources allow.

4.3 Support Electrification Through Incentives and Programs

As part of a larger goal to meet the climate needs of Vermont, VEC utilizes a portfolio of projects and programs to decarbonize the heating and transportation sectors. VEC offers incentives for several Tier III measures such as heat pumps, heat pump water heaters (HPWHs), EVs, pellet stoves, inductive cooktops, electric forklifts and electric lawnmowers. VEC also offers discounts on line extensions and service upgrades for larger custom projects that result in the elimination or reduction of fossil fuel usage. Additionally, VEC works with partners on non-electric efforts such as weatherization.

Tier III of the RES requires that Vermont retail electric providers achieve fossil-fuel savings from energy transformation projects at a level equivalent to 2% of the utility's annual retail sales (BTU equivalent) beginning in 2017, increasing by 0.667% each year until reaching 12% in 2032.

4.3.1 Meeting Tier 3 Requirements

As shown in Figure 4.2.5.A below, VEC has exceeded its Tier III targets since the program started in 2017. We anticipate continuing to do so and the following section provides an overview of our assumptions and forecasts for energy transformation we expect to see in our service territory. We currently have a bank of over 190,000 MWh, more than our goals due in large part to the success of the Clean Air Program.

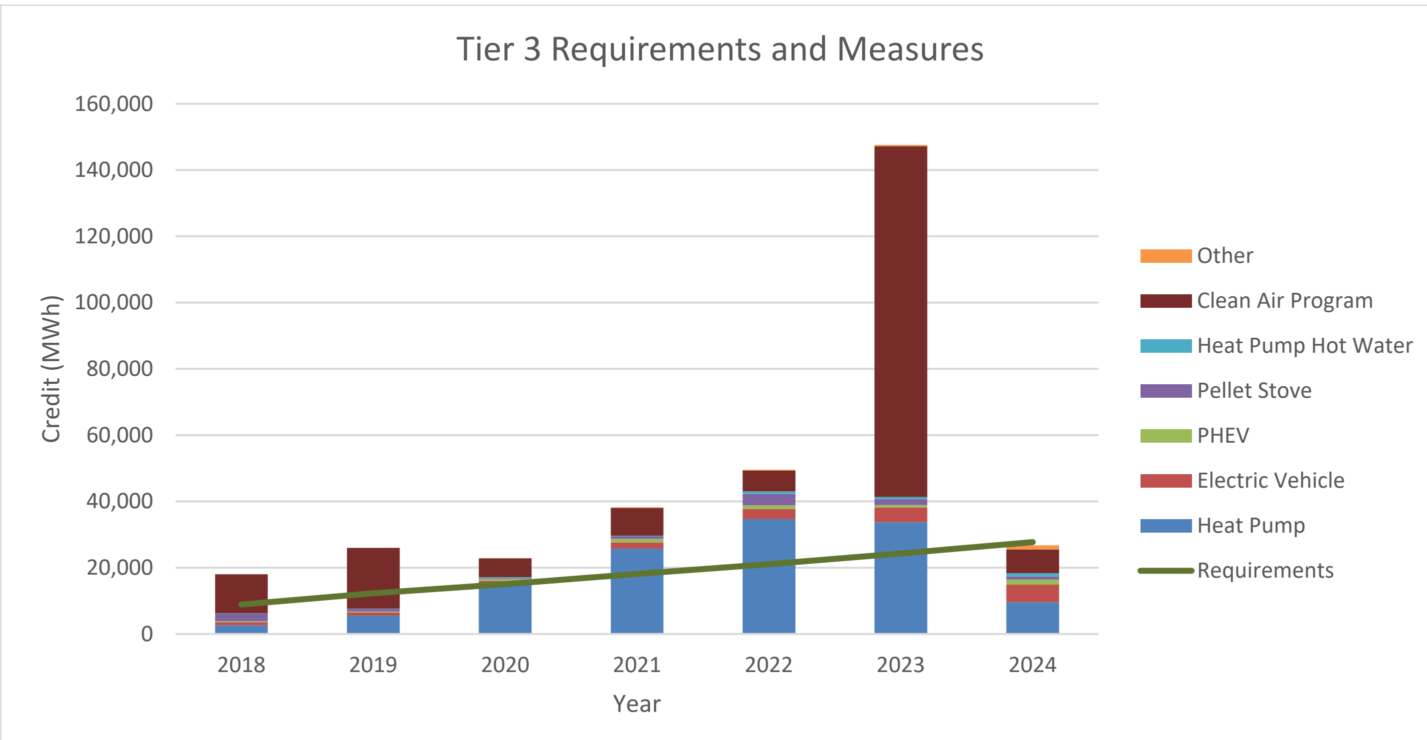


Figure 4.2.5.A VEC's Requirement for Tier III and type of Energy Transformation used to meet the goal

4.3.2 Programs and Incentives

VEC's Tier III programs and incentives come in several categories:

Heating and Cooling | Transportation | Home and Communitiy | Line Extensions and Increase in Service

Heating and Cooling

Heat Pumps, Heat Pump Water Heaters, and Pellet Stoves

VEC provides incentives for the above device types.

On-bill Financing Pilot Project- Weatherization Repayment Assistance Program (WRAP)

VEC is working with Vermont Housing Finance Agency (VHFA) and a coalition of distribution and energy efficiency utilities to implement a "to-the-meter" tariff that would allow energy efficiency, electrification, and weatherization projects to be paid for through the electric bill. In addition to "on-bill financing," the program would include:

- a low-cost energy audit for income-qualified participants
- additional incentives to help make the projects more affordable (up to $1 million, maximum of $20K each)
- the program will be accessible to renters in addition to homeowners

VHFA was allocated $9 million to support this effort over the next two years with 1,000 participants anticipated statewide. The program was launched in 2024, and VEC currently has two members enrolled.

VEC Low- and Moderate-Income Heat Pump Incentives (Act 151 + VLITE grant)

The cost of these heat pump installations is being shared between VEC and Efficiency Vermont through funding authorized by Act 151. In 2022, VEC was awarded $100,000 from VLITE to help low- to moderate-income members pursue thermal fuel-switching, which will help them reduce fossil fuel usage and save money on heating. The target population is those who have already pursued weatherization through the Weatherization Assistance Program (WAP) or Efficiency Vermont programming.

- Eligible members are those who meet income eligibility and have homes that have been weatherized.
- At or below 80% of AMI (low income): Free installation. Around 34 units have been installed to date.
- Between 80% and 120% of AMI (Moderate income): $2000 per unit on top of existing incentives. Seven units were installed.
- An estimated 50 units total will be installed in VEC's territory.

Transportation

AEVs, Plug-In Hybrid Electric Vehicles (PHEVs) and Chargers

VEC provides bill credits for both All Electric Vehicles (AEVs) and Plug-in Hybrid Electric Vehicles (PHEVs).

Since 2023, VEC has provided a free home level II charger to members. Participants are responsible for the installation and must enroll the charger in VEC's communications platform. When VEC expects peak demand, we send a signal to the charger and request that it not charge during that time, typically 2-4 hours.

VEC also offers an incentive of $250 for members who purchase their own level II charger and set a schedule to avoid charging from 5-10 pm Monday – Friday.

VEC Low Income Adders for Income Qualified Members

VEC provides a low-income adder of $500 to income-qualified members who purchase EVs and has offered incentives for previously owned vehicles (in addition to new vehicles) since the initial launch of our Energy Transformation program in 2017. About 25% of members receiving an EV or charger incentive self-identify as having an income at or below 80% of area median income.

VEC promoted MileageSmart when it was available, and both promoted and for a time administered that state electric vehicle incentive program to help members afford an electric vehicle.

Home and Community

Collaboration with Partners.

VEC partners with Energy Smart Vermont which provides energy coaching through Community Action Agencies. In addition, we also work with EVT and Neighborworks to promote available programs and opportunities.

Line Extensions and Increase in Capacity

Clean Air Program

VEC's innovative Clean Air Program and tariff offers customized opportunities to members with off-grid or underserved homes or businesses to replace fossil fuel usage with electricity. These opportunities may include service upgrades or line extensions, the costs of which will be shared between the utility and the member through customized agreements. For example, someone in VEC's service territory who has a maple sugaring operation currently powered by a diesel or propane generator may be eligible to participate in the Clean Air Program and receive an incentive from VEC to assist with the cost of a line extension to retire the generator.

The benefits of the program include reduction in carbon-emitting fuels, and incentives (discounts) that are paid back to the membership through margins from new electric sales. Since VEC began offering the program in 2016 we have completed 39 projects saving over 350,000 gallons of fossil fuel annually.

Energy Transformation Transformer Upgrades

VEC provides free transformer upgrades for members who install a level two EV charger or heat pump. In many cases the transformer serving their home cannot handle the additional load and to encourage carbon reduction we do not pass this cost on to the member. The additional kWH sales from either an EV or a heat pump provide a quick payback for the cost of upgrading the transformer.

4.3.3 Utility Incentive Comparison

The following table is a comparison of VEC's incentive offerings with other utilities in the state as of March 2025.

Measure	VEC	VPPSA	GMP	WEC	Stowe	BED

Ductless HP*	0	350/450	350/450	0	350/450	2450-2950
HP thermal efficiency bonus	150	200	0	0	0	0
HP income-qualified adder	0	0	2000	250	0	400-500
Pellet Stove*	200	0	0	300	200	0
HP water heater*	300 - 600	300-600	300-600	300-700	300-600	800-1200
Centrally Ducted HP*	1000 - 2000	1000 - 2000	1000 - 2000	1100 - 2100	1000 - 2000	1500-2500
A2W Heat Pump*	1000/ton	1000/ton	1000/ton	1500/ton	1000/ton	2000/ton
Ground source HP*	2100/ton	2100/ton	2100/ton	2100/ton + 500-2000	2100/ton	1500/ton
HP pool heater	600	0	0	0	0	
All electric vehicle**	500	500 - 1250	1500 - 2200	250 - 500	350-700	1300-2300
AEV income-qualified**	1000	900 - 1650	2500 - 3200	750- 1000	1250	2000-3000
Plug-in hybrid EV**	250	250 - 500	750-1000	250	350-500	1300-2000
PHEV income-qualified**	750	650 - 900	1750 - 2000	750	1250	1500-2300
Level 2 home charger	Free or 250	0	Free charger	0	250	700-900
Public charging station	500	950	750	0	500	2500
Residential lawnmower	50	50 - 100	50-100	0	50-100	100-200
Commercial lawnmower	1000	100 - 1500	50-100	0	150-1000	500-3500
Electric forklifts	1000	2500	1500-3000	0	0	4000-6000
Home batteries	Monthly credit	0	Lease or $850 - 1050/kW	0	0	
Yard care	0	50	25	0	50	50-150

Electric snowmobile	0	250	0	0	0	0
E-Bike	0	100	200	0	150	600
Electric golf cart	0	100	0	0	0	0
Electric motorcycle	0	500	500	0	0	500
Induction cooktop	100	0	0	0	200	200

Table 4.2.2.A VEC's Incentives for Tier III programs as compared to other utilities in Vermont

*Joint incentive with Efficiency Vermont **Other DUs offer different incentives for used vs new

4.3.4 How does VEC Develop Tier III Programs?

VEC developed an economic model for energy transformation to analyze and encourage our members' transition from carbon emitting fuels to VEC's renewable energy portfolio without creating subsidies from other VEC members. Our energy transformation model evaluates VEC's level of incentives while comparing the results to the expected gross contribution margins from new or incremental sales that could be realized by transforming our members' energy use into our clean energy portfolio.

The model takes into consideration the following:

- Net margins based on rate class ($/kWH)
- Expected fuel reduction (MMBtu)
- Power supply and transmission impacts ($/kWH)
- Direct & indirect costs such as vegetative maintenance, overhead and underground line maintenance, and property taxes
- Alternate Compliance Payment savings

Those values are then used to calculate an expected ROI for the incentive. While the model calculates payback for appliance purchases, it also can evaluate more sophisticated new applications such as line extensions or VEC system upgrades. VEC targets a less than 6-year ROI for all investments. VEC files an example economic model with the PUC for each incentive offering and Clean Air Program project.

4.3.5 Which members are using our incentives?

At the end of 2024, we had 799 (or 13%) self-reported low income (LMI) member participants in VEC's energy transformation program out of 6,408 total participants (note that we do not collect income information for incentives provided jointly though Efficiency Vermont). Additionally, around 21% of the total participants also participate in net metering.

4.4 Expand and Optimize VEC Virtual Power Plant (VPP)

Over the past several years, VEC has been working to expand its Virtual Power Plant through residential, commercial, and utility scale load management programs. VEC considers load management to be a key component in maintaining affordable rates and meeting our electrification targets. Regionally, transmission operators are replacing aging transmission assets due to condition and adding new transmission to support new generation. As a result, VEC's transmission costs are on the rise.

4.4.1 VPP and Flexible Load Strategy

VPP Value

- Increase value beyond peak shaving to infrastructure deferral
- Explore other value streams such as frequency regulation, generation constraint reduction

DER Size

- Increase enrollment in existing flexible load programs
- Continue to expand utility scale resources where financially viable
- Reduce program administration

Technology

- Maintain flexible and cost effective technology to manage DER (DERMS),
- Leverage AMI upgrade

DER Quantity and Type

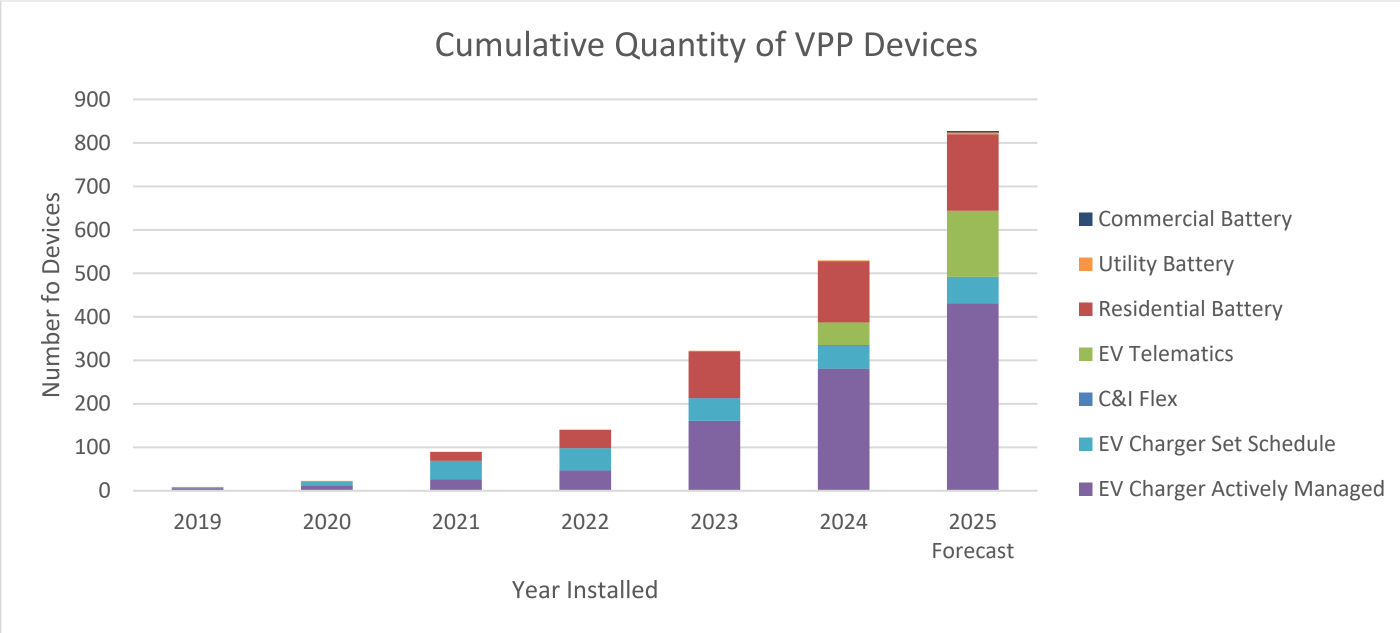
- Experiment with pilots to add additional device
- Explore third party aggregator relationships
- Continually analyze performance of residential and utility scale programs

DER Availability

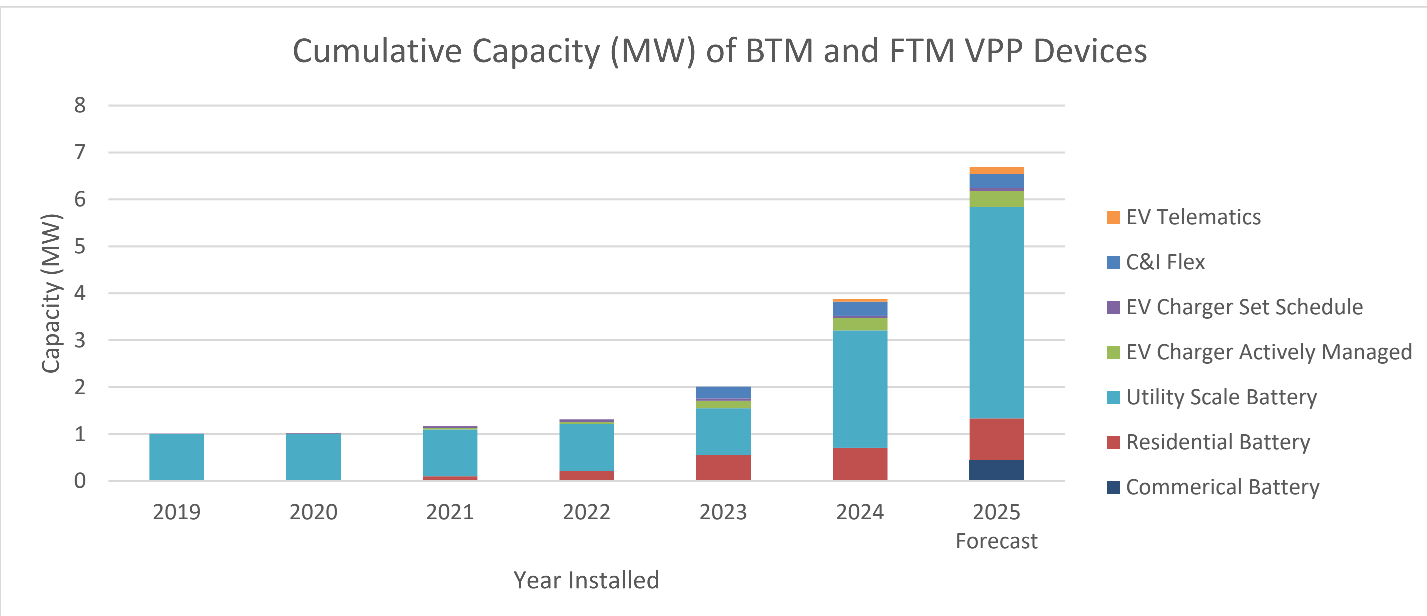
- Utilize AI to more accurately predict peaks
- Leverage control center resources to dispatch DER

4.4.2 Increase Overall DER portfolio MW and MWH

VEC is currently managing almost 600 VPP devices and anticipates that number to grow to almost 900 by end of 2025.



Utility scale assets continue to represent the largest capacity of VPP devices on VEC's system.



VEC Flexible Load – Residential and Commercial Scale Programs

As of January 2025, VEC managing approximately 500 residential scale devices for a total of 1MW of total capability.

Behind the Meter Battery Storage

In the fall of 2021 VEC launched its Flexible Load – Home Battery Program. This program offers members an incentive if they share their battery with VEC for peak management purposes. VEC utilizes Tesla PowerHub to communicate with eligible device types. VEC is manufacturer agnostic and will accept any battery type if we can arrange for an economic way to communicate with and dispatch any battery type. Enrolled members can choose 100% of the incentive as a monthly bill credit or they can elect to take the net-present value of 50% of the monthly bill credit as an upfront payment with the remaining 50% as a monthly bill credit. For a single, 5 kW Tesla Powerwall this works out to a $32 per month bill credit or a $1,340 upfront payment and a $16 monthly payment.

VEC currently does not offer a leasing program like what GMP offers currently. The ROI of close to 8-10 years is too risky for VEC to invest in.

Program Name	Devices Managed	Total Managed MW	Total Managed MWH	Monthly Bill Credit
Bring Your Own Home Battery Program	146 (145 Tesla, 1 Generac)	0.735MW (0.75 MW unmanaged - 1.5MW total)	1.944 MWH	• Monthly bill credit of $6.40 per kilowatt (kW), OR • Upfront payment of $268 per kW and monthly bill credit of $3.20 per kW

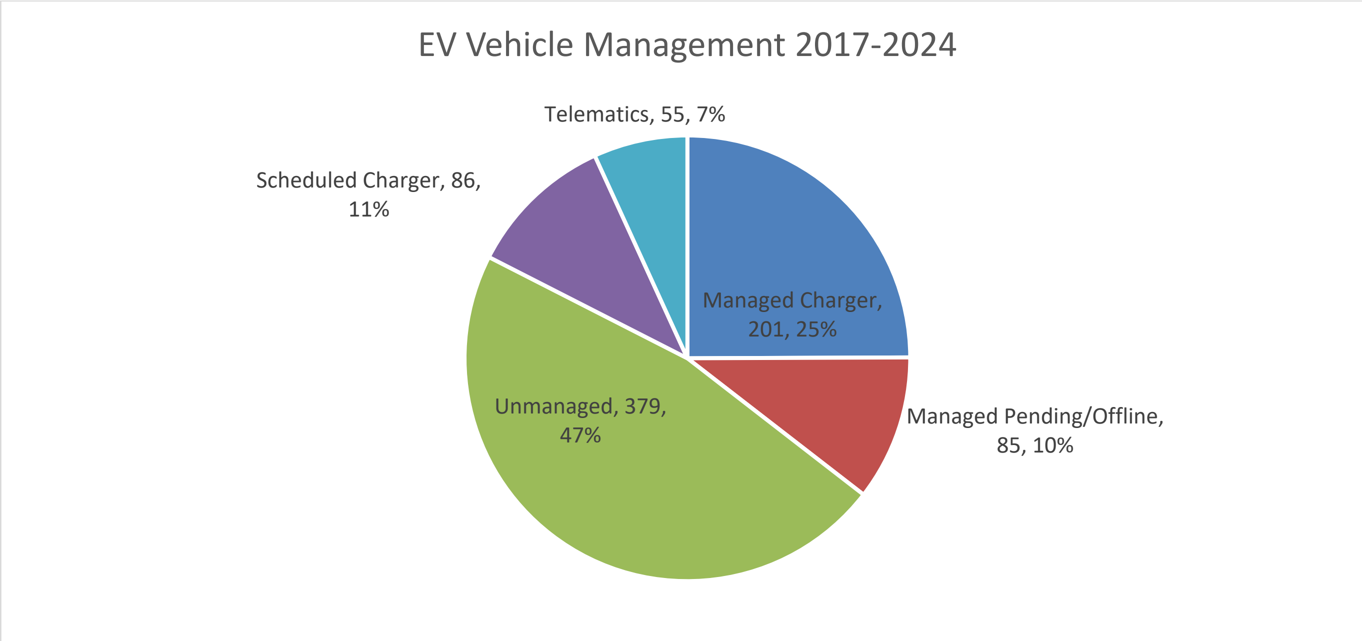
EV Chargers

VEC's managed EV charging program comes in three flavors.

Program Name	Devices Managed	Total MW	Total MWH	Monthly Bill Credit
Managed Level 2 Charger	331 (201 Emporia, 80 ChargePoint, 50 Flo)	0.331MW	~1.5 MWH	• $8/month
Scheduled Level 2 Charger	51	0.51MW	~.250 MWH	• $8/month
Telematics EV Management	62 (50 Tesla)	0.62 MW	~.300 MWH	• $8/month • The program began in April 2024

In exchange for allowing VEC to send a signal to their EV charger during peak times to curtail charging, VEC provides an $8 per month bill credit. If the member opts out of the peak event for any given month or their device is disconnected (e.g. they changed their Wi-Fi password and haven't yet reconnected their EV charger), they simply do not receive the credit the following month. Members receive an e-mail notification at least 4 hours ahead of a peak event which includes the option to opt out of peak events.

VEC is currently managing 53% of the ~800 EV and PHEV vehicles in its territory.



While all EV's are not always charging during peak times VEC sees an average of a little over 1kW of reduction across the EV fleet. This value is used to calculate the member incentive for the program. More information here: https://lookerstudio.google.com/s/g1zG7L1j04Q

Beat the Peak

For several years now VEC has issued an alert 2-4 times per summer encouraging members to reduce electricity consumption for a specified window of hours with a reasonably high likelihood of being the ISO-NE annual peak hour. This is an optional program with no direct incentive to participating members, beyond the personal satisfaction of their small contribution to reduce costs and high-carbon peak sources of generation. VEC maintains a list of members who want to do their part to curb use during peak-demand periods. VEC members can sign up to receive alerts by e-mail, text, or phone. As of early 2025, about 850 members had signed up to get Beat the Peak alerts.

Program Name	Devices Managed	Total MW	Total MWH	Monthly Bill Credit
Beat The Peak	850	0.05MW	0.2 MWH	No monetary incentive

In late 2023, VEC worked with Qilo to perform an analysis on how much load was typically shed as part of beat the peak calls. The value varied based on the time of year and event but was typically between 30-50kW. While small in quantity the effort required (an email) for VEC is very minimal.

Commercial and Industrial Flexible Load Management Tariff

In May of 2024 VEC filed for a tariff for its Commercial and Industrial Flexible Load Program - 24-1550-TF. The tariff is the culmination of an 18 month innovation pilot that focused on C&I members. VEC currently has three members enrolled in the program:

- Williston Public safety building- management of geothermal heating and cooling.
- Jay Peak Ski Resort – management of HVAC systems, ice rink, and water park pumps, resulting in about 350kW of reduction without noticeable impact on operation
- Jericho Armory – management of geothermal heating and cooling.

Program Name	Devices Managed	Total MW	Total MWH	Monthly Bill Credit
C&I Flexible Load	3 Locations	0.4MW	1 MWH	$4-$5/kW/month

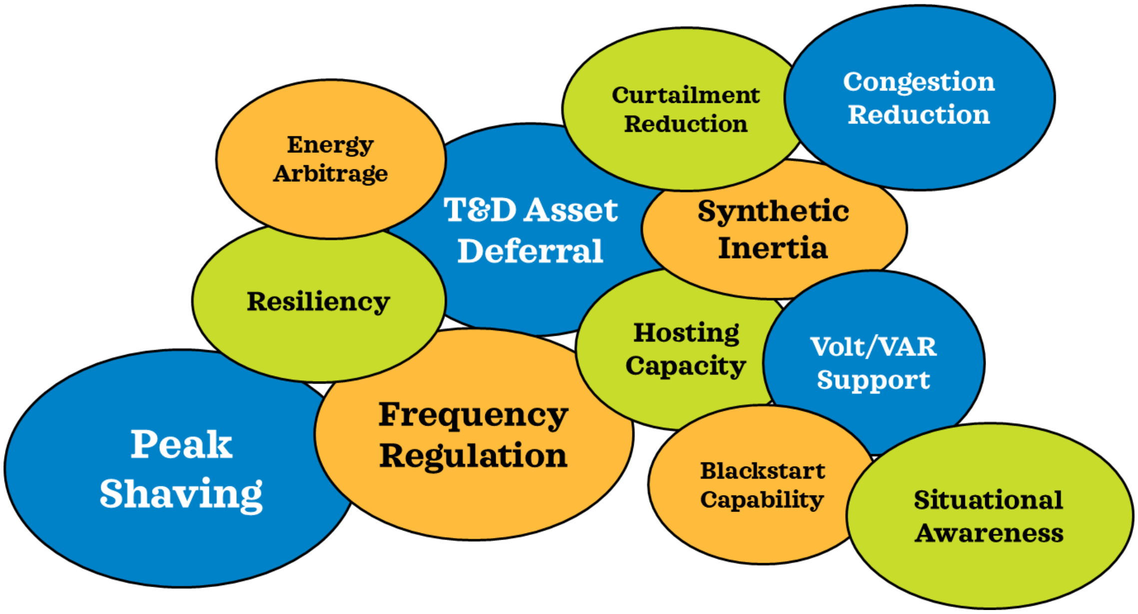
Utility Scale Load Management

Utility scale storage is any storage project that is not located at a specific customer site and greater than 150 kW in size. VEC has four active locations totaling 4.5MW and is working on several other potential projects.

Device Location	Ownership Model	Total MW	Total MWH	In Service Date	Grid Services
Hinesburg Substation	Developer Owned	1 MW	4 MWH	November 2019	• Peak Shaving (VEC – 400 hours per year) • Frequency Regulation (Developer)
North Troy	GMP and VEC	3 MW	12 MWH	July 2024	• Peak Shaving (VEC and GMP) • Frequency Regulation (GMP) • SHEI Constraint Management
Richford Substation	VELCO Owned	0.25 MW	1.2 MWH	Dec 2024	• Peak Shaving (VEC – 400 hours per year) • Radio Site Resilience (VELCO)
Montgomery Substation	VELCO Owned	0.25 MW	1.2 MWH	Nov 2024	• Peak Shaving (VEC – 400 hours per year) • Radio Site Resilience (VELCO)
South Hero Substation	Developer Owned	3 MW	12 MWH	Expected 2026	• Peak Shaving (VEC – 400 hours per year) • Frequency Regulation (Developer)

4.4.3 Increase VPP Value

Flexible Load management, when cost-effective, has many practical uses, especially as the generation profile shifts from baseload fossil-fuel to intermittent renewable generation.



These benefits include (in order of importance):

1. NEPOOL Transmission Cost Reduction – also referred to as Regional Network Service reduction (RNS)
2. ISO-NE Capacity Market Cost Reduction – savings on the Forward Capacity Market (FCM)
3. Frequency Regulation/Spinning Reserve
4. Generation Constraint Management
5. T&D investment deferral/T&D support
6. Energy arbitrage
7. Member resiliency
8. Reliability of the power system as electrification increases

Transmission Peak Shaving

As a member of the New England Power Pool (NEPOOL) and a participant in ISONE, VEC is responsible for paying for its share of the costs of the bulk transmission system in New England.

Regional Network Service (RNS)

RNS charges help support the high-voltage transmission system in New England. These charges are assessed to Load Serving Entities (LSE or LSEs) based on rates approved by the Federal Energy Regulatory Commission (FERC) and the LSE's Monthly Regional Network Load value, which is its load at the time of the monthly peak for the transmission owner that serves the LSE.

With VELCO being the transmission owner for the entire state, VEC's RNS costs are based on its load during the peak demand hour in Vermont each month. By managing load during these peak periods, VEC can reduce its share of RNS costs and, consequently, its transmission charges.

There are four rates that drive RNS costs:

- **ISO Tariff Schedule 1 -** Covers costs for scheduling, system control, and dispatch services. Charges are a function of rates established by ISO-NE, and approved by FERC, based on costs projected to be incurred and true-ups to actual costs for previous years.

- **ISO Tariff Schedule 5 -** Pertains to costs for voltage support services. Charges are a function of rates established by ISO-NE, and approved by FERC, based on costs projected to be incurred and true-ups to actual costs for previous years.

- **NEPOOL OATT Schedule 1 -** Covers costs for scheduling, system control, and dispatch services by New England Power Pool (NEPOOL). Similar to ISO Tariff Schedule 1 but provided by NEPOOL. Charges are a function of rates established by ISO-NE, and approved by FERC, based on costs projected to be incurred and true-ups to actual costs for previous years.

- **NEPOOL OATT Schedule 9 -** Pertains to costs for regional network service (RNS). Ensures sufficient transmission system capacity to meet electricity demand. Charges are a function of rates established by ISO-NE, and approved by FERC, based on costs projected to be incurred and true-ups to actual costs for previous years.

The table below shows actual rates for 2019-2025 and the projected rates for the ISONE and NEPOOL rates for 2026-2045.

Year	ISO Tariff Schedule 1 ($/kW-month)	ISO Tariff Schedule 5 ($/kW-month)	NEPOOL OATT Schedule 1 ($/kW-month)	NEPOOL OATT Schedule 9 ($/kW-month)	Total ($/kW-month)
Jan-19	$0.172850	$0.007110	$0.132330	$9.202369	$9.51466
Jan-20	$0.176260	$0.008820	$0.132784	$9.328223	$9.64609
Jan-21	$0.193830	$0.006260	$0.145442	$10.771818	$11.11735
Jan-22	$0.191750	$0.007360	$0.155715	$11.898269	$12.25309
Jan-23	$0.204750	$0.007010	$0.145932	$11.803749	$12.16144
Jan-24	$0.269540	$0.008070	$0.162640	$12.862825	$13.30308
Jan-25	$0.295820	$0.007160	$0.182058	$15.439760	$15.76095
Jan-26	$0.324929	$0.007299	$0.192388	$15.316667	$15.66508
Jan-27	$0.356903	$0.007442	$0.203305	$16.416667	$16.79539
Jan-28	$0.392023	$0.007587	$0.214840	$17.083333	$17.49573
Jan-29	$0.430598	$0.007734	$0.227031	$18.083333	$18.53303
Jan-30	$0.443516	$0.007966	$0.233842	$18.625833	$19.08902
Jan-31	$0.456822	$0.008205	$0.240857	$19.184608	$19.66169
Jan-32	$0.470526	$0.008452	$0.248083	$19.760147	$20.25154
Jan-33	$0.484642	$0.008705	$0.255525	$20.352951	$20.85909
Jan-34	$0.499181	$0.008966	$0.263191	$20.963540	$21.48486
Jan-35	$0.514157	$0.009235	$0.271087	$21.592446	$22.12941
Jan-36	$0.529582	$0.009512	$0.279219	$22.240219	$22.79329
Jan-37	$0.545469	$0.009798	$0.287596	$22.907426	$23.47709
Jan-38	$0.561833	$0.010092	$0.296224	$23.594648	$24.18140
Jan-39	$0.578688	$0.010394	$0.305110	$24.302488	$24.90684
Jan-40	$0.596049	$0.010706	$0.314264	$25.031562	$25.65405
Jan-41	$0.613930	$0.011027	$0.323692	$25.782509	$26.42367
an-42	$0.632348	$0.011358	$0.333402	$26.555985	$27.21638
Jan-43	$0.651319	$0.011699	$0.343404	$27.352664	$28.03287
Jan-44	$0.670858	$0.012050	$0.353707	$28.173244	$28.87386
Jan-45	$0.690984	$0.012411	$0.364318	$29.018441	$29.74007

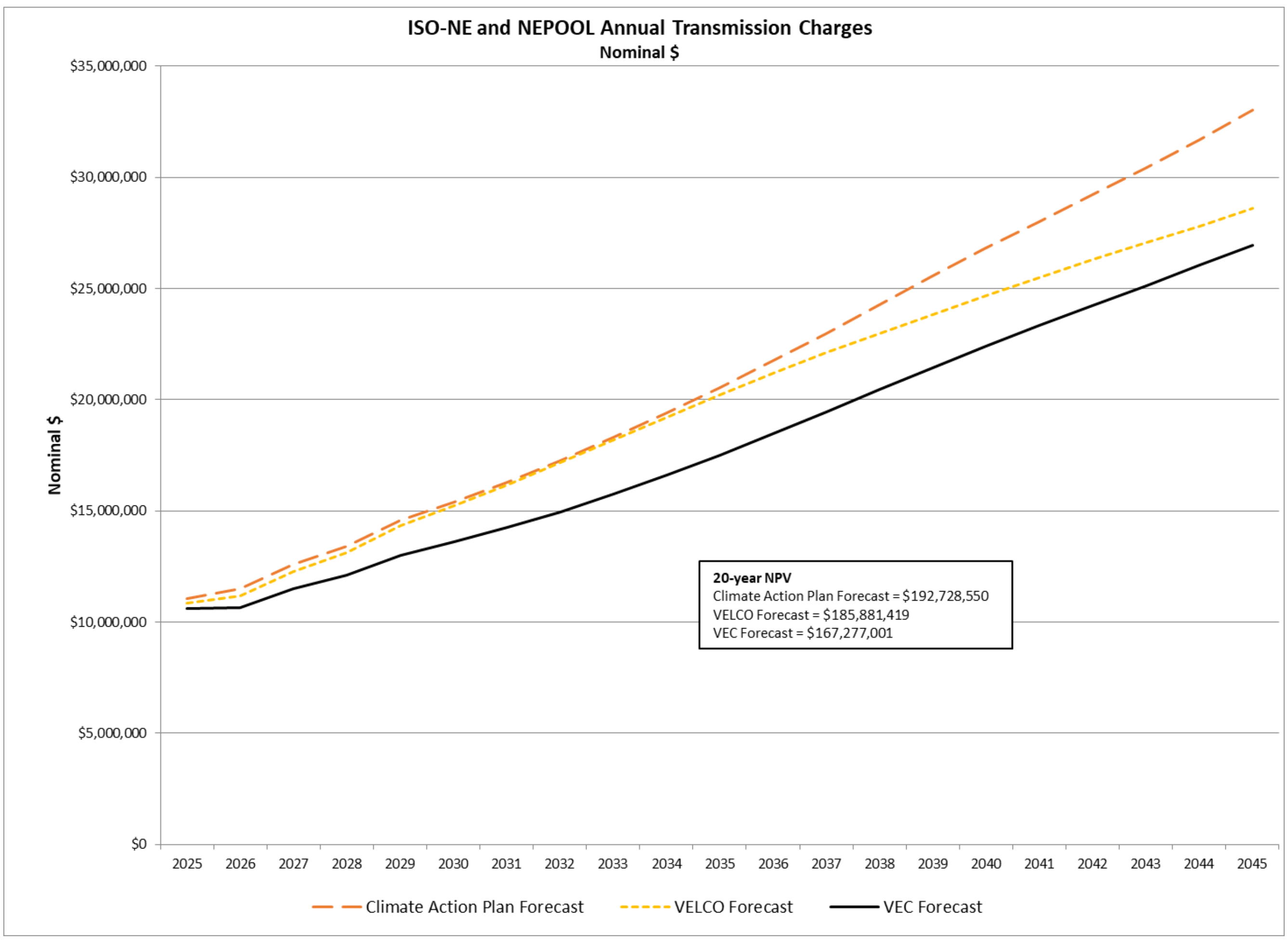
- *Table 4.4.2A – Projected ISONE and NEPOOL OATT Tariff Rates*

Rates through January 2025 are actuals for all tariff rates.

Projected rates for NEPOOL OATT Schedule 9 for 2026-2029 are based on projections from ISO-NE released in August 2024 (ISONE provides 5-year projections each summer). Rates for 2030-2045 are the projection for the previous year increased by 3%.

Projected rates for ISO Tariff Schedules 1 and 5, and NEPOOL OATT Schedule 1 2026-2029 are based on January 2025 actual rates escalated at the average annual increase from January 2019 – January 2025, which were approximately 9.84% or ISO Tariff Schedule 1, 1.95% for ISO Tariff Schedule 5 and 5.67% for NEPOOL OATT Schedule 1. Rates for 2030-2045 are the projection for the previous year increased by 3%.

Multiplying the rates and peak projections shown in Section 3 result in the total cost projections in the figure below:



ISONE Forward Capacity Market (FCM)

The Forward Capacity Market (FCM) is an ISONE managed regional wholesale market designed to ensure that the New England power system has sufficient resources to meet future electricity demand. Resources compete in auctions to obtain a commitment to supply capacity in exchange for market-priced capacity payments. Generators owners receive payments to support the development of new resources and help retain existing resourcves by providing a stable revenue stream.

Historically the FCM has operated through annual Forward Capacity Auctions (FCAs) held three years in advance of the operating period. The most recent auction set prices through the June 2027-May 2028 capacity commitment period. Capacity market rates are fairly well known through May 2028 except for minor changes that will be the result of annual and monthly reconfiguration auctions that fine tune the capacity requirements, resources and prices based on new data since the original auctions for the commitment periods were conducted.

Beyond May 2028, the FCM is transitioning to a market with winter and summer seasonal markets beginning with the June 2028 commitment period. Rules for this new market structure are being developed now through stakeholder discussions, with the final rules unknown at this time. VEC is working under the assumption that the generalities of the market will remain intact, specifically that its capacity requirement will be a function of its percentage share of total ISONE load in the one hour New England peaks each calendar year, and the clearing prices for each capacity commitment period auction, with possible refinements due to the performance of resources with capacity supply obligations. However, With the final rules unknown, it is difficult to predict the resulting rates load serving entities will be charged.

The table below shows VEC's best estimates for the Low and High ranges of potential costs, with a Base scenario that will be used for planning purposes.

Start of Commitment Period	End of Commitment Period	Actual ($/kW-month)	Low ($/kW-month)	Base ($/kW-month)	High ($/kW-month)
Jun-16	May-17	$3.15			
Jun-17	May-18	$15.00			
Jun-18	May-19	$9.55			
Jun-19	May-20	$7.03			
Jun-20	May-21	$5.30			
Jun-21	May-22	$4.63			
Jun-22	May-23	$3.80			
Jun-23	May-24	$2.00			
Jun-24	May-25	$2.67			
Jun-25	May-26	$2.53			
Jun-26	May-27	$2.59			
Jun-27	May-28	$3.58			
Jun-29	May-30		$3.00	$3.69	$15.00
Jun-30	May-31		$3.09	$3.80	$15.45
Jun-31	May-32		$3.18	$3.91	$15.91
Jun-32	May-33		$3.28	$12.00	$16.39
Jun-33	May-34		$3.38	$5.00	$16.88
Jun-34	May-35		$3.48	$5.15	$17.39
Jun-35	May-36		$3.58	$5.30	$17.91
Jun-36	May-37		$3.69	$5.46	$18.45
Jun-37	May-38		$3.80	$5.63	$19.00
Jun-38	May-39		$3.91	$5.80	$19.57
Jun-39	May-40		$4.03	$5.97	$20.16

Jun-40	May-41		$4.15	$6.15	$20.76
Jun-41	May-42		$4.28	$6.33	$21.39
Jun-42	May-43		$4.41	$6.52	$22.03
Jun-43	May-44		$4.54	$6.72	$22.69
Jun-44	May-45		$4.67	$6.92	$23.37

The Low case starts at $3.00/kW-month in June 2029, which is slightly lower than the most recent Forward Capacity market clearing price. This Low case reflects the possibility that loads will not grow at the pace ISONE is projecting in its most recent Capacity, Energy, Load and Transmission (CELT) Report. The rate has been escalated by 3.00% per year as a proxy for trends in operating and maintenance costs.

The Base case starts at $3.69/kW, which is 3% higher than the most recent Forward Capacity Market clearing price, and escalates at this 3% per year through May 2032 as a proxy for trends in operating and maintenance costs. The rate spikes to $12.00/kW-month in June 2032 to reflect the first year the CELT report shows projected capacity supply obligations less than 120% of projected peak loads, and the step function nature of prices as the market transitions from excess to shortfall. This price then drops to $5.00/kW-month in June 2033 as the market transitions back to excess, then increases at the 3% proxy to capture operating and maintenance costs.

The High case starts at $15.00/kW-month, which is the highest price the capacity market has seen in the past decade, and escalates by 3.00% per year as a proxy for trends in operating and maintenance costs.

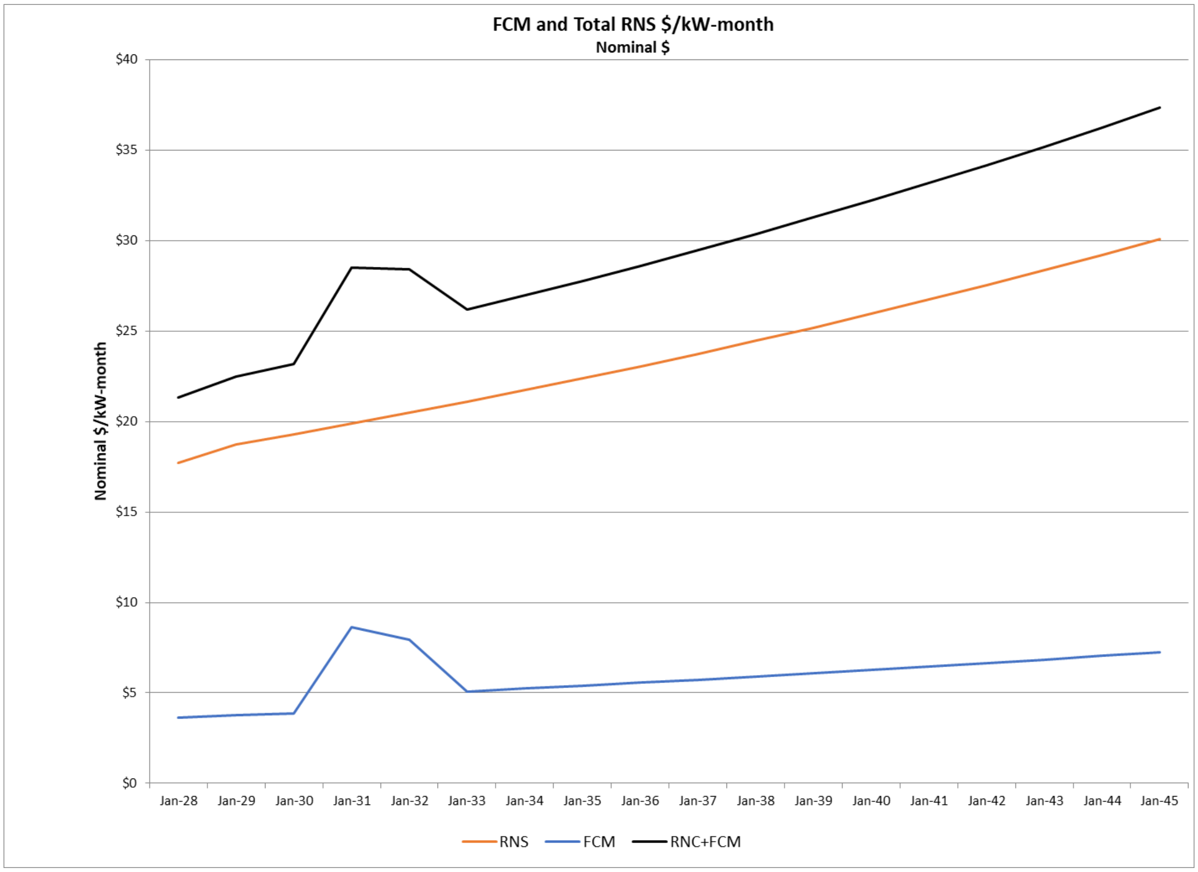
Combined RNS and FCM Value

The table below shows the combined peak shaving value of RNS and FCM rates, with the FCM rates for the year shown being the Base scenario weighted average of the FCM rates for the auctions that are part of each calendar year.

Year	Total RNS ($/kW-month)	FCM $/kW-month)	RNS + FCM ($/kW-month)	RNS + FCM ($/kW-year)
Jan-26	$15.84	$2.57	$18.41	$220.88
Jan-27	$16.98	$3.17	$20.15	$241.82
Jan-28	$17.70	$3.64	$21.34	$256.09
Jan-29	$18.75	$3.75	$22.50	$270.01
Jan-30	$19.31	$3.86	$23.18	$278.11
Jan-31	$19.89	$8.63	$28.52	$342.25
Jan-32	$20.49	$7.92	$28.40	$340.85
Jan-33	$21.10	$5.09	$26.19	$314.27
Jan-34	$21.73	$5.24	$26.98	$323.70
Jan-35	$22.39	$5.40	$27.78	$333.41
Jan-36	$23.06	$5.56	$28.62	$343.41
Jan-37	$23.75	$5.73	$29.48	$353.72
Jan-38	$24.46	$5.90	$30.36	$364.33
Jan-39	$25.20	$6.07	$31.27	$375.26
Jan-40	$25.95	$6.26	$32.21	$386.51
Jan-41	$26.73	$6.44	$33.18	$398.11
an-42	$27.53	$6.64	$34.17	$410.05
Jan-43	$28.36	$6.84	$35.20	$422.36
Jan-44	$29.21	$7.04	$36.25	$435.03

Jan-45	$30.09	$2.97	$33.06	$396.68

The $/kW-month values are shown graphically below:



Value: ~220/kW/month

Frequency Regulation/Spinning Reserve

The ISONE frequency regulation market is a system where ISO New England compensates participants who help balance electricity supply and demand by adjusting their output or consumption every four seconds. This ensures the stability of the power grid by maintaining the system frequency within required limits.

VEC does not actively participate in this market due to its required dedicated resources and expertise. However, several of VEC's utility scale storage contracts include a frequency regulation component managed by the developer or partner utility. VEC believes that, as more batteries are installed in New England, potential profits in the Regulation market could deteriorate, as occurred in the PJM Regulation market.

Value: Limited value to VEC. Value in partnership with developers to reduce costs of utility scale assets.

Generation Constraint Management

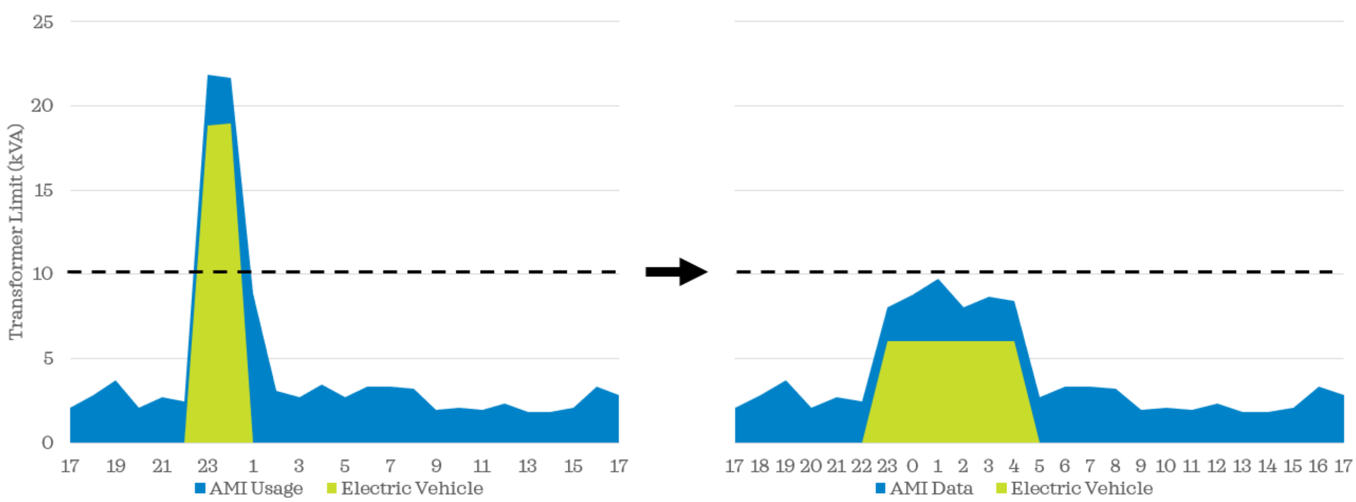
VEC's recently installed North Troy Battery is designed to significantly enhance the generation capabilities in the SHEI (Sheffield-Highgate Export Interface) area. The battery storage will help mitigate wind curtailment issues on projects such as Kingdom Community Wind (KCW) by storing excess energy generated during periods when generation exceeds load and transmission export capability.

> **Value:** No assigned value yet. VEC's North Troy battery project will provide real world learnings this year.

T&D Investment Deferral and T&D Support

To date VEC has upgraded almost 50 transformers due to EV overloads and is upgrading between 10-20 transformers annually for EV's. In June 2020, VEC began offering free transformer upgrades for EV's through an addition to section 17 of VEC's Line Extension Tariff (20-1528-TF).

As the transformer is being significantly overloaded, VEC would typically upgrade this transformer from 10kVa to 25 kVA at a cost to the VEC membership of ~$5,000. In this example and across VEC's system, typical EV charging sessions last between 2-3 hours. By shifting or ramping down the charging speed we can leverage the flexibility of EV charging and defer the transformer upgrade.



While in some cases replacing the transformer is the most reliable and justified through additional kWH sales from EVs, VEC has filed an innovative pilot to explore the types of constraints and charging behaviors that lend themselves to managed charging vs. transformer replacement. This is discussed later in this document.

> **Value:** Depending on the asset but VEC estimates the value here could be anywhere between $4-$40/kW/month reduced.

Energy Arbitrage

Energy arbitrage involves strategically purchasing electricity when prices are low and storing it for use or sale when prices are higher. The ability to extract value from batteries through energy arbitrage is a function of the difference between the energy prices at the time of discharge (which results in revenue) and re-charge (which results in a cost) as well as the round-trip losses in the system. For example, if a battery has round-trip losses of 10%, the utility will need to incur a charge for 1.1 MW of energy to re-charge the battery for every 1.0 MW of energy it discharges to generate revenue.

The average real-time price for wholesale power in the ISONE region in 2023 was $35.70 per megawatt-hour. In other parts of the country other like Texas evening power prices in July and August were trading up at $400/Mwhr. Although there is potentially some money to be gained there, VEC believes that, under current market conditions (and even more so as utility load shapes flatten out over time as expected) the amount of profit to be made is quite small compared to the potential cost reduction savings from peak load reduction.

> **Value:** Limited value to VEC within current markets.

Member Resiliency

Batteries placed at substations or other VEC-owned property can also be used as backup power to improve reliability for several customers on connected circuits, while smaller batteries located behind an individual customer's meter can be used to supply that customer in the event of an outage on the circuit serving that customer. While VEC uses the FEMA societal value of resiliency, there is limited direct reduction in storm costs for member sited battery installations. As such VEC has not directly invested in battery installations as a solution to outage response.

VEC currently has few, if any, locations on its system in need of significant upgrades that can be deferred or eliminated cost-effectively using batteries, so this, by itself, is not a major factor in a decision of whether to invest in battery storage. However, as there are points on the system that can make better use of batteries than others, location will be a consideration when we decide to deploy a battery.

> **Value:** Limited direct cost savings to VEC. VEC continues to offer bring your own battery programs to help with member adoption of batteries. Half of VEC's members already have a backup generator which is often a more cost effective option and uses minimal fossil fuel resources.

Overall Value Chart

While there are a lot of opportunities to increase VPP value the values VEC use today to justify programs are peak shaving focused

VPP Category	Value In 2025	Current /Future
Peaking Shaving - VT Monthly RNS	~$190/kW	Current
Peaking Shaving - ISONE Yearly	~$30/kW	Current

FCM		
Frequency Regulation	$Varies	Current
Energy Arbitrage	$0	Current
T&D Asset Deferral	$4-$40/kW	Future
Generation Constraint Management	TBD	Future
Member Resiliency	$0	Future
Total	**~$204/kW/year**	

Today's Value: $220/kW/year

4.4.4 Modular and No Regrets Technology to Manage DER

The DER management software landscape is nascent, risky and ever-changing. While VEC has been managing programs since 2019 we have done so in a way that limits the amount of risk as technology vendors change. Our goal is to create a flexible and cost-effective technology infrastructure to manage DER.

VPP Software Categories and DERMS

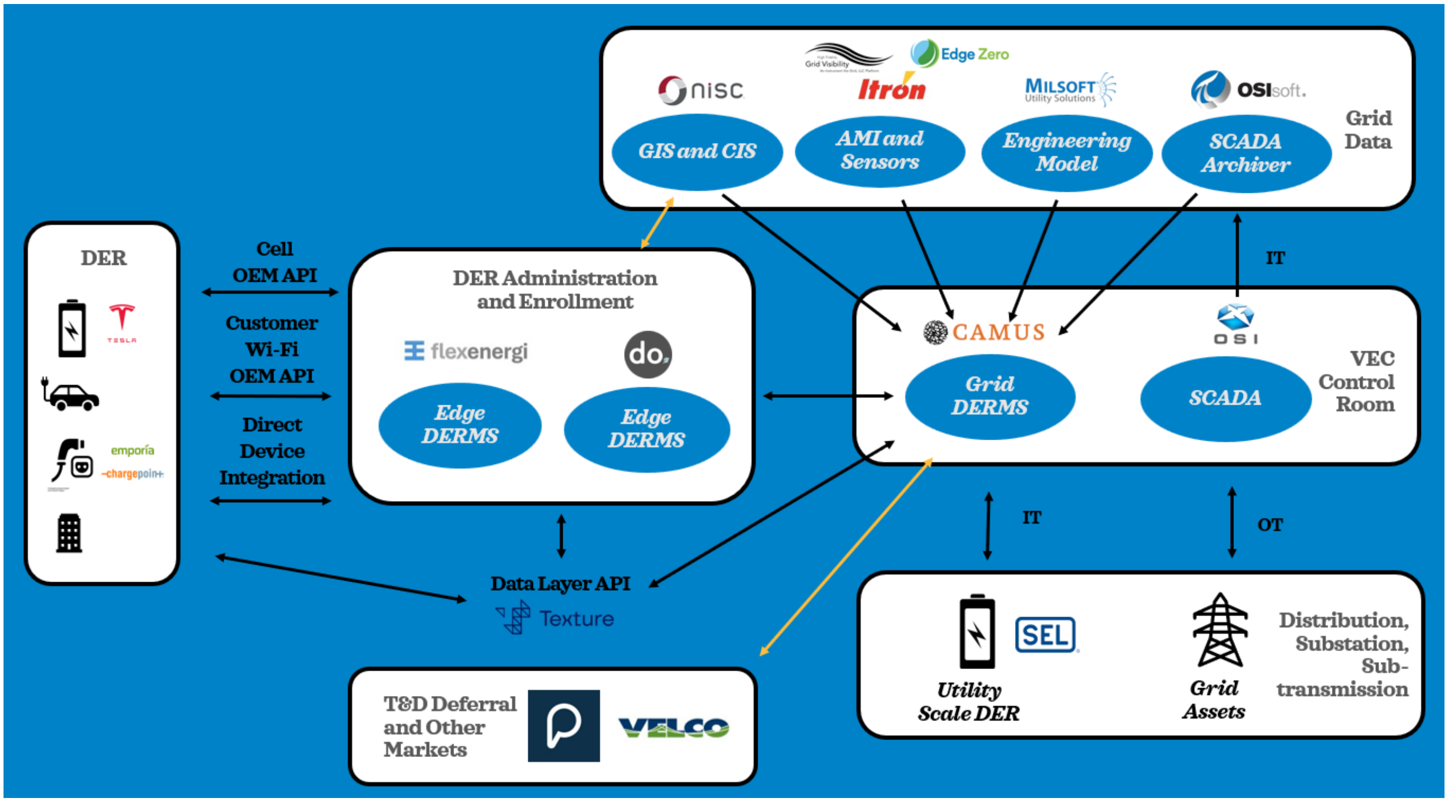
There are a variety of software categories utilized to manage DER. Distributed Energy Resource Management Systems (DERMS) are the foundational software solution that help utilities manage the integration of distributed energy resources (DERs) into the power grid. Within the industry there are many DERMS vendors and product offerings, and the solutions come in two forms:

- Edge DERMS - Communicates and controls with DERs, simple controls, handles member enrollment.
- Grid DERMS - Monitors grid assets, Distribution Transformer loading, Peak forecasting, Real time operations. Integration with Grid Edge DERMS can also have direct DER integrations.

Category	Services	Vendor Examples
Grid Data	CIS, AMI, Grid Sensors, GIS, Engineering Model	NISC, SEL, Milsoft Utility Solutions, Aclara, Itron, Edge Zero
SCADA (Supervisory Control and Data Acquisition)	Control and Data of Substations, Transmission, Primary Lines, Large generation	OSI, Siemens, GE
ADMS (Advanced Distribution Management Systems)	Fault location and restoration (networked systems) Conservation Voltage Reduction	OSI, Siemens, GE
Grid DERMS (Distributed Energy Resource Management System)	Monitors grid assets, Transformer loading, Peak forecasting , Real time operations	Camus, OSI, rhythmOS.io
Edge DERMS	Communicates and controls with DERs, simple controls, handles member enrollment and administration	EnergyHub, flexenergi, Tesla, do, Virtual Peaker
DER OEMs (Original Equipment Manufacturer)	DER devices	Generac, Ford, Tesla, chargepoint, emporia

VEC's Existing DER Technology Architecture

VEC has several different vendors providing services:



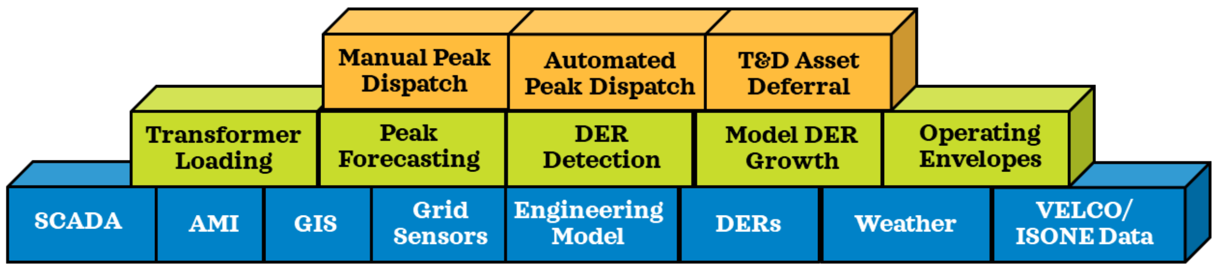
- *FlexEnergi Edge DERMS* – Enables dispatch of EV and PHEV vehicles through telematics as well as other DER devices such as chargers and potentially batteries. FlexEnergi has an integration with Camus.
- *Tesla Gridlogic Edge DERMS –* Enables dispatch of VEC's bring your own device Tesla Powerwalls.
- *Dynamic Organics Edge DERMS –* Enables dispatch of C&I Flexible Load members. VEC recently completed an innovation pilot and filed for a tariff for this program. Discussed further in next section
- *T&D Deferral and Other Markets* – Efforts are already underway to explore how non-wires solutions such as DER management can reduce or eliminate the need for costly distribution and transmission upgrades in Vermont. VELCO plays a key role in this effort as do companies like Picolo Flex who provide a marketplace for aggregators and participants to bid into local flexibility markets.
- *Data Layer* – VEC has recently begun discussions with data layer providers such as Texture or Derapi who provide an aggregated lightweight (and therefore cost effective) data service. The value in these entities is that they can offer DER visibility and management at a fraction of the cost of traditional edge DERMS providers. VEC believes that Edge DERMS providers provide an important role in enrollment and administration of devices.
- *Camus Energy Grid DERMS* – Provides VEC with a visibility of all meters, GIS data, SCADA data and DER data. Enables analytics such as transformer loading and distribution DER management. Also enables dispatch of VEC's ChargePoint chargers and some utility scale resources. Integrations with Tesla and FlexCharging are underway.

What Does the Camus Product Allows Us to Do?

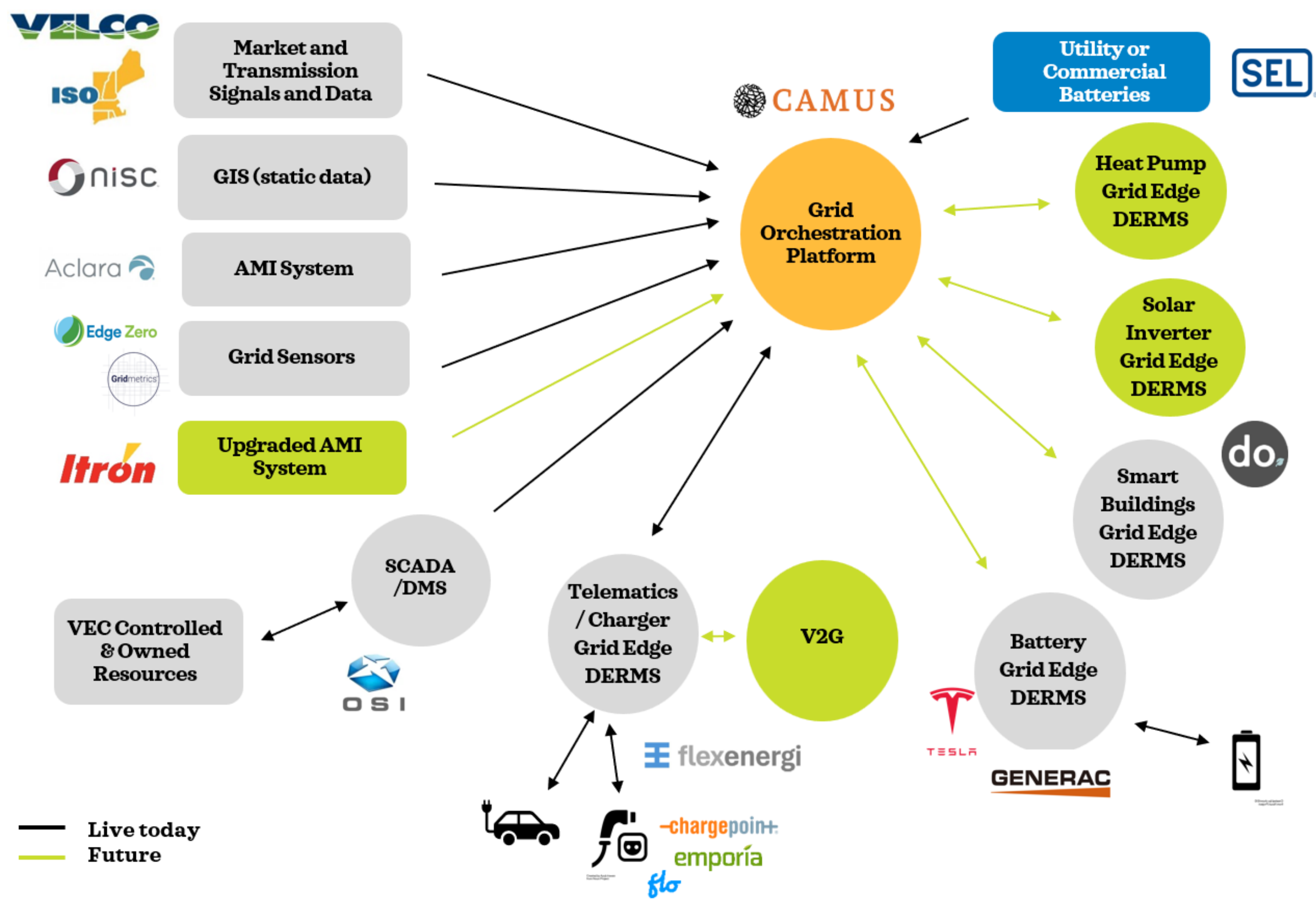
Camus Energy is a Grid DERMS product. VEC is using a three-tiered approach when it comes to Grid DERMS solutions.

1. Utility and DER data integration – Integration of data to provide a single pane of glass for organization wide visibility of DER and grid data

2. Analytics to view data and model DER's – data building blocks enable analysis such as EV detection or transformer loading
3. Orchestration – Peak dispatch of DERs and future use cases such as T&D asset deferral



Over the past year VEC has integrated several utility datasets and DER datasets. The image below describes VEC's existing Grid Edge DERMS products (grey) and future planned integrations (green).



The Camus product provides VEC with the following functionality which are discussed in further detail below:

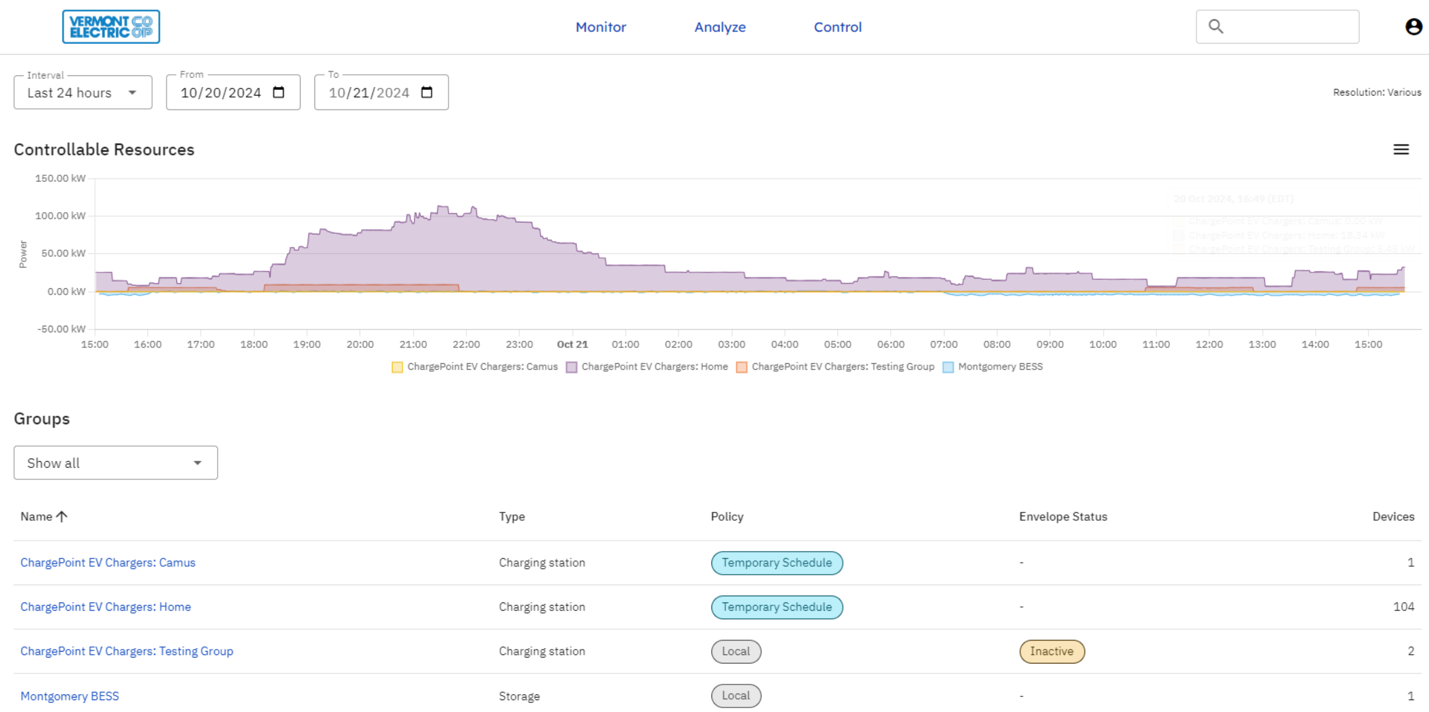
1. Management of DERs through common platform
2. *Situational Awareness through visibility of system assets and DERs*
3. EV Detection
4. Data Analytics
5. Peak Shaving
6. AMI Aggregation

7. Future use cases such as T&D asset deferral

DER Management Through a Common Platform

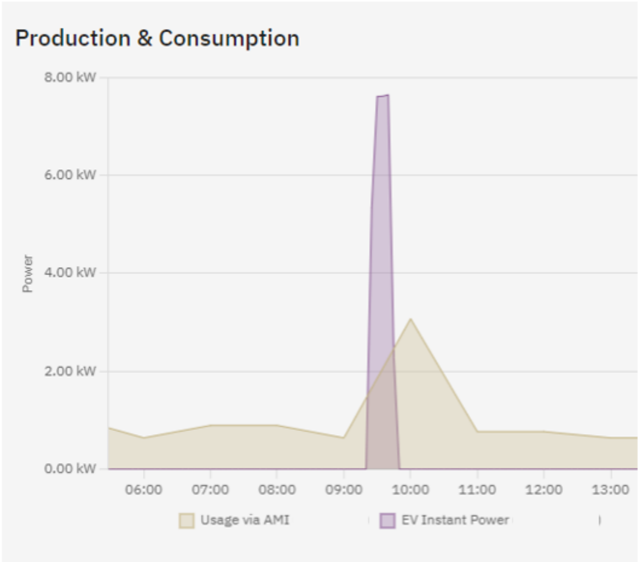
The Camus tool provides a single platform to manage a variety of programs and potentially a variety of Grid Edge DERMS. Prior to implementing the Camus tool VEC needed to manually set schedules in several platforms. As the number of integrated devices increases that also increased the number of platforms and VEC has already found it challenging to administrate the status of these devices within existing tools. In the future we are considering how we optimize DER schedules outside of traditional peak management times. This may be to avoid/defer distribution upgrades or optimize load to match renewable loads, doing this manually would not be possible.

Camus is currently integrating with FlexEnergi and other vendors. VEC currently can manage utility scale batteries and ChargePoint chargers in Camus as shown in the screenshot below.

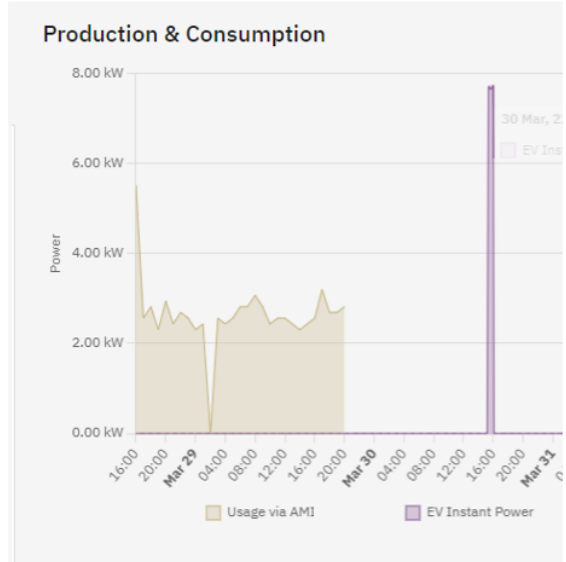


Situational Awareness Through Visibility of System Assets and DER's

Many Grid Edge DERMS products prioritize the ability to control individual DER's. The data associated with those DER's is extremely valuable from a grid analytics perspective. Understanding charging behaviors as an example can help the utility better understand grid impacts. Additionally, since DER data typically comes back to VEC through cell or member Wi-Fi we can view the data much faster than AMI and in a much higher resolution. The example below shows this difference in data.



AMI Data – Hourly kWH
ChargePoint – 5 min



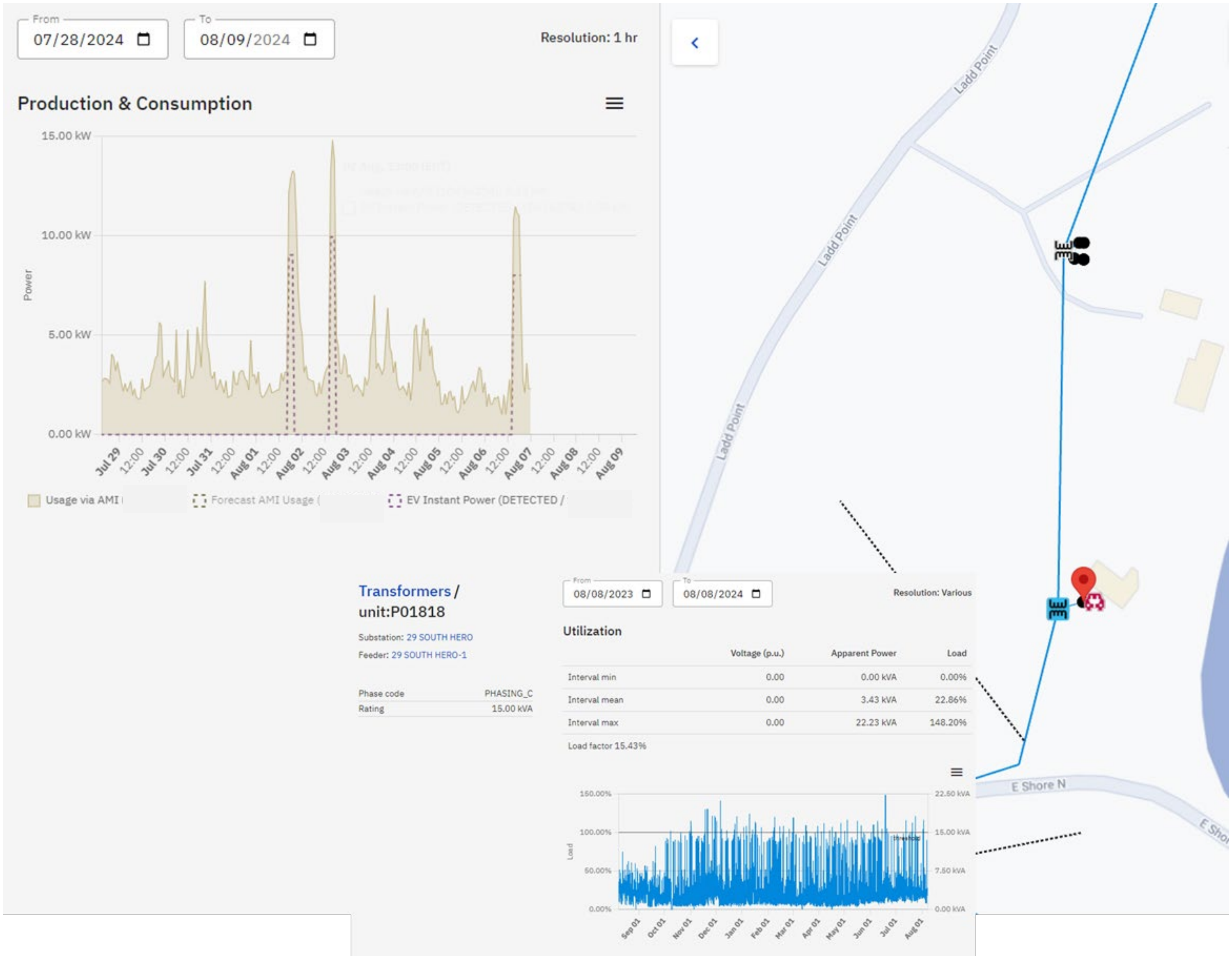
AMI Data – 20-30 hrs. delayed
ChargePoint – 1 min

The Camus platform also enables VEC to view the following information:

- SCADA –*While the DERMS platform will not directly control SCADA devices it will need near real time visibility of devices and the data associated with them at the substation and transmission levels.*
- AMI– *Providing data on members usage and impacts to voltage are necessary to ensure that transformer assets are not overloaded. In addition, the AMI data feeds engineering models and allows detection of EV's and other DER's*
- GIS- *Geographical locality of existing resources (poles, wire, equipment) and DERs paired with asset nameplate data feed the operational visibility, engineering and planning functions.*
- Member Information – *Data from our CIS provides details on equipment, service locations, and account details that help feed planning and operational analysis.*

EV Detection

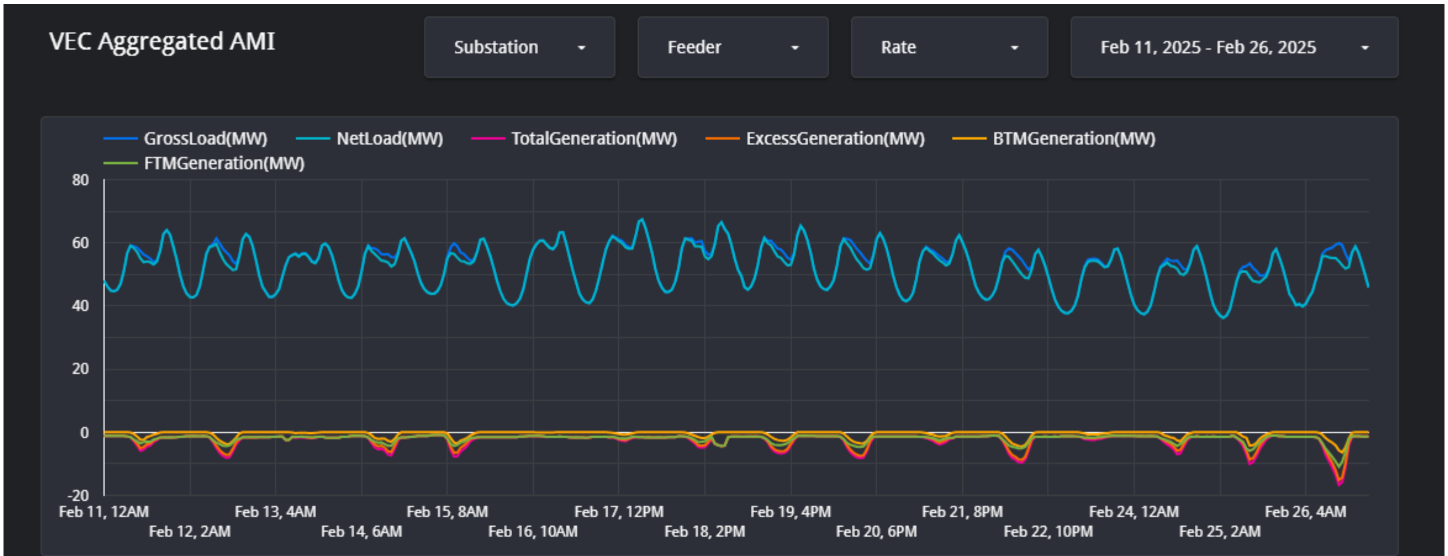
The Camus platform also runs an EV detection algorithm to identify potential level 2 charging. This information is then referenced with any transformers that may be overloaded.



VEC tracks EV and PHEV incentives through the Tier 3 program. While the data captures most EVs that are on the road, VEC does have many out of state part time residents who may not be eligible to receive an incentive in Vermont. The EV detection tool fills those gaps.

AMI Aggregation

One other use case is to aggregate historical load and generation data to support VELCO transmission planning. While VEC sends substation level SCADA data to VELCO this masks the true output of distributed energy resources, so AMI data must be manually aggregated instead. VEC created a dashboard that aggregates anonymized data by substation, feeder and rate class.



	amiendtimehour (Date Hour)	GrossLoa...	NetLoad(...	TotalGener...	ExcessGe...	FTMGenerat...	BTMGenerati...
1.	Feb 26, 2025, 11PM	45.87	45.87	-1.39	-1.39	-1.39	-0
2.	Feb 26, 2025, 10PM	49.69	49.68	-1.39	-1.39	-1.39	-0
3.	Feb 26, 2025, 9PM	53.29	53.28	-1.38	-1.38	-1.38	-0
4.	Feb 26, 2025, 8PM	56.7	56.7	-1.27	-1.28	-1.27	-0
5.	Feb 26, 2025, 7PM	58.84	58.84	-1.28	-1.29	-1.28	-0
6.	Feb 26, 2025, 6PM	57.04	56.91	-1.33	-1.22	-1.2	-0.13
7.	Feb 26, 2025, 5PM	54.34	52.31	-4.27	-3.25	-2.24	-2.03
8.	Feb 26, 2025, 4PM	56.6	51.84	-11.05	-9.69	-6.28	-4.76
9.	Feb 26, 2025, 3PM	59.28	52.89	-15.78	-14.34	-9.39	-6.4
10.	Feb 26, 2025, 2PM	59.95	54.19	-16.69	-15.14	-10.92	-5.77

1 - 100 / 384

This dashboard is visible publicly here: https://lookerstudio.google.com/u/1/reporting/7786cb5f-9acd-4a2c-b826-41ab9ec88f32/page/p_e4ofadfkad

Future Use Cases such as T&D Asset Deferral

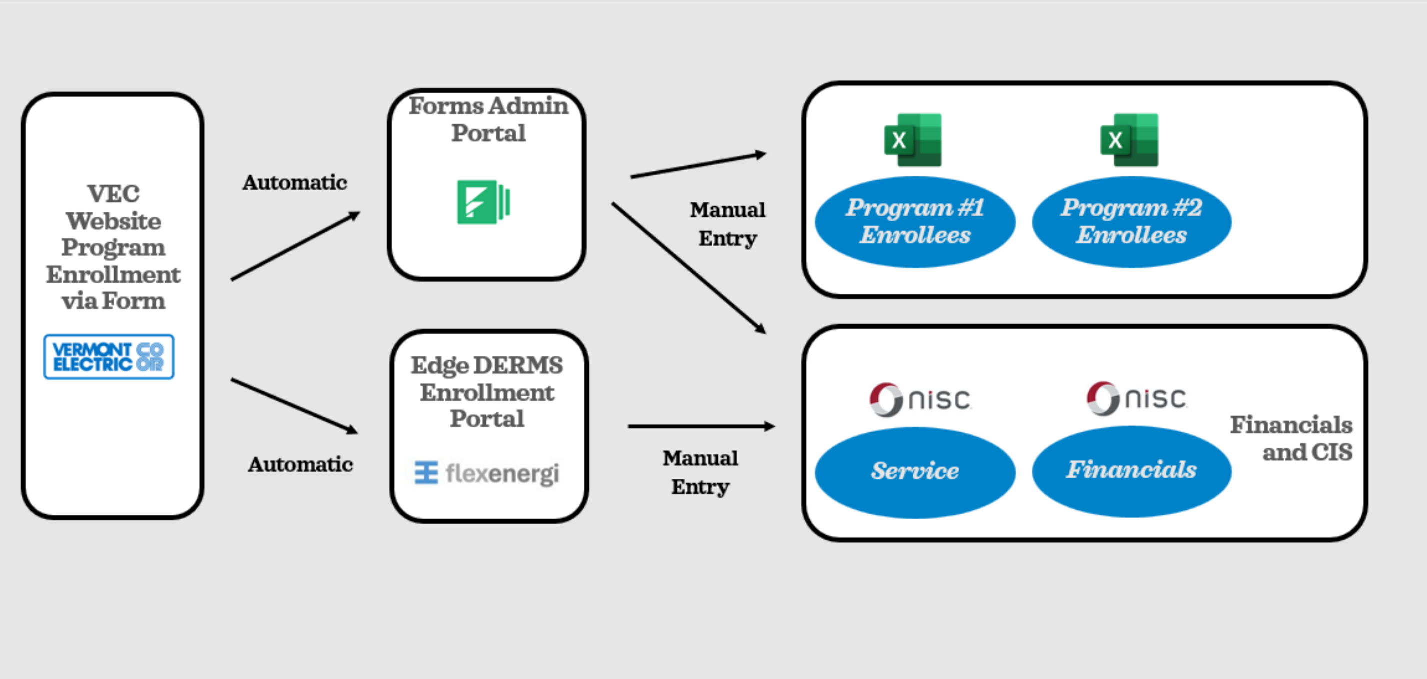
The Camus product enables us to both gain visibility of grid assets such as transformers and manage DERs such as electric vehicles. Without dual visibility and integration managing DER for T&D constraints would not be possible. VEC hopes to apply this DER management philosophy to more valuable T&D assets like primary lines or substation transformers or even to decrease transmission investment.

Program Administration

While VEC's programs were small, program administration and tracking enrollment were straightforward and managed through various Excel tracking tools. As VEC has expanded the number of programs and members enrolled, our strategy needs to adapt to a more structured and easily analyzable approach.

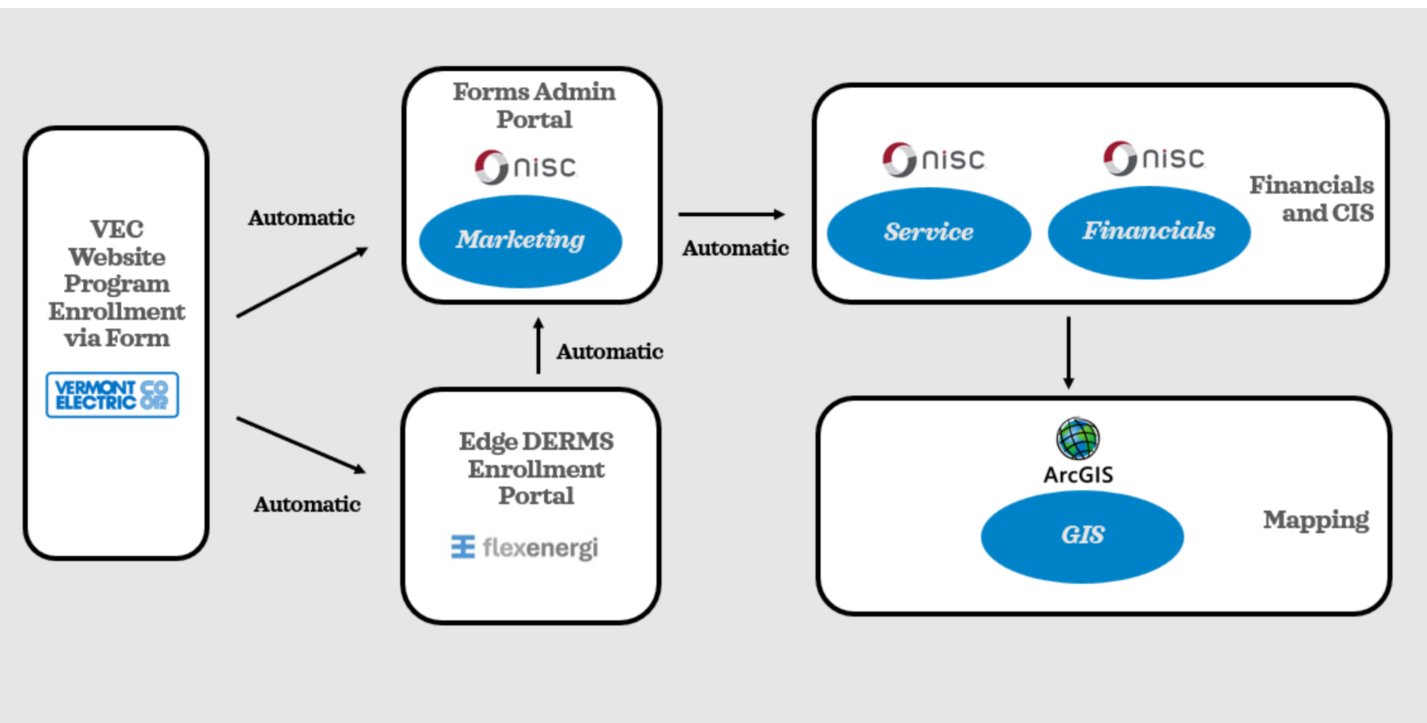
Current Strategy

VEC currently uses a variety of tools, including Formstack, Excel, and NISC, to track program participation. However, the process remains very manual.



NISC Program Management

VEC is in the process of implementing an integration with NISC's Program Management and Marketing tools which will enable a more automated process from program enrollment to billing and incentive management.



GIS Visibility for Planning

One of the values in getting VEC's program enrollment data into a common location is that we can more easily correlate that information to substation and feeder locations in GIS. This data can then be used by VEC planners to understand the impacts to the distribution system of this load growth, the data can also be fed to the Camus for further analysis. In addition, VELCO can leverage that information to aggregate load by transmission bus and better inform their long-range planning efforts.

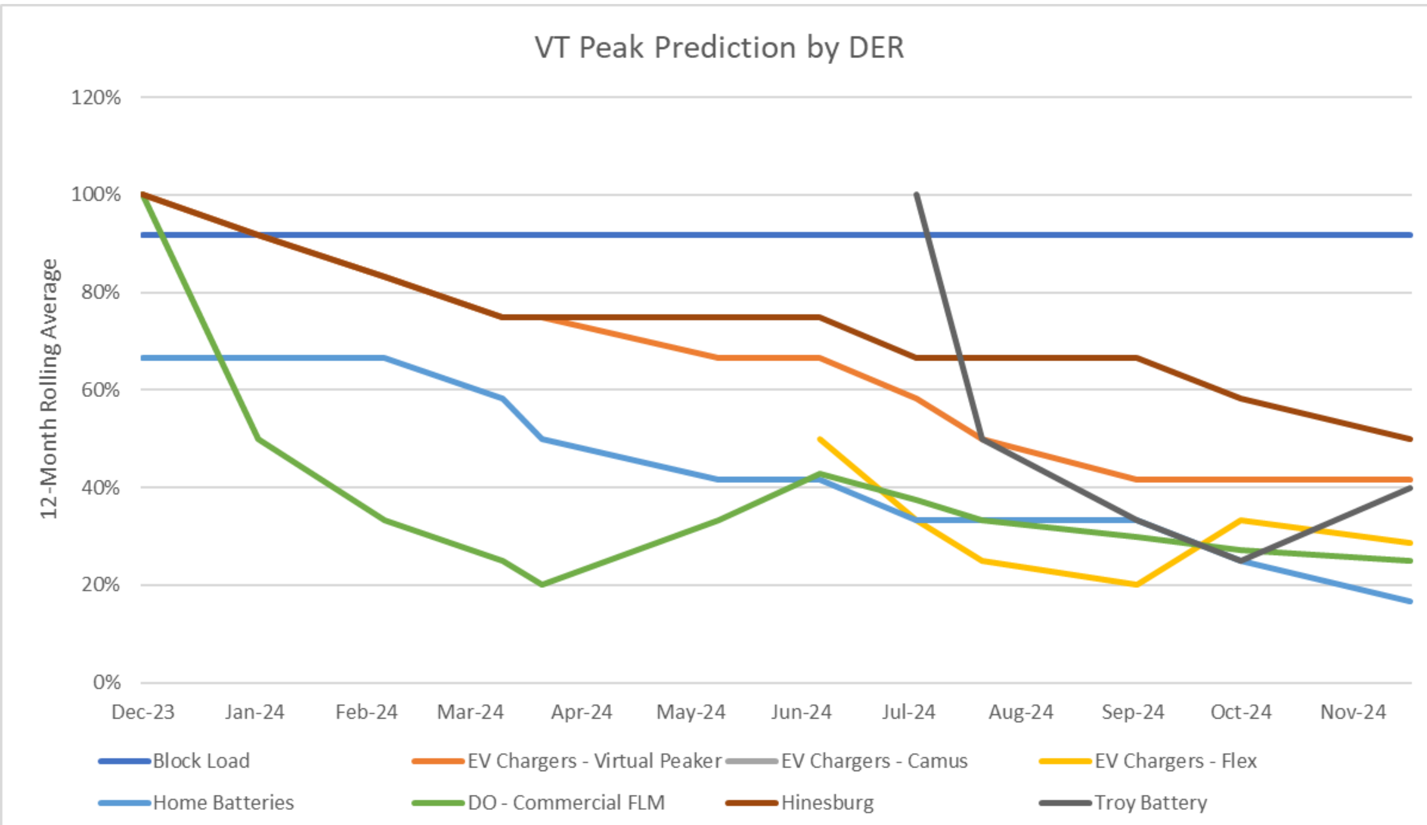
4.4.5 Enhance DER Availability

Peak Forecasting

Peak shaving continues to be the biggest driver of VPP value for VEC and as a result accurately forecasting the peak is extremely important to maximize value for VEC members.

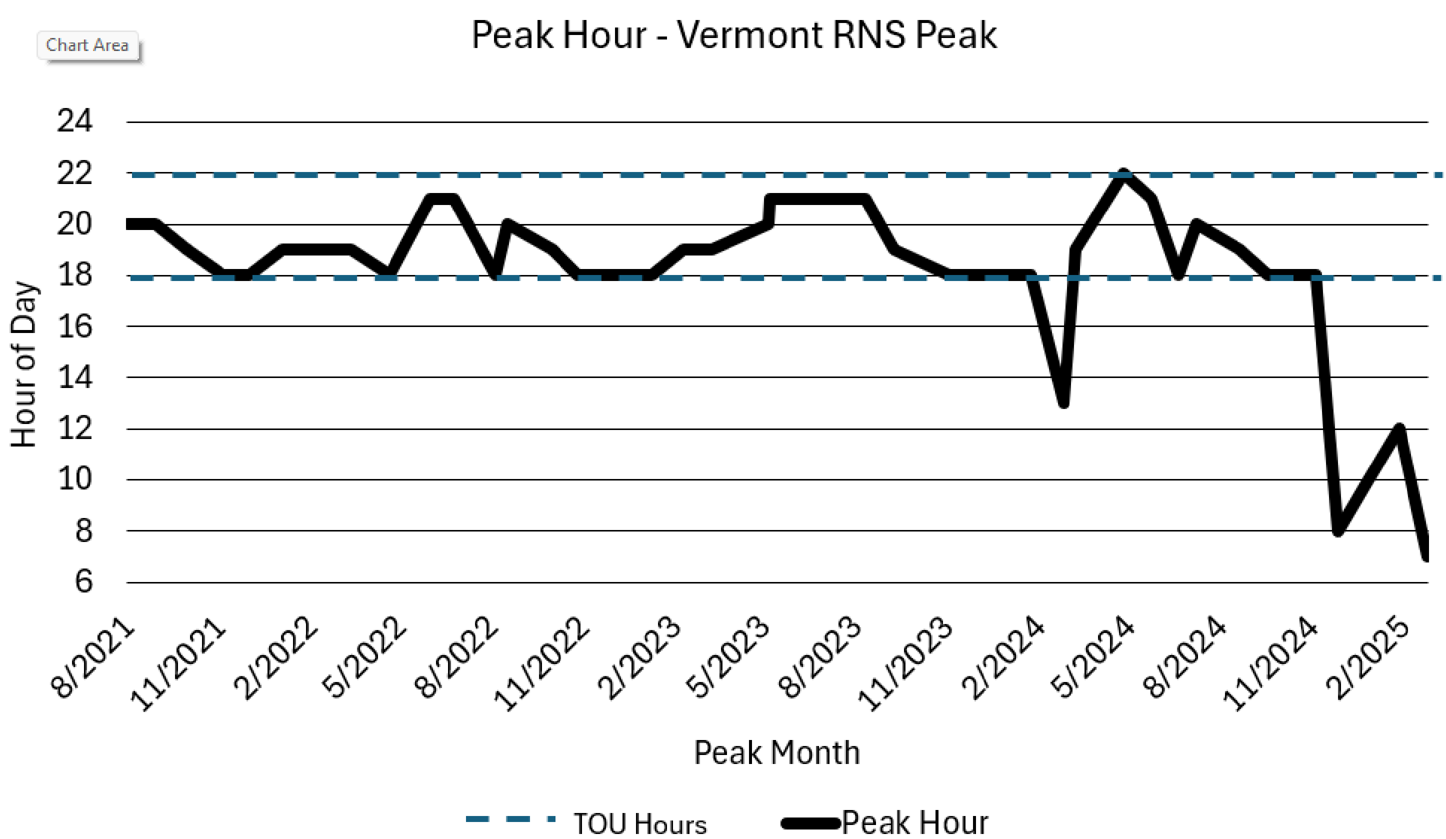
RNS Performance

After years of success, VEC has seen a decrease in in our ability to accurately predict monthly RNS peaks.



RNS Peak hour

VEC has also seen more irregularity in peak hours which have typically been between 4-10 PM. Recent peaks have occurred in morning hours or weekends making traditional TOU hours far less valuable.



Sustainability Assessment of VEC's Current Utility-Scale Battery Storage Strategy

VEC's current utility-scale battery storage strategy has been to enter Battery Energy Storage Service (BESS) agreements through which VEC can use a battery for peak shaving purposes for a certain number of hours per day and year. VEC provides prior notice to the developer of its intent to dispatch the battery by a time-certain prior to the requested dispatch. At VEC's expense, the developer charges the battery for VEC's use, with 50% of the battery charged in the 2 hours immediately preceding VEC's requested dispatch and 50% in the 2 hours immediately following the dispatch. In all other hours the developer can enter the battery in the ISO New England Regulation market to enhance its revenues.

Below shows is a table with the percentage of days each month of 2024 the daily peak load for Vermont occurred in a given hour. For example, in January the daily peak for Vermont occurred in hour ending 1800 in 81% (25 days) of the days, in hour ending 0800 in 10% (3) of the days, in hour 0900 6% (2) of the days and hour 1900 3% (1 day) . The actual peak hour for the month is highlighted in yellow. This is a change from 2021 when the peak hour in January was hour ending 1900 in 30 out of 31 days.

% of Days Peak Occurred in a Given Hour				Peak Hour for the Month								
Hour	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
3	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
4	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
5	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
6	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
7	0%	0%	6%	7%	0%	0%	0%	0%	0%	0%	0%	0%
8	10%	7%	19%	3%	0%	0%	0%	0%	0%	13%	3%	3%
9	6%	0%	6%	0%	0%	0%	0%	0%	0%	0%	0%	0%
10	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	3%
11	0%	0%	0%	3%	0%	0%	0%	0%	0%	0%	0%	3%
12	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	3%	0%
13	0%	0%	3%	0%	0%	0%	0%	0%	0%	0%	0%	0%
14	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
15	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
16	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
17	0%	0%	0%	0%	0%	3%	0%	3%	0%	0%	0%	3%
18	81%	48%	6%	0%	0%	0%	6%	6%	0%	10%	87%	77%
19	3%	45%	19%	13%	6%	7%	3%	6%	23%	77%	7%	0%
20	0%	0%	35%	43%	10%	17%	32%	68%	73%	0%	0%	6%
21	0%	0%	3%	30%	77%	63%	55%	10%	3%	0%	0%	3%
22	0%	0%	0%	0%	6%	10%	3%	6%	0%	0%	0%	0%
23	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
24	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

Figure 4.3.4.A – Percentage of Days Monthly Peak Occurred in a Given Hour

For January and February, dispatching peak shaving resources in a two-hour window starting at 6:00 PM and ending at 8:00 PM would have reduced a utility's load at the time of the Vermont peak in 53 out of 60 days, and in the three days each month with the highest loads. The window of hours in which the peak occurs begins to widen in March and through the spring and summer, when a three of four-hour dispatch window would have been required to hit the Vermont peak.

These monthly patterns have changed since 2021 as utilities have installed more batteries and/or other load management devices, causing the Vermont peaks to become flatter, making calling dispatches a day before more difficult and also increasing the risk of recharging batteries in peak hours.

VEC raised this peak-flattening concern in its 2022 IRP, and developed a spreadsheet that allows the user to estimate the impact of various quantities of load management or peak shaving devices on the Vermont hourly load shape. VEC continues to use the tool, with updated hourly Vermont loads, to help it predict monthly peaks and the impacts additional batteries and other load management devices can have on the hour Vermont peaks.

The following table shows the percentage of days each month of 2024 the daily peak load for Vermont would have occurred in a given hour with 50 MW/200 MWh of additional load management and/or battery storage.

% of Days Peak Occurred in a Given Hour					Peak Hour for the Month							
Hour	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
3	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
4	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
5	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
6	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
7	0%	0%	3%	7%	0%	0%	0%	0%	0%	0%	0%	0%
8	10%	7%	16%	0%	0%	0%	0%	0%	0%	13%	0%	3%
9	3%	0%	6%	0%	0%	0%	0%	0%	0%	0%	0%	0%
10	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	3%
11	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
12	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	3%	0%
13	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
14	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
15	6%	0%	3%	0%	0%	0%	0%	0%	0%	0%	0%	0%
16	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	7%	13%
17	0%	0%	0%	0%	0%	0%	0%	3%	0%	6%	0%	6%
18	58%	31%	3%	0%	0%	3%	13%	19%	23%	0%	63%	58%
19	3%	34%	13%	10%	3%	17%	0%	6%	17%	61%	7%	0%
20	0%	0%	29%	27%	3%	13%	29%	52%	57%	0%	0%	3%
21	19%	28%	26%	57%	84%	53%	42%	10%	0%	19%	17%	3%
22	0%	0%	0%	0%	10%	3%	3%	0%	0%	0%	3%	10%
23	0%	0%	0%	0%	0%	10%	13%	10%	3%	0%	0%	0%
24	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

Figure 4.5.11.B - Percentage of Days Monthly Peak Occurred in a Given Hour with 20MW/80MWh of Additional Batteries or Load Management

Comparing the two tables provides insight into how the daily peaks can move as more load management and/or peak shaving devices are installed in the state. In this case, the peak day changed in four months of the year (January, March, August and September), and the peak hour changed in ten months of the year (all except May and July).

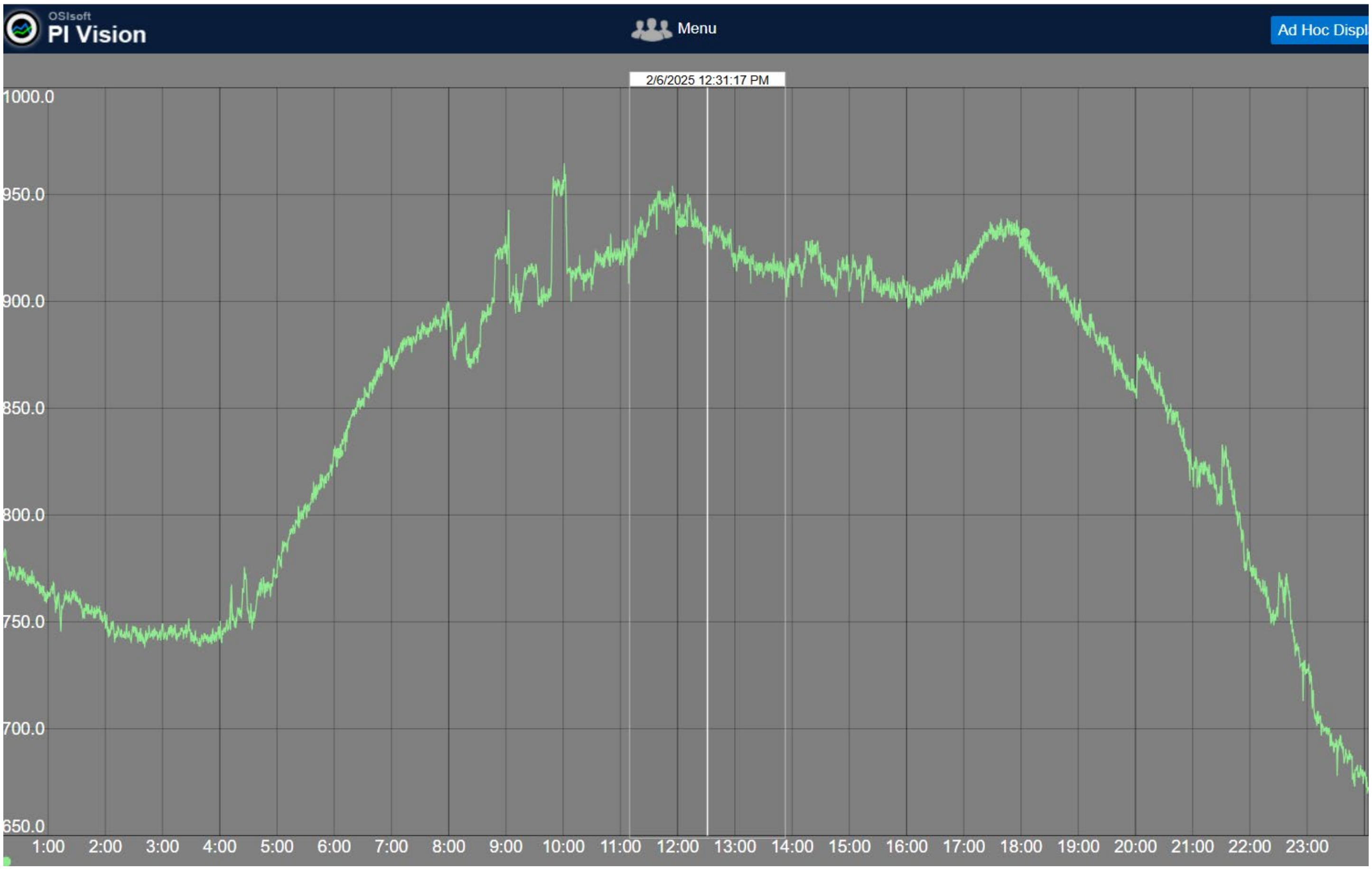
VEC will continue to use the analysis tool to provide insight into its load management/peak shaving strategies going forward.

Observations:

- VEC may want to reassess the charging and discharging terms of any future battery energy storage service agreements it enters with developers and providers of peak shaving services.
- VEC may want to consider owning utility-scale batteries in the future to provide more flexibility in charging and discharging.

GMP's Peak Shaving Resources Are Driving the Vermont RNS Peak

While VEC and other utilities expand their flexible resources, Green Mountain Power (GMP) stands out with over 120 MW of shiftable load, making it the primary influencer of the RNS peak. On a sample February day, GMP's resource dispatch highlights how close Vermont's peak hours are separated by less than 15 MW. Although VEC can affect peak times, larger utilities like GMP have more capacity to shift the peak.



VEC has observed that, although GMP's initiatives are effective in reducing costs for their own ratepayers, the current peak shaving mechanism (RNS) shifts a significant portion of these costs to other utilities. Many of these utilities may lack the resources to acquire assets on the same scale as GMP. As a result, the existing framework fosters a zero-sum environment where utility actions extend the overall peak yet inadvertently generate competition rather than encouraging potential collaboration.

While Vermont utilities already work together on the annual ISONE Forward Capacity Market peak, the equivalent incentive to collaborate is absent for the monthly RNS peaks.

VEC Peak Forecasting Tools

For many years VEC was able to accurately predict peak times through a variety of online weather sites and institutional knowledge. As the number of flexible resources in Vermont and the ISONE region have increased this strategy no longer works

Dynamic Organics

In 2023, as part of VEC's C&I Flexible Load Program, VEC began working with Dynamic Organics (DO) to leverage AMI data, machine learning, and weather forecasting to more accurately predict peaks. In addition to monitoring the weather VEC relies heavily on the DO forecast. VEC has released found that snow cover on solar sites can have a significant impact on peak forecasting, especially the day after large precipitation events. VEC is continuing to work on how to feed additional datasets to DO to more accurately predict peaks.

Dispatch Strategies

VEC anticipates that peak forecasting will become increasingly complex with the rise of DERs, making previous, simpler peak predictions unlikely. To improve resource utilization, VEC is testing new dispatch strategies; while most assets currently require 12-24 hour advance notice due to program terms. Some resources such as the VELCO radio site batteries can be dispatched almost instantly. To leverage this, VEC is shifting some dispatch duties from its programs team to the 24/7 control center staff, who can monitor loads in real time using SCADA. Eventually, VEC aims to automate these processes, as GMP has done with a portion of its Tesla Powerwall fleet.

4.4.6 Expanding DER Quantity and Type

While VEC currently manages almost 800 EV's, batteries or C&I buildings we have goals to manage more type of devices.

Residential Scale Pilots

Energy Storage Access Program – Income Qualified Residential and Municipal Batteries

The Energy Storage Access Program (ESAP) is designed to provide battery storage solutions to income-qualified residential and municipal members. The primary goals of the program are to enhance resilience, support income-qualified households, and address emergency needs. By providing backup power during outages, the program ensures that essential services such as refrigeration, medical equipment, and heating remain operational. It targets low- and moderate-income households, making battery storage accessible and affordable for those who might not otherwise be able to afford it. Additionally, the program helps households manage during emergencies, reducing the impact of power outages on vulnerable populations.

The program is funded through a state grant, which enables low or moderate-income homes to receive battery storage at no or a heavily discounted cost. VEC expects to enroll approximately 55 low and moderate-income members in the initial phase, with the batteries provided being used for peak reduction in addition to resilience. VEC was unable to demonstrate a reasonable ROI for battery investment, so our existing battery storage program is "bring your own device." This grant funding bridges that gap and provides VEC with an avenue to offer batteries to members.

Program/ Pilot Name	Expected Devices	Total MW	Total MWH	Monthly Bill Credit
Income Qualified Battery Program	50	0.5MW	1.3 MWH	• Low Income – No payment • Moderate Income - $5/month

Grid Aware Managed Charging – Support Your Local Grid Pilot

As discussed earlier in this document, VEC has filed an innovative pilot to manage EV charging for distribution transformer constraints. This is discussed later in this document.

Program/ Pilot Name	Expected Devices	Total MW	Total MWH	Monthly Bill Credit

Support Your Local Grid Pilot	20	0.02MW	0.08 MWH	• $4-$8/month • Depends on size of kW reduction and locational need

Heat Pump Management Pilot

While EV's represent that largest load growth category, VEC is anticipating significant load increases from heat pumps as well. There are several challenges in managing heat pumps:

- Device Connection – Unlike many DER's which have direct to device connectivity options many heat pump manufacturers in the US are not connected to Wi-Fi directly. Only 1% of VEC's ~4,000 heat pumps are Wi-Fi enabled. While there are several thermostat vendors that have heat pump connectivity capability (Ecobee, Sensibo, Flair), they all require an additional device or a hardwired connection.
- kW Measurement – While batteries and EV chargers measure kW through the device manufacturers like Mitsubishi and Daikan do not. This makes it very difficult to provide incentives based on usage without measurement at the panel through a smart breaker or other device.
- Flexibility – Unlike an EV which has around 9 hours of flexibility during the night (12 hours minus a 2-3 hour charging session) most buildings in Vermont are not well insulated. VEC is unsure how much flexibility and how long that flexibility will last.

VEC is currently working with other electric cooperatives, mainly in the midwestern part of the country, to develop a pilot program to determine if controlling Cold Climate Heat Pumps can be used to reduce heating and cooling load during projected peak hours.

The purposes of the pilot are to:

- Estimate mini-split ASHP load reduction impact for both utilities and end-users
- Study ASHP load profiles and how they are affected by DR events
- Learn how different DR control strategies affect occupant comfort and system performance
- Create a repeatable control option for mini-split ASHPs

This effort is still underway, and a final report is planned to be released in mid-2025

Program/ Pilot Name	Expected Devices	Total MW	Total MWH	Monthly Bill Credit
Heat Pump Management Pilot	TBD	TBD	TBD	• $4-$8/kW/month • Depends largely on duration of flexibility

Vehicle to Grid/Home/X

Vehicle-to-Grid (V2G) and Vehicle-to-Home (V2H) are two distinct applications of electric vehicle (EV) technology that enable EVs to interact with the power grid and home energy systems. V2H technology allows EVs to supply power directly to a home, ensuring that the amount of discharge does not exceed the household load, unlike VEC's battery program. On the other hand, V2G technology can either draw electricity from the grid to charge the vehicle or send electricity back to the grid from the vehicle's battery. For instance, VEC could dispatch vehicles in a manner similar to how residential batteries are dispatched, potentially exceeding the load at home.

The average EV has a capacity of approximately 50 kWh, which is more than four times the size of a standard Tesla PowerWall. While this technology holds great promise, the space has been plagued by misinformation from vendors regarding product availability and capability. Additionally, questions remain about the impacts on battery degradation and warranties. Although there are several small pilots in progress, they come at significant costs that are not feasible for VEC members. As the market continues to mature and implementation costs decrease, VEC expects to offer a pilot that further explores this technology.

Program/ Pilot Name	Expected Devices	Total MW	Total MWH	Monthly Bill Credit
Vehicle to Grid Pilot	TBD	TBD	TBD	• Modeled similarly to battery program • Monthly bill credit of $6.40 per kilowatt (kW), OR • Upfront payment of $268 per kW and monthly bill credit of $3.20 per kW

Past Pilots

Residential Water Heater Management – Packetized Energy

VEC had an active water-heater-control program with Packetized Energy utilizing their Mello smart controller hardware and their "Nimble" management platform. However, Packetized Energy was recently bought out by Energy Hub. Unfortunately, Energy Hub is not interested in supporting programs on the scale of this program and VEC will no longer have visibility or control over the devices installed under this program. Packetized and Energy Hub were able to provide a set peak schedule that the enrolled devices will follow moving forward. VEC anticipates that the number of active devices will decline over time as Wi-Fi passwords change, houses are sold, or devices break down.

> **Learning: Additional Device Installations in Home are Challenging**
>
> The program highlighted the challenge of installing devices in member's homes. VEC needed to install a load control device on the water heater which required coordination with an electrician and the member. VEC does not have an electrician on staff and relied on a series of electrician contractors. This is experience highlights the importance of remaining flexible and managing member expectations when engaging in pilot projects that utilize new technology.

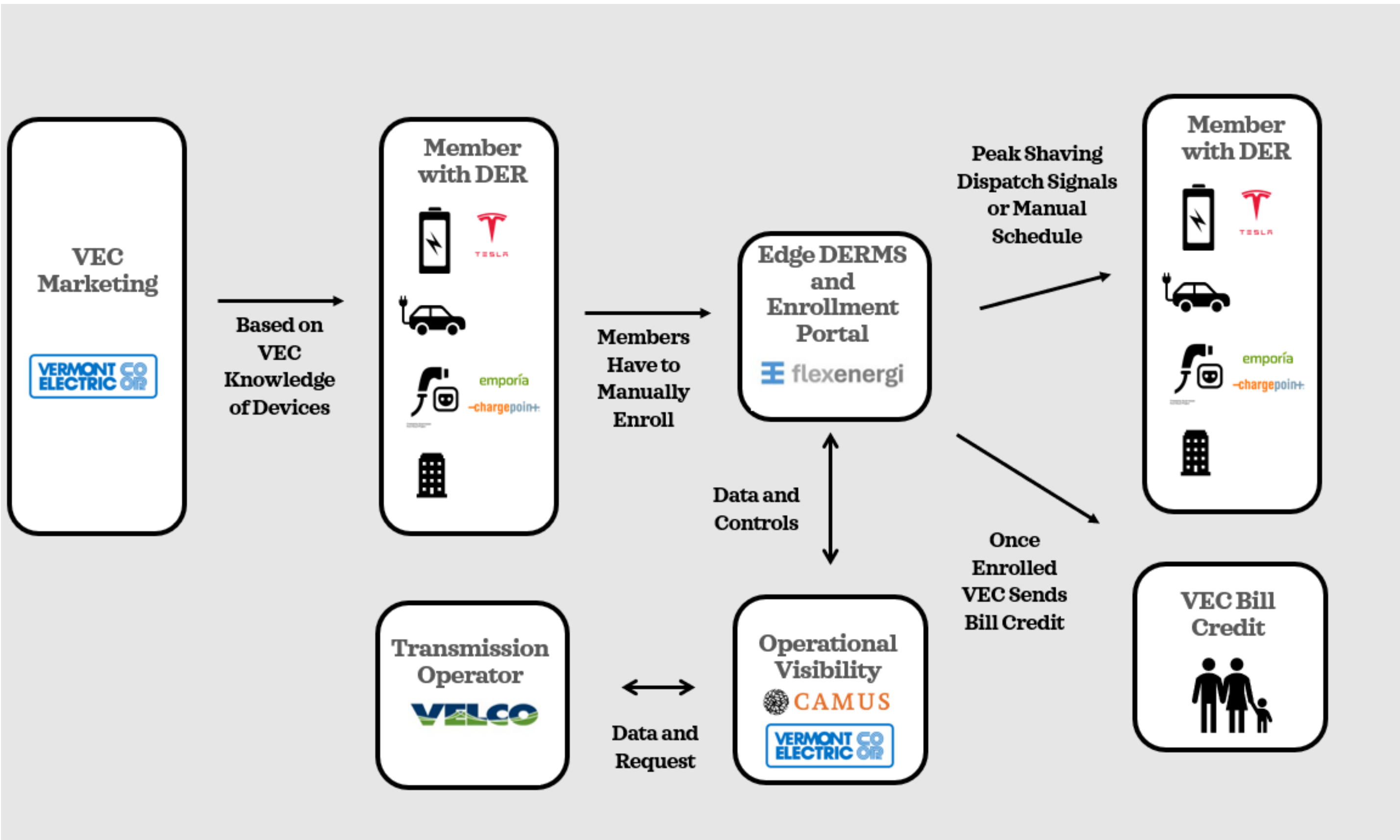
Level 1 EV Charger Management Pilot

VEC, partnered with BED and WEC to implement a Level 1 EV Charger Pilot in 2022. VEC's member survey has indicated that while most members charge with a level 2 charger at home around 1/5 of our members charge through a standard wall plug (level 1 charging). This project utilized smart plugs to manage the Level 1 EV load.

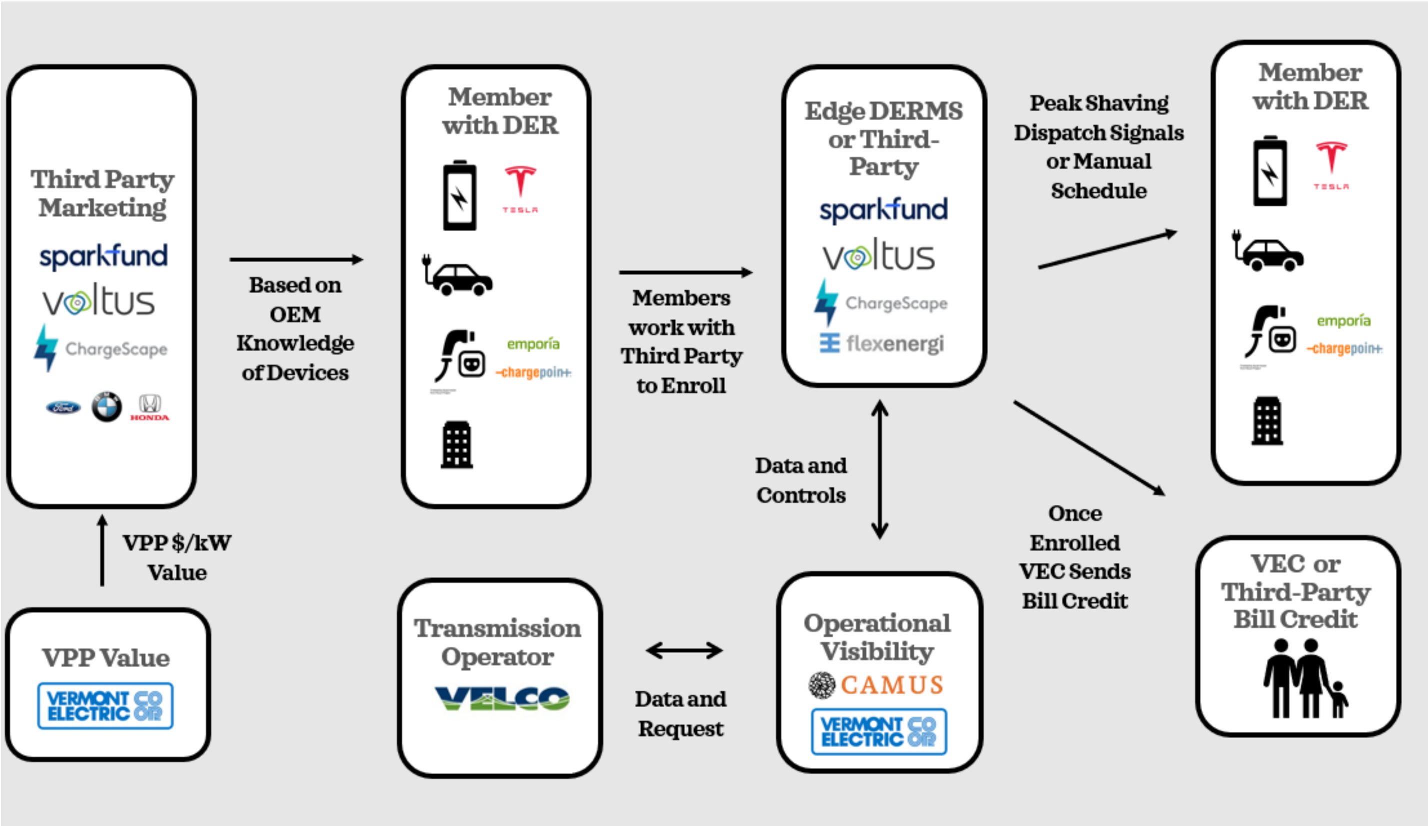
> **Learning: Limitations with Smart Plugs**
>
> Most smart plugs support up to 10 amps, but Level 1 chargers can draw up to 15 amps, limiting compatible options. Not all electric vehicles charge simultaneously. VEC observes about 1.5 kW per location on average for Level 2 charging. Level 1 chargers draw less than 0.3 kW, making it challenging to justify a program.

Third Party Aggregators

All of VEC's programs and pilots are currently member owned and utility run. An available alternative that is quickly expanding is to leverage third-parties like Sparkfund, Tesla, ChargeScape, and Voltus to more rapidly deploy DER. These models empower third parties to market and sell directly to VEC members all while VEC maintains visibility and potentially management of those devices. VEC's current process is shown below



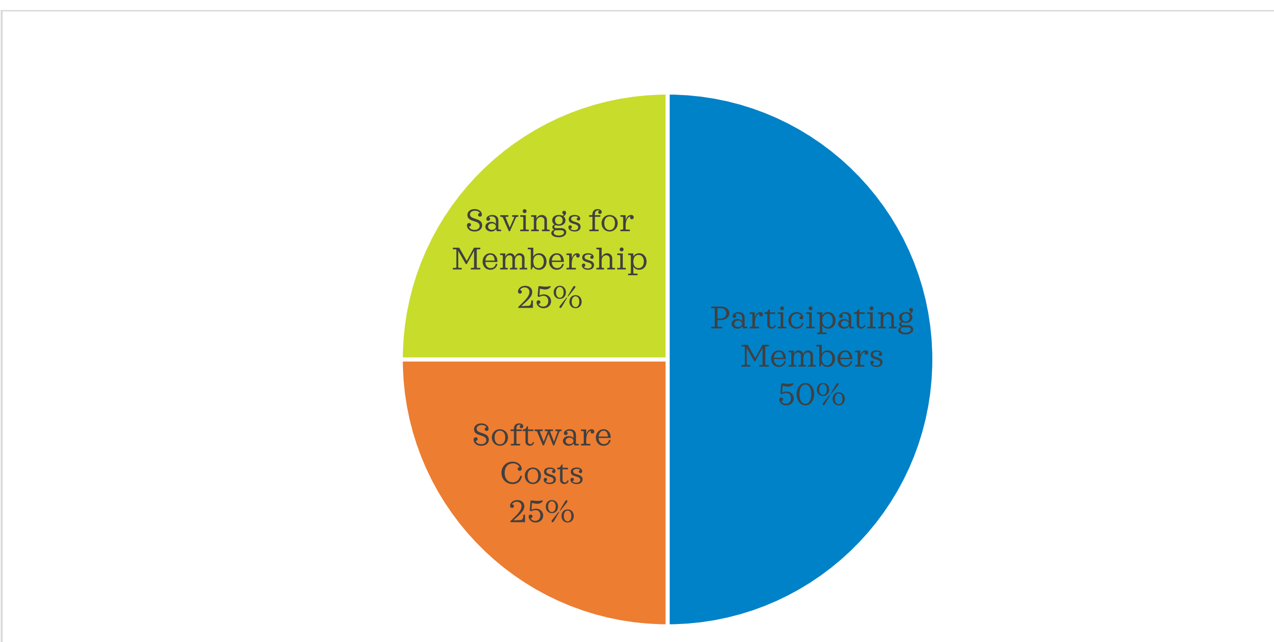
The third-party aggregator model could look like this



VEC highly recommends This Volts Episode for those interested in this concept.

DER Management Cost Effectiveness

VEC's goal in all Flexible Load programs is to maximize the value to non-participating members (savings to the membership)



All of VEC's flexible load programs programs offer some savings to the membership, but large OEM fees can significantly impact these economics. Below is an example based on the existing peak shaving value (reduced by 75% for peaks) of charger and EV telematics programs.

Program Components	Charger $/kW /Year	Telematics $/kW /Year	Telematics with OEM Fee $/kW /Year
Peak Shaving Value	$162	$162	$162
Edge DERMS per Device Fee	$60	$60	$60
OEM Fee	$0	$0	$100
Participating Member Incentive	$96	$96	$96
Total Savings	**$6**	**$6**	**-$94**

VEC does not collaborate with OEMs that charge for vehicle access, as this would not demonstrate savings to VEC members.

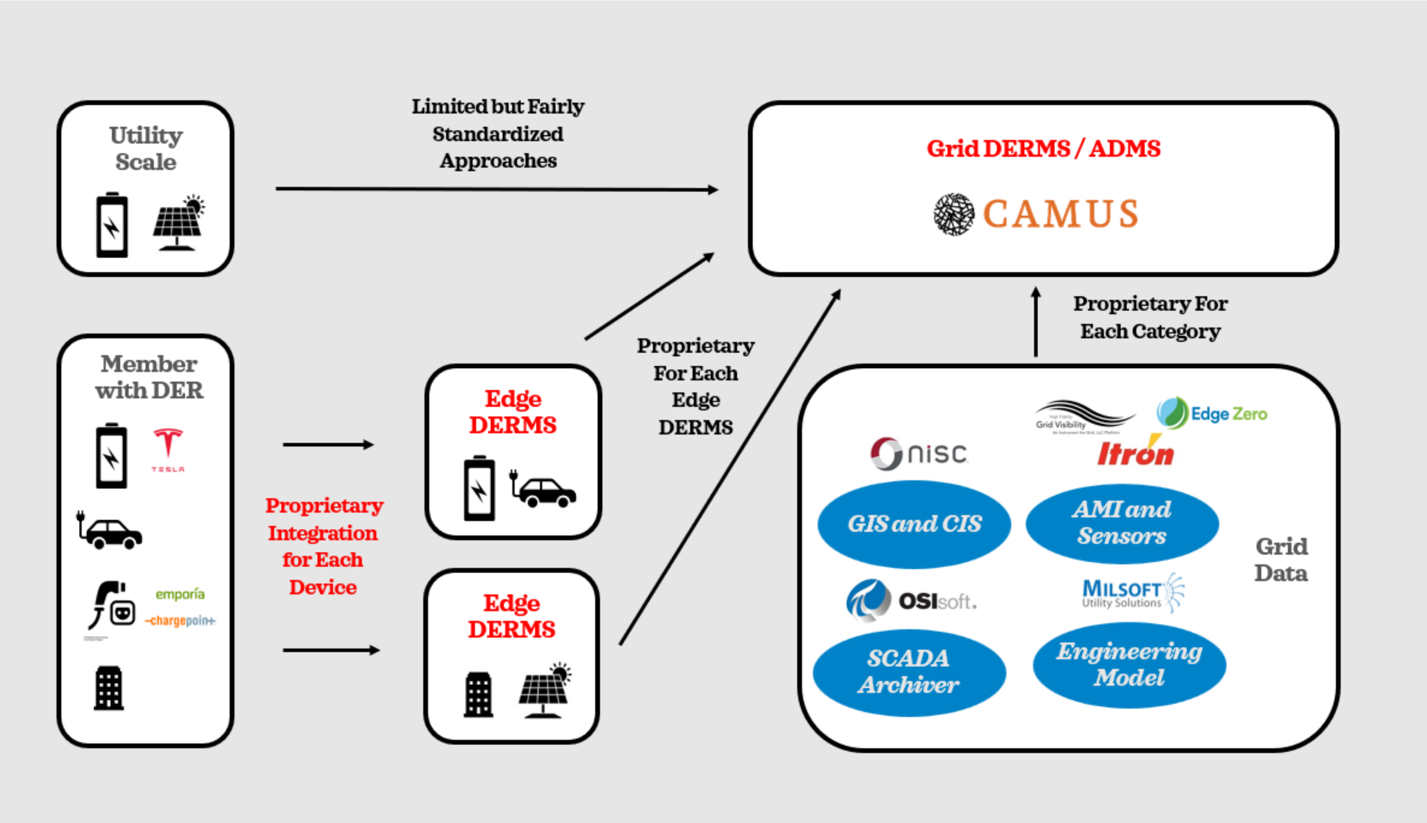
4.4.7 VPP Future Challenges and Opportunities

As we look to the future, we see the following challenges and opportunities from Virtual Power Plants. Many of these are described online here.

VPP Technology and DER Management

VEC sees three primary and closely related challenges in the VPP Space

- Proprietary Device Communications increasing cost and reducing options
- Edge DERMS Pricing
- Nascent Grid DERMS Vendor Environment and Integration Risks



__**Proprietary Device Communications increasing cost and reducing options**__

To manage a DER device an integration needs to be made between the Edge DERMS vendor and OEM. In some cases, different integrations are required for different device models but generally this is done through a defined OEM API. A recent [Volts podcast](#) discusses this topic and the Mercury Consortium and its attempt to direct vendors towards open standards such as OpenADR. By using open standards like Bluetooth this can decrease the integration costs and ensure that devices can be managed even if an OEM no longer exists. A recent example of this is EnelX and over 125,000 chargers that were no longer accessible.

> **Strategy #1: Encourage Standardization**
>
> While VEC believes that standard device communications are important it does not have the ability to mandate those standards as the industry at large determines what will be used. OEMs are currently charging for access to devices and therefore generating revenue, making a standards-based approach less likely. Regulatory requirements could support these efforts.

__**Edge DERMS Pricing and Capabilities**__

Since 2019, VEC has contracted with several Edge DERMS vendors to manage DER devices. Whenever entering these relationships, VEC conducts a cost-benefit analysis considering the current peak shaving value (RNS and FCM), the number of devices managed, and the cost of DER management.

VEC has been able to partner with vendors that provide a positive cost benefit to the VEC membership. However, some initial partners have come back with significant price increases that no longer make the programs economic. Additionally, VEC has learned that some smaller utilities struggle to utilize vendor-quoted integrations due to the limited number of devices. OEM vendors that the DERMS vendors collaborate with still need to authorize access to devices within the utilities' service areas and may not be if there are small device quantities.

> **Strategy #2: Experiment with Pilots and Explore Data Layer Partners**
>
> To reduce risk VEC has experimented with pilots to fully understand device costs and ensure that DER management can provide benefit to the VEC membership. VEC is also actively exploring partnerships with data layers companies like Texture to reduce integration costs and expand device types.

Nascent Grid DERMS Vendor Environment and Integration Risks

The DERMS vendor environment is filled with many choices, some who have been around for many years such as OATI and others that are much newer. Integrations with ADMS or Grid DERMS can take time and are typically proprietary and therefore costly.

> **Strategy #3: CIM Integration**
>
> Through VELCO and PNNL partnership VEC has explored what it would take to Utilize the Common Information Model (CIM) as the standards-based platform to reduce custom or proprietary data sharing/formats. This format is common in Europe and is currently being implemented by several other Transmission operators in the US. While its use in DER management is nascent it could create a no regrets option for VEC , especially with the ever changing vendor environment.

Grid Constraint Identification

VEC identifies constraints today through traditional distribution physics-based planning models work. These models are essential tools for utility planners and rely on key inputs such as connectivity, SCADA, and AMI data. At VEC, GIS connectivity is used to create a distribution model on a daily basis. This model is then cleaned up a couple of times per year to ensure accuracy and reliability for the planning team. Unfortunately, as a result of the lack of speed this model is not useful for DER management so we would be unable to dispatch an EV or battery to solve a primary conductor overload

> **Strategy #4: Physics Informed Distribution Online Power Flow**
>
> Can we leverage real-world data by using machine learning to inform traditional physics models? Would that tear down the barriers created by slow-to-run or inaccurate models today?
>
> VEC is collaborating with UVM and Camus to build distribution online power flows down to the meter level. These online power flows can run fast (5 minutes) and can reduce the barriers created by slow-to-run or inaccurate models of today. VEC describes this in more detail here

Cybersecurity

There are two main Cybersecurity components to consider in the DERMS environment – Secure communications, and Secure data

Strategy: Isolation

VEC ensures secure communications in the DERMS environment by isolating DER data from the rest of the grid's critical systems like SCADA (Supervisory Control and Data Acquisition) and GIS (Geographic Information Systems). Since DER data is often transmitted through less secure public networks, such as member Wi-Fi or public cellular connections, isolating these communications helps prevent any unauthorized access to the utility's core systems. SCADA data is sent to DERMS but from a corporate network that is isolated from VEC's operational network.

DER Quantity

EV Detection

Electric Vehicles can potentially add up to 20kW worth of load in an instant which puts pressure on VEC's infrastructure. While VEC encourages members to notify VEC of any load increases, VEC mostly hears of load increases through incentive offerings. Each EV is analyzed for impacts and VEC has also contracted Camus Energy to provide EV detection services. At some point in the future VEC will stop providing incentives for electric vehicles as they become more readily adopted which will limit VEC's ability to identify where EV's are affecting the grid proactively.

Strategy: Access to Vermont Motor Vehicle Registration database

The Vermont DMV maintains registration data on vehicles and could make this data available to utilities. This would reduce the need for ratepayers to fund EV detection and ensure the grid remains reliable with EV growth.

Additional Device Types

VEC receives many requests from members to enroll new device types into our flexible load management programs. However, there are often only a handful of those device types in VEC's territory, and each device requires its own integration to a DERMS. These integration costs typically only make economic sense if spread across many devices.

Strategy: Encourage Standardization

This strategy is discussed above. With greater standardization the device integration costs for VEC are reduced and VEC can expand the quantity of devices in its programs.

DER Availability

Device Connectivity

In general, most DER programs utilize API connections through member Wi-Fi to gain data access. A weak or inconsistent Wi-Fi signal can result in missed events and reduce the reliability of a DER program. Some of VEC's members have chargers located in detached garages which can be on the outer bounds of reliable Wi-Fi and sometimes this may result in VEC sending a fixed schedule to the device.

Through FlexEnergi, VEC has had much better success with device connectivity even in areas of limited to no cell service. Unfortunately, VEC has only been able to target vehicles that have free communications such as Tesla. Many OEM's charge monthly fees to access the vehicles in addition to a per device fee which makes enrolling them in the program uneconomic.

> **Strategy : Program Options**
>
> VEC offers a variety of programs to meet members needs. For those members with weak Wi-Fi signals VEC can offer a scheduled DER management option versus the preferred direct management option.

Home Battery Winter Performance

During winter months when solar output is limited many of VEC's members' home batteries are unable to charge from solar. About half of VEC's enrolled participants have taken advantage of an Investment Tax Credit that requires a certain percentage of charging comes from solar. For those members, VEC is limited in how frequently we can dispatch those resources from November through February. The solar charging requirement is no longer applied to new installations.

> **Strategy: Device Grouping**
>
> VEC is exploring how to group its battery resources into various categories that don't limit the dispatch across the entire fleet.

Peak Forecasting

As indicated in the prior sections peak forecasting continues to increase in difficulty as flexible resources in the state and region increase.

Dispatch Notification and Timing

Except for utility scale battery projects almost all VEC's programs are member-owned and require longer duration notifications (up to 24 hours) before dispatch. This requires a longer duration forecast and results in a lower success percentage when hitting peaks

> **Strategy #1: Decrease Notification Timing**
>
> VEC is exploring modifying its terms and conditions to decrease the amount of notification time required. Additionally, VEC is launching an income-qualified battery program that is VEC owned and will therefore have no notification requirements.

Additionally, VEC has seen an increase in variability in peak times with some occurring early in the morning and others occurring on weekends. Peak dispatches are currently managed by VEC's Power Supply team, however VEC has a 24/7 managed control center that could fulfill this role.

> **Strategy #2: Explore Control Center Management**

> VEC's control center operators have visibility of the Vermont peak in real time and are currently managing two utility owned batteries. VEC anticipates shifting dispatch responsibilities of batteries and EV's to the control center by end of year.

RNS Collaboration with Other Vermont Utilities

There is currently no incentive for utilities who are competing against each other to reduce load during Vermont Peaks to collaborate. The mechanism encourages competition unlike the ISONE annual peak which encourages collaboration.

> **Strategy: Regulatory Requirements for Collaboration**
>
> VEC believes that this is a zero-sum game that will ultimately shift cost to the smaller Vermont utilities and their ratepayers. Those who are unable to invest in load management will bear a significant increase in transmission expenses. VEC would be eager to explore potential pathways to collaboration with the other Vermont utilities but that would likely need to be initiated by regulators.

Program Administration

Device Participation

As VEC's programs have increased from a handful of devices to over 500 managed devices at the end of 2024, keeping track of participants in a scalable and easy to query manner has bene a challenge.

> **Strategy: NISC Program Management**
>
> VEC is in the process of implementing an integration with NISC's Program Management and Marketing tools which will enable a more automated process from program enrollment to billing and incentive management.

Member Questions

With this rise in participants, VEC has also seen an increase in the amount of troubleshooting required to get devices connected, issues with Wi-Fi, or general device questions

> **Strategy: Explore Third Party Support**
>
> VEC's telematics program through FlexEnergi offers enrollment and device support. This model has drastically reduced the amount of internal staff time required to address questions and is a model that VEC is eager to explore moving forward.

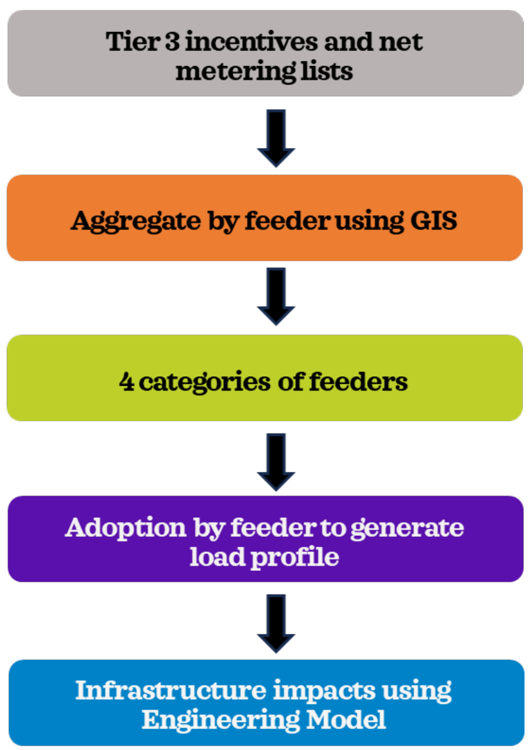
Operator Trust

As VEC seeks to expand VPP programs to manage grid constraints engineers and operators will need to be comfortable and trust that DER management can provide these services. There are many gaps in visibility of these resources, the visibility of distribution system and the constraints on the transmission system. VEC describes some of these challenges in more detail here.

> **Strategy: Start Small, Experiment and Learn**
>
> VEC is exploring this type of management with distribution transformers and expects to understand the requirements operators need for this low-risk asset. This will help inform future projects on substation transformers or transmission systems.

4.5 Utilize Flexibility in the Distribution Grid to Reduce Electrification Impacts

As with any type of load growth, quantity and location of electrification can have significant impacts on the electrical grid. For this IRP, VEC examined four representative feeders and their historical and projected adoption of electric vehicles and heat pumps. While recognizing the impacts of other types of electrification such as water heating and commercial & industrial building electrification, VEC chose to concentrate on the two most significant loads: electric vehicles and heat pumps.



4.5.1 Projected Electrification by Feeder

Income and Political Leaning Most Impact Adoption

VEC used historical data from Tier 3 incentives to map feeder load growth. This was done for both heat pumps and electric vehicles. These maps are available on VEC's website https://vermontelectric.coop/electric-system/grid-data-and-mapping

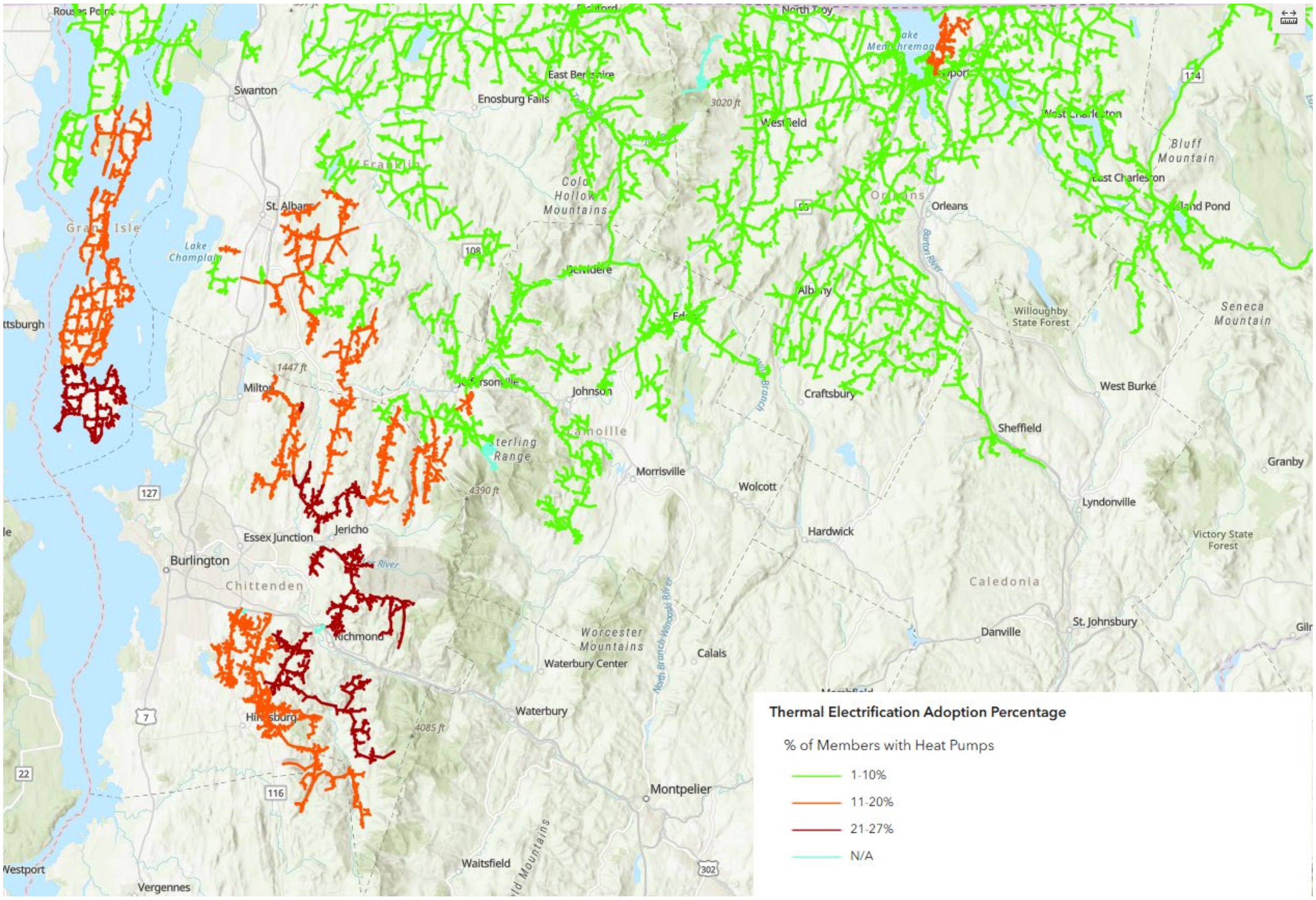


Figure 4.5.1.A VEC Thermal Electrification Adoption Percentage (data through 12/31/2024)

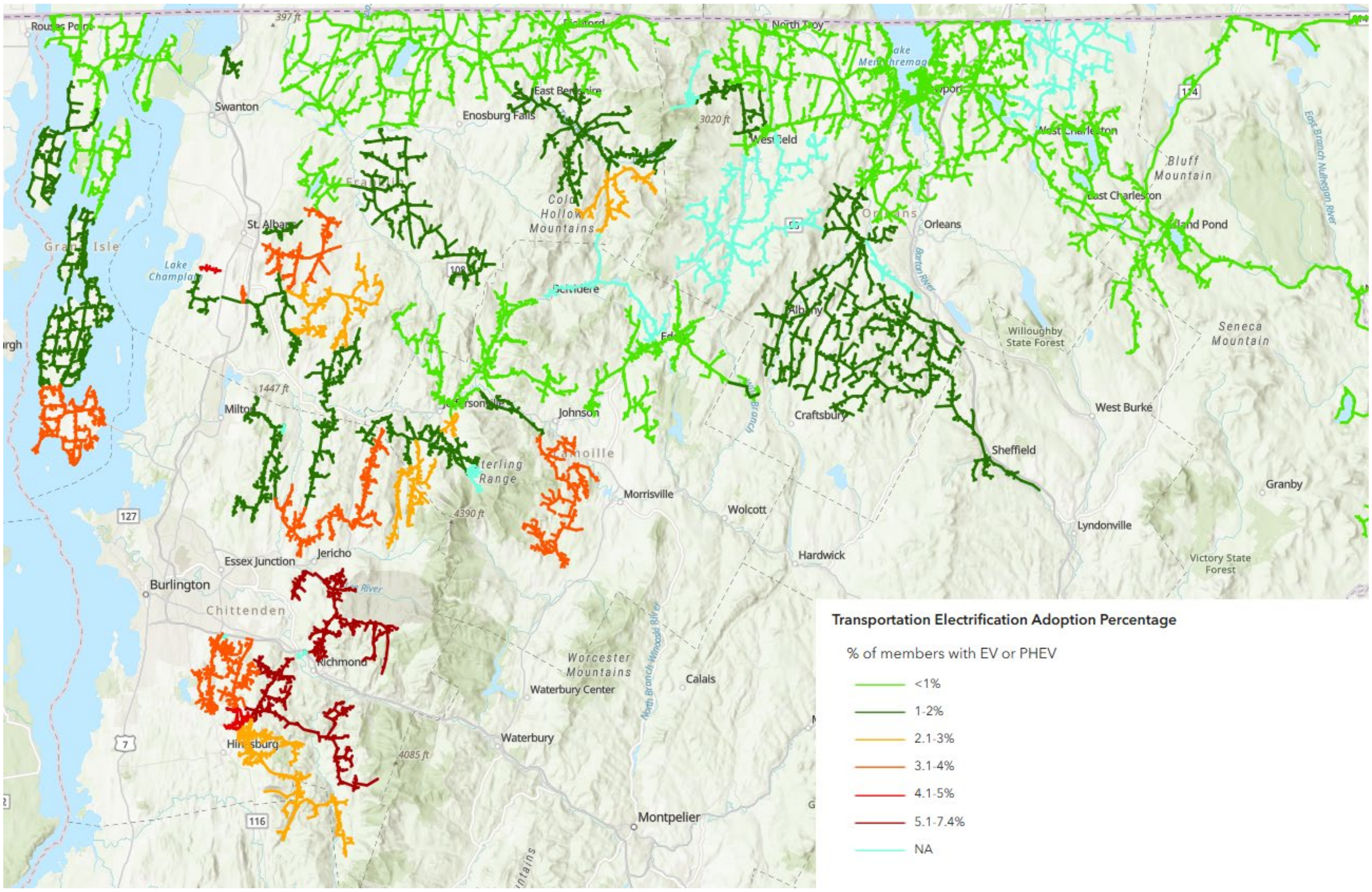


Figure 4.5.1.B VEC Transportation Adoption Percentage (data through 12/31/2024)

Past load growth is concentrated in areas of higher income and more Democrat-leaning.

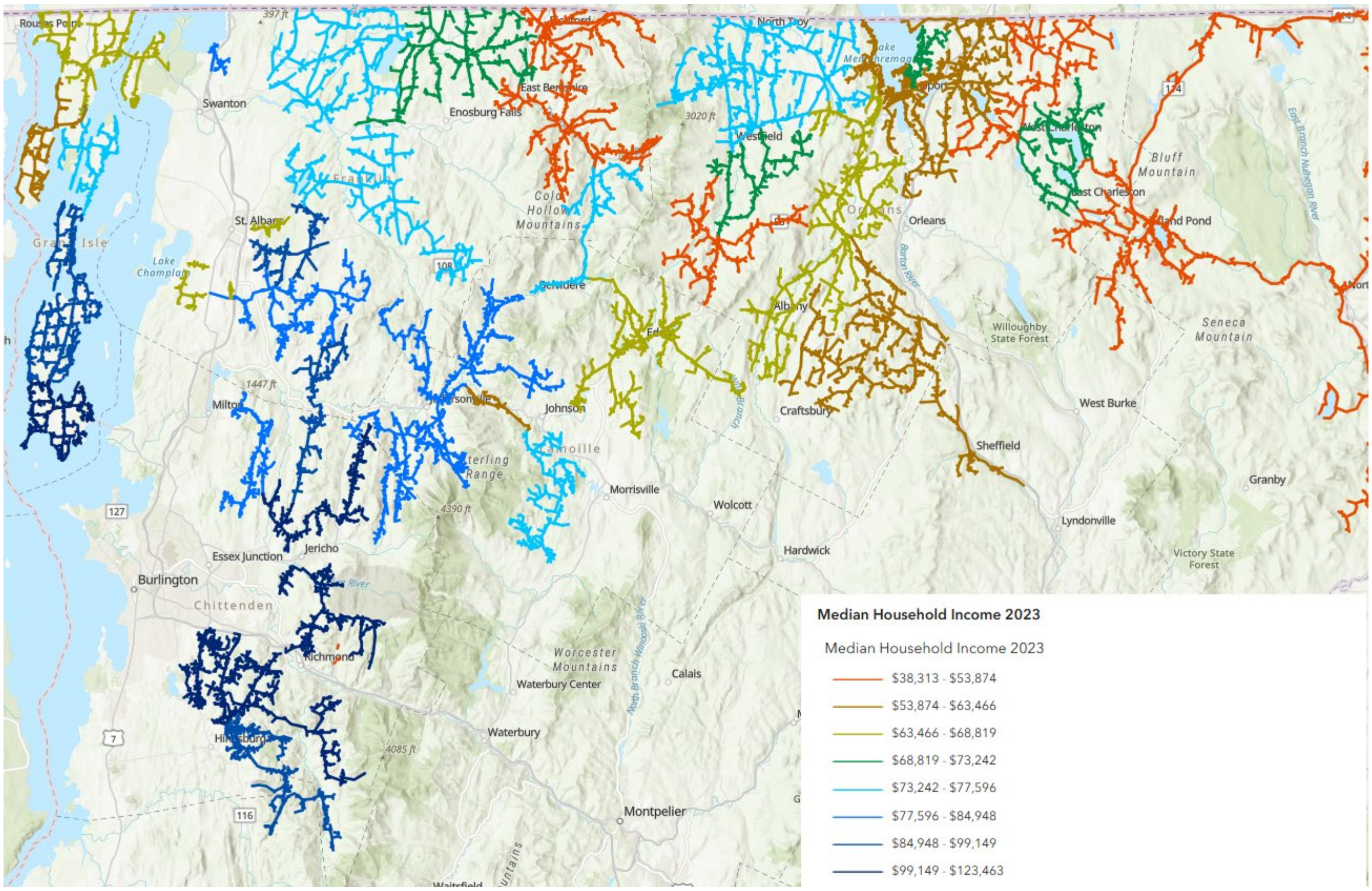


Figure 4.5.1.C Median household income from 2023 census data

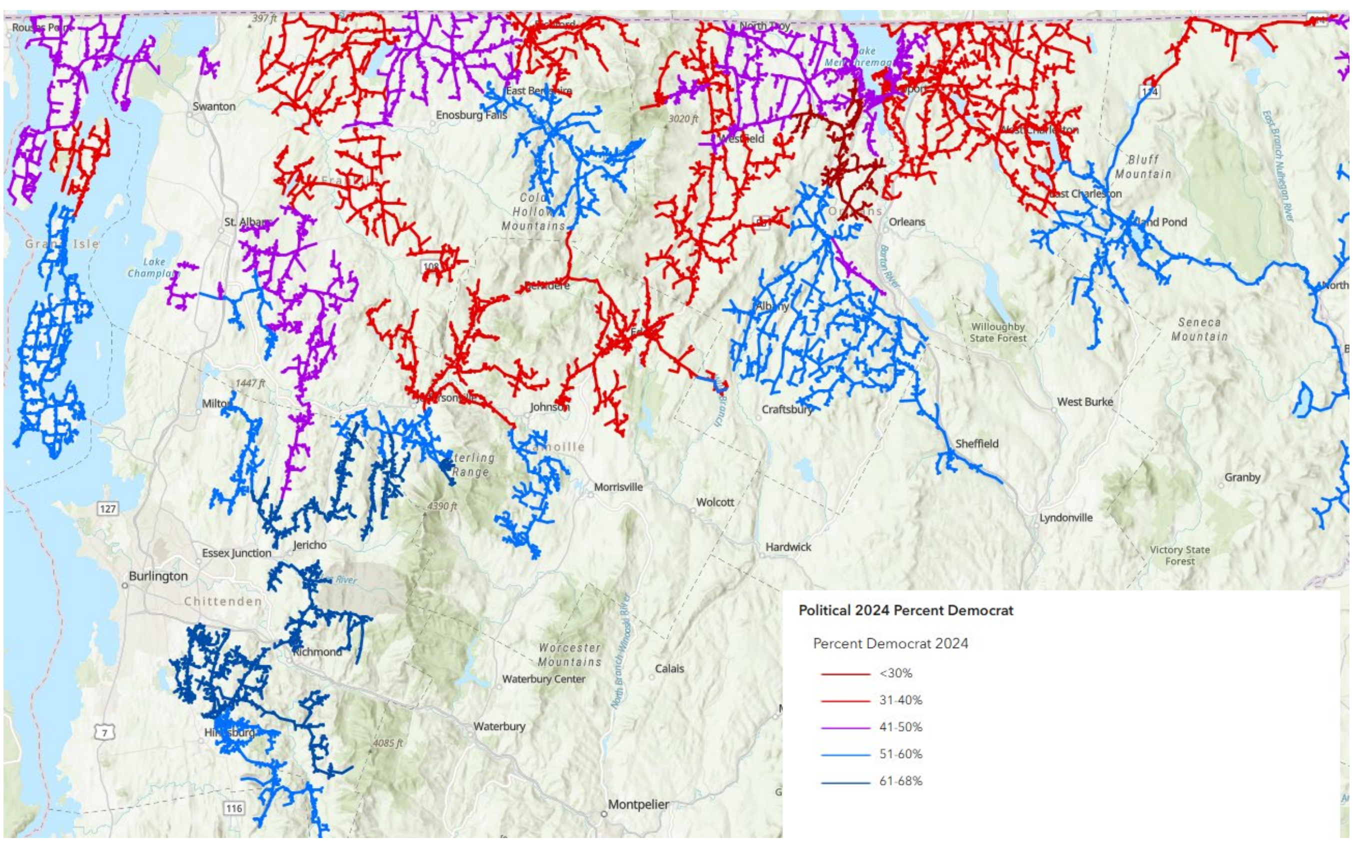


Figure 4.5.1.D Political leaning based on 2024 VT state treasurer election

This is consistent with academic research on electrification adoption in rural areas:

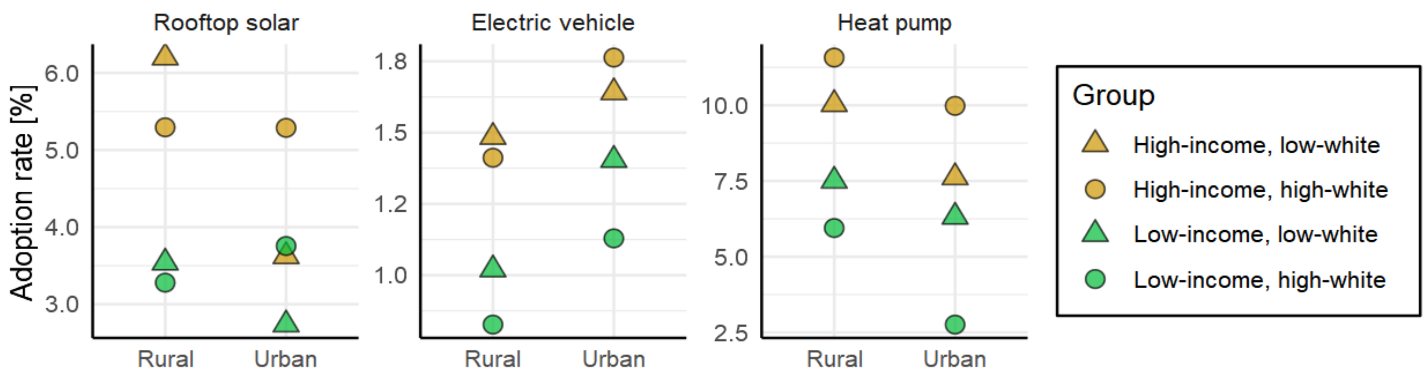


Figure 4.5.1.E Min, Mayfield. 2023. Rooftop solar, electric vehicle, and heat pump adoption in rural areas in the United States". Energy Research and Social Science. https://doi.org/10.1016/j.erss.2023.103292

Representative Feeders

VEC did not have the capacity to model load growth impacts on the entire VEC system, so we chose to group our feeders into four categories:

- High solar, high electrification
- High solar, low electrification
- Low solar, high electrification
- Low solar, low electrification

Using the tier 3 incentive data and net metering records we were then able to identify four feeders within these categories.

Feeder	Sub	Feeder #	Meter	Annual kWH	Generation (kW)	Gen < 130kW	Gen > 130kW	Small Gen /Meter	Total Gen/Meter	AEV	Batte	ccHP	HPWH	PHE	Total Therm	PercentagThermal	Total Transpo	Percentage Transport	Total Electrification	Total electrification/meter	Category
					Based on PNNL Timeframe																
10 JERICHO-3	10	3	326		2287.4	787.4	1500	2.42	7.02	11	9	88	3	12	88	27%	23	7.1%	123	38%	High solar high electrification
04 UNDERHILL-4	4	4	267		293.3	293.3		1.10	1.10	7	6	61	6	3	61	23%	10	3.7%	83	31%	High solar high electrification
19 HINESBURG-1	19	1	774		2341.0	1041.0	1300	1.34	3.02	41	27	175	7	16	175	23%	57	7.4%	266	34%	High solar high electrification
29 SOUTH HERO-3	29	3	1190		817.6	817.6	0	0.69	0.69	25	6	258	9	18	258	22%	43	3.6%	316	27%	Low solar high electrification
08 RICHMOND-1	8	1	646		2372.0	722.0	1650	1.12	3.67	22	24	134	10	15	134	21%	37	5.7%	205	32%	High solar high electrification
11 WESTFORD-3	11	3	29		6.6	6.6		0.23	0.23			6			6	21%	0	0.0%	6	21%	Low solar high electrificaiton
09 WILLISTON-3	9	3	1164		1485.5	1095.5	390	0.94	1.28	25	12	235	16	16	235	20%	41	3.5%	304	26%	High solar high electrification
29 SOUTH HERO-1	29	1	1965		6779.0	1330.0	5449	0.67	3.42	21	11	397	17	11	397	20%	32	1.6%	457	23%	High solar high electrification
11 WESTFORD-1	11	1	427		447.3	447.3		1.05	1.05	4	8	77	9	4	77	18%	8	1.9%	102	24%	High solar high electrification
01 FAIRFAX-1	1	1	345		507.0	359.0	148	1.04	1.47	9	5	62	8	2	62	18%	11	3.2%	86	25%	High solar high electrification
28 South Alburgh-3	28	3	836		247.6	247.6		0.30	0.30	4	3	150	3	1	150	18%	5	0.6%	161	19%	Low solar high electrification
38 MILL RIVER-4	38	4	46		76.0	76.0		1.65	1.65	1	3	8		1	8	17%	2	4.3%	13	28%	High solar high electrification
19 HINESBURG-4	19	4	243		231.3	231.3		0.95	0.95	7	1	41	2	4	41	17%	11	4.5%	55	23%	High solar high electrification
12 FAIRFAX-3	12	3	261		224.6	224.6		0.86	0.86	1	2	43	8	3	43	16%	4	1.5%	57	22%	High solar high electrification
04 UNDERHILL-2	4	2	298		380.4	380.4		1.28	1.28	10	13	49	3	1	49	16%	11	3.7%	76	26%	High solar high electrification
01 FAIRFAX-4	1	4	271		290.7	290.7		1.07	1.07	1	4	43	7	2	43	16%	3	1.1%	57	21%	High solar high electrification
03 CAMBRIDGE-3	3	3	38		7.6	7.6		0.20	0.20			6		1	6	16%	1	2.6%	7	18%	Low solar high electrificaiton
20 ST ALBANS-2	20	2	96		72.2	72.2		0.75	0.75	1		15	1		15	16%	1	1.0%	17	18%	High solar high electrification
19 HINESBURG-3	19	3	1177		1102.5	952.5	150	0.81	0.94	20	24	183	19	8	183	16%	28	2.4%	254	22%	High solar high electrification
12 FAIRFAX-1	12	1	315		235.6	235.6		0.75	0.75	3	1	40	3	1	40	13%	4	1.3%	48	15%	High solar high electrification
13 PLEASANT VALLEY-3	13	3	324		1356.4	356.4	1000	1.10	4.19	8	7	38	3		38	12%	8	2.5%	56	17%	High solar high electrification
44 NEWPORT-4	44	4	599		271.8	271.8		0.45	0.45	1	4	64	4	4	64	11%	5	0.8%	77	13%	Low solar high electrificaiton
14 JOHNSON-3	14	3	564		306.5	306.5		0.54	0.54	16	11	59	7	3	59	10%	19	3.4%	96	17%	Low solar high electrificaiton
06 ST ROCKS-4	6	4	281		182.9	182.9		0.65	0.65	1		29	3	1	29	10%	2	0.7%	34	12%	Low solar high electrificaiton
28 South Alburgh-4	28	4	714		452.1	452.1		0.63	0.63	8	5	71	2	6	71	10%	14	2.0%	92	13%	Low solar high electrification
17 JAY-3	17	3	103		37.8	37.8		0.37	0.37	1		10	1		10	10%	1	1.0%	12	12%	Low solar high electrificaiton
28 South Alburgh-1	28	1	1631		1804.7	659.7	1145	0.40	1.11	8	4	158	9	3	158	10%	11	0.7%	182	11%	High solar low electrificaiton
37 POLLY HUBBARD-4	37	4	104		42.5	42.5		0.41	0.41			9	1	1	9	9%	1	1.0%	11	11%	Low solar low electrificaiton
07 MONTGOMERY-1	7	1	232		89.4	89.4		0.39	0.39	3	9	19	3		19	8%	3	1.3%	34	15%	Low solar high electrificaiton
01 FAIRFAX-2	1	2	482		248.9	248.9		0.52	0.52	5	2	38	3	7	38	8%	12	2.5%	55	11%	Low solar low electrificaiton
13 PLEASANT VALLEY-1	13	1	242		317.7	167.7	150	0.69	1.31	2	6	18	3	2	18	7%	4	1.7%	31	13%	High solar high electrification
15 MADONNA-1	15	1	368		428.4	289.4	139	0.79	1.16	2	2	27	4	2	27	7%	4	1.1%	37	10%	High solar low electrificaiton
07 MONTGOMERY-3	7	3	207		76.4	76.4		0.37	0.37	3		15	1	3	15	7%	6	2.9%	22	11%	Low solar low electrificaiton
32 SHELDON SPRINGS-1	32	1	1281		845.7	845.7	0	0.66	0.66	6		90	8		90	7%	6	0.5%	104	8%	Low solar low electrificaiton
03 CAMBRIDGE-1	3	1	978		471.1	471.1		0.48	0.48	6	7	67	9	3	67	7%	9	0.9%	92	9%	Low solar low electrificaiton
17 JAY-1	17	1	283		142.2	142.2		0.50	0.50	1	2	18			18	6%	1	0.4%	21	7%	Low solar low electrificaiton
45 DERBY-2	45	2	536		284.9	284.9		0.53	0.53	5		32	1		32	6%	5	0.9%	38	7%	Low solar low electrificaiton

- High solar, high electrification (South Hero 29-1A)
- High solar, low electrification (South Alburg 28-4A)
- Low solar, high electrification (Burton Hill 43-3A)
- Low solar, low electrification (Burton Hill 43-1A)

VEC hopes to review electrification across all feeders and was recently awarded Technical Assistance to do so and hopes to provide this information in a future IRP.

Forecast Adoption by Feeder

With help from PNNL, VEC was able to develop a singular logistic model that fits all feeders in VEC service territory.

$$P(t, I, C) = \frac{L(I,C)}{1 + e^{-k(t-x_0)}}$$

- Key Parameters:
  - L: saturation level – maximum penetration rate
  - $P(t, I, C)$: penetration rate at time t, given income I and category C
  - k : growth rate of penetration
  - x_0: year when 50% of saturation level is reached
  - I : income
  - C: category
- Dynamic Saturation Level:
  - $L(I, C)$ adjusts saturation level based on income (I) and category (C)

$$L(I, C) = L_{base} + \alpha I + \beta C$$

  - L_{base}: baseline saturation level
  - α: income factor on saturation level (higher income → higher adoption potential)
  - β: category factor on saturation level

- Data-driven approach when determining L_{base}, α, β, k, x_0 using historical data

Figure 4.5.1.F PNNL singular logistic model

PNNL was then able to project Heat Pump and EV adoption out to the 2040 study period. This projection is based off of prior growth along with income. This forecast is highly dependent on current technology, pricing and political incentives.

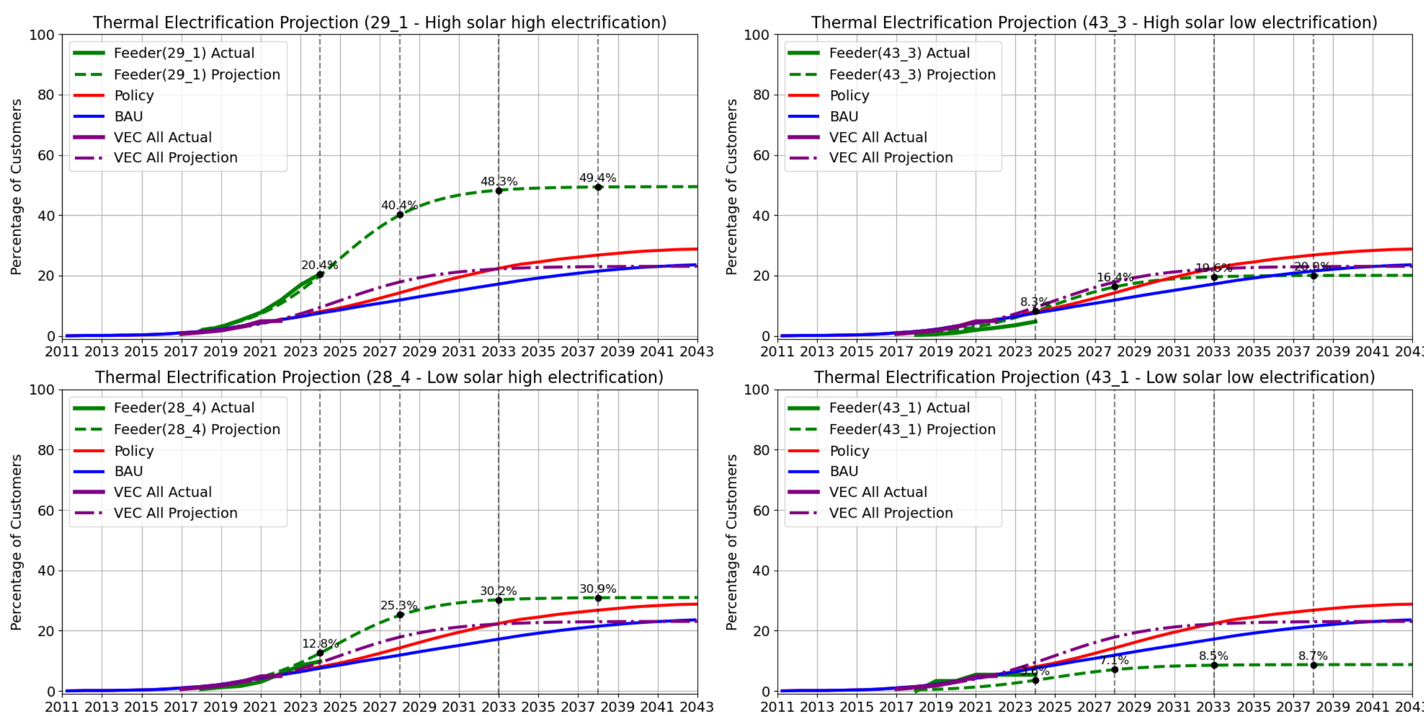


Figure 4.5.1.G Thermal electrification adoption forecast across 4 representative VEC feeders

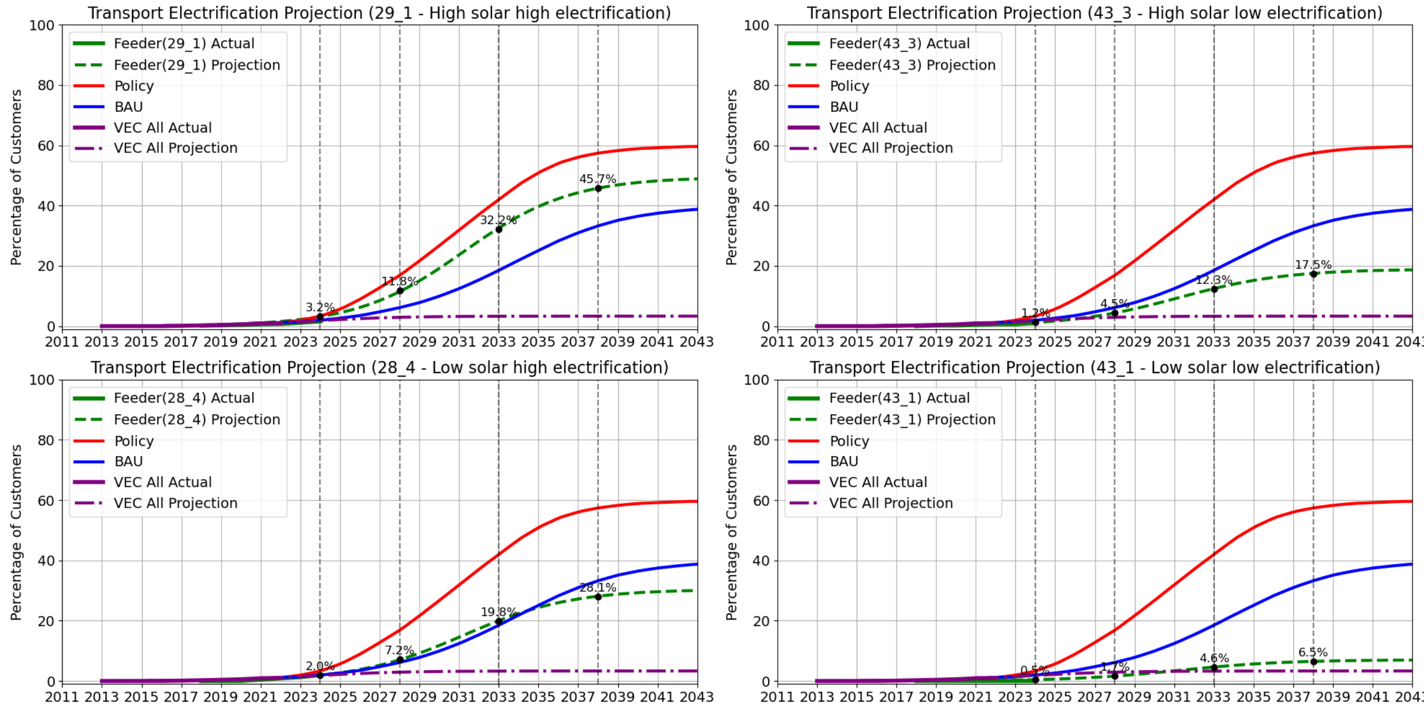


Figure 4.5.1.H   Transportation electrification adoption forecast across 4 representative VEC feeders

4.5.2 Load Growth by Category

Prior to modeling the above adoption curves, VEC first needed to identify the peak load impacts of electrification.

Electric Vehicles

EV load represents the largest impact during peak hours. Based on VEC survey data, 93% of VEC EV drivers currently charge at home. Level 2 chargers range in power level from 3.5kW to 19.2kW, while Level 3 chargers can be up to 150kW. The most common level 2 chargers are 7.7kW (32 Amps at 240V on a 40 Amp circuit) and 9.6kW (40 Amp max draw on a 50 Amp circuit). However, as battery sizes increase, automobile manufacturers are increasing the size of their chargers. For instance, the new Ford F150 Lightning can charge on an 80 Amp circuit, and that 80 Amp is required for the vehicle-to-home technology option.

VEC was able to collect data from over 100 ChargePoint chargers to identify the average per EV charging power (kW). The current average during peak hours (18-22) is 1.45 with a peak in the winter months of around 1.6kW.

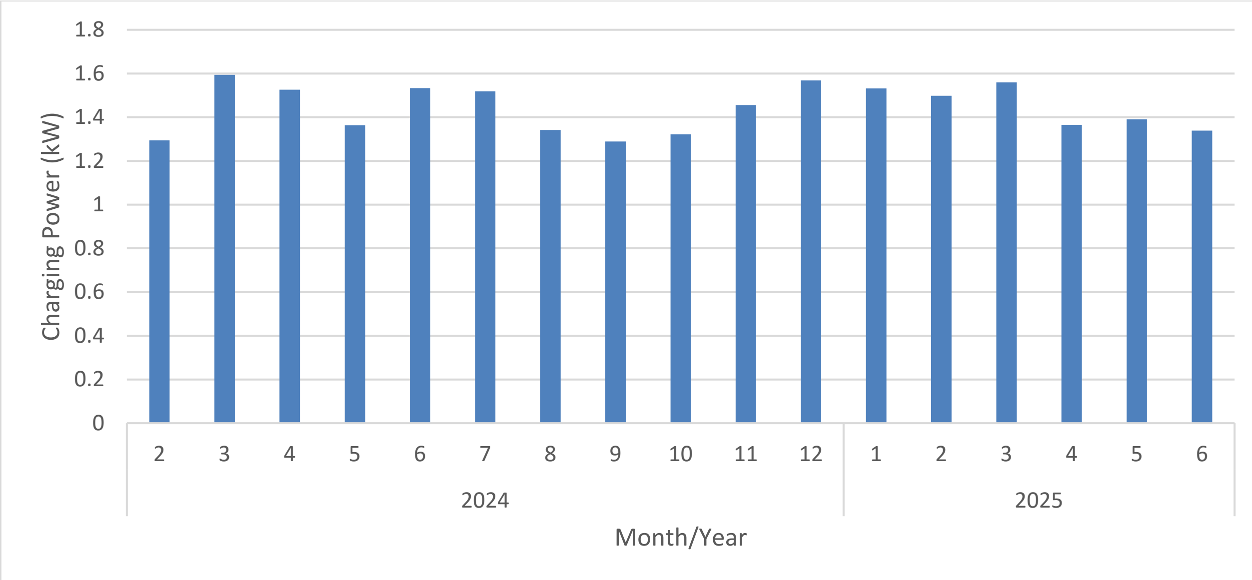


Figure 4.5.2.A Average per EV charging power during hours 18-22

VEC does not currently have any electrified fleet vehicles or school buses in its territory. VEC anticipates including this in future analyses of load growth impacts on infrastructure.

Heat Pumps

Heating

Heat pumps represent the second largest impact on load growth. In collaboration with Qilo, VEC analyzed data from over 1,800 accounts equipped with heat pumps. The AMI data of members was disaggregated both before and after the installation of heat pumps to determine the load throughout the year. Usage varies significantly based on behavior and the size of the heat pump, particularly regarding how extensively the heat pump is used as the primary heating source.

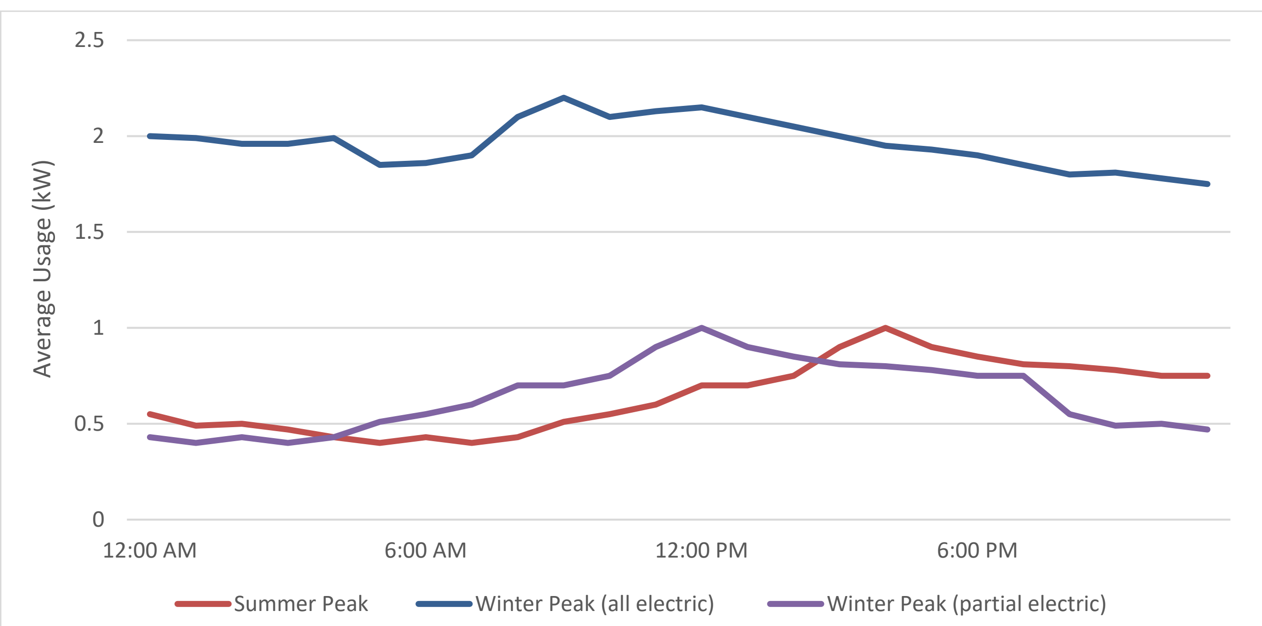


Figure 4.5.2.B Qilo Heat Pump Analysis - Coldest Day usage by category 02/04/2023

The analysis is discussed further in the appendix.

Other Electrification Loads

Other electrification loads such as heat pump hot water heaters, electric lawnmowers, pellet stoves, or electric forklifts can have impacts to load growth but often are minimal. As a result, VEC did not perform any locational assessment as a result of a member adding these loads.

Underlying Load Growth

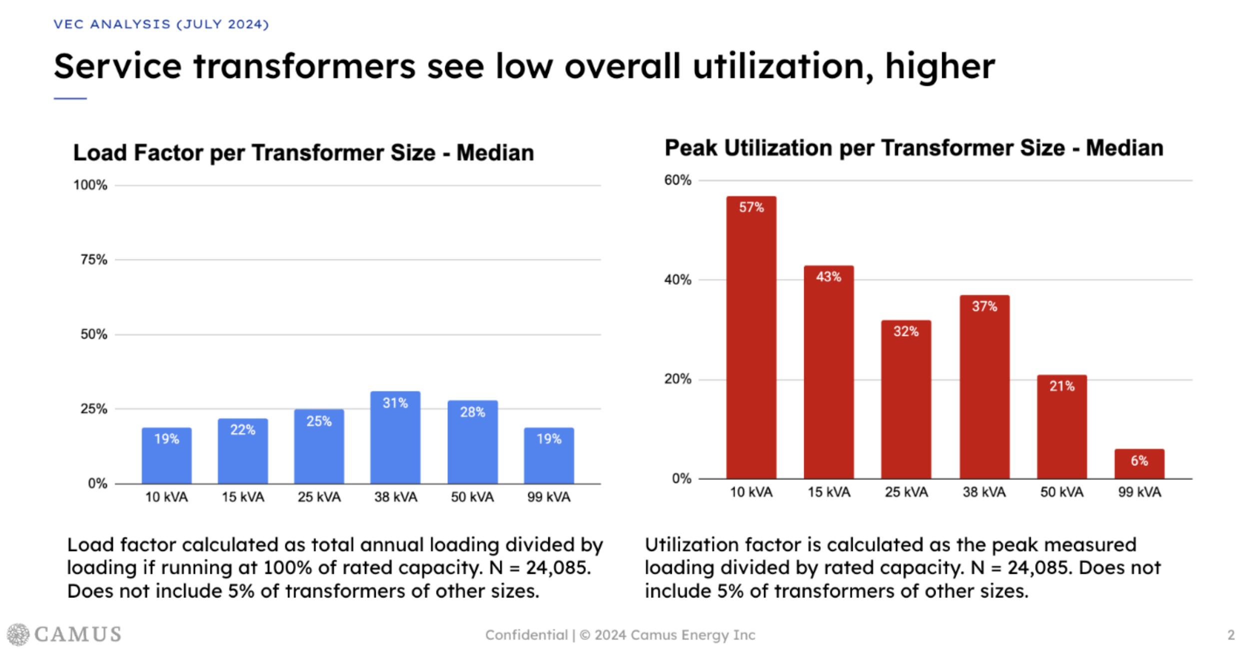
Underlying load growth refers to the increase in load before considering the effects of flexible load, Net Metering, or electrification load growth. This includes new members constructing or expanding homes in our service area and the establishment of new businesses. This rate is approximately 0.6% per year.

4.5.3 Load Growth Impacts on Local Service Assets

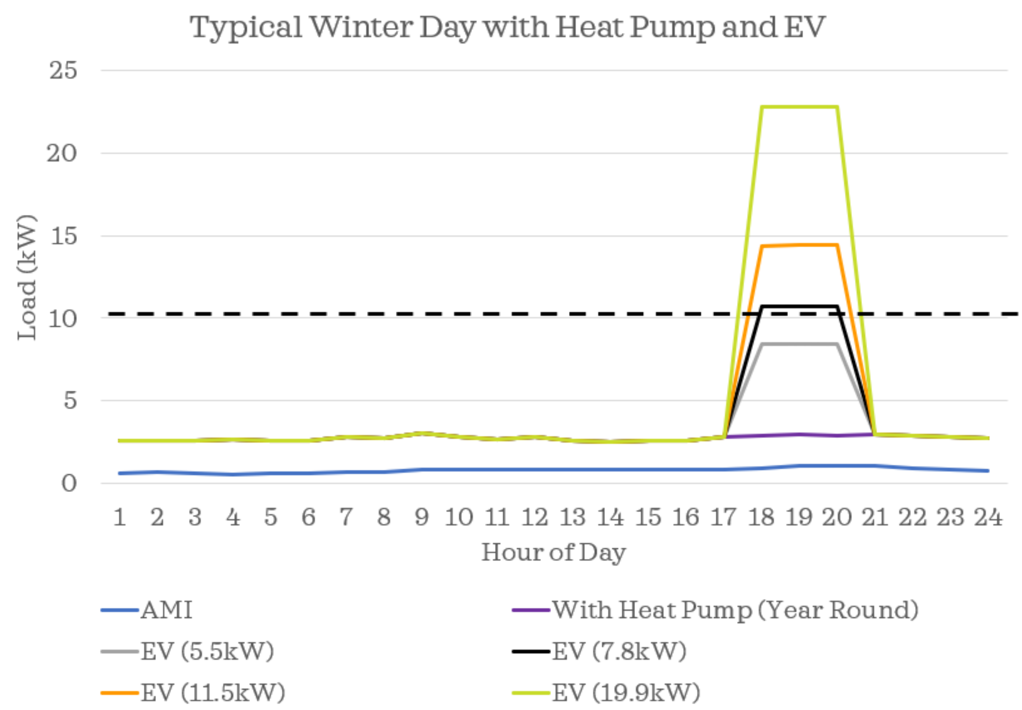
Local service assets impacts include everything from the service transformer down to the house panel. While system level impacts are modeled in the engineering model, these impacts were reviewed based on asset size.

Distribution Transformers

Even though overall electrification growth, in particular, EVs has not met state policy goals, unmanaged EV charging activity is causing distribution transformer overloads on VEC's system. The median peak utilization of a 10 kVA transformer on VEC's system is currently 57%, which does not leave much room for additional electrification growth. 15 kVA transformers are loaded less during peak times though often have more than one member on them, making them vulnerable to increased load resulting from electrification.



In the past, a 10 kVA transformer would have been adequate for two or even three members. However, with electrification and, in particular, EV charging, members' electricity loads can quickly overload transformers when not managed according to distribution system constraints.



To date, VEC has upgraded almost 50 transformers due to EV charging overloads and upgrades between 10 to 20 transformers annually to accommodate EV load growth. In 2020, VEC increased its standard service transformer size:

- For two or fewer meters on a transformer, from 10 kVA to 15 kVA.
- For three or more meters on a transformer, from 15 kVA to 25 kVA or larger on a case-by-case basis.

However, more than half of the approximately 24,000 transformers installed on VEC's system are 10kVA or smaller. VEC anticipates that transformers 10kVA or smaller will not be adequate to serve load without load management.

> **2040 Impact - Distribution Transformer Replacements**
>
> VEC anticipates needing to replace around 19% of all transformers (~5,000) before 2040 due to load growth.

Service Conductor

For overhead conductor, VEC sizes service conductor (from transformer to service panel) based on the load rating of the panel and the distance. For underground conductor, the member owns the conductor and as such we rely on the electrician to size this appropriately. In general, the NEC (National Electric Code) sizes service panels and conductor to far exceed the usage in the house. It is unlikely that the service conductor would need to be upgraded as part of electrification but VEC reviews these when a new incentive is applied for and as part of transformer loading reviews.

> **2040 Impact – Service Conductor Replacements**

Given that the member owns this asset VEC has not estimated the replacement cost.

Service Panels

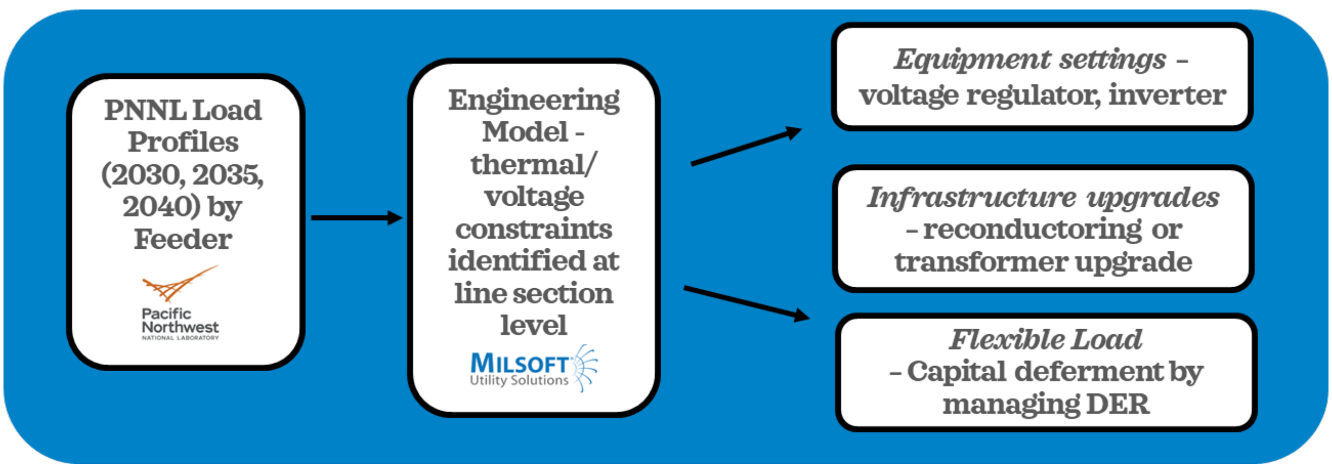
VEC has seen an increase in service panel upgrades due to electrification. VEC's data on service panel sizes on its system is limited given it is not a VEC-owned asset. However, around 27% of new services installed between 2017 and 2022 were 100-amp services. In general, if a member is installing a new level 2 charger and a heat pump a 100-amp service may not be adequate without secondary load management such as smart splitters.

2040 Impact – Service Panel Replacements

VEC does not inventory service panel sizes or own service panels and thus cannot estimate the number of replacements.

4.5.4 Load Growth Impacts on VEC's System

To perform these impacts, VEC leveraged load profiles created by PNNL based on feeder level adoption and applied those load profiles to the engineering model.



Anticipated Load Growth

PNNL created load profiles based on the assumptions below:

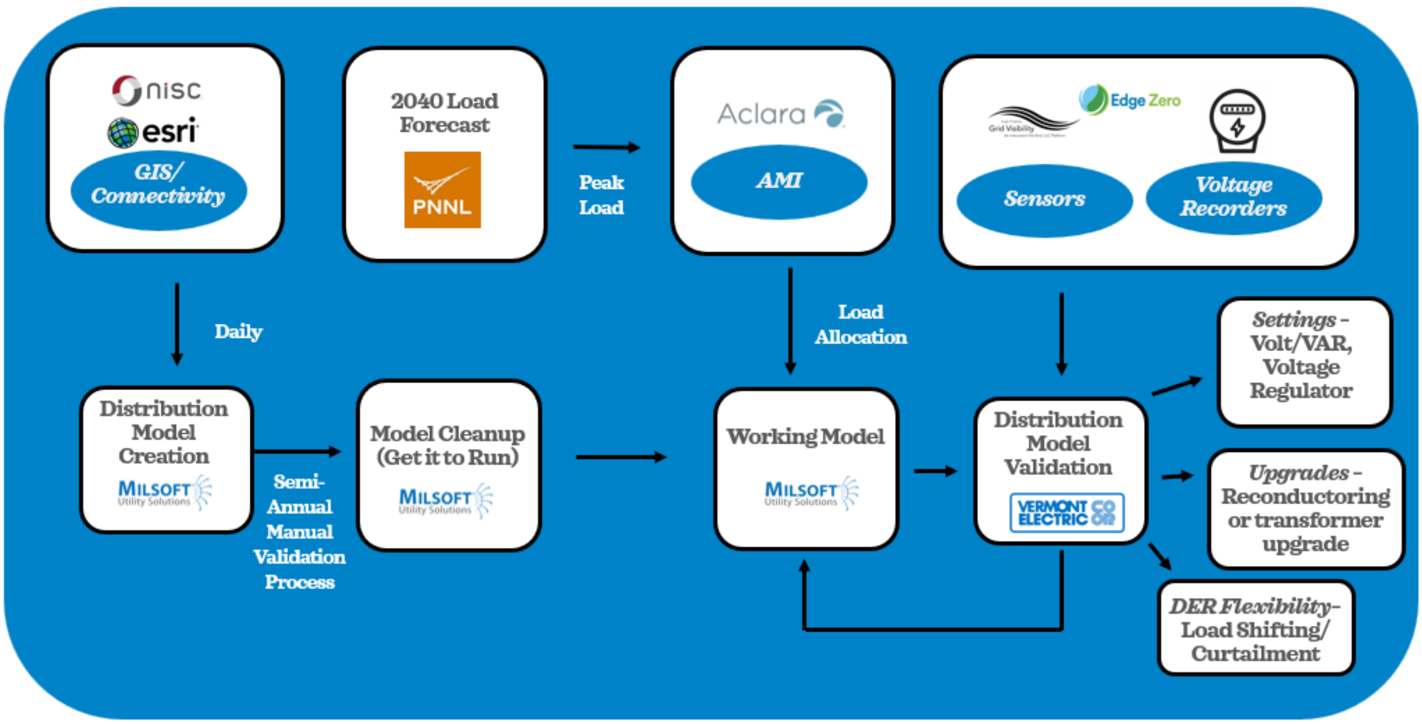
- Peak Time – **Winter, 6-10 PM**
- Electric Vehicle Load - **2.2 kW**. This is currently 1.59kW based on VEC's charger data but VEC anticipates this will increase as more members electrify larger vehicles such as trucks and SUVs.
- Heat Pump Load – **1.7 kW** – Per Qilo analysis wintertime peak
- Underlying Load Growth – **0.47%** annually based on power supply forecast
- Solar/Net Metering – **0 kW** - No contribution due to peak time in winter
- Flexible Load – **0 kW**, while VEC intends to use flexible load to support load growth, we are modeling the most conservative impact.

Applying Load Growth to the Engineering Model

The load forecast was then used to identify a peak load (MVA).

Feeder	Meters	Peak Load 2025 (MVA)	2040 EV Adoption (%)	2040 HP Adoption (%)	2040 Feeder EV (MVA)	2040 Feeder HP (MVA)	Underlying Load Growth	2040 Peak MVA	% growth
South Hero 29-1A	1,999	**6.66**	49.4%	45.7%	2.173	1.553	0.470	**10.855**	163%
South Alburg 28-4A	706	**1.613**	30.9%	28.1%	0.480	0.337	0.114	**2.544**	158%
Burton Hill 43-3A	1,441	**2.266**	20.9%	17.5%	0.663	0.429	0.160	**3.517**	155%
Burton Hill 43-1A	94	**2.813**	8.7%	6.5%	0.018	0.010	0.198	**3.040**	108%

Using this peak, VEC allocated loads using a peanut butter approach – increasing all loads on the feeder by the growth percentage.

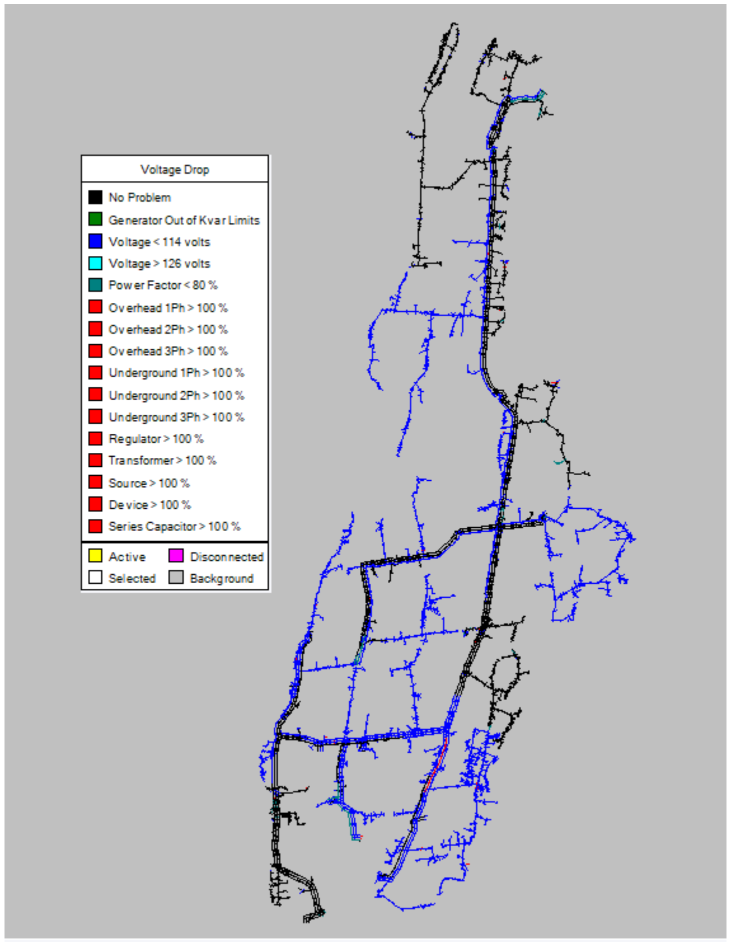


In the future, VEC hopes to allocate loads more geospatially, perhaps by line section or better yet a bottom-up approach from the meter level.

Model Results

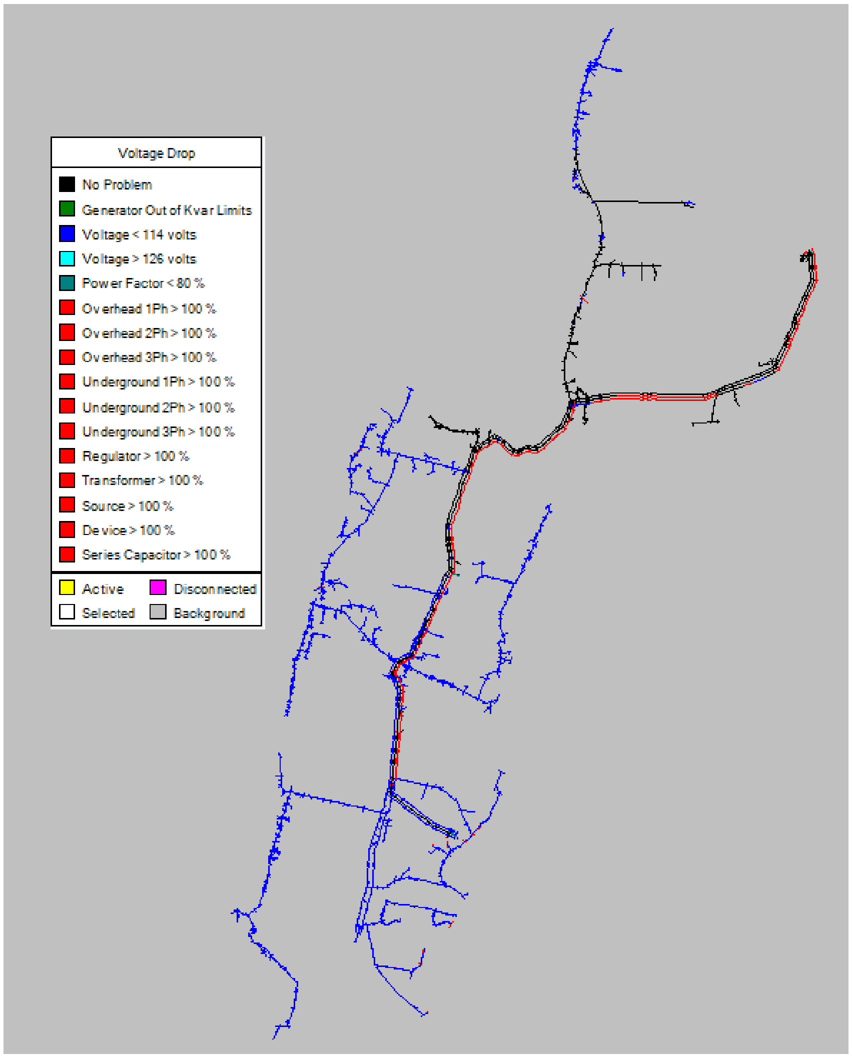
<u>South Hero 29-1A High solar, high electrification</u>

This circuit saw a 163% increase in peak load which resulted in a substation overload, several overloaded voltage regulators, voltage collapse on entire 1A circuit and 18 spans of overloaded three phase. VEC has provided a visual representation of the model output below:



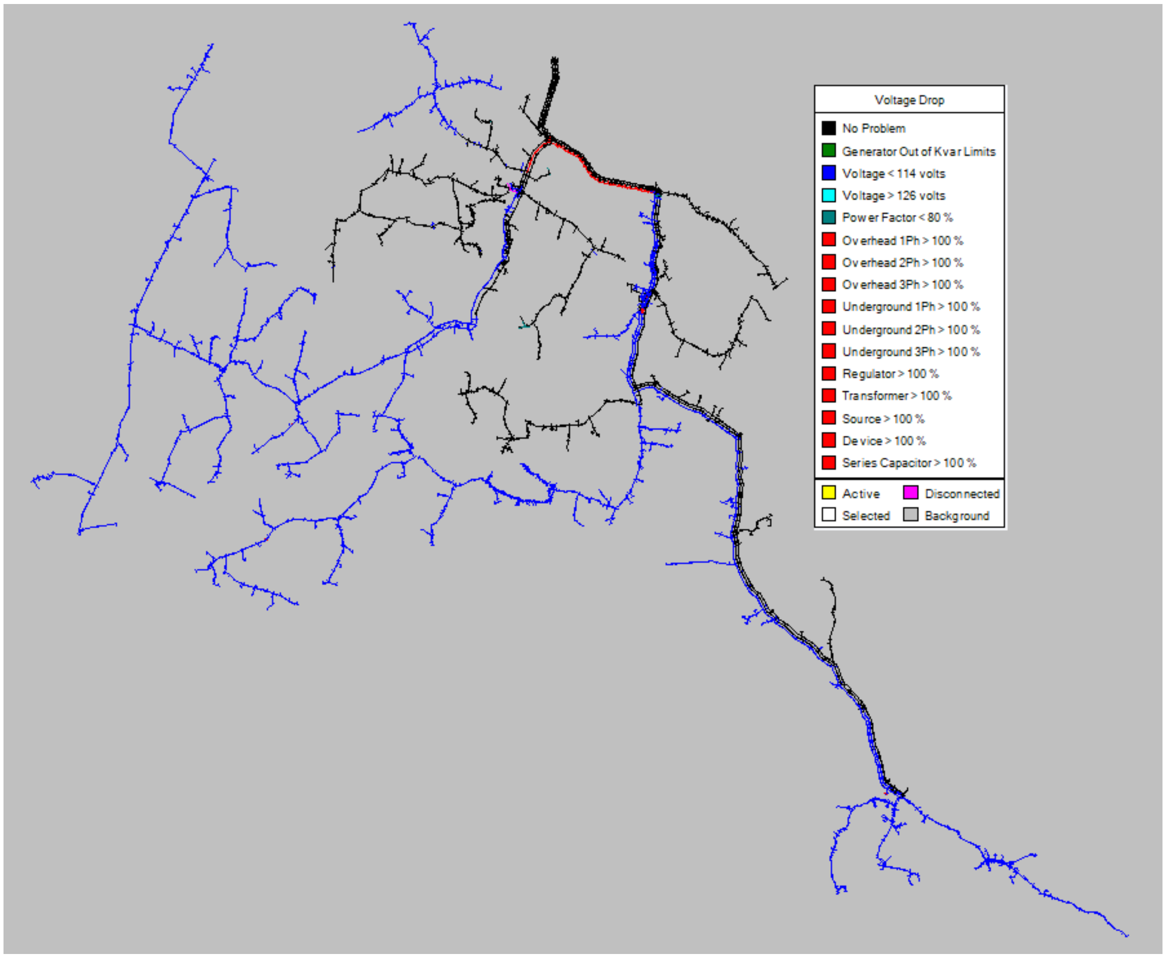
South Alburg 28-4A High solar, low electrification

This circuit saw a 158% increase in peak load which resulted in a substation overload, several overloaded voltage regulators, significant voltage collapse on entire 4A circuit and 51 spans of overloaded three phase. VEC has provided a visual representation of the model output below:



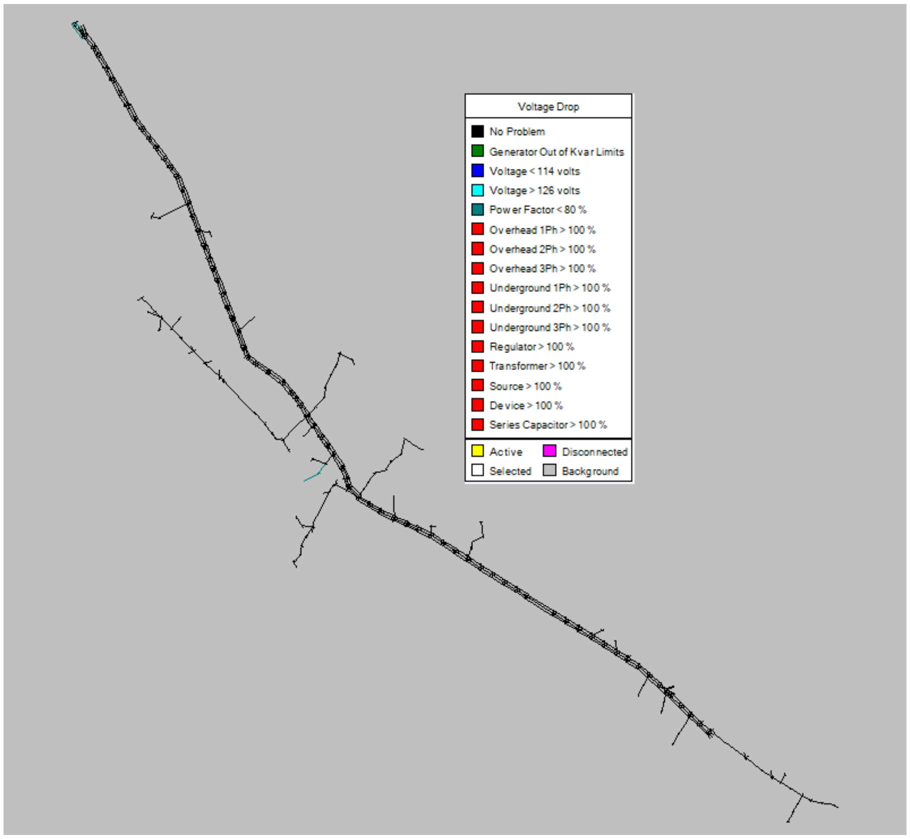
Burton Hill 43-3A Low solar, high electrification

This circuit saw a 155% increase in peak load which resulted in a substation overload, several overloaded voltage regulators, significant voltage collapse on entire 3A circuit and 30 spans of overloaded three phase. VEC has provided a visual representation of the model output below:



Burton Hill 43-1A Low solar, low electrification

This circuit saw a 108% increase in peak load which resulted in a substation overload which was identified in the prior circuit. VEC has provided a visual representation of the model output below:



4.5.5 Overall Impacts

VEC then categorized the remainder of VEC's feeders into the appropriate category to determine the overall impacts to VEC's infrastructure:

Feeder Category	# of Members in Category	% of Total
High solar high electrification	9,207	22%
Low solar high electrification	4,586	11%
High solar low electrification	8,796	21%
Low solar low electrification	18,335	45%

Primary Conductor

VEC has 2,445 miles of overhead and underground conductor. The modeling performed showed much more conductor that was overloaded or was experiencing voltage collapse. VEC has indicated the impact based on the amount of conductor needed to be replaced to mitigate the overload or voltage collapse (often less than the impacted total).

Feeder Category	Miles of Total Primary Conductor	% Conductor Replacement (Representative Feeders)	Miles of Conductor to Replace
High solar high electrification	550	35%	193
Low solar high electrification	274	24%	66
High solar low electrification	526	2%	11
Low solar low electrification	1,095	1%	11

Total	2,445		280

2040 Impact – Primary Conductor Replacements

VEC anticipates needing to replace at least 8.5% of primary conductor by 2040 to meet electrification load growth needs. This is in addition to reliability and existing maintenance needs.

Substation Transformers

VEC has 35 substation transformers with approximately 262 MVA of capacity.

Feeder Category	# of Substation Transformers	Approximate Transformer Capacity (MVA)	% of Substation Transformers Overloaded	Transformers to Replace (MVA)
High solar high electrification	8	59.1	100%	59.1
Low solar high electrification	4	29.4	100%	29.4
High solar low electrification	8	56.4	40%	22.6
Low solar low electrification	16	117.6	0%	0.0
Total	**35**	**262.2**		**111**

2040 Impact – Substation Transformer Replacements

VEC anticipates needing to increase around 42% of substation transformers to meet 2040 electrification needs.

Voltage Regulators

VEC has over 200 voltage regulators substation and line.

Feeder Category	Total Voltage Regulators	% Voltage Regulators to Replace	Number of Voltage Regulators to Replace
High solar high electrification	46	100%	46
Low solar high electrification	23	50%	12
High solar low electrification	44	50%	22
Low solar low electrification	92	25%	23
Total	**205**		**103**

2040 Impact – Voltage Regulator Replacements

VEC anticipates needing to replace at least 50% of voltage regulators by 2040 to meet electrification load growth needs.

Protective Devices

VEC has approximately 5,700 fuses and reclosers.

Feeder Category	Total Protective Devices	% Protective Devices to Replace	Number of Protective Devices to Replace
High solar high electrification	1,289	9%	122
Low solar high electrification	642	6%	38
High solar low electrification	1,231	5%	60
Low solar low electrification	2,567	3%	64
Total	**5,729**		**285**

2040 Impact – Protective Device Replacements

VEC anticipates needing to replace at least 5% of fuses and reclosers by 2040 to meet electrification load growth needs.

Distribution Transformer

As VEC indicated above, we have around 24,000 distribution transformers.

2040 Impact - Distribution Transformer Replacements

VEC anticipates needing to replace around 19% of all transformers (~5,000) before 2040 due to load growth.

Summary Table

Feeder Category	# of Assets to Replace	% of Total
Primary Conductor	280 miles	8.5%
Substation Transformers	111	42%
Voltage Regulators	103	50%
Protective Devices	285	5%
Distribution Transformer	~5,000	19%

Limits to the Analysis

Infrastructure of Representative Feeders

VEC selected feeders based on DER adoption, though its infrastructure varies. Some circuits have smaller conductors, numerous 4.2kV circuits, while other circuits have are denser. VEC views the analysis as a conservative examination of electrification impacts.

Peanut Butter Approach

VEC allocated loads using a peanut butter approach – increasing all loads on the feeder by the growth percentage. This could over allocate load to certain parts of the feeder and under allocate to others. In the future, VEC hopes to allocate loads more geospatially, perhaps by line section or better yet by a bottom-up approach from the meter level.

Feeder Backup and Contingency Impacts

VEC has several substations that allow for feeder backup from another substation or another feeder. The above analysis was performed using an N-1 state. In the event of an outage or an N-1-1 state, the system will be more limited and therefore additional capital improvement may be needed to maintain the operational flexibility of the system.

4.5.6 Cost of Impacts (PNNL Identified Upgrades)

To develop an overall cost impact of the overloaded assets or voltage collapse VEC used the following cost assumptions:

Asset Type	Average Cost to Replace	Justification
Primary Conductor	$265,048 (per mile)	5-year average of single and three phase projects
Substation Transformers	$73,781 (per MVA)	10/14 MVA transformer, using average sell price of the 6 transformers that we received bids for
Distribution Transformer	$3,200	Tariff charge, average of 10-15kVA, 10-25 kVA cost
Voltage Regulators	$55,000	5-year project average
Protective Devices	$1,000	5-year project average

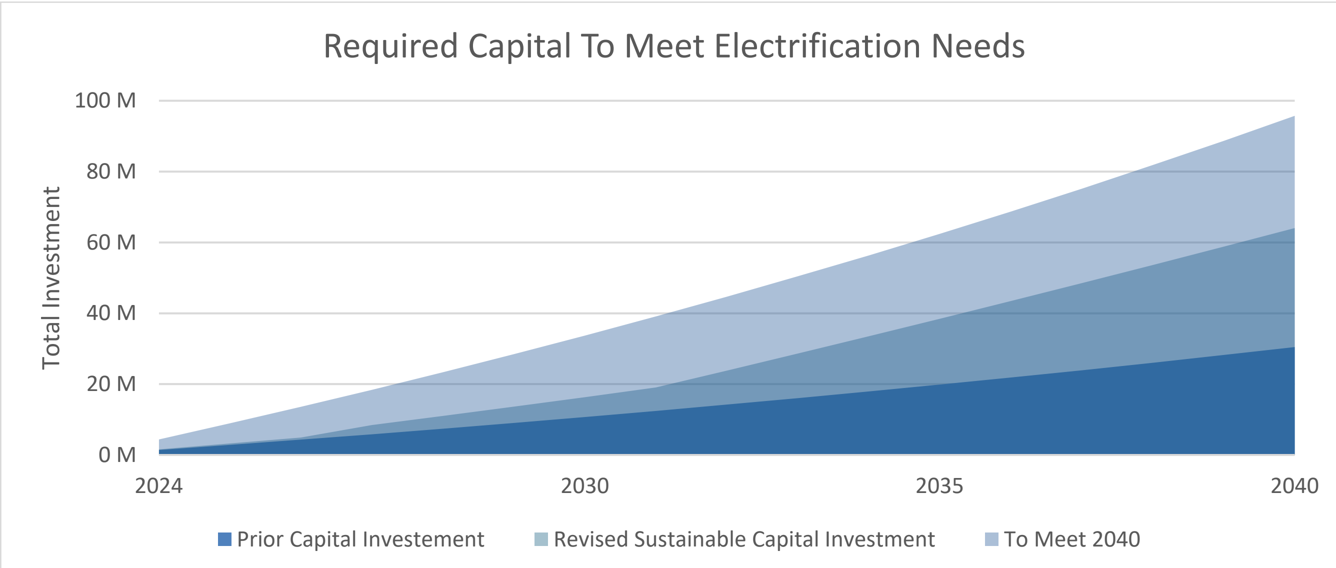
Asset Type	# of Assets to Replace	Cost to Replace
Primary Conductor	280 miles	$ 74,146,409
Substation Transformers	111 MVA	$ 8,192,717
Distribution Transformer	103	$ 10,803,477
Voltage Regulators	285	$ 2,562,500
Protective Devices	~5,000	$ 284,535
Total		**$ 95,989,638**

2040 Impact – System Impacts

VEC anticipates that the overall cost of upgrades needed to meet the forecasted 2040 load is over $96 million.

4.5.7 Managing DER for Infrastructure

VEC plans to invest in capital improvements for load growth, but the projected $100 million upgrades surpass VEC's sustainable investment strategy and current spending. VEC is also prioritizing reliability, resiliency, and system maintenance. In 2024, VEC raised its capital budget for more distribution system investments, but we will still lag in infrastructure upgrades.

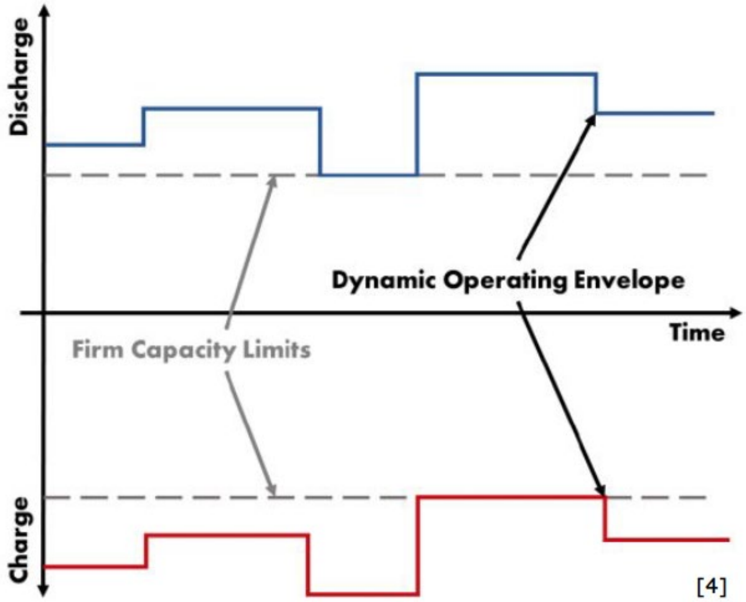


VEC believes managing EVs and heat pumps through DER programs is essential to meet our members' electrification goals without raising rates. This approach can maintain stable rates and potentially reduce transmission investment. VELCO estimates more than $500 million in upgrades due to load growth in the 2024 VELCO Long Range Transmission Plan, most of which is due to increased DER on the system.

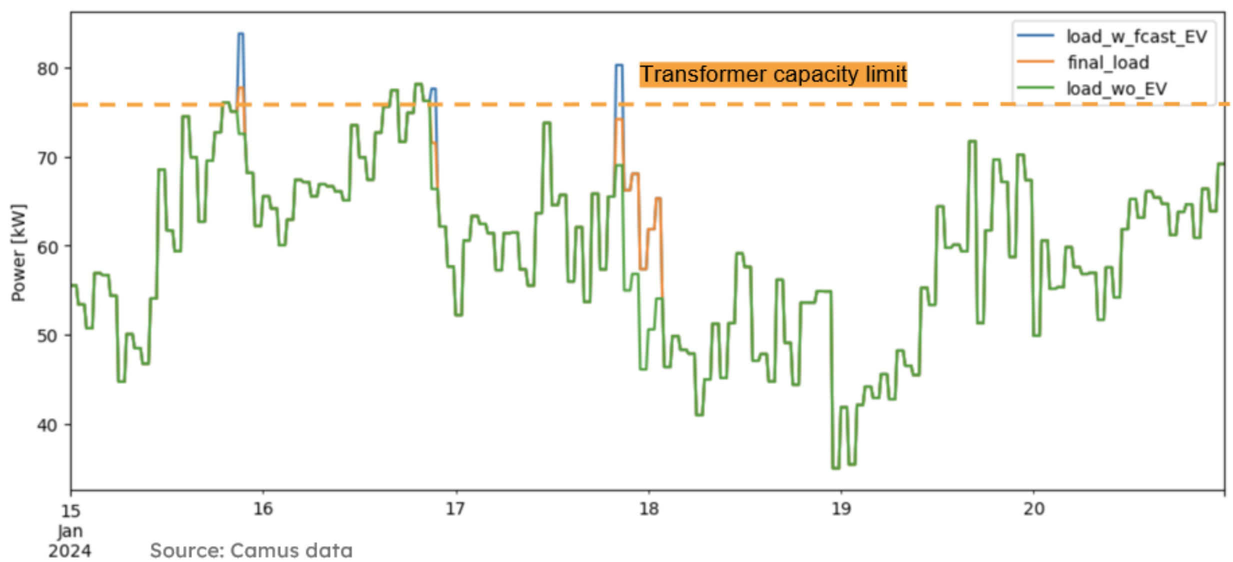
Support our Local Grid Transformer Pilot

As VEC discussed in the Increase VPP Value section above, we recently filed an innovative pilot to explore the types of constraints and charging behaviors that lend themselves to managed charging vs. transformer replacement. VEC intends to use its existing flexible load programs and Camus DERMS to enable this pilot. Orchestrating DER for capital deferral requires a robust understanding of real-time and near-future network constraints as well as available DER flexibility.

The Camus platform provides both capabilities. The Pilot is intended for members who have ChargePoint charges or participate in the FlexCharging telematics program. As Camus and Grid Edge DERMS vendors like FlexCharging build additional integration, the Pilot could include members with other charger types. To manage EVs to an identified constraint, the Camus platform uses operating envelopes or do-not-exceed values to prevent transformer overloads.



The chart below shows electricity demand for a distribution service transformer with managed vs. unmanaged EV charging.



The Pilot will initially concentrate on fixed operating envelopes, as they are a static limit that does not change with other variables.

Valuation

VEC will compensate members who participate in the Pilot based on the value of deferring the distribution transformer and the amount of kW that the member can shift. VEC has developed a deferral value calculator tool that is included as Attachment 1. The valuation includes these variables:

- T&D Upgrade Cost Today ($): Total upgrade cost of the asset in today's dollars including labor, materials, overheads and stores. This value changes based on the size of the transformer and could be applied to other T&D assets like primary lines or substation transformers.

- Expected Deferral Timeframe (years): An estimate of the expected deferral of the asset based on the age and condition of the asset. The estimate will be lower for older or more conditionally poor assets as at some point the assets will need to be replaced regardless of the DER management.
- Load Reduction Need (kW): This is the total kW reduction needed to defer the upgrade and calculated via the Camus tool. For distribution transformers, Load Reduction Need will typically be associated with one member though for future use cases it could be spread over many members.
- T&D Cost Escalator (%): The annual percentage increase in costs of replacing T&D assets while accounting for inflation
- T&D Financial Asset Life (years): The estimated duration over which VEC's assets are expected to remain functional and economically viable. For VEC, this is 33.33 years.
- WACC (%): Weighted Average Cost of Capital or the cost of borrowing to finance VEC's assets.
- Annual O&M Deferred Costs ($): In some cases, operating and maintenance costs or savings may result from the upgrade. For a distribution service transformer, there may be a slight increase or decrease in property taxes for a smaller or larger transformer. In the future, VEC may be able to defer an upgrade that would reduce annual vegetation management expenses, for example an overhead to underground or roadside relocation.
- Annual Software Costs for Management ($): VEC anticipates that all participating members will already be participating in VEC's Flexible Load Program and therefore VEC will not incur an additional cost. The Flexible Load Program incorporates software costs in its compensation structure.
- Assumed # of Participating Members Per Deferral: This will typically be "1" as we are focused on distribution transformer constraints. In future use cases, such as substation transformers or transmission, there may be many participants for a particular constraint.
- Value Percentage Share with Member (%): VEC's Flexible Load Program targets a 50% value share. The goal is to maximize the savings for the non-participating members while maintaining a high enough incentive to encourage participation.

The attached calculator is used to develop the total deferral value to VEC. VEC uses that deferral value to then calculate the following:

- Deferral value per kW, the total deferral value based on the duration of the asset deferral;
- Annual Deferral Value per kW, the total deferral value divided by the number of deferral years
- Annual Value Shared with Member per kW, which is based on the Value Percentage Share with Member (%);
- Monthly Value Shared with Member per kW, the Annual Value Shared with Member per kW divided by 12 months
- Monthly Bill Credit, the amount that members receive to participate in the Pilot.

Member Experience

VEC will pre-screen members for the Pilot using the Camus platform to identify overloaded transformers where an EV is present. The goal of VEC's Flexible Load Program is to maximize savings to the non-participating members while device management remains invisible to participating members. VEC has been running these programs since 2020 and, so far, has consistently found that participating members want two things: limited or no involvement in management and for their EV to be fully charged in the morning.

Compensation will vary based on the value of the asset deferral and whether a participating member is already enrolled in VEC's Flexible Load Program. VEC will compensate members based on the following:

- If a participating member is not already enrolled in VEC's Flexible Load Program, VEC will send them a communication to encourage them to enroll. The communication will include the monthly bill credit associated with the Flexible Load Program and the calculated monthly bill credit for asset deferral.
- For a participating member already enrolled in VEC's Flexible Load Program, VEC will send them a communication with the additional calculated monthly bill credit for asset deferral.

If the distribution transformer needs to be replaced or fails, the participating members will no longer receive the additional calculated monthly bill credit for asset deferral. Members will be asked to commit to good-faith participation for a period of at least one year after enrollment. If the Pilot is successful, VEC will apply for a tariff that would establish a permanent compensation structure.

When peak events are called in VEC's Flexible Load Program, members receive an email describing the timing of the event and providing a link to opt out of the event. Since 2020, VEC has called roughly 200 events with approximately 100 participants and seen fewer than 20 opt outs (less than 0.05%)

In this Pilot, VEC does not plan to notify participating members every time VEC is managing their charging. As VEC will be managing EVs and chargers more frequently (potentially several times a day), it would be overwhelming for participating members to receive multiple daily emails.

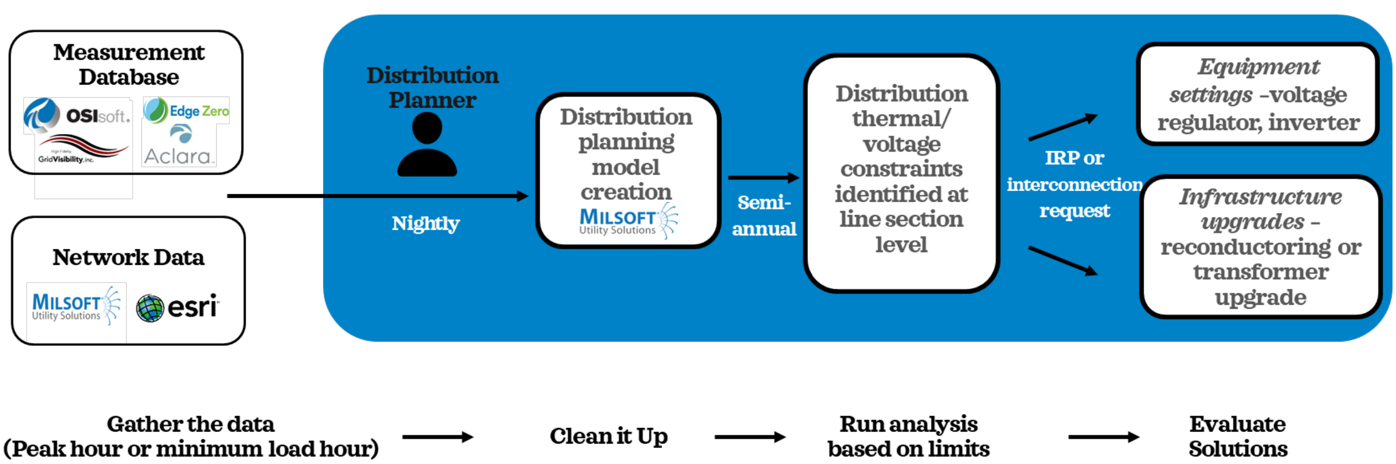
VEC plans to explore how to perform grid-aware managed charging while ensuring that members' use of their EVs is not impacted. To achieve this, the Pilot will consider using:

- Minimum states of charge. For example, VEC could guarantee a 20% minimum charge.
- Setting a fixed time that an EV will be charged to its set maximum by. For example, charged to 80% to – 90% by 5 A.M.
- The value of additional software integrations with OEMs or aggregators to enable easier opt-outs.

The Challenge of Traditional Planning Tools

VEC has identified and forecasted thermal service level transformer constraints using existing AMI data and the Camus Grid DERMS product. To manage voltage and constraints further upstream with DER, a more advanced planning tool will be required.

Traditional distribution planning models are essential tools for utility planners and rely on key inputs such as connectivity, SCADA, and AMI data. At VEC, GIS connectivity is used to create a distribution model on a daily basis. This model is then cleaned up a couple of times per year to ensure accuracy and reliability for the planning team.



The process effectively identifies system constraints during peak or minimum load hours (often 3-4 hours per year) but does not model the available flexibility during the remainder of the year. Without identifying this flexibility, it is unclear to distribution planners and operators how to leverage DER to potentially defer infrastructure upgrades.

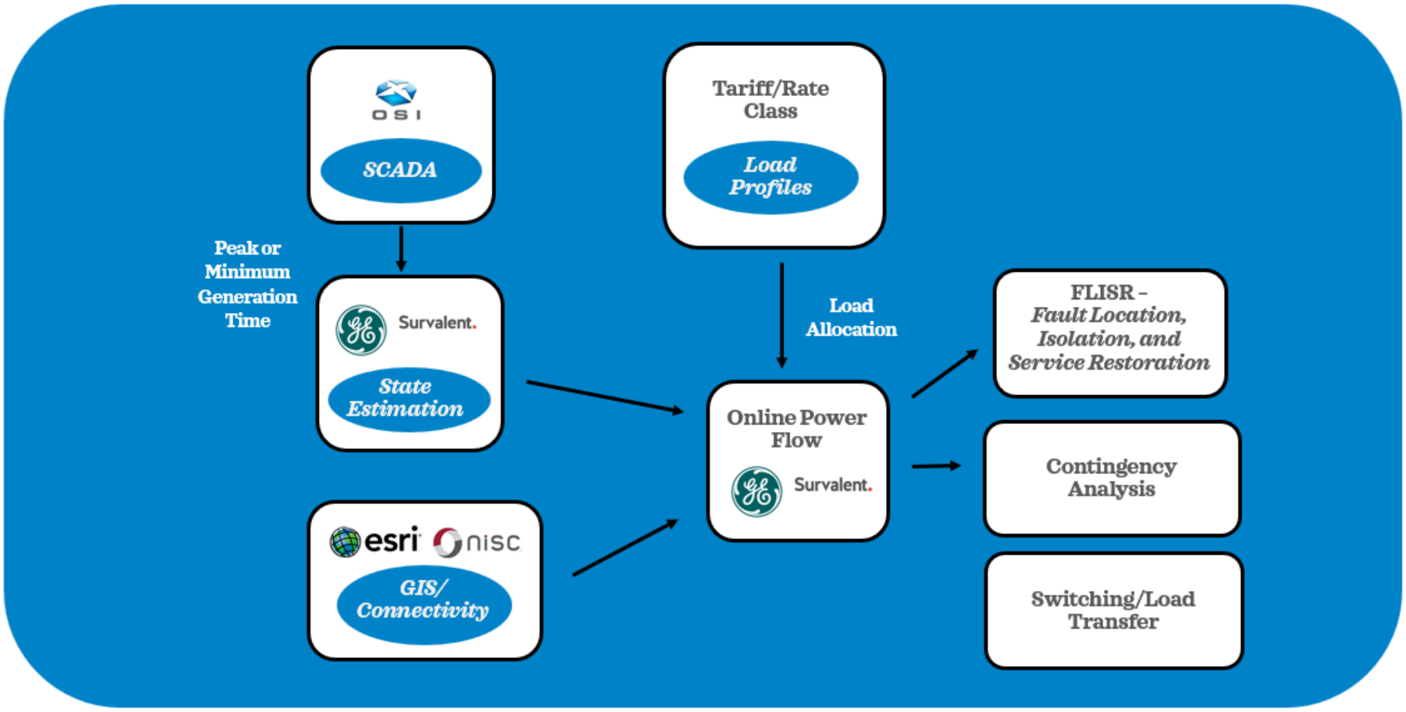
Online Power Flows

To identify and forecast these constraints in near real time, and preferably a day ahead we need distribution online power flows. These online power flows come in three options:

	PLANNING MODELS	ONLINE POWER FLOW		
Category	**Physics Based**	**Pseudo Informed**	**Model Free**	**Physics Inspired**
Input Data Requirements	SCADA, AMI with usage data, connectivity, equipment data	SCADA, connectivity, synthetic load profiles	SCADA, AMI with kW, V, and Q data	SCADA. AMI with kW, V, and Q data, connectivity, equipment data
Input Data Latency	Days	Hourly	Minutely	Minutely SCADA and AMI, Daily Equipment
Model Resolution	Annual, case by case basis for interconnections	Daily, no forecast	Minutely , Up to day ahead Forecast	Minutely , Up to day ahead Forecast
Accuracy	High	Low	Medium	Highest
Challenges	Not suitable for DER management	Limited accuracy, Voltage constraints difficult	High dependency on communication, future use cases challenging	Still in development
Examples		Survalent, GE	Australia flexible export limits for rooftop solar Project EDGE YouTube	ThinkLabs AI, Inc. Camus Energy GRIDSIGHT.

Pseudo Informed - ADMS

Advanced Distribution Management System (ADMS) solutions are widely used by many utilities. However, they are primarily focused on real-time outage and contingency use cases, such as Fault Location, Isolation, and Service Restoration (FLISR). These systems place less emphasis on forecasted voltage and thermal constraints.

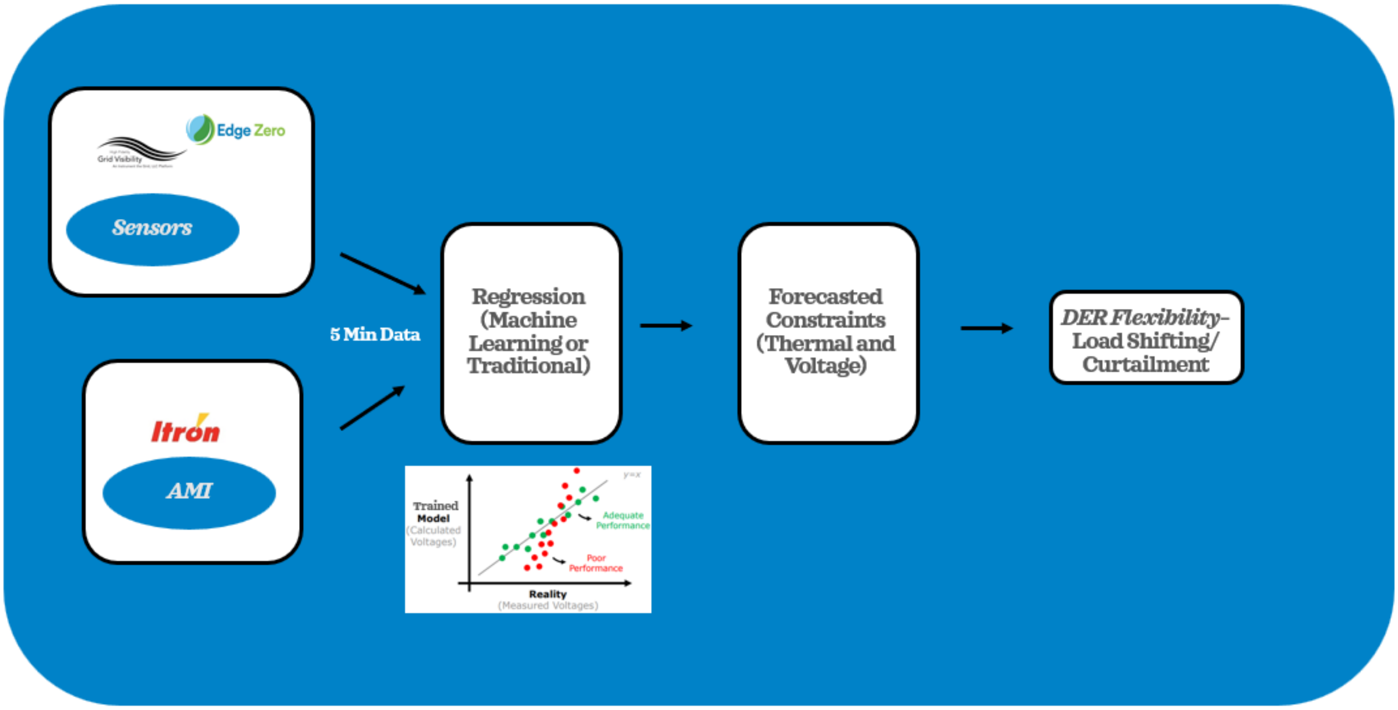


ADMS systems, such as those from **Survalent**, **GE** , rely on load profiles based on tariff or rate class and do not utilize AMI. Typically, these systems also lack connectivity models that extend beyond the feeder level, meaning they do not include meter-to-transformer relationships or transformer loading. Additionally, these systems typically exist behind OT firewalls, making it very difficult to send signals to Edge DERMS/Aggregators, which typically sit in the IT domain. It's a good thing they do, as the majority rely on public Wi-Fi/Cell to communicate with DER devices.

Model Free

Model-free approaches use real world data and regression (machine learning/traditional) to generate a profile of the system performance. These models can be generated really quickly (within minutes) and are already being used in Australia with **flexible export limits for rooftop solar** **Project EDGE YouTube**

Model Free

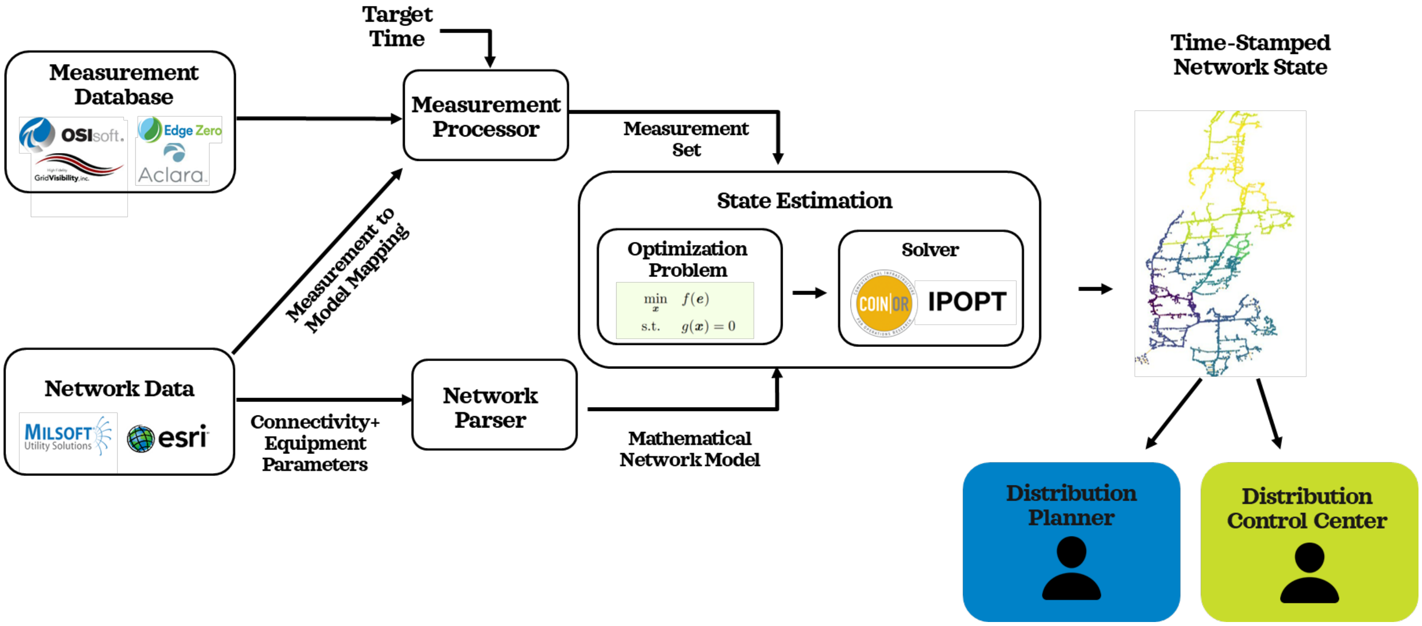


Since model-free approaches rely on measurement data, you need to have that data readily available from whoever you are working with. We're in the midst of an AMI upgrade with **Itron, Inc.** , and even with a modern "AMI 2.0" system, it's likely our systems will only receive and be able to use the data 15-30 minutes after real-time measurements. While leveraging a fiber backbone or cellular network could speed up the data collection, those costs can be significant. Additionally, if the data streams stop due to a communication failure, the Model Free approach ceases to function.

While physics-based models can consider any current/past or future scenario, model-free approach models are well suited to identifying the current state.

Physics Inspired

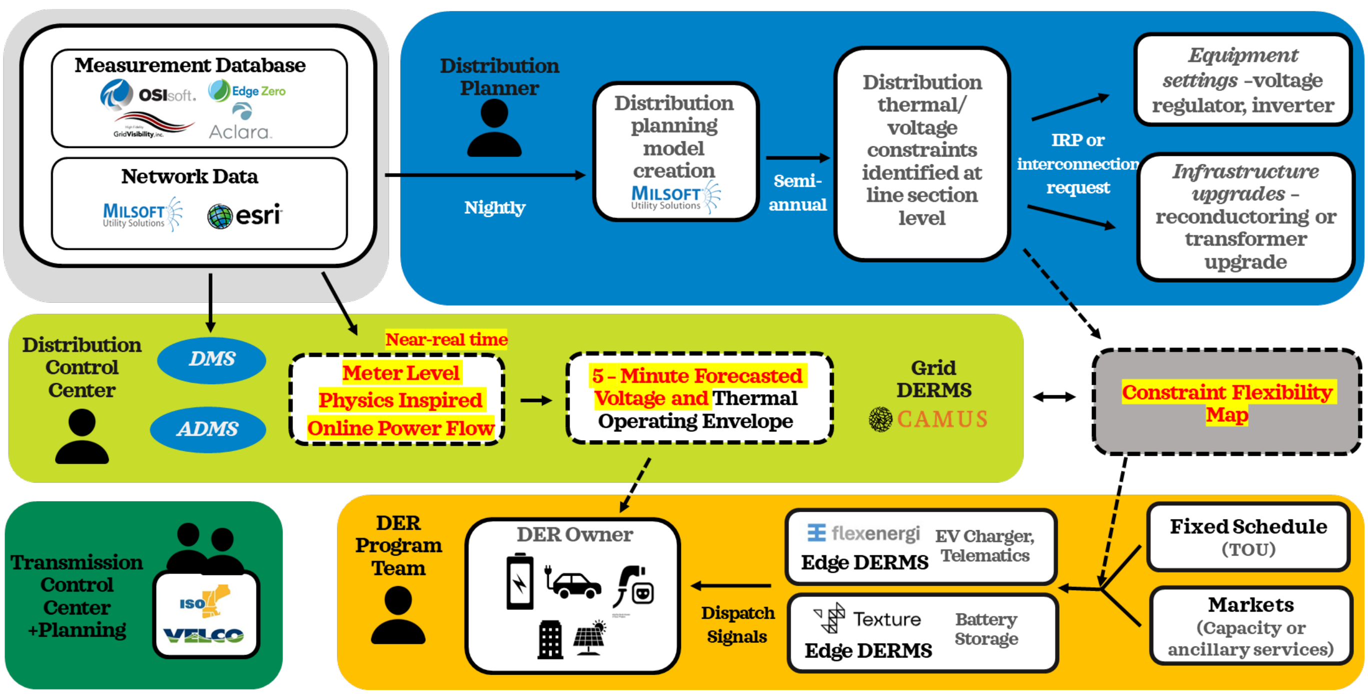
VEC and UVM are collaborating on the FOREST project, funded by the Leahy Institute for Rural Partnerships, to develop a tool that identifies distribution system constraints quickly. This helps utility programs or DER aggregators defer or eliminate infrastructure upgrades. The goal is to create a time-stamped network state every 5 minutes and forecast where constraints exist.



VEC is also working with Camus to operationalize this tool which would include a 24-hour forecast.

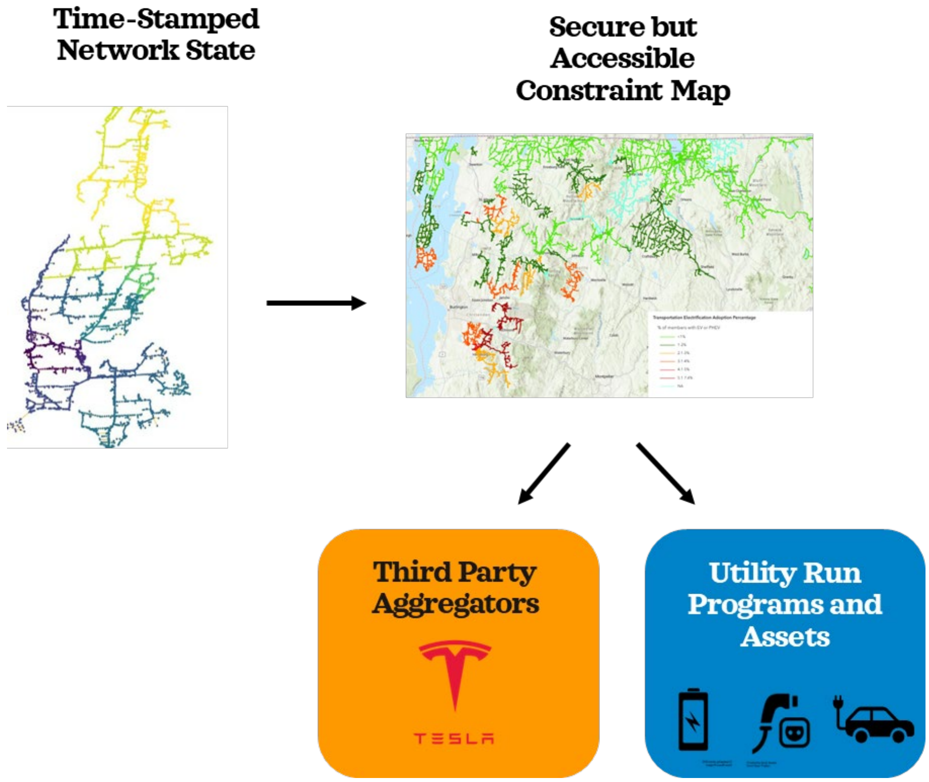
Evolving the Planning Framework for DER Management

A physics inspired online power flow would help enable an expanded framework that not only considers longer term planning needs but also enables near real time management of DER to defer infrastructure upgrades.



Mapping Distribution System Constraints to Enable DER Value and Deployment

VEC's goal is to publish a secure constraint map for online power flow, enabling VEC and third-party aggregators like SparkFund and Tesla to react to price signals. This will help developers and aggregators optimize the power, energy, location, and size distribution of energy storage on VEC's system.



While maps of distribution constraints are limited in North America, similar projects exist in Australia. The National Electricity Market (NEM) derived from publicly accessible NEM DI constraint equation and identifies where the system is constrained.