VERMONT ELECTRIC CO OP

2024 Innovation Report

Utility Partners

vermont electric power company VELCO

STOWE ELECTRIC DEPARTMENT

WEC Washington Electric CO-OP

GREEN MOUNTAIN POWER

ISO new england

Efficiency Vermont

Industry Partners

Edge Zero

flexenergi

encoord

CAMUS

RHIZOME

NRECA America's Electric Cooperatives

High Fidelity GridVisibility, inc.

do.

ELEVATE ENERGY CONSULTING

Research Partners

University of Vermont

CREATE Center for Resilient Energy and Autonomous Technologies in Engineering

University of Vermont Spatial Analysis Lab

Pacific Northwest NATIONAL LABORATORY

OAK RIDGE National Laboratory

With Support From

University of Vermont

Leahy Institute for Rural Partnerships

U.S. Department of ENERGY

Office of Electricity – Sensors and Data Analytics

U.S. Department of ENERGY

Office of Energy – Efficiency and Renewable Energy

Drafted by Cyril Brunner with support from VEC partners

VERMONT ELECTRIC CO OP

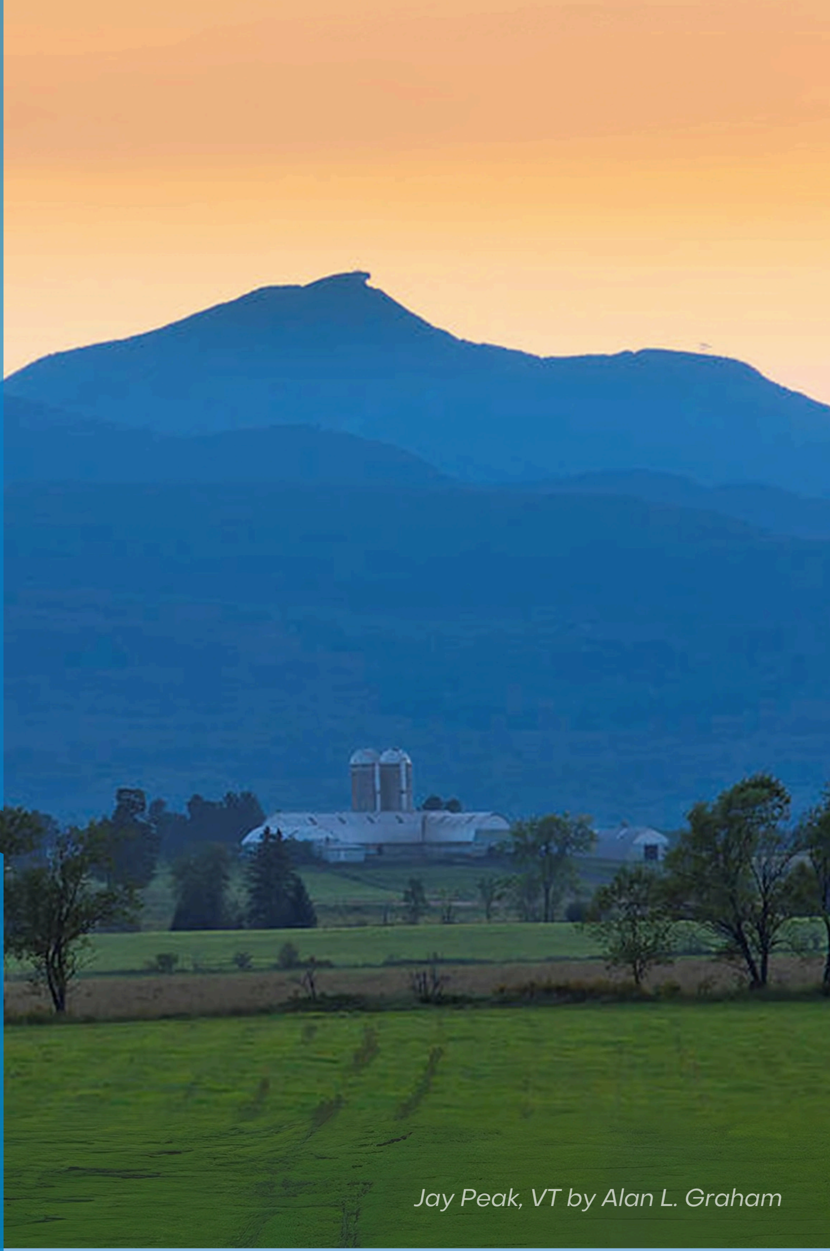
Lead With People

Pursue Operations Reliability

Engage Members

Orchestrate Distributed Renewable Energy

Maintain Financial Strength



Jay Peak, VT by Alan L. Graham

- ***Distribution*** *Only*
- ***100%*** *Self -Procured Power Supply*
- ***Regulated*** *by Vermont PUC*
- ***43,000*** *Meters*
- ***87*** *MW Peak Demand*
- ***100% Renewable*** *by 2030*
- ***>50 MW*** *of Distributed Renewables*
- ***15%*** *Heat Pump Adoption*
- ***3%*** *EV and PHEV Adoption*
- ***1.2*** *Meters per transformer*
- ***109*** *Employees*

Lighting the path to affordable clean energy, ***together***.

TABLE OF CONTENTS

01. **VEC CHALLENGES**

An overview of VEC's challenges of reliability, affordability, and people provides an overview of the key issues the organization faces in these areas.

02. **VEC'S STRATEGIC PLAN**

Our guiding strategic vision that outlines how we can continue providing safe, affordable and reliable energy services to our 34,000 members.

03. **INNOVATION FRAMEWORK**

This framework outlines the process of identifying and prioritizing challenges and solutions, forming thought partnerships, and formalizing projects with funding and internal champions. It includes steps for experimentation and evaluation to determine readiness for program or technology management.

04. **THOUGHT PARTNERSHIP PROJECTS**

VEC's 2024 Thought Partnership Projects including an overview, list of partners, learnings and next steps. Also included is a sneak peak of 2025 work.

Our Challenges

Decreasing Reliability

Extreme Weather, Outages from Vegetation Outside of the Right of Way, Emerald Ash Borer

Stressed Infrastructure

Limited Capital Dollars, Impacts of Electrification Load Growth and Distributed Generation

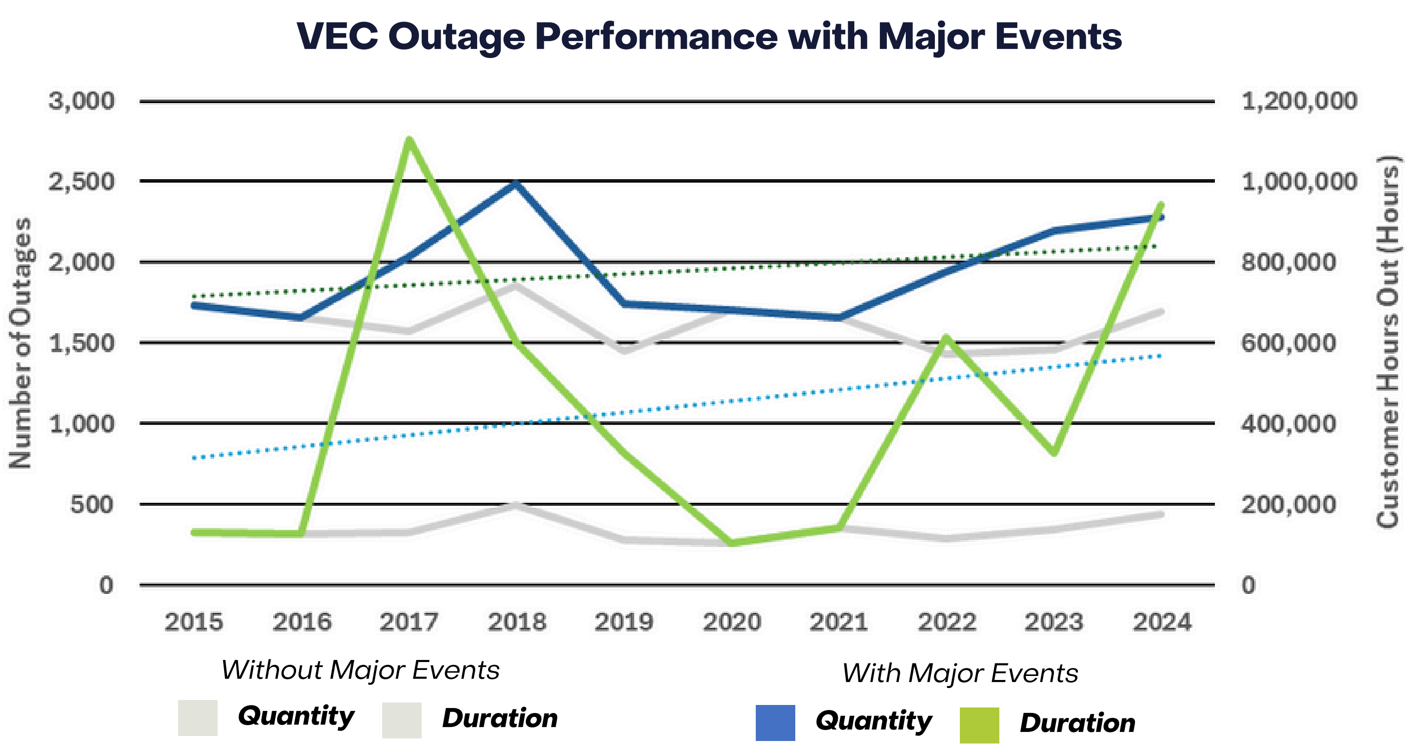
Rising O&M Expenses

Major storms, Transmission , Vegetation Management, Labor and Benefits

Increasing Member Expectations

Reliability Needs, Energy Engagement, Affordability Challenges

Decreasing Reliability



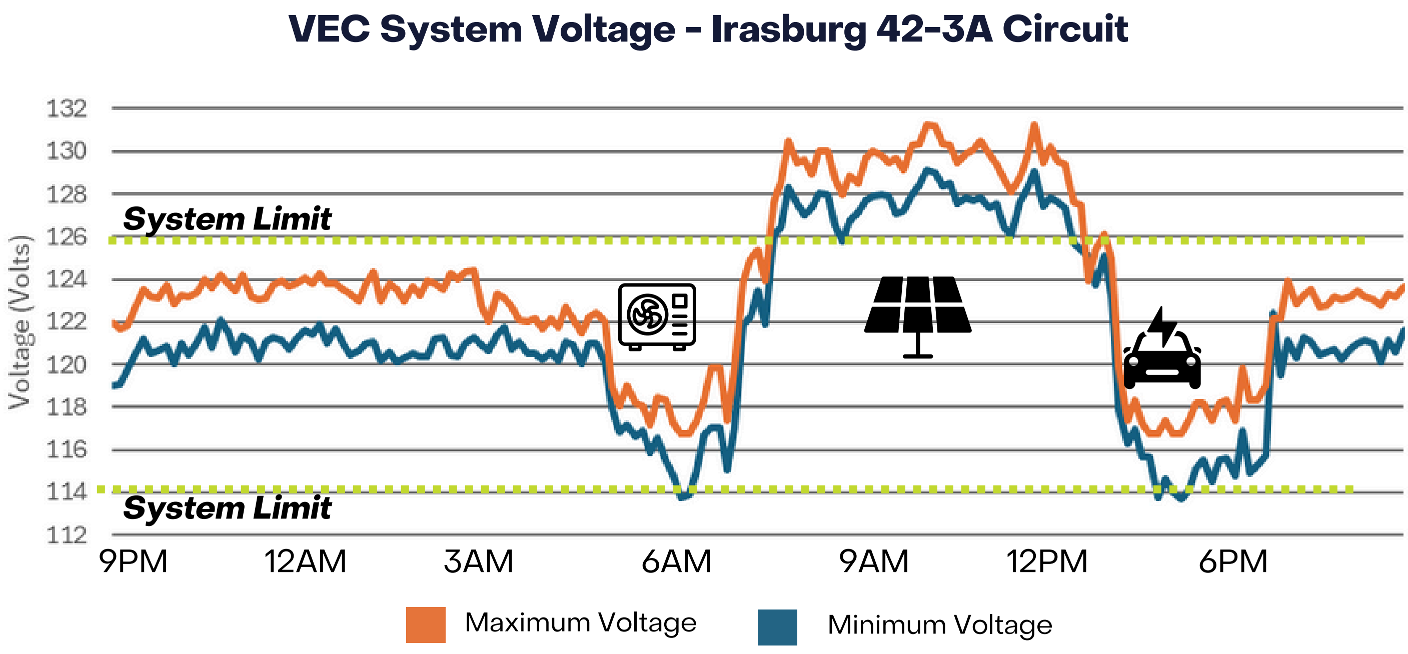
Outage Quantity and Duration Increasing

- *Extreme weather (in particular - wind and ice)*
- *Legacy software tools to manage major events*

Vegetation Management

- *Increasing outages from vegetation outside of the Right of Ways*
- *Risks from Emerald Ash Borer (EAB) increasing*

Stressed Infrastructure



Electric Vehicles and Heat Pumps Growth

- *VEC estimates $100 million in infrastructure upgrades by 2040 - low voltage constrained end of line locations.*
- *VELCO estimates over $1 billion in upgrades needed on the transmission system due to DER growth.*
- *Residential EV load growth impacting distribution transformers today.*
- *Measured Heat pump data is limited, impacts on the aggregate unknown.*
- *DER adoption difficult to forecast.*

Grid Visibility - For Operations and Engineering Model Validation

- *Overwhelming choice of grid edge solutions.*
- *Transmission and distribution operators have the same tools, but the grid is increasingly complex.*

Distributed Generation Causing Instability

- *High voltage due to distributed generation.*
- *More severe Transmission contingencies with inverter based resources*
- *DG Hosting capacity (thermal and transient).*
- *Distribution bus load power factor out of tolerance due to distributed generation.*

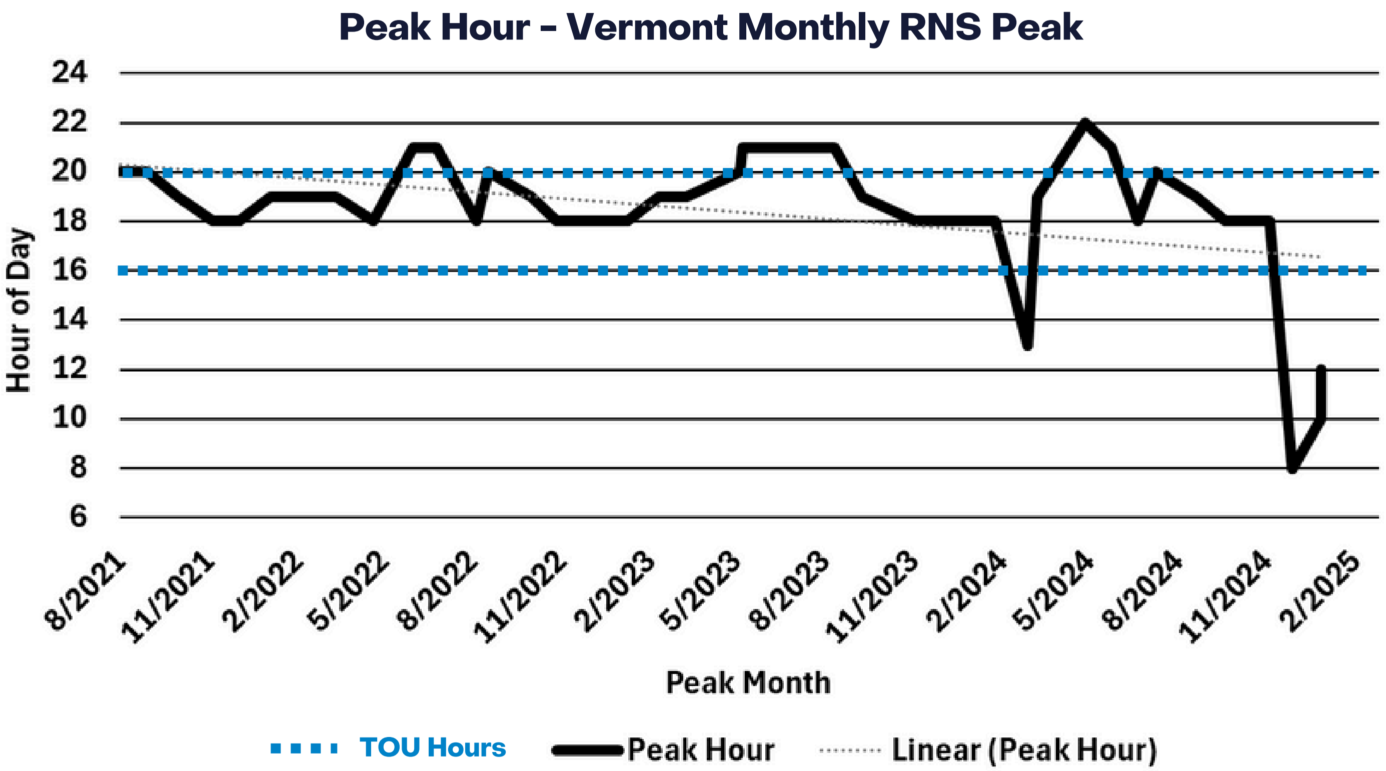
Infrastructure Assets are Difficult to Optimize

- *Limited decision making frameworks.*
- *Gap in tying engineering results to economic analysis.*

Non-Wires Alternatives Are Untested

- *Limited tested and trusted alternatives to traditional T&D investment.*

Rising O&M Expenses



Transmission and Operations Costs Rising (2.4% increase on rates in 2024)

- *Transmission owners in the ISONE region replacing aging assets.*
- *Labor, benefits, vegetation management.*

Use Inspired Research can be Expensive and Time Consuming

- *Data sharing frameworks limit research capabilities.*
- *Federal grant dollars in flux*
- *Utility funded research is often expensive.*

DER Management Cost Benefit

- *DER management costs outweigh peak shaving benefits and member incentive.*

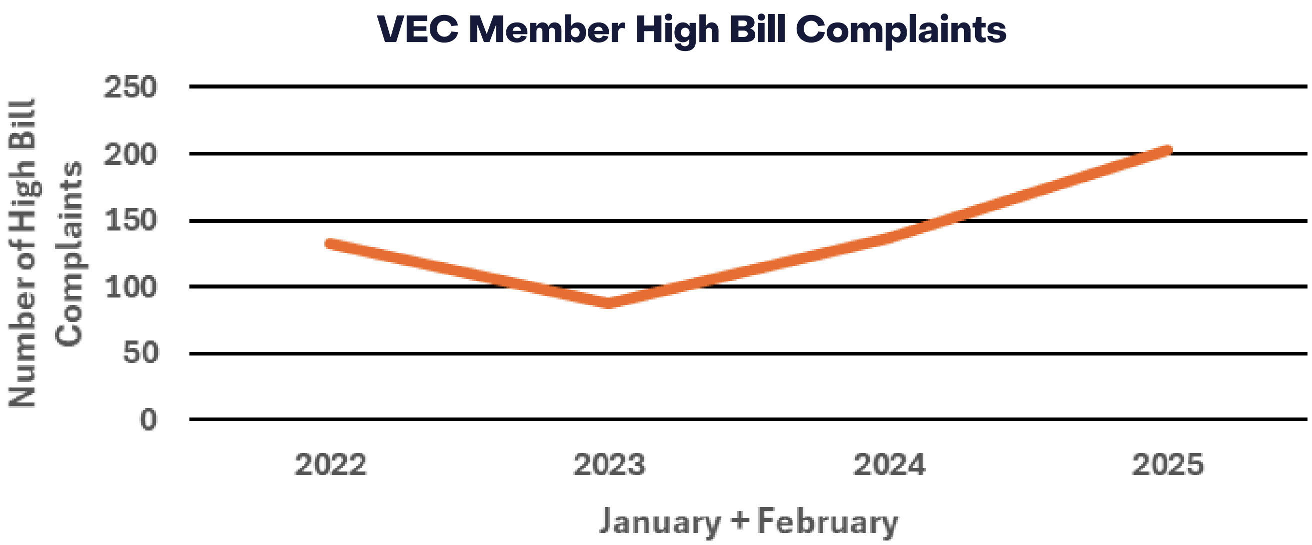
Peak Forecasting Increasing in Difficulty

- *Peak is shifting from evening to morning as statewide flexible assets continue to increase.*
- *Static or scheduled/behavioral programs are not flexible enough to meet changing peak hours.*

Meeting 100% Renewable Goals

- *Above market cost of net metering.*
- *In state renewable options are limited and intermittent .*
- *Offshore wind delays.*
- *Regional baseload supply costs.*

Increasing Member Expectations



Board President Rich Goggin with two VEC members

Reliability Needs

- *Member expectations exceeding outage performance*
- *Increasing reliance on electricity for heating and transportation*

Energy Engagement

- *Members are requesting increased program offerings and more involvement in their energy bill*
- *Limited understanding of intersection of member behavior and incentives*

Affordability Challenges

- *High cost of regional energy*
- *Many fixed income members and high local living expenses*

Our Strategic Plan

Lead With People

- Maintain a safety-first culture
- Prioritize cybersecurity
- Develop a culture of innovation and learning
- Leverage data to implement Thought Partnership Projects

Pursue Operations Reliability

- Proactively prevent and detect outages
- Advance event readiness and response
- Prioritize resiliency in investments
- Implement and explore innovative resiliency solutions
- Maintain Transmission and Distribution assets

Engage Members

- Reduce impacts of electrification on the grid
- Focus on affordability strategies for all members
- Support electrification through incentives and programs
- Expand and optimize VEC virtual power plant

Orchestrate Distributed Renewable Energy

- Forecast overall load needs
- Reduce impacts of generation on infrastructure (voltage and load power factor)
- Identify affordable and reliable resources for 100% carbon free today , 100% renewable by 2030
- Explore 100% renewable on an hourly basis

Maintain Financial Strength

- Utilize 5 year financial forecast to understand challenges
- Explore smart rates
- Pursue grants to support investments

Why Does VEC Focus on Thought Partnership Projects?

A New, Complex and Challenging Grid

Unprecedented behind the meter drastically impacting load and generation, extreme weather increasing outages, and abundant affordability pressures

Limited but Nimble Resources

Small staff and reliance on grant dollars to fund research.

Comprehensive Grid Data

Systemwide AMI, GIS, SCADA and modeling data that is readily and quickly shared with partners

Partner with utilities, industry, and research to make the most use of limited resources and solve complex challenges .

Helping our members, communities, and utility network increase reliability and affordability.

How do We Build TPP's - VEC's Innovation Framework

1. Innovation - *Identify Challenges*

- Reliability
- Affordability
- Members

2. Innovation - *Identify and Prioritize Solutions*

- Solutions responsive to challenges

3. Ideation - *Identify Thought Partnerships*

- Use inspired research based on challenges and solutions

4. Discovery

- Formalize TPP:
  - Funding
  - Internal Champions
  - Scope Definition

5. Learn and Define

- Experiment
- Evaluate - Is the TPP solution read for Program or Technology Management

Technology/Program Management

Completed
Technology Partnership Projects

Project	Timeline
FlexEnergi EV Telematics *Explore the value of EV telematics in expanding EV program enrollment and in addressing data communications gaps*	2024
Qilo Heat Pump Disaggregation *Using disaggregated AMI data and VEC's heat pump incentive database identify heat pump total kWH by usage category*	2024
EdgeZero Sensor Deployment *Transformer sensors to enable near real time visibility of distribution voltage for highly saturated distributed solar areas*	2024

TPP : Flexenergi EV Telematics

Explore the value of EV telematics in expanding EV program enrollment and in addressing data communications gaps

Thought Partnership Project Overview

1. Expand EV management to members who cannot currently participate due to charger incompatibility with a particular focus on Tesla vehicles.
2. Mitigate WIFI connection issues by leveraging telematics cell coverage
3. Decrease EV program enrollment duration and administration
4. Demonstrate ability to see state of charge and manage vehicle charging time and speed.

Challenges Addressed

DER Management Cost Benefit

- *DER Management costs outweigh peak shaving benefits and member incentive*

Strategic Goals

Engage Members

- Reduce impacts of electrification on the grid
- Expand and optimize VEC virtual power plant

Learnings

- **Tesla** : VEC is now managing over 40% of all Tesla vehicles.
- **Connectivity** to vehicles even in locations with little to no cell service.
- **Enrollment** process takes less than 5 minutes, VEC does not need to wait for an electrician to install a charger.
- **OEM telecommunication** costs can be a burden to creating a program that demonstrates savings to the membership.

Technology/Program Management

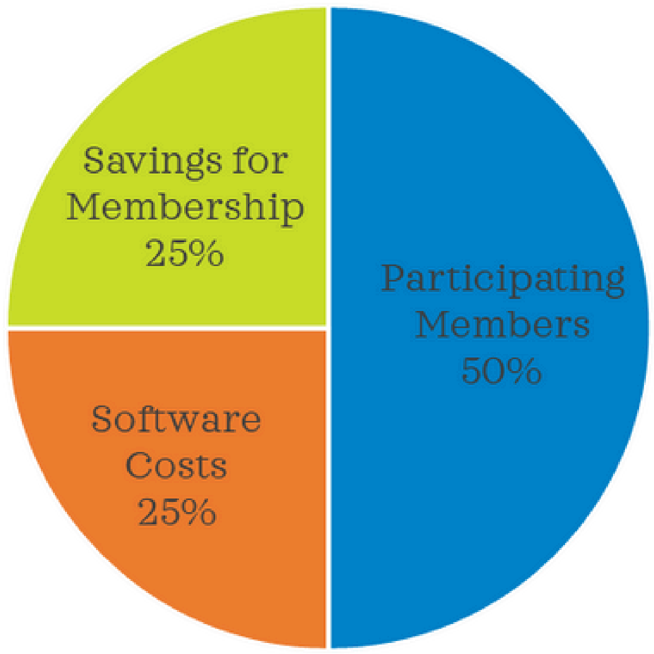
- Continue to expand program to remaining vehicles
- Complete integration with Camus for vehicle dispatch and operating envelope use cases.
- Explore how to build an economically viable program with OEM telecommunications costs.
- Explore NISC DERMS integration with FlexEnergi

flexenergi VERMONT ELECTRIC COOP

Learnings Expanded

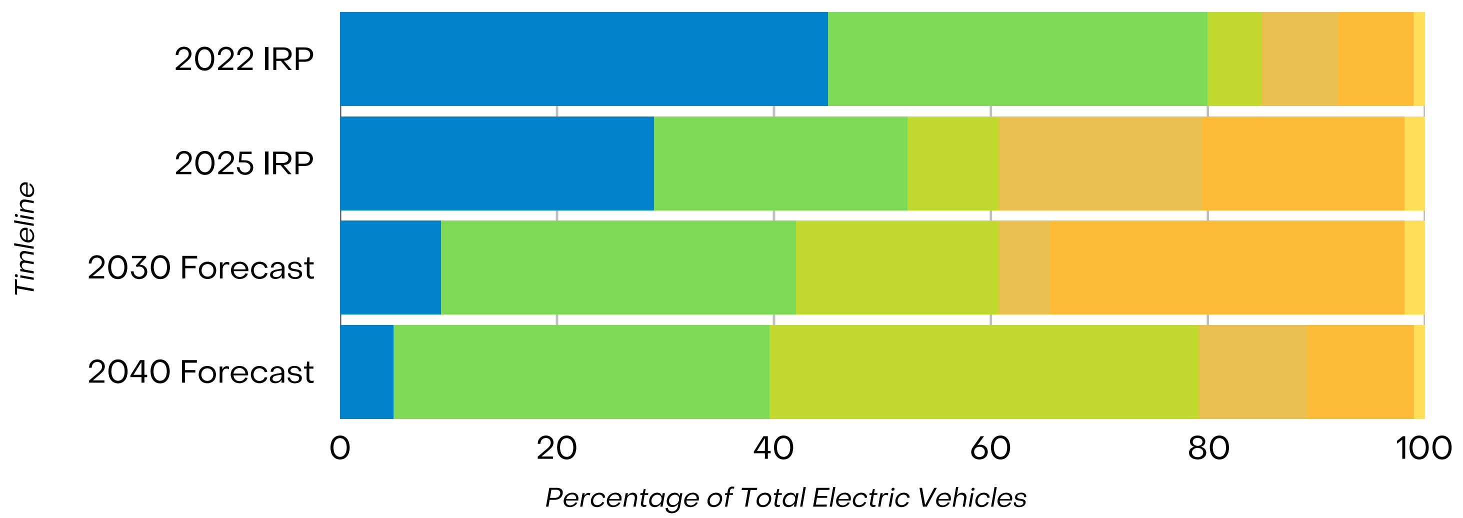
- OEM telecommunication costs can be a burden to creating a program that demonstrates savings to the membership. VEC currently sees an average kW usage across the EV fleet of a little over 1kW during peak times. VEC can save $204/kW if load is decreased during the 13 (annual ISONE FCM and monthly Vermont RNS) transmission peaks.

- VEC provides participating members a $96/year ($8/month) bill credit. This leaves ~$100 to cover software costs and demonstrate savings to the membership. While some OEM's offer free or trial periods for vehicle access , most OEM's are charging members between $100-$120/year to access their vehicles. This is on top of any fees that FlexEnergi or other DERMS providers are charging. Therefore there it is not economic for VEC to cover that telecommunications cost. With that being said - ~5% of enrolled program participants are paying for that service themselves.



Learnings Expanded

- Leveraging Flexenergi telematics vehicle data and ChargePoint charger data VEC was able to group electric vehicle users into various categories and begin to understand how those groups will change over time



Category	Annual Mileage	Annual kWH	Comment
EV Low	*< 4,000*	*1,325*	*Early adopter, lives and commutes in city/town*
EV Mid	*~ 14,000*	*3,878*	*Vermont average annual miles, typically mid sized sedan*
EV High	*> 14,000*	*6,799*	*Greater than Vermont average annual miles or light duty truck*
PHEV Low	*< 4,000*	*683*	*Early adopter, lives in city/town*
PHEV Mid	*~ 14,000*	*2,476*	*Vermont average annual miles, sedan or mid-sized vehicle*
PHEV High	*> 14,000*	*6,389*	*Greater than Vermont average miles and uses workplace charging*

Annual kWH data based off 2024 sample of 136 vehicles/chargers

TPP : Qilo Heat Pump Disaggregation

Using disaggregated AMI data and VEC's heat pump incentive database identify heat pump total kWH by usage category

Thought Partnership Project Overview

1. Create a baseline and profile using AMI data for VEC members before and after heat pump adoption
2. Identify the average annual change in usage across several groups and seasonal usage. Create an 8760 load profile to be used for VEC planning efforts
3. Group into several profiles that indicate the timing of use (summer, fall, winter, spring)

Challenges Addressed

Electric Vehicles and Heat Pumps Growth

- *Measured Heat pump data is limited, impacts on the aggregate unknown*

Strategic Goals

Engage Members

- Reduce impacts of electrification on the grid
- Expand and optimize VEC virtual power plant

Learnings

- **Usage**: Average across all groups is ~ 3,219 kWH annual change in usage.
- **Grouping:** More than expected all seasons (offsetting heating) household usage . Significant variability in heat pump size, usage patterns and kW impact

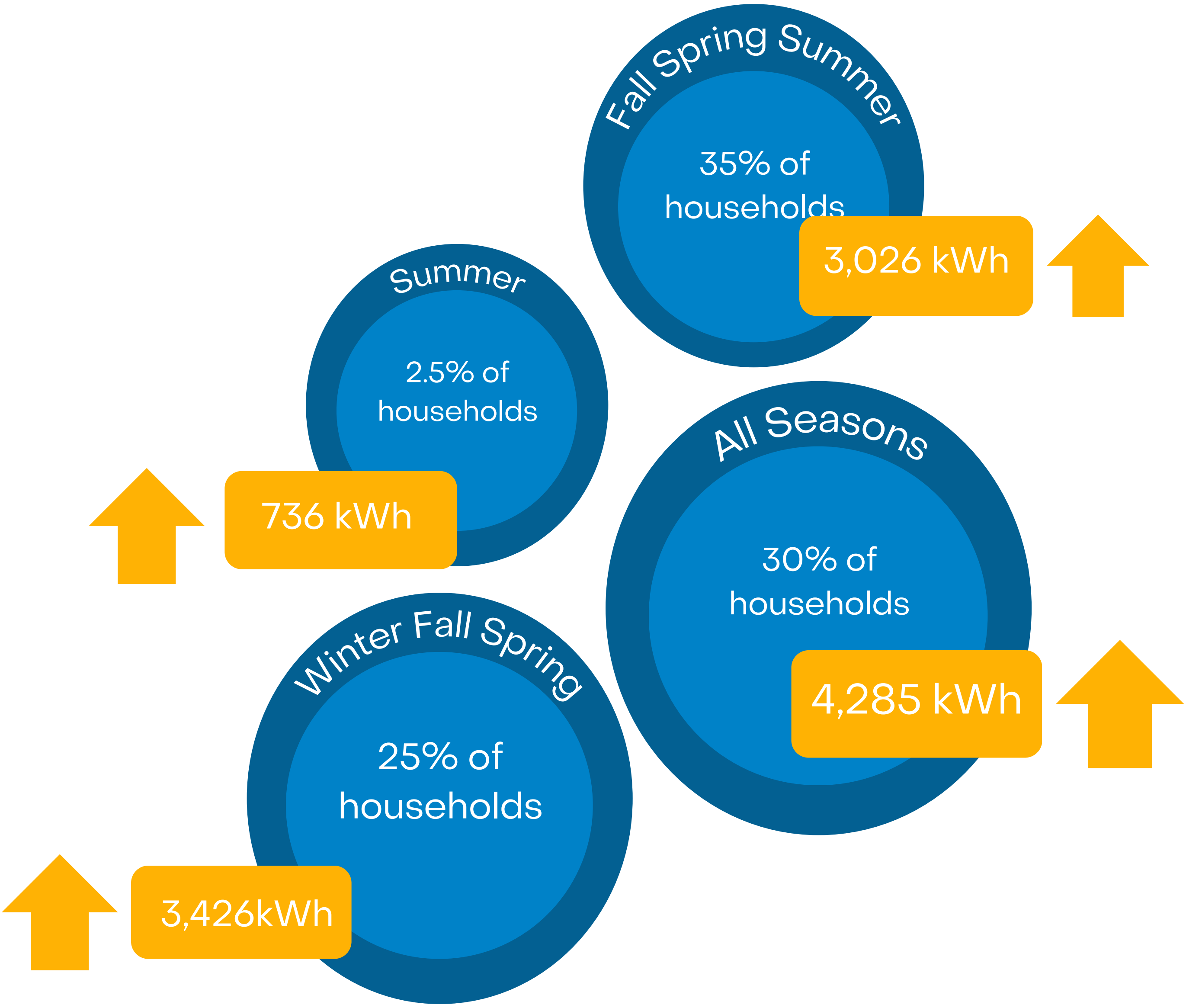
Technology/Program Management

- Validate with real world measurements
- Explore the flexibility of pumps through thermostat controls or fuel switching
- Leverage as part of IRP forecasting
- Share with VELCO to inform Long Range Planning Efforts

qilo. VERMONT ELECTRIC CO OP

Learnings Expanded

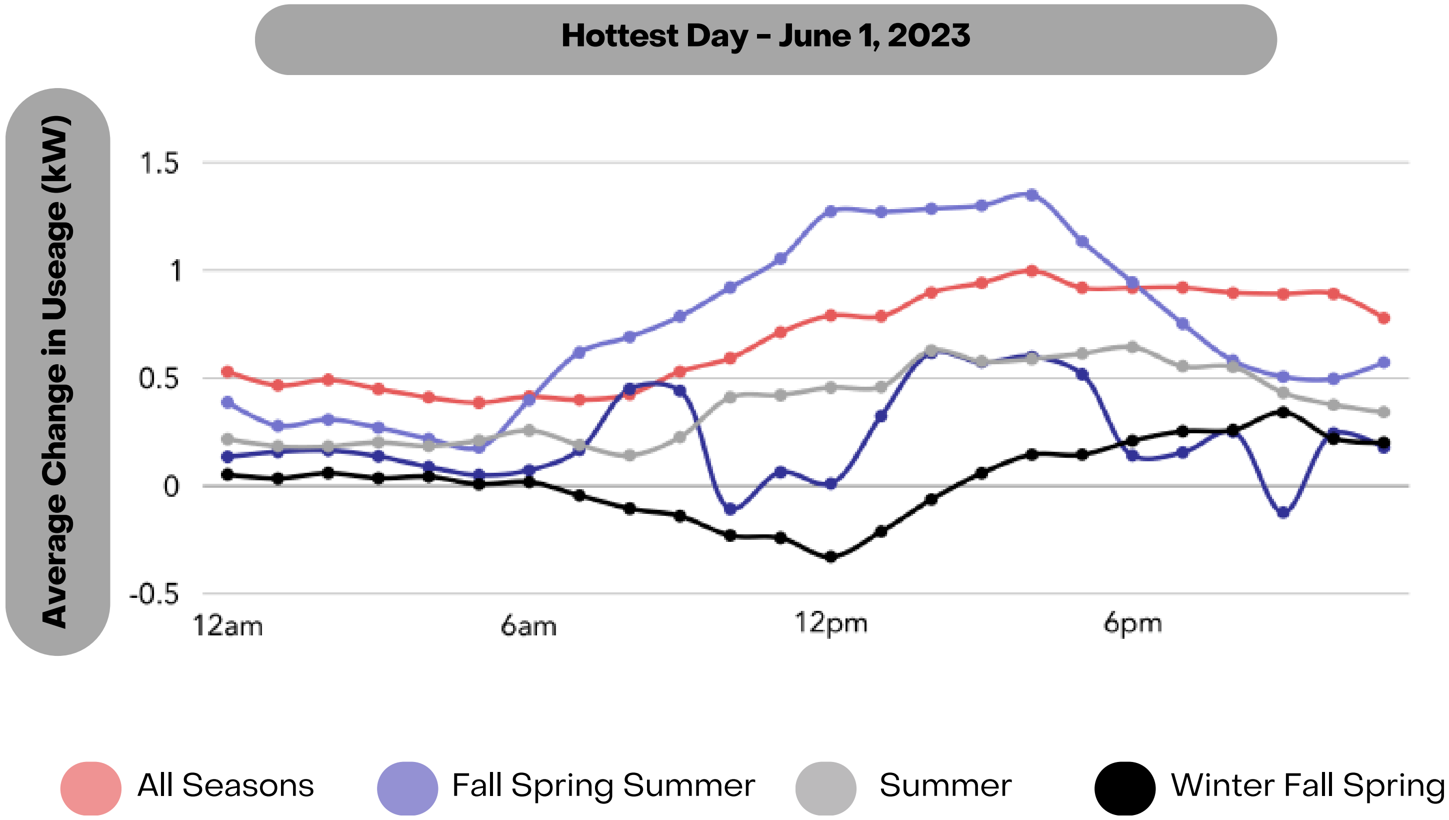
- Average annual change in usage ranges based on category
- Average across all groups is ~ 3,219 kWH annual change in usage. VEC's average residential member uses approximately 6,500 kWH annually. Vermont has one of the lowest annual kWH usages in he country. Data provided by Brett Adlard and Dave Brost of Qilo.

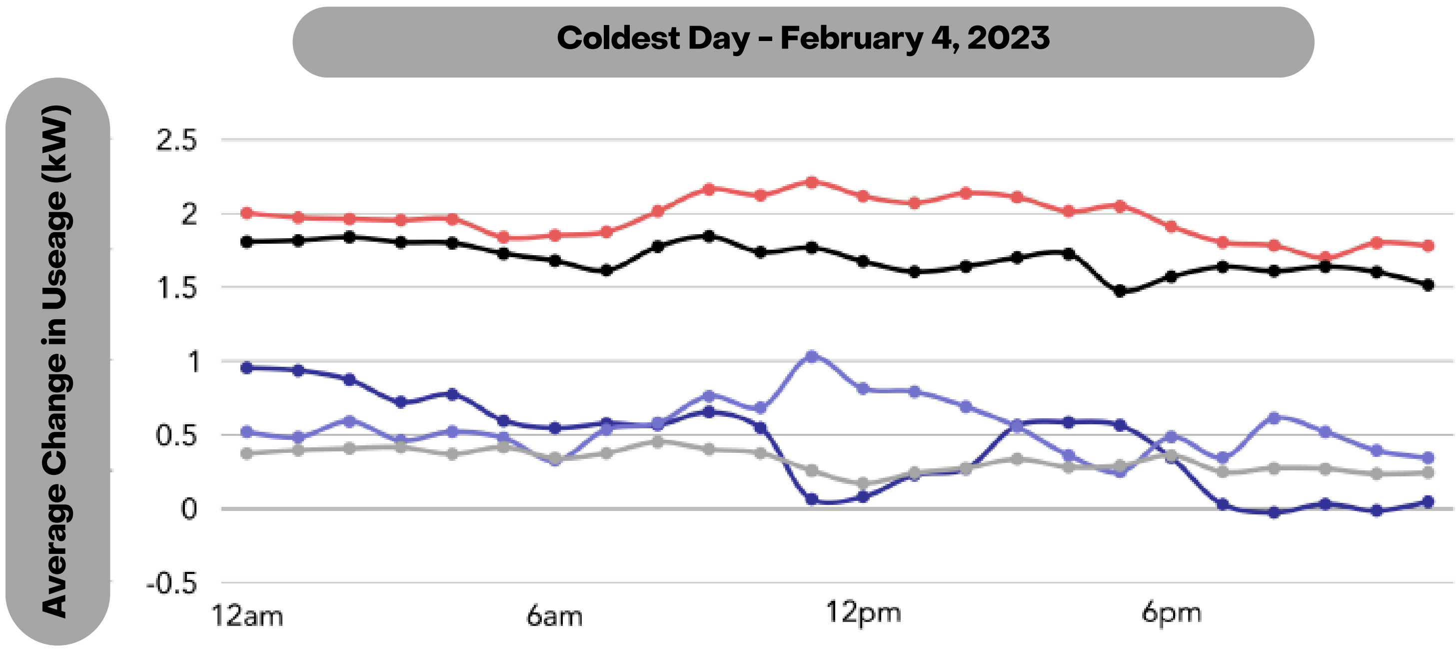


- Summer – Members who are only using in the summer who did not have AC prior to heat pump install.
- Fall Spring Summer– Not supplementing non-electric heating – cooling only
- All Seasons – Supplementing or eliminating non-electric heating
- Winter Fall Spring – Members who already had AC and are now using to supplement or eliminate non-electric heating.

Learnings Expanded

- The change in usage on the hottest and coldest day in Vermont are shown below. Wintertime peaks are higher as expected and can be over 2kW based on heat pump size. Data provided by Brett Adlard and Dave Brost of Qilo.





TPP : EdgeZero Sensor Deployment

Transformer sensors to enable near real time visibility of distribution voltage for highly saturated distributed solar areas

Thought Partnership Project Overview

1. VEC's AMI system does not collect distribution voltage at meters. Install transformer sensors to provide voltage visibility to operators and system planners
2. Understand where and how many sensors are required to meet the planning and operations needs
3. Identify if sensor deployments can help expand feeder backup limitations at South Alburg and South Hero substations
4. Integrate EdgeZero platform with Camus to provide single pain of glass visibility

Challenges Addressed

Distributed Generation Causing Instability

- *High voltage*
- *DG Hosting capacity (thermal and transient)*

Strategic Goals

Orchestrate Distributed Renewable Energy

- Reduce impacts of generation (voltage and load power factor)
- Support VEC mission of 100% carbon free today , 100% renewable by 2030

Learnings

- **Operations Visibility :** Near real time distribution voltage visibility helps inform control center operators of end of line system voltage. Prior understanding was model based and only real time at the substation level
- **Planning** : Initial sensor deployment was concentrated to one feeder which is less helpful for planners who are seeking to validate models key points (end of line and mid line)

Technology/Program Management

- Redeploy existing sensors to other feeders to better support system planning efforts (more feeder coverage with less sensors on each circuit)
- Understand the value of EdgeZero sensors in comparison with other sources like AMI or GVP

Check out PowerMap to see VEC's sensor data

Edge Zero CAMUS VERMONT ELECTRIC CO OP

Current Technology Partnership Projects

Project	Timeline
PNNL MAPLE LEAF *Build a standardized data sharing framework to enable use inspired research and future industry relationships.*	2022-2025
PNNL MAPLE BRANCH *Explore the engineering and economic value of inverter based controls to solve high voltage and load power factor issues in the distribution system.*	2023-2025
VELCO PHASOR Analytics *Secondary voltage sensors to enable near real time visibility of distribution voltage for highly saturated distributed solar areas*	2024-2025
UVM SOLVER *Leverage statewide LiDAR data to identify at-risk electrical infrastructure in Vermont*	2024-2025
UVM EnergyShed *Create tools to simulate the growth of DER and develop models that help communities make decisions*	2024-2026
Camus Grid Optimized EV Management *Develop operating envelopes to shape electric vehicle load and prevent overloaded distribution transformers*	2024-2025
Dynamic Organics Peak Forecasting *Leverage AI based forecasting tools to improve VEC's ability to accurately forecast peaks*	2024-2025

TPP : PNNL MAPLE LEAF

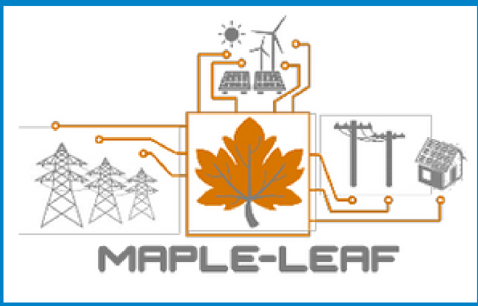
Build a standardized data sharing framework to enable use inspired research and future industry relationships.

ENERGY

Office of Electricity (OE)
Sensors and Data Analytics

Thought Partnership Project Overview

1. Utilize the Common Information Model (CIM) as the standards-based platform to reduce custom or proprietary data sharing/formats.
2. Develop T&D co-simulation models to simulate how distribution can affect transmission
3. Leverage VEC GIS and ArcGIS FME to decrease model sharing challenges.



Challenges Addressed

Use Inspired Research can be Expensive and Time Consuming

- *Data sharing frameworks limit research capabilities*

Strategic Goals

Lead With People

- Develop a culture of innovation and learning
- Implement Thought Partnership Projects

VEC Learnings

- **Common Architecture:** CIM provides us with a no regrets, research and vendor flexible architecture to perform research and eventually implement tools for operations.
- **Model Exports Challenges**: VEC Milsoft Engineering model exports to OpenDSS or GridLab-D are challenging for our partners to utilize.
- **Faster Data Sharing:** By creating a framework with clear roles and responsibilities we are now able to share data faster and perform more research to solve VEC challenges.

Next Steps

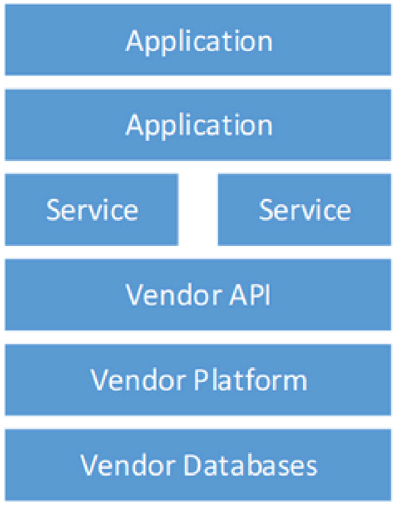
- Leverage framework to explore other use inspired research:
  - MAPLE BRANCH - Volt/VAR to mitigate high voltage and load power factor issues.
  - DOE Technical Assistance - DER forecasting and infrastructure impacts across VEC's territory.

VELCO PNNL University of Vermont GREEN MOUNTAIN POWER VERMONT ELECTRIC CO OP ISO new england

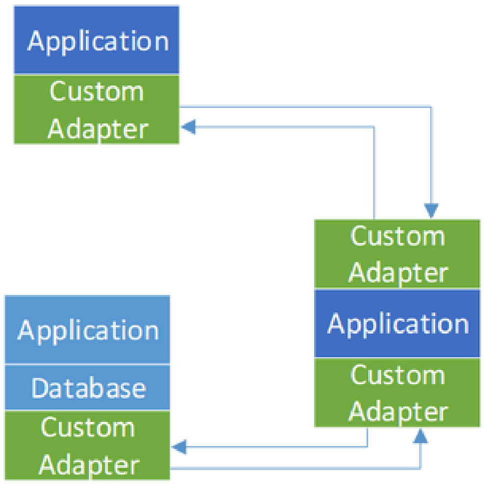
Learnings Expanded

- There are a variety of approaches to data integration but the CIM standards based platform is the best approach to guarantee no regrets integrations with vendors and data sharing with partners. Charts provided by Alex Anderson of PNNL.

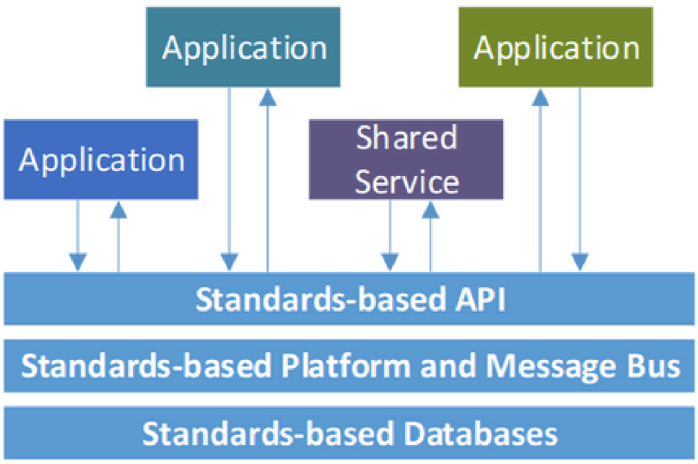
- Single-vendor EMS/ADMS
- Proprietary Data Format
- Proprietary API



- Custom Application Integration
- (Very costly & fragile)

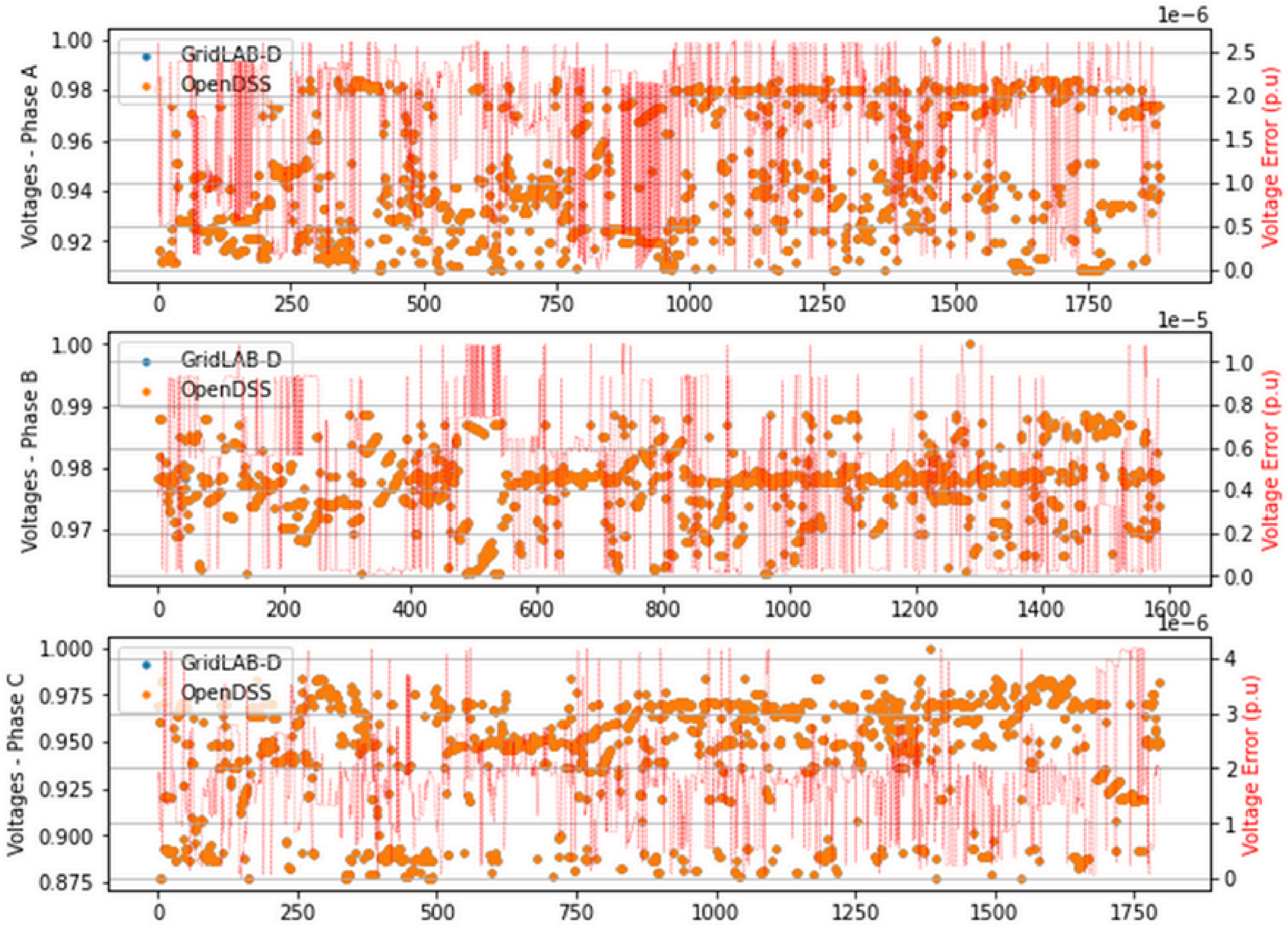


Standards-based Platform using an Agreed-upon Information Model



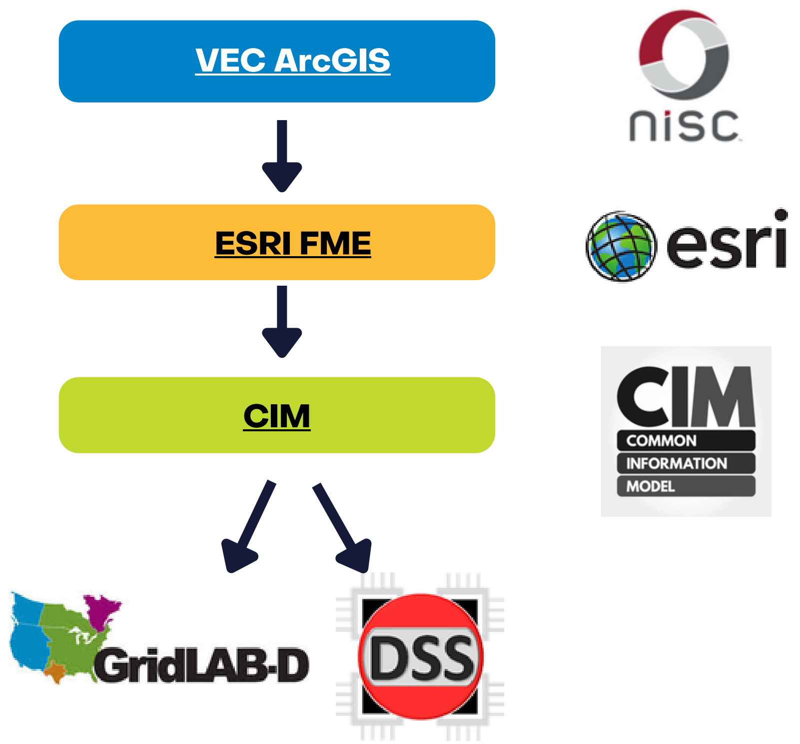
Learnings Expanded

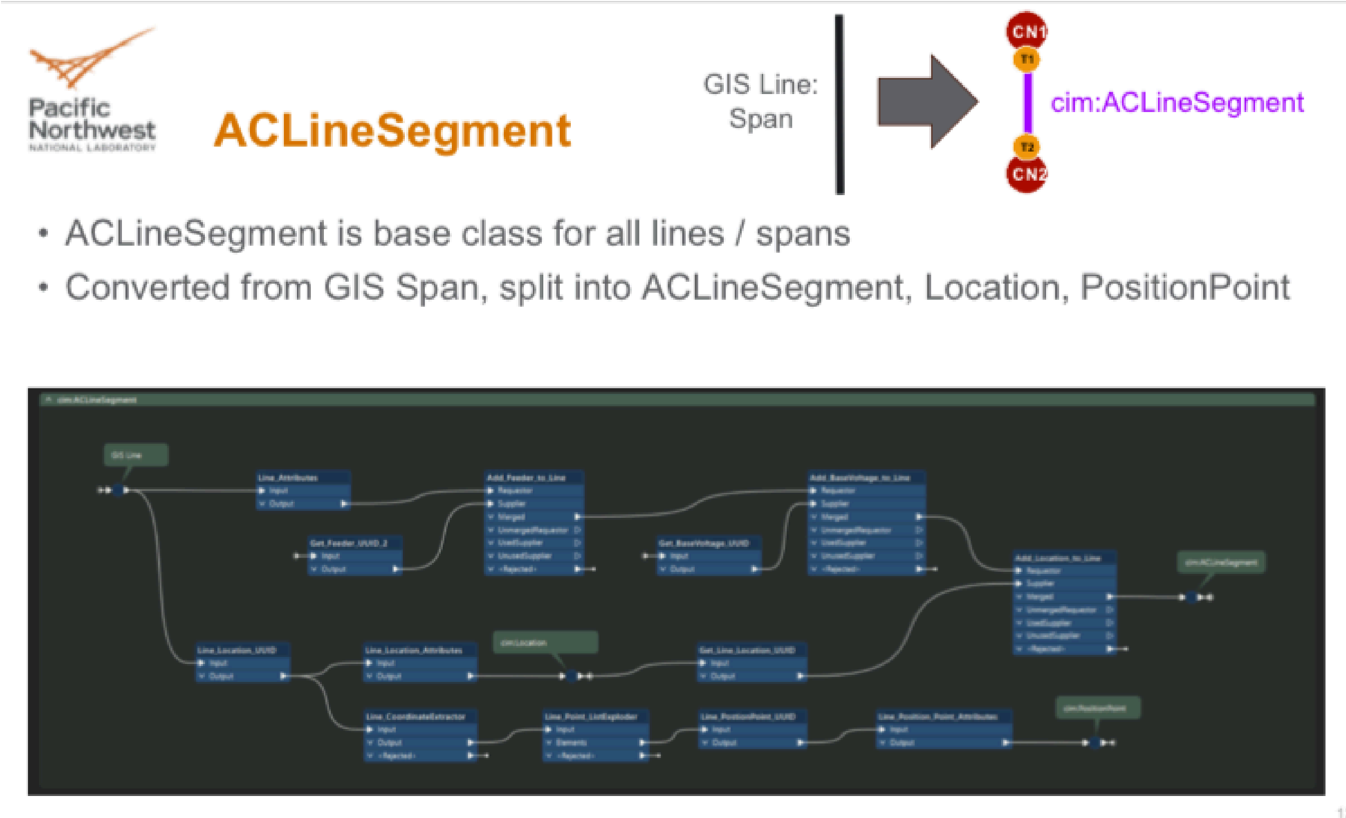
- VEC Milsoft engineering model exports to OpenDSS or GridLab-D are challenging for our partners to utilize without significant and time consuming model clean up . Images courtesy of Shiva Poudel at PNNL.



Learnings Expanded

- VEC utilizes Milsoft WindMil as a distribution engineering model. VEC has found that exporting a OpenDSS or GridLAB-D model from Milsoft creates many issues for researchers and partners. By GIS, ESRI FME, and CIM we have found a more accurate and more timely approach to engineering model sharing. Work and images below courtesy of Alex Anderson at PNNL





TPP : PNNL MAPLE BRANCH

Explore the engineering and economic value of inverter based controls to solve high voltage and load power factor issues in the distribution system.

U.S. Department of ENERGY

Office of Electricity (OE)
Sensors and Data Analytics

Thought Partnership Project Overview

Using PNNL MAPLE LEAF data foundations:

1. Model how Volt/VAR distributed generation inverter based controls impact voltage and load power factor (LPF) for South Hero 29 and South Alburg 28.
2. Identify the reduction in real power output.
3. Create an economic analysis tool to evaluate the cost-effectiveness of traditional distribution investments versus inverter based controls. Explore potential member compensation for grid services.

Challenges Addressed

Distributed Generation Causing Instability

- *High voltage*
- *Distribution bus Load power factor out of tolerance*

Strategic Goals

Orchestrate Distributed Renewable Energy

- Reduce impacts of generation (voltage and load power factor)
- Support VEC mission of 100% carbon free today , 100% renewable by 2030

VEC Learnings

- **System Improvement :** Volt/VAR inverter controls significantly reduce voltage and load power factor impacts, some areas of high voltage remain.
- **Curtailment :** Impacts to real power output are minimal but implementing changes with solar developers has been challenging.
- **Least Cost :** Economic analysis indicates that inverter based controls are the least cost option to addressing the challenges.

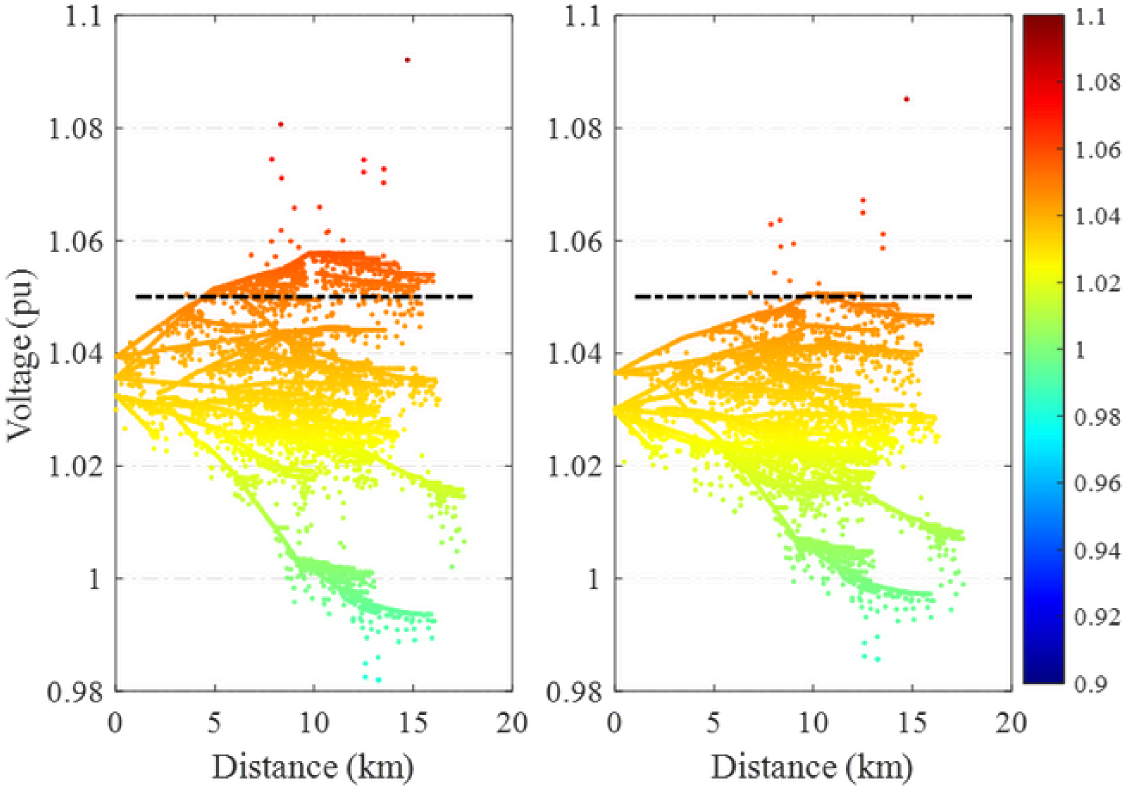
Next Steps

- Explore the possibility of requiring Volt/VAR on all new installations. Consider program design that includes compensation for grid services or encourages load use during high generation times.
- Share results with the DPS, other Vermont distribution utilities, and ISONE .

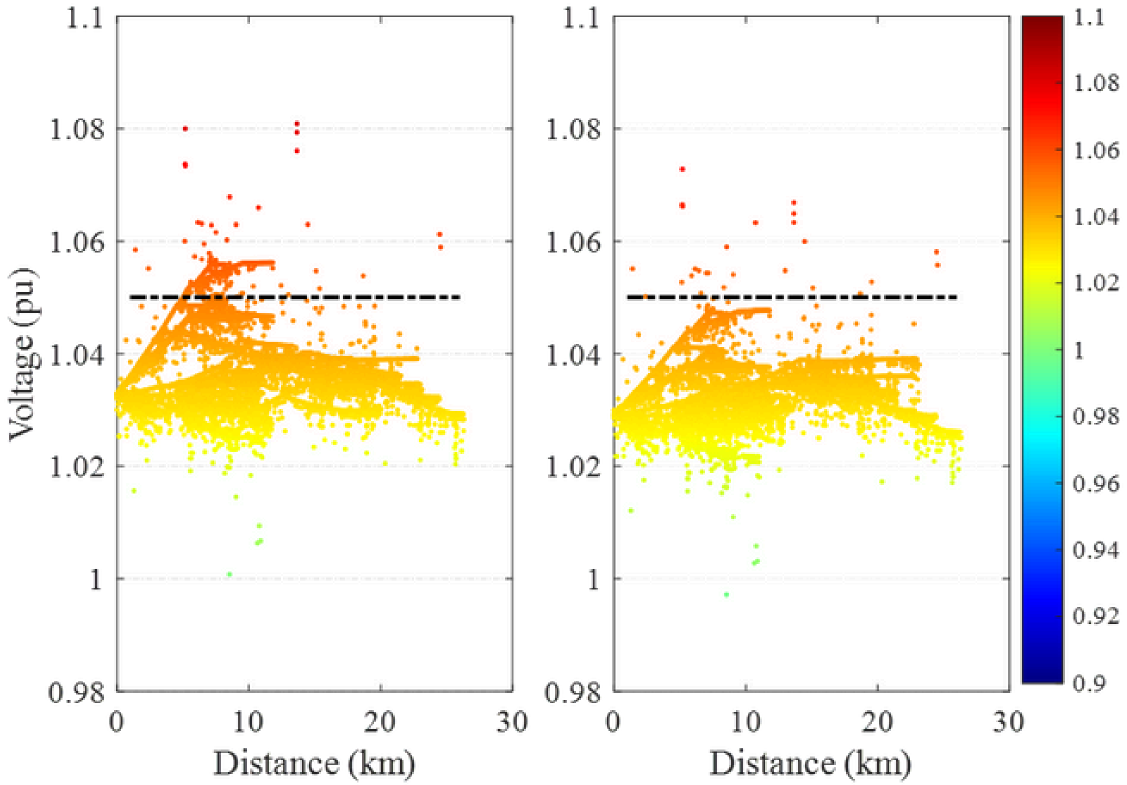
VELCO PNNL OAK RIDGE National Laboratory University of Vermont VERMONT ELECTRIC CO OP

Learnings Expanded

- Volt/VAR inverter controls significantly reduce voltage and load power factor impacts, some areas of high voltage remain. VEC is required to maintain a max voltage of 1.05 per unit to meet ANSI C84.1 Modeling results below are for enabling Volt/VAR controls at 7 sites 150kW and above. Analysis and charts below provided from Shiva Poudel from PNNL.



South Alburg



South Hero

TPP : VELCO PHASOR Analytics

Enhancing Grid Visibility and Reliability in Vermont's Electric Grid

Thought Partnership Project Overview

1. Pilot a low cost high resolution solution to provide visibility to distribution and transmission planners
2. Understand the impact of the distribution system on transmission level events.
3. VEC has no voltage data from AMI, visibility only at the substation. Therefore limited model validation capabilities outside of manual installation of power recorders.

Challenges Addressed

Grid Visibility - For Operations and Engineering Model Validation

- *Overwhelming choice of grid edge solutions*
- *Transmission and distribution operators have the same tools, but the grid is increasingly complex*

Strategic Goals

Orchestrate Distributed Renewable Energy

- Reduce impacts of generation (voltage and load power factor)
- Support VEC mission of 100% carbon free today , 100% renewable by 2030

Learnings

- **Broadband:** communications provide highly reliable and near real time visibility of the distribution system to the VEC team
- **No Current**: Voltage only measurements limit model validation value.
- **Easy Deployment:** "Voltage as a service'' requires no installation or maintenance resources from VEC.
- **Transmission:** operators (VELCO and ISONE) visibility into the distribution system is fundamental to model validation for contingency analysis.

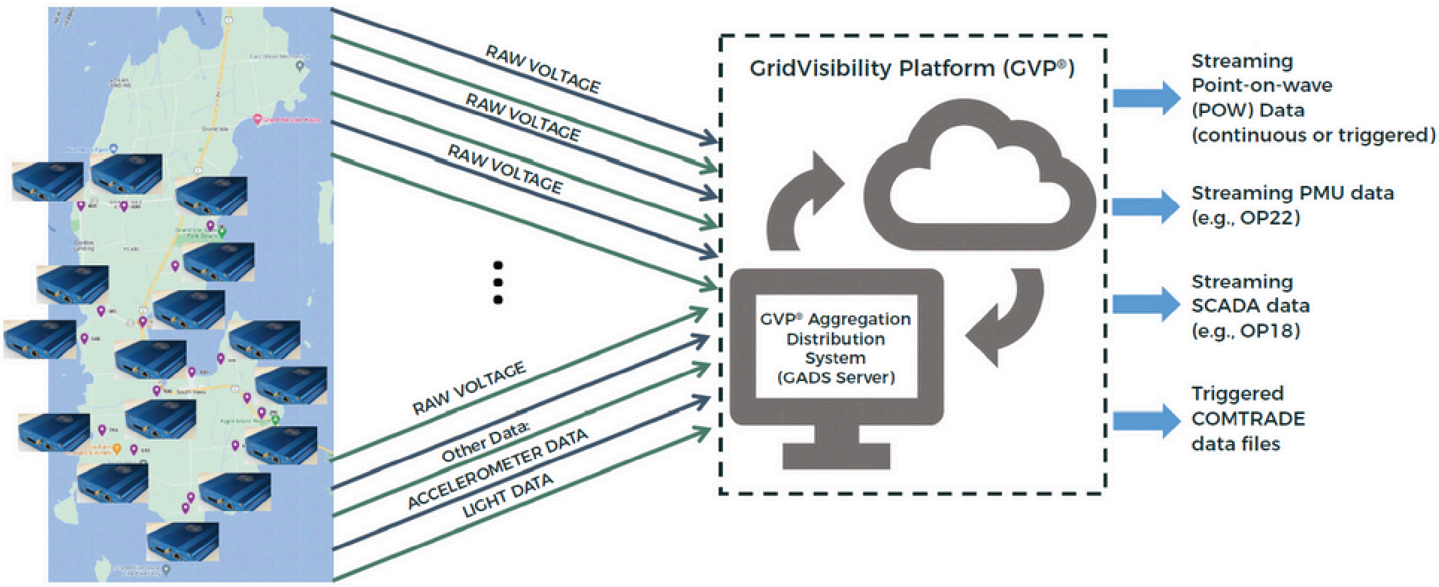
Next Steps

- GIS visibility of sensor locations
- Expand event filtering for distribution operator and planner use cases
- Continue to explore how this data can support ISONE and VELCO transmission planning

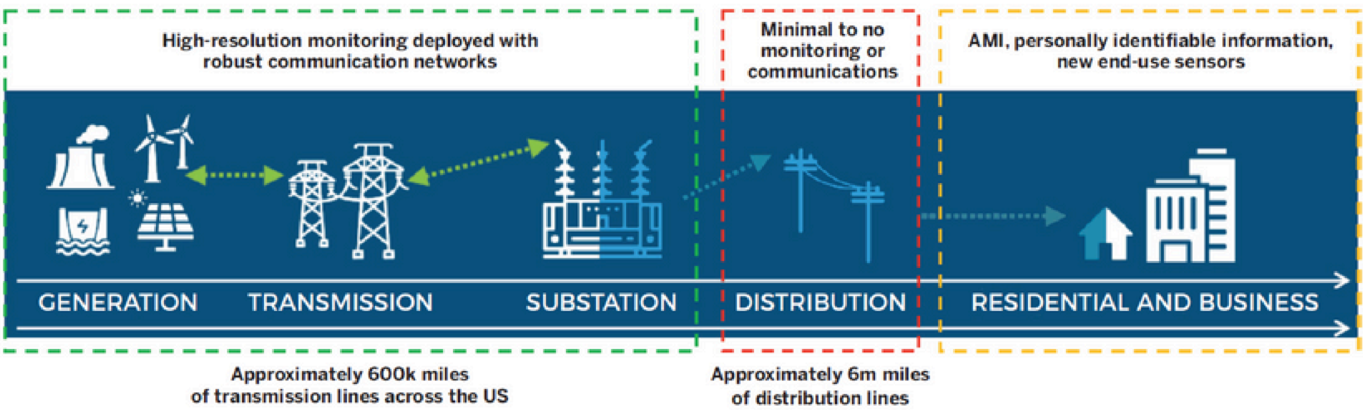
VELCO · Grid Visibility · ELEVATE ENERGY CONSULTING · VERMONT ELECTRIC CO OP · ISO new england

Learnings Expanded

- “Voltage as a service” requires no installation or maintenance resources from VEC. While VEC is only interested in 1 minute streaming voltage the platform is capable of streaming phasor quality level data (4,000 samples per second for events). Charts from Instrument the grid and Elevate Energy Consulting



- The focus of the product is on primary distribution lines where minimal to no monitoring or communications exists



TPP : UVM SOLVER

Leverage statewide LiDAR data to identify at-risk electrical infrastructure in Vermont

University of Vermont

Leahy Institute for Rural Partnerships

Thought Partnership Project Overview

1. Enhanced distribution grid models leveraging statewide LiDAR data.
2. A combined transmission and distribution simulation platform to analyze models
3. Simulation-based analysis of the most disastrous climate-driven contingencies, as identified from statewide LiDAR data.
4. Categorized lists of the most-at-risk electrical infrastructure elements in Vermont.

Challenges Addressed

Outage Quantity and Duration Increasing

- *Extreme weather (in particular - wind and ice)*

Strategic Goals

Pursue Operations Reliability

- Advance event readiness and response
- Implement and explore innovative resiliency solutions

Learnings

- **LiDAR acquisition:** was not designed for this use case - system parameters need better tuning (altitude, sensor strength) to identify all distribution poles and overhead wire.
- **Reliability Impact :** GridLab-D network model files show the impact of the contingencies on VEC's system based on analysis of LiDAR vegetation data

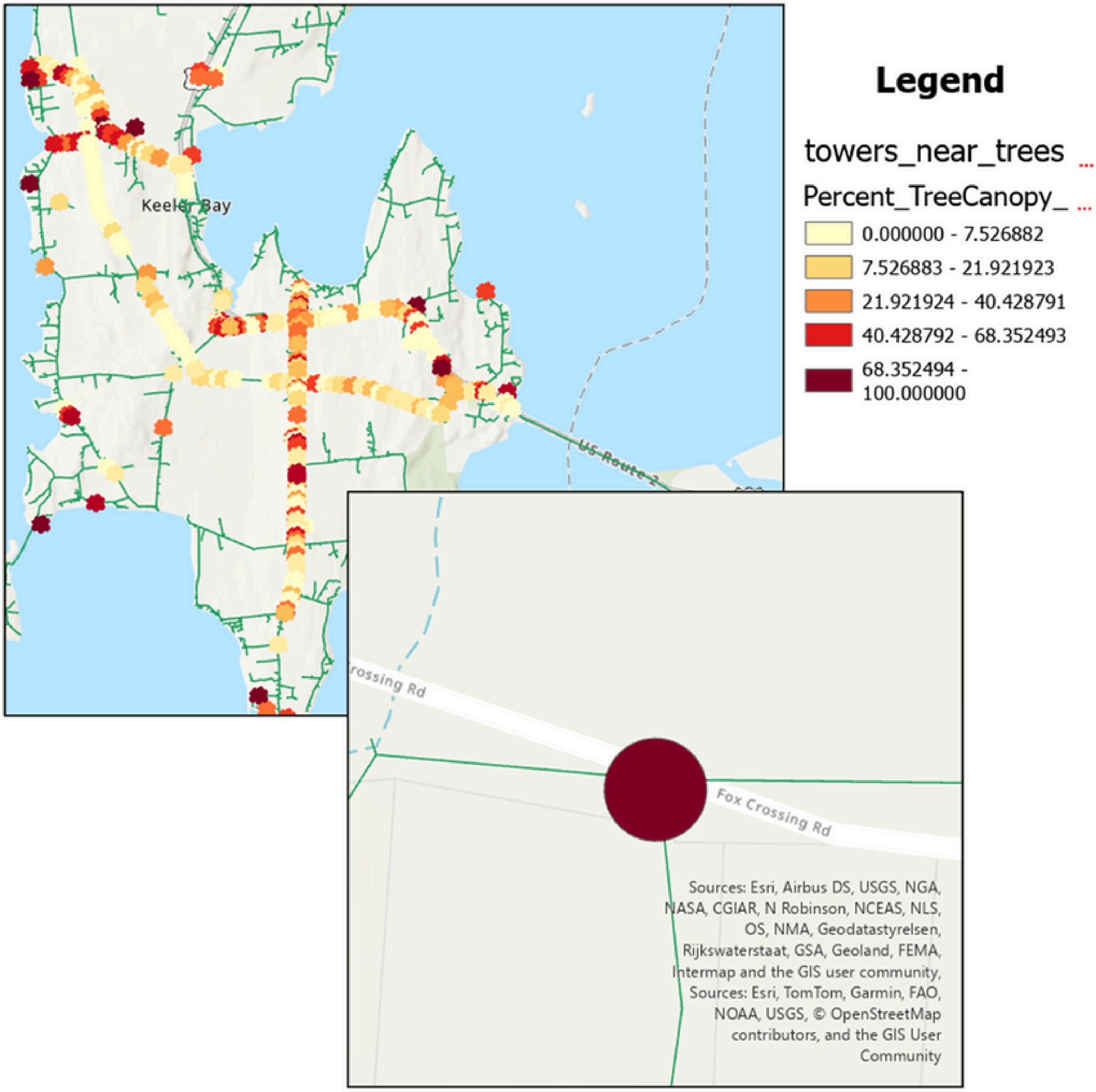
Next Steps

- Understand how to improve Lidar collection parameters for next statewide flyover
- Identify percentage of open space (parking lots/agricultural) by circuit to help inform contractor bids.
- Improve models with real world measurements such as EdgeZero sensor data
- Automate the data and modeling pipeline for next statewide LiDAR flight

VELCO | STOWE ELECTRIC DEPARTMENT | WEC Washington Electric CO-OP | GREEN MOUNTAIN POWER | University of Vermont | VERMONT ELECTRIC CO OP

Learnings Expanded

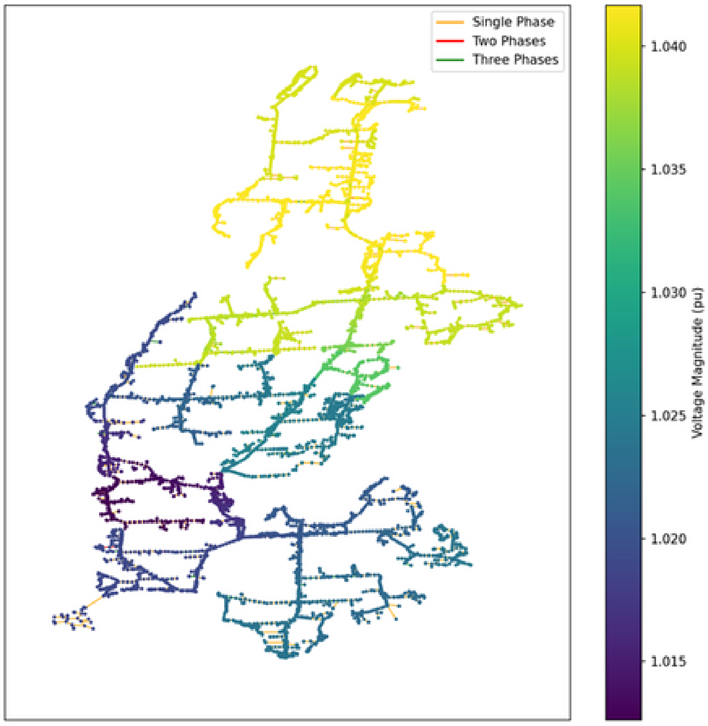
- The UVM Spatial Analysis Lab matched poles in GIS with percent tree cover in a 30ft radius.
- They then outputted a list of highest-risk spans based on this tree cover metric which can be automated be automated using ArcPy python package
- Images courtesy of UVM Spatial Analysis Lab

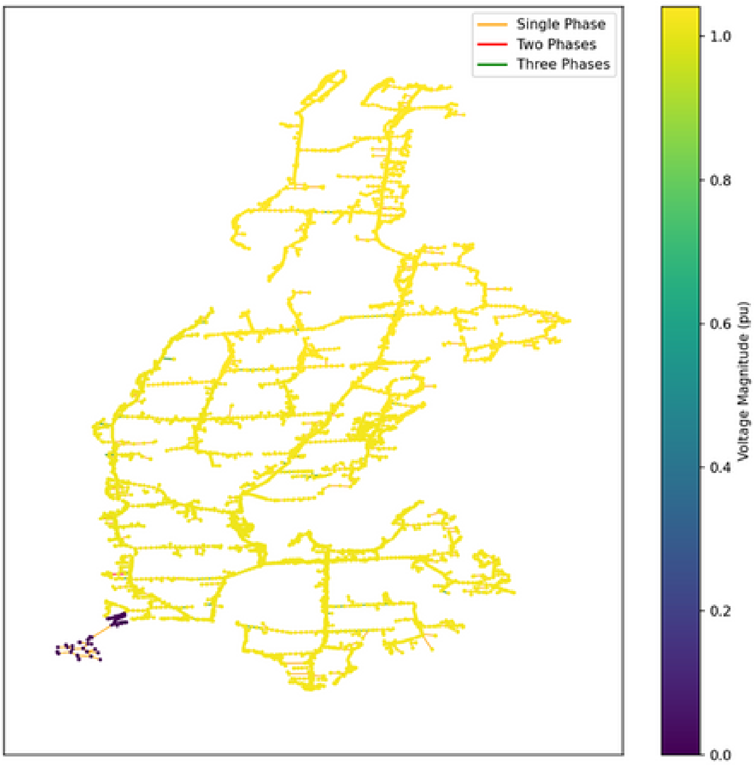


Learnings Expanded

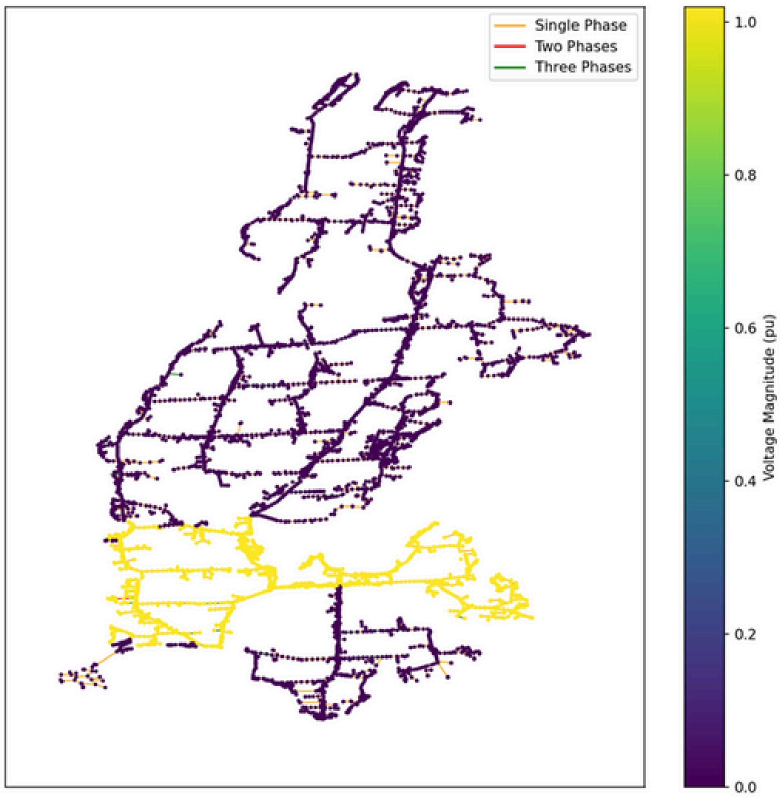
- Using GridLab-D and a Python script UVM CEMS identified upstream switches of high-risk spans using a NetworkX package. This opened upstream switches to simulate severe weather-based outages.
- Models were run for each contingency plotting voltages for the entire feeder
- Images courtesy of Peter Fisher, Alby Penney, Dakota Hamilton and UVM CREATE team.

Pre - Contingency No Faults





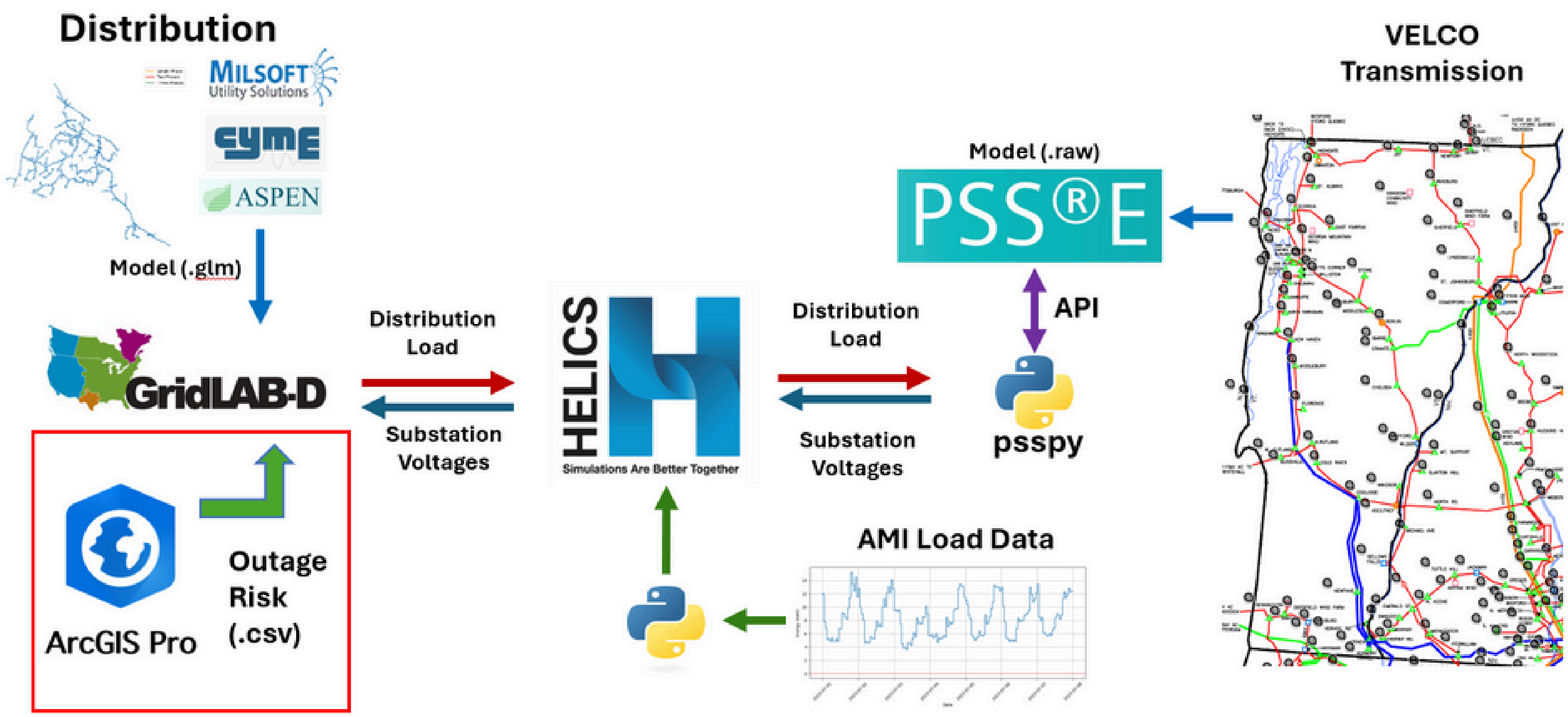
Single Line Fault

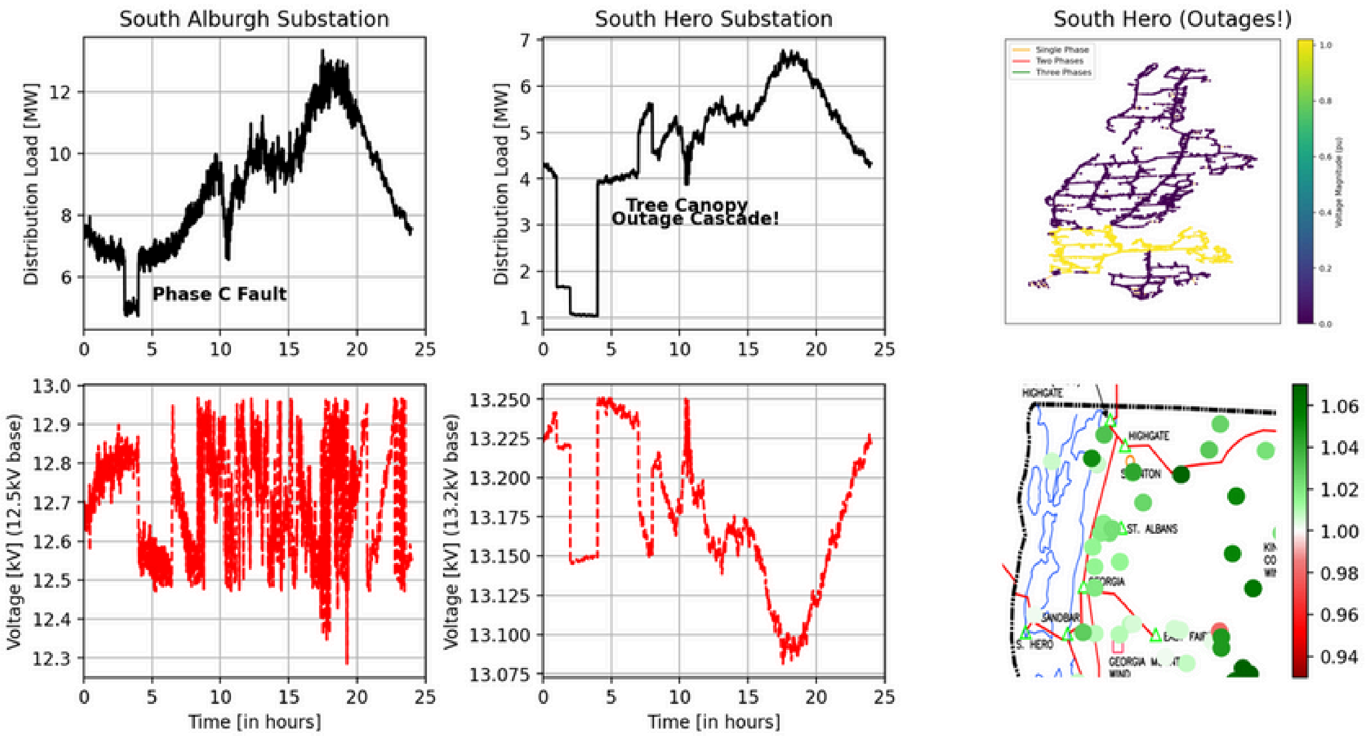


12 Line Faults

Learnings Expanded

- Using the T&D Co-simulation framework show below UVM was able to model the impact of distribution faults on the transmission system
- Images courtesy of Peter Fisher, Alby Penney, Dakota Hamilton and UVM CREATE team.





TPP : UVM Energysheds

Create tools to simulate the growth of DER and develop models that help communities make decisions

Office of Energy Efficiency and Renewable Energy

Thought Partnership Project Overview

1. Tool Development: Create tools to evaluate economic, environmental, and social trade-offs of energyshed characteristics.
2. Simulation Tools: Develop tools to understand Distributed Energy Resource (DER) development within energysheds.
3. Community Engagement: Provide a model for community decision support and broaden stakeholder participation in local energy systems.

Challenges Addressed

Electric Vehicles and Heat Pumps Growth

- *Many voltage constrained end of line locations, not suited for load growth*

Strategic Goals

Engage Members

- Reduce impacts of electrification on the grid
- Focus on energy equity

Learnings

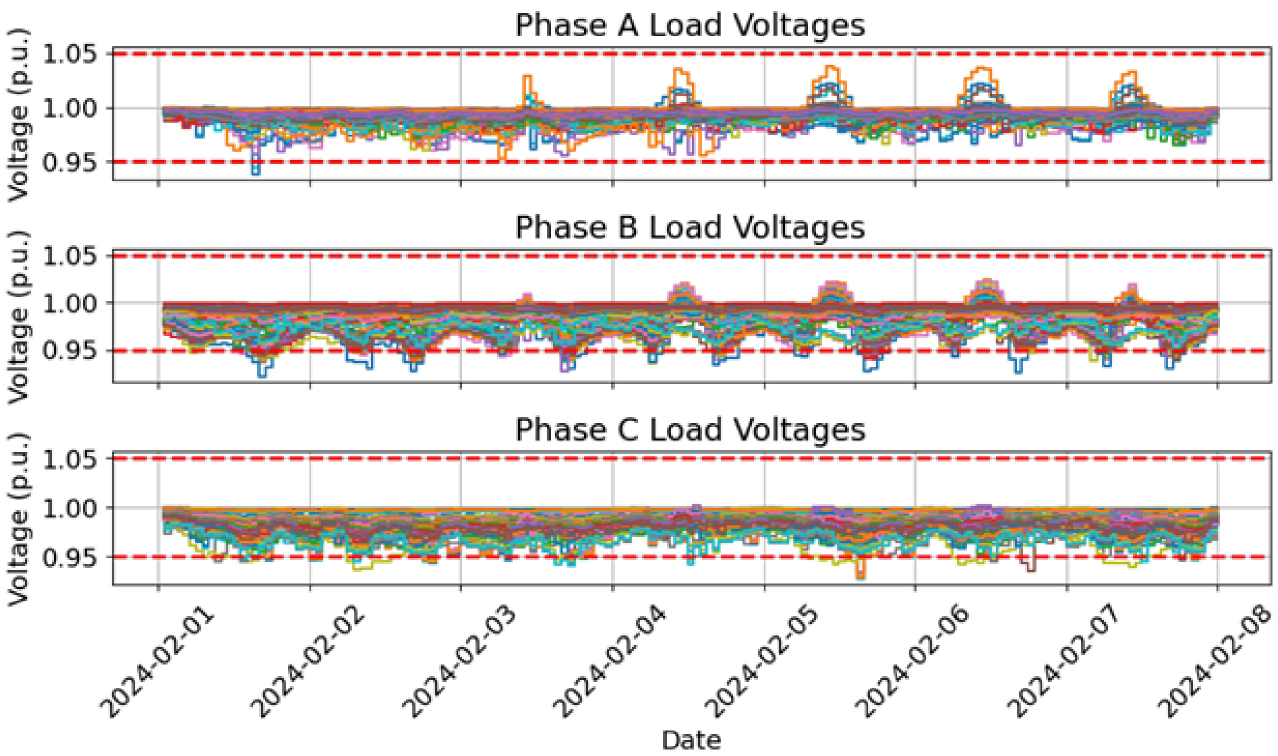
- **Co-simulation:** capabilities using VEC distribution feeders and VELCO transmission network will support future scenario analysis
- **Heat Pump Impact** : high adoption scenario shows minimal distribution transformer overloading but does indicate some low voltage violations on primary lines
- **Model Validation :** using EdgeZero sensors and SCADA data is needed

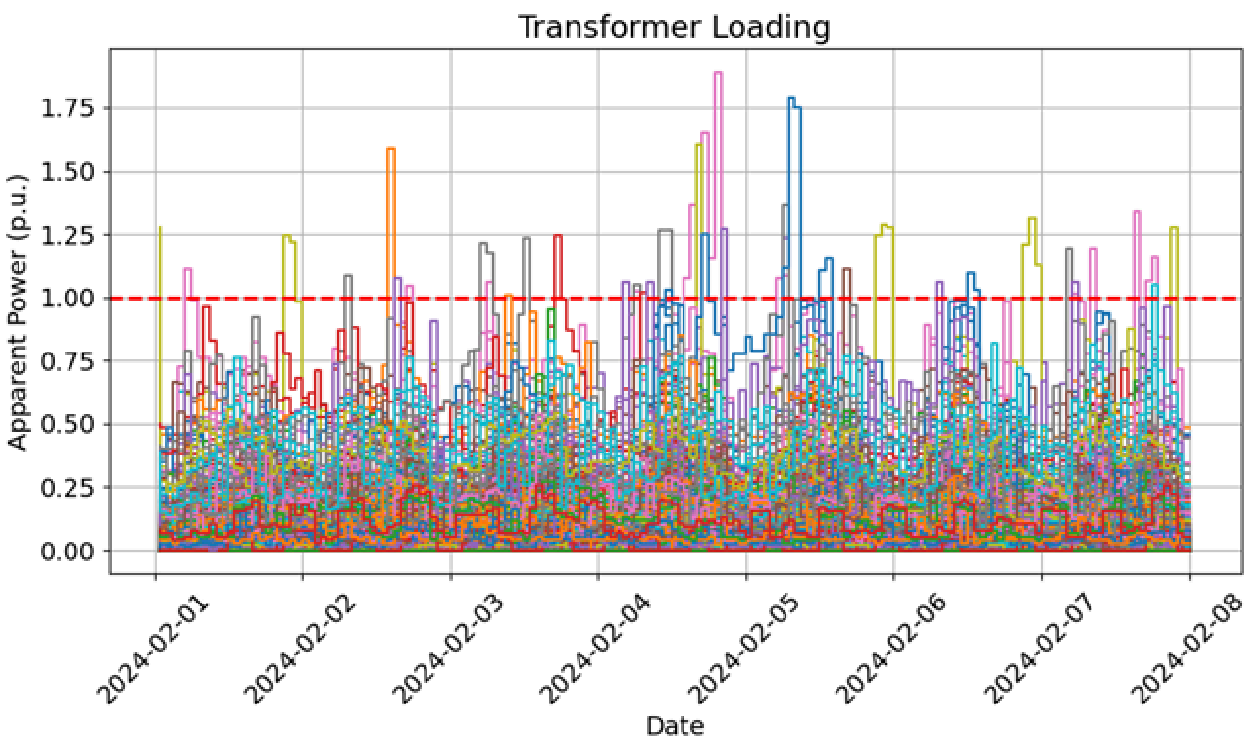
Next Steps

- Validation of GridLAB-D models against sensor data (SCADA, EdgeZero, GridMetrics)
- Extend tools to include other DU feeders (GMP, SED)
- Optimization on transmission side
- Review planning tool with stakeholders (Glover Energy Committee for VEC territory)

Learnings Expanded

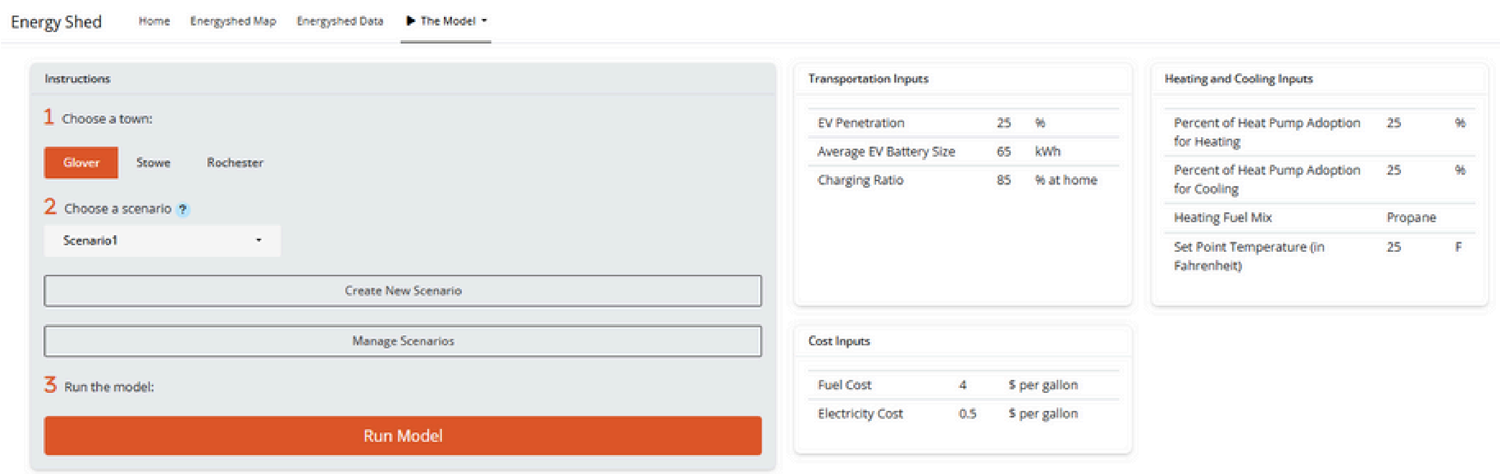
- High heat pump adoption scenario shows minimal distribution transformer overloading but does indicate some low voltage violations on primary lines. Charts below courtesy of Dakota Hamilton and UVM.

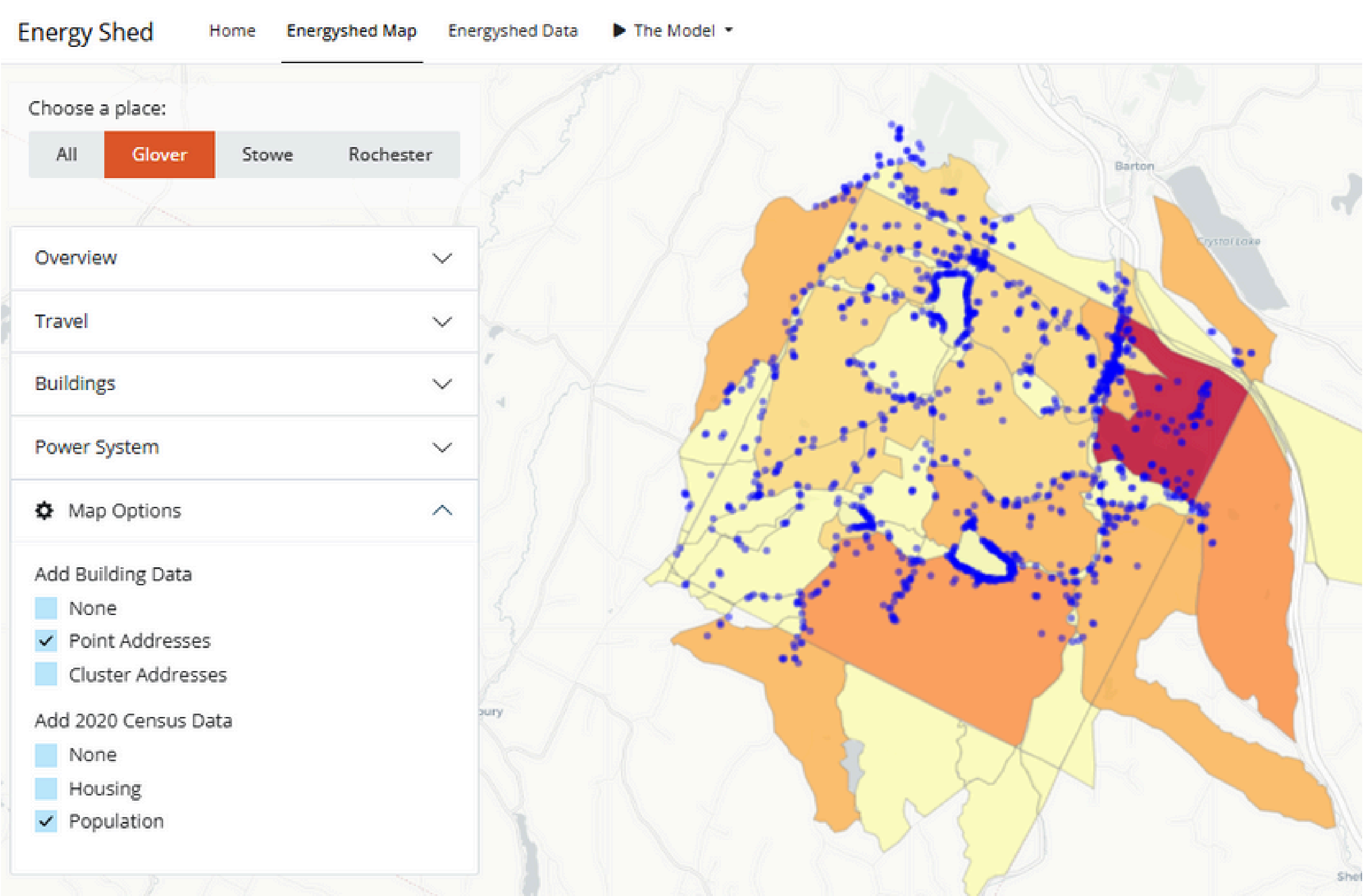




Learnings Expanded

- Data sharing from VEC and tools from UVM can help better inform town energy committees on the impacts of distributed generation and electrification to their towns. Images of tool below courtesy of Dakota Hamilton and UVM.





TPP : Camus Grid Optimized EV Management

Develop operating envelopes to shape electric vehicle load and prevent overloaded distribution transformers

Thought Partnership Project Overview

1. Leverage existing AMI data, GIS topology and connectivity, and weather forecasting to create a forecasted distribution transformer operating envelope.
2. Demonstrate if ChargePoint EVSE can be used to manage Electric Vehicles to this envelope. In addition explore value stacking with peak shaving.
3. Develop valuation for asset deferral and submit Vermont Innovation pilot filing.

Challenges Addressed

Electric Vehicles and Heat Pumps Growth

- *EV load growth impacting distribution transformers today.*

Strategic Goals

Engage Members

- Reduce impacts of electrification on the grid
- Expand and optimize VEC virtual power plant

Learnings

- **Forecast :** 32-hour ahead meter forecast critical for operation envelope generation given VEC's 24-36 hour delayed AMI data.
- **Curtailment :** Using a test EVSE location VEC and Camus were able to curtail to the envelope max power limit during all sessions and the DR event was executed successfully in conjunction with the envelope operations.
- **Valuation framework** : indicates a ~\$48-\$96 annual value in deferring a 10 kVA to 15kVA transformer upgrade for 10 years. Link

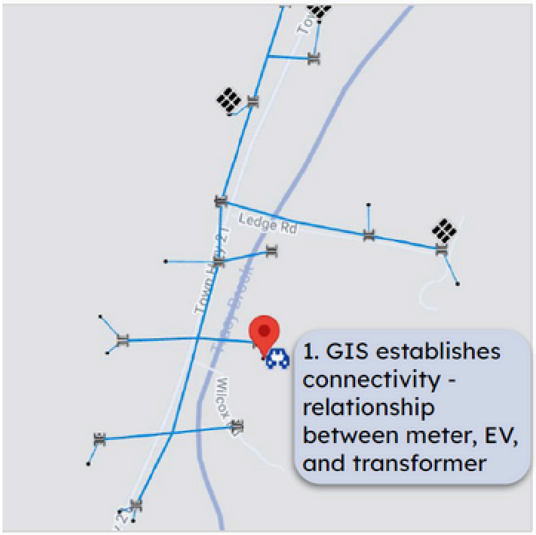
Next Steps

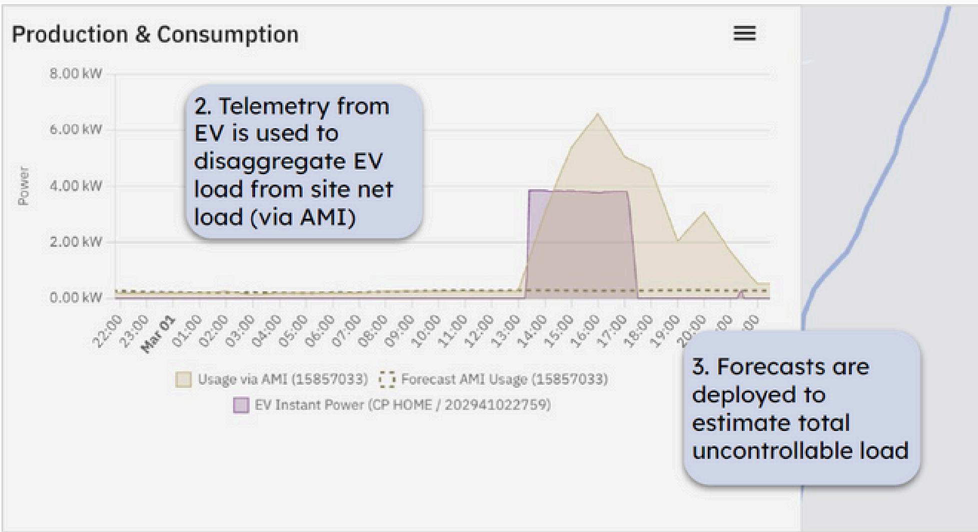
- Begin enrolling members with transformer overload issues in pilot program in 2025
- Expand DER device types to Emporia chargers and EV telematics.
- Leverage FlexEnergi EV telematics state of charge data to better inform EV management while under operating envelope.

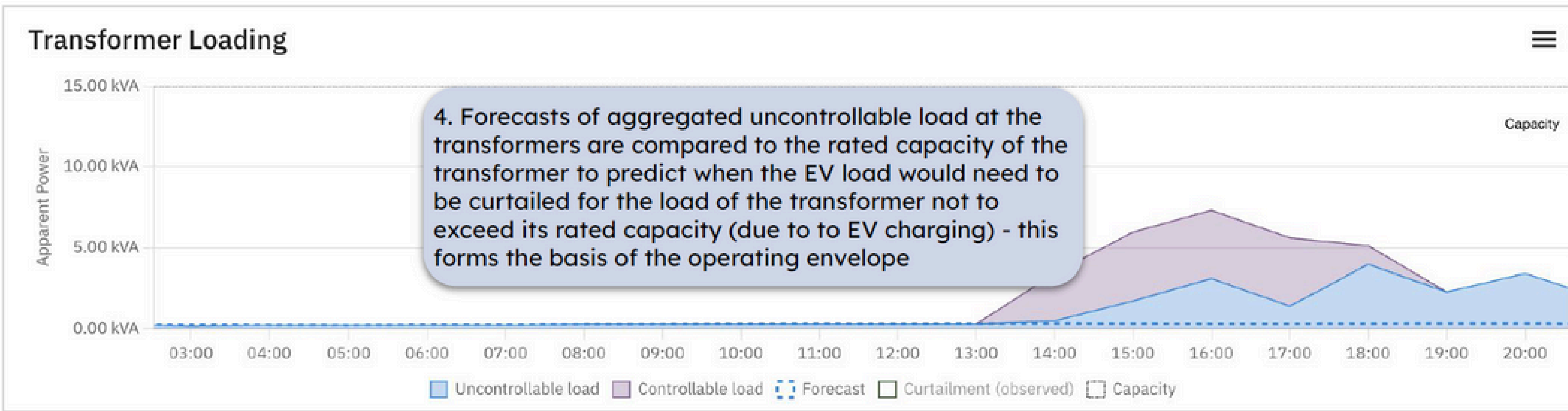
CAMUS VERMONT ELECTRIC CO OP

Learnings Expanded

Operating envelopes are derived based on (1) uncontrollable load forecasts and (2) comparison with rated capacity of upline devices, in this case a 10 kVA transformer.

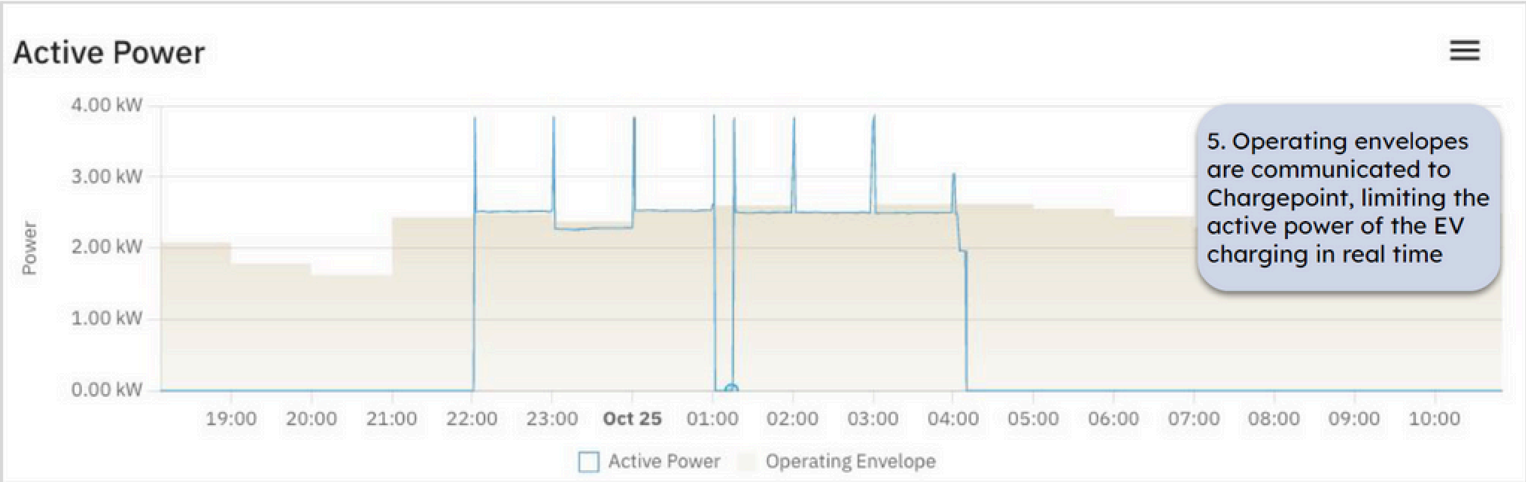






Learnings Expanded

- Below is a time series chart showing the combination of curtailment for compliance with operating envelopes and curtailment to 0kW for the scheduled DR event from 1-1:15AM



- While the particular test site did not have an overloaded transformer we were able to demonstrate a successful test of the operating envelope functionality and also ensure that a scheduled DR event would not conflict with management
- All charts and images courtesy of the Camus team with special thanks to Dylan Cutler, Emma Elgqvist and the development team,

TPP : Dynamic Organics Peak Forecasting

Leverage AI based forecasting tools to improve VEC's ability to accurately forecast peaks

---

Thought Partnership Project Overview

1. Transmission costs are rising as regional transmission owners replace aging assets making peak shaving more valuable than ever
2. Peaks are shifting into the morning hours due to a mix of high quantities of statewide flexible resources and VEC load growth
3. Predicting peaks is more difficult than ever and AI based tools are needed to maximize value of peak shaving resources

Challenges Addressed

Peak Forecasting Challenging

- Peak is shifting from evening to morning as GMP peak shaving assets continue to increase

Strategic Goals

Engage Members

- Reduce impacts of electrification on the grid
- Expand and optimize VEC virtual power plant

Learnings

- **Peak Forecasting Improvement :** AI based forecasting tools improve VEC's ability to accurately forecast peaks
- **Snow** cover on solar sites can have a significant impact on peak forecasting especially the day after large precipitation events.

Next Steps

- Explore how to account for GMP peak shaving actions as they are the primary driver of peak times.
- Expand data sharing to create models for solar sites in VEC's territory

Proposed 2025
Technology Partnership Projects

Project	Timeline
PNNL MAPLE ROOT *Identify challenges in implementing operating envelopes for DER management.*	2025-2026
DOE Key Assist Technical Assistance *Systemwide DER forecasting and modeling to identify electrification infrastructure impacts*	2025-2026
UVM FOREST *Develop generative AI tool to understand the value of DER flexibility*	2025
Elevate Transmission VPP *Explore how distribution DER can support transmission and the challenges they provide*	2025
UVM Rhizome Climate Modeling *Interactive visualizations of historical extreme weather trends, hazard intensity projections, and asset vulnerabilities*	2025

TPP : MAPLE ROOT

Identify challenges in implementing operating envelopes for DER management

U.S. Department of ENERGY

Office of Electricity (OE)
Sensors and Data Analytics

Thought Partnership Project Overview

1. Identify the challenges to creating dynamic operating envelopes for DER. Group challenges by asset classes
2. Identify the following for each asset class
    a. Data requirements (AMI, sensor data, timescales which may be different timescale requirements for distribution and transmission)
    b. Gaps in operator trust
    c. Gather information from other utilities

Challenges Addressed

Non-Wires Alternatives Are Untested

- *Limited tested and trusted alternatives to traditional T&D investment*

Strategic Goals

Engage Members

- Reduce impacts of electrification on the grid
- Expand and optimize VEC virtual power plant

Project begins in 2025

VELCO PNNL OAK RIDGE National Laboratory University of Vermont VERMONT ELECTRIC CO OP

TPP : DOE Key Assist Technical Assistance

Systemwide DER forecasting and modeling to identify electrification infrastructure impacts

U.S. Department of ENERGY

Office of Energy Efficiency & Renewable Energy

Thought Partnership Project Overview

1. Utilize learnings of MAPLE BRANCH and LEAF to develop a system wide temporally and spatially granular DER forecast
2. Leverage forecast to understand impacts to distribution infrastructure and identify thermal and transient violations
3. Identify how this forecast can be leveraged by VELCO in the next Long Range Plan

Challenges Addressed

Electric Vehicles and Heat Pumps Growth

- *EV load growth impacting distribution transformers today.*

Strategic Goals

Engage Members

- Reduce impacts of electrification on the grid

Orchestrate Distributed Renewable Energy

- Reduce impacts of generation (voltage and load power factor)

Project begins in 2025

VERMONT ELECTRIC CO OP

PNNL

VELCO

TPP : UVM FOREST

Develop generative AI tool to understand the value of DER flexibility

University of Vermont

Leahy Institute for Rural Partnerships

Thought Partnership Project Overview

1. Utilize learnings of MAPLE LEAF, UVM SOLVER, and UVM Energyshed to develop a system wide temporally and spatially granular DER forecast
2. Identify the value of reducing T&D investment by leveraging flexibility through DER management
3. Explore how generative AI can be integrated into network modeling tools

Challenges Addressed

Non-Wires Alternatives Are Untested

- *Limited tested and trusted alternatives to traditional T&D investment*

Strategic Goals

Engage Members

- Reduce impacts of electrification on the grid
- Expand and optimize VEC virtual power plant

Project begins in 2025

University of Vermont

VERMONT ELECTRIC CO OP

VELCO

TPP : Elevate Transmission VPP

Explore how distribution DER can support transmission and the challenges they provide

Thought Partnership Project Overview

1. Can actively managed/controlled DERs a VEC hosted VPP support transmission congestion management?
2. Can a much more actively controlled distribution system used to alleviate transmission congestion result in unexpected distribution congestion?
3. If DERs are dispatched around network constraints, how does this affect distribution and transmission level congestion?

Challenges Addressed

Non-Wires Alternatives Are Untested

- *Limited tested and trusted alternatives to traditional T&D investment*

Strategic Goals

Engage Members

- Reduce impacts of electrification on the grid (minimize or eliminate the need for costly transmission upgrades
- Expand and optimize VEC virtual power plant

Project begins in 2025

ELEVATE ENERGY CONSULTING encoord VERMONT ELECTRIC CO OP VELCO

TPP : Rhizome Climate Modeling

Interactive visualizations of historical extreme weather trends, hazard intensity projections, and asset vulnerabilities

Thought Partnership Project Overview

1. Historical extreme weather trends in graphs and charts along with hazard intensity projections for thresholds at various decades.
2. Asset vulnerability per asset class and hazard
3. Interactive visualizations of hazards and asset vulnerabilities

Challenges Addressed

Outage Quantity and Duration Increasing

- *Extreme weather (in particular – wind and ice)*

Strategic Goals

Pursue Operations Reliability

- Prioritize resiliency in investments
- Implement and explore innovative resiliency solutions

Project begins in 2025

RHIZOME