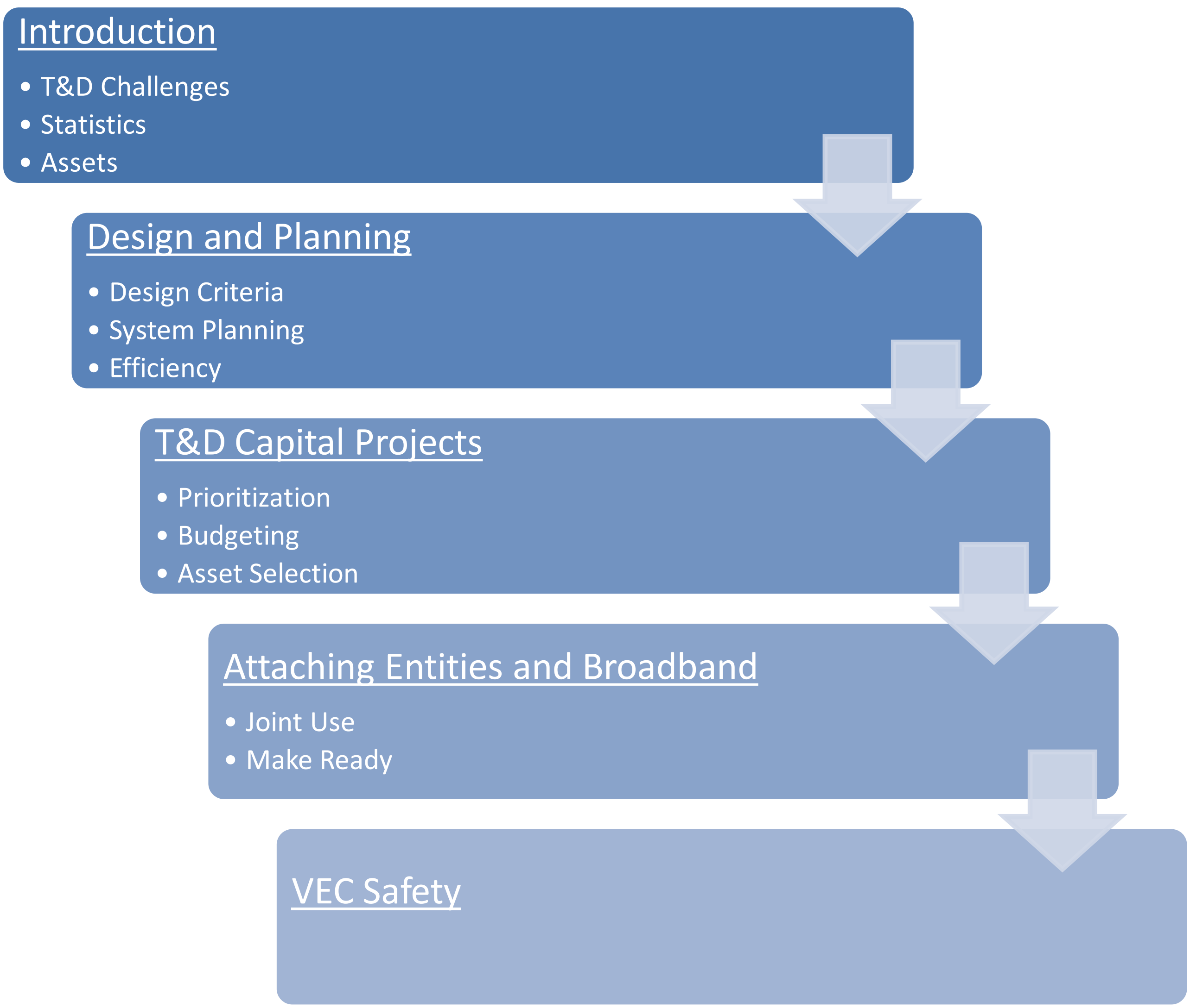
# 8 Assessment of Transmission and Distribution System

## 8.1 Introduction

This section of the IRP contains an overview of VEC's Transmission and Distribution (T&D) philosophies as well as an overview of VEC's safety program. With growing consumer expectations, renewable proliferation, and regulatory policy and incentives driving significant changes to the electrical grid, it is becoming increasingly challenging to ensure that VEC is providing the least cost of service while maintaining a high level of safety and reliability. This plan addresses these challenges and corresponding opportunities.

### 8.1.1 General Overview



### 8.1.2 Statistics

| | |
|---|---|
| Services per Mile of Line | ***~16 per Mile*** |
| Meters | ***39,963*** |
| Peak Load | ***87.55 MW (01/02/2014)*** |
| Distribution Poles | ***55,263*** |
| Primary Distribution Overhead Line Miles | ***~2,438 miles*** |
| • Single Phase | ***~1,996 miles (82%)*** |
| • Two Phase | ***~39 miles*** |
| • Three Phase | ***~403 miles*** |
| Primary Distribution Underground Conductor | ***~303 miles*** |
| Equipment (Reclosers, Sectionalizers) | ***~450*** |
| Line Regulators and Capacitors | ***115, 117*** |
| Transformers | ***~21,000 (Pole mount), ~3,200 (Padmount)*** |
| Transmission Poles | ***2,575*** |
| Transmission Line Miles | ***136 Miles*** |
| Substations | ***35 (Distribution), 2 (Transmission)*** |
| Metering Points | ***3 (All with GMP)*** |
| VEC Owned Fiber Optic Cable | ***63 Miles*** |

*Table 8.1.2.A VEC T&D statistics as of 01/01/2022*

## 8.1.3 Assets

VEC is a rural electric cooperative utility consisting of legacy Citizens and VEC assets. VEC's mission is to provide safe, affordable, and reliable power to all its members. However, its network of poles, wires, and assets poses unique challenges. Unlike many rural electric cooperatives in the country, VEC is not currently a RUS borrower. However, because it had been a RUS borrower prior to bankruptcy in 1995, parts of its distribution system were built to RUS standards. The legacy Citizens assets, on the other hand, did not follow RUS standards and as a result, it has been a continual challenge, since the acquisition in 2004, to merge and standardize the two electrical systems.

VEC's assets consists of following categories:

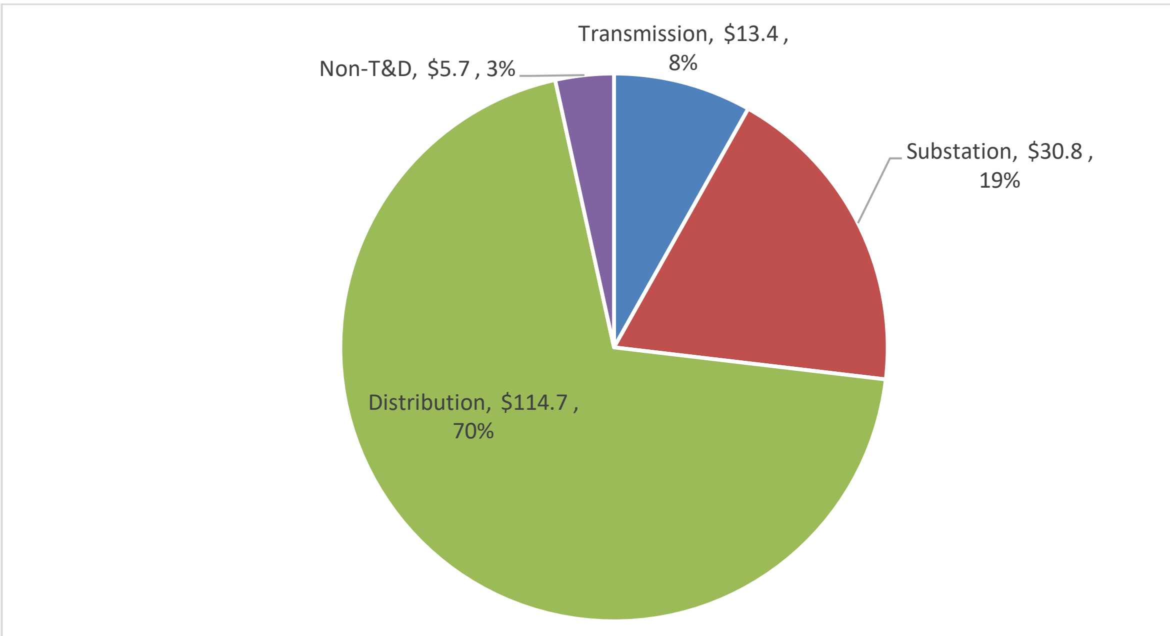



*Figure 8.1.3.A VEC assets (in millions)*

The largest category,VEC's distribution system assets, can be further broken into the following areas:

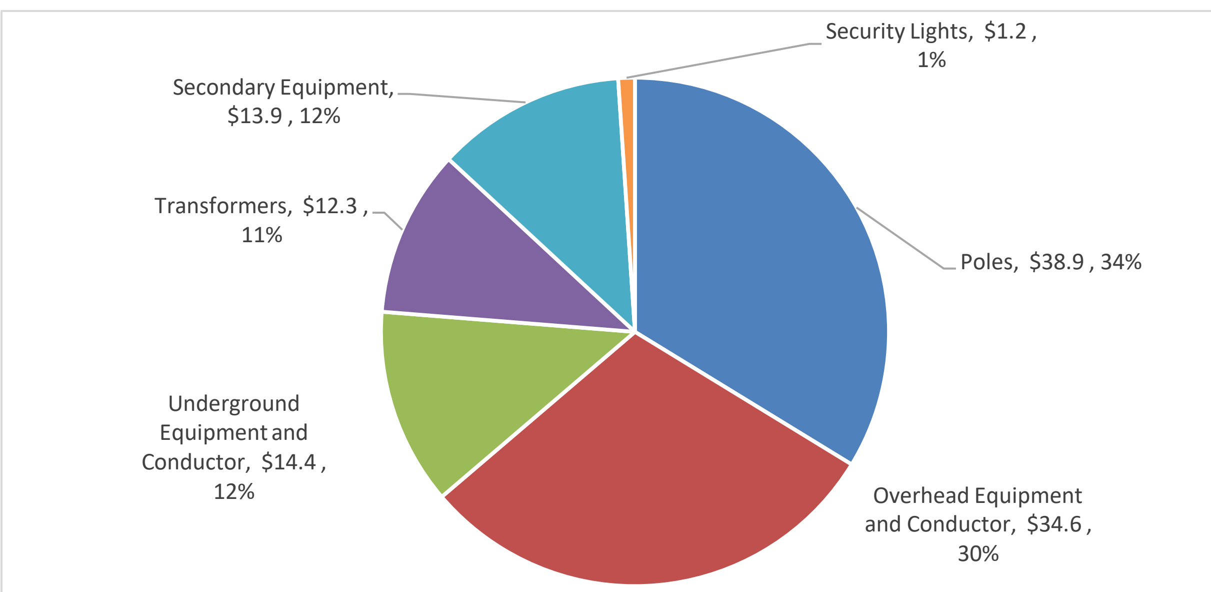



*Figure 8.1.3.B Distribution assets by sub-category (in millions)*

Feeding power to this distribution system, VEC owns and maintains a subtransmission network that stretches from Canaan to the Islands of Alburgh and South Hero. VEC's transmission network is long, predominantly rural, and represents roughly eight percent of total assets. The remaining 19 percent of assets are within VEC's 40 distribution substations, transmission substations, and primary metering points.

## 8.2 Design and Planning Philosophies

### 8.2.1 Design Criteria

VEC conducts distribution planning to ensure it can deliver power safely and reliably with a focus on voltage performance adhering to ANSI Standard C84.1. VEC developed criteria detailing these planning requirements. These criteria ensure both the adequate performance of the power system and the safety of those working on the system. More detailed information regarding VEC's distribution criteria is available in Appendix - A.

#### Distribution

VEC's standard distribution system voltage is 12.47 kV/7.2 kV grounded wye. In some areas, VEC also utilizes 34.5 kV/19.9 kV distribution voltage. VEC operates approximately 85 miles of 4.16 kV/2.4 kV grounded wye lines; however, we are steadily converting these voltages to the standard 12.47 kV/7.2 kV grounded wye.

#### Transmission

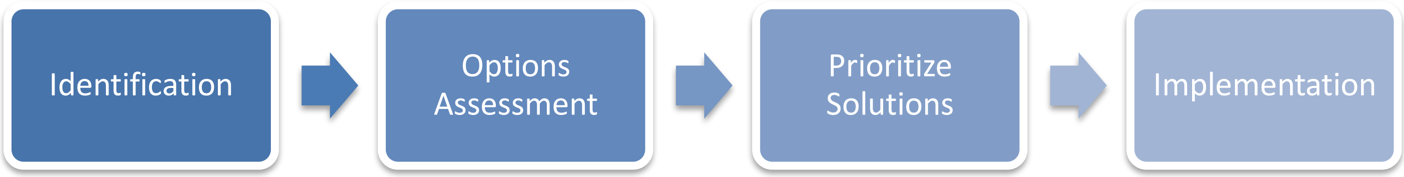
VEC's standard subtransmission voltages are 34.5 kV and 46 kV. VEC transmits power from VELCO, GMP, Eversource and Hydro Quebec on its subtransmission system to its distribution substations and large industrial members. VEC strives for "N-1" planning criteria for all looped transmission lines and radial transmission lines. The term N-1 refers to the ability to continue serving uninterrupted power even if we have an equipment or line failure. "N" is the total number of components that the system relies on to operate properly. The number subtracted from N is the number of components that can fail but power is still able to be served in a given scenario. Therefore, N-1 means that only one component has failed but the system is still functional. N-1-1 means that two components have failed, which is generally worse than having only one fail. To achieve N-1 on radial transmission lines, VEC looks for feeder backup opportunities.

More detailed information regarding VEC's transmission criteria is available in Appendix - A.

### 8.2.2 System Planning

To provide the least cost solution while monitoring efficiency, enhancing reliability, and allowing for growth, VEC approaches system planning as a balance between day-to-day analyses and longer-range holistic reviews of the system.

While the timing for day-to-day analysis and overall system reviews are different, VEC uses a similar process for both categories:




- **Identification** – Examination and definition of project/area versus design criteria, which will provide triggers for further review.
- **Options Assessment** – Detailed analysis via software tools and data to solve problems identified. Proposed solutions are developed using engineering calculations, cost/benefit analysis, or power load flow simulations, as required.
- **Prioritize Solutions** – Least cost, most feasible, and most reliable solutions are recommended. Projects are prioritized, timelines are established, and detailed cost estimates are developed and proposed for capital budget inclusion.
- **Implementation** -- Once approvals are secured, projects are scheduled, constructed, and closed out.

## Distribution System Planning

VEC has 38 distribution substations and primary metering points that supply 74 distribution circuits. Distribution system planning is broken up into four general categories:

- Forecasting (load and generation)
- Power Flow Analysis (peak capacity, contingency, ampacity)
- Power Quality Analysis (voltage analysis)
- Fault Analysis (protection and coordination)

VEC performs various studies to address these four categories that are described in further detail below:

### System Load and Voltage Study (SLVS)

VEC completes the SLVS annually. The study reviews all VEC's 74 distribution circuits via equipment loading, voltage performance, and phase load balancing design criteria. VEC utilizes Supervisory Control and Data Acquisition (SCADA), Automated Metering Infrastructure (AMI) data, and Milsoft WindMil model to identify system constraints and appropriate solutions. VEC completes this system-wide study annually to identify constraints up to five years from the study completion. Given the substantial increase in distributed generation and increased load through beneficial electrification initiatives (e.g., electric vehicles and heat pumps), planning outside the five-year horizon is more uncertain than it ever has been. The report includes the following analysis tasks:

- Peak loads for each substation.
- Percent unbalance of the phase amps at the substation low side bus.
- Any substation or distribution equipment that is overloaded.
- Any single-phase circuits that are loaded greater than 288 kVA (40 amps at 7.2 kV)
- Any circuit elements experiencing voltage outside of 0.95-1.05 per unit.
- Any distribution circuits with greater than two percent voltage unbalance.
- Solutions to any criteria violations.

### 4.900 Reliability Report

Public Utility Commission (PUC) Rule 4.900 requires that VEC file a 4.900 Reliability Report annually. This report contains a detailed assessment of VEC's outage performance and a plan for how to improve reliability to its members. Target reliability metrics used in the report are defined via VEC's Service Quality and Reliability Plan (SQRP) approved by the PUC. Through this analysis, VEC identifies its top 10 worst performing circuits. VEC rates its top ten worst performers, prioritizing by the number of outage events first then customer hours out. VEC reviews these worst performers based on type and location of the outages to develop projects to mitigate these outages in the future.

### Transmission and Sub-Transmission System Planning

VEC coordinates with other Vermont utilities to ensure reliable electric service to VEC's members and the customers of other utilities fed from VEC's sub transmission facilities. These Vermont utilities include Green Mountain Power and the villages of Barton, Orleans, Swanton, and Enosburg.

In addition, VEC works very closely with VELCO, Vermont's transmission operator, to provide analysis and collaboration on system improvements. VELCO in turn works with New England's regional electric grid operator, ISONE England (ISONE).

In addition, VEC is a member of the Vermont System Planning Committee (VSPC) and brings forward all reliability issues at the substation and transmission level to determine whether a potential resolution exists to the issue considering energy efficiency, demand response and distributed generation, or a hybrid of transmission and non-transmission solutions.

If the project is eligible via either the Docket 7081 VSPC Non-Transmission Alternatives Screening or the Docket 6290 Screening tool, the VSPC and VEC will work together to identify solutions. All the electric utilities in Vermont complete this screening on an annual basis.

VEC anticipates that energy transformation will result in load growth but through load management we hope to defer or eliminate system upgrades altogether. As a result, most of the projects that are reviewed via Dockets 7081 and 6290 are categorized as either asset management or reliability improvement projects.

## 8.2.3 Efficiency

### 2021 VEC Loss Study

VEC completed a loss study in August of 2021. Power loss values for VEC's solely owned subtransmission and distribution system as a percentage of total load were found to be approximately 1.8 percent for the transmission and 3.6 percent for the distribution and within the national averages for all electric utilities per the 2012 EPRI document titled, "Assessment of Transmission and Distribution Losses in New York State".

| | | Annual Load (MWH) | Annual Losses Estimated (MWH) | % losses of MWH load |
|---|---|---|---|---|
| Distribution (VEC) | | 418960 | **14873** | **3.6** |
| Transmission (VELCO) | | 393213 | **7122** | **1.8** |

VEC's financial system power losses are derived by comparing ISONE's load settlement of VEC's monthly power purchases to VEC's metering software tabulation of kWH's sold that month. For 2018, the focus of this 2021 loss study, financial power losses were approximately seven percent.  The bulk power transmission losses from the various ISONE's 'inlet' revenue meters to VEC's sole owned power system can be estimated by subtracting the total VEC system loss study results of 5.4 percent from 7 percent equaling 1.6 percent.  The 2012 EPRI study found that on a national basis, distribution losses ranged from 1.9 to 4.6 percent and transmission system losses ranged from 1.5 to 5.8 percent, further validating the reasonableness of the VEC loss study results.

While there are some approaches to loss reduction that can be applied system-wide, such as load balancing and power-factor correction, most efficiency improvements are evaluated on a case-by-case basis.

The two main areas that utilities focus on to reduce losses are (1) replacing existing infrastructure and (2) changing design and planning criteria for future infrastructure investments to improve efficiency. The cost to replace existing infrastructure can be high compared to the cost savings through loss reduction; however, the incremental cost to build higher efficiencies into future capital projects could be low compared to efficiency gains.

Based on the work performed by the New York utilities, EPRI, and SAIC, as well as their reviews of other industry studies, electric losses can be reduced by system improvements on the distribution system. Generic or case-specific cost/benefit analysis is required to justify required expenditure for these system improvements.

**Efficiency Improvements**

- Phase balancing – rearranging loads on each phase of the circuit to reduce residual flows.
- Reactive power optimization – additional capacitor banks or altered switching scheme.
- Voltage upgrades.
- Conservation voltage reduction – intentional lowering of distribution circuit voltage within allowed ANSI range.
- Reconductoring replacing selected conductor sections with larger, lower-resistance conductors
- High-efficiency line transformers – replacing lower-efficiency line transformers with higher-efficiency transformers.

## Phase Balancing

To achieve an efficient distribution system network, VEC developed the following design criteria for distribution line loading and voltage:

- Three-phase distribution line voltage shall be less than two percent unbalanced.
- The substation low side bus phase currents shall be not more than 20 percent unbalanced.
- Engineering model predicting loading shall not exceed 40 Amps on 7.2/12.47 kV single-phase taps per RUS Bulletin 1724D-101B and 1724D-101A. More detailed information regarding VEC's distribution criteria is available in Appendix-A.

Balancing load between phases improves the efficiency and operability of the distribution circuits. Balancing phase loading helps to keep voltage balanced and creates a better foundation for voltage regulation on long single-phase taps and to three-phase customers. A balanced system also reduces neutral current on three-phase lines, leading to a reduction in losses.

VEC aims to reduce the number of large radial single-phase lines to more easily manage the system from a load balancing perspective. Having multiple phases also improves VEC's ability to serve new load by freeing up capacity and improving system voltage through reducing high single-phase line loading.

## Power Factor

Power factor is the ratio between the real power and apparent power. A common analogy that is used is a mug of beer. The beer has some liquid (real power or watts) and foam (reactive power or VARs). The whole mug is the apparent power (kVA).

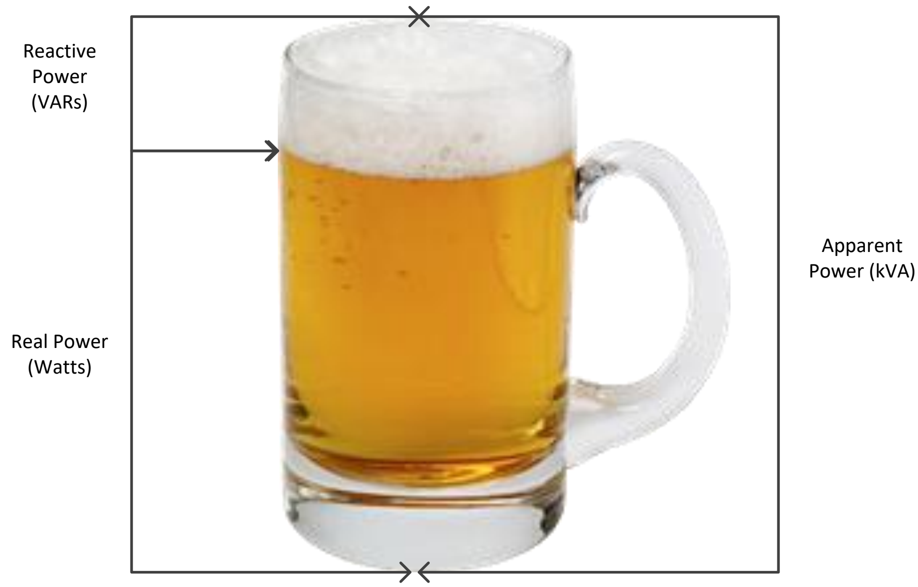



*Table 8.2.3.A Beer mug power factor analogy*

VEC only bills for the liquid, which turns the meter. The foam is necessary to maintain voltage. That reactive power needs to come from somewhere, ideally as close as possible to where the real power is being used.

Regarding the VEC system, VEC is striving to maintain a power factor at or above 0.95 lagging and equal to or less than unity. To meet this goal, VEC measures the power factor at each of its substations. Using this information, VEC ensures that the system is operating as efficiently as reasonably possible. When appropriate, VEC may require that power factor correction equipment be paid for and installed by the member. The revenue meter for commercial accounts measures power factor for those services.

In addition, ISONE and VELCO require VEC to maintain a power factor of between 0.95 lagging and unity for all its primary metering points with other utilities. Commercial accounts are also required to meet a power factor value between 0.95 lagging and unity.

Typically, VEC achieves power factor correction using fixed capacitors on the distribution circuits. By placing the capacitors on the distribution circuits where the VARs (Volt Amperes Reactive, i.e., reactive power) are needed, we avoid excess current across the distribution lines, thus reducing losses. Placing capacitors on the distribution system also affects system voltage, and we take these effects into account. Fixed capacitors are a relatively inexpensive solution for voltage support and often also provide the necessary VAR support that the load requires.

In some cases, voltage support is required but the VARs are not, which can cause leading power factors and line losses. In these instances, a voltage regulator may be the appropriate solution. Voltage regulators are more expensive and require periodic maintenance to function properly. Increased conductor sizes, voltage conversions to higher voltages, and the addition of multiple phases to help balance loads and reduce phase line currents may also be required.

VEC continues to review alternative methods of improving system voltage such as adding voltage regulators and installing larger (to reduce resistivity) wire to reduce voltage drop on its long radial lines. VEC completes this analysis on an annual basis as part of the System Load and Voltage Study. The goal is to find a balance between low losses, affordability, and system operability.

### Voltage Upgrades

Per VEC's Design Criteria, voltage performance must meet ANSI standard C84.1. Basic Criteria include:

- System voltage equal or above 114 V (0.95 per unit) and equal or below 126 V (1.05 p.u.),
- Target consumer voltage at the meter is 12 0V +/- 5% (114 V – 126 V), and
- Conductors below normal ampacity rating (< 1 p.u.), and
- Equipment below normal ampacity rating (< 1 p.u.).

While VEC attempts to analyze the system each time a new project is added and every three years, these proactive efforts do not guarantee acceptable power quality for all VEC's members. VEC prioritizes power quality complaints and investigates them immediately. VEC gives high priority to power quality incidents that require capital improvements.

## 8.2.4 Voltage Regulation

All VEC's electric substations employ bus voltage regulation as opposed to feeder or individual line voltage regulation. This reduces capital costs and maintenance costs by minimizing the number of voltage regulators on the system. Generally, we set a base voltage set point, bandwidth, and time delay. These settings are to keep the load within acceptable range and to minimize regulator switching and mechanical degradation.

The VEC system has many relatively long single-phase distribution feeders with sparse loading per mile and small conductors. During peak times, we need to boost bus voltage to stay within acceptable range further out on the feeders.

### Conservation Voltage Reduction (CVR)

VEC has reviewed the potential costs and benefits of implementing a Conservation Voltage Reduction (CVR) program but has no immediate plans to install this on its system. CVR lowers the voltage during high resistive load times to conserve energy. By lowering the voltage to a resistive load such as an incandescent light bulb, the current would also be reduced proportionately, hence decreasing losses and costs.

Motors and pumps require constant power, so if the voltage is reduced, the motor draws more current to maintain the same amount of power output (Power = Voltage x Amperage). This can make regulating the line voltage more difficult: if we were to lower the bus voltage, the line current may increase leading to further voltage drops and causing the end of line voltages to be below an acceptable range.

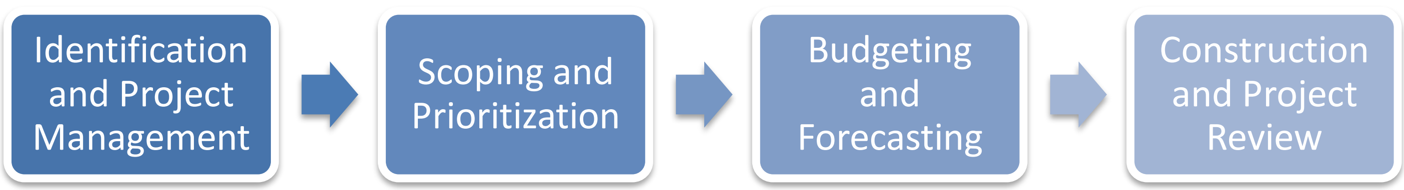
In recent years, due to efficiency programs in Vermont, lower watt alternatives such as Compact Fluorescent Lamps (CFLs) and Light Emitting Diodes (LEDs) have displaced resistive lighting load. Both alternatives draw almost constant power across their allowable voltage range. This displacement has made CVR less effective at conserving energy than in the past when incandescent lighting accounted for nearly 80 percent of residential service loading.

VEC employs voltage regulator load compensation settings in some circumstances to mitigate the impact of larger solar generation projects located further from the substation that generate the most during times of low feeder loads. Load compensation settings set the bus voltage to a lower voltage during low load times and increase the bus voltage as the load increases. The low bus voltage during low loads and peak generation tends to keep the line voltages within tolerance for all the feeders out of the substation. These settings would be determined by the project's system impact study and due to the location on the feeder, the conductor size, generation capacity, and associated voltage rise from the generator as the current travels to the load that appears further from the source than during peak feeder loading.

## 8.3 T&D Capital Projects

### 8.3.1 T&D Capital Project Process

Any project over $20,000 is specifically identified in VEC's capital project process. VEC manages around 1,000 other projects such as line extensions, increase in capacities, and minor equipment replacements within annual buckets. These projects still follow the same work management process but are not identified individually during the budgeting process.




#### Identification and Project Management

T&D capital projects are identified from studies performed by VEC engineers, maintenance procedures performed by VEC line and substation crews, and outside entities such VAOT or other electrical utilities. All T&D projects are tracked in a SharePoint database with identifying attributes.

Once a project is identified a Project Manager will be assigned. Typically, this is an Operation Supervisor for T&D projects or a System Engineer for Substation projects. In addition, VEC will plan out projects two to three years in advance of construction and uses its NISC CIS Work Management System to manage project status:

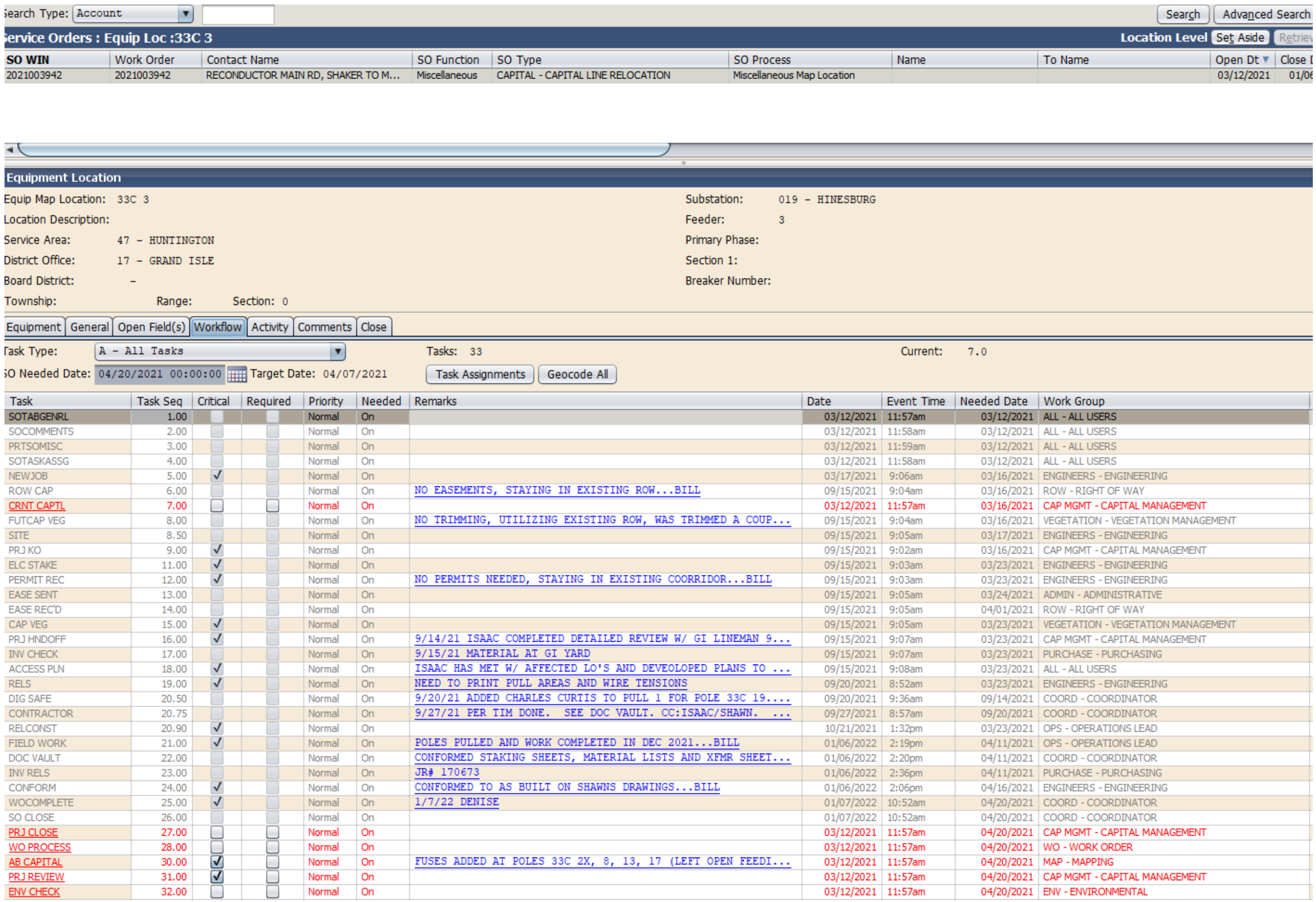



*Figure 8.3.1.A VEC Work Management System*

This system allows all project managers and stakeholders to see the current project status, add tasks and receive notifications. In addition, project folders are utilized for project scoping documents, landowner identification, and other project documents.

## Scoping and Prioritization

Each project receives a detailed scope which identifies construction types, line relocations, reliability impacts, and future costs impacts.

Each project also receives a prioritization number which VEC updates annually. The prioritization process takes into consideration components such as economic payback, impact to reliability, number of members, size of loads, efficiency, and safety considerations. The process is as follows for all projects:

- VEC enters each project into an internal VEC database and places it through the prioritization process.
- Reviews occur with the appropriate stakeholders involved in the project (Engineering and Operations) and an overall value is assigned to each project. These reviews include:
  - A discussion of impacted stakeholders (landowners, attaching entities etc.)
  - Alternatives to the project (overhead versus underground, relocations, retirements)

- A capital budget target is developed, and projects are chosen based on their ranking, resource planning, and time constraints. For instance, some projects may require permitting or easement acquisition. In other cases, there may not be adequate internal resources available to accomplish the work.

A chart of the ranking scheme is provided below along with an explanation of each metric and adder.

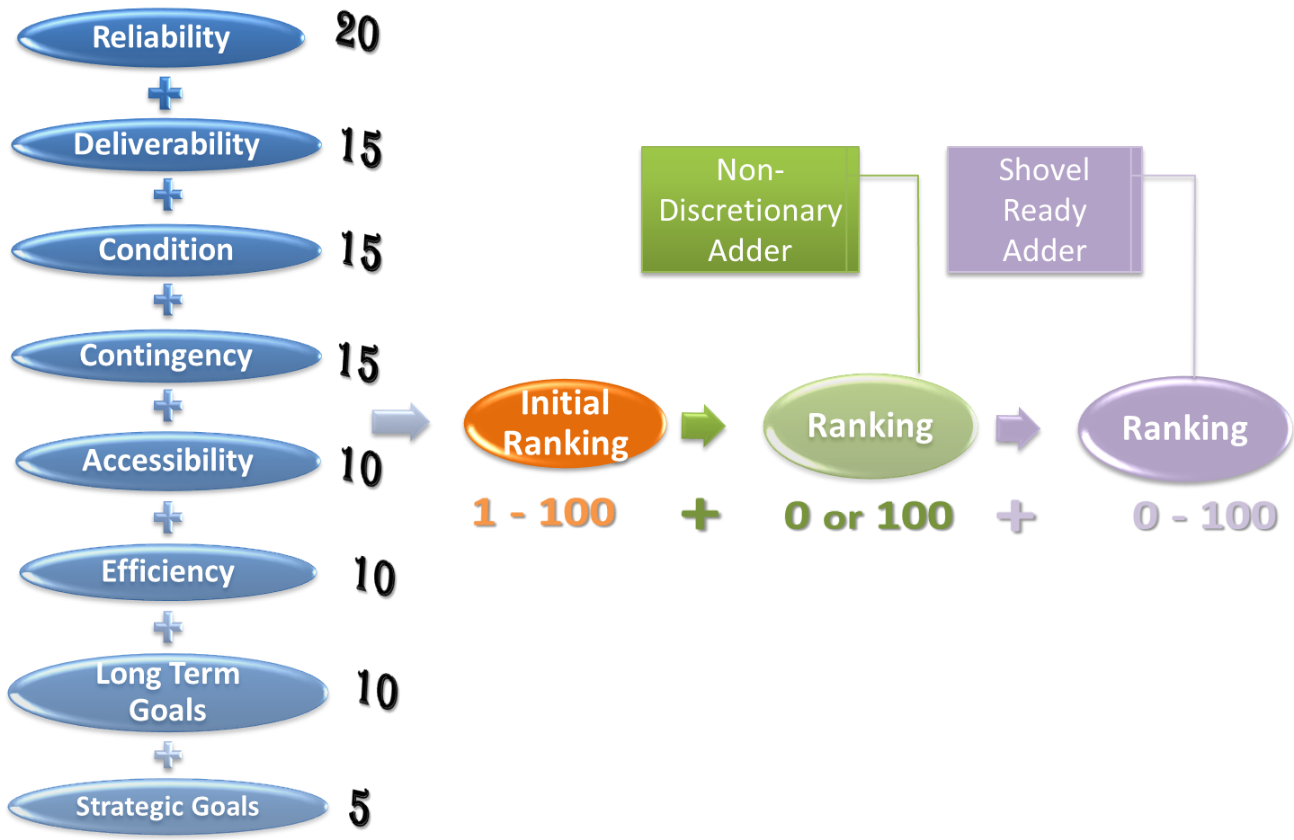



*Figure 8.3.1.B VEC T&D capital project ranking scheme*

**Initial Metrics**

VEC reviews each project for seven initial metrics, which make up an initial ranking:

- Reliability – VEC gives higher priority to projects that reduce outage frequency and outage duration on the worst performing circuits.
- Deliverability – This metric takes into consideration both the number of members and the load used. Higher priority is given to T&D projects that affect more load and/or more members.
- Condition – Higher priority is given to T&D projects to address conditions that do not meet standards or have a high severity (high impact).
- Contingency – This metric measures the ability of a project to reduce restoration times or otherwise improve the operability of the system by reducing planned outages for maintenance and other switching operations. Projects that add feeder backup or add a tie would receive a higher ranking on this metric.
- Accessibility – VEC gives higher priority to projects that improve accessibility to locations with poor/no accessibility in normal and extreme weather.
- Efficiency – VEC gives higher priority to projects that reduce power system losses.

- Long Term Goals – VEC identified four long term T&D goals and ranked them in priority
    1. Building tie lines.
    2. Reconductoring or underground replacements.
    3. Relocation of lines from off-road ROWs to the roadside.
    4. Reliability improvements via sectionalizing.
- Strategic Goals – Each year VEC puts together a strategic plan, which lists certain goals/targets; VEC gives priority to T&D projects that help meet these goals/targets.

VEC weights these initial metrics with the following values:

| Weighting | Value |
|---|---|
| **Reliability** | 20 |
| **Contingency** | 15 |
| **Deliverability** | 15 |
| **Condition** | 15 |
| **Accessibility** | 10 |
| **Efficiency** | 10 |
| **Long Term Goals** | 10 |
| **Strategic** | 5 |

*Table 8.3.1.C Initial metric weighting values*

**Non-Discretionary Adder**

The non-discretionary adder exists to prioritize certain projects above all others. The value for this adder will be either 0 or 100. If a project meets one of the following criteria, it is automatically rated ahead of any discretionary project:

- Regulatory (VAOT, FairPoint IOP, NERC, PUC, Tier 3 Projects, etc.).
- Code Violations (NESC, IEEE, ANSI, etc.).
- Load Growth.
- VELCO Projects.

**Shovel Ready Adder**

To account for projects that may have already been designed, for example multiyear projects, the following "adders" are available:

| Value | Description |
|---|---|
| **10** | Project fully designed and or staked |
| **10** | Project permitted (VAOT, CPG, etc.) |
| **10** | Material has been installed or purchased |
| **10** | Agreement in place (Joint Ownership or other) |
| **10** | Multi-Year Project |
| **50** | Net present value (NPV) payback period of less |

| | |
|---|---|
| | than six years |

*Table 8.3.1.D Shovel ready adder table*

The prioritization process guides VEC's capital investment and once completed, we review the information with the appropriate stakeholders involved with the project.

## Budgeting

Every year, VEC identifies a capital budget target and then choses projects based on their ranking, resource planning, and time constraints. VEC fills out a Construction Estimate Worksheet (CEW) for every project and these are used during the budget process.

Projects often span multiple fiscal years and are tracked accordingly.

## Construction and Project Review

Once a project has met all the necessary pre-construction criteria such as permits, vegetation management, and easement acquisition, it will be ready for construction. VEC reviews financial results monthly and Project Managers receive real-time financial information through its NISC Mosaic ABS portal.

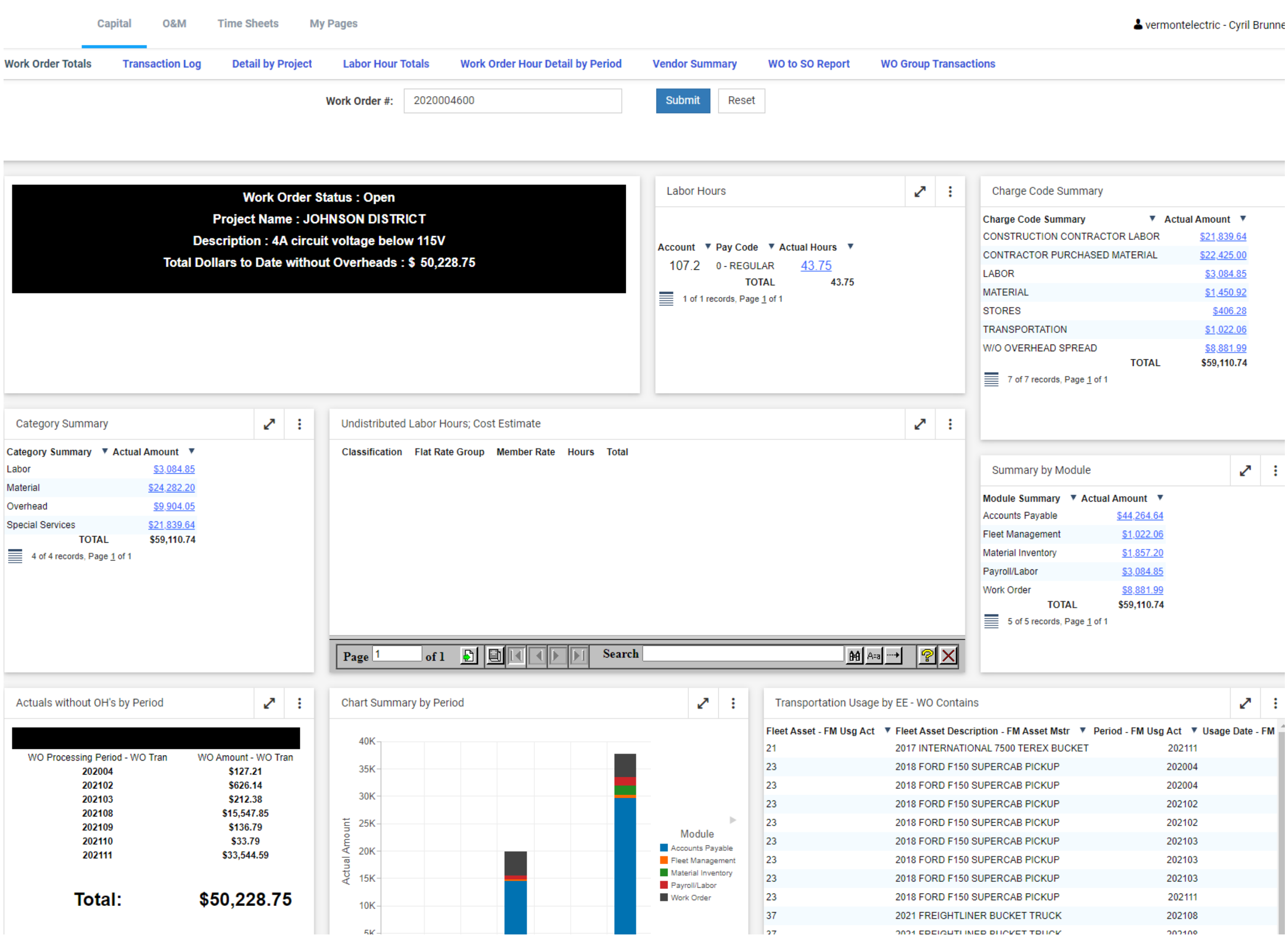



*Figure 8.3.1.E VEC Financial reporting tool*

In addition, an excel Gant Chart is used to manage the schedule of all VEC T&D capital projects.

| Project | December-21 | January-22 | February-22 | March-22 | April-22 | May-22 | June-22 | July-22 |
|---|---|---|---|---|---|---|---|---|
| 01- 4A Meter Point 2 - Poly Hubbard/Reynolds Road | JOHNSON | | | | | | | |
| Voltage Conversion - 48-3E East Echo Lake Rd | NEWPORT | | | | | | | |
| FEMA 14 3L, Sterling Valley, Morristown Tie Line | VEG | | | | | | | |
| 17-1-4B5A Beadle Hill Road Underground | | | | | MORSE | RICHFORD | | |
| FEMA 14 3L, Sterling Valley, Morristown Additional Phases | JOHNSON | JOHNSON | | | | JOHNSON | CONTRACTOR | |
| 01- 4A Meter Point Retirements | | JOHNSON | JOHNSON | | | | | |
| L220 South Alburg Transmission Insulator and Pole Replacements | | | | GRAND ISLE | GRAND ISLE | | | |
| Missionary Acres URD/Culvert Replacement | | | | | | NEWPORT | | |
| Fairfax 01 Transmission Insulator and Pole Replacements | STAKING - JF | | | | JOHNSON | JOHNSON | | |
| 42-44A MOAB | | | | NEWPORT | | | | |
| 2147 ORR River Road Lemington Solar (500kW) | | STAKING - SC | | | | NEWPORT | SUB | |
| 2901 BLOOM Route 102 Bloomfield Solar (500kW) | | STAKING - SC | | | | NEWPORT | SUB | |
| 50-2D Norton Route 114 Phase Addition Reconductor (Phase 1) | STAKING - JF | STAKING - JF | ROW - JF | ROW - JF | | CONTRACTOR | CONTRACTOR | CONTRACTOR |
| Fairfax 12-1A Three Phase Extension | | | | | | GRAND ISLE | GRAND ISLE | GRAND ISLE |
| 29-11 MOAB | | | | | | | | |
| FEMA 30-1L Lost Nation Road Berkshire Reconductor | RIGGS DISTLER | RIGGS DISTLER | RIGGS DISTLER | | | | | |
| FEMA 02 3C. Ober Hill Rd, Johnson (Phase 2) | VEG | ROW - KK | ROW-KK | ROW-KK | | | | |
| 19-3J1 Main Road Hanksville Relocation | ENV - TCE | ENV - TCE | ENV - TCE | ENV - TCE | | | | |
| FEMA 3-1E4 Metcalf Pond Road Relocation | ROW - KK | ENV | ENV | ENV | ENV | VEG | VEG | VEG |
| FEMA 30-1L Lost Nation Road Berkshire Reconductor (Phase 2) | | STAKING - JF | ROW - JF | ROW - JF | ROW - JF | | VEG | VEG |
| 50-2D Norton Route 114 Norton Pond Relocation (Phase 2) | | | | | STAKING - JF | ROW - JF | ROW | |
| SLVS- 01-2G Howrigan to Will George Road Relocation | ROW - MD | ROW - MD | ROW - MD | | | | | |
| 34-1A1 Snipe Island South Line Relocation | STAKING - TW | STAKING - TW | | | | | | |
| FEMA 19-3E Relocation | FEMA | FEMA | FEMA | | | | | |
| FEMA 19-1DX2 Camels Hump Road Relocation 2023 | | | ROW - KK | ROW - KK | ROW - KK | ROW - KK | ROW - KK | |
| Bakersfield 03-1D Relocation | | | STAKING - JF | ROW - JF | ROW - JF | | | |
| SLVS- 01-2G Will George to Ellsworth Road Phase Addition/Relocation | | | | STAKING - JF | ROW - JF | ROW - JF | | VEG |
| 28-4G Main Street Isle La Motte Relocation | | | | | STAKING - JF | ROW - JF | ROW - JF | ROW - JF |
| Poker Hill Road Three Phase 04-2A to 04-2D | | | | | | STAKING - JF | ROW - JF | ROW - JF |
| 19-1B Gillette Pond to Stonefence Relocation | | | | | | | STAKING - JF | ROW - JF |
| Jericho Nashville Road Relocation | | | | | | | | STAKING - JF |
| 12-3A5 Plains Road Westford Reconductoring #6 Steel | | | | | | | | |

*Figure 8.3.1.F VEC T&D capital project Gantt chart*

## 8.3.2 Environmental Program

As part of VEC's ongoing commitment to the environment, we mitigate environmental impacts on our construction projects and to participate in a proactive regulatory framework. In 2022, VEC is working with VHB to develop an environmental guidance manual ("EGM") with the primary goal of creating an easy-to-use comprehensive guide to environmental regulations, permits, and best management practices ("BMPs") for common VEC projects. The manual describes common work practices that occur as part of VEC's routine operation and highlights required environmental reviews, common regulatory situations and jurisdictional triggers, and applicable BMPs that may allow work to occur without requiring regulatory notifications or permits. The workflows described in the document are intended to avoid and minimize impacts to natural resources associated with both routine and larger-scale projects that are typically done outside of Vermont Public Utility Commission or District Environmental Commission purviews. The manual can be included as a supplement to those permit filings however, to describe general work practices and VEC's commitment to avoid or minimize impacts to natural resources and Vermont's environment.

VEC's EGM has been prepared for the sole purpose and exclusive use of the Vermont Electric Cooperative and is intended as a reference for all VEC employees. Engineers, designers, vegetation management crews, construction crews and contractors should be made aware of the contents and will participate in a brief training before conducting work on VEC's infrastructure. VEC also added a glossary of terms is included which defines terms, acronyms, and resource types.

While we have engaged with VHB to help develop the EGM, VEC is the owner of the document and will help ensure adherence to work procedures and BMPs. Additionally, VEC will be responsible for updating the manual on a routine basis, presumed to be at least every five years, but as needed based on regulatory changes and practicable use. The manual is designed to reference outside sources to reduce the frequency of updates required within the document, however VEC should be aware of regulatory modifications, permit modifications and updates to BMPs that could affect the accuracy of this manual.

Prior to designing Projects or conducting work on VEC's system, all employees and contractors shall be required to participate in environmental training that highlights the contents of the manual. The training will provide general environmental awareness while working on VEC's system and can be modified to better reflect individual's responsibilities or a specific project. Training will inform personnel of the rules, regulations, procedures, and BMPs to follow during a project. Additional trainings may be held throughout a project to reinforce previous training topics or provide additional information.

To help ensue adherence to permit conditions and BMPs outlined in this manual, VEC will conduct intermittent inspections on routine maintenance projects. In addition, certain projects may require more frequent inspections as outlined in permit conditions. VEC and VHB created a template that can be used for routine inspections and modified to incorporate project-specific conditions. Environmental inspections will be performed by a VEC representative or a third-party consultant for the duration of a project or on an as-needed basis.

The EGM provides an overview of typical work practices, associated BMPs, and potential practices requiring permit approvals. There will be instances or projects that require more field assessments and permitting needs. Should questions arise through the desktop or field review process, a subject matter expert at VEC or a qualified third-party consultant working on VEC's behalf will help identify the need for additional natural resource review or to identify additional permitting needs.

Specific permit related conditions may supersede or be required in addition to the BMPs and work practices described in the EGM. It is critical to fully understand project-related permits and to implement the requirements of each to maintain compliance. Some examples of permits include, but are not limited to Certificate of Public Good (Section 248), Vermont Wetlands Permit, U.S. Army Corps of Engineers Section 404 Permit, Stream Alteration Permit, Construction Stormwater Permit, Operational Stormwater Permit, and Vermont RTE Takings Permit.

This document is designed to be a tool used in conjunction with VEC's suite of guidance documents. These include, but may not be limited to:

- Vegetation Management Plan for Vermont Electric Cooperative, Inc. – Transmission and Distribution Systems
- VEC Operation Procedure 27: Oil Spill Reporting Procedure
- Best Management Practices (BMPs) Associated with the Use of Pentachlorophenol-treated Utility Poles in Vermont
- Facility specific SPCC Plans;
- Facility specific Operational Stormwater Management Requirements; and
- On-going Project-Specific Requirements and Permit Conditions

### 8.3.3 Asset Selection and Replacement

The following section provides an overview of VEC's processes used to select all major equipment according to least-cost principles.

In general, on material purchases of $50,000 or greater, VEC's purchasing policy requires three competitive bids which are evaluated based on least overall cost, lead time, efficiency, and quality of product. VEC may opt to purchase a unit that is higher in initial cost if that unit has a substantially shorter lead-time (where time is important) or if the unit to be purchases needs to be identical to the existing unit. VEC attempts to take all aspects of a product or service into consideration when deciding which to purchase.

#### Transformers

**Distribution Transformers**

For new distribution transformer purchases, VEC utilizes a spreadsheet developed from a tool provided by the Vermont Department of Public Service (DPS). The tool uses current and future energy and capacity market projections along with transformer nameplate data to calculate an estimate of lifecycle losses and resulting total ownership cost. VEC has provided the most recent version of VEC's transformer purchase spreadsheet in Appendix-G, which includes VEC's transformer acquisition multipliers. The spreadsheet utilizes the following measures:

- Avoided energy and transmission costs.
- VEC's Weighted Average Cost of Capital (WACC) and discount rate.
- Transformer loss factors that utilize average load and no-load losses over standard transformer sizes.
  - Load losses are also referred to as copper or winding losses and vary with the square of the current through the transformer winding.
  - No-load losses also referred to as iron or core losses and vary exponentially with the voltage applied.
- Avoided capacity costs which include fixed costs and capacity charges for power including on peak line losses.
- Expected load growth.
- Peak and average system losses.

The Department of Energy (DOE) CFR part 431 (Energy Conservation Program: Energy Conservation Standards for Distribution Transformers) outlines standards for distribution transformers. The DOE amended this document to increase the energy efficiency standards for distribution transformers beginning in January 1, 2016. While VEC takes into consideration the total cost of ownership identified in the tool described above, it has found through internal analysis that choosing the transformer with the lowest initial cost may not provide the lowest total ownership cost option for the VEC membership. This is because the increased cost of losses for the lower initial cost unit never intersects with the higher initial cost, lower loss unit, over the 30-year financial life period of the transformers.

The following table shows the initial ownership cost, no load and full load losses, and total ownership cost of three 10 kVA transformers.

| Transformer | Sell Price | No Load Losses | Full Load Losses | 30 Year Losses | Total Ownership Cost |
|---|---|---|---|---|---|
| Howard 10 kVA | ***$590.86*** | $334.39 | $108.51 | $397.71 | $1,099.94 |
| PPI 10kVA | ***$702.23*** | $365.74 | $106.98 | $434.70 | $1,025.56 |
| Eaton 10 kVA | ***$907.42*** | $229.89 | $100.87 | $272.36 | $1,179.78 |

*Table 8.3.3.A   Total cost of ownership, no load, full load, and 30-year losses by transformer manufacturer*

The following graph presents the total ownership cost of a 10-kVA transformer by year and manufacturer:

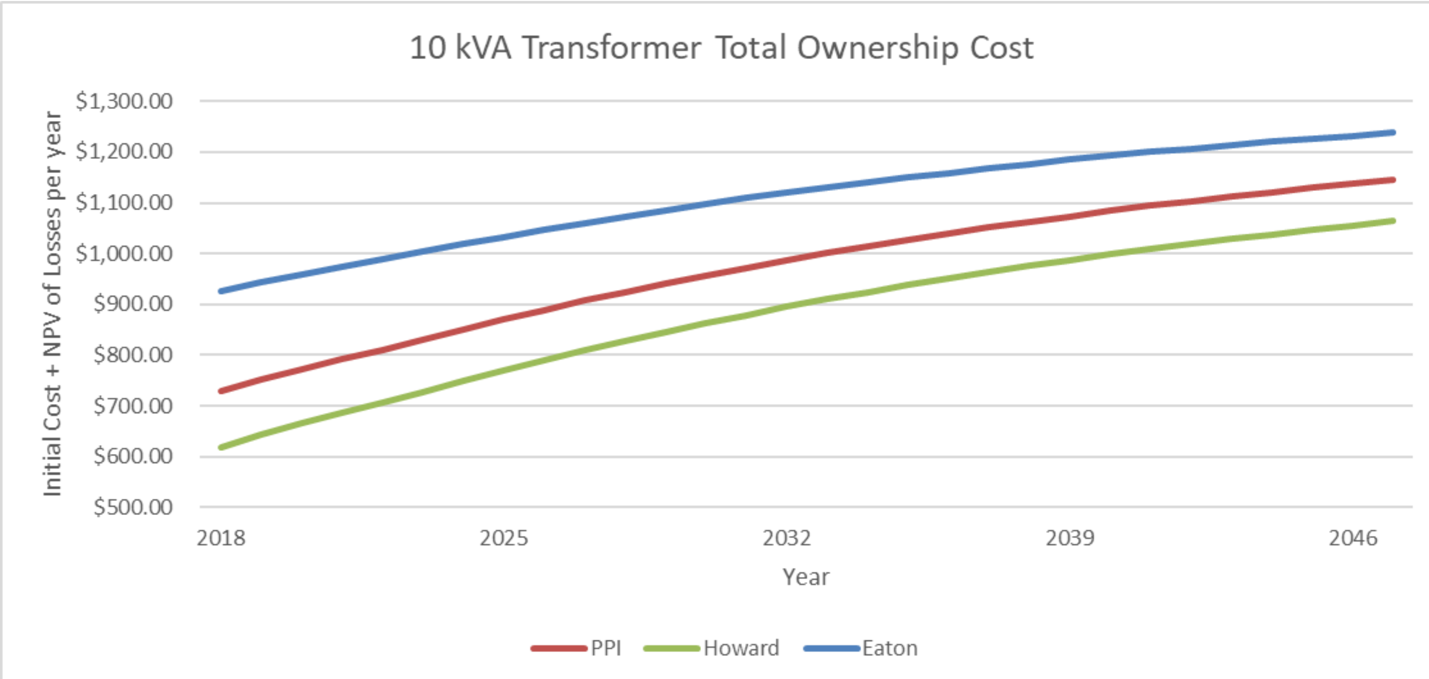



*Figure 8.3.3.B Total transformer ownership cost by year and manufacturer over 30 years*

As shown in the graph above, savings from fewer losses does not justify the increase in initial cost of a more efficient transformer.

There are two common types of overhead transformers, conventional and CSP (Completely Self-Protected). VEC has recently standardized on conventional transformers but still maintains some CSP inventory. VEC utilizes the following distribution transformer sizes:

- Pole Mounted – 1 kVA, 5 kVA, 15kVA, 25 kVA, 37.5 kVA, 50 kVA, 100 kVA, 167 kVA
- Pad Mounted– 15 kVA, 25 kVA, 50 kVA, 100 kVA, 167 kVA, 250 kVA, 333 kVA

VEC personnel identify the proper transformer size to ensure high-quality electric service and lowest life cycle cost for VEC membership. The smallest transformer size VEC utilizes on residential loads is a 15-kVA pole mounted transformer while 1 and 5 kVA transformers are used for station service and street lights. VEC discusses a recent change to increase its standard transformer size from 10 to 15 kVA in the Energy Transformation section of this IRP.

VEC has found that a typical residential member will draw around 3 kVA and, in some cases, up to 10 kVA if the member has multiple electric vehicles. A 15-kVA transformer is utilized for residential loads which would allow for an additional member to be added without changing the transformer.

For commercial loads, VEC utilizes a required member load sheet and comparable sized loads to determine the transformer size needed. VEC also regularly monitors loading on larger transformers typically associated with commercial or small industrial members to ensure efficient transformer sizing.

Utilizing the calculated losses of the transformer purchase tool VEC was able to model the approximate lifecycle losses based on transformer size.

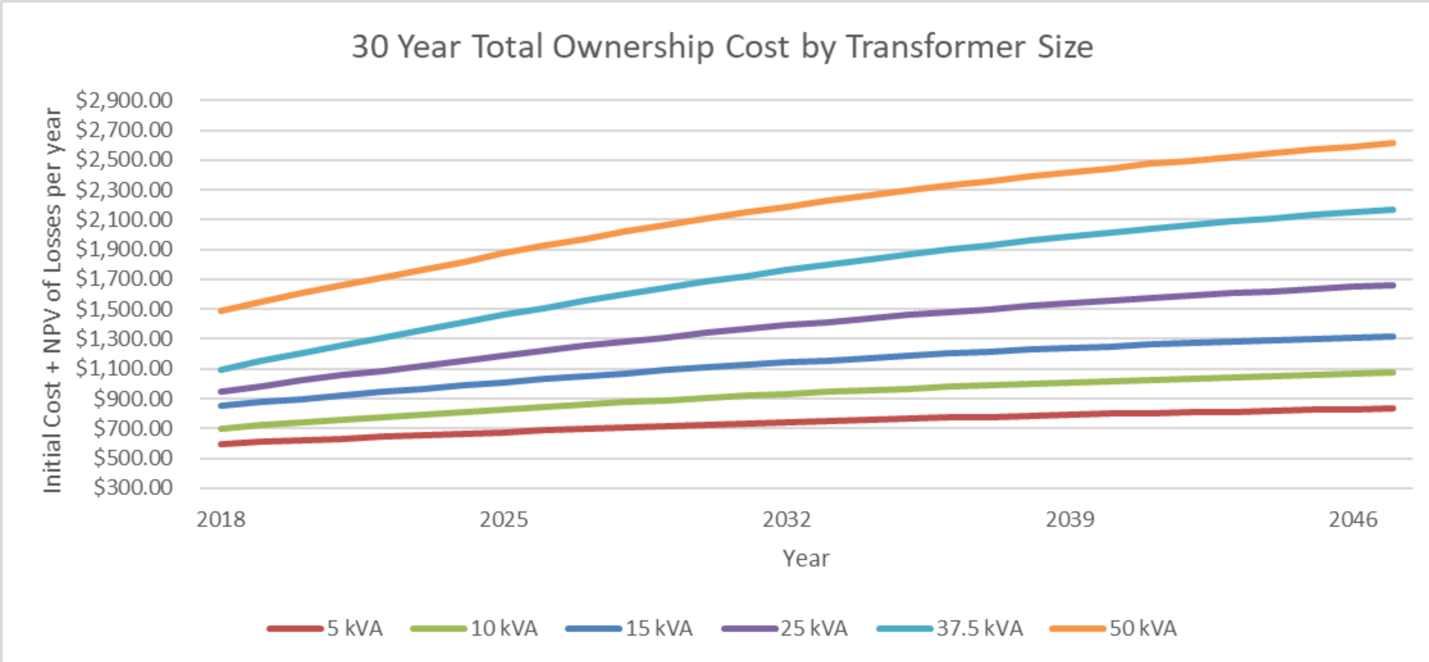



*Figure 8.3.3.C  Total transformer ownership cost by year and transformer size over 30 years*

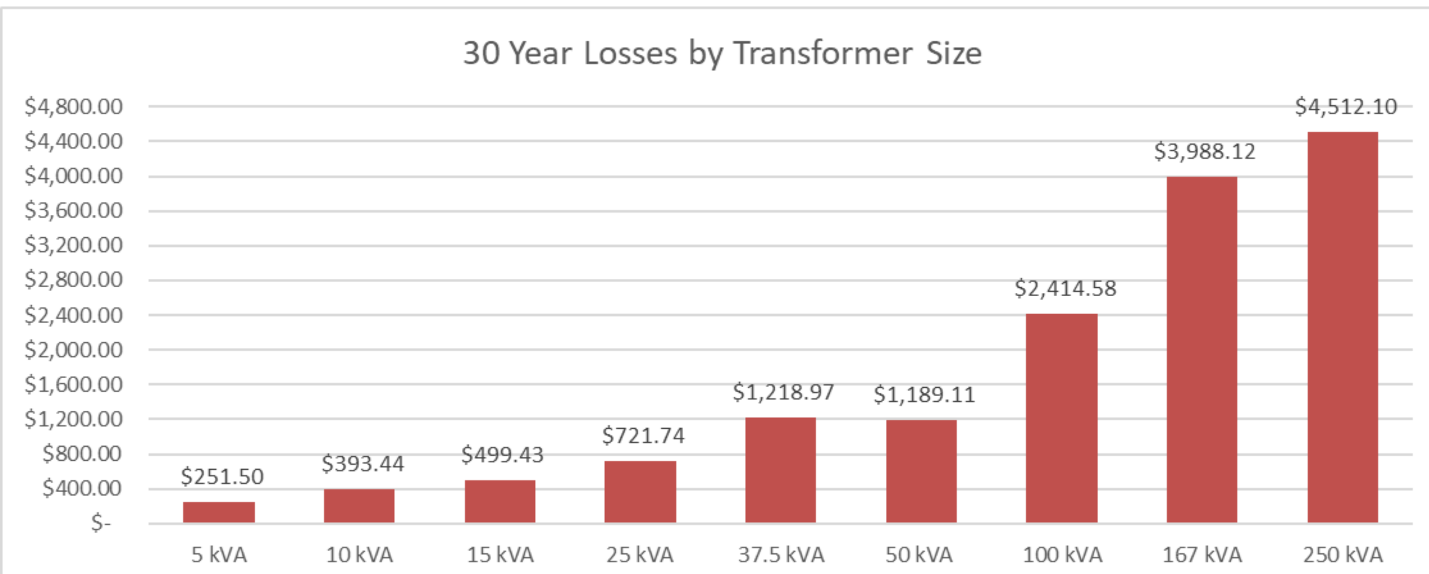



*Figure 8.3.3.D   Total transformer losses over 30 years by transformer size*

VEC replaces undersized transformers as soon as concerns are identified; however, we will replace oversized transformers on a case-by-case basis when cost-justified. An hour of line worker time including labor, transportation, and indirect costs is approximately $575, exceeding the difference in losses between transformer sizes. This price does not include the transformer cost or salvage value of the existing transformer.

VEC has seen an increase in overhead and transformer replacement because of voltage conversions and underground reconductoring projects. VEC typically replaces transformers due to condition, load growth, or capital projects. The charts below details VEC's transformer replacements associated with load growth, condition (generally like for like), or capital projects for both overhead and underground transformers.

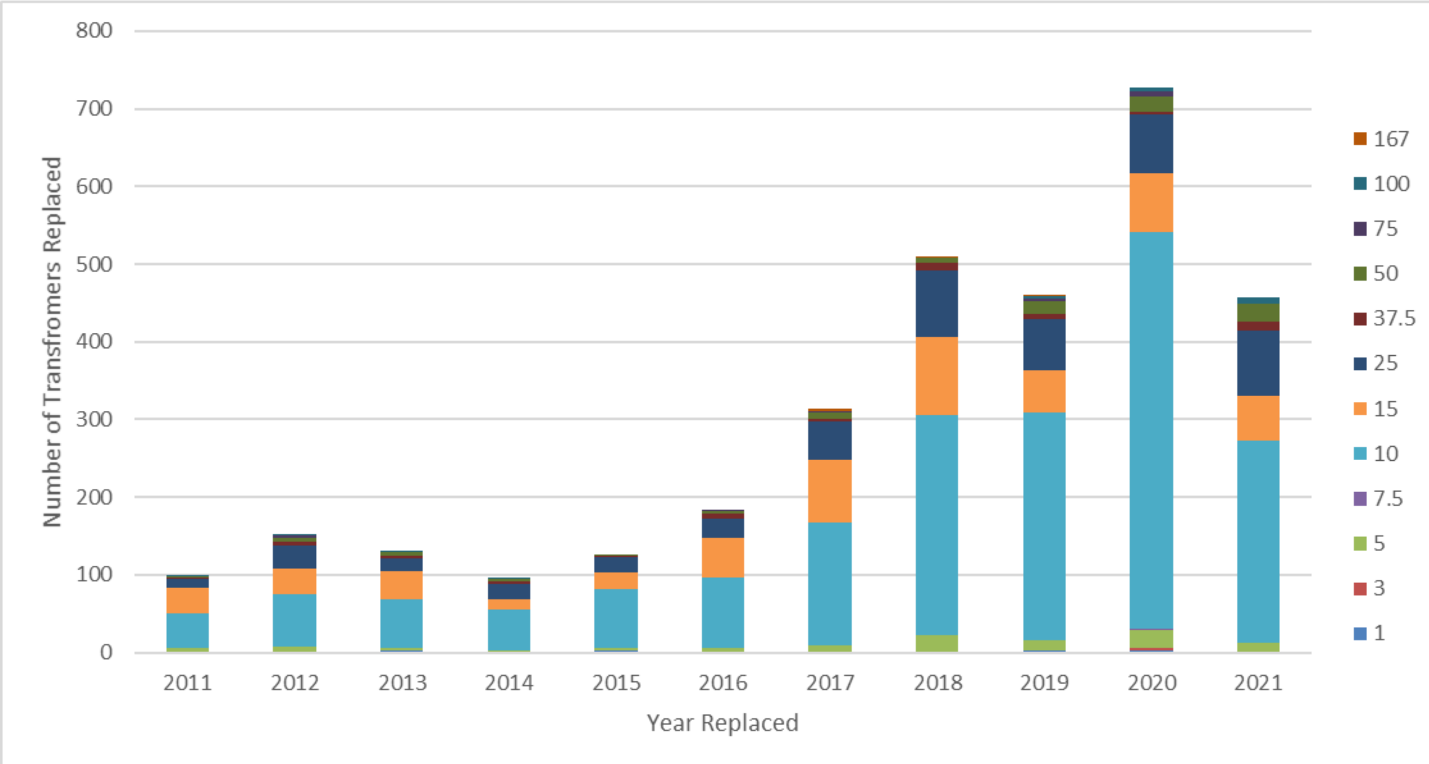



*Figure 8.3.3.E Number of overhead transformers replaced by size (kVA) 2011-2021*

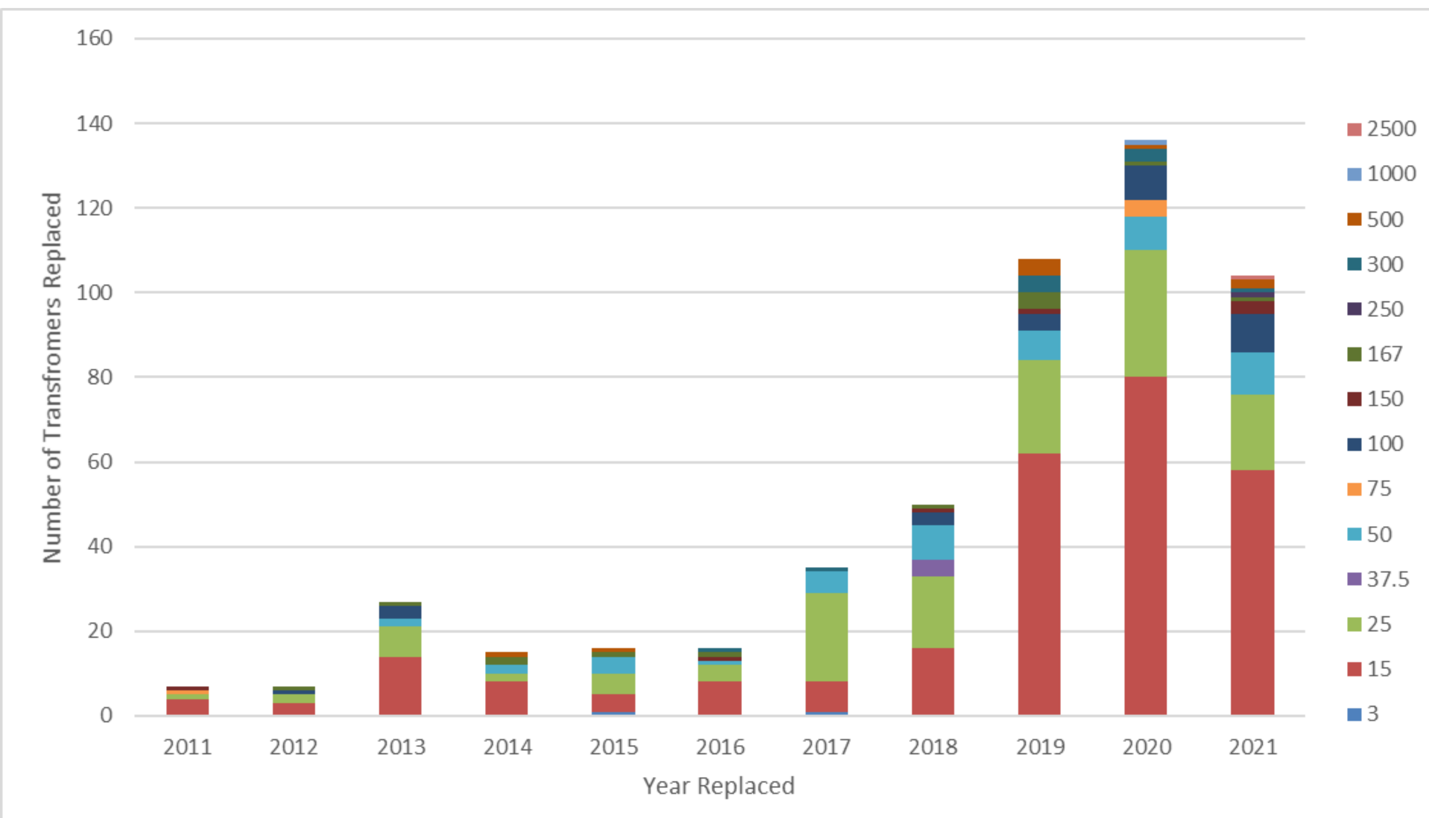



*Figure 8.3.3.F Number of padmounted transformers replaced by size (kVA) 2011-2021*

### Substation Transformers

VEC evaluates substation transformers using the same analytical tool described in the distribution section. The following table shows the initial ownership cost, no load and full load losses, and total ownership cost of four 5/6.25 MVA transformers.

| Transformer | Sell Price | No Load Losses | Full Load Losses | Total Losses | Total Ownership Cost |
|---|---|---|---|---|---|
| ABB 5/6.25 MVA | ***$128,871*** | $48,590 | $25,753 | $66,050 | $194,921 |
| Howard #1 5/6.25 MVA | ***$136,968*** | $46,333 | $18,741 | $56,260 | $193,228 |
| Niagara 5/6.25 MVA | ***$161,916*** | $41,798. | $25,218 | $56,596 | $218,512 |
| Howard #2 5/6.25 MVA | ***$185,000*** | $42,321 | $25,294 | $55,709 | $240,709 |

*Table 8.3.3.G Total cost of ownership, no load, full load, and 30-year losses by transformer manufacturer*

The following graph shows the same information in a different format.

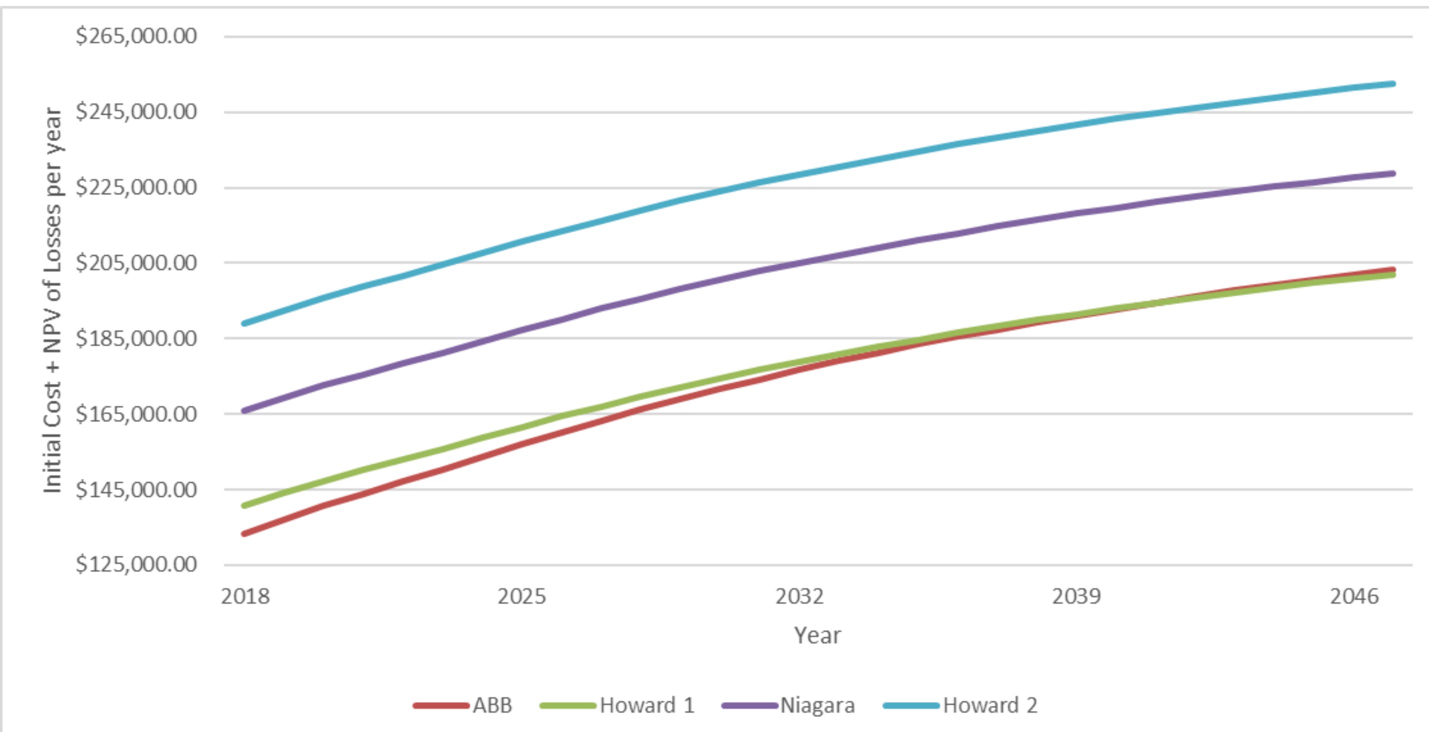



*Figure 8.3.3.G 5/6.25 MVA substation transformer total ownership cost*

Due to the low cost of energy and more efficient transformers, selecting the substation transformer with the lowest initial cost provides the least cost option for the VEC membership.

Substation transformers will be reviewed for replacement once the load exceeds 80 percent of base rating (no fans) MVA. VEC's substation criteria are detailed in further detail in the Appendix-A.

## Overhead Conductor

### Conductor Selection

Replacement of conductor (wire) generally occurs either because of poor condition or as needed for load growth or reliability. Loss savings alone generally do not justify a reconductoring project. VEC has recently standardized on the following conductor sizes:

- 1/0 AAAC (Azusa)
- 336 ACSR (Linnet)
- 556 ACSR (Dove)

VEC takes into consideration the total ownership costs of conductor upgrades. VEC uses a six-year net present value (NPV) payback period for major investment decisions. VEC calculates losses by multiplying the resistance by the square of the current. VEC models the initial cost of our three conductor standards along with the NPV of six years of losses per mile per conductor given a specific amperage. The analysis utilizes the approximate spot market savings in $/kWh to determine the value of losses. The chart below shows this comparison:

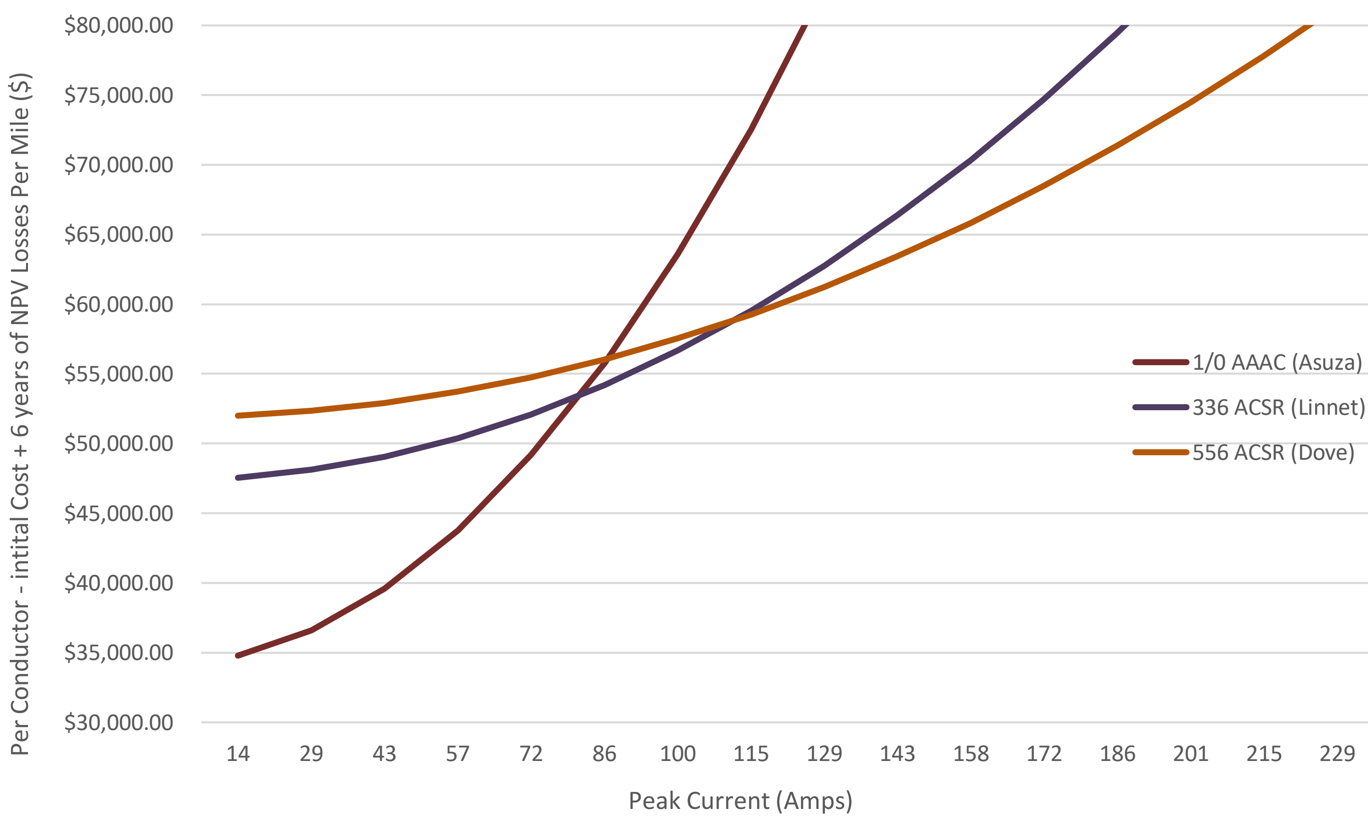



*Figure 8.3.3.H Per conductor initial cost + 6-year losses versus current (Amps)*

From this analysis, VEC developed a wire chart, which is provided in the provided in Appendix-H.

## Underground Conductor

An overhead line is considered a best utility practice from an overall power system installation and operating cost perspective. Overhead lines allow for flexibility such as the ability to add phases, upgrade conductors due to overload, identification of faults or damage, to convert to higher voltages, add secondary services, and to provide VAR support by adding capacitors and voltage regulators; all of which help manage the overall design and operation of the power system.

However, approximately 78 percent of VEC's new line extensions are underground primarily due to aesthetic preferences on behalf of VEC members. While aesthetic and reliability benefits exist for undergrounded systems, underground cable has a greater impedance and voltage drop than overhead cable due to trapped conductor heat and magnetic coupling. Underground cables have more power losses due to heating and the lack of cooling within the conduit itself (unlike that of an overhead conductor that is cooled by the temperature and movement of the surrounding ambient air). For this reason, larger conductors are needed for underground cables versus overhead conductors to serve the same load levels.

**<u>Construction Practices</u>**

Proper installation of underground requires the following:

- Conduit (for protection).
- Jacketed EPR (ethylene propylene rubber-insulated) Cable
- Proper burial, installation, and termination.

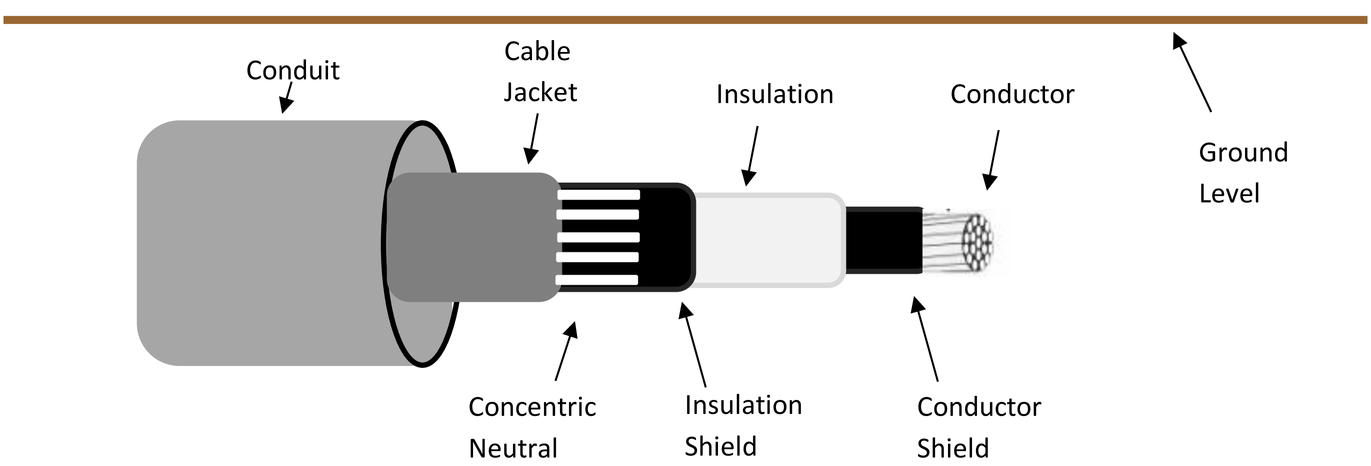



*Figure 8.3.3.J VEC standard installation of underground conduit and conductor*

**Direct Buried Underground**

While the above installation is VEC's standard today, direct buried underground cable was common practice in the 1970s and earlier.

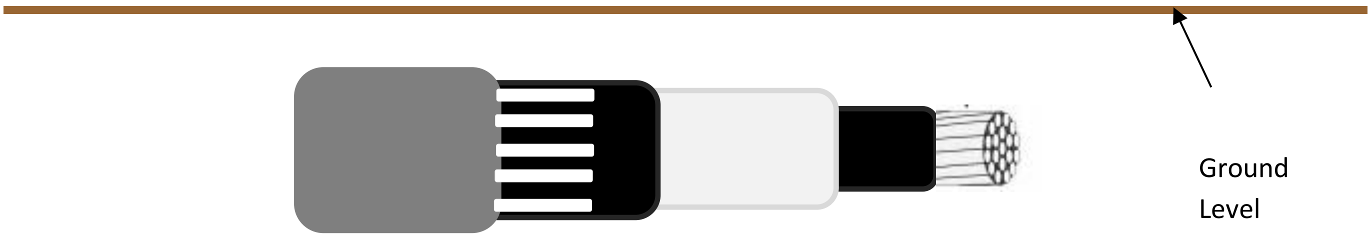



*Figure 8.3.3.K    Direct buried underground installation*

Direct buried cable is not in conduit and can be more susceptible to failure.

**Unjacketed Cable**

In addition to direct buried cable, VEC also has several locations where unjacketed cable was used and the concentric neutral had become separated from the cable. This makes locating a fault extremely time consuming as fault finding equipment depends on this neutral.

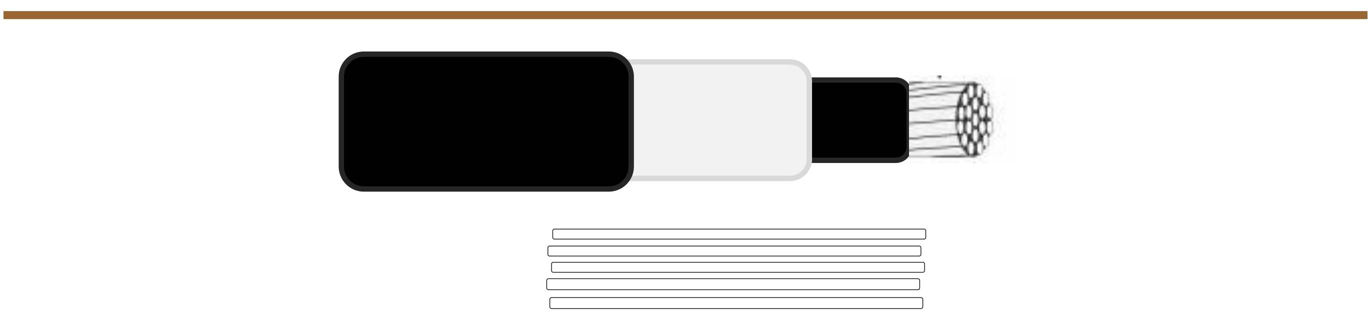


*Figure 8.3.3.L    Unjacketed cable underground installation*

VEC has an unknown quantity of both direct buried and unjacketed cable on its system and is not actively replacing locations simply due to this type of installation. However, VEC is in the process of determining the construction type of all its underground as part of its Maintenance plan. After this analysis is concluded and more information is known, we will develop a plan to address.

## Poles

**Distribution**

VEC has over 54,000 distribution poles on its system, the majority of which are treated with Pentachlorophenol, more commonly referred to as Penta. All VEC's poles are manufactured following American National Standards Institute (ANSI) and American Wood Protection Association (AWPA) guidelines to ensure the desired size, strength, material quality, original treatment loadings, and decay resistance properties. From a depreciation perspective, the average pole life expectancy of a utility distribution pole is 30 years; however, with proper maintenance, including inspection and treatment, life expectancy can exceed 60 years. VEC replaces poles when their condition requires it, assuming they meet clearances (height) or mechanical (tension/weight) requirements. VEC uses 60 years as a guide for asset planning, but will not replace a pole that an inspection shows is still structurally solid simply because it reaches 60 years old.

In fact, approximately 2,800 of VEC's poles are over 60-years old. VEC's average distribution pole manufactured age is 1986 (35 years old). The chart below shows the number of VEC distribution poles by manufacture year using a sample size of 41,606 poles.

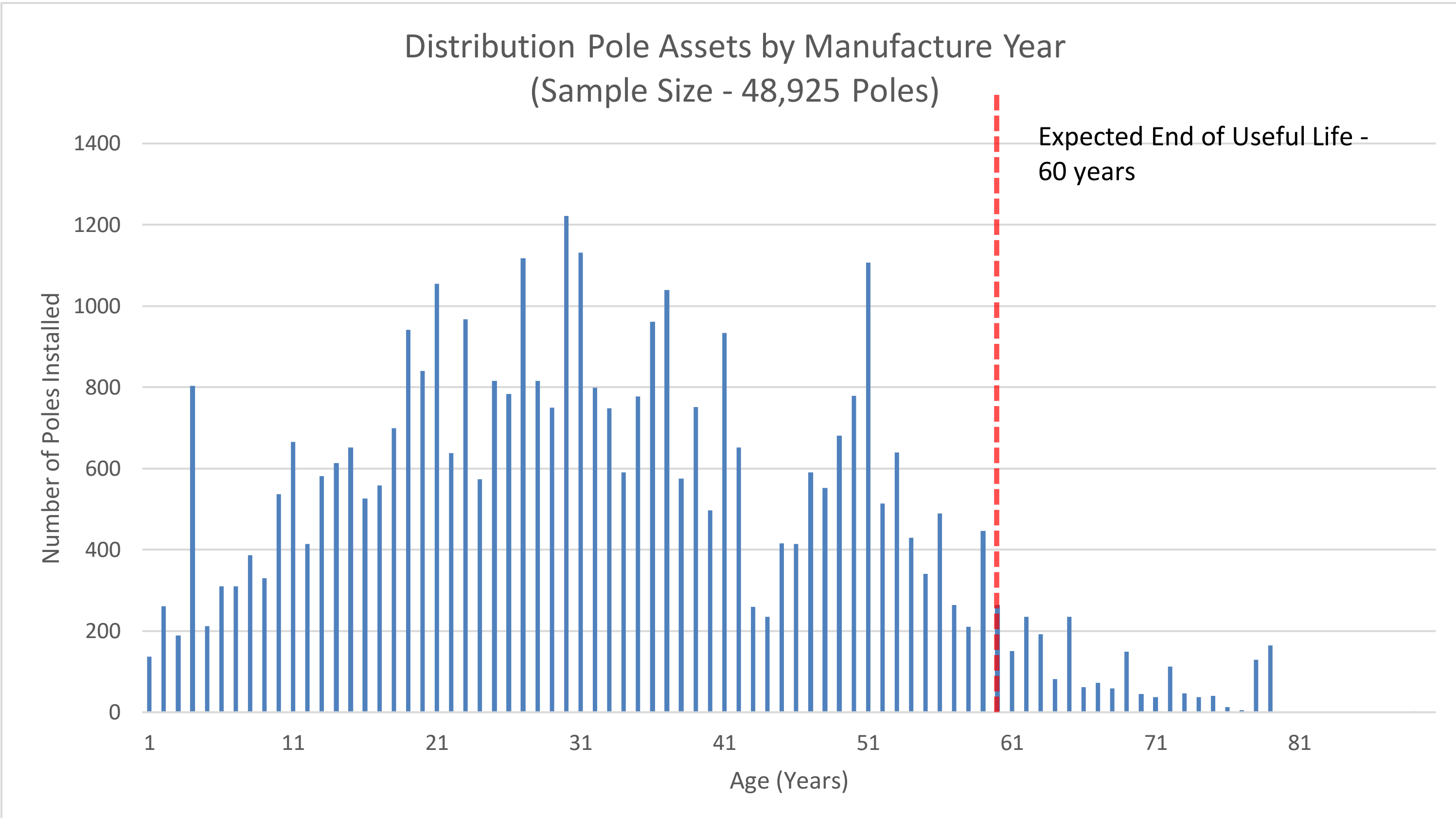



*Figure 8.3.3.M Distribution pole assets by manufacture year*

VEC follows Appendix 1 of the Best Management Practices (BMPs) documented in PSB Docket No. 8310 associated with the use of Pentachlorophenol-treated utility poles in Vermont.

VEC continues to increase the number of poles it replaces annually due to change in use or because of VEC's pole inspection program. The last four-year average is over 380 poles replaced annually, compared to the prior six years where VEC averaged only 232 poles replaced annually. The pole inspection program identifies approximately 100 deficient poles annually. The chart below shows the height (in feet) and quantities of poles replaced since 2011.

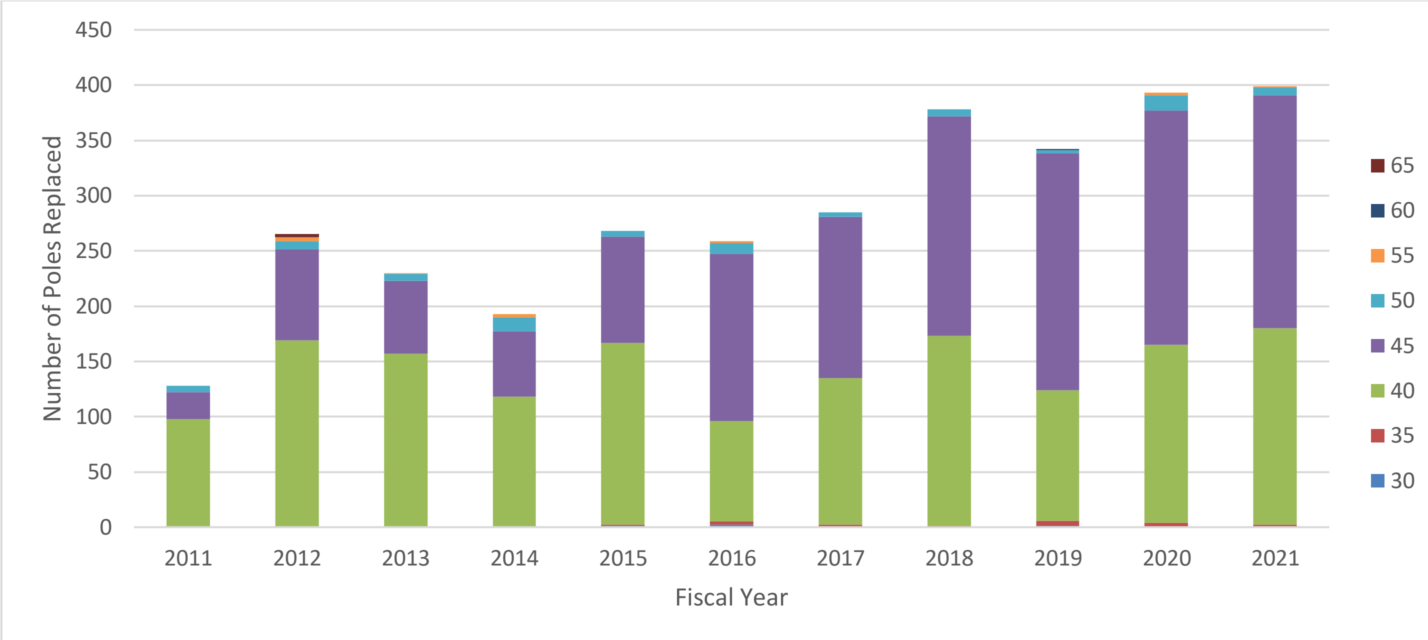



*Figure 8.3.3.N Number of VEC poles replaced by height 2011-2021*

VEC is replacing approximately one percent of its pole assets annually; at this rate it would take approximately 100 years for all poles to be replaced on VEC's system. VEC expects the quantity of pole replacements to continue to increase in the future as VEC increases spending on reconductoring projects (requiring mid-spans and pole replacements), new construction (additional phases), and line relocations. In addition, the continue broadband rollout and associated make ready work will also affect the quantity of pole replacements.

**Telephone Pole Replacements**

Telephone pole replacements refer to any pole replacement within Franklin Telephone and Consolidated Communication's joint owned set area or at the request of Consolidated or Franklin Telephone. VEC replaces around 130 of jointly owned telephone poles annually and expects this number to decrease in coming years due to VEC's 2019 and 2020 acquisition of approximately 9,000 joint owned poles from Consolidated.

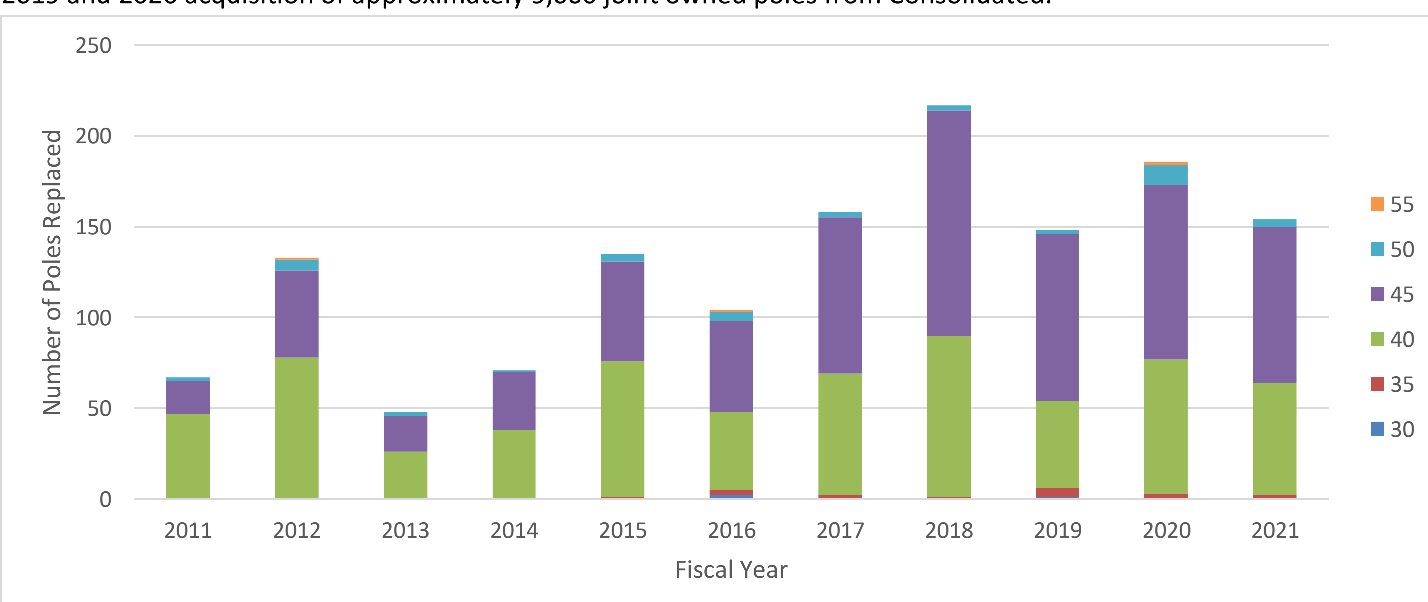



*Figure 8.3.3.O Number of telephone poles replaced by height 2011-2021*

**Transmission**

VEC has over 2,300 transmission poles on its system with around 171 poles (nine percent) older than 60 years. The average transmission pole manufacture year is 1989 (making the average pole 32 years old) with the oldest poles being on the Portland Pipe line (Barton Tap-to-Portland Pipe) and the South Alburgh line (Highgate to South Alburgh)

VEC completed a transmission pole inspection of all transmission poles in 2020 that yielded a reject rate of approximately two percent. The inspection found only 46 rejected poles and the average reject pole age was 51 years old. As with VEC's distribution poles, most pole replacements completed outside of the inspection program are due to the condition of the pole top due to decay from water ingress. The chart below displays quantity of VEC transmission poles by manufacture year using a sample size of 2,032 poles.

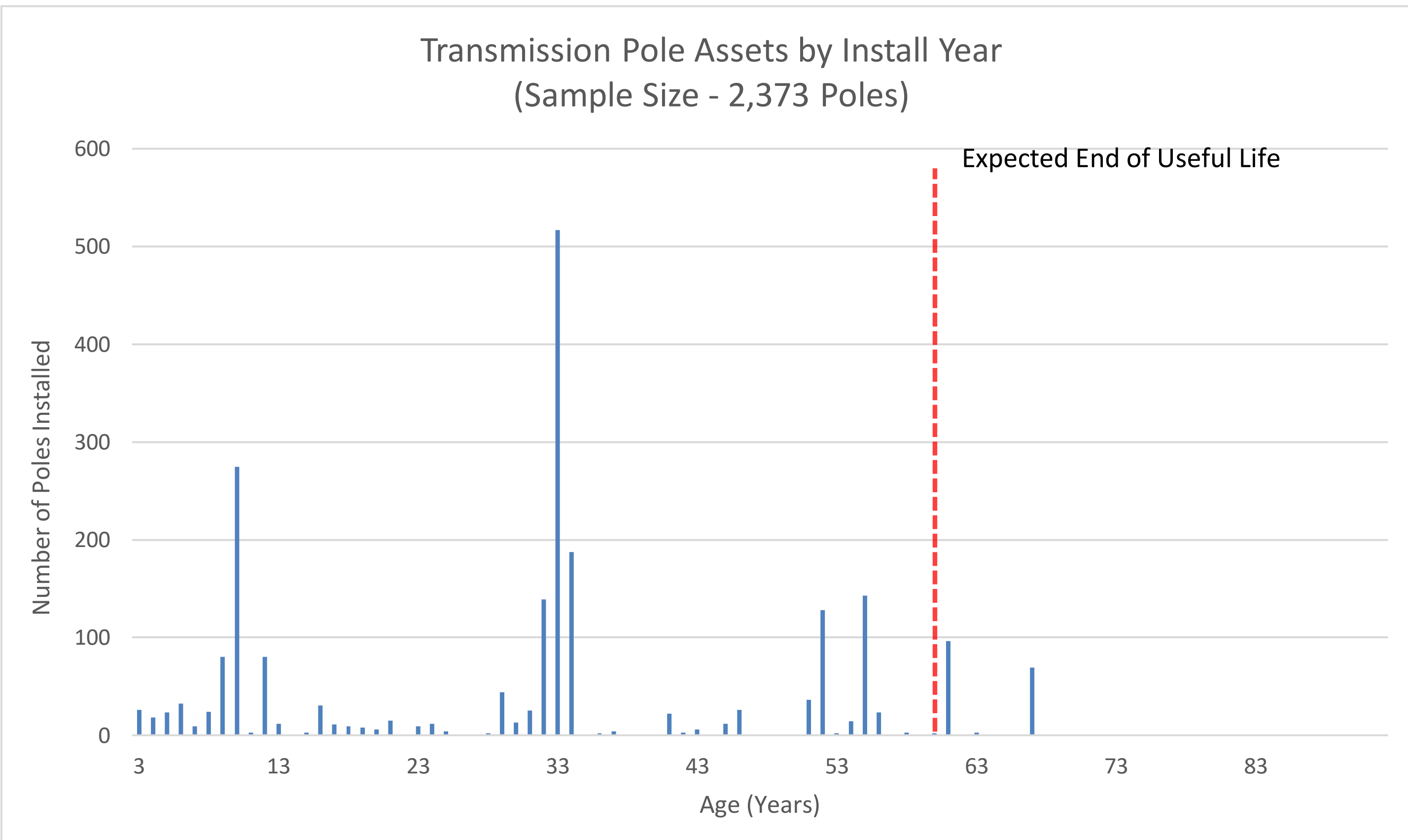



*Figure 8.3.3.P  Transmission pole assets by manufacture year*

**Pole Treatment - Penta Production and Alternatives**

As was described in the previous section, the majority of VEC's poles are Southern Yellow Pine treaded with Penta. The United States is currently the only country in the world that still permits the use of Penta for pole treatment and all other countries have banned its use. The Mexican government recently forced the closure of the only remaining producer of Penta plant by the end of 2021. By the end of 2022, VEC will no longer be able to purchase new Penta poles and expects to have shortages on common types of poles by the start of 2023.

There are several alternatives to Penta that have been in use by other nearby utilities for many years.

- **CCA -** Chromated Copper Arsenate (CCA) is a water or oil-based treatment that has been used in treating Southern Pine and Western Red Cedar poles for many decades. CCA provides effective protection for poles because it chemically "fixes" or bonds to the wood, reducing the chances of potential migration of the preservative into the soil or groundwater. VEC utilized a small quantity of CCA poles in the 1970's and 1980's but there were significant issues when trying to climb these poles. Unlike Penta, which stays soft through its lifetime, the CCA poles became hard, especially in winter, as they aged making it nearly impossible to safely climb these poles. In the early 2000's, newer treatments were developed that included an oil impregnation to soften the CCA poles.

Currently Hydro Quebec uses Red Pine poles with a CCA treatment. Hydro Quebec (HQ) has been installing red pine CCA poles on its system since the late 1940's and standardized on CCA-PA (an oil-based additive to aid in climbing ability) in the early 2000's. HQ has performed 320,344 inspections on poles with a CCA treatment since 2009. Of those inspected only 0.3% were rejected comparing to VEC's reject rate of 2.45%. Even better, if the replacements are filtered out for all causes except natural decay the replacement rate is 0.02%.

| | | | | | | | REPLACEMENTS | | REPL RATE DUE TO NATURAL DECAY | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| INTALL YR | EX | IN | RP | RU | RC | Total | Total | PCT | Total | PCT | PCT OF ALL REPL |
| 1946 to 1950 | 55 | | 3 | 2 | | 60 | 5 | 8,33% | 2 | 3,33% | 40% |
| 1951 to 1955 | 129 | 1 | 6 | 5 | 1 | 142 | 12 | 8,45% | 5 | 3,52% | 42% |
| 1956 to 1960 | 41 | | 3 | 2 | 2 | 48 | 7 | 14,58% | 5 | 10,42% | 71% |
| 1961 to 1965 | 115 | 1 | 5 | 3 | | 124 | 8 | 6,45% | 5 | 4,03% | 63% |
| 1966 to 1970 | 131 | 1 | 3 | 4 | | 139 | 7 | 5,04% | 6 | 4,32% | 86% |
| 1971 to 1975 | 166 | 1 | 4 | 2 | 1 | 174 | 7 | 4,02% | 4 | 2,30% | 57% |
| 1976 to 1980 | 5 481 | 138 | 71 | 57 | | 5 747 | 128 | 2,23% | 18 | 0,31% | 14% |
| 1981 to 1985 | 7 589 | 598 | 126 | 64 | 2 | 8 379 | 192 | 2,29% | 13 | 0,16% | 7% |
| 1986 to 1990 | 912 | 2 461 | 16 | 9 | 2 | 3 400 | 27 | 0,79% | 3 | 0,09% | 11% |
| 1991 to 1995 | 401 | 12 095 | 43 | 37 | 7 | 12 583 | 87 | 0,69% | 6 | 0,05% | 7% |
| 1996 to 2000 | 121 | 3 940 | 11 | 4 | 1 | 4 077 | 16 | 0,39% | | 0,00% | 0% |
| 2001 to 2005 | 394 | 66 496 | 85 | 45 | 7 | 67 027 | 137 | 0,20% | 3 | 0,00% | 2% |
| 2006 to 2010 | 401 | 117 704 | 144 | 60 | 3 | 118 312 | 207 | 0,17% | 1 | 0,00% | 0% |
| 2011 to 2015 | 201 | 75 450 | 86 | 25 | 4 | 75 766 | 115 | 0,15% | | 0,00% | 0% |
| 2016 to 2020 | 61 | 23 865 | 16 | 3 | 2 | 23 947 | 21 | 0,09% | | 0,00% | 0% |
| 2021 to 2021 | | 419 | | | | 419 | 0 | 0,00% | | 0,00% | 0% |
| **Total** | **16 198** | **303 170** | **622** | **322** | **32** | **320 344** | **976** | **0,30%** | **71** | **0,02%** | 7% |

*Figure 8.3.3.Q Pole reject information from Hydro Quebec – CCA Poles*

Even after 40 years, none of the poles were below the minimum effective concentration level. While HQ still inspects their poles on a similar 10-year cycle to VEC, they have found cost savings both by not having to retreat CCA poles and, more significantly, the need to replaced fewer poles because of the inspections.

**Given the results above VEC is planning to switch over to Red Pine poles with CCA treatment starting at the end of 2022 or earlier as Penta stock runs out. We are beginning to hear from our Canadian supplier that they won't know whether they can supply VEC with the requested quantities of Red Pine poles in the class and sizes we use the most until later in the year. At this point we would have no direct replacement for Penta treated poles that are proven safe to climb by our line workers and as such would or may need to resort to purchasing poles that are bucket accessible only.**

- **<u>DOCI</u>-** (4,5-Dichloro-2-n-octyl-4-isothiazolin-3-one) is the newest oil-type preservative available for utility poles and crossarms. DCOI has been standardized as a wood preservative by the AWPA since 1989 and ground contact uses were added in 2017.

  Unfortunately, given that the treatment is new, there is little information on the long-term performance of DCOI treated poles. DCOI is oil based so we image it will have the same tendency as Penta to migrate out of the pole over time – though it does appear to be less toxic. If this is the case, it may require a full test/treat inspection after 30 years.

- **ACZA -** Ammoniacal Copper Zinc Arsenate (ACZA) is a copper-based preservative. Developed by the University of California in the 1920's, ACZA treatment is particularly effective for hard-to-treat species like Douglas Fir. In addition to utility poles, ACZA preserved wood is often used in aquatic environments, docks, piers, and applications where wood will be exposed to water. ACZA treated poles protect against the major causes of wood degradation: decay and termites (including Formosan), marine organisms, carpenter ants, and woodpeckers. Hydro Quebec has shared that they have significant carpenter ant and woodpecker pole related issues and are thus looking at testing ACZA poles in certain areas beginning in 2022.

## Material Supply Chain Challenges

Supply chain issues and inflationary pressures have a significant impact on VEC's ability to provide the most reliable and lowest cost electric service to our members. Both also play a part in our ability to meet our members' demands (e.g., upgrades, new services, etc.) in an expeditious manner. VEC continuously monitors market intelligence reports and weekly updates from our primary equipment vendor WESCO to understand current impacts, make judicious business decisions (e.g., reprioritization work), and forecast future effects.

The challenges with regards to VEC's supply chain of materials includes the following:

1. According to market intelligence reports, VEC has not seen the full impact of the current market price increases. VEC's NISC system uses a blended price for major materials, so as we deplete old stock and replace with new, the price is adjusted within the system. Since we have not depleted older material bought at lower prices, overall costs for internal and member work could increase for several months before leveling.
2. Minor material has not seen the significant increases over the past year unlike major material, staying relatively flat with minimal increase. In turn, our stores rate/overhead charges have remained at 28 percent since January 2021.
3. Lead-times for major material purchases are a significant challenge for VEC's ability to meet necessary timeframes and expectations of our members. For example, pole-mounted units have a 52-week lead time and pad-mount transformers have an 84-week lead time. However, almost all other material lead-times are increasing. Poles are the only major material that does not seem to be impacted by long lead-times.
4. Increasing fuel costs in conjunction with lack of transportation (e.g., decrease in freight drivers, ports not being able to offload material from waiting ship) is another challenge. Not only are higher fuel costs adding to the cost of material, lead-times are affected by the inability to transport those materials to VEC.
5. The war between Russia and Ukraine is having a global impact on many raw materials used in the utility industry. For example, nickel and porcelain are two examples and currently in short supply. There is a lot of volatility in with aluminum and copper due to many industries focusing on electrification causing additional challenges to procure utility equipment (e.g., battery and electric car manufacturers).
6. The entire supply chain and manufacturing both domestically and globally is still recovering the COVID-19 pandemic from 2020 through the end of 2021. Manufacturing and supply chain increases are starting to recover but in many areas are still lagging pre-COVID levels. This is especially true in major exporters such as China. However, returning to pre-COVID levels may not occur for several months as many companies have been force to reduce hours or days of production due lack of workforce.
7. Purchase decisions must be made much more quickly. Rather than having 30-60 days to decide on a purchase from a price quote, most manufactures are only giving 24 hours or less to place the order and retain the right to make market adjustments as necessary due to material deficiencies, fuel, or other natural and man-made disasters.

VEC is addressing these challenges by:

1. Increasing the amount of on-hand/in-stock major inventory by approximately $600,000 to help counter the slower replenishment rate.
2. High turnover items such as transformers, cutouts, poles, etc. are closely monitored weekly for in stock quantities and orders placed, accordingly.
3. Sourcing material from other vendors outside of primary vendor WESCO such as Graybar, Irby, CED/Twinstate, Green Mountain Electric Supply, and United Utility Supply. We are using every avenue we have at our disposal to augment material that WESCO may be lacking or have longer lead-times. VEC is also working with other Electric Utilities to exchange and replace material as material is delivered to one utility or another.
4. Shifting from purchasing only new transformers to utilizing companies that rebuild transformers (e.g., T&R Electric, Emerald Transformers, Florida Transformers, etc.). Rebuilt transformers typically tend to have shorter lead-times but we are unsure to the longevity of these transformers which may impact future capital replacement schedules.
5. Salvaging material is assessed for reuse. For example, older non-PCB transformers that may be slightly rusted or need repainting but are dielectrically good are no longer automatically disposed. We are assessing this reuse for other materials such as cutouts, hardware etc.
6. Sending out bi-weekly reports key stakeholders across VEC indicating stock quantities of key items, current pricing, percentage cost increase from different time periods, lead times, order/arrival status, etc. VEC monitors market analysis reports focusing on Utility Market Commodity Impacts. Scheduling meetings are much more frequent and work changes implemented weekly to accommodate for material shortages. Finally, long lead time items required for future jobs are brought into inventory as soon as possible, sometimes months in advance of the project start date to ensure no delays for the membership.

While VEC continues to look for innovative ways to mitigate the impacts of the supply chain and increasing inflationary pressure on material prices, we cannot eliminate all risk to our members. “Keeping the lights on” is VEC’s number one priority and this may mean we make hard choices between prioritizing reliability project and delaying a member request for a new service or upgrade. These decisions are not easy but are imperative to ensure we maintain the safest and most reliable grid possible.

### 8.3.4 Collaboration with other Entities

VEC maintains several joint substations with Green Mountain Power (GMP) and VELCO.

- GMP – Richmond #8 Substation, Cambridge #3 Substation, Jay Tap #39, Taft’s Corners #9, and Lowell #5 Substation.
- VELCO - Jay Tap #39, Newport #44, South Hero #29, and Taft’s Corners #9.

An example of collaboration includes a project VEC is working on with GMP at its jointly owned Richmond #8 Substation to add breakers to the two incoming GMP 35 kV transmission lines and VEC’s radial line to Hinesburg. This improvement in system protection will automatically sectionalize GMP’s lines keeping the Richmond and Hinesburg members energized if a fault exists on the GMP transmission system fed either side of the Richmond substation.

### LED Replacements Collaboration with VEIC

In October 2011, VEC began working with Efficiency Vermont (EVT) to determine our stranded costs for converting older streetlight technologies such as high-pressure sodium (HPS) to the more efficient LED technology. VEC determined that the average stranded cost was $175 and EVT offered a $100 per light rebate, leaving with the towns to pay VEC the $75 difference. We calculated how long it will take each town to recover the $75 in monthly savings from the more efficient LED lights. Some towns chose to eliminate unnecessary lighting while others chose to convert to LEDs. To date, VEC has replaced older technology streetlights with 1,292 LEDs in all the towns it serves except for Charleston

The savings per year from these conversions is roughly 724,000 kWh. The project is ongoing, and VEC expects towns to complete conversions by 2023.

## 8.3.5 Duplicate Electric Facilities

In 2004, VEC acquired Citizens Utilities, identified significant overlap of the two systems, and has since made efforts to consolidate the two systems resulting in operations and maintenance (O&M) cost savings and in many cases improved reliability to VEC members. There are two remaining locations where there are opportunities for further consolidation that VEC expects to complete this work by the end of 2024. These locations are:

- 11 Spans of cross-country single-phase line off Loop Road in Westfield.
- 3500 feet of single-phase line off Route 105 in Troy.

In cases where duplication exists with other utilities, VEC will work with the other utilities to eliminate this duplication.

## 8.3.6 Flood Plains

When considering locations to build or relocate a substation, VEC reviews all environmental impacts to ensure the least cost, most reliable solution. Among other considerations, VEC reviews current Flood Insurance Rate Maps (FIRMs) available through the Flood Map Service Center (MSC) for each substation location. The FIRM maps are the official public source for flood hazard information produced in support of the National Flood Insurance Program (NFIP). Unfortunately, VEC was unable to find FRIM maps for seven of our 38 substations.

For locations where a FIRM was available, each location was mapped using a street addressing and or coordinate based search to find the most current (if available) flood map (FIRM panel or FIRMette) for the local area. VEC completed an evaluation of each location to determine if the site was located within the 100 or 500-year floodplain.

Where no FIRM data was available, VEC performed an analysis using the local Vermont Department of Environmental Conservation (DEC) Flood Ready Atlas to confirm local flood data. **Based on available information VEC has determined that none of its 38 substations are in the 100- or 500-year flood plain.**

## 8.3.7 New Services

VEC continues to see significant growth in new service applications and construction in its territory. 2021 was VEC's largest year on record for member applications.

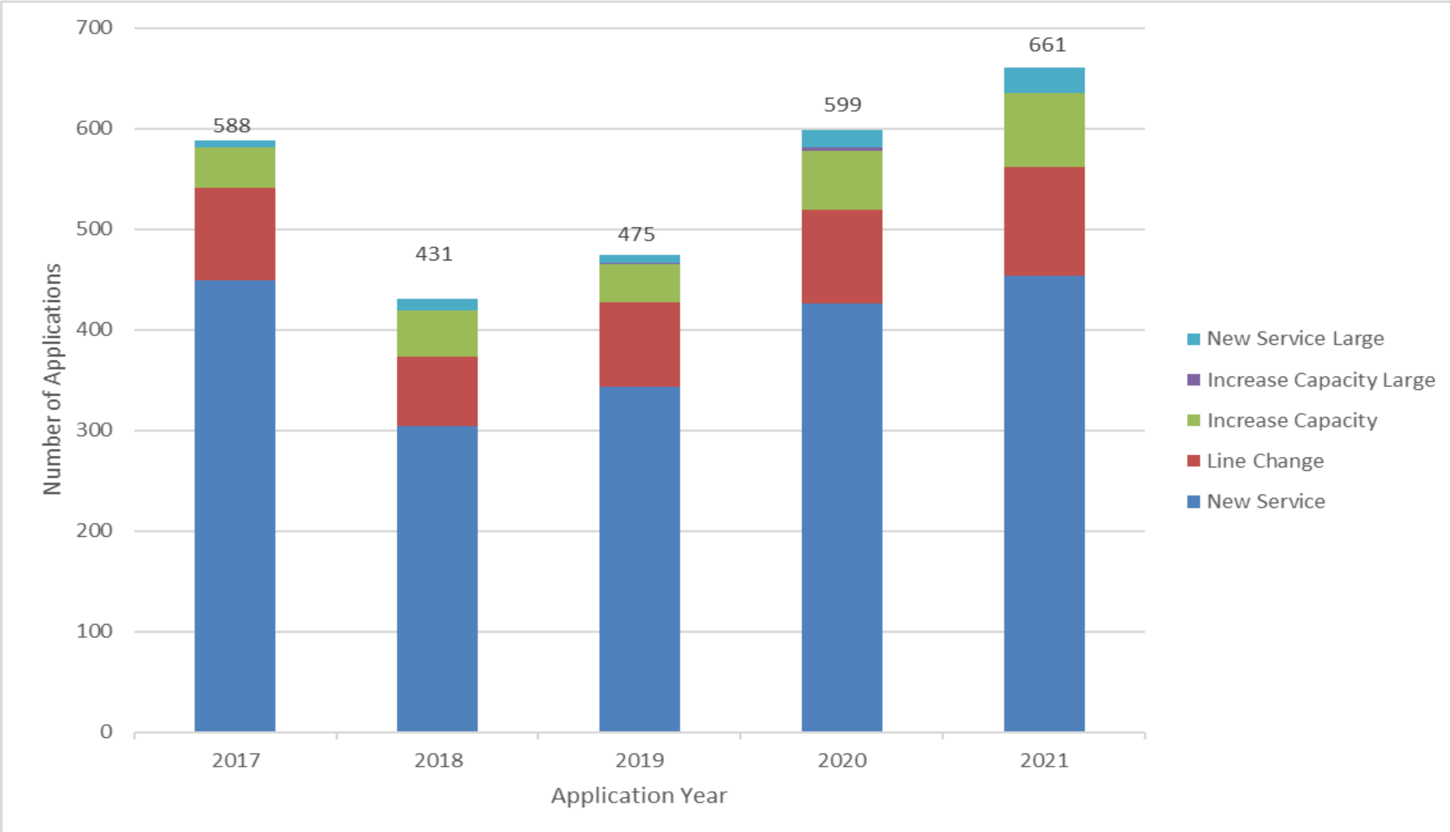



*Figure 8.3.7.A Member Applications received 2017-2021*

Most of these applications have come in the western part of VEC's service territory, Chittenden, Grand Isle and Lamoille counites.

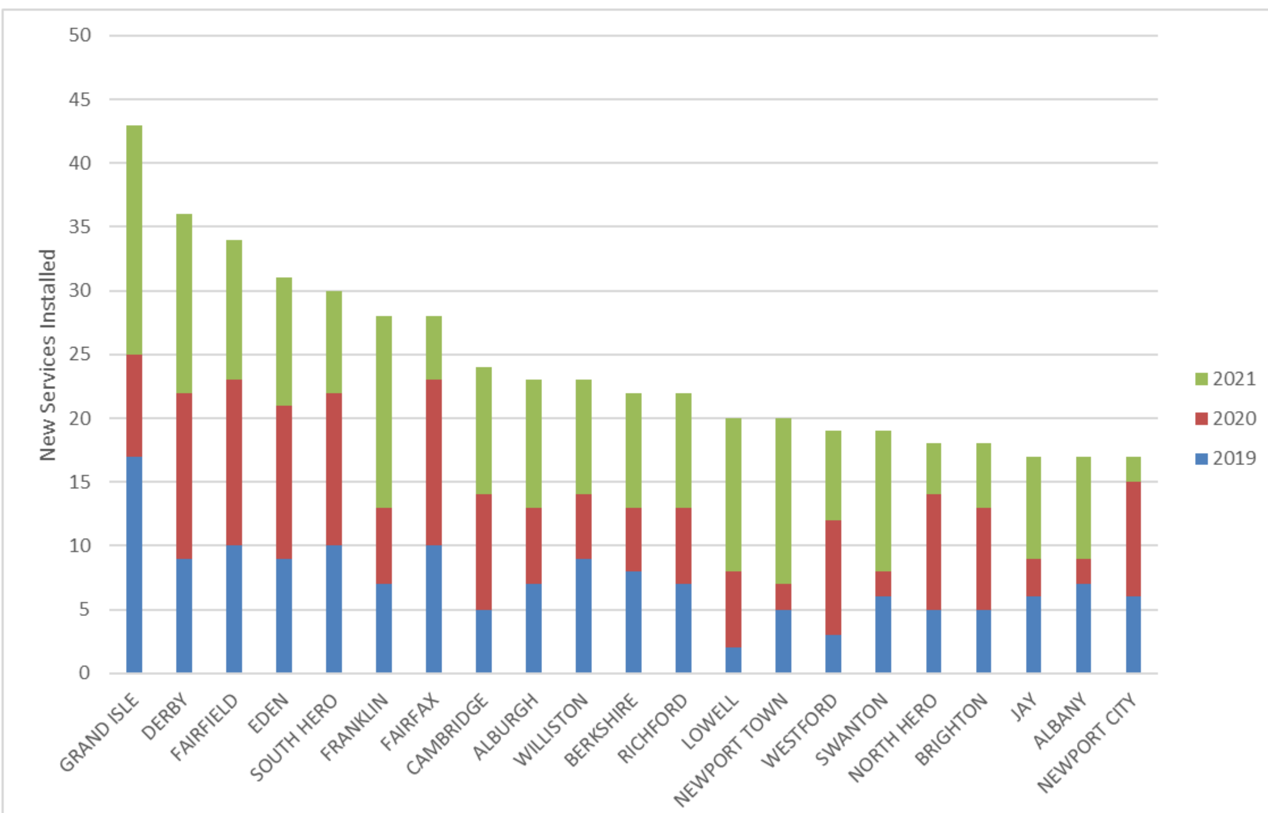


*Figure 8.3.7.B  New services installed by town (Top 20) - 2019-2021*

VEC installed 351 new services in 2021, up from the previous high of 307 in 2020. This is a 13% increase.

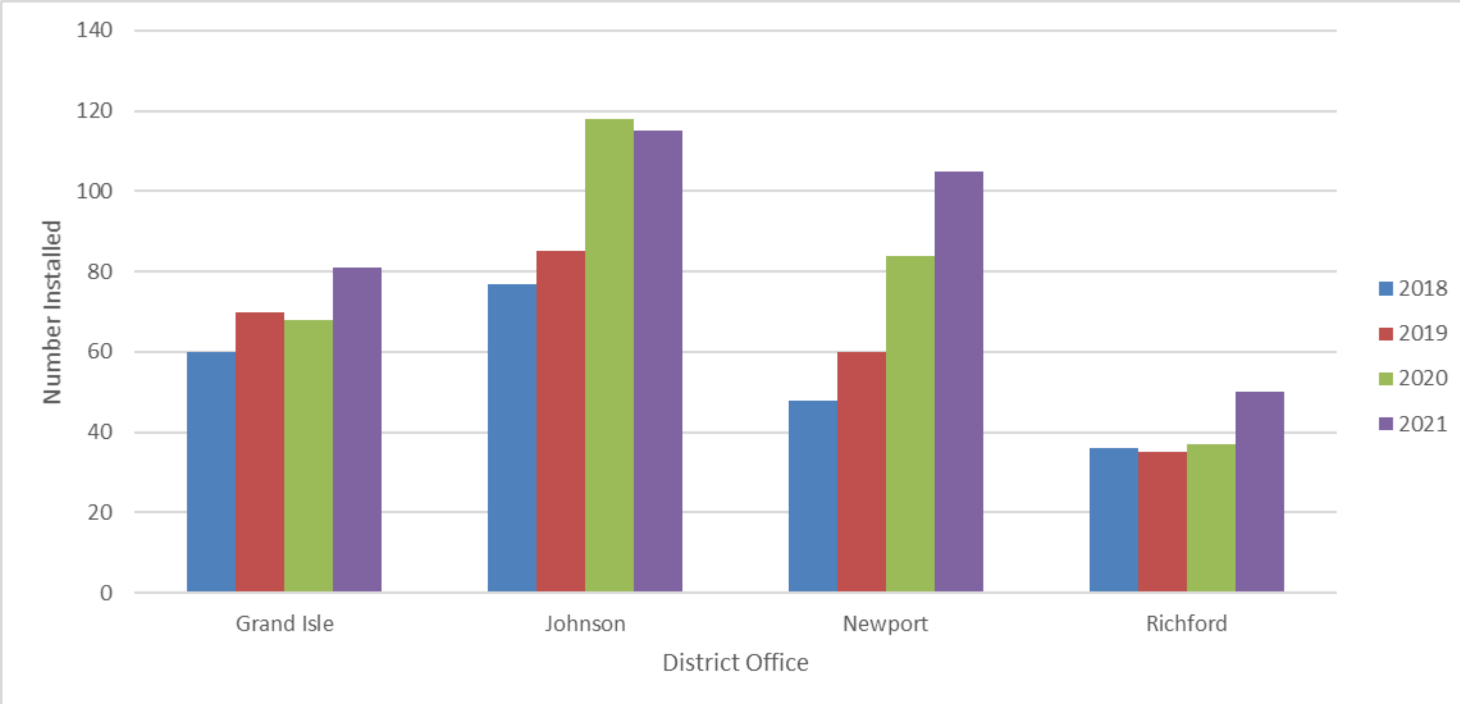



*Figure 8.3.7.B  New services installed by district - 2018-2021*

Roughly 1 in 10 new service projects are abandoned by the prospective member.

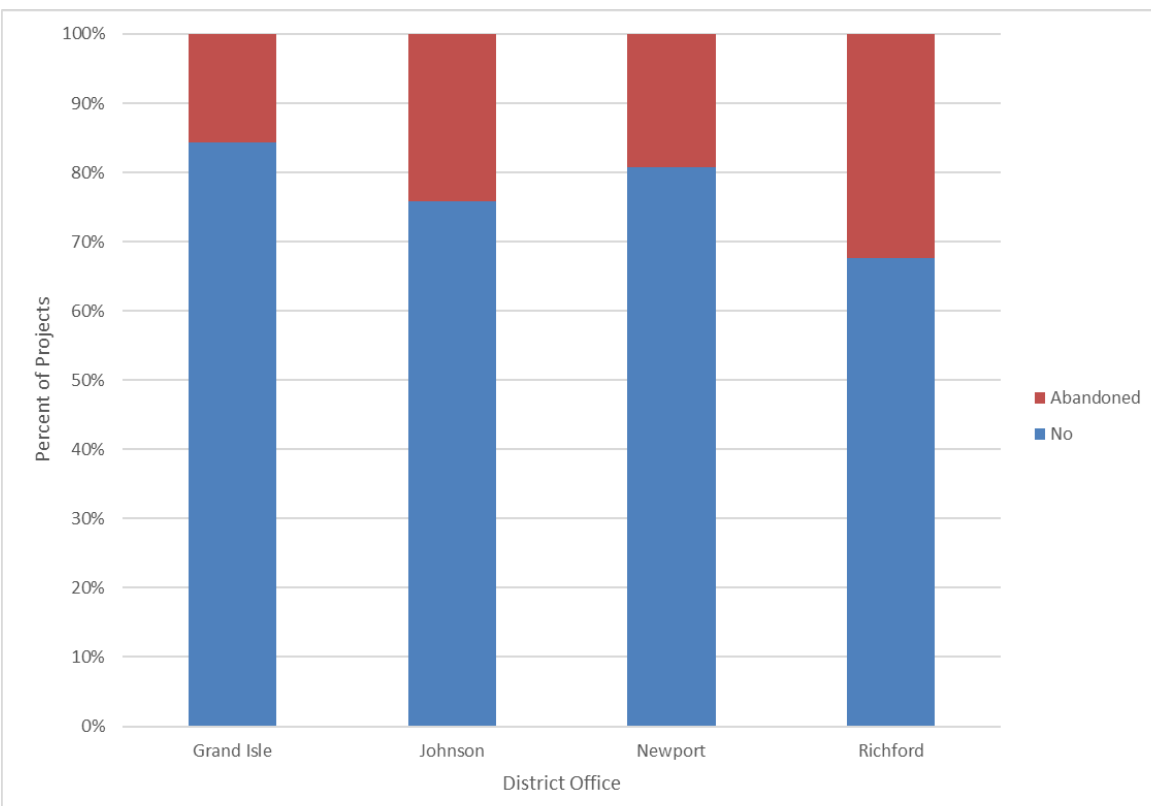



*Figure 8.3.7.C Percent of projects abandoned by Service District - 2019-2021*

Roughly 20 percent of projects are true line extensions. The remainder are additional meters or meters on poles.

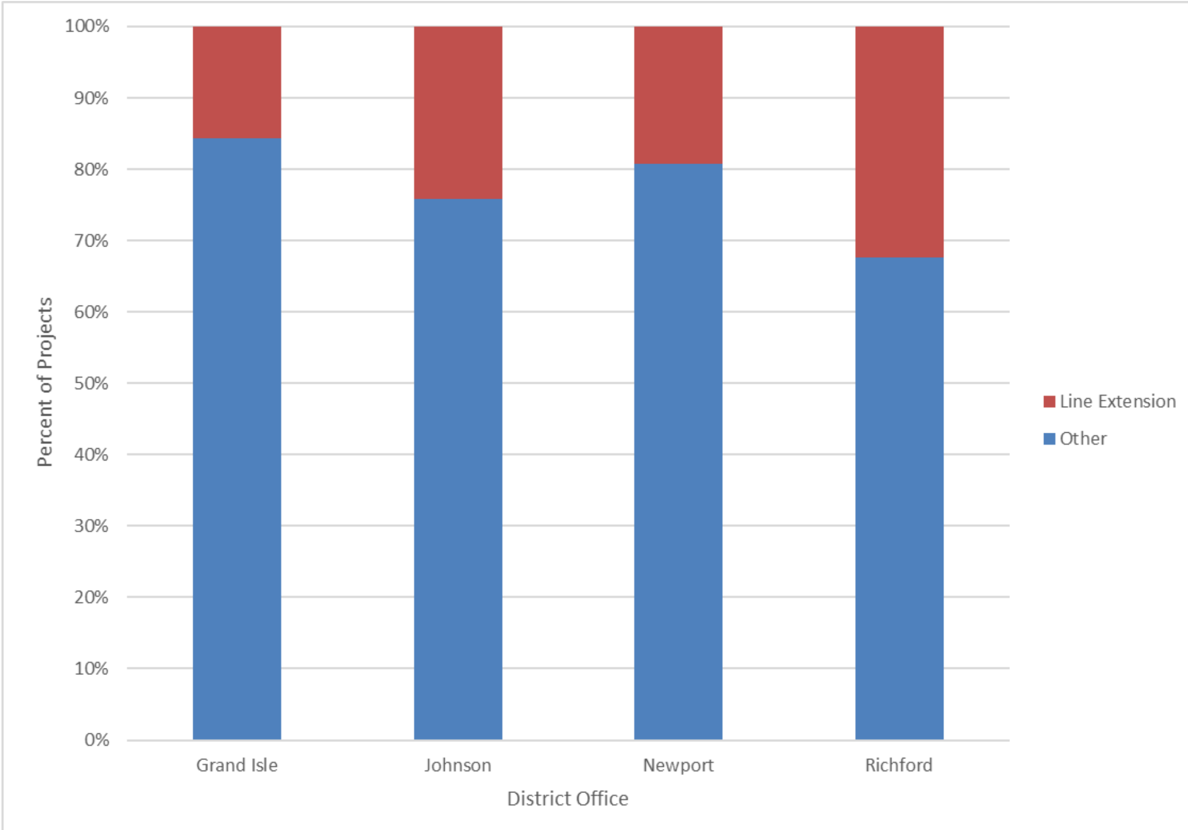



*Figure 8.3.7.D Percent of projects that are line extensions by Service District - 2019-2021*

## 8.4 Attaching Entities and Broadband

### 8.4.1 Attaching Entities

VEC has several telecommunications entities that attach to its distribution system. These entities are broken down into three categories: Joint Use, Joint Ownership, and Attachee. Each entity utilizes the National Joint Utilities Notification System (NJUNS) web-based electronic work management tool to communicate and monitor work requests. The system provides extensive reporting, tracking, and searching capabilities that helps construction and monetary timelines, defines responsibilities, and monitor dual poles.

VEC recognizes that jointly occupied pole lines require larger poles of higher cost, but there are substantial cost savings when compared to the total investment dollars required of multiple companies if they constructed their own separate facilities. In addition, aesthetic and environmental impacts are lower with one line versus multiple.

#### Make Ready Process

VEC's make ready process begins when an application is submitted by the attaching entity along with payment for the field survey to be conducted. Our Utility Designers schedule the field survey with any joint owners and the entity applying to attach. During this survey, all poles are reviewed to ensure they meet NESC standards. If any are found not to meet NESC standards either due to structural integrity or lack of space, these issues are corrected at the pole owner's expense. If the pole does meet NESC standards but is not able to support another attachment, the pole will be replaced at the expense of the attaching entity. All other simple make-ready tasks are also done at the expense of the attaching entity.

Most poles do not require any work prior to the new entity attaching. From 2018 through 2021, VEC surveyed 3,461 poles with a total of 305 requiring work be done by VEC, a little less than 10 percent. Of the poles that do require VEC to perform make ready work, 73 percent are considered "simple make ready" as defined in PUC Rule 3.700, typically raising the electrical neutral or service on the pole.

Once the survey is completed, an invoice is generated for the anticipated cost of the work required unrelated to NESC violations. Simple make ready work is a fixed cost per pole as defined in tariff pricing approved by the PUC (currently $346.00). Capital work, primarily pole replacements, is billed at actual charges for labor and materials, subject to reconciliation once work is complete. Once payment for this invoice is received, the work orders are released to the construction department.

To date, VEC has been able to meet or exceed the timeframe requirements as defined in PUC Rule 3.700. We anticipate in the future there may be times when we will have to rely on contractors to meet these timelines and have had discussions with multiple contractors to ensure this will not be an issue.

Once VEC's work is complete, the signed license is provided to the attaching entity and their construction can begin (e.g., installation of cable, fiber, etc.). In parallel with the attaching entity completing their work, VEC reconciles all labor and material charges for capital work and a credit or invoice is issued to the attaching entity.

## Joint Use

Each entity owns their poles and can set or replace their own poles. The poles are jointly shared pursuant to rental agreements invoiced under 3.700 tariff rates. Both Waitsfield Telephone and FairPoint Classic are classified as Joint Use with VEC.

## Joint Ownership

VEC has five existing joint ownership agreements:

- Consolidated Communications (CCI) – Approximately 28,000 poles.
- Franklin Telephone – Approximately 1,300 poles.
- Washington Electric Cooperative (WEC) – Approximately 100 poles.
- Barton and Orleans – Approximately 170 poles on the H16 transmission line.
- Green Mountain Power (GMP) – Approximately 450 poles.

VEC and the joint-ownership parties generally follow Inter-Company Operating Procedures (IOPs). Utility owners put these IOP's in place to ensure effective savings in capital investment for both companies.

### Consolidated

CCI is VEC's largest joint owner with approximately 28,000 jointly-owned poles. Each company has several designated "maintenance areas" – towns where it is responsible for pole sets - which are shown in the image below:

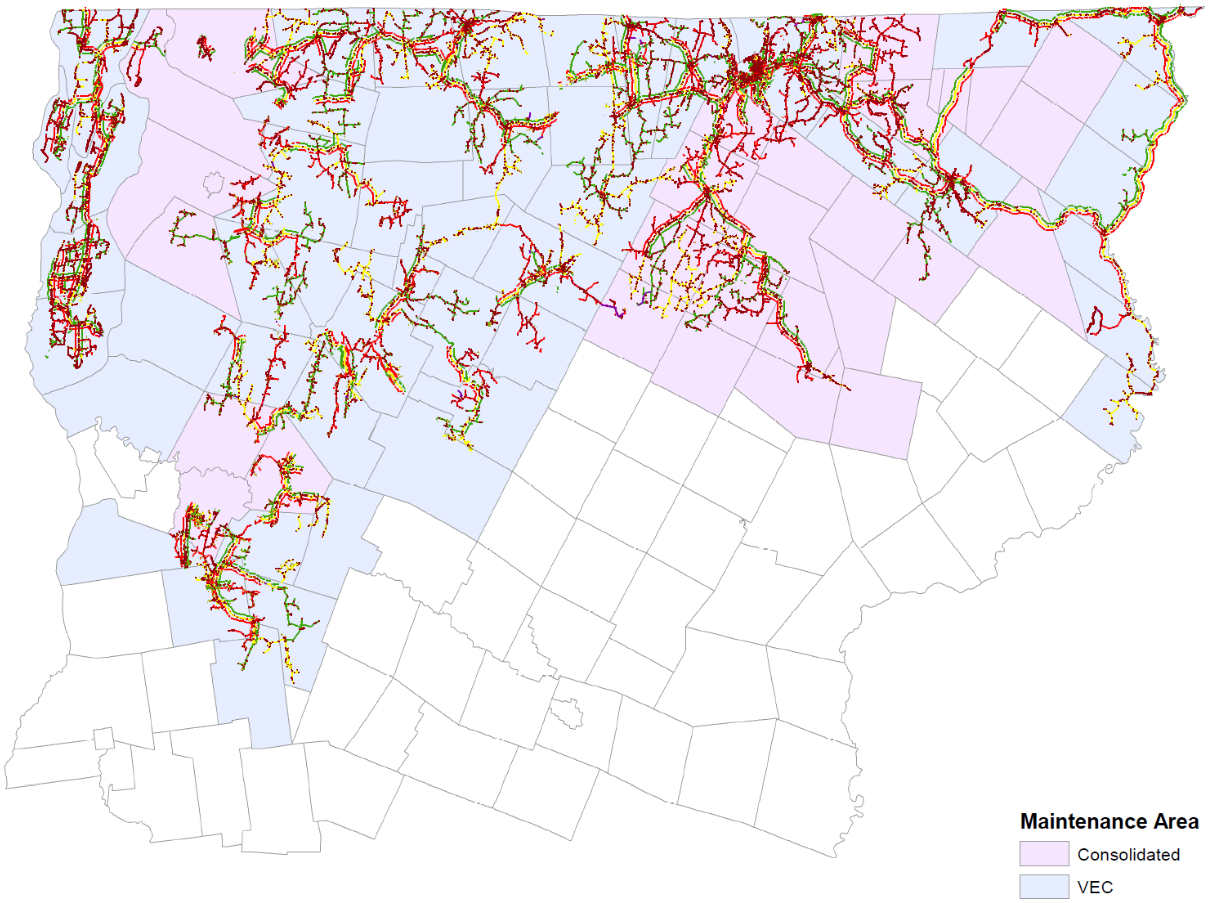



*Figure 8.4.1.A VEC and Consolidated Communications maintenance areas*

In 2018, VEC reached an agreement with CCI whereby VEC took over sole ownership of approximately 7,700 poles and updated certain IOPs. In 2020, VEC took sole ownership of 1,399 additional poles from CCI.

VEC continues to jointly own approximately 28,000 poles with CCI (~48 percent of poles).

#### Attachee

Attachee entities are cable, antenna, communication providers, or municipalities that attach to poles owned by VEC under the terms of Vermont PUC Rule 3.7. Entities such as Comcast, Mansfield Fiber, Stowe Cable, and Verizon Wireless as are classified as an Attachees.

### 8.4.2 Fiber and Broadband

In addition to working with the cable TV and phone attaching entities described above, VEC continues to support the rollout of broadband, to underserved communities in Vermont. VEC will support entities looking to expand broadband into underserved or uneconomic by leveraging our infrastructure, data, technical expertise, and processes.

In early 2020, VEC received a state grant for a feasibility study to examine three possible scenarios for VEC to enter the broadband arena:

1. full deployment of broadband within its territory over a four-year period,
2. a more limited deployment to key underserved areas, and

3. a partnership model where VEC would fund and construct a fiber backbone but would not become a broadband provider. The study also modelled the possibility and risk of obtaining Rural Development Opportunity Fund (RDOF) dollars to augment VEC's investment. The results of the study showed that even with RDOF funding, all three options would impose significant financial risk on VEC's members, and our Board declined to move in that direction.

While showing that becoming an internet service provider was not an option for VEC, the feasibility study and subsequent discussions helped sharpen our goals with respect to broadband:

- Leverage VEC's resources to accelerate and support broadband for our members. This includes access to GIS information and a commitment to following the established 3.700 requirement and timelines for pole attachments and make-ready work.
- Define VEC's unique role in broadband deployment, i.e. what would not get done without us?
- Represent VEC electric cooperative member's interests: balance risk and move forward aligned with VEC's financial and strategic goals.
- Collaborate to succeed without redundancy in our service territory, supporting all who improve rural internet connectivity.
- Grasp smart opportunities, particularly grants, in this evolving broadband world.

We believe that supporting broadband deployment in unserved locations in our service territory will help remove inequities and allow all VEC members to participate fully in all VEC's services. VEC's service territory is rural, and economic development efforts have often been challenging. We have been heartened by a recent surge in new services or service upgrades as people move to or expand their homes in Vermont. We have also heard, anecdotally, that potential new residents pass over properties that lack adequate internet service. In addition, our feasibility study included a member survey which provided significant support for VEC to move forward with initiatives that support broadband.

With internet access becoming more of a necessity, expanded broadband access, especially to the unserved locations within VEC territory, could have significant impact on the vibrancy of the towns and communities in Northern Vermont. The COVID-19 pandemic has also demonstrated that the internet enables important options that will improve people's lives. These include the ability to access telehealth resources, the flexibility for working or studying from home, the ability to connect remotely with loved ones or colleagues, and the ability to participate in public life.

## Tariff Rider

In February of 2021, VEC proposed and the PUC approved a three-year pilot program to provide a discount on make-ready costs to broadband providers who extend service to unserved areas within VEC's territory. More specifically, VEC provides a $2,000 discount on necessary make-ready construction costs per unserved address as designated by the Department of Public Service or a successor agency tasked with making such a designation. This is a credit to capital construction costs only and would be capped at $3 million over the three-year program with the intention to allocate $1 million each year of the pilot program. The discounts would generally be awarded on a first-come, first-serve basis for the unserved address passed with each address eligible for only one discount from VEC. Unserved areas are defined as having internet speeds less than 4 Mbps down and 1 Mbps up (4/1). To be eligible for the discount, the broadband provider must provide internet speeds at or greater than FCC Standards (25 Mbps down and 3 Mbps up, i.e. 25/3) and complete construction within 15 months of acceptance into the program.

### Make Ready Miles

While VEC did not receive as many applications from Communication Union Districts (CUDs) and other new providers as anticipated, we have seen a marked increase beginning in late 2021 due the focus on broadband initiatives in Vermont. We suspect that this trend will continue for the next several years.

The chart below details the number of make ready miles and poles VEC has replaced from 2017 to what we expect to see in 2022.

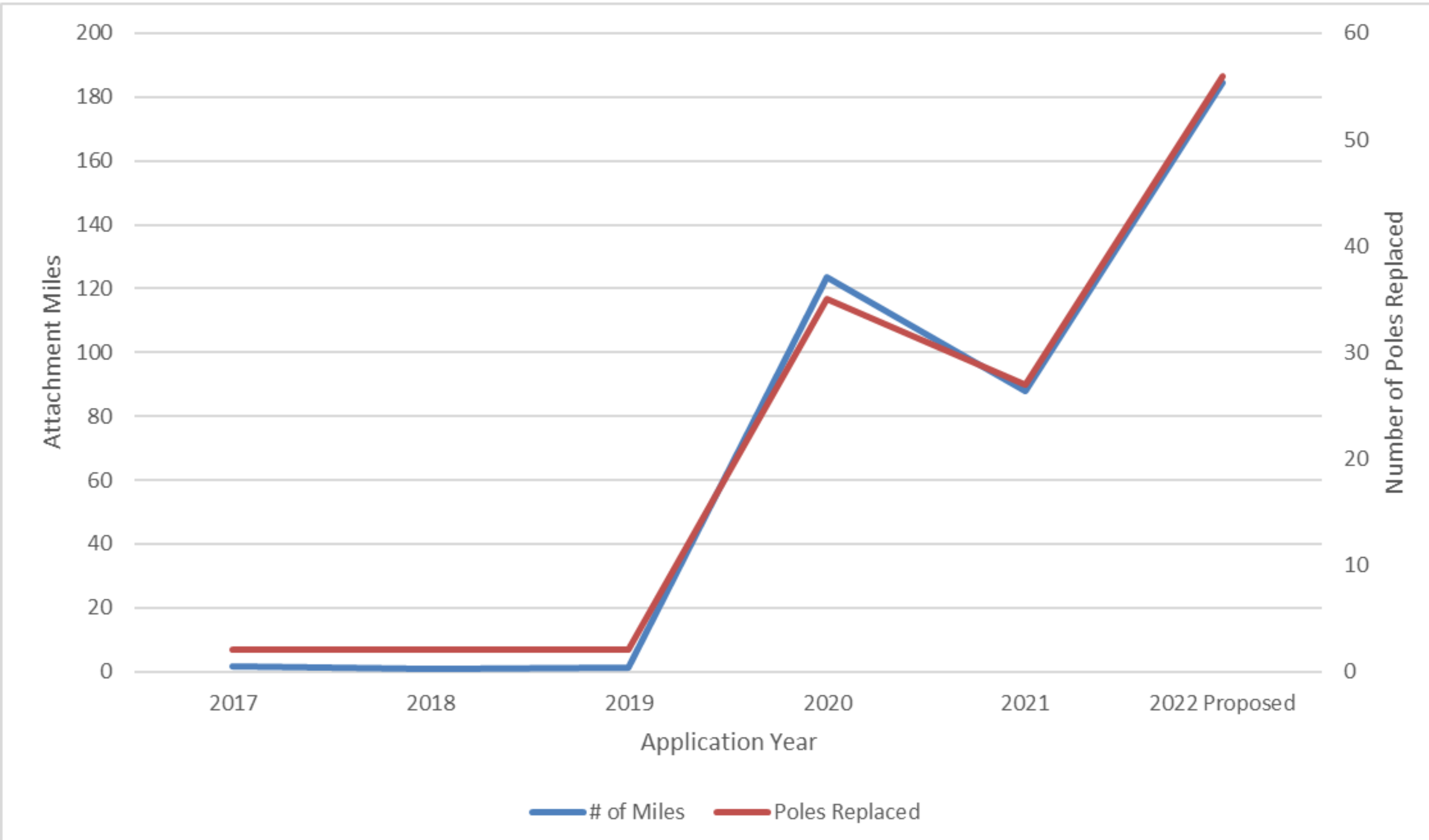



*Figure 8.4.2.A Number of make ready miles and poles replaced 2017-2022 Proposed*

## 8.5 VEC Safety

VEC takes the safety of our members, employees, and the community-at-large seriously. We share recommendations with our members on various safety topics, including how to use a generator safely and how to be safe during an outage, and we produce regular safety videos which are all available on our website https://vermontelectric.coop/electric-system/safety. We regularly share safety-themed messages with our members through our social media venues as well as the quarterly "Coop Life" newsletter.

### 8.5.1 VOSHA VPP

Vermont's Occupational Safety and Health Administration (VOSHA) awarded Vermont Electric Co-op the Green Mountain Voluntary Protection Program (VPP) health and safety designation in 2017 and we have maintained that status ever since. VEC's preparation for VOSHA's on-site review took more than five years and addressed a total of 28 safety and health elements. During the on-site review, VOSHA compliance officers conducted an intensive inspection of VEC's four district facilities and dove deeply into VEC's safety programs. The review included 14 formal interviews and more than 25 informal interviews.

To be recognized, VEC had to demonstrate a strong history of management commitment to safety and employee involvement in safety programs. VEC also had to show strong processes for worksite analysis, hazard prevention and control, and employee safety and health training. VEC is the only power distribution utility in New England currently with the high-level VPP recognition, and joins just five other non-utility organizations across Vermont with the certification. Our relationship with VOSHA propels us to make continuous improvements to all aspects of our safety program, which includes internal and external focuses.

### 8.5.2 Safety Teams

VEC has several safety teams focused on various aspects of the company's safety culture.


- **<u>The Safety Committee</u>** is made up of VEC field and office personnel and is focused on updating the VEC safety manual to bring it up to date with current standards and practices.
- **<u>The Health and Wellness Team</u>** creates programs and activities that foster a culture of wellness within VEC -- with a continuing emphasis on health and wellness while working remot. VEC received the "Outstanding Culture of Well-Being" award from Cigna Life and Health Insurance Co., for the third consecutive year and we

were the only US organization to receive this award for three years. Likewise, VEC was awarded the Governor's Vermont Worksite Wellness Award for the eighth consecutive year.

- **The Incident Analysis Team** conducts 4-step investigations for injury or near miss events that warranted an investigation.
- **The Safe Worksite Analysis Team (SWAT)** has conducted facility inspections for over nine years, and focuses on organization and cleanliness of our four district offices.
- **The Communications Team** focuses on issuing our employee safety-themed calendar, summer safety quiz, and our annual Safety Pledge that all VEC employees sign.
- **Joint Apprentice Training Committee (JATC)** reviews apprenticeship steps, requirements, expectations, and documentation. Last year the JATC also established a 34.5 kV gloving/hot work apprenticeship program for First Class Line Workers.
- **The First Aid Team** receives biennial certifications in first aid, CPR and AED. If needed they respond to any injury events within VEC district offices.

### 8.5.3 Damage Prevention Plan

VEC is a member of Dig Safe and adheres to their procedures for the mapping, marking of our facilities and locating of our facilities. We contract locate services to Vermont Underground Locators (VTLocators) and map all transmission, distribution primary, and secondary underground facilities in our GIS system. VEC does not map member owned secondary systems but our underground locating contractor, VTLocators, will locate them when requested by VEC or the member. In addition to mapping, VEC marks new underground systems with marking tape and above ground stakes.

VEC utilizes an internal OP-26 that identifies procedures and protocols for marking, locating VEC facilities, and the protocols for VEC excavating work. VEC's procedure follows PUC Rule 3.800 and V.S.A. Chapter 86 to guarantee the reliability of service to our members, avoid damage to VEC underground facilities, and ensure the safety of our employees and the public. VEC OP-26 can be found in Appendix-E.