Vermont Electric Cooperative, Inc.

Vermont PUC Rule 4.900

2023 Electricity Outage Report

January 31, 2024

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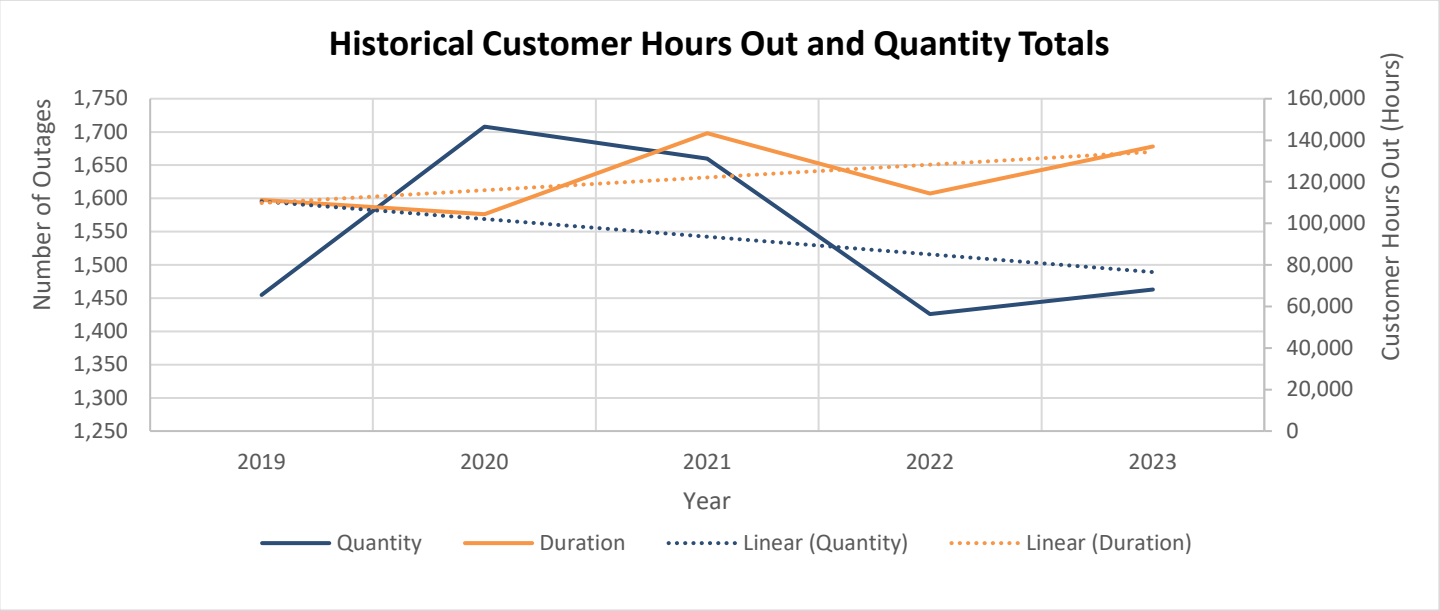
1 Executive Summary

This report contains a detailed assessment of Vermont Electric Cooperative's (VEC's) 2023 outage performance and a plan for how to improve reliability to its members. VEC's 2023 System Average Interruption Frequency Index (SAIFI) and Customer Average Interruption Duration Index (CAIDI) year-end indices, excluding all major storms, were 1.38 and 2.48, respectively. The SAIFI and CAIDI, including major storms, were 2.25 and 3.60, respectively, as shown in the table below.

	SQRP Goals	2023 without Storms	2023 with Major Storms
SAIFI	**2.5**	1.38	2.25
CAIDI	**2.6**	2.48	3.60

This report follows the Vermont Public Utility Commission's (PUC) 4.900 Rule definitions. As a result, the information provided here includes only outages greater than five minutes. However, VEC does include all company initiated, power supplier, and weather-related outages. The report excludes major storm outages from the data, and they are discussed separately in the Storm Exclusions section below.

The figure below details VEC's outage durations and quantity from 2019-2023.



VEC saw an increase in outage duration and outage quantity in 2023. And, the general trends are flat or slightly increasing. VEC plans to utilize the following process to continue to improve system performance:

1. Continue to utilize locational outage report data to determine specific reliability improvement projects for the worst performing circuits including devoting Transmission and Distribution (T&D) capital spending to reliability improvement projects.
2. Continue implementing the comprehensive maintenance plan to enhance reliability and proactively reduce preventable outages for VEC's members. Information gathered from this program will assist with various studies and system-wide root cause analyses to enhance specific maintenance initiatives, starting with VEC's worst performing circuits.

3. Continue to pursue hazard mitigation funding through FEMA and the State of Vermont.
4. Continue to implement proactive vegetation management strategies in accordance with VEC's long-range Vegetation Management Plan with a focus on proper planning, scheduling, the use of data to prioritize maintenance activities, and integration of advanced technology, tools and equipment to improve program efficiencies and overall system performance.
5. Pursue opportunities to perform construction and maintenance activities in a manner that reduces the need for company-initiated outages.

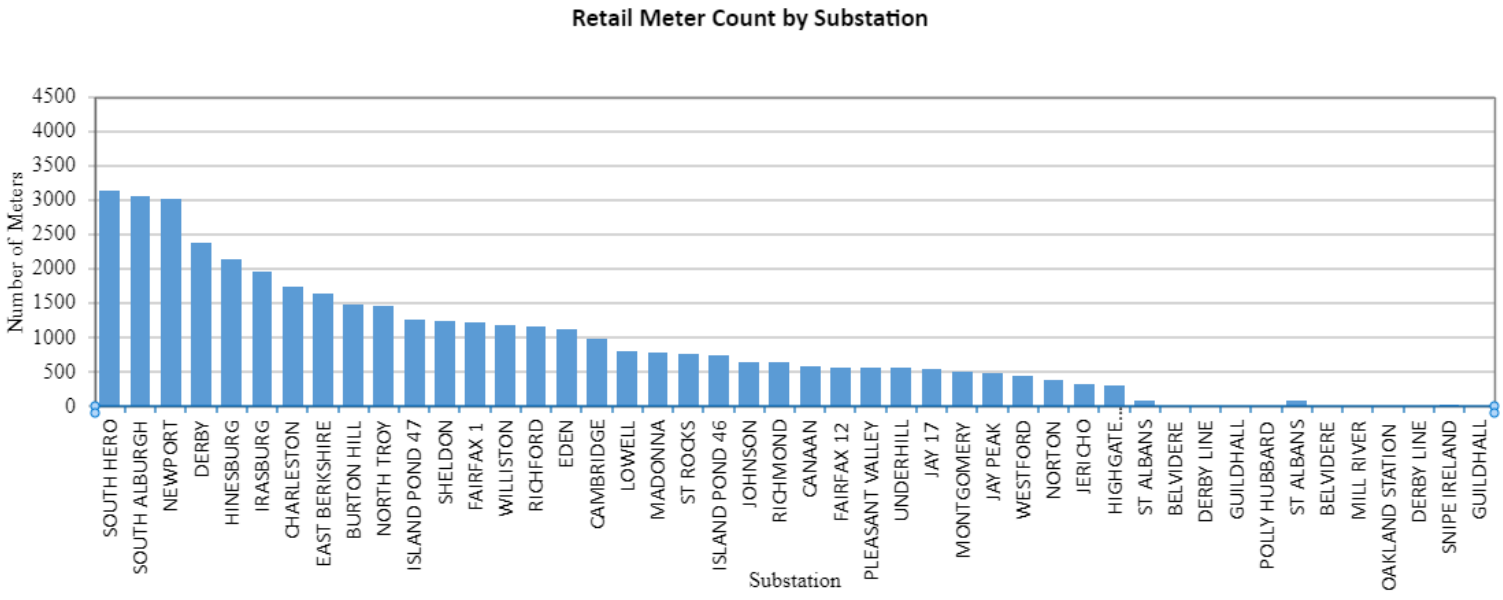
2 Vermont Electric Cooperative

VEC is a rural, member-owned, not-for-profit, electric cooperative utility that presently serves approximately 40,245 retail meters in 74 towns throughout Northern Vermont. VEC's territory stretches across Addison, Caledonia, Chittenden, Essex, Franklin, Grand Isle, Lamoille, and Orleans counties.

VEC operates 159 miles of transmission lines and approximately 2,500 miles of distribution overhead and underground lines. VEC owns and operates 32 substations and 4 primary metering points. VEC is interconnected with, and served by 5 VELCO connections, 13 GMP connections, 2 Eversource (formerly PSNH) connections, 3 Hydro-Quebec connections, and 1 connection to Swanton Village Electric.

VEC tracks all outages, compiles outage statistics, and continually monitors system performance with a goal of providing exceptional service to its members. In accordance with the Vermont PUC Rule 4.900, VEC submits this report, which analyzes system performance and proposes affirmative plans for future improvement.

On average, VEC serves approximately 1,100 consumers per substation or meter point and averages 15.98 meters per mile of distribution line. The following table represents the number of retail meters served by each substation or metering point area at the end of 2022.



3 Storm Exclusions

VEC experienced the following major storm events in 2023:

1. Winter Storm Gerald - The November Snow Event started on November 27 at hour 01:55 and ended on November 28 at hour 19:40. At peak, the storm caused over 17,910 VEC meters to be without power and 229 outage events occurred during the storm.

2. Winter Storm Jake – The December Snow event started on December 3 at hour 23:27 and ended on December 5 at hour 15:43. At peak, the storm caused over 8,405 VEC meters to be without power and 178 outage events occurred during the storm.

3. Winter Storm Kendall – The December Snow Event started on December 11 at hour 02:28 and ended on December 13 at hour 12:00. At peak, the storm caused over 37,052 VEC meters to be without power, and 402 separate outages.

VEC's Service Quality & Reliability Plan ("SQRP") defines a major storm as a severe weather event that satisfies all three of the following criteria:

1. Extensive mechanical damage to the utility infrastructure has occurred;
2. More than 10 percent of the customers in a service territory are out of service due to the storm or the storm's effects; and
3. At least 1 percent of the customers in the service territory are out of service for at least 24 hours.

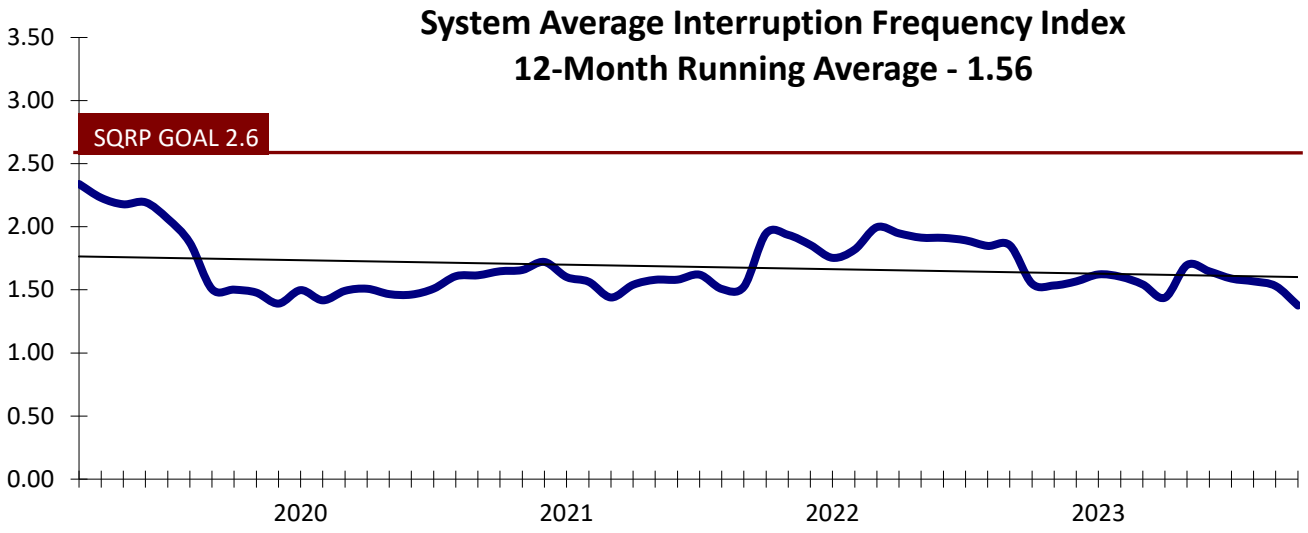
4 Outage Assessment

4.1 Long Term Trends (Major Storms Excluded)

Below are the five-year SAIFI and CAIDI trends.

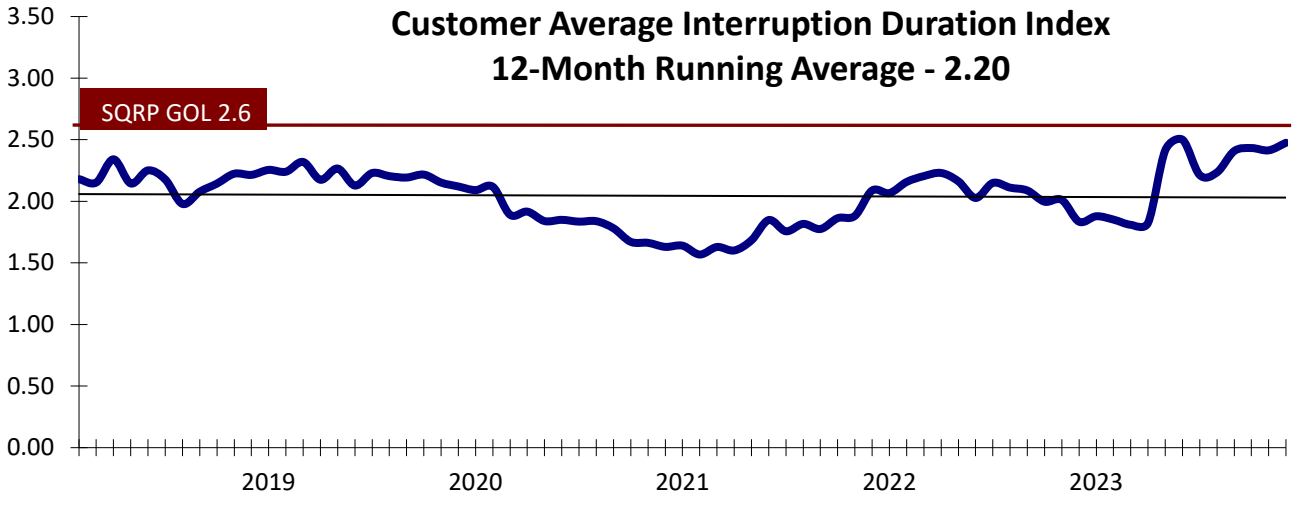
4.1.1 Long Term SAIFI Performance Trends

VEC tracks a monthly running 12-month SAIFI average. The table below shows SAIFI performance back to January 2019.



4.1.2 Long Term CAIDI Performance Trends

VEC also tracks a monthly running 12-month CAIDI average. The table below tracks CAIDI performance back to January 2019.

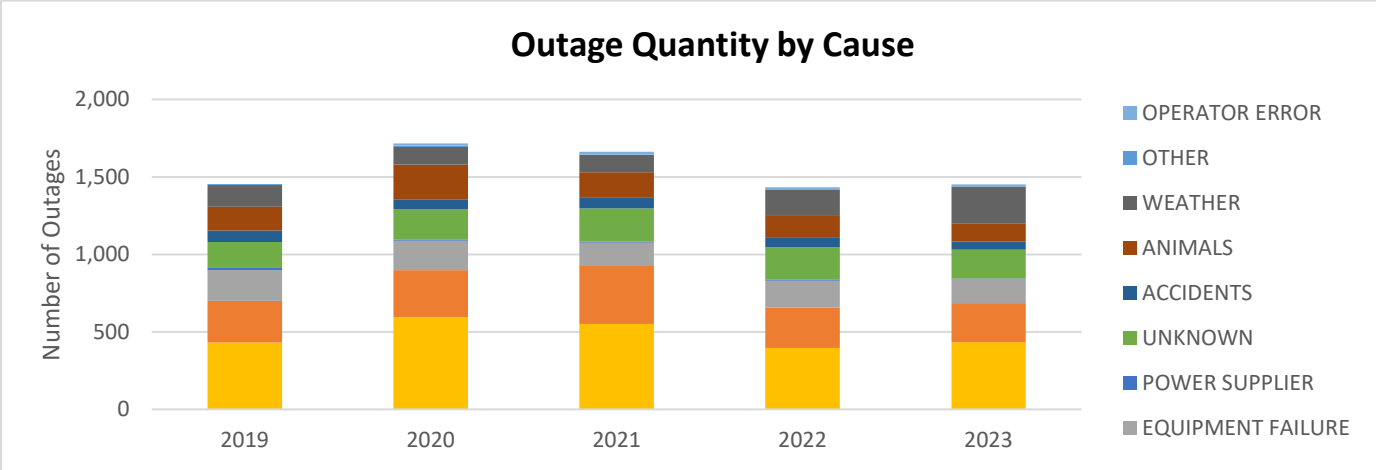


4.1.3 CAIDI and SAIFI Performance by Year (2019-2023)

	SQRP Goal	2019	2020	2021	2022	2023
VEC Customers		39,179	39,539	39,953	40,253	40,245
# of Customers Out		58,537	64,548	76,284	62,966	55,369
Customer Hours Out (CHO)		111,279	104,405	143,386	115,825	137,055
CAIDI	2.60	1.49	1.62	1.88	84	2.48
SAIFI	2.50	1.90	1.63	1.91	1.56	1.38

4.2 Outage Quantity by Outage Cause

VEC experienced 1,463 outages in 2023 and averaged 1,621 outages per year over the five year period between 2019 and 2023. The chart below identifies outage quantity by cause for 2019-2023.



The chart below details the quantity of total outages by outage cause for 2023 and the five-year average (2019-2023).

RANK	CAUSE	2023 (Quantity)	Average (Quantity)
1	COMPANY INITIATED	434	481
2	TREES	251	184
3	WEATHER	239	296
4	UNKNOWN	186	194
5	EQUIPMENT FAILURE	155	174
6	ANIMALS	115	160
7	ACCIDENTS	49	63
8	POWER SUPPLIER	16	88
9	OTHER	10	4
10	OPERATOR ERROR	5	12
11	NON-POWER SUPPLIER	0	0
	TOTAL	**1,463**	**1,621**

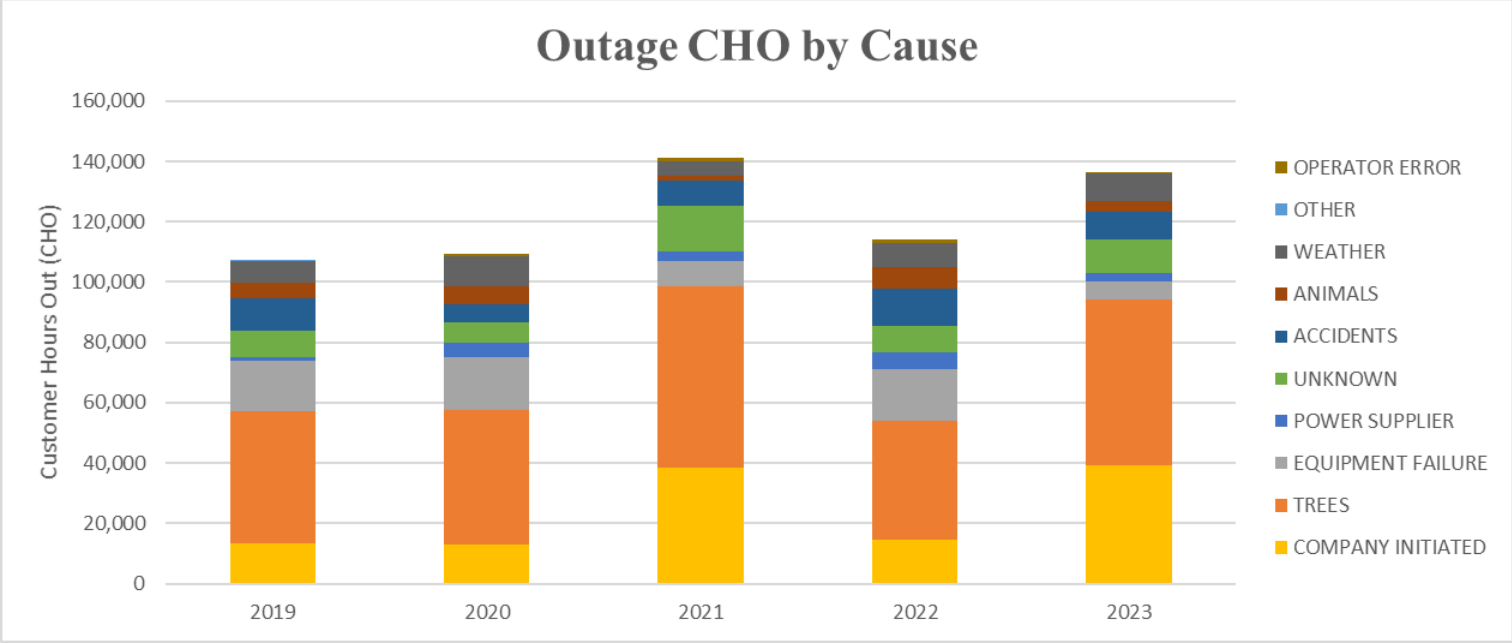
As shown in the table above company-initiated, and tree-related outages continue to be the primary drivers for VEC's outages; however, trees and company-initiated were at or below their respective five-year lows. Company-initiated

outages were primarily due to outages required for capital projects generally associated with reliability improvements and other initiatives such as installing animal guards.

With regard to the tree related outages, VEC saw a below average in tree related outages in 2023. An action plan for each of these causes is located in Section 5.

4.3 Customer Hours Out by Outage Cause

VEC experienced 137,055 customer hours out (CHO) in 2023 and averaged 134,549 hours out per year over the five-year period between 2019 and 2023. The chart below identifies outage duration by cause for 2019-2023.



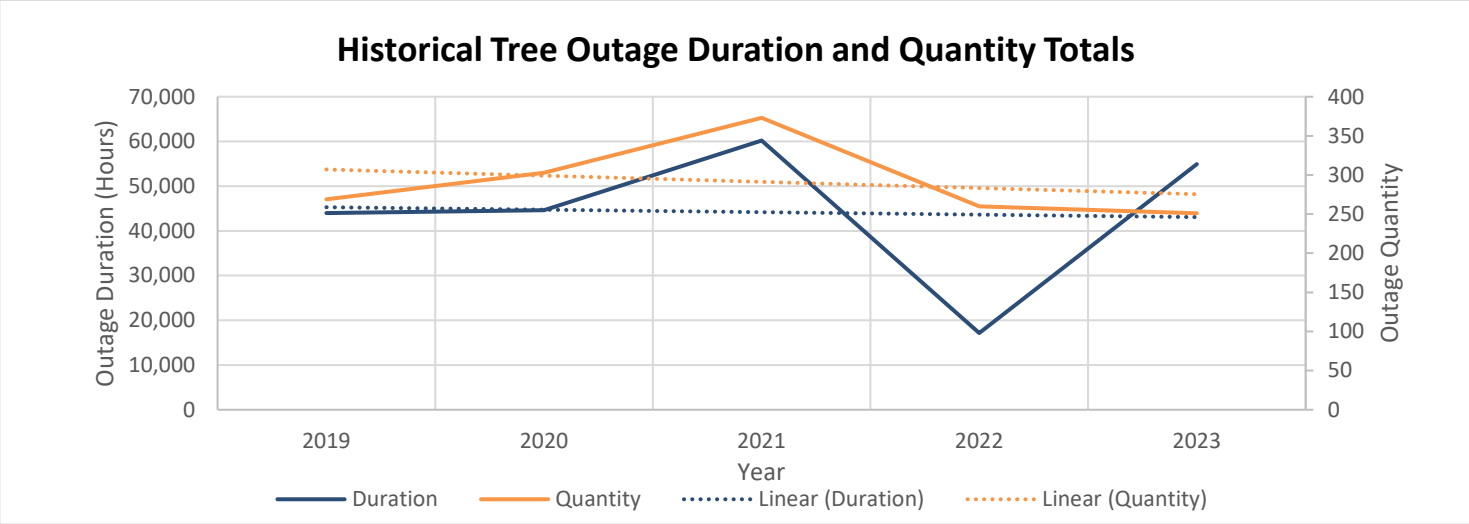
The chart below details the duration in hours out by outage cause for 2023 and the five-year average (2019-2023).

RANK	CAUSE	2023 (Hours)	Average (Hours)
1	TREES	59,950	57,919
2	COMPANY INITIATED	39,119	14,726
3	UNKNOWN	10,871	22,788
4	WEATHER	10,036	12,886
5	ACCIDENTS	9,438	11,976
6	EQUIPMENT FAILURE	5,995	13,564
7	ANIMALS	3,470	5,613
8	POWER SUPPLIER	3,080	4,760
9	OTHER	72	48
10	OPERATOR ERROR	23	540
11	NON-POWER SUPPLIER	0	1
	TOTAL	**137,055**	**134,549**

As shown in the above table, tree-related outages are the primary driver with regard to customer hours out. Equipment failure and animal outages saw a significant decline in customer hours out. However, there was a large increase in company-initiated outages resulting in an increase in customer hours out.

4.4 Tree Outages

For 2023, tree outages rank first in customer hours out and second in outage quantity. Tree outages typically occur due to severe weather such as strong winds, heavy snow, and ice. The chart below shows a comparison of outage duration, quantity, and a five-year trend line which is decreasing.



In 2009, VEC filed a vegetation management plan that addressed funding, maintenance cycles, and reliability. That analysis identified a five-year cycle for transmission rights-of-way (ROW) maintenance and an 8-year cycle for distribution ROW maintenance based on then industry best practices and VEC's experience of managing utility ROW in Vermont. Due to the rate impact associated with moving directly to an 8-year distribution cycle, VEC and the Department of Public Service agreed that VEC would achieve an 8-year cycle over a period of a cycle and a half, or 12 years.

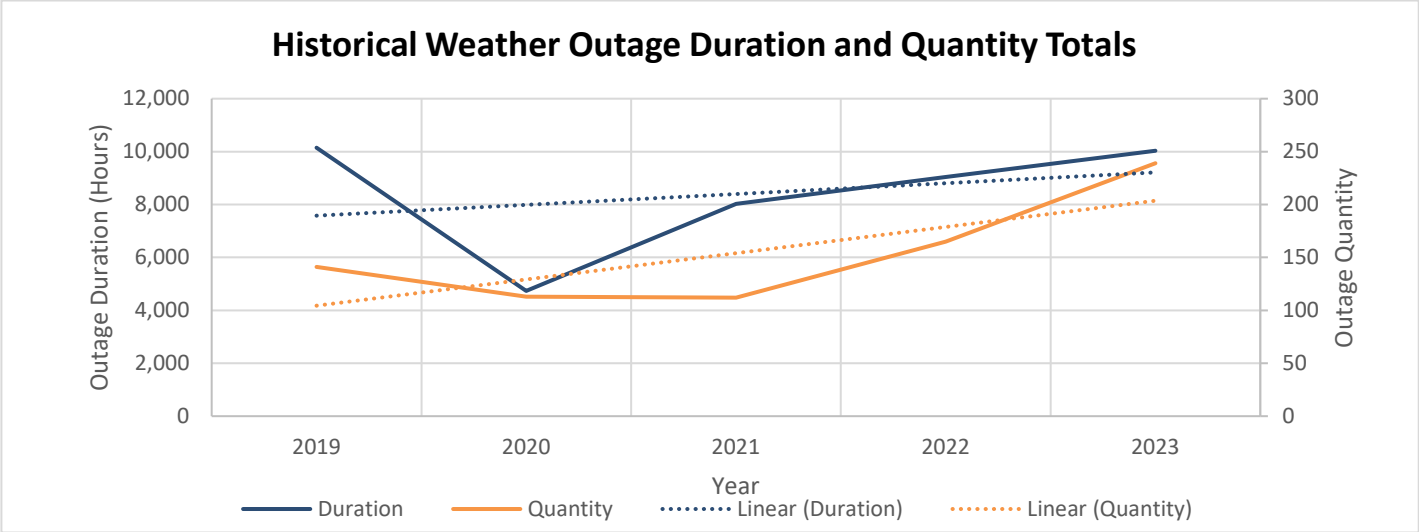
Since then, VEC has executed its plan with a commitment to meet annual mile targets while remaining flexible to address immediate safety and reliability (e.g., hot spotting and danger tree removal) and member concerns. The plan has proven to be effective, with VEC achieving a five-year cycle for transmission ROWs and moving to an 8-year cycle for distribution in 2022.

In 2023, VEC encountered budgetary constraints, leading to the deferral of a couple of projects. Nevertheless, the organization remains committed to an 8-year distribution cycle, which equates to about 320 miles per year, and persistently pursues opportunities to enhance its effectiveness and efficiency. Despite the challenges, VEC is dedicated to its vegetation management program and actively seeks ways to improve its operations and achieve its objectives.

VEC also continues to budget funds annually to address Emerald Ash Borer (EAB) infestation. EAB mitigation includes removing ash trees within striking distance of primary power lines with member approval and consultation, with a strong focus on areas within VEC's service territory with advanced EAB infestations.

4.5 Weather Outages

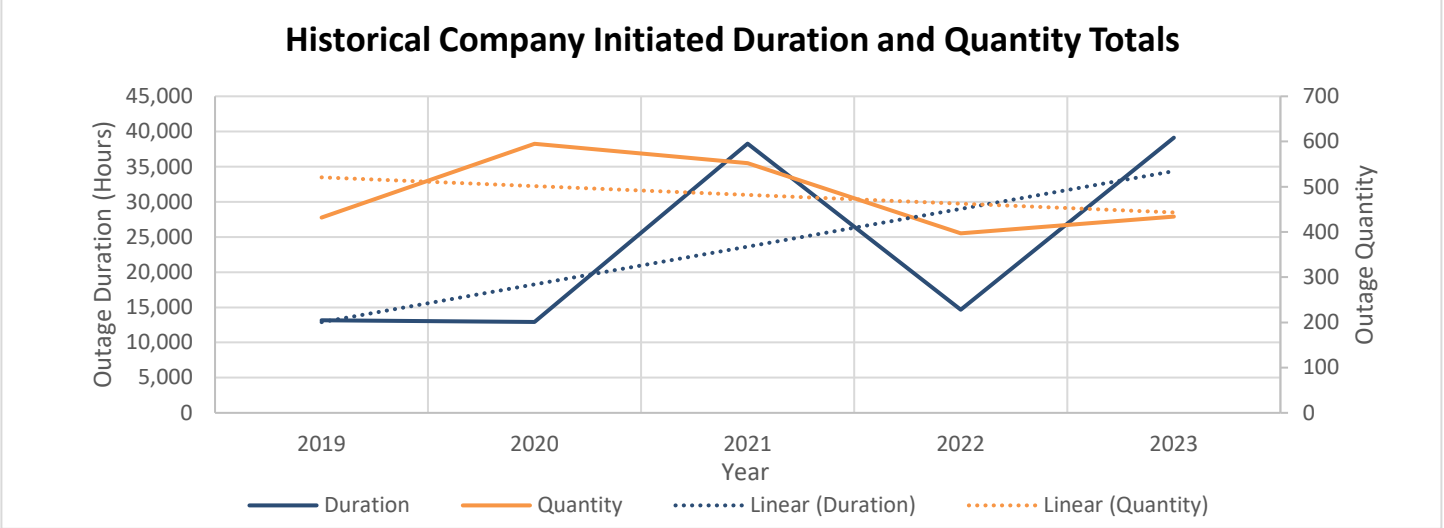
Weather related outages rank fourth in customer hours out and third in outage quantity in 2023.



The primary causes of these outages were snow unloading and lightning. The general trend is that weather-related outages are decreasing. However, per PUC guidelines, VEC codes any tree related outages caused by severe weather such as strong winds, heavy snow, and ice as tree outages, not weather. Refer to Section 5.1, Northview Weather, for more discussion on VEC's initiatives around climate analysis to drive asset investment.

4.6 Company Initiated Outages

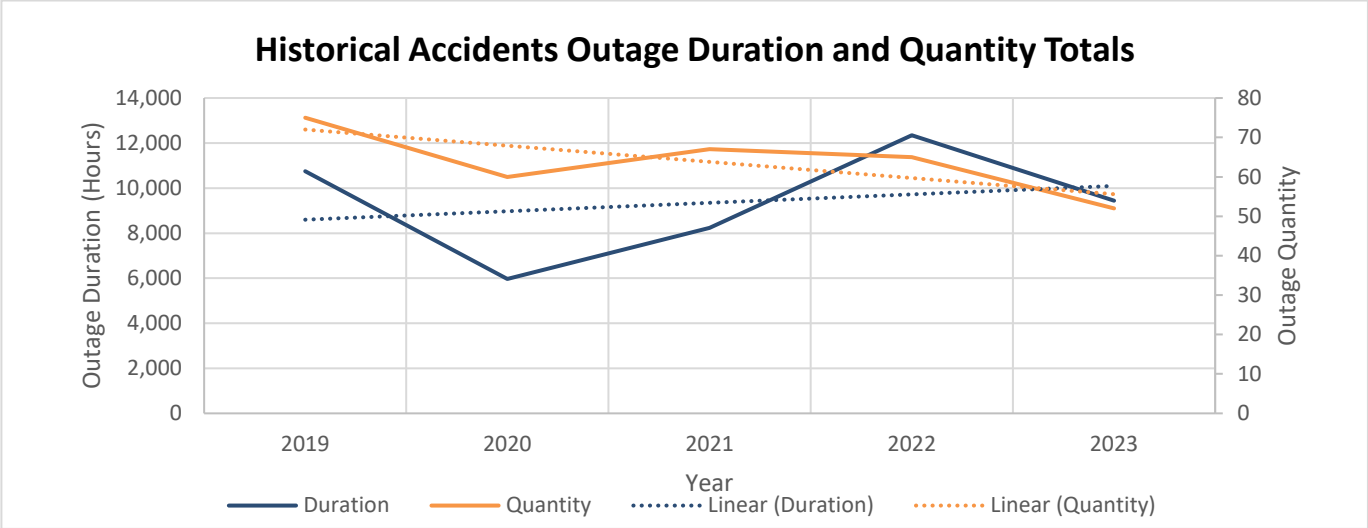
Company initiated outages ranked second in customer hours out and first in outage quantity in 2023.



The past year saw company-initiated outage quantity lower, but an increase in duration. Capital improvements (e.g., line relocations, equipment replacements, voltage conversions, etc.) continue to be the primary driver of this outage category.

4.7 Accident Outages

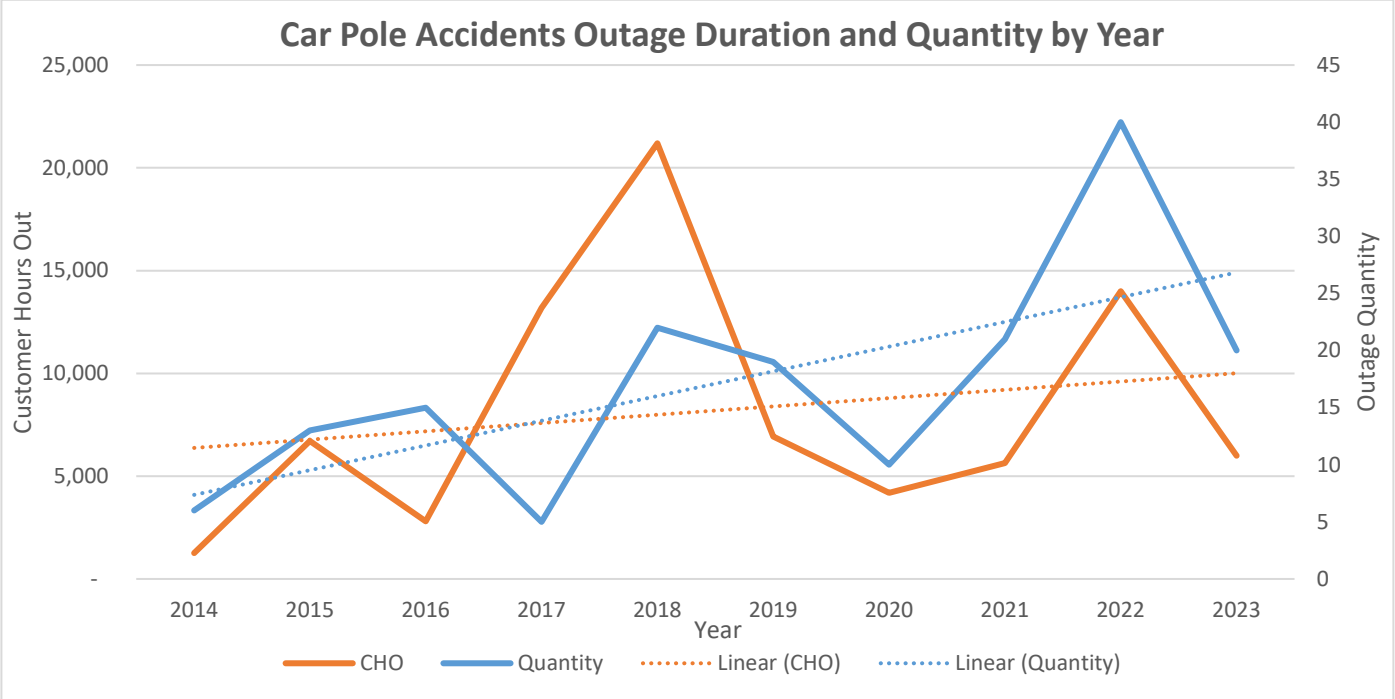
Accidents rank fifth in customer hours out and seventh in outage quantity in 2023.



Member caused outages, such as car-pole accidents and trees that members cut into proximity of power lines, are the largest share of accident related outages. VEC's Safety Department has a policy to follow up with members after tree incidents to review the safety hazards that exist. VEC also encourages our members to notify VEC should they plan to conduct activities in close proximity to electric facilities in the future. Car-pole accidents, especially those involving three-phased poles, are also a large contributor to Customer Hours Out due to accidents.

4.7.1 Car Pole Accidents

The number of car-pole accidents decreased significantly, whereas the number of customer hours out due to such accidents decreased in 2023. The nature and location of these accidents has a significant impact on the duration of car pole outages. A picture of a three-phase car pole accident are included after the chart below.

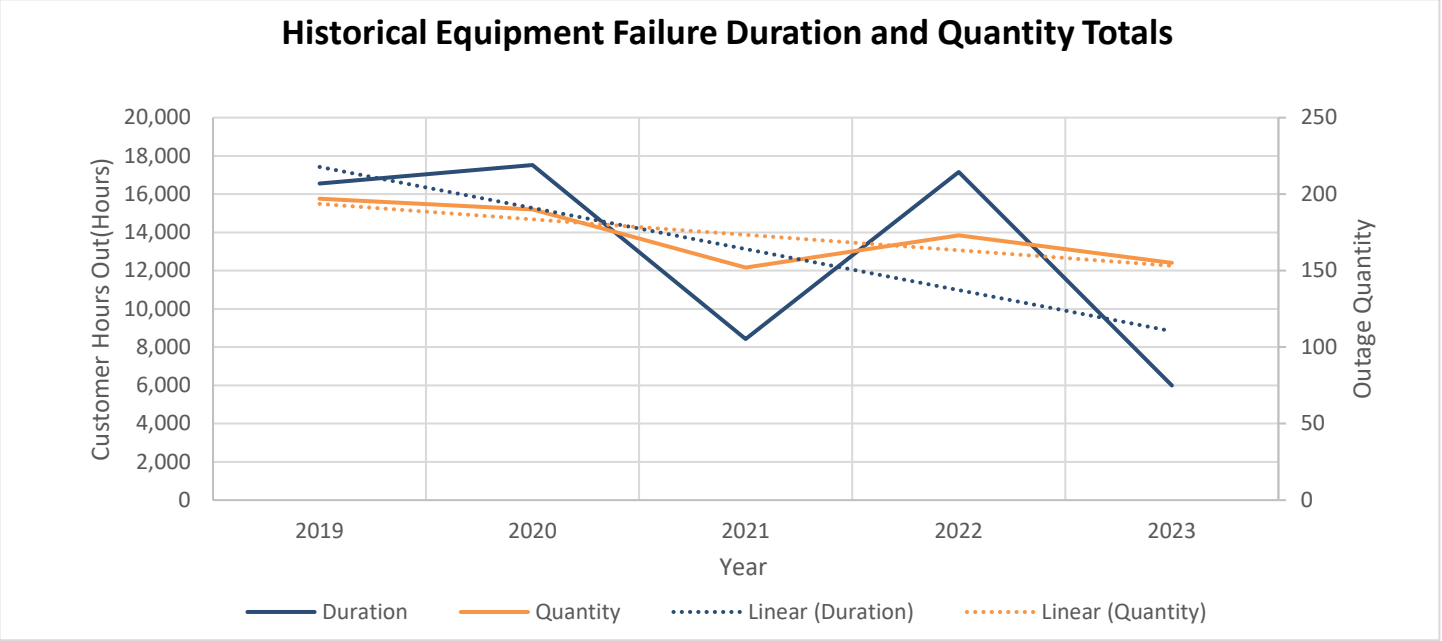


Example of VEC Line Crews repairing a car pole accident.

4.8 Equipment Failure Outages

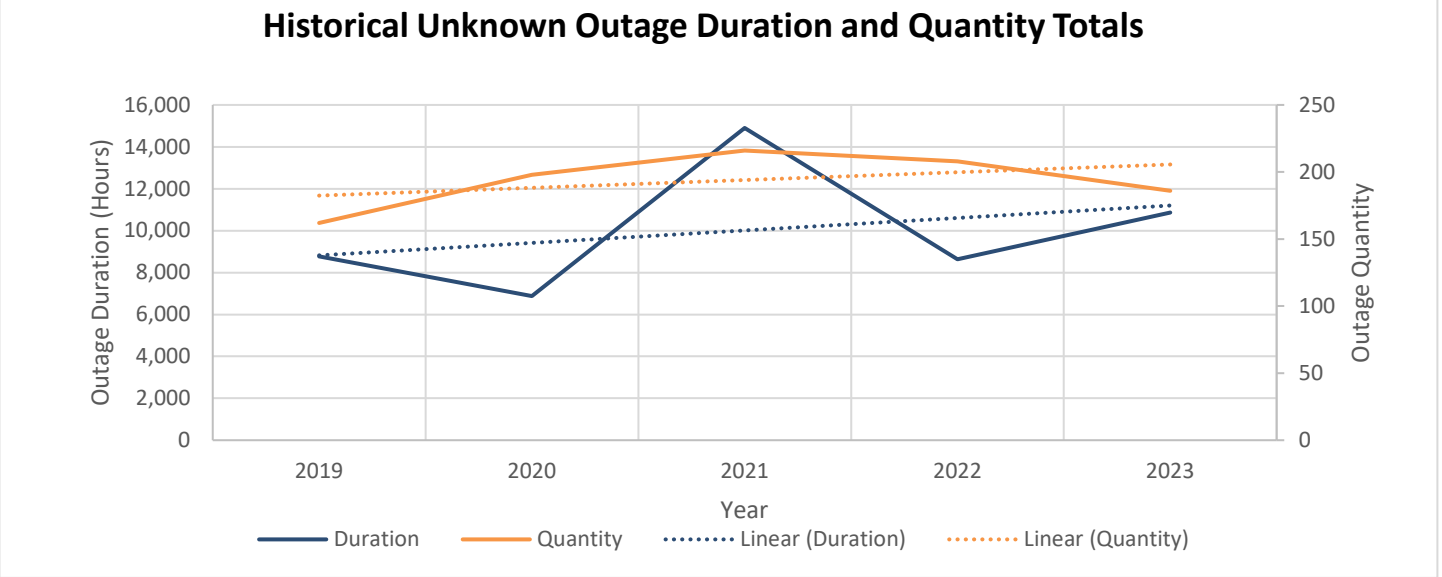
Equipment Failure outages rank sixth in customer hours out and fifth in outage quantity in 2023.

2023 experienced a decrease in quantity, but a significant duration declines from equipment failure related outages.



4.9 Unknown Outages

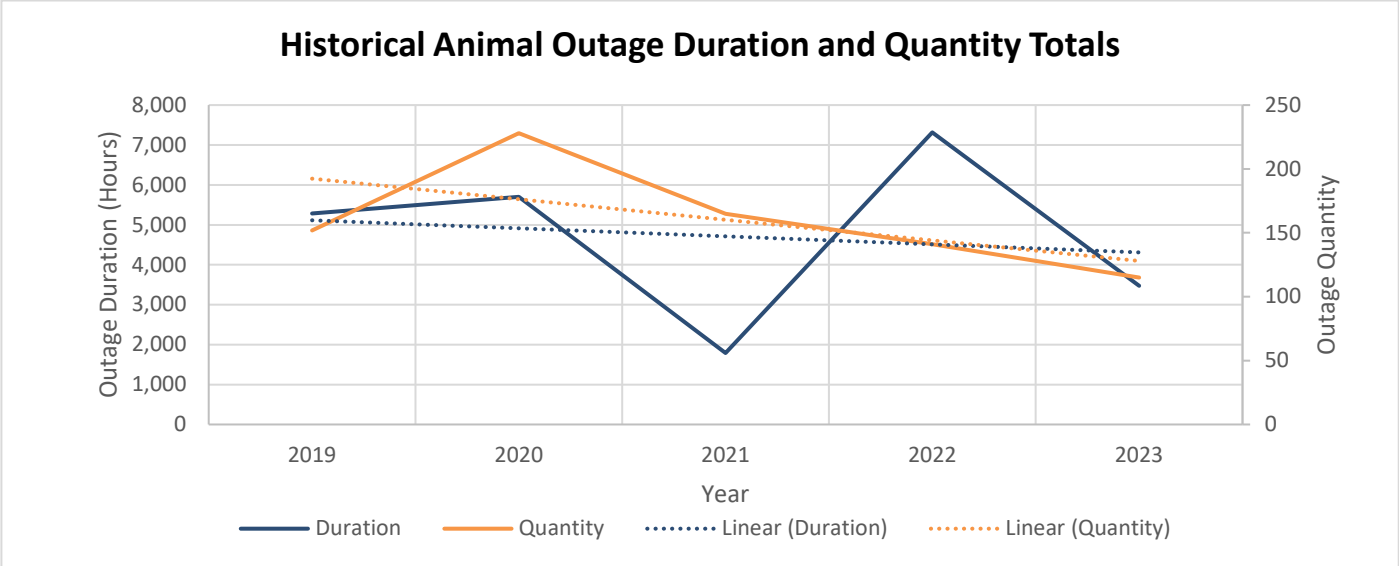
Unknown outages rank third in customer hours out and fourth in outage quantity in 2023.



VEC Line Operations reviews each unknown outage to attempt to determine the cause, but in many cases, we could find no concrete evidence of the cause.

4.10 Animal Outages

Animal outages rank seventh in customer hours out and sixth in outage quantity in 2023.

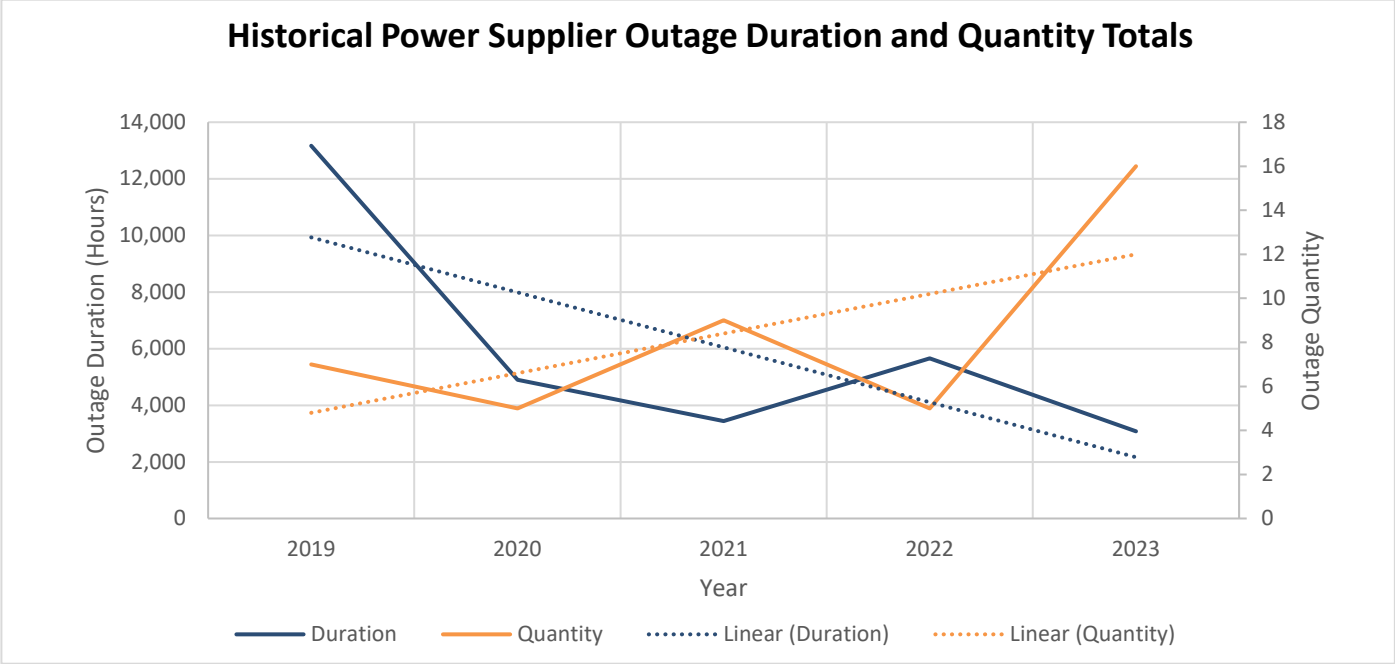


88 percent of these outages are caused by squirrels and birds on equipment without animal protection such as transformers, insulators, and lightening arresters (e.g., equipment without guards). While VEC has animal protection on the majority of its system, VEC has a number of transformers without adequate protection on gap arrestors. In addition, VEC has found that many of the older style animal protectors allowed birds to peck at bugs inside the arrester protection cap. In 2018, VEC updated its standards for distribution transformer wildlife protection and now uses a new RUS approved Reliaguard product that combines effectiveness and durability while considering the least cost solution. In 2021 and 2022 VEC continued its deployment of the new animal protection product.

For outage locations where animal guarding was present but ineffective, VEC either immediately installs a newer style animal guard or returns to install a newer animal guard a day after the outage is restored (e.g., nighttime outages). VEC takes a more holistic approach on circuits listed on the top 10 worst performing circuits if we find animals to be the largest cause of outages. The overall trend for the number of Animal Outages and the duration is decreasing.

4.11 Power Supplier Outages

Power Supplier outages rank eighth in customer hours out and eighth in outage quantity in 2023.



The number of Power supplier outages increased during 2023, but the duration trended down.

5 Action Plan

5.1 System Wide

Vegetation Management

VEC remains committed to identifying and leveraging efficiencies wherever possible and seizing opportunities to advance the target vegetation maintenance schedule, even in the face of budgetary constraints.

In addition to planned vegetation maintenance activities scheduled to achieve the target maintenance cycles, VEC conducted unplanned vegetation maintenance activities on the following circuits in 2023: 01-2A, 01=2G, 02-3C, 03-1E4, 19-3J, and 30-1L associated with capital line relocation projects and addressed other random hotspots and DT removals for safety and/or reliability reasons in many other places across the system. Comprehensive DT patrols and removals were conducted on the following circuits: 15-3A, 17-3B, 17-4A, 19-3A, 42-1A, 45-3B, 45-4E, 47, 4B, Line 418 Eden/Montgomery, and Jay Tap. Selective herbicide application was also conducted along transmission lines scheduled for routine maintenance in 2023 and distribution circuits which were mechanically cleared in 2022.

Overall, VEC spent approximately $4,113,375 in 2023 on Vegetation Management for both Transmission and Distribution. The results of this expenditure include:

- 247 miles cleared/covered
- 2,200 danger trees removed
- 78 acres of selective herbicide application

Emerald Ash Borer

The Vermont Agency of Agriculture and Department of Forest, Parks, and Recreation confirmed the existence of this invasive beetle in several areas in VEC's service territory in early 2018. The EAB is extremely destructive to ash trees and has no known cure. EAB infestations have already decimated ash tree populations in other states and Vermont is one of the last states to feel its affects.

As EAB spreads across VEC's service territory, funding is identified annually for EAB mitigation and efficiencies gained in other areas are applied to mitigation efforts whenever possible. Mitigation in 2023 focused on the removal of ash within confirmed EAB infested and high-risk areas which overlapped with scheduled maintenance projects. Approximately $161,433 was spent removing 278 ash trees ($581 per tree).

Maintenance Plan

We changed our approach to the Maintenance Plan to conduct inspections and data gathering every other year. This gives the line crews an opportunity to address damage assessment findings in the "off years". In 2024, VEC will return to conducting inspections and data gathering, its fifth year of its comprehensive maintenance program. VEC has inspected over 40 percent of the system. This program continues to assess the condition and gather data on all of VEC's electrical assets over an eight-year period, ending at the end of 2026. The objectives of VEC's maintenance program include:

1. Maintain VEC's electric transmission, substation, distribution, and metering systems on an established schedule and scale that allows for work prioritization and changing requirements while complying with industry standards and best practices.
2. Enhance reliability and proactively reduce preventable outages for VEC's members as measured annually by duration (SAIDI,) frequency (SAIFI,) and customer average (CAIDI) outage minutes to drive maintenance on VEC's worst performing circuits.
3. Extend plant life of VEC's capital assets and thereby reduce upward pressure on member rates.
4. Deliver accurate system data to various departments within VEC and ensure the highest level of data integrity. This will provide a feedback loop to help mitigate outages in the future.
5. Provide a documented electric transmission, substation, and distribution system maintenance policy that clearly defines VEC's system operations core business, employee expectations, and specific maintenance work functions. In addition, this program provides the information that ensures consistency across all maintenance guidelines to system operations personnel in the inspection, testing, and maintenance of VEC's electric system plant, equipment, and other facilities.

Infrared Inspections

VEC retains an independent contractor to inspect with infrared cameras all substations, transmission lines, tie switches, and SCADA operable switches twice per year (July and December). This inspection makes use of infrared thermography, which detects differences in ambient temperature with sensitive, non-contact, non-destructive electronic equipment and converts the infrared energy into a video image. Since infrared energy is a direct and proportional function of temperature, the video image is designed to depict various shades of gray or color to indicate a difference in temperature levels. In color mode, lighter shades correspond with higher temperatures. In black and white mode, darker shades of gray correspond with lower temperatures, and lighter shades of gray or white correspond to higher temperatures; referred to as "hot spots." The thermal-graphic information can be used to help solve a variety of issues and, in many cases, allow technicians to mitigate an issue before a failure occurs.

The thermo-graphic images show the temperature difference between the areas of concern/deficiency and corresponding reference ("normal") areas. However, temperature variances alone do not necessarily indicate the severity of the issue. The importance of each potential issue is reviewed within the framework of the system as a whole and the resulting report assists with the process of properly identifying area of potential maintenance or replacement. VEC utilizes the infrared criteria from MIL-STD-105 (Military Specification for Electrical Inspection Criteria):

Severity Code	Temperature Rise degrees C Over Ambient	Repair Priority	Severity/Recommendation
1	Less than 74 degrees Fahrenheit (0-24 degrees Celsius)	Desirable	Component failure is improbable, but corrective action is required at the next maintenance period or as scheduling permits
2	75-103 degrees F (25-39 degrees Celsius)	Important	Component failure is probable unless corrective action is taken
3	104-157 degrees F (40-69 degrees C)	Mandatory	Component failure almost certain unless corrective action is taken
4	Over 158 degrees F (Over 70 degrees C)	Immediate	Component failure imminent, repair Immediately

The external contractor provides a report for analysis by VEC's Manager of Engineering and Manager of Service Operations. They plan for and implement corrective action based on the Repair Priority and system outage impact. VEC also conducts annual infrared inspections on the Kingdom Community Wind (KCW) transmission line at peak times of generation.

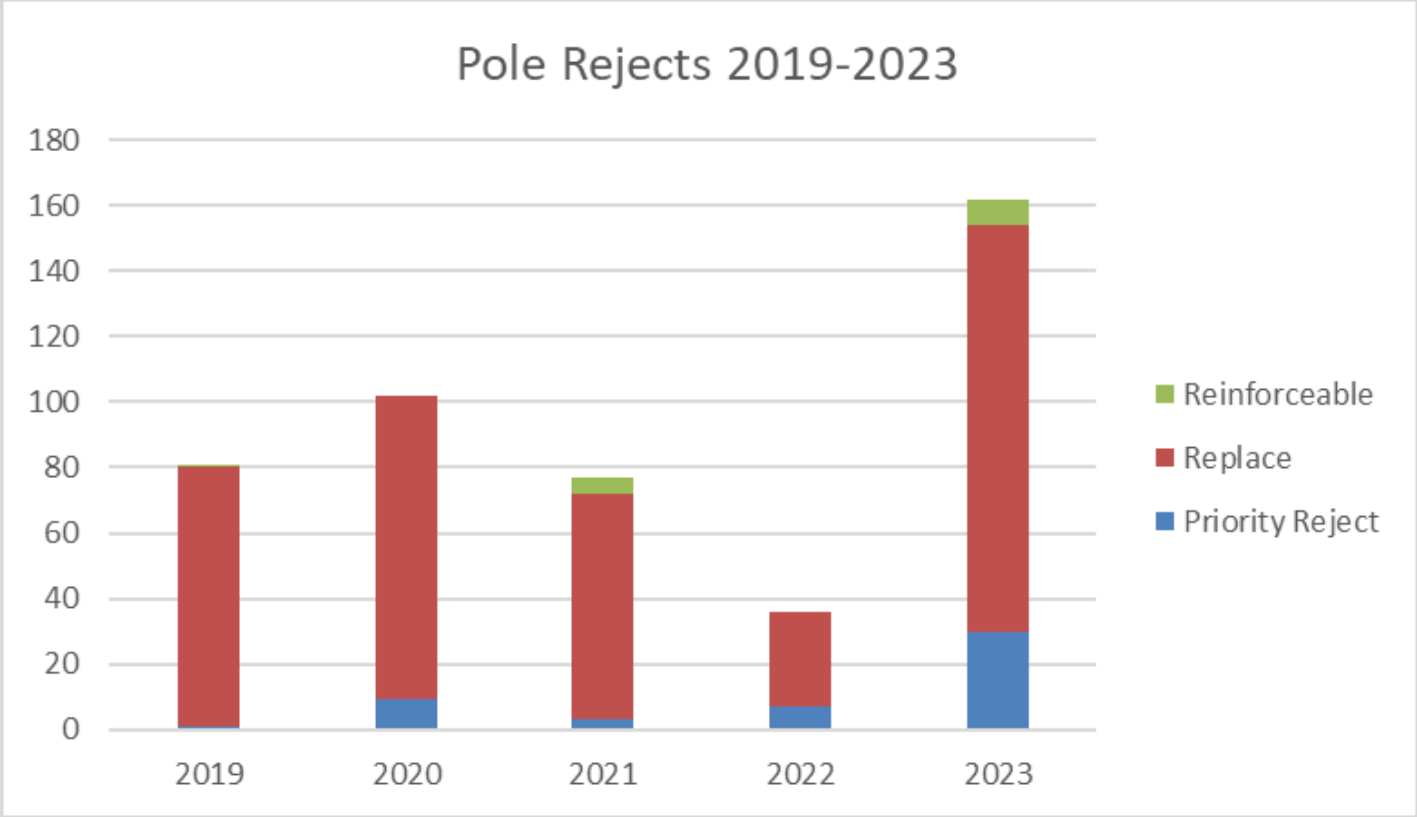
Pole Inspections

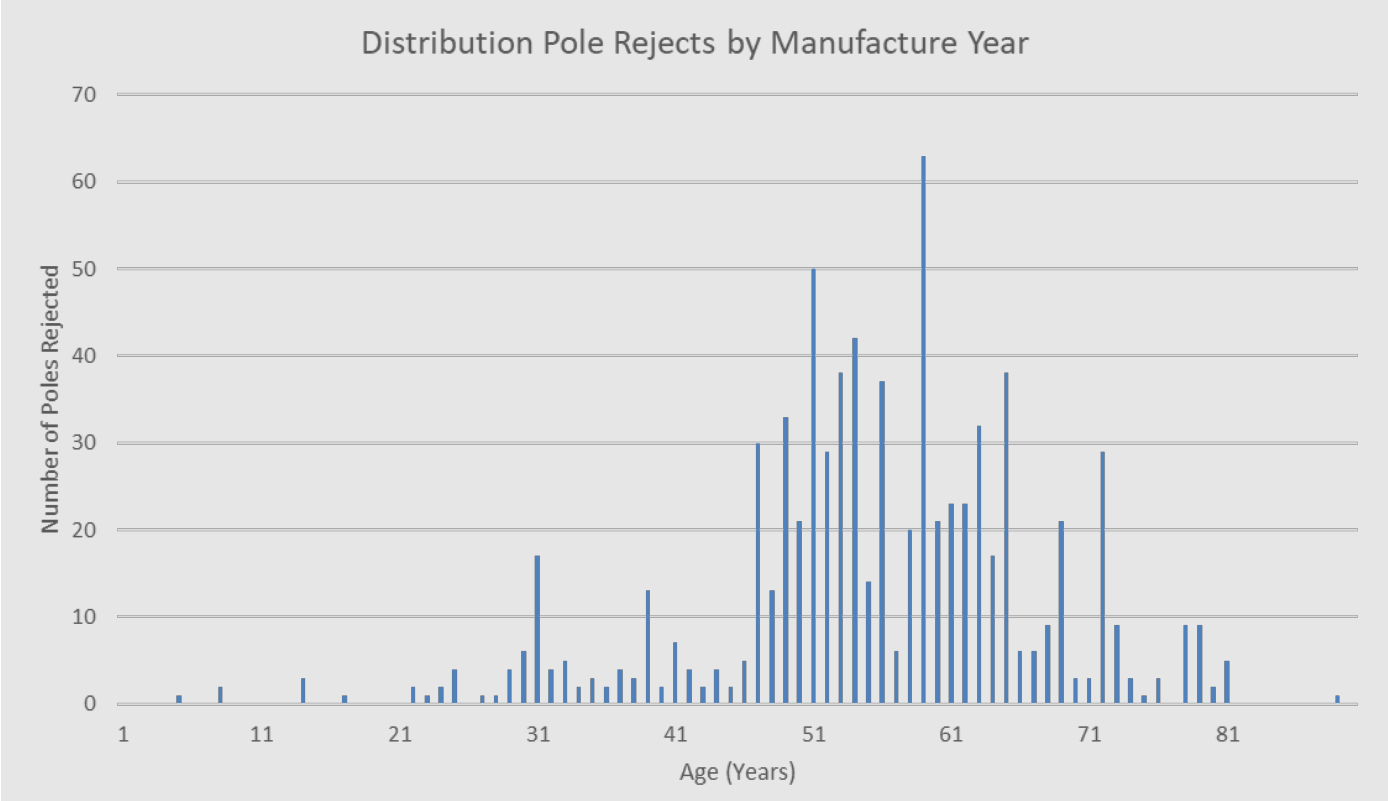
VEC conducts pole inspections and treatments on its transmission and distribution poles over a 10-year cycle. This timeline is consistent with RUS Bulletin 1730B-121. VEC's program consists of ground line inspection; treatment at 18 inches below ground level for transmission with distribution receiving a partial excavation of 6" in most cases, internally if voids are present and a visual inspection of above ground condition. In addition, inspectors also perform other maintenance work such as replacing missing guy guards, pole numbers, general maintenance identification and pole top photos for GIS reference.

VEC has a joint ownership agreement with Consolidated Communications, which establishes pole set and maintenance areas. We inspect all of our solely-owned distribution poles across the system and all jointly-owned poles within our maintenance area.

VEC categorizes rejects into three categories: priority rejects, reinforceable rejects, and replace pole. VEC replaces priority rejects as soon as possible/practical. Other replacements occur within twelve months of the pole inspection.

VEC completed its first distribution and second transmission 10-year cycle of our pole inspection process in 2022. Our average reject percentage was 2.68 percent. VEC hired Alamon to complete the pole inspections in 2023 and they identified 88 reject poles.





The average age of rejected poles is 58 years old (manufactured in 1963).

Emergency Action Plan OP-57 and Storm Response

VEC Operating Procedure (OP) 57 documents procedures for responding to threats to the reliability of the power system. While these threats tend to be primarily weather-related outage events, the plan includes responses to natural disasters, cybersecurity threats, and acts of sabotage. The plan identifies an organizational structure and processes for initiating preparedness actions based on the level of threat. The OP is modeled after the FEMA based Incident Command Structure (ICS).

VEC categorizes events into four Emergency Planning Levels (EPL): Green (No Concerns), Yellow (Medium Concern), Orange (Probable), and Red (Imminent). An Orange or Red EPL level initiates the ICS, lower level EPL levels are handled by an event manager. Once a VEC publishes the status on its intranet, it communicates changes in status to VEC employees via a variety of communication methods (e.g., email, text, Microsoft Teams, etc.). As new weather forecasts or other threats develop that change the EPL, VEC updates it accordingly. Establishing and adjusting the EPL Levels (and the corresponding response from planning (Green/Yellow) to response (Orange/Red)) is at the discretion of the Event Manager/Incident Commander with reference to the EPL Criteria and in consultation with Operation and Planning Section Chiefs. At least with the General and Command staff, there is one primary and one backup individual well trained to handle the requirements of those positions. In other areas, a backup may not be available. VEC continuously looks for improvements of the system and enhance personnel training.

VEC uses numerous weather sources as well as its experience from past events to predict both outage magnitude and duration. VEC uses a weather predictive resource coordinated by VELCO, which is monitored closely by System Operations. VEC also participates in the statewide utility emergency calls and internal calls/communication before and during larger events. In addition, depending on the EPL and following OP-57, VEC will create internal crew rosters for each event based on the available personnel and estimated type and duration of damage. VEC will also determine external crew requirements.

If external crews are required, VEC will reach out to a set of pre-defined contractors as well as request aid from local cooperatives and utilities or the National Guard. VEC also offers Mutual Aid assistance to the following categories of utilities:

- Any utility in Vermont, New Hampshire, Maine or New York.
- Cooperatives up to a 500-mile radius of Johnson, VT.
- Municipals in any New England state.

External crews are led by VEC qualified personnel or provided circuit points on radial circuits absent of other personnel with VEC-specified material and GIS mapping tools and communicate directly with a T&D Branch Director.

Communication and data sharing are imperative to manage events and incidents effectively. VEC's currently leverages several software platforms providing two-way communications via several modes (e.g., text, email, voicemail, radio, and Microsoft Teams, etc.) on a company-wide scale, several lists and pages on Microsoft's SharePoint, Excel, and Teams to manage staff availability and various emergency response information, and other software from National Information Solutions Cooperative (NISC) to manage Service and Work Orders, Outage Management and Mapping, and Customer Management (e.g., member inquiries).

While VEC has successfully managed several major and minor events since 2017 utilizing these software packages, we are always looking to streamline the process, make improvements, and enhance effectiveness. As such, VEC continues to evaluate software to more effectively consolidate and manage storm related information.

NorthView/DisasterTech Weather

While we have collaborated with Northern Vermont University - Lyndon and a startup company, Northview Weather, Northview has merged with DisasterTech in 2023. However, Dr. Jason Shaffer of Northview continues to focus on enhanced approaches to utility forecasting. In particular, they are studying utility impacts of wet snow, ice, and wind, with the goal of reducing outage restoration costs. Northview/DisasterTech is developing these forecasting tools to provide electric utility operators with reliable and actionable forecast information in meaningful formats without the need to assimilate large quantities of numeric data typically processed by a meteorologist.

These tools continue to reduce the time that utility personnel will spend to analyze the weather forecast, and allow for more efficient and effective response planning. Highly accurate temporal and spatial forecasts will allow utility management to plan for the appropriate personnel and to deploy those personnel to targeted locations, in some cases prior to the event. In addition, Northview/DisasterTech is also developing systematic verification to understand storm performance metrics such as the accuracy of the forecast and the resilience of grid held to weather hazards.

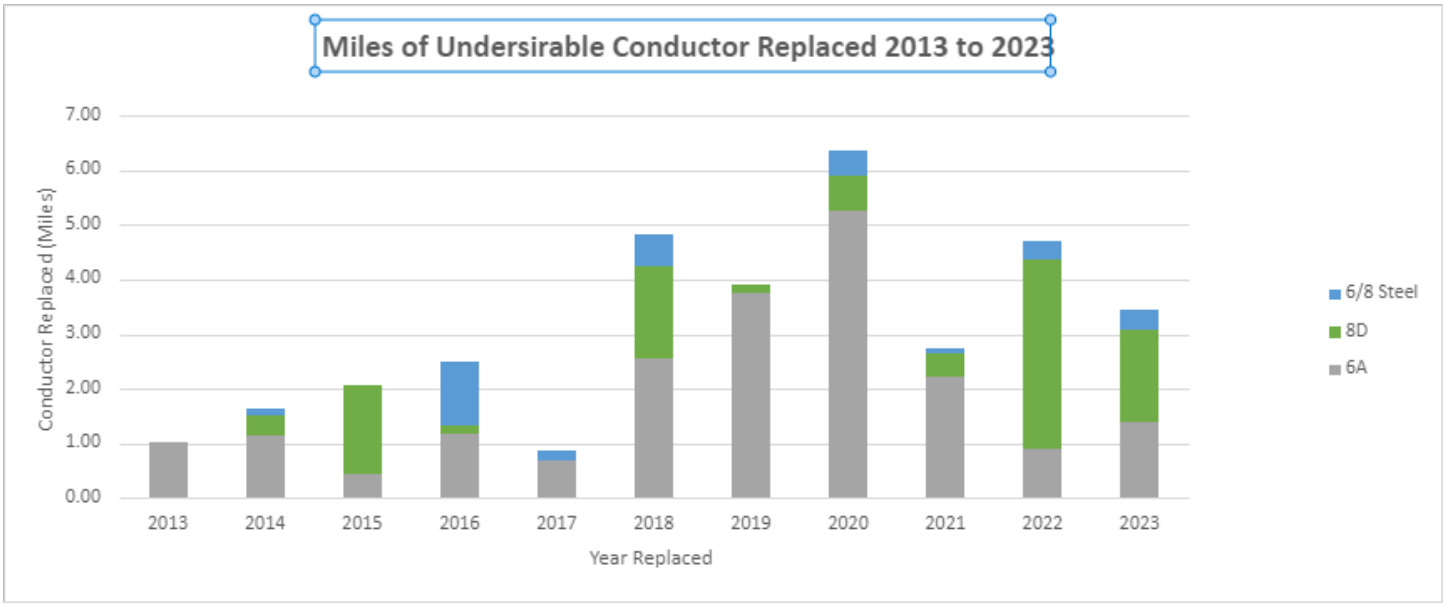
Aerial Patrols

Qualified VEC personnel conducted aerial patrols and one infrared scan of all VEC transmission lines three times in 2023. The objective is to identify equipment concerns, danger trees and/or vegetation concerns, and any safety hazards that may exist due to public activity taking place in close proximity to transmission structures or facilities. However, these aerial patrols by helicopter were suspended indefinitely by VEC's Chief Operating Officer after a helicopter crash in New Hampshire resulted in the death of a pilot that used to work closely with VEC. There have been at least two helicopter crashes since 2022 resulting in VEC re-evaluating the use of helicopters for this type of work. As such, VEC has partnered with Firmatek, a Drone based company to complete not only maintenance activities, but also Transmission aerial patrol. VEC completed a comprehensive pilot in 2023 and is in the process of implementing the use of Drones more comprehensively by May 2024. Drones, and the subsequent evaluation of the data obtained by qualified Line worker personnel, offer benefits such as improved safety, efficiency and cost effectiveness, higher quality data, and enhanced accuracy without the significant safety hazard to VEC employees.

5.2 Distribution

Investing in infrastructure

VEC has prioritized building infrastructure that allows for feeder backup, replacement of obsolete wire (overhead and underground), and relocation of lines from hard-to-access ROWs to the roadside. In 2024, VEC plans on reconductoring approximately seventeen miles of obsolete wire and relocating several miles from difficult to access rights-of-way to the road.



VEC retired almost four miles of 8D, 6A, and 6/8 steel in 2023.

FEMA Hazard Mitigation

The Federal Emergency Management Agency (FEMA) has two types of hazard mitigation grants: section 404 – Hazard Mitigation Grant Program, and section 406 – Public Assistance Program. As a not-for-profit electric cooperative, VEC has an opportunity to qualify for both of these grants. FEMA designs these grants to cover costs for restoration and mitigation projects that make the system affected by an event more resilient, sometimes called "hardening."

This assistance allows VEC to benefit from additional capital funding to achieve its goals of improving reliability via reconductoring, moving lines to the road, and feeder backup. While the additional funding is valuable, it does require resources and time to build the grants and monitor them, but VEC finds this effort is worthwhile. In 2020, VEC applied for over $2 million of mitigation funding for two projects. In 2021, we received over $536,000 for one of the two projects submitted. This project includes Hinesburg reliability improvements by relocating hard to access facilities and installing mid-span poles (to strengthen spans from potential tree fall-ins, and reduce snow unloading). It will significantly reduce outages from these types of storm events from line connectivity from ice loading/snow unloading. In addition, with better access to this line, outage duration will improve as well.

Also, five project proposals are being submitted to FEMA for Winter Storm Elliot. VEC applied for over $1.5 million of mitigation funding and the proposal results should be received in the first quarter of 2024.

System Protection

We will ensure that distribution system protection continues to improve by reviewing the distribution system for sectionalizing of circuits and system events to enhance device coordination/operation. VEC System Protection reviews are done for each of the worst performing circuits and for any SAIDI > 1 events and SAIFI > 3 on a particular circuit.

Covered Conductor ("Tree Wire")

The majority (86 percent) of VEC's distribution conductor is bare, and the remaining 14 percent is covered conductor (often referred to as "tree wire"). VEC installs covered conductor in areas where line relocation is not feasible and in locations of likely exposure to tree-related outages. Contact with fallen or wind-driven trees and vegetation not only provides a path to earth and between conductors, but can damage bare conductors and cause contact between conductors, resulting in arcing and sparking. VEC has seen that covered conductor can prevent these types of outages due to the benefit of insulating cable.

In general, covered conductor adds approximately 58 percent to material costs (because it is more expensive and requires shorter span lengths and more poles due to increased weight) and 13 percent to the total project cost. However, VEC finds that covered conductor and compact construction can improve reliability and provide flexibility in space constrained areas. VEC expects to continue reconductoring areas with outage concerns with covered conductor.

Wildlife Protection

On its distribution system, VEC adds wildlife protection to all new and replacement reclosers, regulators and transformers. In addition, VEC adds wildlife protection on all new substation reclosers, switches, regulators, and transformers.

VEC also continues to expand its avian protection plan that involves patrolling three phase main lines and removing Osprey nests identified on these. If the Osprey comes back to same location, VEC sets a pole away from our distribution line to allow the Osprey to build their nest while not affecting the power system.

Fault Indicators

Fault indicators provide a cost-effective visual indication of faults on the power system. They help to identify fault locations and to reduce outage duration and restoration costs. VEC utilizes Schweitzer Engineering Laboratories (SEL) AutoRanger fault indicators with approximately 300 devices installed on its system. In general, VEC installs fault indicators where power lines cross the road in areas that are difficult to access.

5.3 Transmission

VEC installed a SCADA-controlled MOAB switch with load break capabilities to improve sectionalizing faults. This will reduce outage durations for several thousand members.

VEC has had several L220 transmission line insulator failures with resulting outages associated with vintage Ohio Brass metal cap post insulators. This line is the VELCO Highgate transmission line source to VEC's South Alburgh 28. In 2022 VEC replaced approximately 112 of those insulators with new K-Line clamp top insulators along with 2 pole structures identified in the 2020 transmission pole inspections, this work was continued in 2023. Also, four Fairfax transmission poles were replaced due to osmose pole inspection failures.

5.4 Substations

VEC identified issues with the Jay Tap substation circuit breakers, C91 and C92. The breakers are critical to stabilizing the capacitance of the transmission system. They were maintained and settings were readjusted to ensure proper working function. Also, we updated several regulators for the new North Troy Battery project.

VEC conducted oil samples on all substation level transformers. After the analysis was complete there was no further action required. VEC conducted five-year maintenance on 4 substations in 2023. During the five-year maintenance, VEC tests all the relays, Doble testing, TTR test, and inspect all the switches and disconnects. Substations are also inspected for structural integrity.

We are also continuing to work with our transmission and sub-transmission suppliers to minimize the duration of planned outages and to address any protection or sectionalizing concerns.

VEC continues to utilize portable substations from time to time to minimize planned outages and capture opportunities to enhance feeder backup capability between substation circuits. We will continue our substation maintenance program that tests substation equipment on a five-year cycle. The following items are tested:

Batteries - tested annually for their specific gravity, strap resistance and voltage.

Relays - tested every five years using calibrated test equipment for all overcurrent protection settings and if installed under frequency load shed (UFLS).

Transmission Breakers - tested every five years; tests include Hi-Pot, Ductor, Doble, and Megger.

Capacitor Banks- tested every five years using Doble test equipment and procedure.

Regulators - tested via a visual Inspection, a Functional Test, a Transformer Turns Ratio Test (TTR) and Insulation Resistance Test (Megger test) every five years.

Reclosers - tested every five years. These tests include Power Factor Test (DOBLE), Low Resistance Test (DUCTOR), High Voltage Test (AC HIPOT) along with Functional Test. VEC performs visual Inspection of the recloser and its relay monthly.

Substation transformers - tested every five years. The tests include Power Factor Test (DOBLE), Insulation Resistance Test (Megger test), Transformer Turns Ratio Test (TTR) and visual inspection.

Dissolved Gas Analysis (DGA) - performed annually along with moisture content and other oil tests.

The VEC substation crew performs monthly substation checks. As part of VEC's maintenance plan, seven substations are planned to be de-energized and all apparatus inspected and tested.

6 Top Ten Worst Performing Circuits

In this section, VEC has broken down its reliability data into substation circuits for this report. VEC rates its top ten worst performing circuits by prioritizing the number of outage events first and then customer hours out. VEC personnel review these worst performers based on type and location of the outages.

Section 6.1 details a review of our progress on the 2022 worst performing circuits and section 6.2 details the 2023 worst performing circuits.

6.1 A Review of the Worst Performers in 2022

The following table lists VEC's 2022 worst performers and their 2023 year-end ranking.

	2022				2023		
Circuit Name	**Rank**	**Quantity**	**CHO**		**Rank**	**Quantity**	**CHO**
***South Alburg 1A**	1	54	7039		24	37	2178
Hinesburg 3A	2	46	7301		6	49	10457
***South Hero 1A**	3	65	5008		52	62	518
***East Berkshire 3A**	4	26	9307		43	20	969
Hinesburg 1A	5	29	8115		7	29	9747
***Burton Hill 3A**	6	52	4455		13	75	7162
Cambridge 1A	7	46	4902		9	58	7714
West Charleston 1A	8	32	5380		4	43	11180
***Derby 1A**	9	37	3879		34	16	1280
***East Berkshire 1A**	10	37	2947		28	36	1828

*Six of the circuits on the 2022 top 10 Worst Performers list are no longer on the 2023 list. Thanks to enhanced outage data, in particular specific pole locations for tree outages and equipment failures, VEC was able to perform a more detailed assessment of its worst performing circuits and develop specific actions to address outages on those circuits. We detail below the improvements made to the 2022 worst performers.

For the analysis presented below, the nomenclature is as follows.

- First number is the substation. For example, 47 is VEC's Island Pond substation
- Second number is the phase or phases that were affected. Those number represent the following:
  - 1 = Phase A only
  - 2 = Phase B only
  - 3 = Phase C only
  - 4 = Phases A and B
  - 5 = Phases B and C
  - 6 = Phases A and C
  - 7 = All three phases A, B, and C
- Third number is the main circuit off the substation that was affected.
- Example: 47-7-4C = Island Pond substation, all three phases, 4C circuit which is the third protection device off the 4A circuit.

6.1.1 #1 – South Alburgh 28 1A

The 1D had an aluminum stirrup on a copper conductor burn the wire down. While only a single phase was affected, all three needed to be opened in order to repair. This outage is considered a "Company Initiated" outage because repair outage had 616 members for 2.5 hours or 1,274 CHO.

VEC's Standards Committee is reviewing copper conductor for aluminum connections that could cause conductor to fail due to copper salt corroding aluminum and causing heated connections.

6.1.2 #2 – Hinesburg 19 3A

The 3E appears to be the highest priority for improvement due to long spans, construction type out to top of Lincoln Hill area with total of 1,745 CHO due to snow and trees.

Routine mechanical vegetation maintenance and danger tree removal were conducted along the entire 19-3 feeder in 2020, followed by selective foliar herbicide application in 2021. With much of this circuit located in wooded areas, tree-related outages are common during weather events. A comprehensive DT patrol and subsequent removals were conducted in the Lincoln Hill area in 2022. The circuit is scheduled for routine maintenance again in 2028. In the interim, tree-related outages will be monitored and additional hotspot maintenance and/or danger tree patrols/removals will be conducted, if determined to be necessary.

6.1.3 #3 – South Hero 29 1A

The 1A had a submarine cable termination failure that resulted in 1,478 CHO and an Osprey at pole 76 1 that resulted in 1,022 CHO.

The 1D had 2 outages resulting in 599 CHO combined due to trees at span_14866 and pole 79 119 respectively.

The 1Y had a tree at pole 79 80 resulting in 548 CHO out.

Routine mechanical vegetation maintenance and danger tree removal were last conducted along this circuit in 2018, followed by selective foliar herbicide application in 2019. The circuit is scheduled for routine maintenance again in 2026. In the interim, tree-related outages will be monitored and hotspot maintenance and/or danger tree patrols/removals will be conducted, if determined to be necessary.

6.1.4 #4 – East Berkshire 30 3A

Car pole accidents at pole 98 59 on the 3B contributed to 5,150 CHO on March 15, 2022 and another accident on the 3B with 3,587 CHO at pole 98 59 on July 3, 2022. Weather also impacted the 3B with 780 CHO. And, a failed insulator was replaced at pole 21 73 on the 3F which resulted in 587 CHO.

6.1.5 #5 – Hinesburg 19 1A

Outages on the 1B6 with 1,561 CHO, the 1Y with 2,710 CHO, the 1H4 with 680 CHO, and the 1B with 563 CHO were all tree related.

Routine mechanical vegetation maintenance and danger tree removal were conducted along the entire 19-1 feeder in 2023. Selective foliar herbicide application will take place along this circuit in 2024.

6.1.6 #6 – Burton Hill 43 3A

A broken conductor due to a tree fell-in near pole 128 156 down-stream of the 3D17A resulted in 894 CHO.

Also, a broken guy/anchor down-stream the 3E resulted in 1,110 CHO. Finally, a car pole accident at pole 130 99 on 3F resulted in 670 CHO.

Routine mechanical vegetation maintenance and danger tree removal were conducted along the entire 43-3 feeder in 2022. Selective foliar herbicide application will take place in 2024.

6.1.7 #7 – Cambridge 3 1A

The 1A saw 846 CHO due to snow-weather related with no direct cause found beyond pole 13 2A 44. This occurred on March 13, 2022 before the new recloser at point 1B had been installed put in place to help sectionalize this portion of a long radial circuit to prevent more wide spread outages in the future.

6.1.8 #8 – West Charleston 48 1A

A tree affected the 1A out at pole 109 24resulting 2,820 CHO and another tree at pole 109 32 affected the 1A out resulting in 1,989 CHO.

Routine mechanical vegetation maintenance and danger tree removal were conducted along the entire 48-1 feeder in 2022. Field assessment was conducted following these tree-related outages and additional trees were identified for removal in the area. Selective foliar herbicide application was conducted on this circuit in 2023.

6.1.9 #9 – Derby 45 1A

A failed cut-out at span_213555 (1G8) resulted in 888 CHO.

6.1.10 #10 – East Berkshire 30 1A

Numerous tree related outages in the 2F area caused high CHO for this circuit.

Routine vegetation maintenance and danger tree removal are scheduled for the entire 30-1 feeder in 2027. In the interim, field assessment will take place based on data from tree-related outages and hotspot maintenance and/or danger tree patrols/removals will be conducted where necessary.

6.2 Worst Performing Circuits in 2023

The chart below displays the worst performing circuits in 2023. Any highlights are circuits that were on the 2022 worst performing circuit list.

Rank	Circuit Name	OUTAGES	HOURS
1	Island Pond 4A	61	17364
2	Johnson 3A	30	12677
3	West Charleston 2A	41	11336
4	West Charleston 1A	43	11180
5	Irasburg 3A	72	10574
6	Hinesburg 3A	49	10457
7	Hinesburg 1A	29	9747

8	Newport 5A	38	9715
9	Cambridge 1A	58	7714
10	Hinesburg 4A	14	7691

NOTE: Highlighted cells are circuits that were also on the 2022 list.

Work is now underway to analyze each of these circuits and identify O&M or Capital projects to improve reliability on these circuits in 2024. In addition, VEC has a strategic plan measure to reduce the number of circuits remaining on the worst performing list.

7 SAIDI and SAIFI Reviews

In addition to analyzing the worst performing circuits, VEC also reviews all outages with a SAIDI) value of greater than one minute and an analysis of any circuit that has a SAIFI value greater than three annually. SAIDI is the average outage duration for each member on VEC's service territory. SAIDI is very similar to CAIDI with one key difference. SAIDI utilizes normalizes the total number of members connected to the system and is a ratio factoring in SAIFI, or the frequency of outages, with the number of outages per member. CAIDI is only averaged by the members interrupted in each outage event.

These reviews include an analysis of operating procedures, lineman efficiency, system protection, and potential system upgrades to increase operational effectiveness moving forward and hopefully reduce the likelihood of future outages.