



**Vermont Electric Cooperative, Inc.
Vermont PUC Rule 4.900
2022 Electricity Outage Reporting
January 31, 2023**

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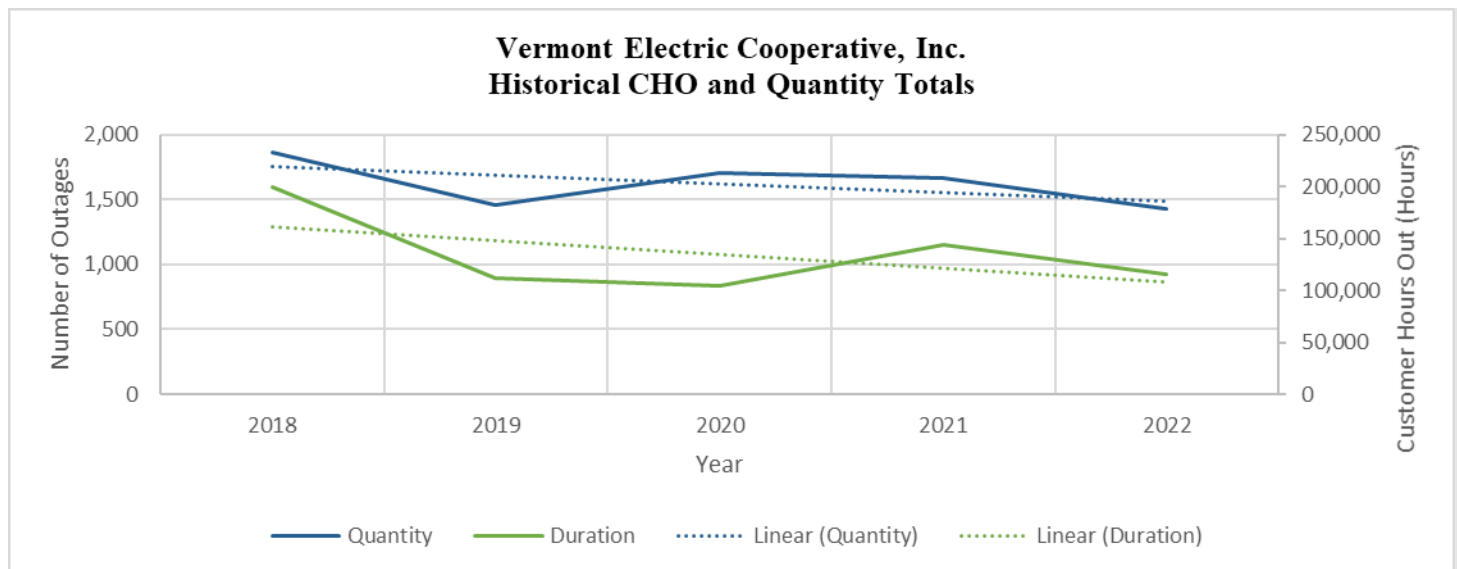
1 Executive Summary

This report contains a detailed assessment of Vermont Electric Cooperative’s (VEC’s) 2022 outage performance and a plan for how to improve reliability to its members. VEC’s 2022 System Average Interruption Frequency Index (SAIFI) and Customer Average Interruption Duration Index (CAIDI) year-end indices, excluding all major storms, were 1.56 and 1.84, respectively. The SAIFI and CAIDI, including major storms, were 2.44 and 6.24, respectively, as shown in the table below.

	SQRP Goals	2022 without Storms	2022 with Major Storms
SAIFI	2.5	1.56	2.44
CAIDI	2.6	1.84	6.24

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 severe weather 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 2017-2022.



VEC saw a decrease in outage duration and a decrease in outage quantity in 2022. However, the general trends are flat or slightly decreasing. 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. Continue to devote 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 decrease annual vegetation management cycle to obtain a six/seven-year (approximately 420 miles per year), blended cycle, by the year 2027. A “blended” cycle means that instead of VEC’s entire service territory being maintained on a standard cycle (e.g., every six years), some of the system will be on a six-year cycle and some of the system will be on a seven-year cycle, depending on the type of construction, vegetation growth rates and successful use of herbicides on different ROWs.
5. Pursue opportunities to perform construction and maintenance activities in a manner that reduces the need for company-initiated outages

2 Vermont Electric Cooperative

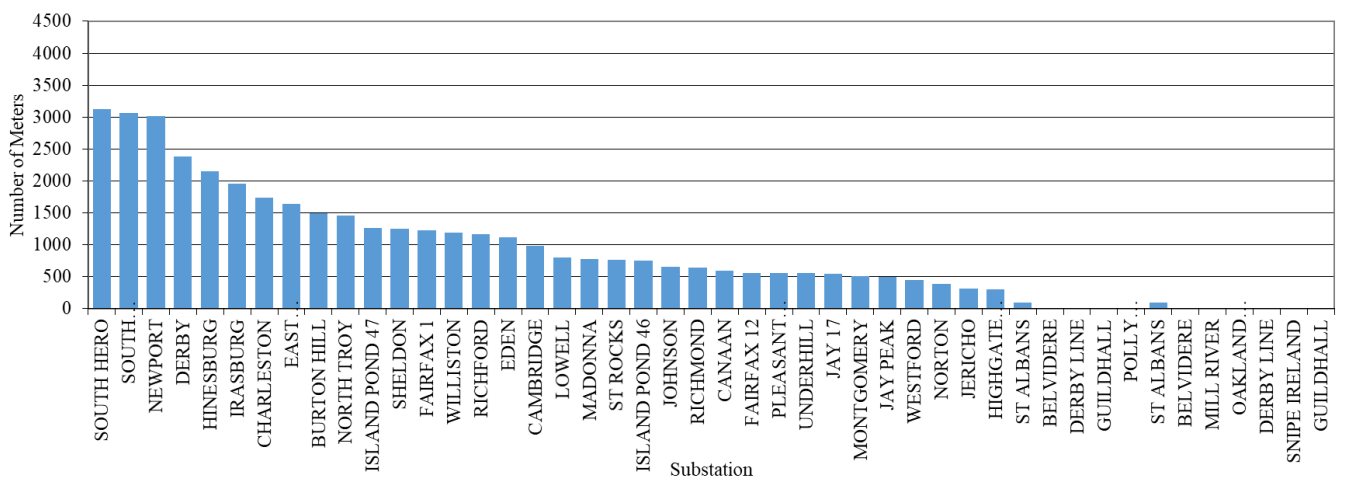
VEC is a rural, member-owned, not-for-profit, electric cooperative utility that presently serves around 40,253 retail meters in 74 towns throughout Northern Vermont. VEC’s territory stretches across Addison, Caledonia, Chittenden, Essex, Franklin, Grand Isle, Lamoille, and Orleans counties.

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 four primary metering points. VEC is interconnected with, and served by five VELCO connections, thirteen GMP connections, two Eversource (formerly PSNH) connections, three Hydro-Quebec connections, and one 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.

**Vermont Electric Cooperative, Inc.
Retail Meter Count by Substation**



3 Storm Exclusions

VEC experienced the following major storm events in 2022:

1. April Wind Snow Event - The April Wind Snow Event started on April 19 at hour 04:00 and ended on April 22 at hour 00:00. At peak, the storm caused over 14,400 VEC meters to be without power, and 231 outage events occurred during the storm.
2. Winter Storm Elliot – Winter Storm Elliot started on December 23 at hour 02:00 and ended on December 28 at hour 15:00. At peak, the storm caused over 13,790 VEC meters to be without power, and 293 outage events occurred during the storm.

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.

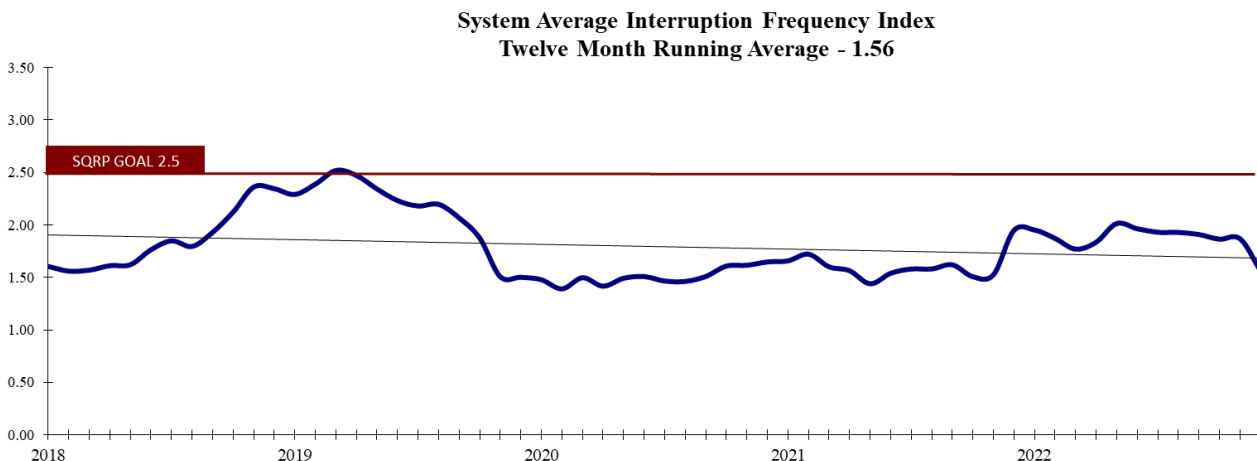
4 Outage Assessment

4.1 Long Term Trends

Below are the five-year SAIFI and CAIDI trends.

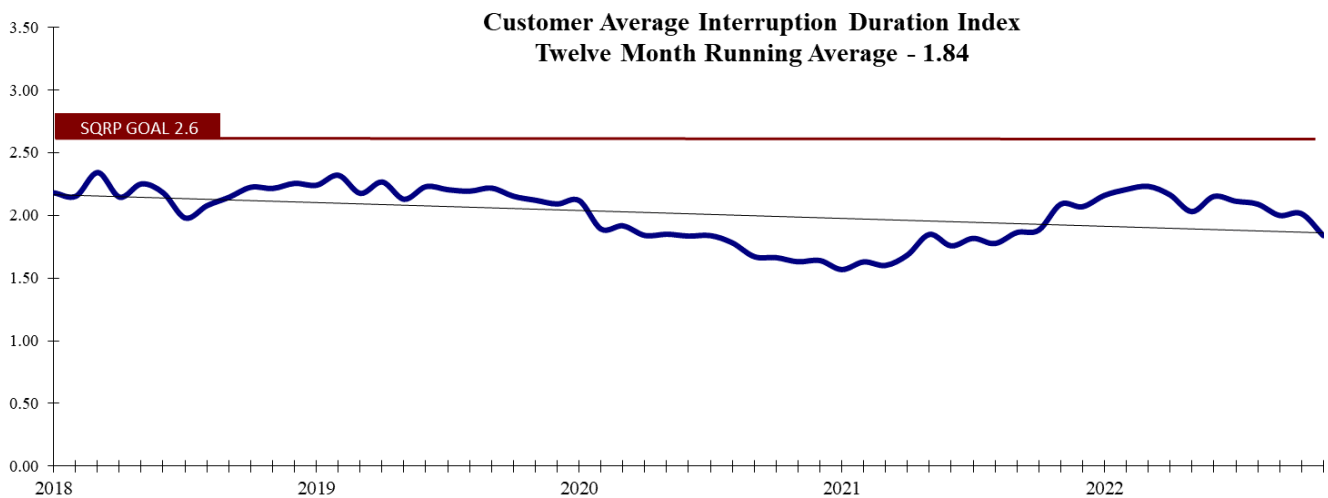
4.1.1 Long Term SAIFI Performance Trend (major storms excluded)

VEC tracks a monthly running twelve-month SAIFI average. The table below shows SAIFI performance back to January 2018.



4.1.2 Long Term CAIDI Performance Trend (major storms excluded)

VEC also tracks a monthly running twelve-month CAIDI average. The table below tracks CAIDI performance back to January 2018.

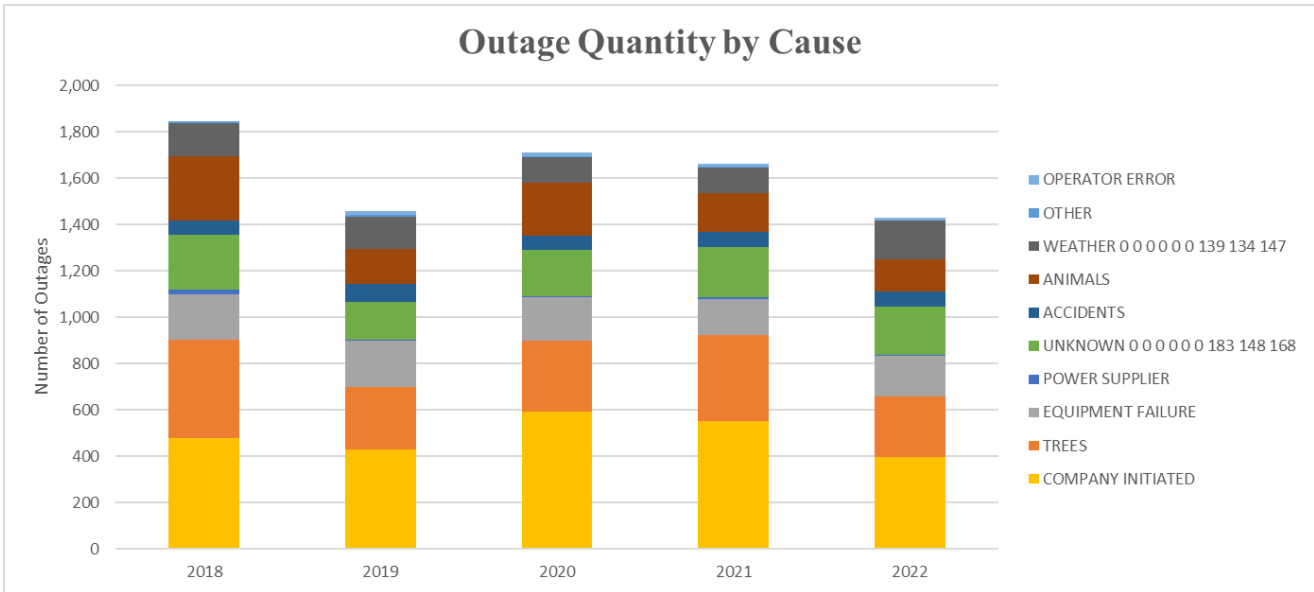


4.1.3 CAIDI and SAIFI Performance by Year (2017-2022) (major storms excluded)

	SQRP Goal	2018	2019	2020	2021	2022
VEC Customers		38,982	39,179	39,539	39,961	40,253
# of Customers Out		91,374	58,537	64,548	76,284	62,966
Customer Hours Out (CHO)		199,287	111,279	104,405	143,386	115,825
CAIDI	2.60	2.54	1.49	1.62	1.88	1.84
SAIFI	2.50	2.34	1.90	1.63	1.91	1.56

4.2 Outage Quantity by Outage Cause

VEC experienced 1,429 outages in 2022 and averaged 1,622 outages per year over the five-year period between 2018 and 2022. The chart below identifies outage quantity by cause for 2018-2022.



The chart below details the quantity of total outages by outage cause for 2022 and the five-year average (2017-2022).

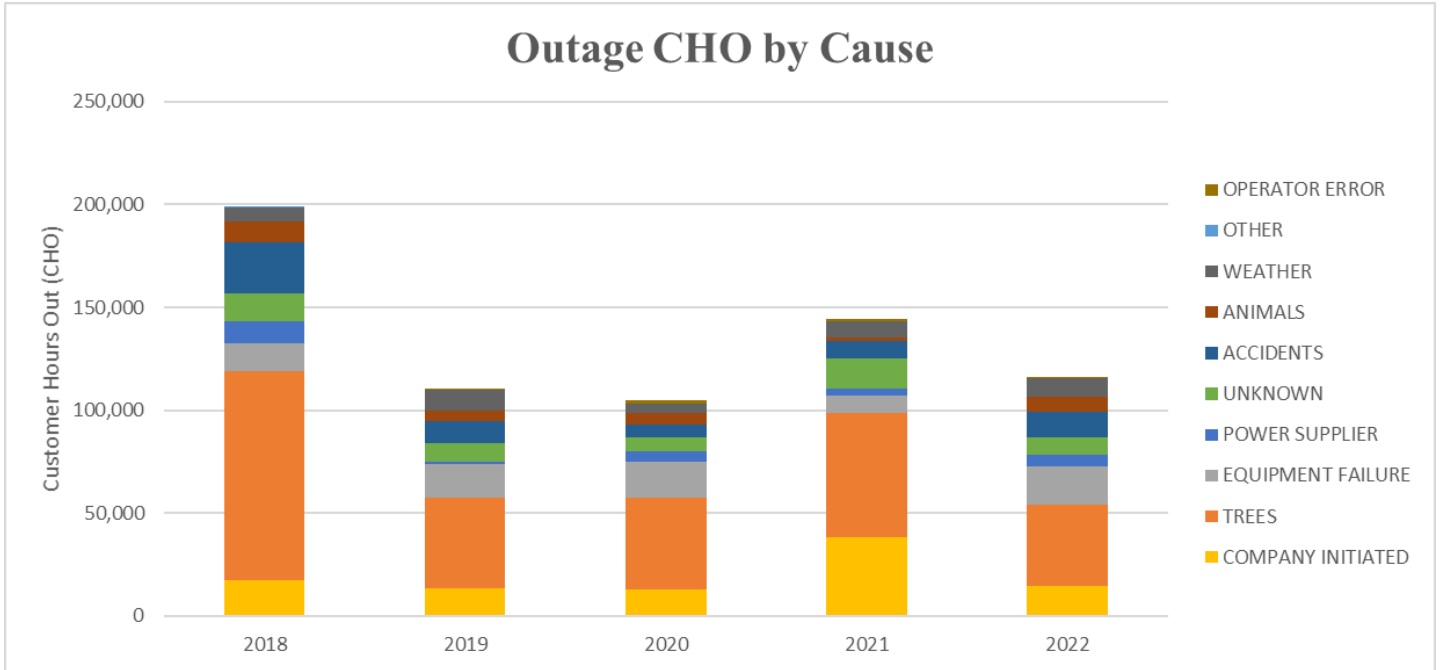
<u>RANK</u>	<u>CAUSE</u>	<u>2022 (Quantity)</u>	<u>Average (Quantity)</u>
1	COMPANY INITIATED	397	491
2	TREES	260	326
3	UNKNOWN	208	204
4	EQUIPMENT FAILURE	175	182
5	WEATHER	165	135
6	ANIMALS	141	193
7	ACCIDENTS	66	66
8	OPERATOR ERROR	12	14
9	POWER SUPPLIER	5	9
10	OTHER	0	3
11	NON-POWER SUPPLIER	0	0
	TOTAL	1,429	1,662

As shown in the table above, company-initiated and tree-related outages continue to be the primary drivers for VEC’s outages; however, both 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 significant decrease in tree related outages in 2022 and was lower than its prior five-year’s for tree related outages. An action plan for each of these causes is located in Section 5.

4.3 Customer Hours Out by Outage Cause

VEC experienced 115,825 customer hours out (CHO) in 2022 and averaged 134,837 hours out per year over the five-year period between 2018 and 2022. The chart below identifies outage duration by cause for 2018-2022.



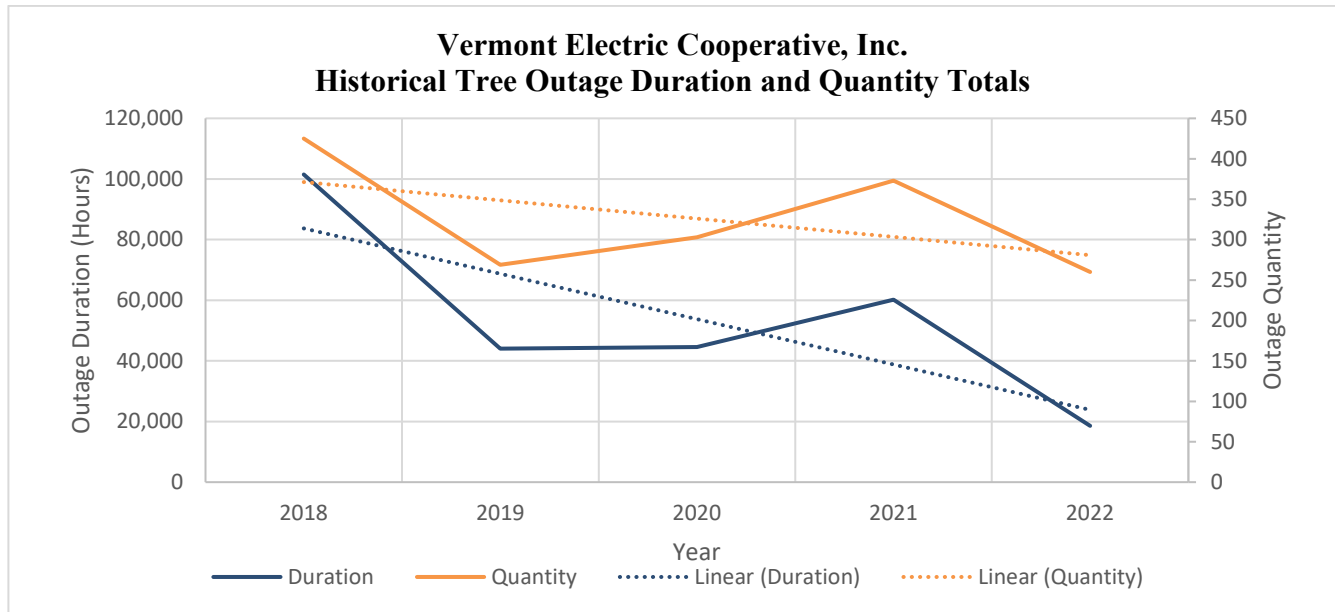
The chart below details the duration in hours out by outage cause for 2022 and the five-year average (2018-2022).

<u>RANK</u>	<u>CAUSE</u>	<u>2022 (Hours)</u>	<u>Average (Hours)</u>
1	TREES	39,320	57,919
2	EQUIPMENT	18,581	15,011
3	COMPANY INITIATED	14,679	19,250
4	ACCIDENTS	12,358	12,487
5	WEATHER	9,043	7,802
6	UNKNOWN	8,629	10,548
7	ANIMALS	7,316	6,041
8	POWER SUPPLIER	5,653	5,096
9	OPERATOR ERROR	247	643
10	OTHER	0	40
11	NON-POWER SUPPLIER	0	1
	TOTAL	115,825	134,837

As shown in the above table, tree-related outages are the primary driver with regard to customer hours out however, lower than previous 5 years. In general, all categories except for equipment failures, accidents and animal outages saw a substantial decline or stayed within the five-year average.

4.4 Tree Outages

For 2022, 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.

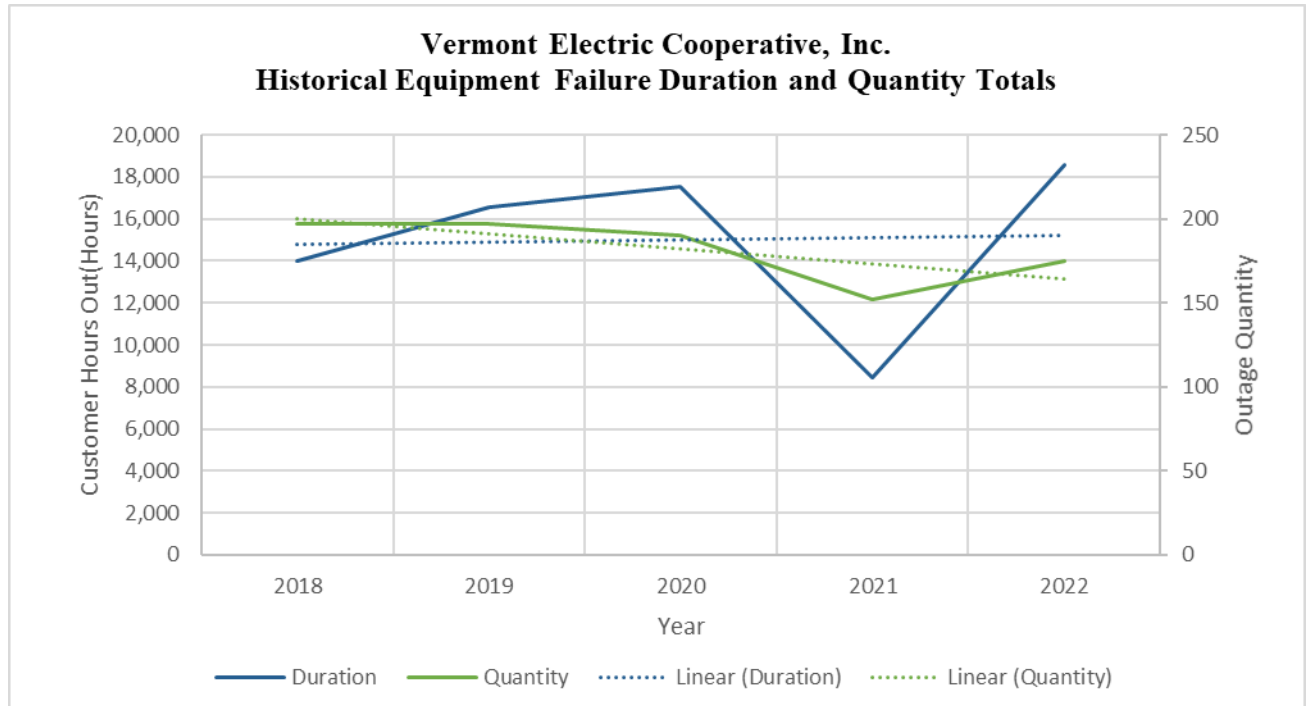


In 2009, VEC filed a vegetation management plan that addressed funding, maintenance cycles, and reliability. That analysis identified a five-year cycle for transmission rights-of-way (ROW) maintenance and an eight-year cycle for distribution ROW maintenance based on then industry best practices and VEC’s experience of managing utility ROW in Vermont. Due to the rate impact associated with moving directly to an eight-year distribution cycle, VEC and the Department of Public Service agreed that VEC would achieve an eight-year cycle over a period of a cycle and a half, or twelve 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 eight-year cycle for distribution in 2022. VEC will continue to implement an eight-year distribution cycle or approximately 320 miles per year through 2026, before moving to a six/seven-year blended cycle or approximately 420 miles in 2027. This decision was made to balance reliability and costs. VEC is also increasing its budget and initiatives from 2022 through 2026 to address Emerald Ash Borer (EAB) infestation. EAB initiatives include removing ash trees that are in VEC ROWs and those ash trees 25 feet outside of our ROW with member approval and consultation, with a strong focus on areas within VEC’s service territory with advanced EAB infestations.

4.5 Equipment Failures Outages

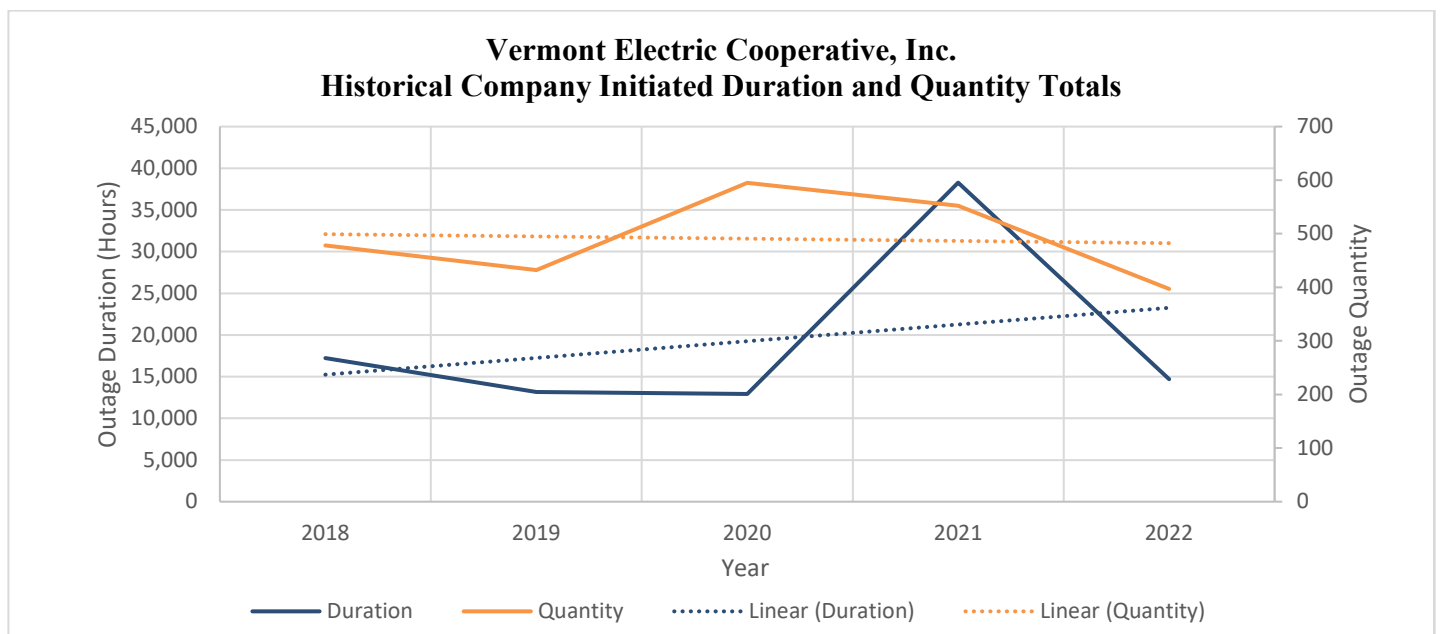
Equipment failure related outages rank second in customer hours out and fourth in outage quantity in 2022.



2022 experienced an increase in quantity but significant duration from equipment failure related outages. Significantly longer patrol times were needed to find some of the causes for them such as a failed lightning arrester on a Newport line with 600 members being served and an ‘untied’ or floating line conductor in East Berkshire.

4.6 Company Initiated Outages

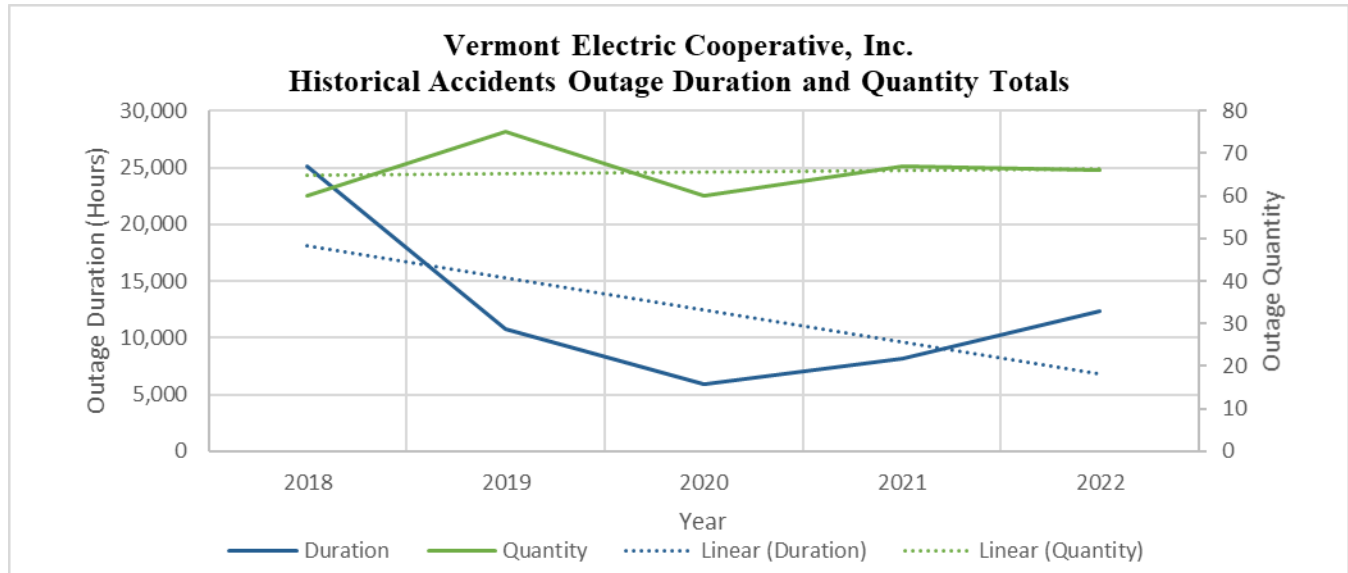
Company initiated outages rank third in customer hours out and first in outage quantity in 2022.



The past year saw company-initiated outage quantity and hour duration at their lowest in five years. 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

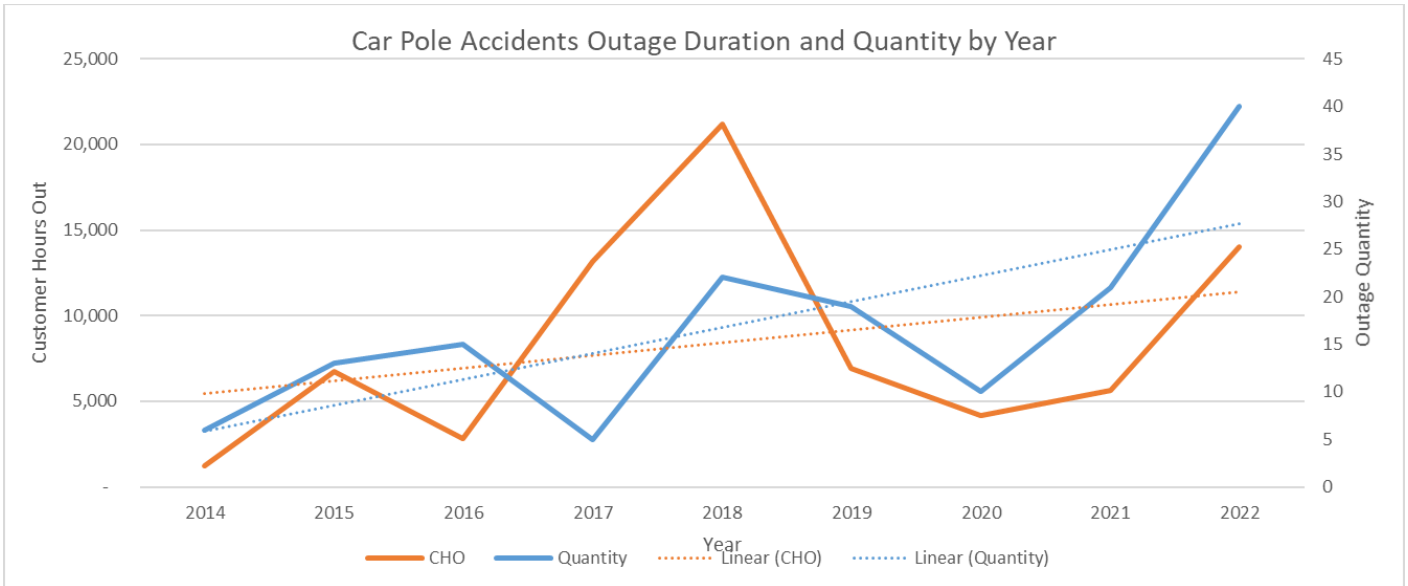
Accidents rank fourth in customer hours out and seventh in outage quantity in 2022.



Member caused outages, such as car-pole accidents and trees 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

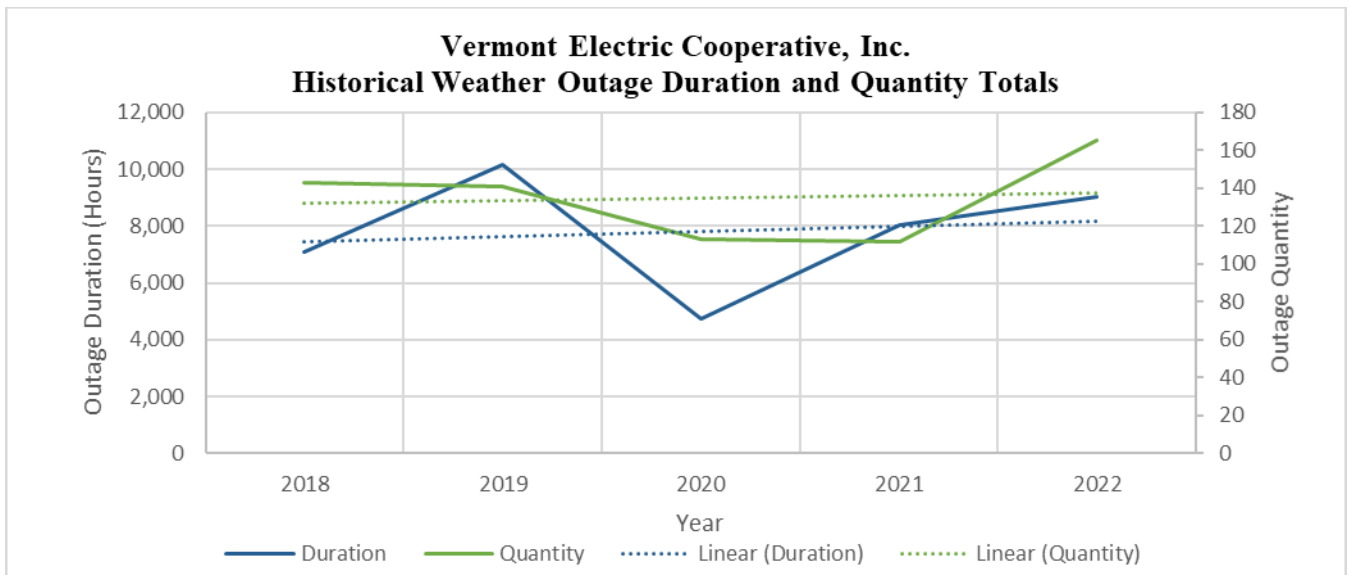
The number of car-pole accidents increased significantly, whereas the number of customer hours out due to such accidents decreased in 2022. The nature and location of these accidents has a significant impact on the duration of car pole outages. Two pictures of a three-phase car pole accident are included after the chart below. This was a significant outage that took over eight hours to repair.





4.8 Weather Outages

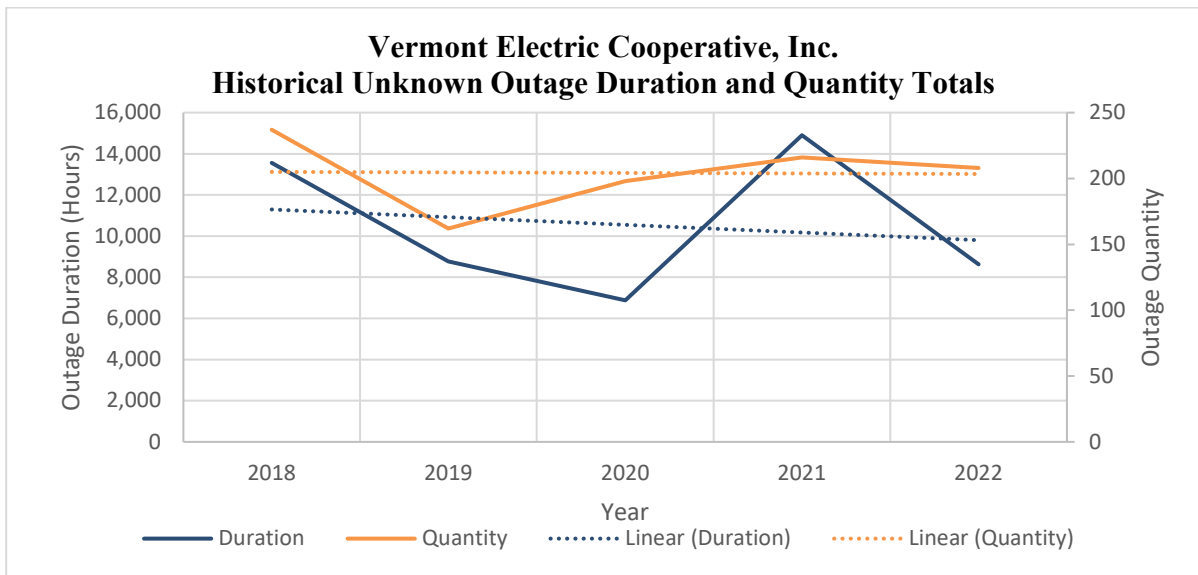
Weather related outages rank fifth in customer hours out and fifth in outage quantity in 2022.



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.

4.9 Unknown Outages

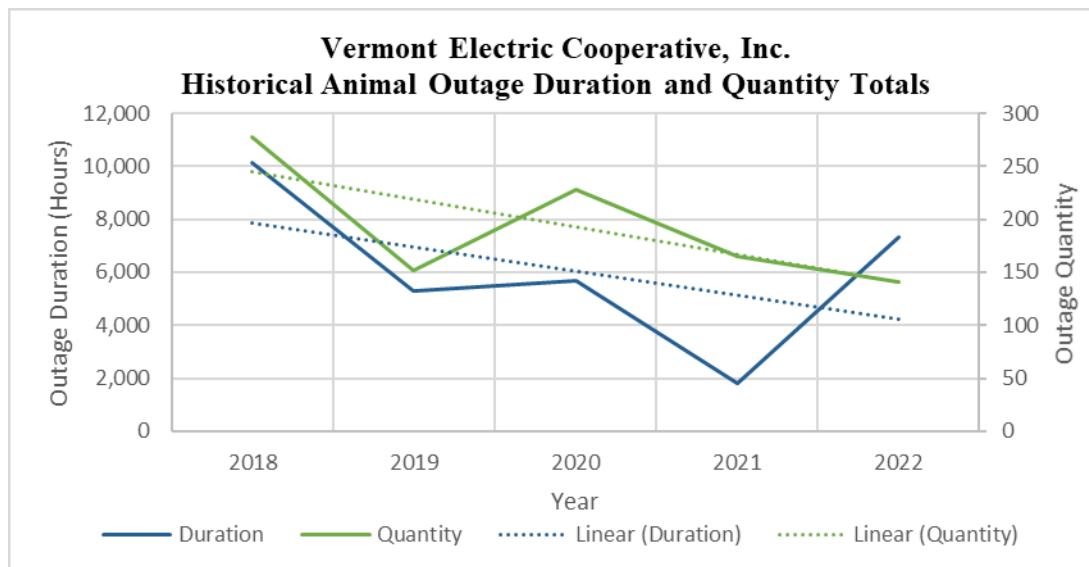
Unknown cause outages rank sixth in customer hours out and third in outage quantity in 2022.



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 2022.



88 percent of these outages are caused by squirrels and birds on equipment without animal protection such as transformers, insulators and lightning arresters (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 arresters. 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

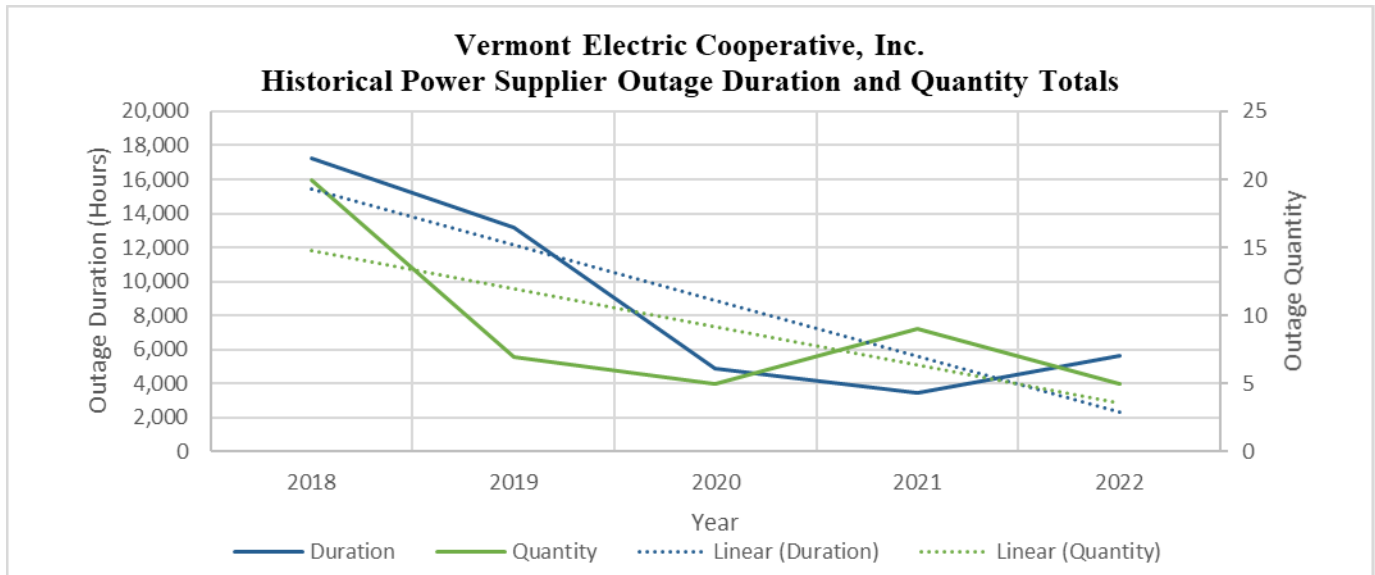
uses a new RUS approved Reliaguard product that combines effectiveness and durability while considering the least cost solution. In 2021 and 2022 VEC continued its deployment of the new animal protection product.

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 is decreasing however, the duration increased in 2022 due mainly to the location of the outage, particularly a racoon got inside the Lowell substation distribution bus and an Osprey caused the outage of the South Alburgh substation's 1A feeder. Both outages were restored in average time of approximately 2 to 3 hours however included more members than usually associated with animal caused outages.

4.11 Power Supplier Outages

Power Supplier outages rank eighth in customer hours out and ninth in outage quantity in 2022.



Power supplier outages have continued to trend lower since 2018.

VEC ID	Date	Duration	Circuit/Substation	Cause
2350	9/22/2022	0:56	L418 Montgomery 7; Belvidere 24	Tree on MT 140
2359	12/17/2022	1:55	3334 Richmond-Bolton; Hinesburg 19	Wet snow loading on GMP transmission line

5 Action Plan

5.1 System Wide

Vegetation Management

As planned, VEC increased distribution line miles scheduled for routine vegetation maintenance in 2022 to approximately 300 miles to move to an eight-year cycle. Due to efficiencies in 2021, 16 miles of the 2022 line miles were actually cleared ahead of schedule, at the end of 2021. The remaining miles were completed on target in 2022. VEC will continue to identify and leverage efficiencies wherever possible and take advantage of opportunities to advance the target vegetation maintenance schedule when they present themselves.

Following a 2018 third-party comprehensive review and assessment of its Vegetation Management Program, VEC has adjusted its previous plan to maintain an eight-year distribution cycle to move to a six/seven-year, blended cycle, by increasing the number of miles of line cleared per year between 2025 and 2027, rather than propose a large one-year rate increase. A “blended” cycle means that instead of VEC maintaining its entire service territory on a standard cycle

(e.g., every six years), some of the system will be on a six-year cycle and some of the system will be on a seven-year cycle, depending on the type of construction, vegetation growth rates, and successful use of herbicides on different ROW.

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 2022: 47-4, 43-3, and 34-1 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: 15-3, 17-1, 17-4, 41-3A, 45-3, Line B7 Cambridge/Madonna, and Jay Tap. Selective herbicide application was also conducted along transmission lines scheduled for routine maintenance in 2022 and distribution circuits which were mechanically cleared in 2021.

Overall, VEC spent \$3,955,571 in 2022 on Vegetation Management for both Transmission and Distribution. The results of this expenditure include:

- 314 miles cleared/covered
- 4,492 danger trees removed
- 137 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, an annual budget of \$250,000 has been identified for EAB mitigation and efficiencies gained in other areas are applied to mitigation efforts whenever possible. Mitigation in 2022 included the proactive removal of ash within confirmed EAB infested and high-risk areas by both dedicated EAB crews, as well as scheduled maintenance crews and the use of specialized off-road equipment. Approximately \$688,828 was spent removing 2094 ash trees (\$329 per tree).

By shifting to a bi-annual data acquisition, VEC will be addressing any maintenance issues found during that inspection the following year. Therefore, every other year between 2022 and 2027, we will move those budgeted dollars (approximately \$300,000) for the data acquisition portion of the maintenance plan for additional EAB mitigation.

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 2021, VEC completed all 2,348 issues found during the 2019 inspection and all but 115 of the 2,117 issues found in 2020. In 2022, VEC will return to conducting inspections and data gathering, its third 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.

VEC completed a lot of internal inspections for 2020 and 2021. This effort is planned to continue into 2022 and 2023.

Inspection Name	Johnson	Richford	Grand Isle	Newport	Done	Total	Overall
2020 Reclosers (OCR)	93%	67%	100%	100%	21	23	91%
2020 Fuses	100%	100%	100%	34%	943	1177	80%
2020 Metering CTPT	98%	90%	100%	96%	243	253	96%
2020 Disconnects	100%	100%	90%	85%	76	81	94%
2020 Switches	100%	100%	22%	100%	5	12	42%
2020 Underground	19%	100%	100%	82%	1135	1656	69%
2021 Metering CTPT	69%	93%	45%	95%	116	169	69%
2021 Reclosers (OCR)	73%	50%	100%	67%	11	16	69%
2021 Alamon Poles					4539	5060	90%
2021 Fuses		35%	60%		252	463	54%
2021 Disconnects		88%	55%		24	39	62%
2021 Underground		0%	54%		154	649	24%
2021 Fault Indicator		28%	100%		45	63	71%
2021 Capacitors		0%	33%		2	9	22%
2021 Stray Voltage	0%	Dec	Dec		0	26	
2021 Switches		Sep	Sep		0	0	
2021 Electronic Reclosers					0	0	
2021 Transmission Switches					0	0	
2021 Joe F. Transmission					1060	2013	53%

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):

<u>Severity Code</u>	<u>Temperature Rise degrees C Over Ambient</u>	<u>Repair Priority</u>	<u>Severity/Recommendation</u>
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.

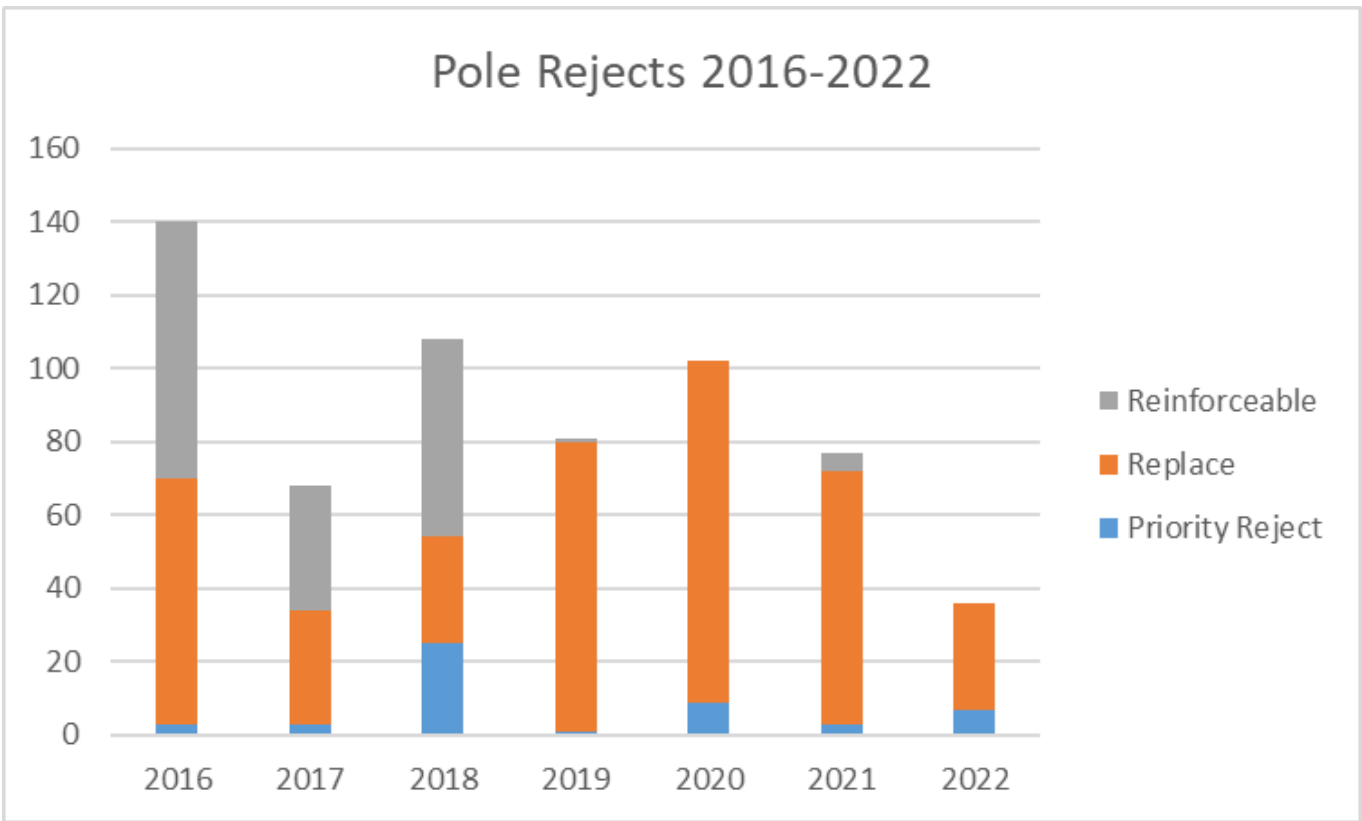
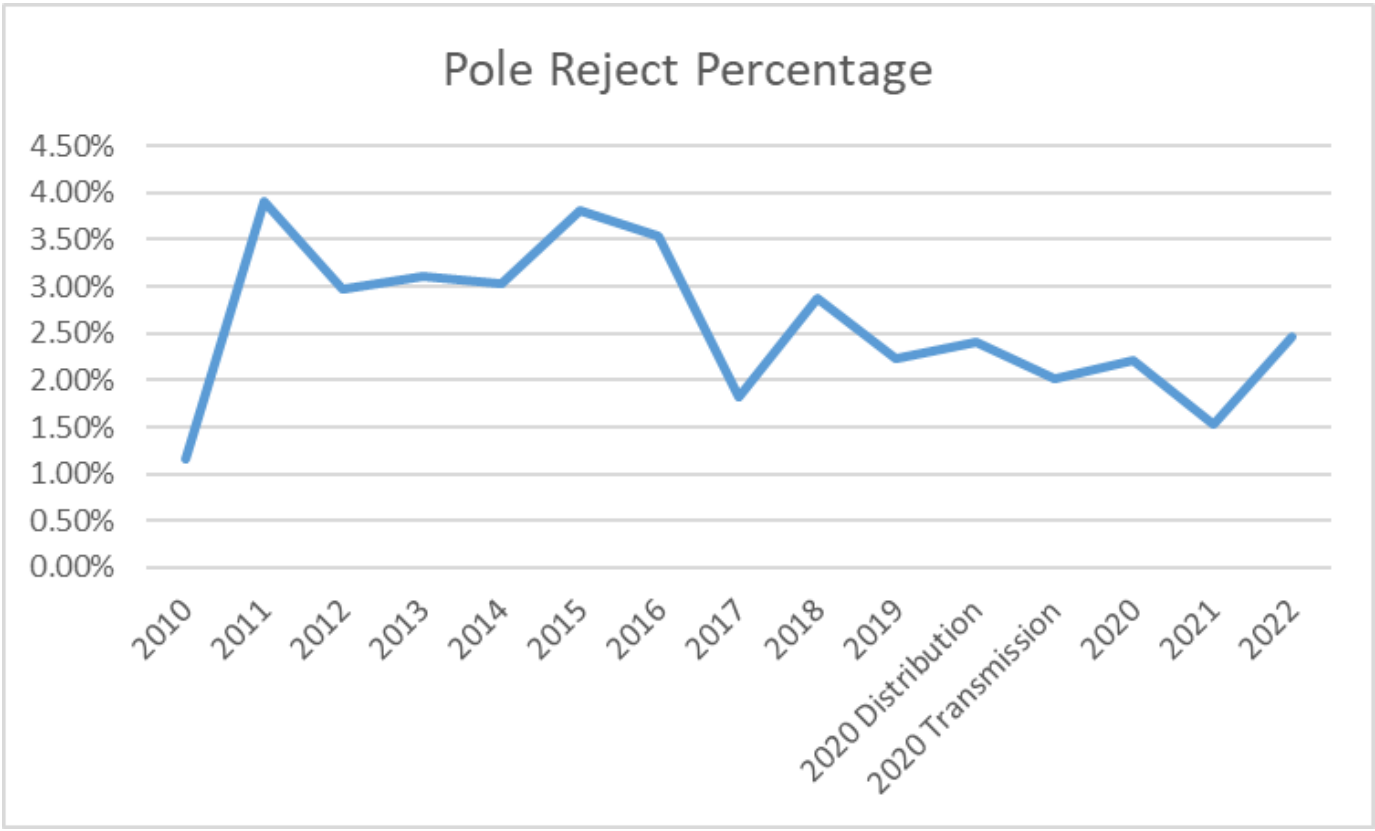
Pole Inspections

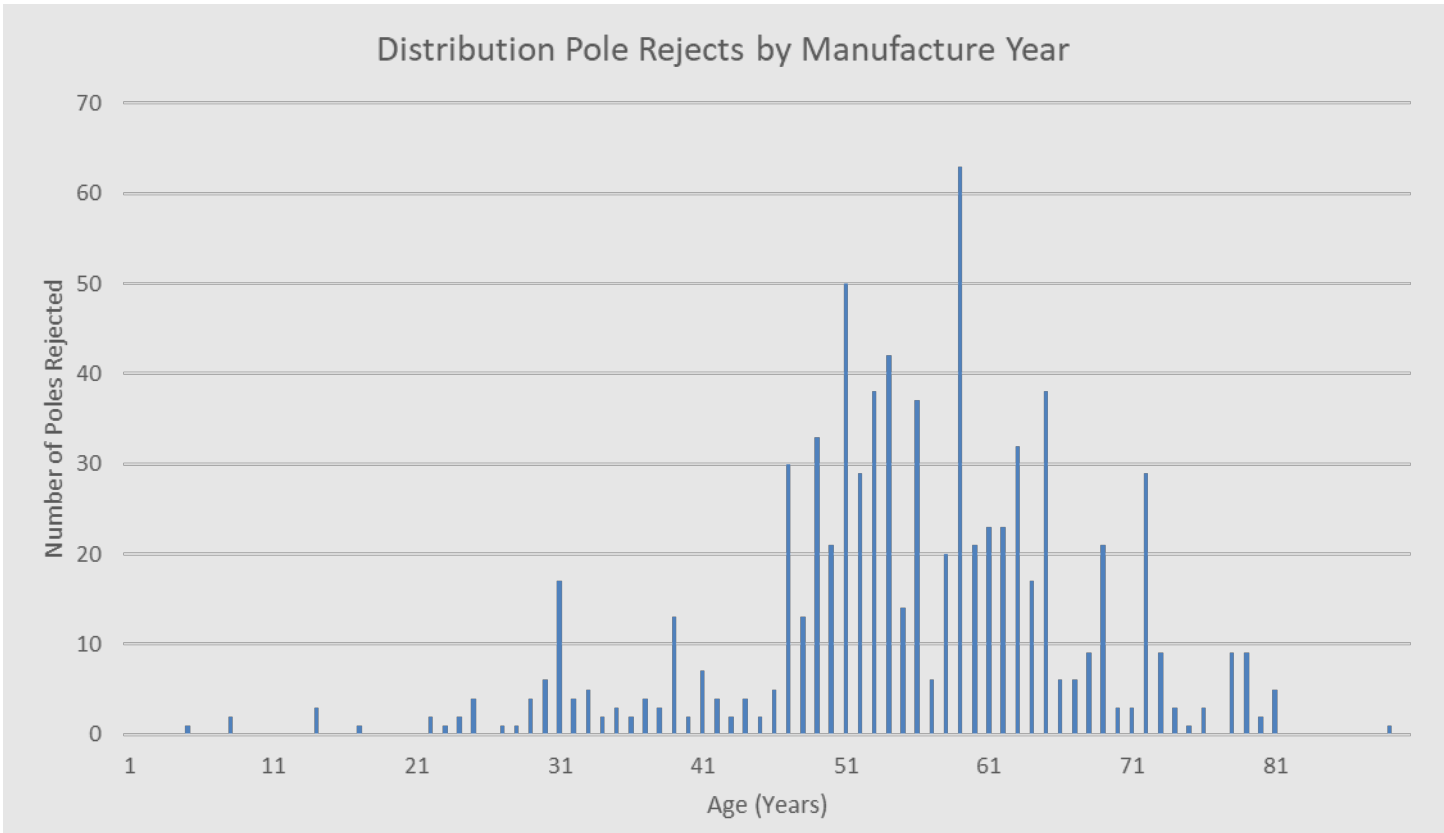
VEC conducts pole inspections and treatments on its transmission and distribution poles over a ten-year cycle. This timeline is consistent with RUS Bulletin 1730B-121. VEC’s program consists of ground line inspection; treatment at 18 inches below ground level for transmission with distribution receiving 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 last year. Our average reject percentage was 2.68 percent. VEC hired Alamon to complete the pole inspection program in 2021 and they identified 77 reject poles. Alamon got a late start this year due to staffing changes and identified 36 reject poles by end of year.





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, pager, 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 at least one primary and one backup individual well trained to handle the requirements of those positions. In other areas, a backup may not yet 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, provided VEC-specified material and GIS mapping tools.

Communication and data sharing are imperative to manage events and incidents effectively. VEC's currently leverages several software platforms comprised of an enterprise notification software Assurance Notification Manager from SunGard Availability Services providing two-way communications via several modes (e.g., text, email, voicemail, etc.) on a company-wide scale, several lists and pages on Microsoft's SharePoint 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 participated in the 2021 Electric Power Research Institute (EPRI) Incubatenergy program which combines electric utility experts, other industry experts, and EPRI employees to evaluate new technologies and innovative startups. From that program, DisasterTech is a software application which helps to replace legacy systems using cutting-edge platform, AI, and predictive analytics. VEC has chosen to pursue leveraging DisasterTech to combine several software applications into a single platform and enhance VEC's responsiveness to events.

DisasterTech integrates directly into Microsoft Teams to allow the seamless sharing of reports, dashboards, and data across the VEC team to maximize situational awareness necessary to make the best possible decisions. DisasterTech also utilizes open source rather than proprietary data, enabling teams to share within and organization or between organizations easily while maintaining one common operating picture. The software was founded by several individuals with extensive FEMA experience and integrates directly with FEMA databases and forms to make applications for FEMA reimbursement streamlined. Outside of the collaboration tools inherent with Microsoft Teams (virtual and video calls, real-time chat, file and other information sharing, lists, action items, and a host of other tools), DisasterTech also offers an enterprise communications system, similar to Assurance that can be leveraged for group two-way communications (e.g., cellular, pagers, LAN lines, email, etc.) This is all included in one package eliminating the need to use several software platforms and SharePoint pages, ultimately reducing complexity. Finally, DisasterTech price point makes it an attractive alternative to using many different software applications, ultimately saving VEC's membership money.

In the first quarter of 2022, VEC plans to migrate from the Assurance platform for group communication to DisasterTech. Once that migrations is complete and employees trained, during the remainder of 2022, VEC will migrate the various forms and lists from SharePoint into the DisasterTech framework and leverage the other FEMA and ICS forms native to the DisasterTech. Our goal is to complete this migration and employee training before the end of October 2022.

NorthView Weather

A collaboration between Northern Vermont University - Lyndon and a recent startup organization, Northview Weather, has focused 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 Weather 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 will significantly 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 Weather 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.

In addition to the forecasting tools above, VEC and the distribution utilities continue to work with Northern Vermont University to identify how our changing climate is affecting weather hazards (primarily wet snow, ice, and windstorms) and to determine the respective impacts to the power system.

The research was broken up into two components:

- What has happened in the past?
 - Examine changes in weather-driven outages with participating Distribution Utilities (DUs).
 - Work with participating DUs to better understand non-weather factors influencing outage variability.
- What may happen in the future?
 - Examine the frequency and magnitude of weather hazards changing in different climate change scenarios.
 - Examine future weather risks as they translate to grid assets to highlight the greatest areas and types of future outage risk.

VEC is analyzing the climate change report generated by Northern Vermont University in late 2021 to determine the impacts of weather hazards driven by a changing climate. This analysis can then be used to refine our philosophies and standards to develop targeted, cost-effective reliability improvements. This report, prepared by Dr. Jay Shafer and Northview Weather, LLC, describes how climate change may present itself through the behavior of weather systems and climate state and how these changes may affect the reliable operation of Vermont's electric grid through 2049. The report is available upon request. VEC is working with Dr. Shafer and Northview Weather on a more detailed analysis to develop technical capabilities and apply GIS analysis to historic VEC power outages to demonstrate the value in VEC's historic data to inform future reliability investments. VEC plans to have this analysis completed by mid-year 2021 to assist with capital planning for 2022 and beyond.

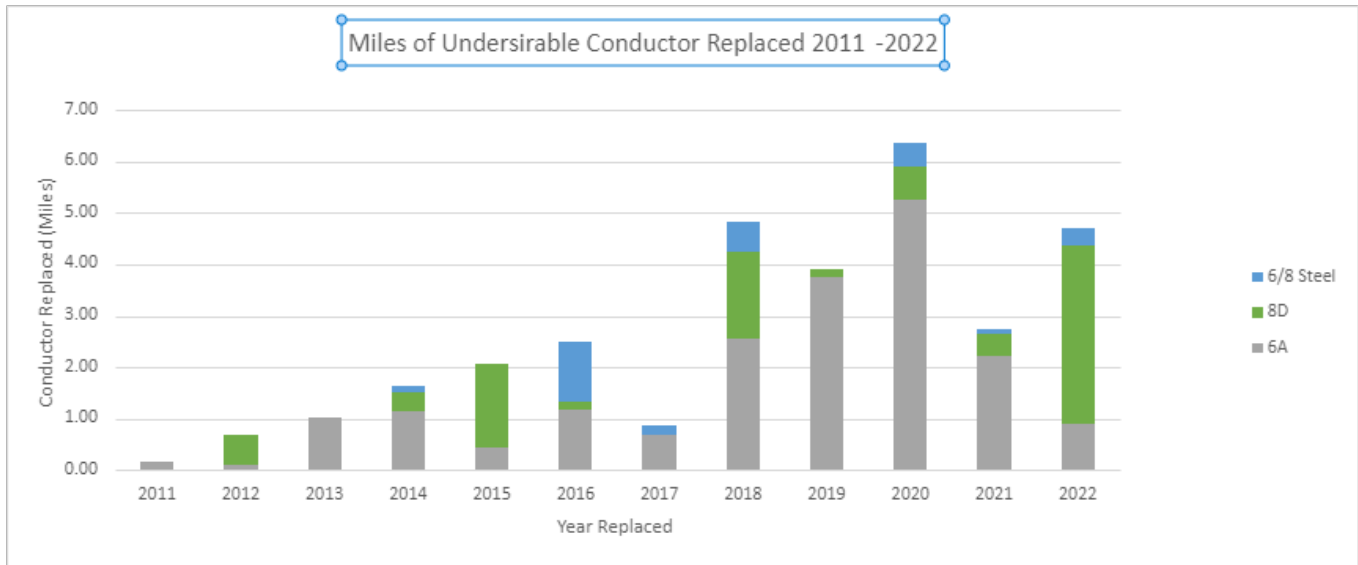
Aerial Patrols

Qualified VEC personnel conduct aerial patrols and one infrared scan of all VEC transmission lines four times per year. 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.

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 ROW to the roadside. In 2023, VEC plans on reconductoring around eight miles of obsolete wire and relocating 2.2 miles from difficult to access rights-of-way to the road.



VEC retired almost five miles of 8D, 6A, and 6/8 steel in 2022.

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.

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 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 spacer cable 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’s worst performing transmission line is the 51Y5 circuit, which feeds its Hinesburg 19 substation. In 2021, VEC completed work to replace several poles and insulators on the line and again in the Spring of 2022. In the Fall of 2022 VEC replaced 10 additional transmission poles for Make-Ready purposes and to improve access.

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.

5.4 Substations

GMP and VEC received a CPG and are now constructing a joint project at the Richmond 08 substation to automatically sectionalize GMP's 3334 sub-transmission line so that if a fault occurs on one section of GMP's line, the new configuration will still allow energy to flow to VEC's substation while shutting off the faulted line. VEC and GMP expect to commission this substation project in Spring of 2023.

In addition to the Richmond 08 joint project mentioned above, VEC has received a CPG to rebuild its' Sheldon 32 substation back in 2021 and completed site work this year. This substation serves VEC's single largest owner-member, Westrock paper mill along with significant hydro and solar power generation with back-up transmission service to GMP's Sheldon substation.

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 2021 worst performing circuits and section 6.2 details the 2022 worst performing circuits.

6.1 A Review of the Worst Performers in 2021

The following table lists VEC’s 2021 worst performers and their 2022 year-end ranking.

Circuit Name	2021			2022		
	Rank	Quantity	CHO	Rank	Quantity	CHO
West Charleston 2A	1	45	14,449	44	43	14,219
Island Pond 4A	2	43	14,219	13	48	4,250
West Charleston 1A	3	44	12,319	8	55	3,113
West Charleston 3A	4	25	12,201	56	13	2,237
North Troy 3A	5	52	5,514	42	20	2,065
Burton Hill 3A	6	52	5,390	6	37	4,644
Hinesburg 1A	7	36	6,491	5	47	4,936
Irasburg 1A	8	47	4,936	31	22	1,986
West Charleston 4B	9	19	11,218	57	12	1,526
Cambridge 1A	10	48	4,250	7	44	2,846

Six of the circuits on the 2021 top 10 worst performers list are no longer on the 2022 list. The circuits that are highlighted are those that are on both the 2021 and 2022 worst performing 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 2021 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 – West Charleston 48-2A

- **48-2A**
 - 65% of the customer hours out (CHO) were company initiated and associated with VELCO transmission line work to extend outward the middle phase on double circuit structures also carrying VEC's East Line from Newport to Derby.
 - 2 main line tree events accounted for 80% of the remaining CHO, the largest of the 2 events occurred on the main line side of a fused lateral / junction.

Routine vegetation maintenance and danger tree removal was conducted along the entire 48-2 feeder in 2021/2022, and was completed in the first quarter of 2022. Selective herbicide application was conducted in July/August 2022.

6.1.2 #2 – Island Pond 46-4A

- **47-4A**
 - 57% of the total CHO were company initiated and associated with VELCO transmission line work to extend outward the middle phase on double circuit structures also carrying VEC's East Line from Newport to Derby.
 - There were two major tree events, 1 on the transmission line source between West Charleston and Island Pond which took out the entire substation and a 2nd on the Henshaw Road just before a single-phase line fuse. The Henshaw Road tree caused the 4A recloser to open causing 32% of the total tree related CHO. The transmission line tree also resulted in 32% of the total tree related CHO. These two tree related outages combined resulted in 27% of the total CHO.

Routine vegetation maintenance, danger tree removal and selective herbicide application were conducted on the transmission line between West Charleston and Island Pond in 2022 and routine vegetation maintenance and danger tree removal is scheduled to take place (currently underway) along the entire 47-4 distribution feeder in 2023. Selective herbicide application will take place along this distribution circuit in 2024.

6.1.3 #3 – West Charleston 48-1A

- **48-1A**
 - 71% of the total CHO were company initiated and associated with VELCO transmission line work to extend outward the middle phase on double circuit structures also carrying VEC's East Line from Newport to Derby.
 - There was 1 major tree event that took out the transmission line which was the same event impacting the West Charleston 2A reliability. The transmission line tree resulted in 71% of the total tree related CHO.
- **48-1E**
 - A second tree event took out the 1E fuse causing 15% of the total tree related CHO.

Routine vegetation maintenance, danger tree removal and selective herbicide application were conducted along the transmission line between West Charleston and Island Pond in 2022 and routine vegetation maintenance and danger tree removal were also conducted along the entire 48-1 feeder in 2022. Selective herbicide application is scheduled along this distribution circuit in 2023.

6.1.4 #4 – West Charleston 48-3A

- **48-3A**
 - 85% of the total CHO were company initiated and associated with VELCO transmission line work to extend outward the middle phase on double circuit structures also carrying VEC's East Line from Newport to Derby.
 - There was 1 major tree event that took out the transmission line which was the same event impacting the West Charleston 2A reliability. The transmission line tree resulted in 64% of the total tree related CHO.

Routine vegetation maintenance, danger tree removal and selective herbicide application were conducted along the transmission line between West Charleston and Island Pond in 2022.

- **48-3E**
 - A 2nd tree event took out the 3E fuse causing 22% of the total tree related CHO.

Routine vegetation maintenance and danger tree removal are scheduled for the entire 48-3 feeder in 2025. 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.

6.1.5 #5 – North Troy 41-3A

- **41-3A**
 - There were 2 major tree events involving the 3A recloser at the substation; worst one was less than 1 mile south of the substation and in an off-road location difficult to access which resulted in 59% of the total tree related CHO. A 2nd tree event involving the 3A recloser was on Cross Rd causing 27% of the total tree related CHO.

Given that the 41-3A experienced 2 major tree related outages in 2021, following routine vegetation maintenance and danger tree removal along the entire 41-3 feeder in 2020, a comprehensive danger tree patrol (and subsequent removals) was conducted along significant off-road portions of this circuit in 2022.

6.1.6 #6 – Burton Hill 43-3A

- **43-3A**
 - 57% of CHO were caused by company-initiated events to provide crews with working clearances associated with the reconductoring of the 1A feeder.
- **43-3E & 3G**
 - 26% of CHO were caused by 2 major car-pole accidents affecting the 3E and 3G and associated with pole replacement #7 – Hinesburg 19-1A
- **19-1A**
 - 4 separate tree events taking out the 1Y recloser resulted in 62% of CHO. These 4 events occurred along the Sherman Hollow Road which has proven difficult to mitigate due to long line with tree exposure and load towards the end of it as opposed to evenly distributed.

Routine vegetation maintenance and danger tree removal is scheduled to take place (currently underway) along the entire 19-1 distribution feeder in 2023. Selective herbicide application will take place along this distribution circuit in 2024.

6.1.7 #8 – Irasburg 42-1A

- **Various points off 42-1A**
 - 39% of CHO were caused by 11 company-initiated events at various points off the 1A and associated with the Lake Road voltage conversion.
- **42-1D**
 - A significant car-pole accident at intersection of Vance Hill and Lake Road took out the 1D fuses and resulted in 36% of CHO.

6.1.8 #9 – West Charleston 48-4B

- **48-4B**
 - 78% of the total CHO were company initiated and associated with VELCO transmission line work to extend outward the middle phase on double circuit structures also carrying VEC's East Line from Newport to Derby.
 - There was 1 major tree event that took out the transmission line which was the same event impacting the West Charleston 2A reliability. The transmission line tree resulted in 15% of the total CHO.

Routine vegetation maintenance, danger tree removal and selective herbicide application were conducted along the transmission line between West Charleston and Island Pond in 2022.

6.1.9 #10 – Cambridge 03-1A

- **03-1A**
 - 53% of CHO were caused by 11 separate tree events. The worst being on the 1A recloser nearly 2 miles north of the substation where the line jogs off from Rte. 109 for a short distance of about 10 spans, causing 53% of the total tree related CHO. A second tree was found on the single-phase point 1Q4 for additional 11% of the total tree related CHO.

Routine vegetation maintenance and danger tree removal is scheduled to take place (currently underway) along the entire 03-1 distribution feeder in 2023. Selective herbicide application will take place along this distribution circuit in 2024.

- **03-1C**
 - A line insulator found on the single-phase point 1C resulted in 41% of the total CHO due to equipment failures. Insulators being the largest cause of the equipment failures.

A capital improvement project to replace fusing and add additional sectionalizing fuse points including 3 new electronic reclosers at 1B was completed in 2022.

6.2 Worst Performing Circuits in 2022

The chart below displays the worst performing circuits in 2022. Any highlights are circuits that were on the 2021 worst performing circuit list.

<u>Rank</u>	<u>Circuit Name</u>	<u>OUTAGES</u>	<u>HOURS</u>
1	South Alburg 1A	54	7039
2	Hinesburg 3A	46	7301
3	South Hero 1A	65	5008
4	East Berkshire 3A	26	9307
5	Hinesburg 1A	29	8115
6	Burton Hill 3A	52	4455
7	Cambridge 1A	46	4902
8	West Charleston 1A	32	5380
9	Derby 1A	37	3879
10	East Berkshire 1A	37	2947

Work is now underway to analyze each of these circuits and identify O&M or Capital projects to improve reliability on these circuits in 2023. In addition, VEC has a strategic plan measure to reduce the number of circuits remaining on the worst performing list.

7 SAIDI Reviews

In addition to analyzing the worst performing circuits, VEC also reviews all outages with a SAIDI (System Average Interruption Duration Index) value of greater than one minute. 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 the total number of members connected to the system and is a ratio with the number of outages per member. CAIDI is only averaged by the members interrupted in each outage event.

These SAIDI 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.