Vermont Electric Cooperative, Inc.

Vermont PUC Rule 4.900

2019 Electricity Outage Reporting

January 30, 2020

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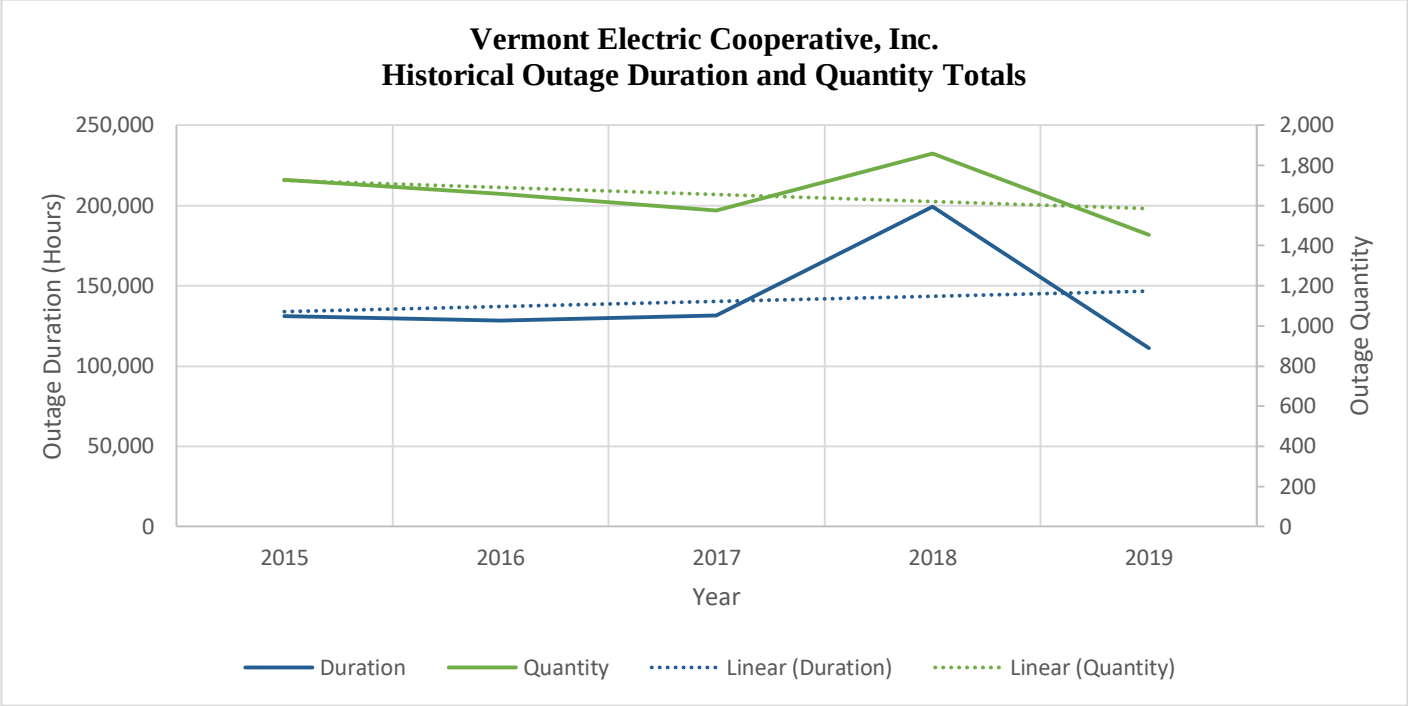
1 Executive Summary

This report contains a detailed assessment of Vermont Electric Cooperative's (VEC's) 2019 outage performance and a plan for how to improve reliability to its members. VEC's 2019 System Average Interruption Frequency Index (SAIFI) and Customer Average Interruption Duration Index (CAIDI) year-end indices, excluding all major storms, were 1.49 and 1.90, respectively. The SAIFI and CAIDI, including major storms for 2019, were 1.96 and 2.83, respectively.

	SQRP Goals	2019 without Storms	2019 with Major Storms
SAIFI	**2.5**	1.49	1.96
CAIDI	**2.6**	1.90	2.83

This report follows the 4.900 definitions and as a result, the information provided here includes only outages greater than five minutes. VEC includes 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 chart below details VEC's outage durations and quantity from 2015-2019.



Overall, VEC saw a decrease in both outage duration and outage quantity in 2019. However, the general trends are flat or slightly increasing. Recognizing that there is room for improvement, VEC has put together a plan to decrease both outage duration and quantity. The plan includes the following actions:

1. 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 a 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. Adjust the company's vegetation management plan to move to a six/seven year, blended cycle, by the year 2023. We will do that by slightly increasing the number of miles of line cleared per year over the next several years, rather than proposing a large one-year rate increase. A "blended" cycle means that instead of VEC's entire service territory being maintained on a standard cycle (*i.e.* 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.

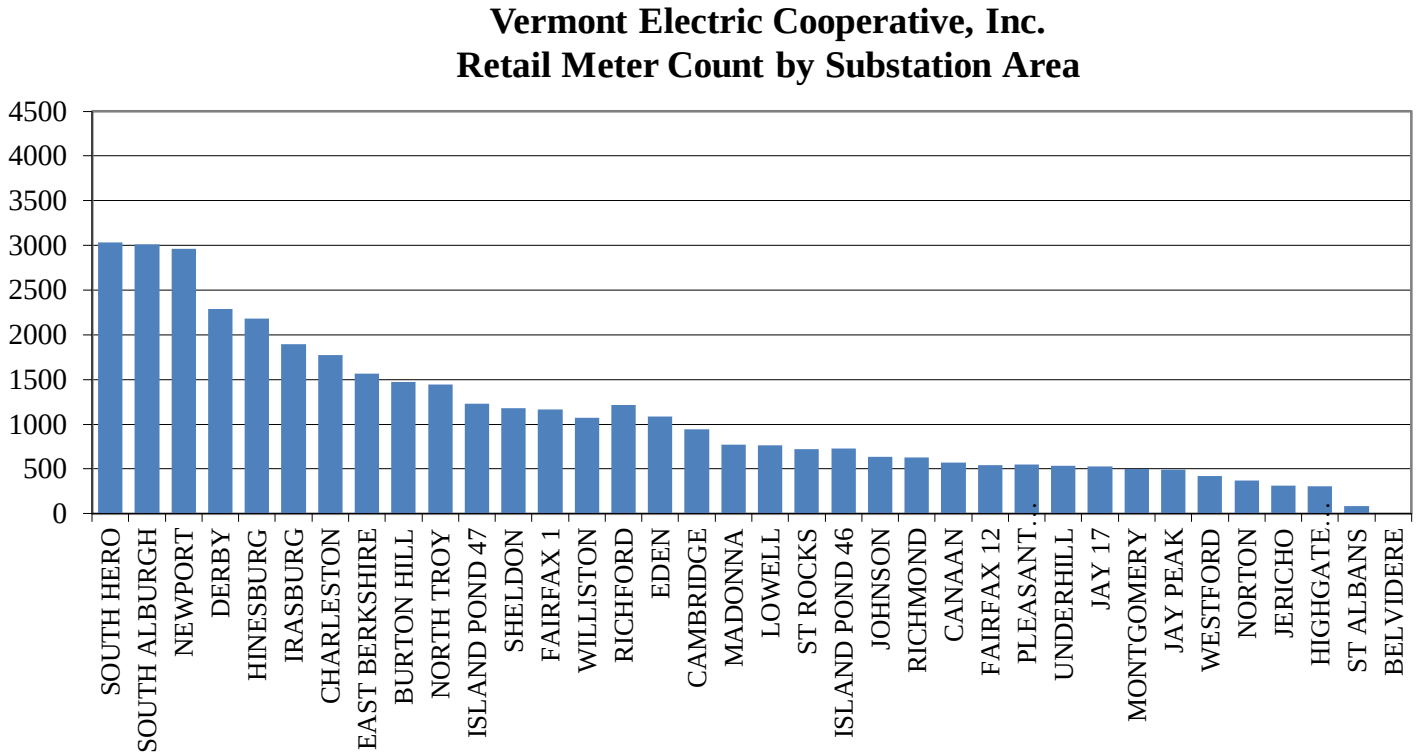
2 Vermont Electric Cooperative

Vermont Electric Cooperative, Inc. (VEC) is a rural, member-owned, not-for-profit, electric cooperative utility that presently serves around 39,200 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 14.2 consumers 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 2019.



3 Storm Exclusions

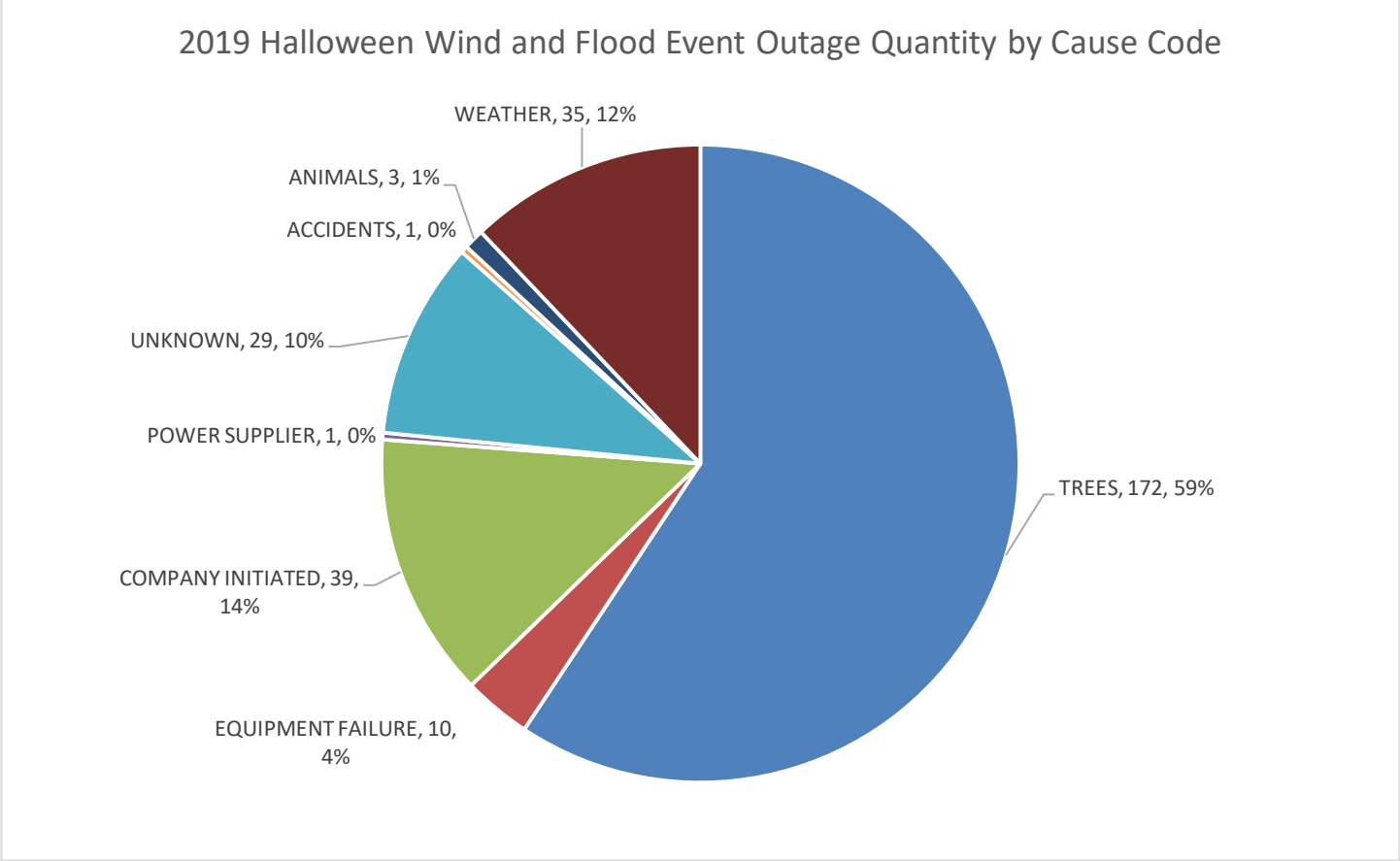
VEC experienced one event in 2019 that qualified as a "Major Storm" as defined in the VEC Service Quality & Reliability Plan ("SQRP"). The outages from the 2019 Halloween Wind and Flood Event were excluded from this report. SQRP defines a major storm as a severe weather event that satisfies all three of the following criteria:

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

3.1 Halloween Wind and Flood Event

The 2019 Halloween Wind and Flood Event started on October 31 at hour 19:00 and ended on November 4 at hour 19:00. At peak, the storm caused over 18,225 VEC meters to be without power, and 327 outage events (290 were greater than 5 minutes) occurred during the storm.

Winds reached gusts greater than 50 mph with sustained winds ranging from 35-45 mph for six hours following 3-5 inches of rain. The storm caused damage in all eight of the counties VEC serves; trees caused the majority of the outages.



Over the course of the storm, VEC had 172 tree-related outages, which caused 18 broken poles, 5 transformer replacements, and several anchor replacements. VEC's Fairfax substation was the most heavily hit circuit with 17 tree-related outages. The Jay, West Charleston, and Burton Hill substations all saw at least 14 tree-related outages.

To aid in restoration VEC hired 28 contract lineman and 32 contract vegetation management personnel.

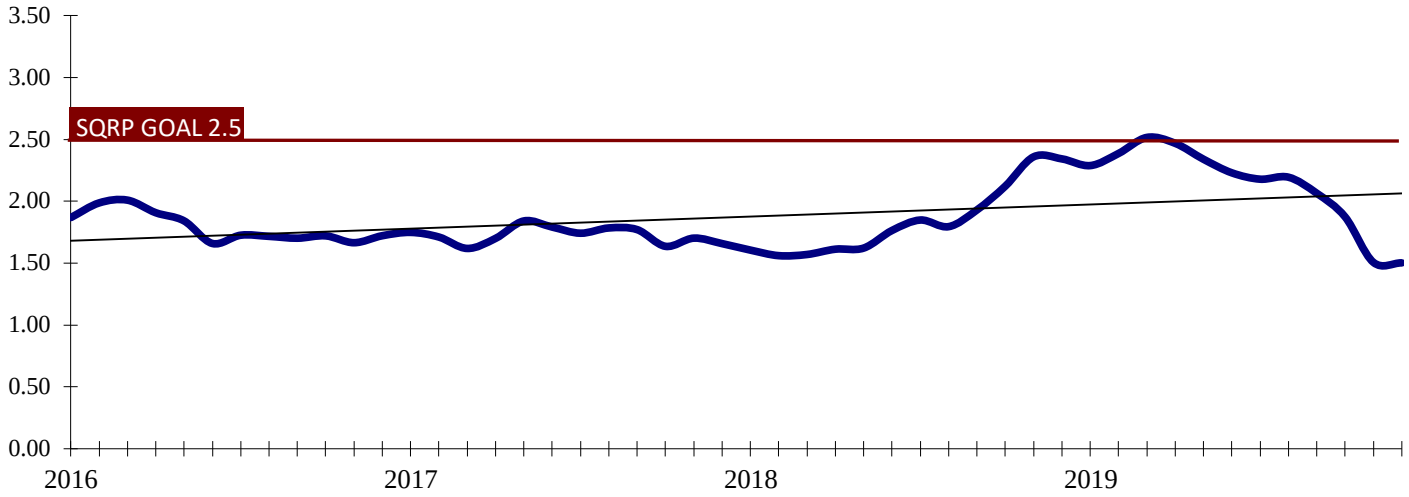
4 Outage Assessment

Below are the five-year SAIFI and CAIDI trends.

	2015	2016	2017	2018	2019
VEC Customers	38,780	38,372	38,538	38,982	39,179
# of Customers Out	72,071	65,406	66,137	91,374	58,537
Customer Hours Out (CHO)	131,007	128,208	131,392	199,287	111,279
CAIDI	1.89	2.12	1.94	2.54	1.49
SAIFI	1.86	1.70	1.72	2.34	1.90

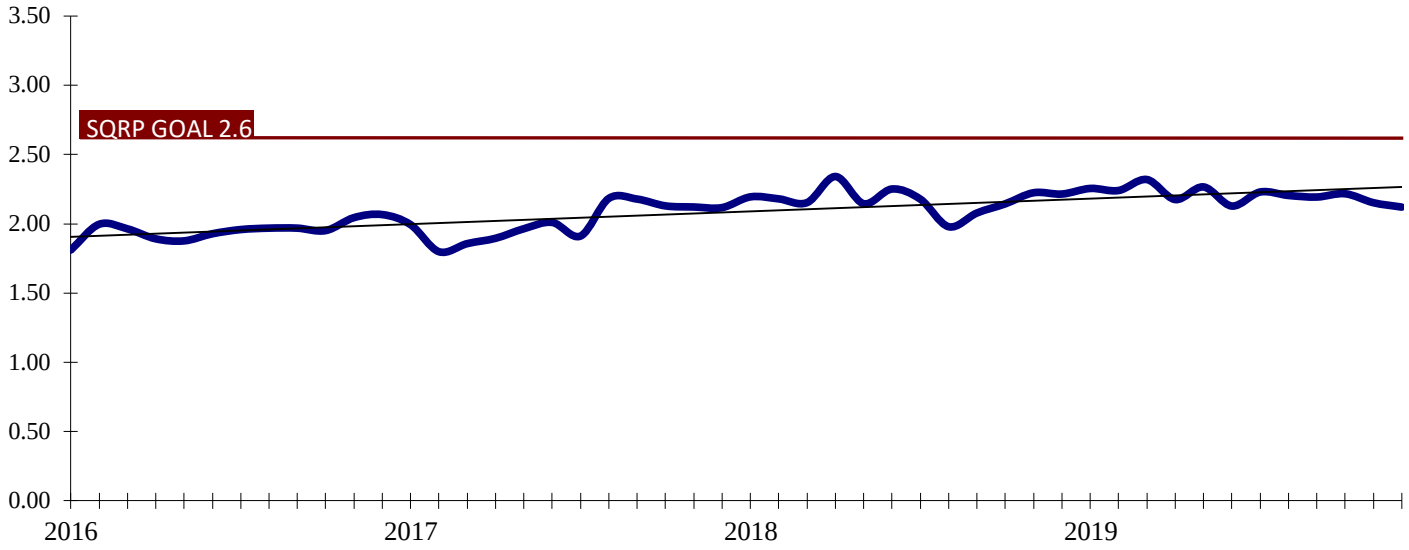
4.1 Long Term SAIFI Performance Trend (major storms excluded)

VEC tracks a monthly running twelve-month SAIFI average. The table below shows SAIFI performance back to January 2016.



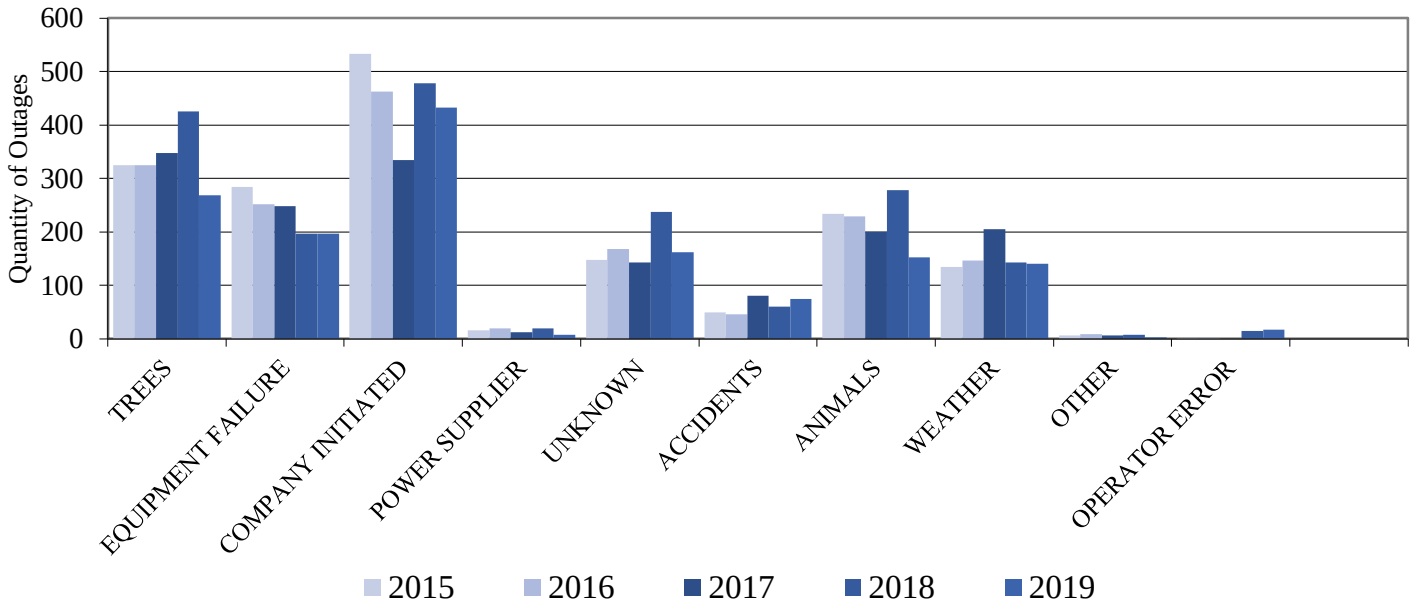
4.2 Long Term CAIDI Performance Trend (major storms excluded)

VEC also tracks a monthly running twelve-month CAIDI average. The table below tracks CAIDI performance back to January 2016.



4.3 Outage Quantity by Outage Cause

VEC experienced 1,455 outages in 2019 and averaged 1,656 outages per year over the five-year period between 2015 and 2019. The chart below identifies outage quantity by cause for 2015-2019.



The chart below details the quantity of total outages by outage cause for 2019 as well as the five-year average.

RANK	CAUSE	2019 (Quantity)	Average (Quantity)
1	COMPANY INITIATED	432	435
2	TREES	269	339
3	EQUIPMENT FAILURE	197	233
4	UNKNOWN	162	174
5	ANIMALS	152	226
6	WEATHER	141	152
7	ACCIDENTS	75	58
8	OPERATOR ERROR	17	6
9	POWER SUPPLIER	7	14
10	OTHER	3	7
11	NON-POWER SUPPLIER	0	0
	TOTAL	**1,455**	**1,656**

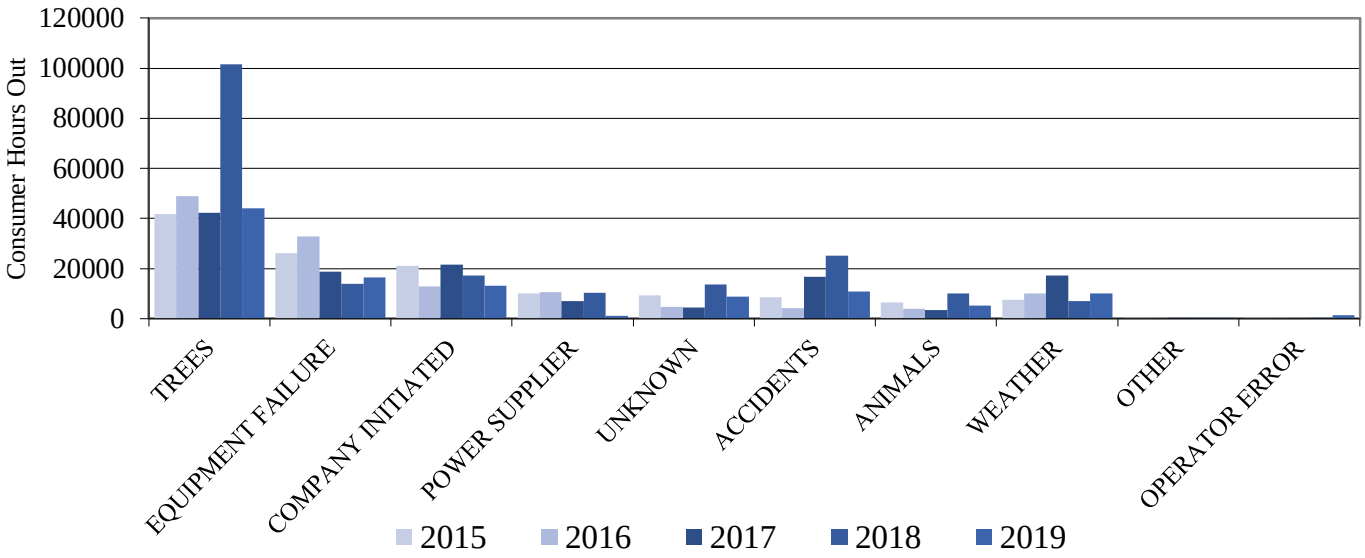
As shown in the table above, company-initiated and tree-related outages continue to be the primary drivers for VEC's outages. Approximately 36 percent (136) of the company-initiated outages were due to outages required for capital improvements generally associated with reliability improvements.

With regard to the tree related outages, VEC saw a decrease in tree related outages in 2019 and was under its five-year average for tree related outages.

An action plan for each of these causes is located in Section 7.

4.4 Customer Hours Out by Outage Cause

VEC experienced 111,279 customer hours out (CHO) in 2019 and averaged 140,235 hours out per year over the five-year period between 2015 and 2019. The chart below identifies outage duration by cause for 2015-2019.



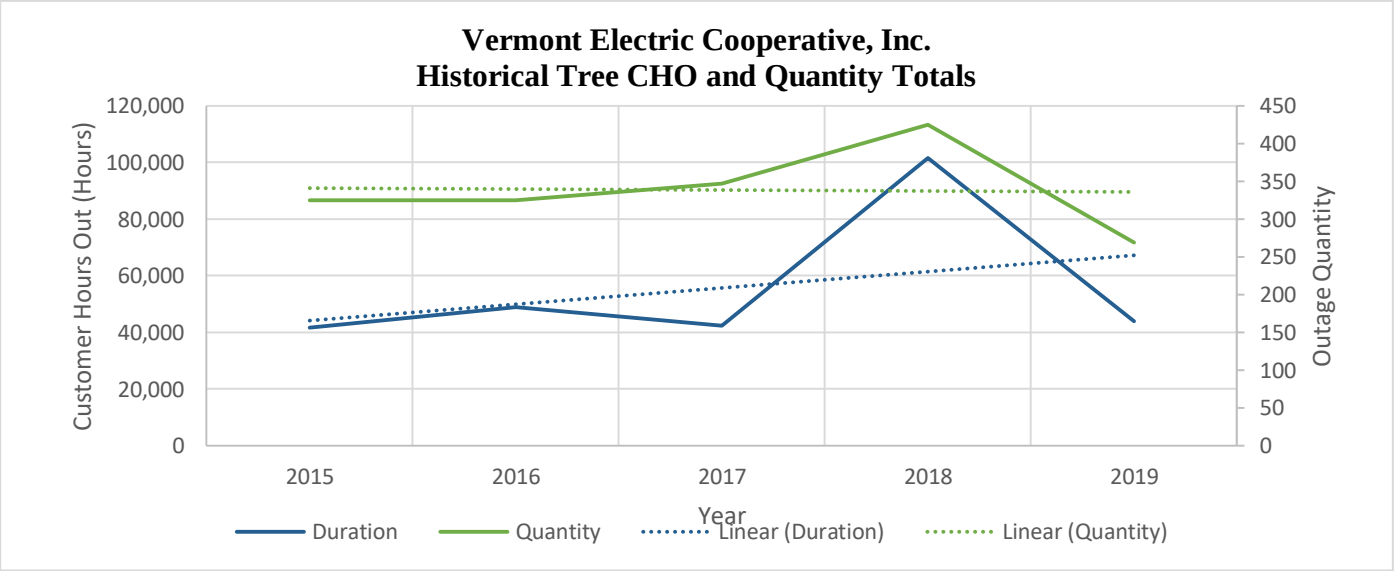
The chart below details the duration in hours out by outage cause for 2019 as well as the five-year average.

RANK	CAUSE	2019 (Hours)	Average (Hours)
1	TREES	44,001	53,746
2	EQUIPMENT FAILURE	16,548	20,402
3	COMPANY INITIATED	13,168	16,826
4	ACCIDENTS	10,755	11,395
5	WEATHER	10,147	9,534
6	UNKNOWN	8,773	8,566
7	ANIMALS	5,282	5,459
8	OPERATOR ERROR	1,274	304
9	POWER SUPPLIER	1,230	8,119
10	OTHER	101	171
11	NON-POWER SUPPLIER	-	1
	TOTAL	**111,279**	**140,235**

As shown in the above table and consistent with outage quantity, tree-related outages are the primary driver with regard to customer hours out. In general, all categories except for operator error and weather saw a drop in 2019 customer hours out when compared to the five-year average.

4.5 Tree Outages

Tree outages rank first in customer hours out and second in outage quantity in 2019. The chart below shows a comparison of outage duration, quantity, and a five-year trend line. By adding a fifth year (2019), the trend line shows improvement, whereas the trend over the past four years has been relatively flat.

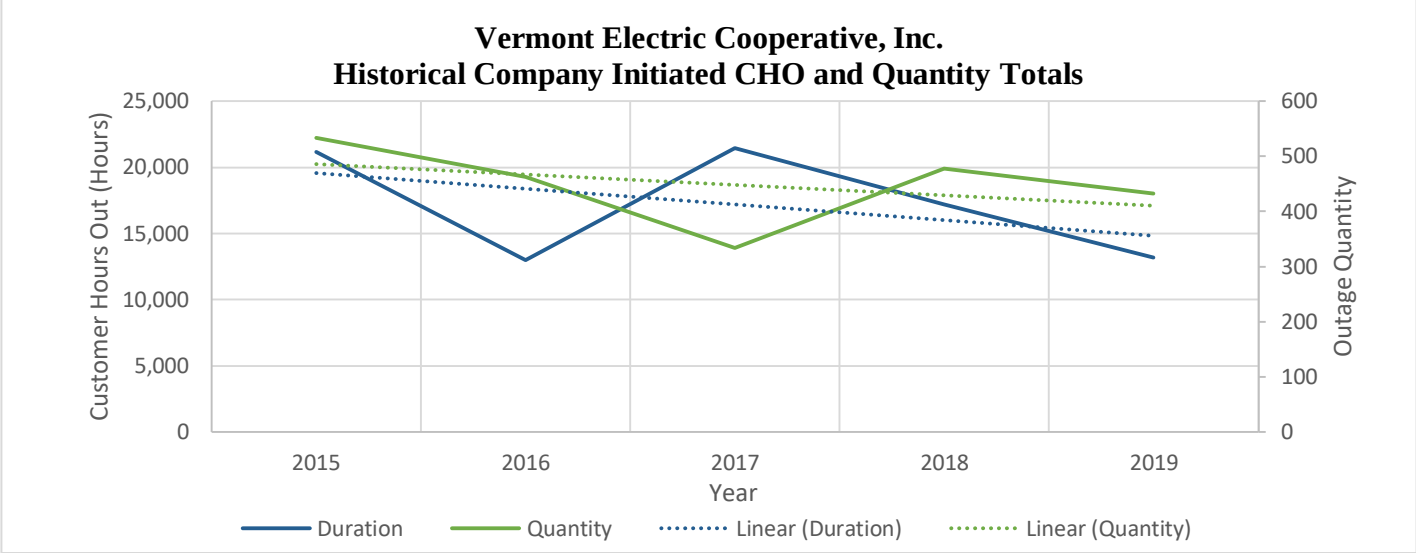


In 2009, VEC filed a vegetation management plan that addressed funding, maintenance cycles, and reliability. That analysis identified a five-year cycle for transmission rights-of-way (ROW) maintenance and an eight-year cycle for distribution ROW maintenance based on then industry best practices and VEC's 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 reaching the tenth year of its twelve-year path to achieving an eight-year distribution cycle. In the early years of its vegetation management program cycle, VEC was able to make relatively quick improvements in reliability. However, after completing almost two cycles of transmission ROW clearing and with the first cycle of distribution ROW maintenance 75 percent complete, the improvement in tree-related outages is slowing. In fact, recent trends in reliability metrics show that tree-related outages are beginning to increase.

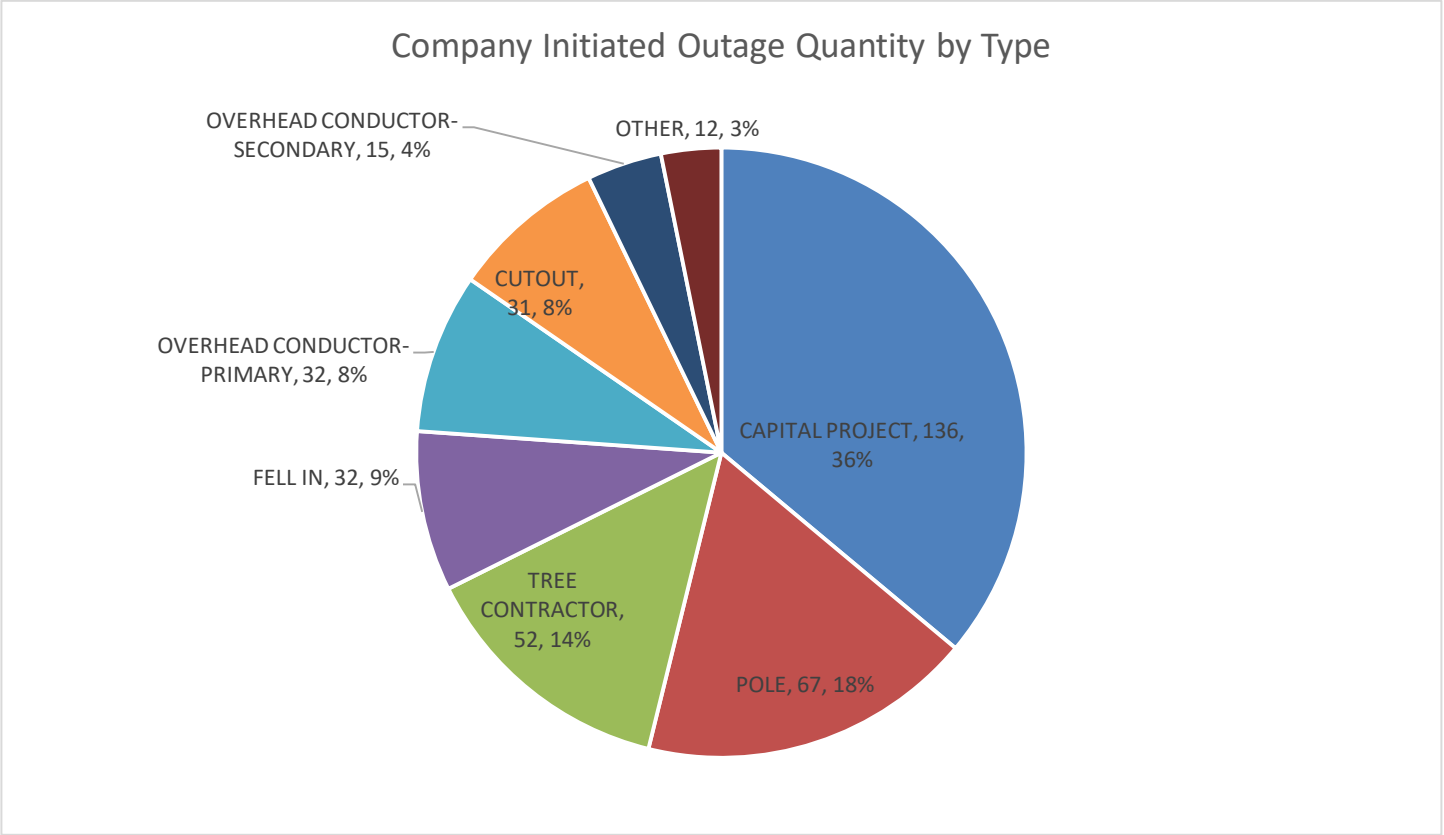
4.6 Company Initiated Outages

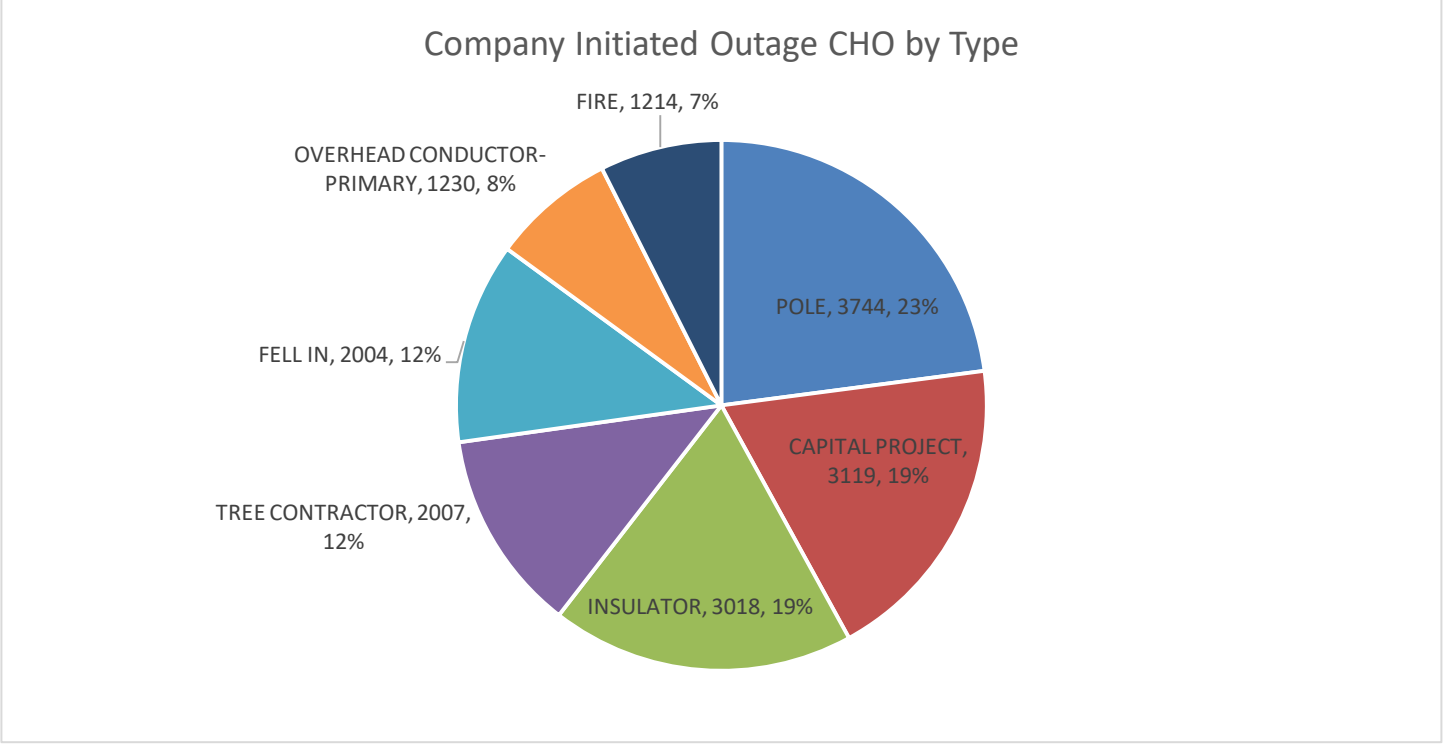
Company initiated outages rank third in customer hours out and first in outage quantity in 2019.



We are seeing a gradual decrease in company initiated outages in both quantity and duration. Capital improvements (line relocations, equipment replacements voltage conversions, etc.) continue to be primary driver of this outage category. This year VEC upgraded over 120 transformers from 2400 to 7200 volts in 2019 in order to improve voltage quality. VEC also continues to replace aging infrastructure, specifically poles (342 replaced in 2019, 67 of which required outages) that are located in ROWs where outages are required to do the work safely.

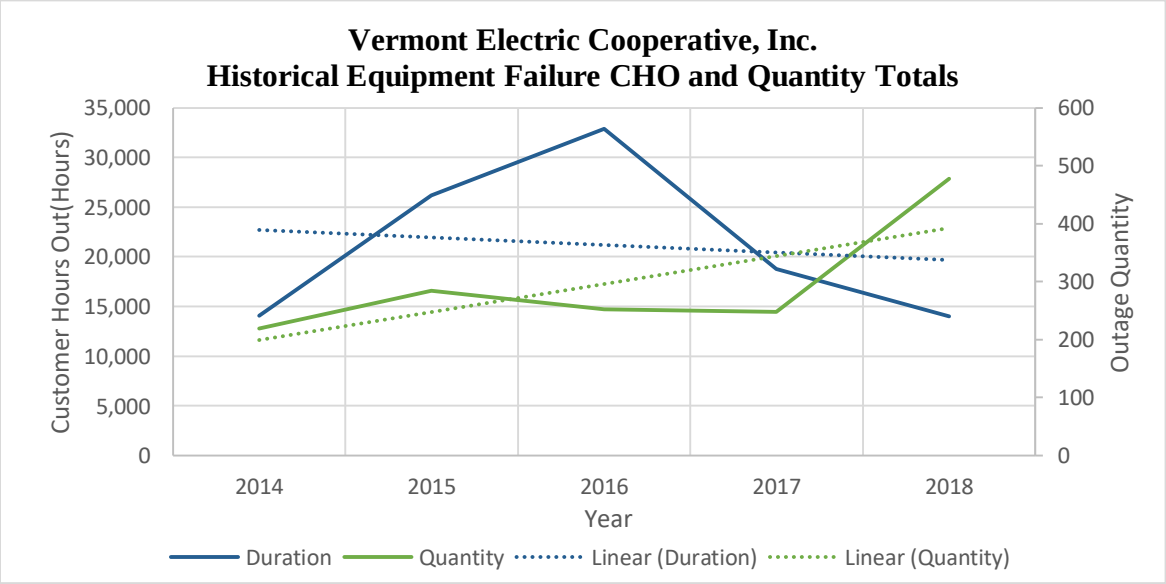
The two charts below show secondary outage codes by quantity and customer hours out. Capital projects and outages required to safely remove vegetation from utility lines is the largest quantity while poles represent the largest impact on customer hours out.



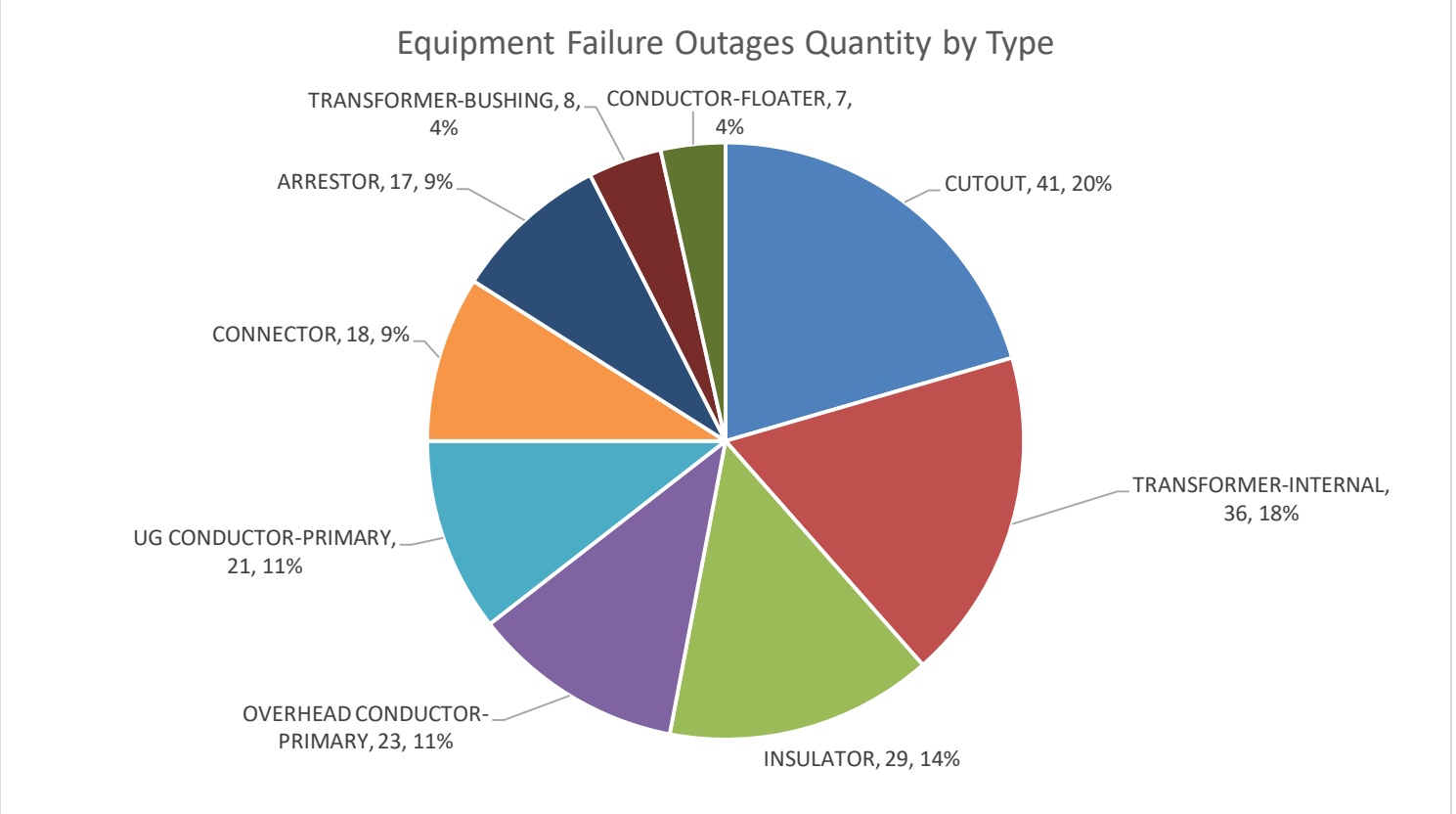


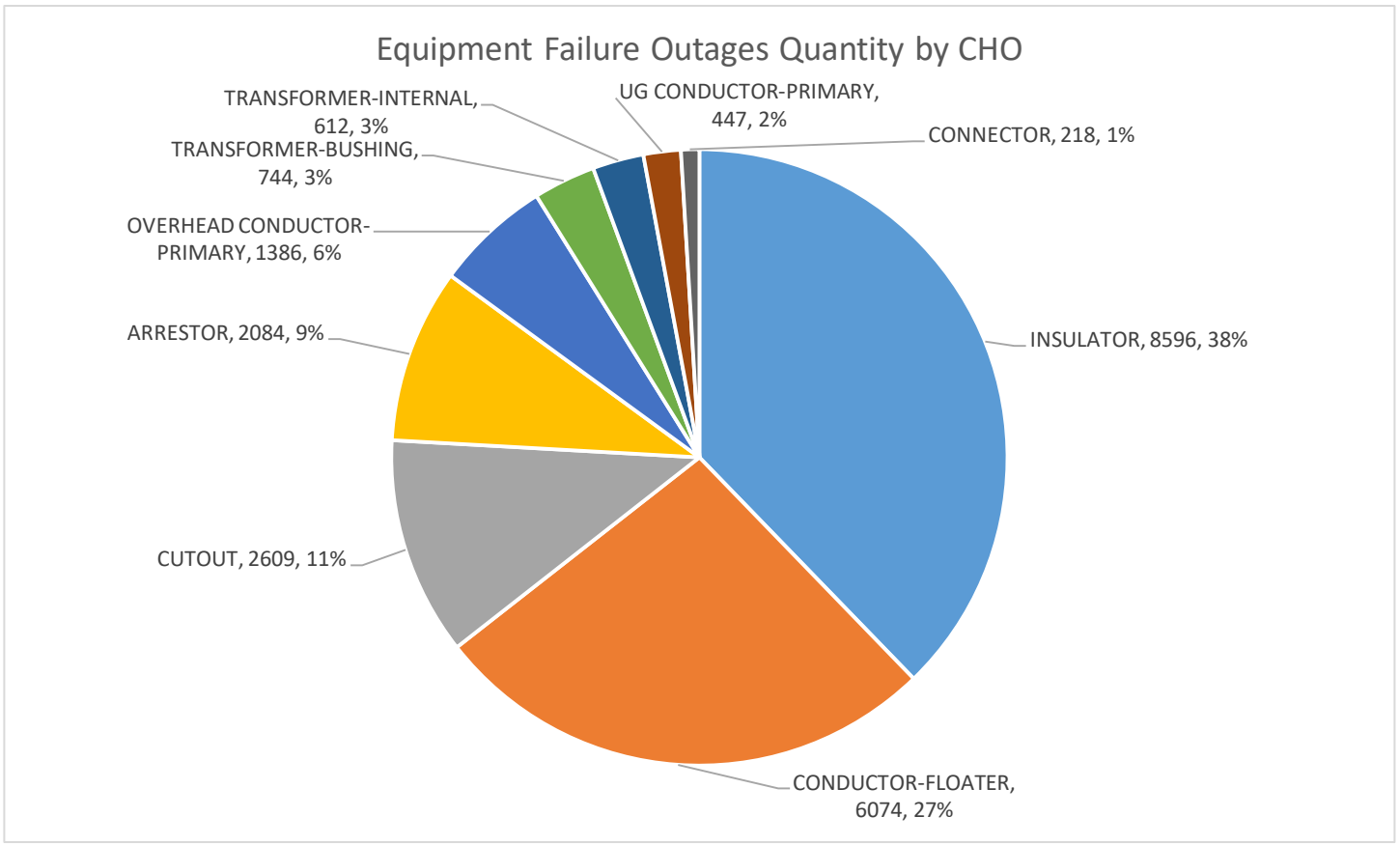
4.7 Equipment Failure Outages

Equipment failure outages rank second in customer hours out and third in outage quantity in 2019.



The two charts below show secondary outage codes by quantity and customer hours out.



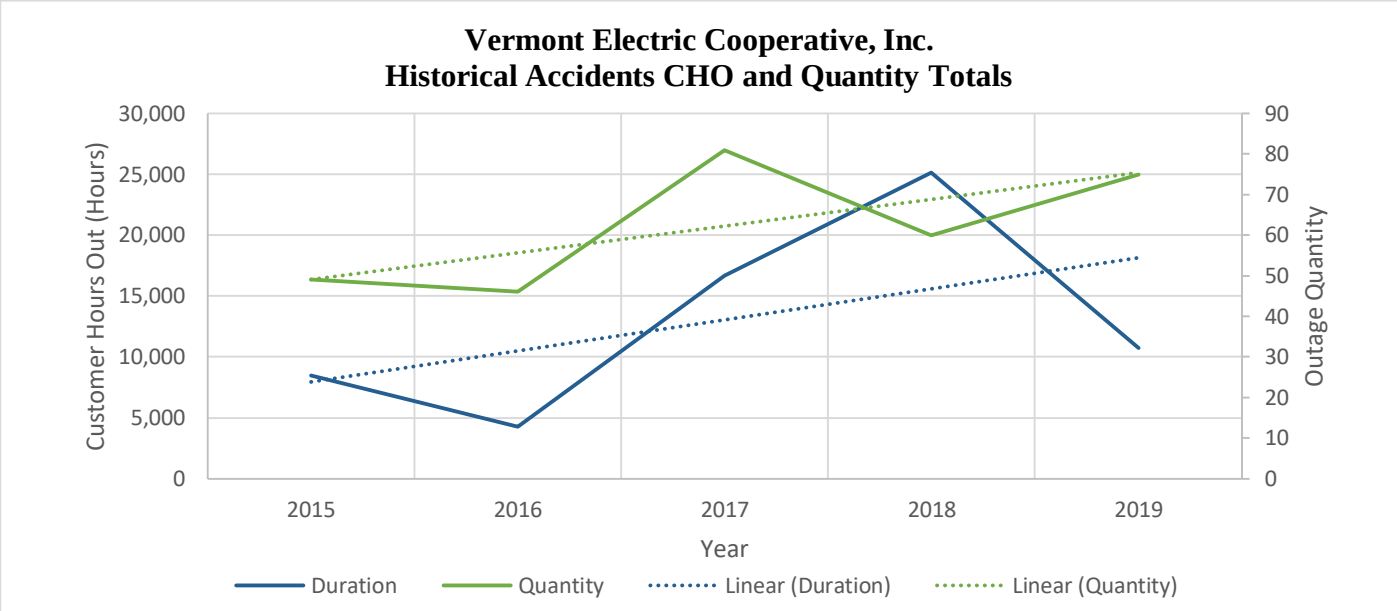


Cutouts and transformer failures (overload and internal) are the two largest equipment failures by quantity and duration. A ~ 3-hour outage where a conductor that had come untied from the insulator (also referred to as a

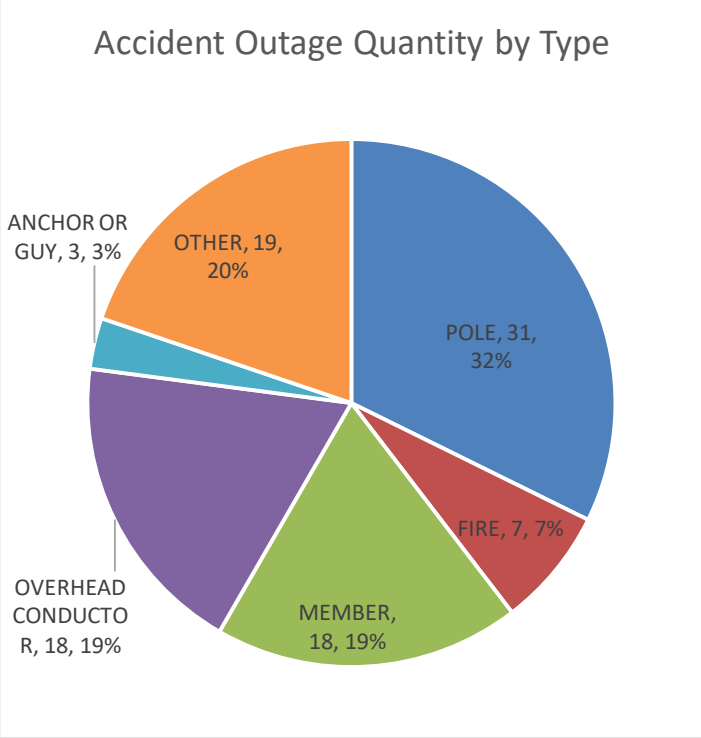
"floater") was VEC's largest equipment failure, which occurred on the 51Y5 transmission line feeding the Hinesburg 19 substation.

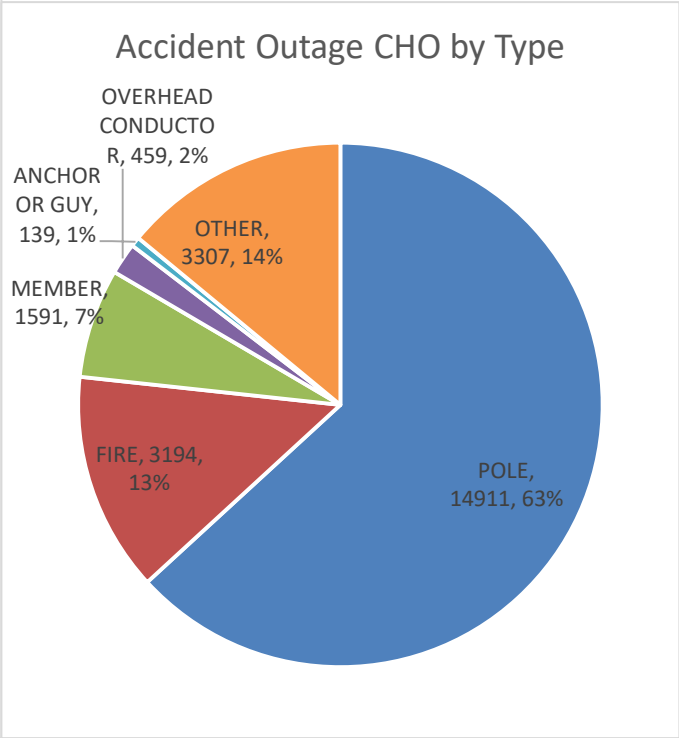
4.8 Accident Outages

Accident outages rank fourth in customer hours out and seventh in outage quantity in 2019.



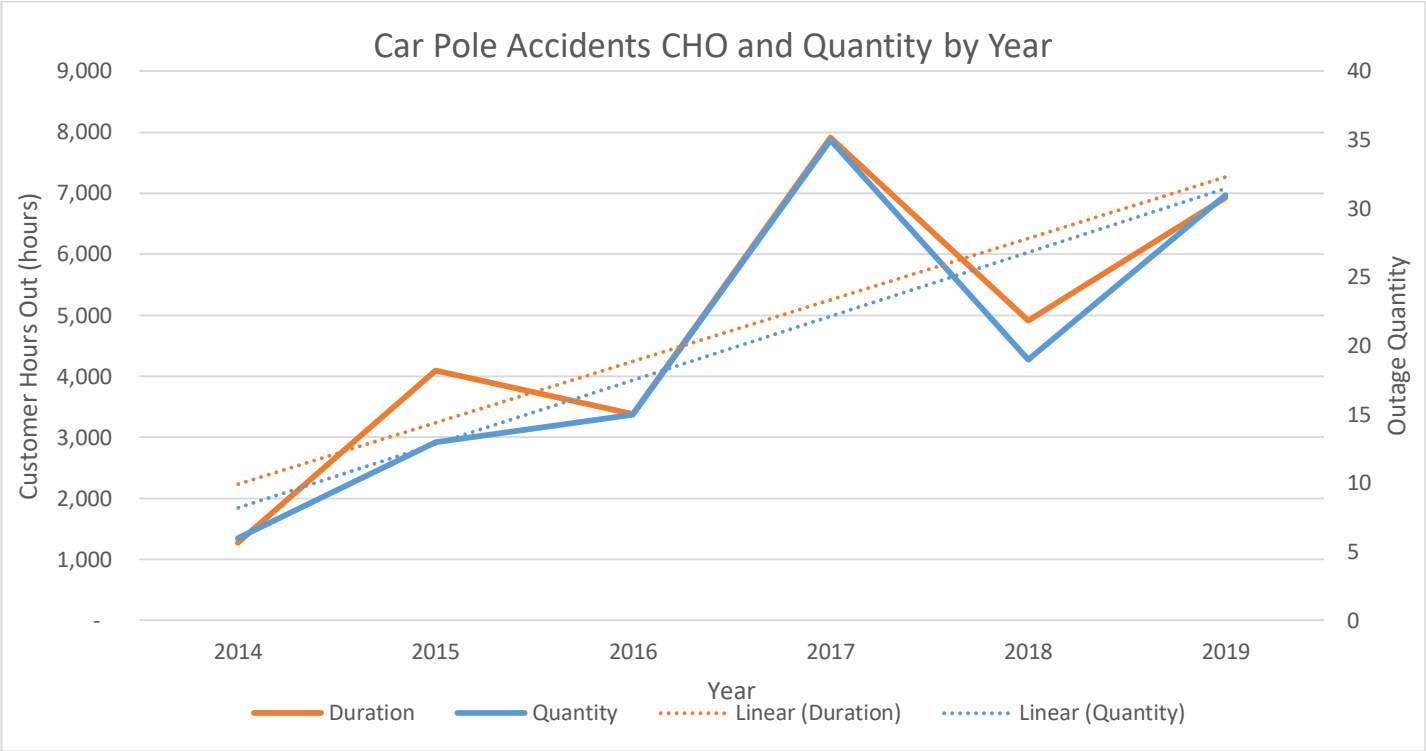
The primary causes of these outages were car pole accidents and member caused outages, such as trees cut in proximity of power lines. VEC's Safety Department has a policy to follow up with members after these incidents to review the safety hazards that exist. VEC also encourages our members to notify VEC should they plan to conduct activities in close proximity to electric facilities in the future. The two charts below show secondary outage codes by quantity and customer hours out.





4.8.1 Car Pole Accidents

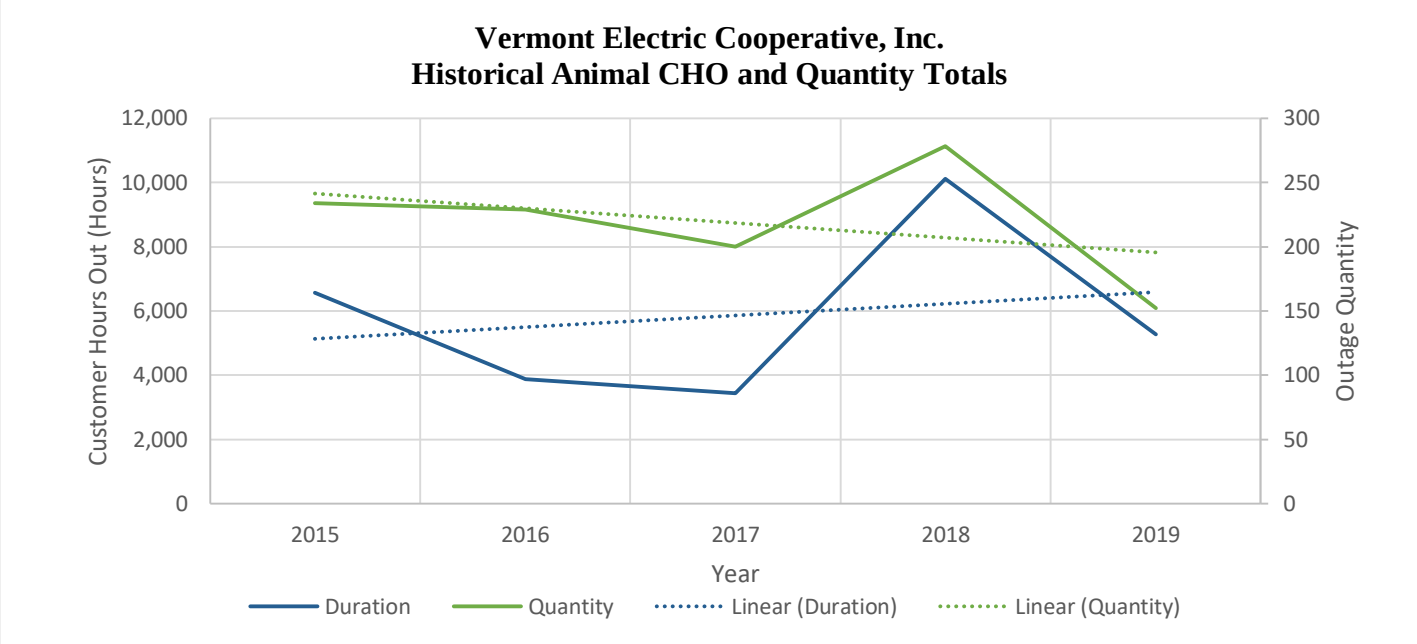
VEC continues to see a rise in car pole accidents and in 2019, VEC experienced 31 car pole accidents, which is an increase from 19 in 2018.



	Total		Car Pole Accidents		Other Accidents	
Year	Quantity	Duration (hours)	Quantity	Duration (hours)	Quantity	Duration (hours)
2014	10	4,196	6	1,270	4	2,926
2015	17	7,812	13	4,097	4	3,715
2016	17	7,674	15	3,378	2	4,296
2017	41	13,635	35	7,911	6	5,724
2018	59	9,394	19	4,910	40	4,484
2019	75	10,755	31	6,930	44	3,825

4.9 Animal Outages

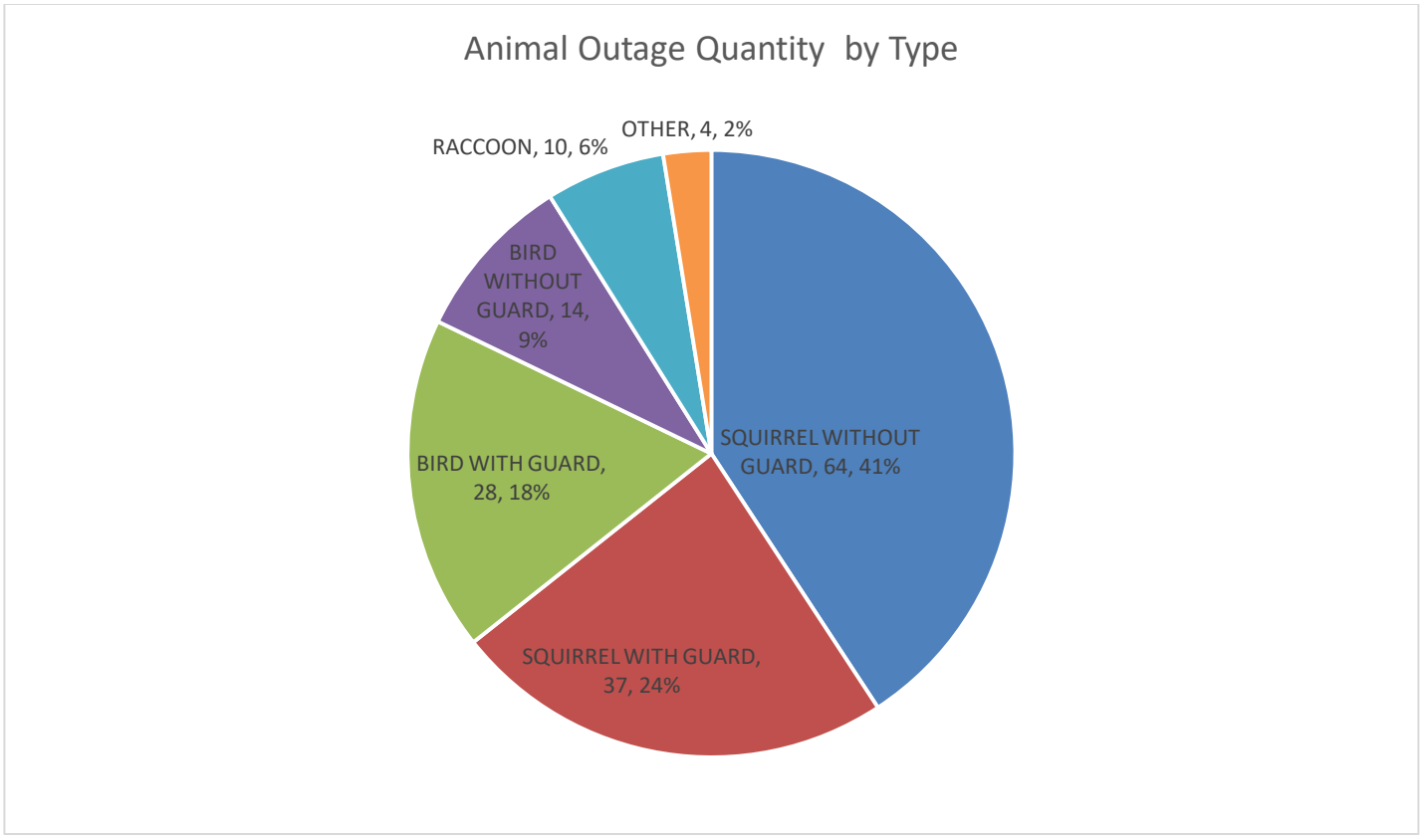
Animal outages rank seventh in customer hours out and fifth in outage quantity in 2019.

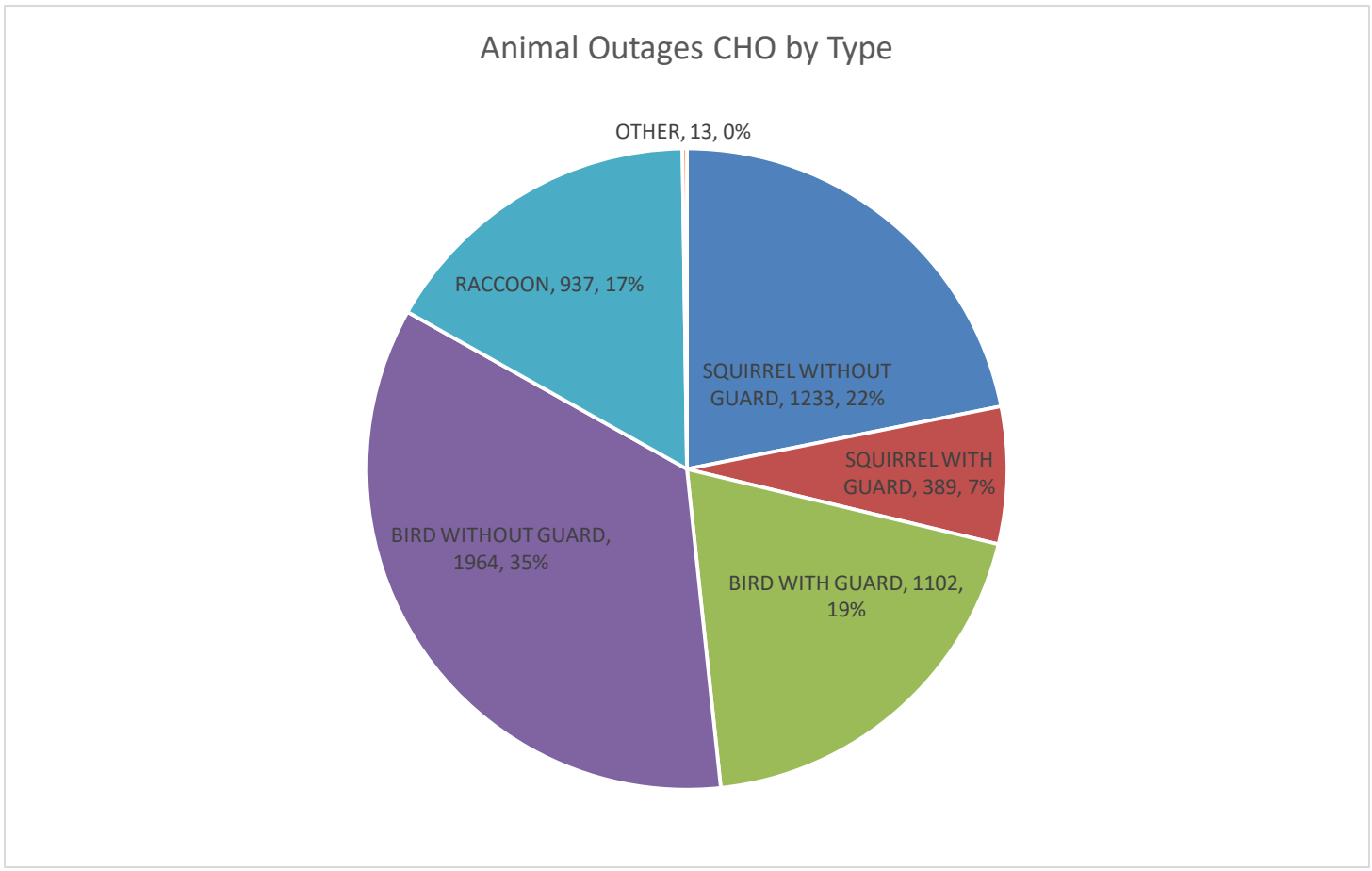


The primary causes of these outages are squirrels and birds. While VEC has animal protection on the majority of its system, we have very few transformers with adequate protection on gap arrestors. As a result, we are continuing to see an uptick in both customer hours out and outage quantity associated with animal contact with 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.

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. 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.

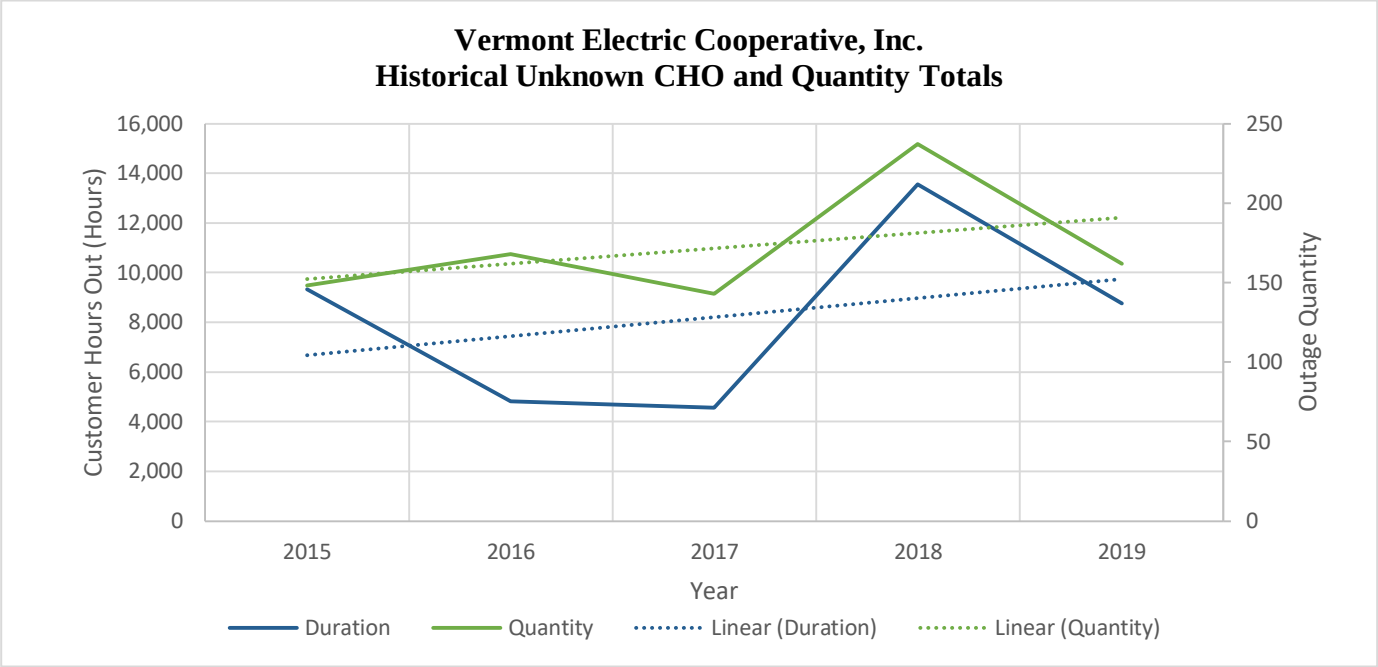
The two charts below show secondary outage codes by quantity and customer hours out.


Animal Outage Quantity by Type
OTHER, 4, 2%
RACCOON, 10, 6%
BIRD WITHOUT GUARD, 14, 9%
BIRD WITH GUARD, 28, 18%
SQUIRREL WITHOUT GUARD, 64, 41%
SQUIRREL WITH GUARD, 37, 24%


Animal Outages CHO by Type
OTHER, 13, 0%
RACCOON, 937, 17%
SQUIRREL WITHOUT GUARD, 1233, 22%
SQUIRREL WITH GUARD, 389, 7%
BIRD WITHOUT GUARD, 1964, 35%
BIRD WITH GUARD, 1102, 19%

4.10 Unknown Outages

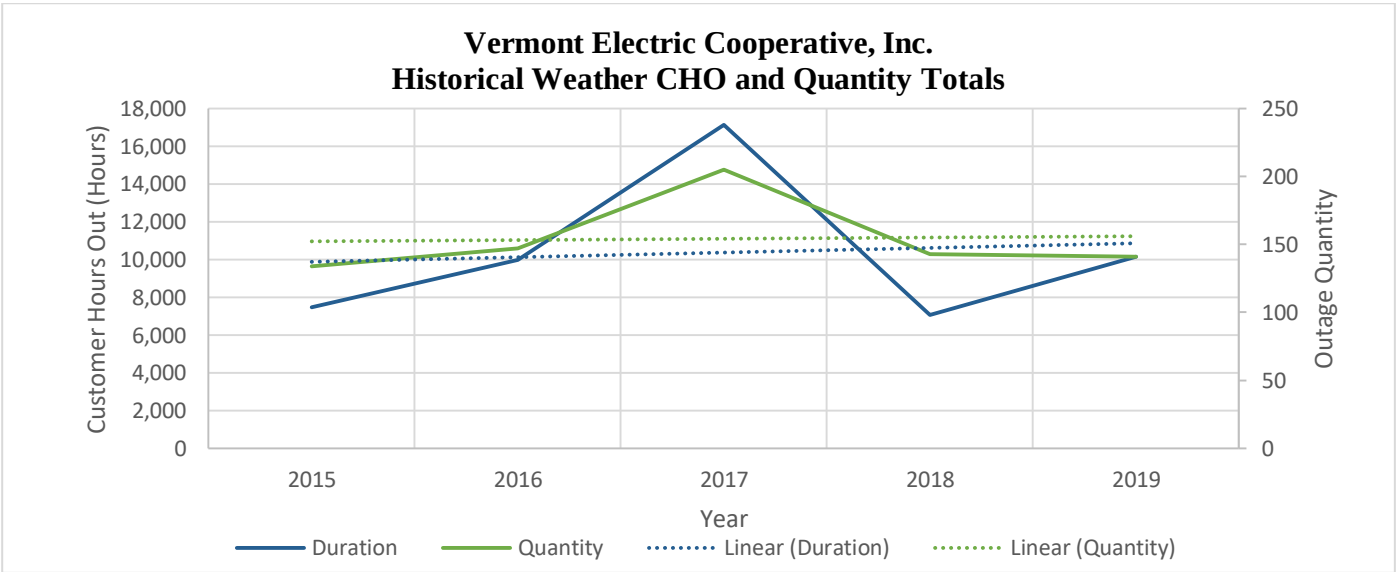
Unknown outages rank sixth in customer hours out and fourth in outage quantity in 2019.



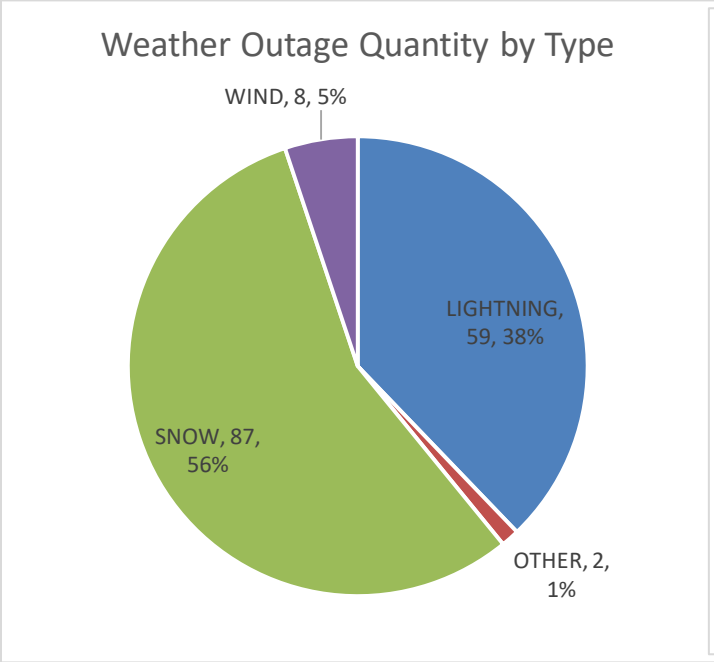
The past year saw a reversal of the rise we experienced during 2015-2018 in unknown outage quantity and duration. VEC Line Operations reviews each unknown outage to attempt to determine the cause but in many cases, we could find no concrete evidence.

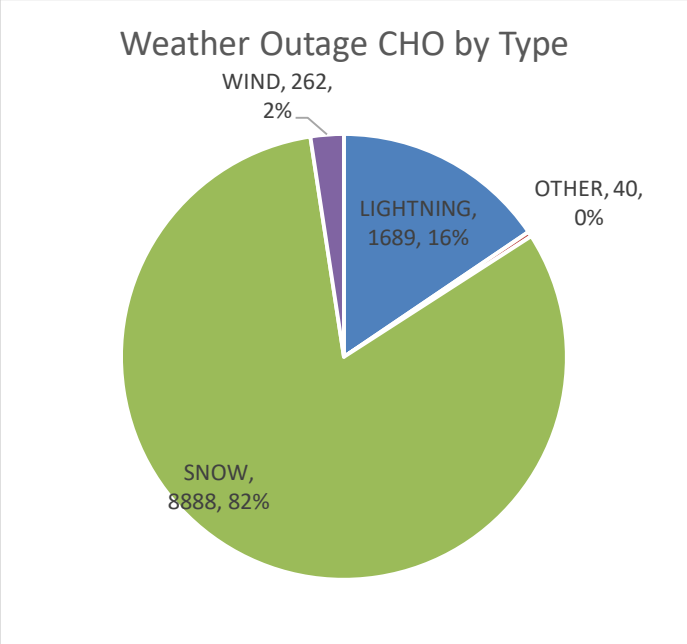
4.11 Weather Outages

Weather outages rank fifth in customer hours out and sixth in outage quantity in 2019.



The two charts below show secondary outage codes by quantity and customer hours out.

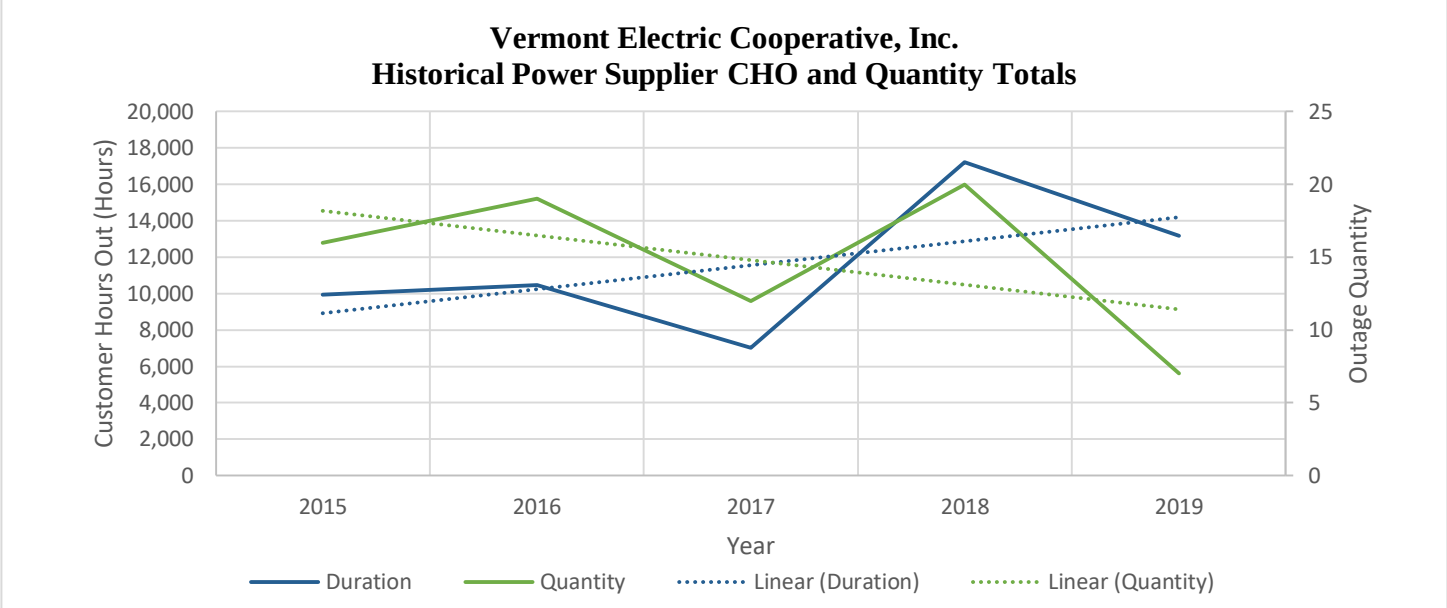




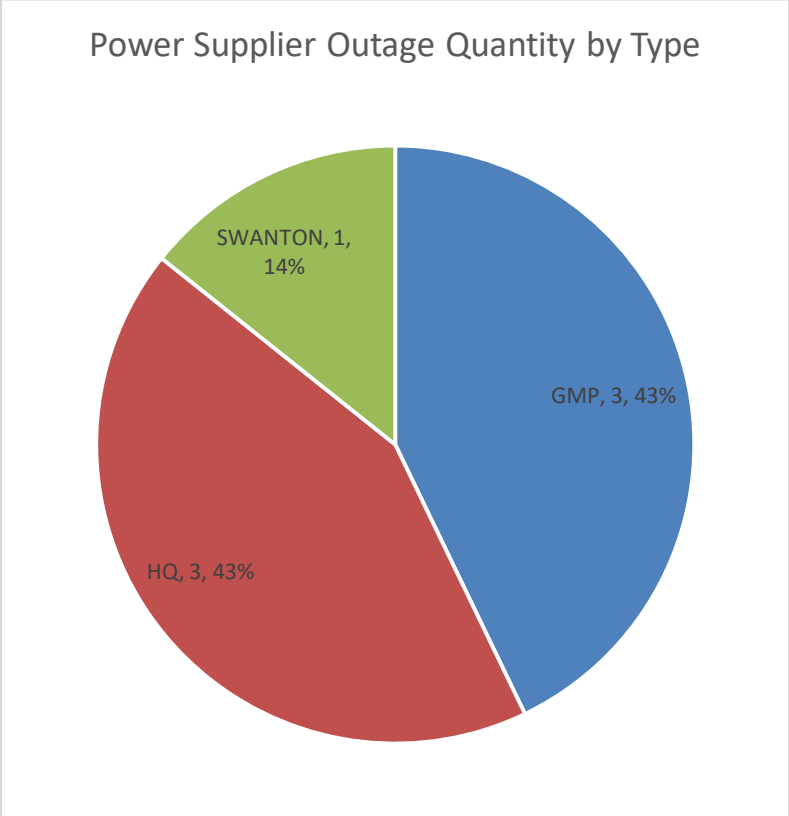
The primary causes of these outages were snow unloading and lightning. The general trend is that weather-related outages are increasing; however VEC has not been able to draw a causation between wind and precipitation and increased outages. VEC and other state distribution utilities are working with Northern Vermont University – Lyndon to identify how our changing climate is affecting weather hazards (primarily wet snow, ice, and wind storms) and to determine the respective impacts to the power system. The outcome of this research project would be a comprehensive public report discussing current and future weather risks to the grid in Vermont and associated utility impacts. This information will help VEC and other participating utilities better understand the impacts of weather on our grid, modify our philosophies and standards, and find cost-effective solutions to maintain reliability for our members.

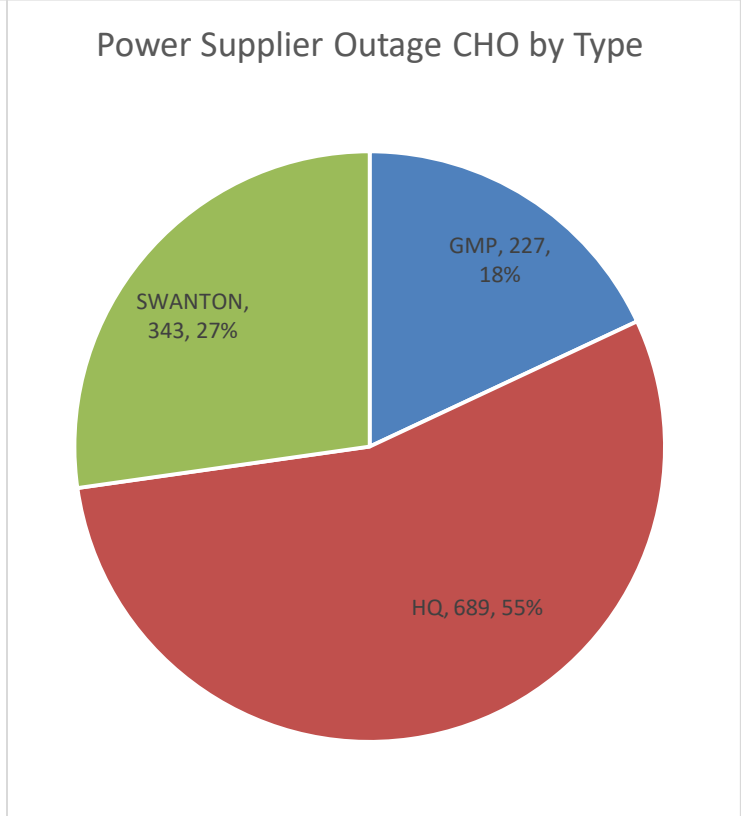
4.12 Power Supplier Outages

Power Supplier outages rank 9th in customer hours out and 9th in outage quantity in 2019.



This past year also saw reversal of the rise we experienced in 2015-2018 of power supplier outage quantity and duration. Several of these longer outages resulted from windstorms that affected GMP's sub-transmission system. In addition, there was an extended outage required for members off VEC's Cambridge #3 and Madonna #15 substations for the commissioning of a rebuilt Cambridge #3 substation. The two charts below show secondary outage codes by quantity and customer hours out.





Hydro Quebecs (HQ) and Green Mountain Power's sub-transmission network feed several substations in VEC's service territory and they are the largest contributors to both outage quantity and duration. VEC provides specific information on each transmission outage in 2019 in detail below:

Date	Duration	Circuit/Substation	Cause

01/24/2019	1:39	CTK-233 and CTK-234 (VEC Canaan 51 and Norton 50)	Unknown fault on HQ
03/22/2019	12:41	Snipe Ireland 34 Metering Point	Unknown fault on GMP
03/28/2019	1:43	Swanton 1204 Line (VEC Highgate Springs 27)	Tree fell on 1204 line
06/26/2019	0:08	CTK-233 (VEC Norton 50)	Animal outage on HQ
06/26/2019	0:08	CTK-234 (VEC Canaan 51)	Animal outage on HQ
07/31/2019	0:52	GMP St. Albans B-14 (VEC St. Rocks 06)	Lightning
10/01/2019	0:13	GMP B-51 (VEC St. Albans 20)	GMP circuit has a failed insulator and burned down conductor

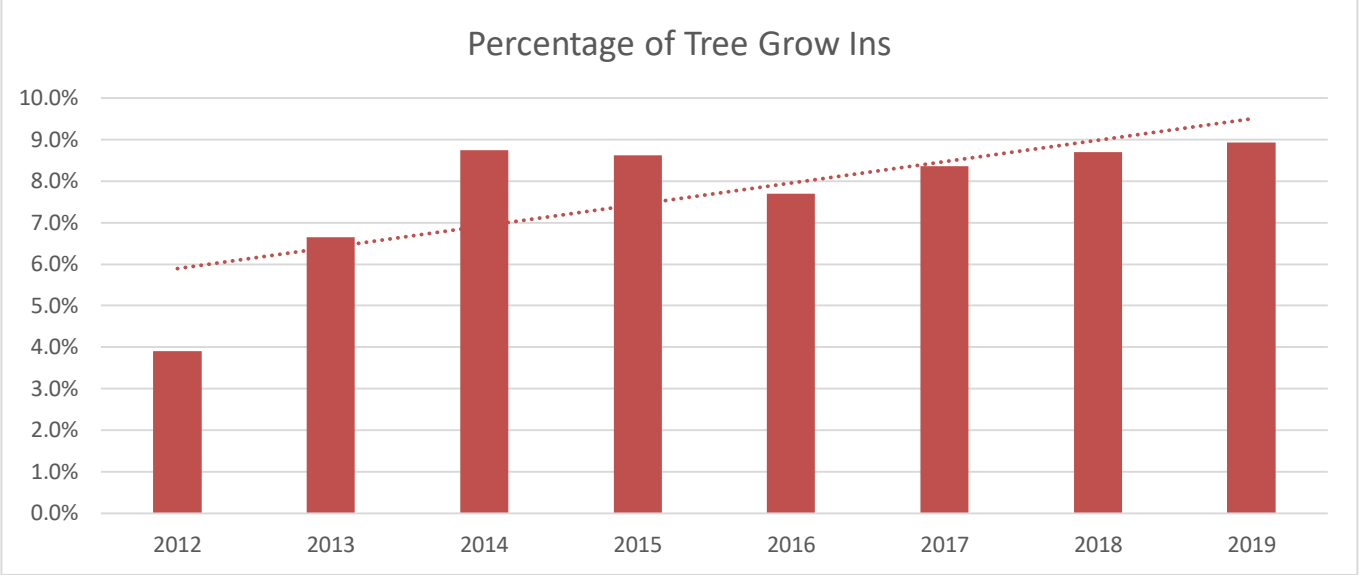
5 Action Plan

5.1 System Wide

Vegetation Management

VEC proposed an increase of $535,300 for VEC's Vegetation Management Program for total 2020 expenditures of $3,369,531. As stated in the 2018 4.900 report, these budgetary numbers consider net contributions by Consolidated Communications Company.

While implementing a longer cycle initially has allowed VEC to minimize rate impacts to the membership, the extended timeframe may have contributed to the increase in tree-related outages. As the chart below shows, although trees falling in from outside of the ROW are the cause of the majority of tree related outages, outages caused by trees growing in and by overhanging branches have begun to increase.



While VEC continues to be on track to meet the eight-year cycle over a 12-year period, we are concerned about the increase in tree-related outages and wanted an assessment of the validity of the eight-year cycle. Therefore, in 2018, VEC hired Arbor Intelligence to conduct a comprehensive review and assessment of its Vegetation Management Program. The assessment included a random sample of VEC's system using the Arborcision ™ stratified random sampling method, and Arbor Intelligence used the findings to assess the system's status.

The Arbor Intelligence Report confirmed what VEC has observed from its own analysis and outage metrics: VEC's current distribution cycle is too long given the vegetation in our service area. Arbor Intelligence recommended a four-year distribution maintenance cycle to achieve an optimal clearing cycle. Arbor Intelligence bases this optimal clearing cycle on growth rates and a number of other factors. It concluded that, while up-front costs may be higher in the first four years of the clearing cycle, the total ongoing cost of the program would be lower with a shorter clearing cycle. However, Arbor Intelligence estimated that the cost to move to a four-year cycle would be $26.4 million over the initial four years, requiring a significant rate impact. This confirms VEC's own internal analysis from 2009 that moving to a more aggressive cycle has significant impacts to rates and costs on the front end even if costs over time are lower. Nonetheless, the report demonstrates that an eight-year distribution vegetation maintenance cycle is too long, if we want the most cost-effective vegetation management program that provides the most reliable system possible.

Opting to fall between these two extremes, VEC proposed to adjust its current plan to move to a six/seven year, blended cycle, by the year 2023. We will do that by slightly increasing the number of miles of line cleared per year over the next several years rather than propose a large one-year rate increase. A "blended" cycle means that instead of VEC's entire service territory being maintained on a standard cycle (*i.e.* 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.

Emerald Ash Borer

In the 2020 rate case, VEC also included an adjustment of $184,240 to support implementation of a new program to address the threat of Emerald Ash Borer (EAB) infestation. 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 treatment or cure. EAB infestations have already decimated ash tree populations in other states and Vermont is one of the last states to feel its affects.

VEC conservatively estimated the cost to remove all ash trees within striking distance of its line within the current EAB confirmed infestation area to be $2,918,190. This number assumes there are 148 ash trees within a striking distance of VEC line in a linear mile and a $165 per tree removal cost. The cost to remove ash trees exponentially increases as the infestation takes over and the EAB infected trees become too dangerous to remove safely by conventional methods. We are requesting $250,000 to conduct a pilot mitigation project in 2020, or approximately 8.5 percent of the estimated program cost. This will allow us to eliminate approximately 1,500 of the estimated 17,690 ash trees in the current EAB confirmed infestation area. Once we have completed the pilot, VEC will be able to estimate the true costs for this program moving forward.

Herbicide and Impacts

VEC is participating in a study to understand the impact of herbicide use on plant and animal species utilizing utility ROW. The targeted use of herbicides is part of an overall strategy to help control vegetation in VEC ROW. The use of herbicides is a cost-effective way to control certain types of vegetation in selected areas. The overarching goal is to promote low, slow growing species that are compatible with power lines and to discourage tall, fast growing species that are incompatible with VEC electrical lines. VEC is seeking to enhance member awareness and perception of herbicide use and combat increasing member resistance to these treatment methods. VEC recognizes that member refusal to implement regularly scheduled herbicide treatments negatively impacts the effectiveness and cost of its overall vegetation management program.

To address this, VEC will collaborate with Vermont Electric Power Company (VELCO) and Green Mountain Power Company (GMP) to commission the services of a third party expert to gather and review existing research data to understand the response of flora and fauna to herbicide use in utility ROW. The resulting study will be a white paper summarizing the environmental benefits and deficiencies of herbicide practices on soil erosion and sedimentation, plant diversity, wildlife, and pollinator habitat within managed utility ROW. We believe the partnership with GMP and VELCO will help to minimize costs while improving our ability to communicate accurate information to our members and validate the use of herbicides in our Vegetation Management program. This study is also aligned with VEC's commitment to environmental stewardship and support of State of Vermont's environmental goals.

Maintenance Plan

VEC finished its first year of its comprehensive maintenance program, which included inspecting 20% of the system. This program will assess the condition and gather data on all of VEC's electrical assets over a five-year period. 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 in July and December. This inspection makes use of infrared thermography, which detects differences in 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 distribution poles over a ten-year cycle, and in the 11th year, VEC treats and inspects its transmission poles. These timelines are consistent with RUS Bulletin 1730B-121. VEC's program consists of ground line inspection, treatment at 18 inches below ground level and internally if voids are present, and a visual inspection of above ground condition. In addition, we also perform other maintenance work such as replacing missing guy guards and pole numbers.

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.

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.

AMI Upgrade

Beginning in 2018 and completed in 2019, VEC purchased and installed new servers, upgraded software, and upgraded substation equipment to support the new eTWACS system. Also in 2019, VEC installed AMI at its Montgomery (07) and Island Pond (46/47) substations. These substations did not have AMI packages and in some cases, meters were read from other substations. Because of these upgrades, members will experience shorter outage response times.

In order to make use of the new eTWACS features, 80 percent of all meters served out of each substation need to have newer meter modules. While some substations already have these types of meters, many do not. VEC has developed a multi-year plan (2018-2026) to replace roughly 20,000 of VEC's meters and perform hardware upgrades at half of the substations to support the performance and feature enhancements. Specifics for the number of meter changes made in 2019 by substation are included in the table below.

Substation	Meters Changed to UMT
Lowell (5)	5
Norton (50)	22
Underhill (4)	25
Westford (11)	30
Highgate Springs (27)	33
Canaan (51)	35
Fairfax (12)	42

Jay Peak (40)	95
Jay (17)	112
St. Rocks (6)	117
Richford (31)	178
Montgomery (7)	324
Pleasant Valley (13)	39
Johnson (14)	123
Total	**1,180**

During 2020, VEC will continue to upgrade and enhance its AMI network. Current plans include:

- Exchanging 3,089 meters for new models.

Substation	Meters to be Changed to UMT
Pleasant Valley (13)	376
Williston (9)	507
Johnson (14)	385
Eden (2)	742
Cambridge (3)	579
West Charleston (48)	500
Total	**3,089**

- Install AMI reading equipment at Jericho (10) substation, eliminating the need for meters to read from the Underhill (4) substation across transmission lines.

The upgrade will also integrate OMS and SCADA to instantaneously create the outage or verify the momentary impact to members without the system needing to "ping" the meters to establish the outage location.

5.2 Distribution

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 2020, VEC plans on reconductoring 10.2 miles of obsolete wire and relocating 3.8 miles from difficult to access rights-of-way to the road.

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 2019, VEC applied for over $1.1 million of mitigation funding for five projects (3 relocations and 2 reconductoring projects). In 2018, VEC received over $1.7 million from FEMA for 10 projects and we expect to continue applying for additional funding through both the section 404 and section 406 grants.

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.

5.3 Transmission

VEC's worst performing transmission line is the 51Y5 circuit, which feeds its Hinesburg 19 substation. In 2020, VEC will complete work to replace several poles and insulators on the line. In addition, GMP and VEC are planning 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.

In addition to the Hinesburg area, VEC is in its seventh year of an eight-year year plan to assess and replace conditionally poor pole plant on the joint-owned H16 transmission line. This transmission line runs from VELCO Irasburg to Portland Pipe and feeds the municipals of Barton and Orleans. This is a joint effort between VEC, Barton, and Orleans. These poles are the oldest transmission poles on VEC's system and VEC has experienced several long duration outages in the past due to structure failures.

5.4 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 also 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 also performs a monthly substation check.

6 Top Ten Worst Performing Circuits

VEC has broken down its reliability data into substation circuits for this report. VEC rates its top ten worst performers 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.

6.1 Worst Performers in 2018

The following table lists VEC's 2018 worst performers and their 2019 year-end ranking.

	2018				2019		
Circuit Name	**Rank**	**Quantity**	**CHO**		**Rank**	**Quantity**	**CHO**
North Troy 3A	**1**	55	16,282		**13**	47	2,139
Irasburg 3A	**2**	63	10,255		**18**	37	1,658
Burton Hill 3A	**3**	66	8,826		**3**	56	3,927
Irasburg 1A	**4**	52	11,156		**5**	47	3,459
Island Pond 47 4A	**5**	52	10,561		**7**	45	2,602
Hinesburg 3A	**6**	50	9,961		**1**	47	9,855
Island Pond 46 2A	**7**	50	9,081		**8**	31	2,602
South Alburg 1A	**8**	61	6,156		**22**	52	1,016
Sheldon 1A	**9**	65	5,440		**15**	61	1,179
West Charleston 2A	**10**	27	9,681		**34**	23	843

Five of the circuits on the 2018 top 10 worst performers list are no longer on the 2019 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.

VEC completed this work in June of last year, and VEC expects to complete the same analysis for the 2019 worst performing circuits at the end of January of 2020. In 2019, VEC invested in capital improvements and devoted additional vegetation management resources to its 2018 worst performing circuits. We detail these improvements below by worst performer and corresponding line section. Highlighed in the table in Section 6.2 are circuits that remain on the 2019 worst performing circuits list:

6.1.1 #1 - North Troy 41-3A

- **41-3A -** The worst line section on this circuit is the 41-7-3A, which has seen 13,113 customer hours out since 01/01/2018. This main line circuit exits the substation and immediately traverses almost 4 miles of ROW that is difficult to access/patrol and prone to tree outages. In addition, to address several equipment failures and animal outages, 11 new animal and arrestor guards, 19 new fused cutouts, 11 insulator and 8 lightning arrestors were installed. Planned mechanical vegetation m management will occur in 2020, followed by herbicide application in 2021.
- **41-7-3M and 41-1-3M5** - 8 of the 13 outages on the 3M and 3M5 were on unfused side taps. VEC fused all side taps.

6.1.2 #2 - Irasburg 42-3A

- **42-7-3F** - The worst line section on this circuit is the 42-7-3F. The 3F is approximately 6 miles of roadside with many open areas (treed about 50% or 3 miles).). We conducted hot spot maintenance on portions of the 42-3F in 2016, followed by herbicide application in 2017 and routine vegetation maintenance and hazard tree removal on the entire circuit in 2019. The circuit will be scheduled for herbicide application again in 2020.
- **42-2-3G6 -** Three snow unloading related outages, two tree outages, and a couple of unknowns caused outages on this line section. We completed work orders to add cutouts to unfused side taps and review sag and tension. In addition, we conducted hot spot maintenance on portions of the 42-3G6 in 2017, followed by herbicide application in 2018, and routine vegetation maintenance and hazard tree removal in 2019. The circuit will be scheduled for herbicide application again in 2020.
- **42-1-3K, 3K3, 3K3F –** This circuit experienced several snow unloading outages and tree outages. We conducted hot spot maintenance on the 42-3K in 2016, followed by herbicide application in 2017, and routine vegetation maintenance and hazard tree removal on the entire circuit in 2019. It will be scheduled for herbicide application again in 2020.

6.1.3 #3 - Burton Hill 43-3A

- **43-7-3A** - Trees along the main line between the substation and route 16 added significantly to the customer hours out. The 43-7-3A and 43-2-3D17D were cleared in 2017 and 2016 with herbicide applied in 2018 and 2017 respectively. This line is scheduled for clearing in 2022, but VEC will review any action to be taken in 2020 as it remains on the worst performing list.
- **43-2-3C3 –** Trees, snow unloading, and equipment failure are the primary causes of outages on this line section. VEC expects to relocate this line section in 2020 to move a hard to access, outage-prone line section to roadside. Easement acquisition and permitting are underway.
- **43-1-3D13D –** Several unfused side taps which were fused during 2019.
- **43-2-3S2 –** This project added midspans and reconductored a section of line that was causing snow unloading outages due to long spans (500 feet on average).

6.1.4 #4 - Irasburg 42-1A

- **42-7-1A** – Three tree outages within six spans were the primary cause of outages on this line section. A long duration car pole accident also affected this circuit. VEC is expecting to hot spot this section of line in 2020.
- **42-7-1A31–** Trees and snow unloading are the primary areas of focus on this line section. VEC has a project to install midspan poles, re-conductor from 6A wire to 1/0 covered conductor ("tree wire") and install fuses on several unfused side taps. This project is expected to be completed in March of 2020.

6.1.5 #5 - Island Pond 47-4A

- **47-7-4C 29-30**- This line section has suffered from significant animal outages. VEC has a 2020 capital project to add animal protection where required and address Hendrix spacer cable at bare wire connections that are also causing some of the outages.
- **47-7-4A –** One car pole accident on the 4A caused 8,582 customer hours out. VEC posted on Facebook warning drivers and also contacted the state police to see if anything can be done to prevent future accidents.

6.1.6 #6 - Hinesburg 19-3A

- **51Y5 Transmission Line –** This line section saw five outages affecting the entire Hinesburg 19 substation. The outages were primarily due to insulator failure and conductor lift. VEC has a 2020 capital project which includes transmission insulator, crossarm and pole replacements with the goal of reducing conductor-related outages. In addition, a joint GMP/VEC Richmond project will add in and out breakers at the Richmond substation to mitigate power supplier related outages. Currently, the line has no automatic source protection scheme.
- **19-7-3E -** 19-3E is among VEC's worst performing line sections. VEC has a 2020/2021 capital project to reconfigure vertical corners and add mid span poles, which will significantly reduce snow-unloading outages. We will also attempt to reduce the number of spans over 300' to improve wind resiliency along with correcting sag issues from past storms. In addition to the capital improvements, VEC's vegetation management staff has completed a hazard tree patrol and has marked trees for removal. This work was planned for 2019, but resource constraints pushed it into routine clearing of the whole circuit in 2020.
- **19-2-3F and 19-1-3G –** The primary cause of outages on this line section are trees. VEC has an ongoing project slated for completion in mid-2020 to move this cross-country line to roadside and replace its aging conductor with covered conductor.
- The Hinesburg transmission and 19-7-3E, 19-2-3F, 19-1-3G are all scheduled for routine vegetation maintenance and danger tree removal in 2020.

6.1.7 #7 - Island Pond 46-2A

- **46-7-2AA** - The 2AA was affected by two long duration car pole accidents and a couple of unknowns. As stated above VEC posted on Facebook warning drivers and contacted the state police to see if anything can be done. Both the 46-7-2AA and 46-7-2A received routine vegetation maintenance and danger tree removal in 2019, which will be followed by herbicide application in 2020.
- **46-7-2D –** Several tree outages occurred on this line. It is scheduled for vegetation maintenance and danger tree removal in 2020 followed by herbicide application in 2021.

6.1.8 #8 – South Alburg 28-1A

- **28-7-1A** - In general, the outages on this circuit have been caused by animals, including one 2.5-hour outage on the 28-7-1A, due to a bird shorting across two phases. This is tight Hendrix construction and in that incident the phases melted to the ground. VEC installed over 60 new standoff brackets and corresponding fused cutouts. These standoff brackets push the cutout away from the pole and prevent squirrels from getting in contact with the line.
- **28-3-1F4 –** A 6.5-hour tree related outage occurred on the 28-3-1F4, and we cleared the circuit in 2019.

6.1.9 #9 – Sheldon 32-1A

- **32-7-1A** – Trees, accidents and animals were the primary causes of outages on this line section. The circuit is well sectionalized, mostly roadside, and in most places void of treed sections. In addition, we cleared the 32-7-1A in 2018 and applied herbicide in 2019.

6.1.10 #10 – West Charleston 48-2A

- **48-7-2A** – Snow unloading, trees, equipment failure, and a long duration car pole accident were the reasons for this being on the worst performers in 2019. The 48-7-2A is scheduled for routine vegetation maintenance and danger tree removal in 2021.

6.2 Worst Performers in 2019

The chart below displays the worst performing circuits in 2019. Any highlights are circuits that were on the 2018 worst performing circuit list.

Rank	Circuit Name	OUTAGES	HOURS
1	Hinesburg 3A	47	9,855
2	Hinesburg 1A	37	8,835
3	Burton Hill 3A	56	3,927
4	Johnson 3A	25	6,978
5	Irasburg 1A	47	3,459
6	Cambridge 1A	43	3,603
7	Island Pond 4A	45	2,602
8	Island Pond 2A	31	3,648
9	Derby 1A	24	4,551
10	Norton 2A	29	3,560

Work is now underway to analyze each of these circuits and identify O&M or Capital projects to improve reliability on these circuits in 2020. In addition, VEC has a strategic plan measure to reduce the number of circuits remaining on the worst performing list.