UES Capital

Reliability Study

2021

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1 Executive Summary

The purpose of this document is to report on the overall reliability performance of the UES Capital system from January 1, 2020 through December 31, 2020. The scope of this report will also evaluate individual circuit reliability performance over the same time period. The outage data used in this report excludes sub-transmission and substation outages (listed in Section 5), as well as outages during IEEE Major Event Days (MEDs). UES-Capital MEDs are listed in the table below:

Date	Type of Event	Interruptions	Customer Interruptions	Cust-Min of Interruption
8/4/2020	Thunderstorm	27	2,998	172,572
12/5/2020	Winter Storm	54	7,534	1,844,423

The following projects are proposed from the results of this study and are focused on improving the worst performing circuits as well as the overall UES Capital system reliability. These recommendations are provided for consideration and will be further developed with the intention to be incorporated into the 2021 budget development process.

Circuit / Line / Substation	Proposed Project	Cost ($)
13W2	Reconductor N Main St with Spacer	$674,174
Various	Animal Guard Installation	$75,000
13W1	Install Recloser on Center Rd	$47,951

Note: estimates do not include general construction overheads

The 2020 annual UES Capital system reliability goal was set at 144 minutes, after removing Major Event Days. The UES Capital SAIDI performance in 2020 was 99.79 minutes. Charts 1, 2, and 3 below show UES Capital SAIDI, SAIFI, and CAIDI, respectively, over the past five years.

Chart 1
Annual Capital SAIDI

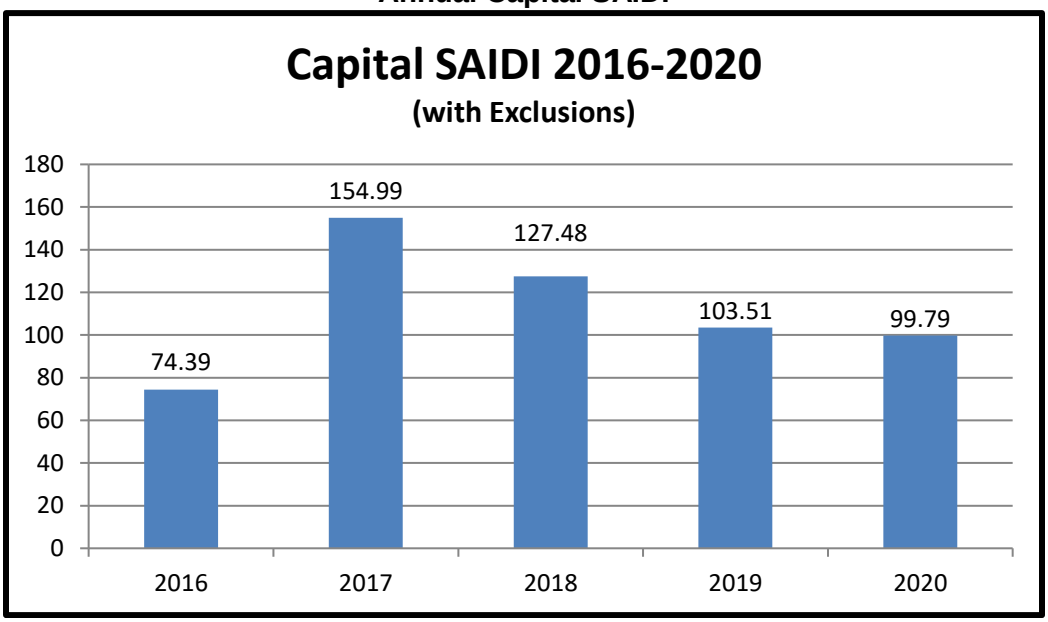


Chart 2
Annual Capital SAIFI

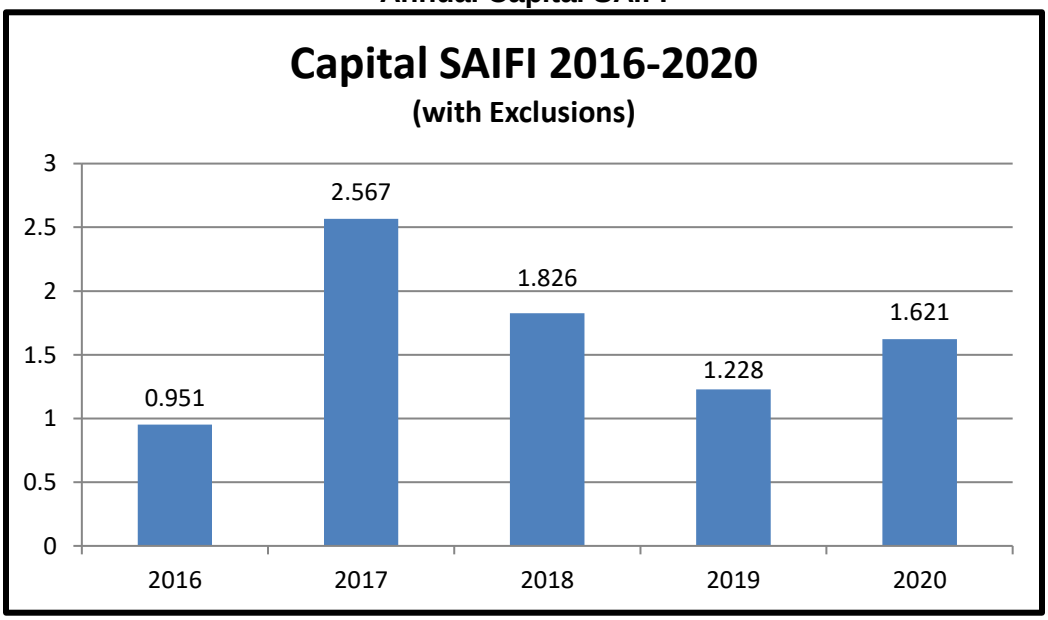
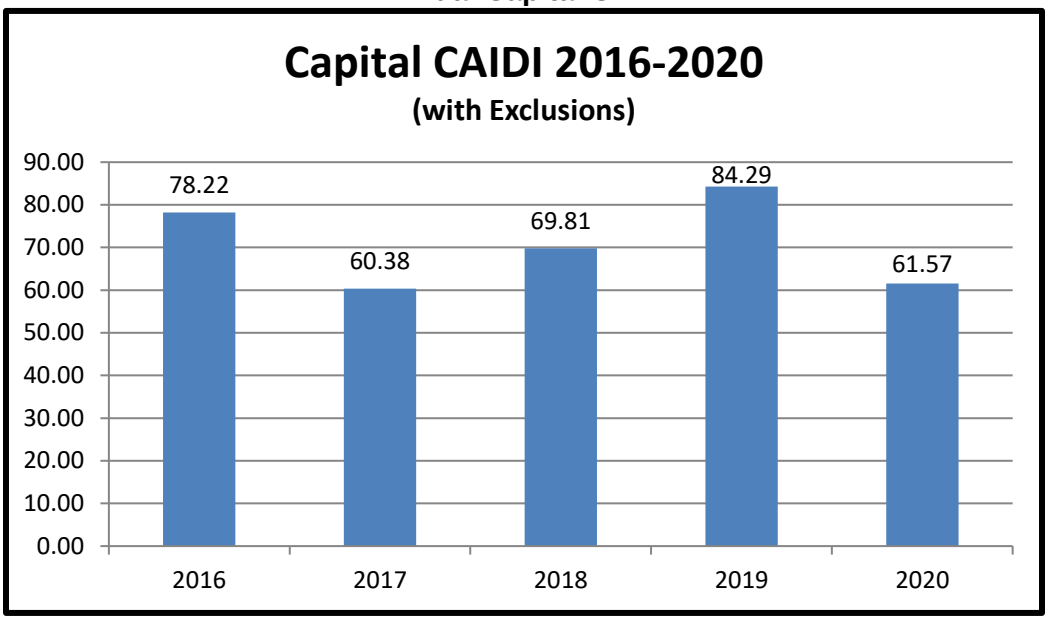


Chart 3
Annual Capital CAIDI



2 Reliability Benchmarks

The new annual UES Capital system reliability benchmark for 2021 is set at 136.91 SAIDI minutes. This was developed by calculating the contribution of UES Capital to the Unitil system performance using the past five year average. The contribution factor was then set against the 2020 Unitil System goal. The 2020 Unitil System goal was developed through benchmarking the Unitil system performance with nationwide utilities.

Individual circuits will be analyzed based upon circuit SAIDI, SAIFI, and CAIDI. Analysis of individual circuits along with analysis of the entire UES Capital system is used to identify future capital improvement projects and/or operational enhancements which may be required in order to achieve and maintain these benchmarks.

3 Outages by Cause

This section provides a breakdown of all outages by cause code experienced during 2020. Charts 4, 5, and 6 show the number of interruptions, the number of customer interruptions, and total customer-minutes of interruptions due to each cause, respectively. Only the causes contributing 3% or greater of the total are labeled. Table 1 shows the number of interruptions for the top three trouble causes for the previous five years.

Chart 4
Number of Interruptions by Cause

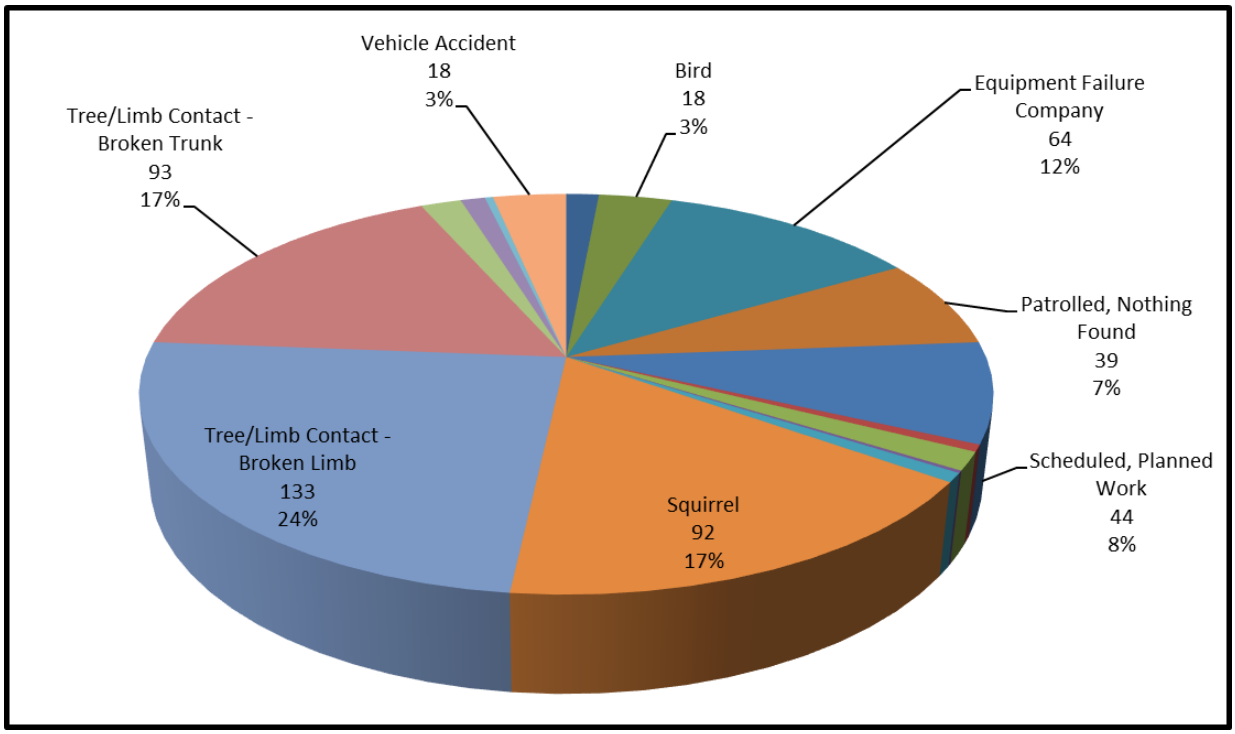


Chart 5
Number of Customers Interrupted by Cause

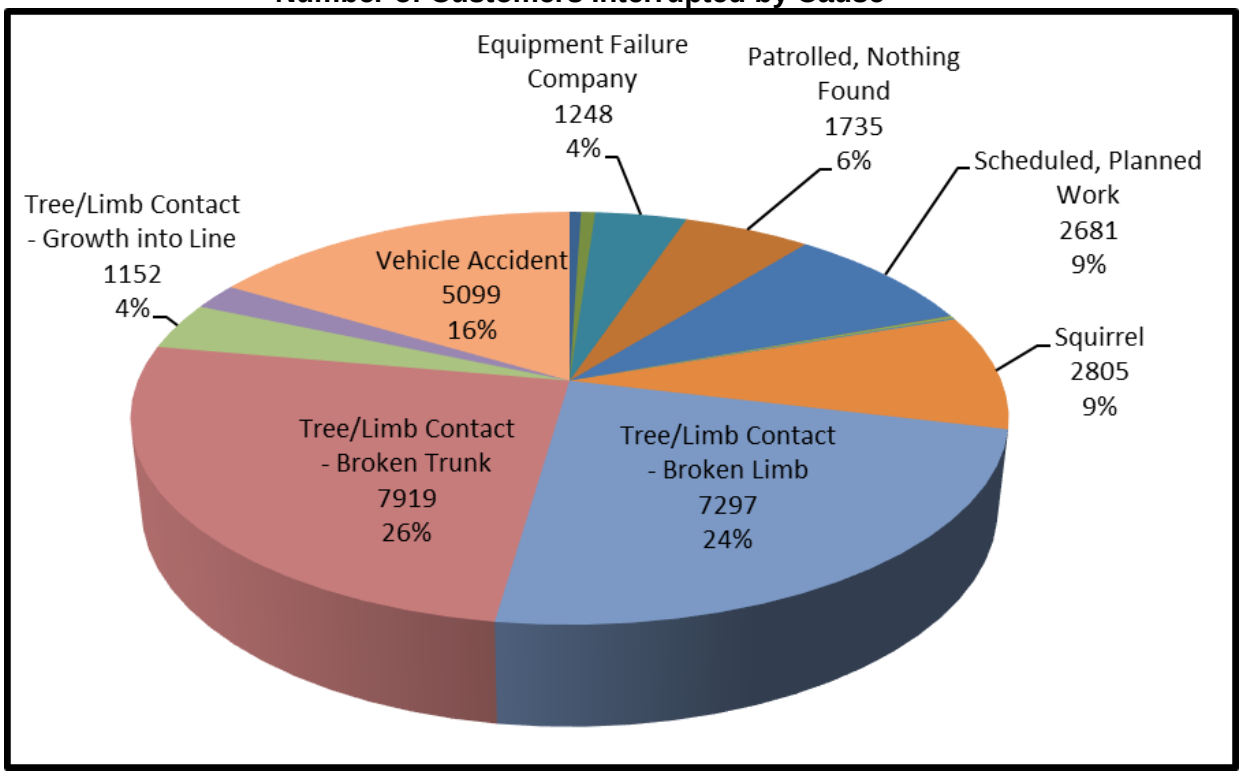


Chart 6
Percent of Customer-Minutes of Interruption by Cause

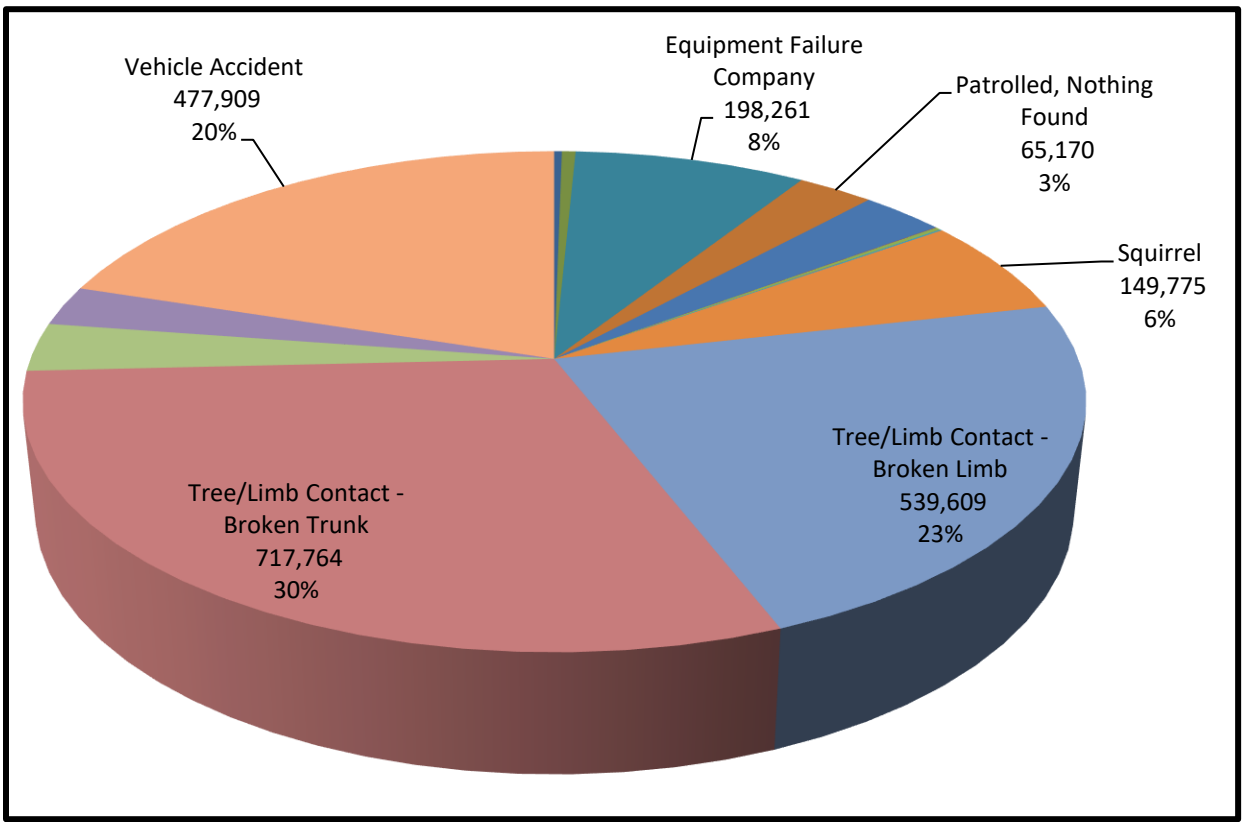


Table 1
Five-Year History of the Number of
Interruptions for the Worst Three Trouble Causes

Year	Tree/Limb Contact - Broken Limb	Tree/Limb Contact - Broken Trunk	Squirrel
2020	133	93	92
2019	74	67	26
2018	134	102	100
2017	86	37	112
2016	117	34	93

4 10 Worst Distribution Outages

The ten worst distribution outages ranked by customer-minutes of interruption during the time period from January 1, 2020 through December 31, 2020 are summarized in Table 2 below.

Table 2
Worst Ten Distribution Outages

Circuit	Description (Date/Cause)	No. of Customers Affected	No. of Customer Minutes	Capital SAIDI (min.)	Capital SAIFI
C4W3	10/17/2020 Vehicle Accident	1,427	198,197	0.00	6.529
C4X1	08/04/2020 Tree/Limb Contact - Broken Trunk	1,927	168,580	0.01	5.553
C13W2	11/23/2020 Tree/Limb Contact - Broken Trunk	2,307	146,665	0.02	4.831
C15W1	02/07/2020 Tree/Limb Contact - Broken Trunk	399	92,907	0.21	3.060
C6X3	08/04/2020 Tree/Limb Contact - Broken Limb	1,065	83,088	0.02	2.737
C4W3	08/29/2020 Tree/Limb Contact - Broken Limb	1,426	66,547	0.00	2.192
C37X1	07/16/2020 Equipment Failure Company	595	62,658	0.21	2.064
C13W2	01/11/2020 Tree/Limb Contact - Growth into Line	987	61,391	0.21	2.022
C8X3	11/22/2020 Scheduled, Planned Work	604	37,448	0.04	1.234
C4X1	03/20/2020 Tree/Limb Contact - Uprooted Tree	393	36,811	0.01	1.213

Note: This table does not include outages that occurred at substations or on the subtransmission system, scheduled/planned work outages, or outages that occurred during excludable events.

5 Subtransmission and Substation Outages

This section describes the contribution of sub-transmission line and substation outages on the UES Capital system.

All substation and sub-transmission outages ranked by customer-minutes of interruption during the time period from January 1, 2020 through December 31, 2020 are summarized in Table 3 below.

Table 4 shows the circuits that have been affected by sub-transmission line and substation outages. The table illustrates the contribution of customer minutes of interruption for each circuit affected.

In aggregate, sub-transmission line and substation outages accounted for 24% of the total customer-minutes of interruption for UES Capital.

Table 3
Subtransmission and Substation Outages

Trouble Location	Description (Date/Cause)	No. Customers Affected	No. of Customer Minutes	UES CAPITAL SAIDI (min)	UES Capital SAIFI	No. Times on List (past 4 yrs)
C38	09/10/2020 Operator Error/System Malfunction	6,818	117,707	3.88	0.225	
C396X1	12/05/2020 Tree/Limb Contact - Broken Trunk	847	117,397	3.87	0.028	
C37	05/09/2020 Tree/Limb Contact - Broken Trunk	3,288	108,936	3.59	0.108	
Bridge St	03/29/2020 Equipment Failure Company	740	80,184	2.64	0.024	
Bridge St	09/28/2020 Other	2,803	78,484	2.59	0.092	
C38	09/10/2020 Tree/Limb Contact - Broken Trunk	1,684	69,770	2.30	0.055	

Table 4
Contribution of Subtransmission and Substation Outages

Circuit	Trouble Location	Customer-Minutes of Interruption	% of Total Circuit Minutes	Circuit SAIDI Contribution	Number of Events
C1H3	Bridge St	72,785	72%	118.35	3
C1H4	Bridge St	5,643	80%	112.87	3
C1H5	Bridge St	8,434	73%	109.54	3
C1X7A	Bridge St	28	99%	28.00	1
C21W1A	Bridge St	7,476	100%	27.79	1
C13W1	Line 37	16,129	14%	32.72	1
C13W2	Line 37	32,884	21%	33.32	1
C13W3	Line 37	53,607	20%	33.03	1
C13X4	Line 37	100	100%	50.13	1
C37X1	Line 37	6,216	25%	33.97	1
C14H1	Line 38	900	87%	9.00	1
C14H2	Line 38	6,003	64%	6.27	1
C14X3	Line 38	54	100%	9.00	1
C15H3	Line 38	688	61%	43.00	2
C15W1	Line 38	42,914	20%	43.04	2
C15W2	Line 38	12,986	32%	43.00	2
C16H1	Line 38	2,709	5%	9.03	1
C16H3	Line 38	5,535	7%	8.99	1
C16X4	Line 38	16,044	16%	27.95	1
C16X5	Line 38	189	2%	9.00	1
C1H1	Line 38	1,656	8%	5.98	2
C1H2	Line 38	2,349	24%	9.00	2
C1X7P	Line 38	81	27%	10.13	3
C24H1	Line 38	16,432	99%	52.00	1
C24H2	Line 38	19,500	100%	52.00	1
C35X1	Line 38	473	61%	33.79	2

Circuit	Trouble Location	Customer-Minutes of Interruption	% of Total Circuit Minutes	Circuit SAIDI Contribution	Number of Events
C35X2	Line 38	172	61%	43.00	2
C35X3	Line 38	215	61%	43.00	2
C35X4	Line 38	43	61%	43.00	2
C374X1	Line 38	54	100%	9.00	1
C375X1	Line 38	54	7%	9.00	1
C38	Line 38	33,838	95%	31.68	1
C3H2	Line 38	6,921	22%	9.00	1
C3W1	Line 38	1,602	42%	9.00	1
C3W3	Line 38	9,387	100%	17.51	1
C18W2	Line 396X1	116,550	63%	127.66	1
C396X2	Line 396X1	847	100%	121.02	1

6 Worst Performing Circuits

This section compares the reliability of the worst performing circuits using various performance measures. All circuit reliability data presented in this section includes sub-transmission or substation supply outages unless noted otherwise.

6.1 Worst Performing Circuits in Past Year (1/1/20 – 12/31/20)

A summary of the worst performing circuits during the time period between January 1, 2020 and December 31, 2020 is included in the tables below.

Table 5 shows the ten worst circuits ranked by the total number of Customer-Minutes of interruption. The SAIFI and CAIDI for each circuit are also listed in this table.

Table 6 provides detail on the major causes of the outages on each of these circuits. Customer-Minutes of interruption are given for the six most prevalent causes during 2020.

Circuits having one outage contributing more than 80% of the Customer-Minutes of interruption were excluded from this analysis.

Table 5
Worst Performing Circuits Ranked by Customer-Minutes

Circuit	Customer Interruptions	Worst Event (% of CI)	Cust-Min of Interruption	Worst Event (% of CMI)	SAIDI	SAIFI	CAIDI
C4W3	5,609	4%	347,427	3%	243.64	3.933	61.94
C4X1	4,731	1%	297,844	5%	154.72	2.458	62.96
C8X3	3,403	0%	276,403	1%	95.21	1.172	81.22
C7W3	3,208	40%	236,148	27%	197.61	2.685	73.61
C13W3	1,882	9%	187,183	15%	115.33	1.160	99.46
C15W1	1,048	38%	134,596	69%	135.00	1.051	128.43
C13W2	2,451	1%	127,423	1%	129.10	2.483	51.99
C22W3	1,416	4%	108,301	8%	67.10	0.877	76.48
C13W1	1,094	45%	97,786	26%	198.35	2.219	89.38
C6X3	1,176	4%	88,904	1%	79.88	1.057	75.60

Note: all percentages and indices are calculated on a circuit basis

Table 6
Circuit Interruption Analysis by Cause

Circuit	Customer – Minutes of Interruption / # of Outages					
	Tree/Limb Contact - Broken Trunk	Equipment Failure Company	Tree/Limb Contact - Broken Limb	Patrolled, Nothing Found	Vehicle Accident	Other
C4W3	17,093 / 3	98,094 / 6	203,884 / 2	15,815 / 4	243 / 1	5,474 / 2
C4X1	239,481 / 6	14,920 / 1	5,598 / 2	451 / 1	778 / 1	0 / 0
C8X3	62,129 / 20	100,153 / 37	12,664 / 1	64,929 / 27	6,220 / 7	2,499 / 3
C7W3	56,541 / 7	13,091 / 7	150,526 / 2	2,012 / 5	10,620 / 4	2,877 / 3
C13W3	45,437 / 12	90,117 / 25	0 / 0	4,475 / 9	65,492 / 10	2,276 / 1
C15W1	132,497 / 6	2,291 / 3	1,499 / 2	1,453 / 1	63 / 1	0 / 0
C13W2	9,335 / 4	33,001 / 4	0 / 0	2,555 / 3	14,538 / 4	61,391 / 1
C22W3	41,346 / 10	39,512 / 16	0 / 0	21,895 / 14	396 / 4	0 / 0
C13W1	40,257 / 9	5,823 / 6	41,278 / 2	3,954 / 7	0 / 0	0 / 0
C6X3	627 / 2	83,201 / 2	0 / 0	0 / 0	497 / 3	0 / 0

6.2 Worst Performing Circuits of the Past Five Years (2016 – 2020)

The annual performance of the ten worst circuits in terms of circuit SAIDI and SAIFI for each of the past five years is shown in the tables below. Table 7 lists the ten worst performing circuits ranked by SAIDI and Table 8 lists the ten worst performing circuits ranked by SAIFI. Table 9 lists the ten worst performing circuits ranked by SAIDI and SAIFI over the past five years.

The data used in this analysis includes all system outages except those outages that occurred during the 2016 July Wind/Thunder storm, 2017 March Windstorm, 2017 October Tropical Storm, 2018 May Windstorm, 2018 June Thunderstorm, 2019 Broken Tree, 2019 October Thunderstorm, 2020 August Thunderstorm, and 2020 December Winterstorm.

The data used in this analysis includes all distribution circuits except those that do not have an interrupting device, e.g. fuse or recloser, at their tap location.

Table 7
Circuit SAIDI

Circuit Ranking (1 = worst)	2020		2019		2018		2017		2016	
	Circuit	SAIDI	Circuit	SAIDI	Circuit	SAIDI	Circuit	SAIDI	Circuit	SAIDI
1	C4W3	243.64	C2H2	467.50	C13W3	532.47	C13W2	577.74	C21W1A	892.82
2	C13W1	198.35	C8X5	256.74	C13W2	327.56	C18W2	560.64	C7W3	272.49
3	C7W3	197.61	C13W3	214.08	C15W2	268.14	C13W1	555.75	C34X2	244.80
4	C4X1	154.72	C6X3	166.25	C22W3	242.20	C13W3	496.50	C37X1	176.22
5	C15W1	135.00	C8X3	141.38	C21W1A	166.74	C396X2	454.70	C18W2	155.42
6	C22W1	133.56	C13W2	134.14	C8X3	164.27	C17X1	410.37	C15W1	147.96
7	C13W2	129.10	C18W2	121.03	C13W1	155.29	C16H3	403.03	C4X1	146.38
8	C13W3	115.33	C15W1	118.34	C7W3	142.86	C8X3	326.03	C13W1	140.76
9	C34X2	111.11	C37X1	117.78	C38	128.52	C33X4	246.98	C22W3	136.51
10	C37X1	102.09	C13W1	108.30	C2H4	87.85	C8H2	246.67	C13W3	117.09

Table 8
Circuit SAIFI

Circuit Ranking (1 = worst)	2020		2019		2018		2017		2016	
	Circuit	SAIDI	Circuit	SAIDI	Circuit	SAIDI	Circuit	SAIDI	Circuit	SAIDI
1	C4W3	3.933	C2H2	3.664	C13W2	6.694	C21W1A	3.993	C21W1A	6.356
2	C7W3	2.685	C8X5	3.388	C13W1	5.818	C37X1	2.418	C16X4	5.023
3	C22W1	2.612	C18W2	1.778	C13W3	5.267	C18W2	1.995	C16H1	5.020
4	C13W2	2.483	C13W3	1.641	C16H3	4.693	C15W1	1.938	C16X5	5.000
5	C4X1	2.458	C37X1	1.506	C18W2	4.131	C13W1	1.785	C16X6	5.000
6	C16X4	2.359	C3H3	1.383	C8H2	3.122	C1X7P	1.778	C375X1	5.000
7	C13W1	2.219	C8X3	1.365	C8X3	3.108	C4X1	1.738	C16H3	4.998
8	C1H1	2.199	C15W2	1.350	C17X1	3.000	C22W3	1.509	C7W3	4.850
9	C37X1	1.568	C13W2	1.335	C396X2	3.000	C7W3	1.396	C13W3	4.567
10	C15W2	1.228	C6X3	1.294	C37X1	2.770	C13W3	1.348	C18W2	4.127

Table 9
Worst Performing Circuit past Five Years

SAIDI			SAIFI		
Circuit Ranking	Circuit	# Appearances	Circuit Ranking	Circuit	# Appearances
1	C13W3	5	**1**	C18W2	4
2	C13W2	4	**2**	C21W1A	2
3	C13W1	5	**3**	C13W1	3
4	C7W3	3	**4**	C13W2	3
5	C18W2	3	**5**	C13W3	4
6	C21W1A	2	**6**	C37X1	4
7	C15W1	3	**7**	C16X4	2
8	C8X3	3	**8**	C7W3	3
9	C4X1	2	**9**	C16H3	2
10	C2H2	1	**10**	C2H2	1

6.3 System Reliability Improvements (2020 and 2021)

Vegetation management projects completed in 2020 or planned for 2021 that are expected to improve the reliability of the 2020 worst performing circuits are included in table 10 below. Table 11 below details electric system upgrades that are scheduled to be completed in 2021, or were completed in 2020, that were performed to improve system reliability.

Table 10
Vegetation Management Projects on Worst Performing Circuits

Circuit(s)	Year of Completion	Project Description
C14H1	2020	Planned Cycle Pruning
C14H2	2020	Planned Cycle Pruning
C14X3	2020	Planned Cycle Pruning
C15W1	2020	Planned Cycle Pruning
C15W2	2020	Planned Cycle Pruning/System Reliability Pruning
C1H2	2020	Planned Cycle Pruning
C1H3	2020	Planned Cycle Pruning
C1H4	2020	Planned Cycle Pruning
C7W3	2020	Planned Cycle Pruning
C7X1	2020	Planned Cycle Pruning
C13W3	2020	Planned Tree-Related Analysis
C8X3	2020	Hazard Tree Mitigation
C4W3	2020/2021	Planned Tree-Related Analysis/Planned Pruning Cycle
C18W2	2020	Planned Tree-Related Analysis
C13W2	2020	System Reliability Pruning
C4W4	2020	System Reliability Pruning
C8X5	2020	System Reliability Pruning
C16H1	2020/2021	System Reliability Pruning/ Planned Pruning Cycle

Circuit(s)	Year of Completion	Project Description
C16H3	2020/2021	System Reliability Pruning/ Planned Pruning Cycle
C16X4	2020/2021	System Reliability Pruning/ Planned Pruning Cycle
C13X4	2021	Planned Pruning Cycle
C37X1	2021	Planned Pruning Cycle
C15H3	2021	Planned Pruning Cycle
C6X3	2021	Planned Pruning Cycle
C21W1P	2021	Planned Pruning Cycle
C2H1	2021	Planned Pruning Cycle
C2H2	2021	Planned Pruning Cycle
C2H4	2021	Planned Pruning Cycle
C18W2	2021	Planned Pruning Cycle

Table 11
Electric System Improvements Performed to Improve Reliability

Circuit(s)	Year of Completion	Project Description
13W2	2020	Fusesaver Installation
15W1	2020	Microprocessor Controlled Recloser Installation
1H2 and 1H3	2020	Replace Switchgear and add Tie
22W3	2020	Fusesaver Installation
37X1	2020	Replace Sub-T Pole and Install Microprocessor Controlled Recloser
6X3	2020	Microprocessor Controlled Recloser Installation
7W3	2020	Fusesaver Installation
8X3	2020	Fusesaver Installation
8X3	2020	Hydraulic Recloser Replaced with Microprocessor Controlled Recloser
8X5	2020	Microprocessor Controlled Recloser Installation

Circuit(s)	Year of Completion	Project Description
18W2	2021	Direct Buried Cable Replacement
18W2	2021	Fusesaver Installation
16H3	2021	Cable Injection
4W4	2021	Cable Injection
4W4	2021	Microprocessor Controlled Recloser Installation
37X1	2021	Cable Injection
6X3	2021	Microprocessor Controlled Recloser Installation
8X3	2021	Microprocessor Controlled Recloser Installation
13W1	2021	Fusesaver Installation
13W2	2021	Fusesaver Installation
13W3	2021	Fusesaver Installation
15W2	2021	Fusesaver Installation

7 Tree Related Outages in Past Year

This section summarizes the worst performing circuits by tree related outage during the time period between January 1, 2020 and December 31, 2020.

Table 12 shows the ten worst circuits ranked by the total number of Customer-Minutes of interruption. The number of customer-interruptions and number of outages are also listed in this table.

All streets on the UES CAPITAL system with three or more tree related outages are shown in Table 13 below. The table is sorted by number of interruptions and customer-minutes of interruption.

Table 12
Worst Performing Circuits – Tree Related Outages

Circuit	Customer-Minutes of Interruption	Number of Customers Interrupted	No. of Interruptions
C4X1	291,213	4,478	8
C8X3	184,966	2,942	62
C13W3	140,532	3,137	39
C15W1	134,789	846	9

Circuit	Customer-Minutes of Interruption	Number of Customers Interrupted	No. of Interruptions
C4W3	120,663	2,389	11
C13W2	103,728	3,133	9
C6X3	83,830	1,155	4
C22W3	80,859	1,310	26
C7W3	72,511	812	17
C18W2	58,088	1,333	18

Table 13
Multiple Tree Related Outages by Street

Circuit	Street, Town	# Outages	Customer-Minutes of Interruption	Number of Customer Interruptions
C8X3	Horse Corner Rd, Chichester	40,716	266	6
C8X3	Monroe Rd, Epsom	1,121	5	5
C22W3	Page Rd, Bow	9,245	157	4
C13W3	Warner Rd, Salisbury	12,558	168	3
C13W3	White Plains Rd, Webster	13,751	177	3
C7W3	Knox Rd, Bow	9,160	132	3
C7W3	Woodhill Hooksett Rd. South, Bow	6,353	36	3
C8X3	Center Hill Rd, Epsom	14,150	143	3

8 Failed Equipment

This section is intended to clearly show all equipment failures throughout the study period from January 1, 2020 through December 31, 2020. Chart 7 shows all equipment failures throughout the study period. Chart 8 shows each equipment failure as a percentage of the total failures within this same study period. The number of equipment failures in each of the top three categories of failed equipment for the past five years are shown below in Chart 9.

Chart 7
Equipment Failure Analysis by Cause

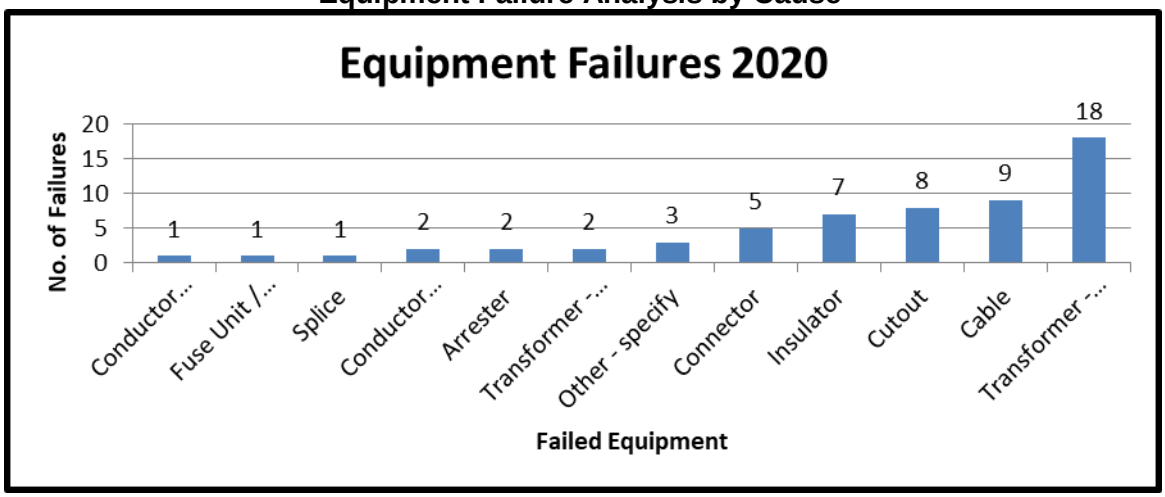


Chart 8
Equipment Failure Analysis by Percentage of Total Failures

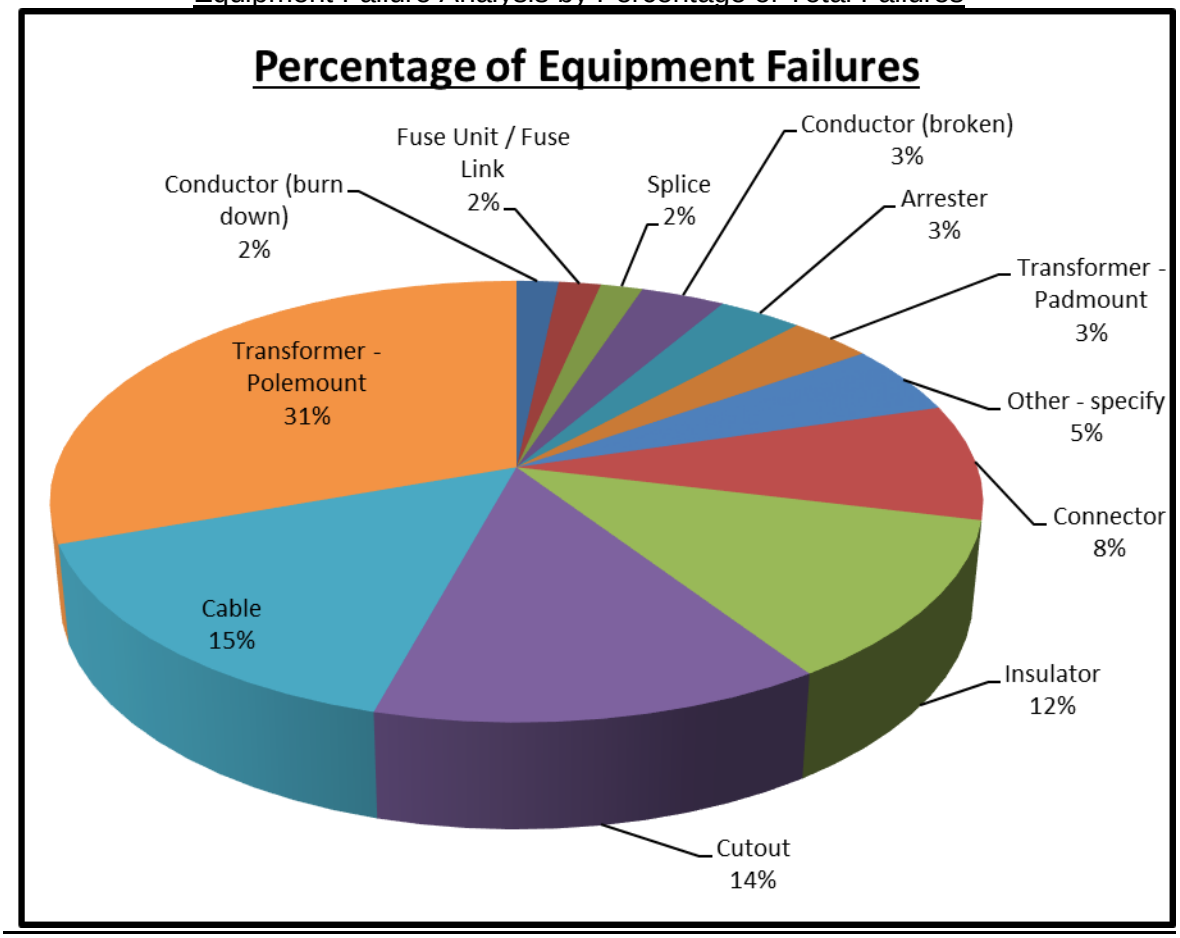
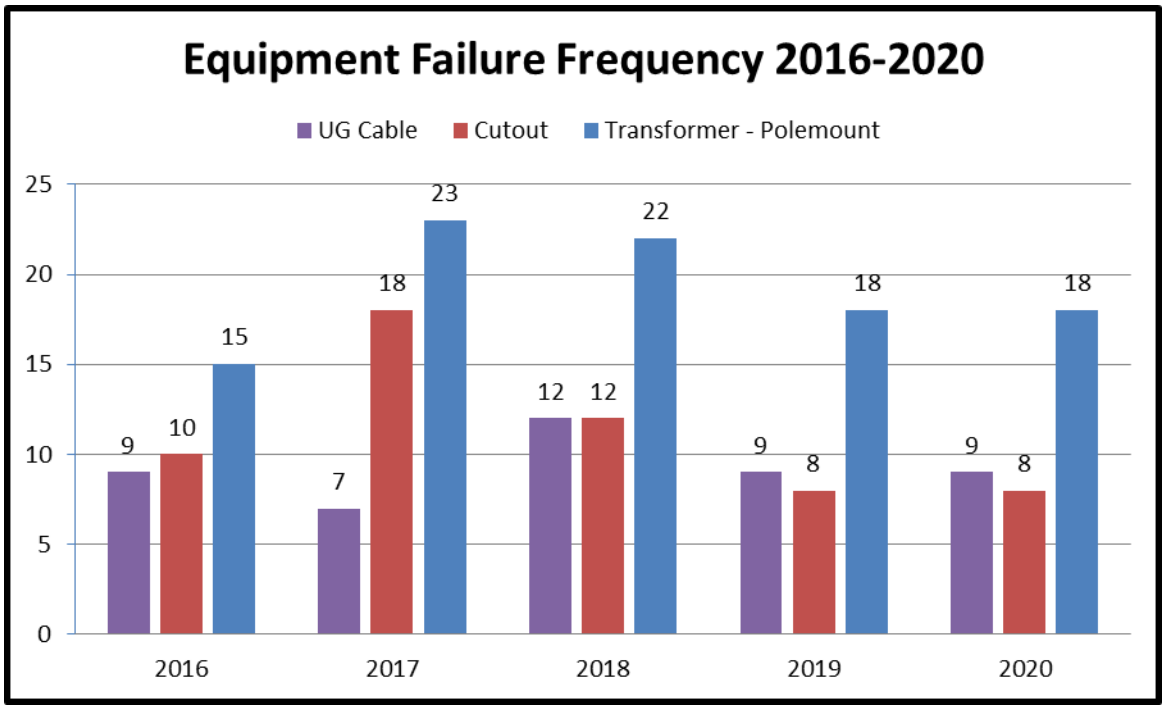


Chart 9
Annual Equipment Failures by Category (top three)



The top three equipment failures continue to be underground cables, cutouts, and polemount transformers. Underground cable failures continue to occur, however, with the cable injection projects in 2016 and 2019, the total failures have remained low. Two life-extending cable injections were executed in 2019. Additional cable injections and direct-buried cable replacement projects are planned for 2021-2022. Starting in 2018, any found porcelain cutouts were replaced. A budgeted porcelain cutout replacement program is planned for 2019-2021. The downtrend of cutout failures is indicative of the replacement programs. Polemount transformer failures continue to be the highest rate of failure; however the number of failures are still below industry average. Presently, there is not a planned replacement program for pole-mounted transformers.

9 Multiple Device Operations and Streets with Highest Number of Outages

A summary of the devices that have operated four or more times from January 1, 2020 to December 31, 2020 are included in table 14 below. Refer to section 11 for project recommendations that address some of the areas identified.

A summary of the streets on the UES Capital system that had customers with 7 or more non-exclusionary outages in 2020 is included in Table 15 below. The table is sorted by circuit and then the maximum number of outages seen by a single customer on that street.

Table 14
Multiple Device Operations

Circuit	Device	Number of Operations	Customer Minutes	Customer Interruptions	# of Times on List in Previous 4 Years
C8X3	Fuse, Pole 2, Bear Hill Rd, Chichester	4	50,332	608	0
C8X3	Fuse, Pole 59, Horse Corner Rd, Chichester	4	35,907	284	0
C4W3	Fuse, Pole 73, Graham Rd, Concord	4	22,369	236	0

Table 15
Streets with the Highest Number of Outages

Circuit	Street	Max Number of Outages Seen by a Single Customer	Number of Times on List in Previous 4 Years
C13W1	New Rd	8	0
C4W3	Graham Rd	8	0
C4W3	Snow Pond Rd	8	0
C8X3	Bear Hill Rd	8	0
C8X3	Ferrin Rd	8	0
C8X3	Leavitt Rd	8	0
C8X3	Short Falls Rd	8	0
C13W1	Morrill Rd	7	2
C13W1	Tioga Rd	7	2
C13W2	Elm St	7	2
C13W2	Weir Rd	7	0
C13W3	Hensmith Rd	7	0
C13W3	Hollings Rd	7	0
C13W3	Loverin Hill Rd	7	0
C13W3	Mountain Rd	7	0
C13W3	White Plains Rd	7	3
C13W3	W Salisbury Rd	7	0
C13W3	Westwind Village	7	0
C15W1	Oak Hill Rd	7	0
C4W3	Becky Lane	7	0
C8X3	Durgin Rd	7	0

10 Other Concerns

This section is intended to identify other reliability concerns that would not necessarily be identified from the analysis above.

10.1 13.8kV Underground Electric System Improvements

There are condition concerns in the 13.8kV Concord Downtown Underground. Portions of the cable have been replaced due to faults. There is historical evidence of connector failure as well. Transformers with primary switches are in the process of being installed in place of the existing transformers. By the end of 2020, 18 of 21 transformers will have switches in them. A project in 2019 combined with the completion of the Gulf St conversion project creates a back up to restore the downtown underground. This is expected to reduce outage duration and allow time for condition-based replacement as opposed to a quick fix to restore customers quickly.

10.2 URD Cable Failure

URD cables are failing at an average rate of 9.2 failures per year over the last five years, for a total of 46 cable failures in five years. When a direct buried cable fails, Unitil splices in a small section of new cable into the existing cable. Generally, cable failures in conduit result in cable replacement. The remaining aged cable in the area is still susceptible to failure. In recent years, projects to address direct buried cable failures have included cable injection and replacement with conduit. Projects for rejuvenation and replacement with conduit were completed in 2020 and further proposed for the 2022 budget.

11 Recommendations

This following section describes recommendations on circuits, sub-transmission lines and substations to improve overall system reliability. The recommendations listed below will be compared to the other proposed reliability projects on a system-wide basis. A cost benefit analysis will determine the priority ranking of projects for the 2021 capital budget. All project costs are shown without general construction overheads.

11.1. Circuit 13W3: Create a Loop between Water St and High St

11.1.1. Identified Concerns

Circuit 13W3 had three of the worst distribution outages in 2018, including the number one worst outage. It has been on the list of worst performing circuits four out of the last five years, ranked by SAIDI and SAIFI.

11.1.2. Recommendations

Build N. Water St, Boscawen from single phase to three phase spacer cable. Extend the phases through to P.50 Old Turnpike Rd, Salisbury. Install two microprocessor reclosers and one three-phase, remote and motor operated switch. Implement an auto transfer scheme. One recloser is to be installed at P.49 Old Turnpike Rd and the other recloser is to be

installed at P.1 Rabbit Rd. The switch is to be installed in the area of the intersection of N. Water St. and Long St., Boscawen. Ultimately, this project is to create a loop between High St and Water St in Boscawen. It will allow for the entirety of the Webster territory or Salisbury territory to be restored after a fault on either Water St or High St, respectively.

Estimated Project Cost (without construction overheads): $1,200,000

Estimated Annual Savings:

Customer Minutes: 144,600
Customer Interruptions: 673

11.2. Circuit 13W3: Install a recloser at P.49 Old Turnpike Rd, Salisbury

Install a microprocessor recloser at P.49 Old Turnpike Rd, Salisbury. This project is a piece of project 11.1., but carries benefit on its own and begins working toward the full project.

Estimate Project Cost (without construction overheads): $50,000

Estimated Annual Savings:

Customer Minutes: 1,746
Customer Interruptions: 21

11.3. Circuit 13W2: Reconductor N. Main St, Boscawen with Spacer

11.3.1. Identified Concern

The master plan is to create a backup for the 37 Line, as it radially feeds the Boscawen S/S. The 13W2 circuit will be converted to 34.5kV and tie with 4X1 from Penacook. This project is expected to provide increased reliability for 13W2 right now, but also establish the back bone for even greater reliability at the sub-transmission and distribution levels.

11.3.2. Recommendation

Reconductor 13W2 mainline from the S/S, down N. Main St, Boscawen, and end at the Village St. bridge in Penacook. The reconductoring and reinsulating will be done to system planning capacity and 34.5kV construction. This construction is approximately 2.5 miles of spacer cable construction.

Estimated Project Cost (without construction overheads): $674,174

Estimated Annual Savings:
Customer Minutes of Interruption: 107,510
Customer Interruptions: 1,294

11.3.3 Alternate Option

Reconductor 13W2 mainline with fully insulated wire in open construction instead of spacer construction.

Estimated Project Cost (without construction overheads):

Estimated Annual Savings:
Customer Minutes of Interruption: 44,348
Customer Interruptions: 534

11.4 Circuit 13W1: Reconductor Morrill Rd, Canterbury

11.4.1 Identified Concern

A number of tree related outages on this single phase lateral occurred in 2018. There are limited trimming abilities in the area. Reconductoring the #6 with 1/0 ACSR fully insulated wire will reduce the number of outages. The insulation and breaking strength improve the overall reliability by being less susceptible to faults and less likely to break (compared to uninsulated, #6 Cu)

11.4.2 Recommendation

Reconductor approximately 14,000 ft of #6 Cu with 1/0 ACSR fully insulated wire on Morrill Rd, Canterbury.

Estimated Project Cost (without construction overheads): $445,000

Estimated Annual Savings:
Customer Minutes of Interruption: 7,630
Customer Interruptions: 84

11.5 Circuit 13W3: Reconductor Long St, Webster with Spacer Cable

11.5.1 Identified Concern

The sectionalizers on P.138 Long St, Boscawen operated several times in 2018, most outages were patrolled and nothing was found. Reconductoring approximately 1.6 miles of three phase mainline will reduce the number of outages normally associated with trees and animals.

11.5.2 Recommendation

Reconductor approximately 1.6 miles of three-phase mainline on Long St, Boscawen and Webster with 13.8kV, 336AAC spacer.

Estimated Project Cost (without construction overheads): $533,935.83

Estimated Annual Savings:
Customer Minutes of Interruption: 23,315
Customer Interruptions: 281

11.6 Circuit 13W1: Reconductor West Rd, Canterbury and Install Recloser

11.6.1 Identified Concern

13W1 does not have a circuit tie that can back feed the circuit for restoration. This project aims to harden the stand alone system, lessen overall outage impact with an additional reclosing point, and prepare for a potential future tie, according to the master plan.

11.6.2 Recommendation

Reconductor approximately 4 miles of three phase mainline on West Rd, Canterbury with 13.8kV, 336AAC spacer.

Install a microprocessor-based recloser at P.35 Center Rd, Canterbury.

Estimated Project Cost (without construction overheads): $750,000

Estimated Annual Savings:
Customer Minutes of Interruption: 73,583
Customer Interruptions: 886

11.6.3 Alternate Option

This project consists of installing a microprocessor based recloser at P.35 Center Rd, Canterbury.

13W1 has no mainline sectionalizing points. This recloser would split the circuit in half to reduce the number of customers affected by faults downline of this recloser.

Estimated Project Cost (without construction overheads): $47,951

Estimated Annual Savings:
Customer Minutes of Interruption: 17,941
Customer Interruptions: 197

11.7 Animal Guard Installation

11.7.1 Identified Concern

The proposed project is to install animal guards in locations known to experience a higher number of animal-related and patrolled, nothing found outages.

11.7.2 Recommendation

The identified areas have experienced multiple animal (other), bird, squirrel, and patrolled, nothing found outages in 2020. Installing animal guards on transformers will reduce the total number of animal-related outages in these areas.

Estimated Project Cost (without construction overheads): $75,000

Estimated Annual Savings:
Customer Minutes of Interruption: 61,236
Customer Interruptions: 972

11.8. Miscellaneous Circuit Improvements to Reduce Recurring Outages

11.8.1. Identified Concerns & Recommendations

The following concerns were identified based on a review of Tables 12 & 13 of this report; Multiple Tree Related Outages by Street and Multiple Device Operations respectively.

Mid-Cycle Forestry Reviews

The areas identified below experienced three or more tree related outages in 2020. It is recommended that a forestry review of these areas be performed in 2021 in order to identify and address any mid-cycle growth or hazard tree problems.

- C13W1
  - Kimball Pond Rd, Canterbury
  - Morrill Rd, Canterbury
- C13W3
  - Mutton Rd, Webster
  - Cashell Lane, Webster
- C15W1
  - Oak Hill Rd, Concord and Loudon
- C18W2
  - Putney Rd, Bow
- C22W3
  - Putney Rd, Bow
- C4W3
  - Mountain Rd, Concord
- C4W4
  - Lakeview Dr, Concord
- C8X3
  - Sanborn Hill Rd North, Epsom
- C8X5
  - North Pembroke Rd, Pembroke

Animal Guard Installation Recommendations

The areas identified below experienced three or more patrolled nothing found / animal outages in 2020.

- C8X3, Old Town Rd, Epsom
- C8X3, Smith Sanborn Rd area, Chichester
- C8X3, Durgin Rd, Chichester
- C8X3, Ferrin Rd, Chichester
- C8X3, Lane Rd area, Chichester
- C21W1P, Warren St area, Concord
- C7W4, Cornell St, Concord
- C18W2, Farrington Corner Rd area, Hopkinton

12 Conclusion

During 2020, tree related outages still present one of the largest problems in the UES-Capital System, compared to other causes. Although compared to previous years, the worst performing circuits have seen a dramatic decrease in Customer Minutes of Interruption from tree related outages. Enhanced tree trimming efforts are still being implemented, which is expected to improve reliability for most of the worst performing circuits identified in this study.

The animal guard installation project was completed in 2019. In 2019, there were the fewest squirrel outages recorded in the last five years. As such, an additional animal guard installation project is submitted for the 2022 budget. Furthermore, animal guards are continually being placed on equipment whenever an animal causes an outage. In addition, when there is an animal-related outage, any equipment in the vicinity will be checked. If nearby equipment does not have animal guards, the animal guards will be installed at that location. Also, all streets and circuits identified as having high numbers of animal related outages will be checked and proper animal protection will be installed where applicable.

Recommendations developed from this study are mainly focused on reducing the impact of multiple permanent outages and improving reliability of the sub transmission system. This report is also intended to assist Unitil Forestry in identifying areas of the system that are being frequently affected by tree related outages to allow proactive measures to be taken. In addition, new ideas and solutions to reliability problems are always being explored in an attempt to provide the most reliable service possible.

Unitil Energy Systems – Seacoast

Reliability Study
2021

Prepared By:

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Unitil Service Corp.
November 12, 2021

Table of Contents

1 Executive Summary

The purpose of this document is to report on the overall reliability performance of the Unitil Energy Systems – Seacoast (UES-Seacoast) system from January 1, 2020 through December 31, 2020. The scope of this report will also evaluate individual circuit reliability performance over the same time period. The outage data used in this report excludes sub-transmission and substation outages (listed in Section 5), as well as outages during IEEE Major Event Days (MEDs). UES-Seacoast MEDs are listed in the table below:

# MEDs in Event	Dates of MEDs	Interruptions	Customer Interruptions	Cust-Min of Interruption
1	3/24/2020	25	5,982	776,011
1	8/4/2020	93	10,410	2,177,873

The following projects are proposed from the results of this study and are focused on improving the worst performing circuits as well as the overall UES-Seacoast system reliability. These recommendations are provided for consideration and will be further developed with the intention to be incorporated into the 2022 budget development process.

Circuit / Line / Substation	Proposed Project	Cost ($)
51X1	Install Sectionalizers on Winnicutt Rd	$15,000
21W1	Install FuseSaver on Main St	$7,000
21W1	Install FuseSaver on East Rd	$7,000
22X1	Install FuseSavers on Sandown Rd	$16,000
15X1/59X1	Install Reclosers and Implement Distribution Automation	$146,000
6W2	Install Recloser on Main St	$72,000

Note: estimates do not include general construction overheads

The 2020 annual UES-Seacoast system reliability goal was set at 114 SAIDI minutes, after removing exclusionary outages. UES-Seacoast's SAIDI performance in 2020 was 132.97 minutes. Charts 1, 2, and 3 below show UES-Seacoast's SAIDI, SAIFI, and CAIDI performance over the past five years.

Chart 1
Annual UES-Seacoast SAIDI

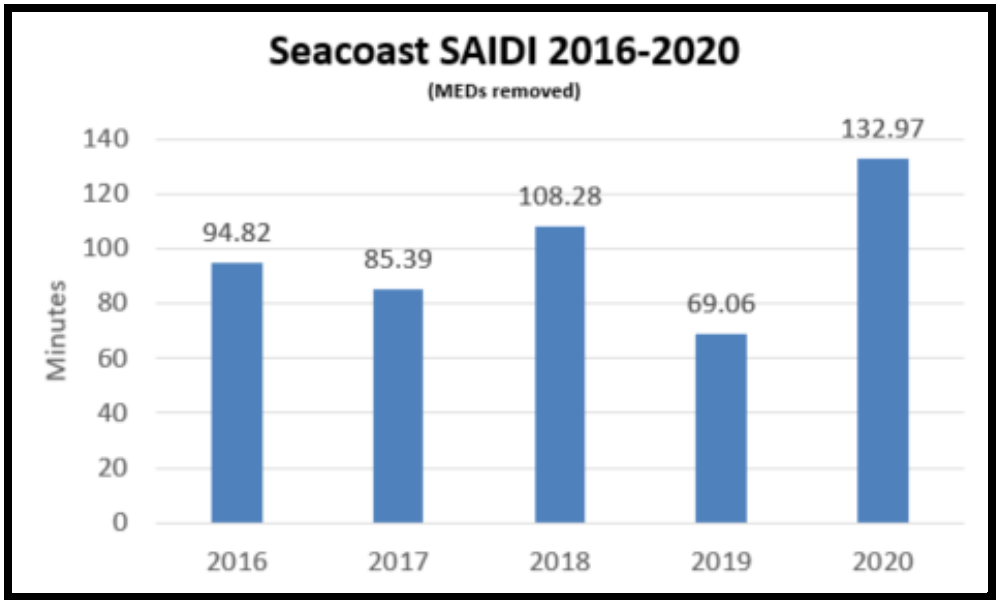


Chart 2
Annual UES-Seacoast SAIFI

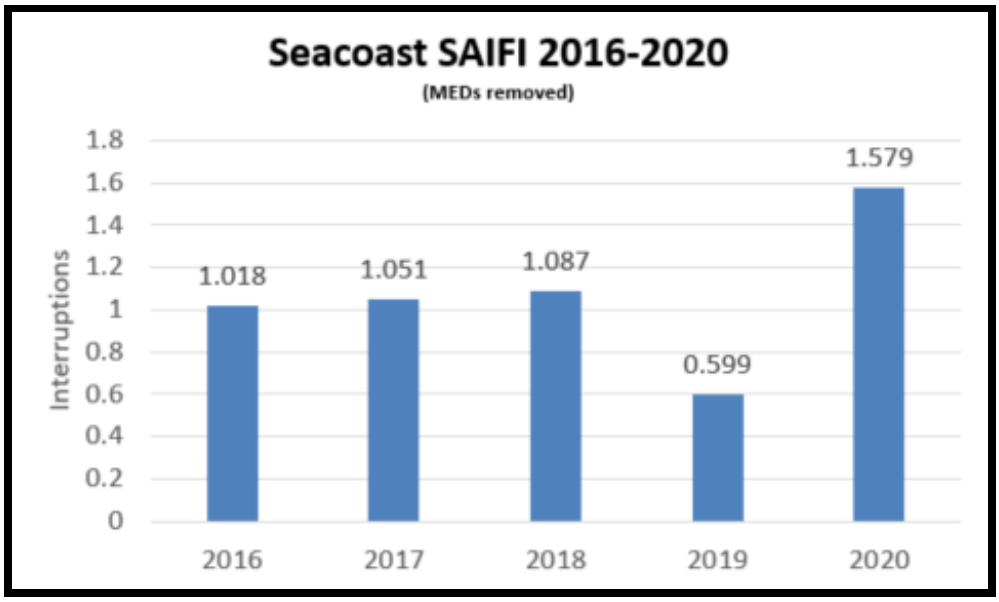
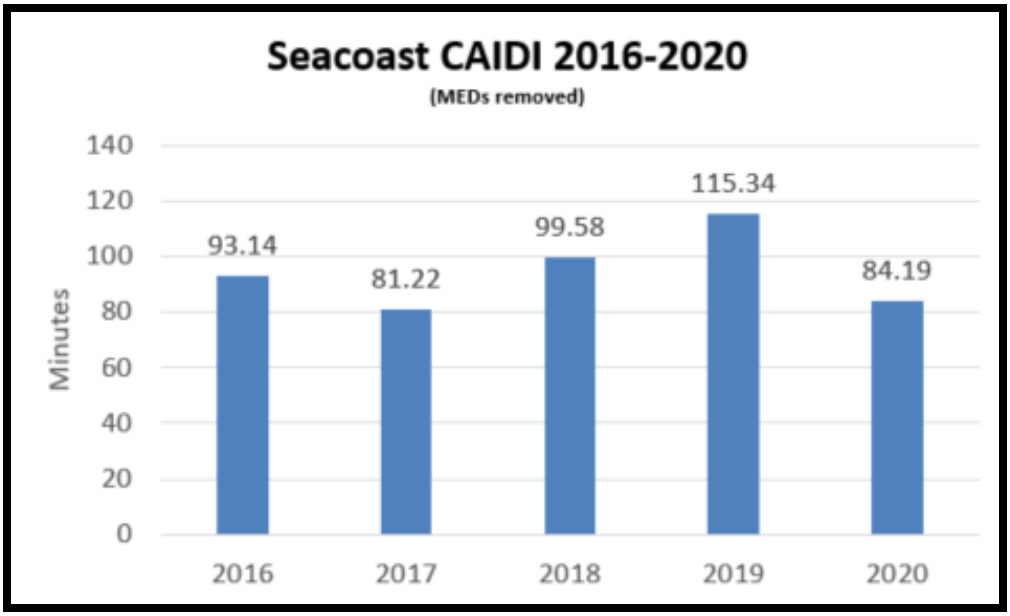


Chart 3
Annual UES-Seacoast CAIDI



2 Reliability Benchmarks

The new annual UES-Seacoast system reliability benchmark for 2021 is 117.33 SAIDI minutes. This was developed by calculating the contribution of UES-Seacoast to the Unitil system performance using the past five year average. The contribution factor was then set against the 2021 Unitil system goal. The 2021 Unitil system goal was developed through benchmarking the Unitil system performance with nationwide utilities.

Individual circuits will be analyzed based upon circuit SAIDI, SAIFI, and CAIDI. Analysis of individual circuits along with analysis of the entire UES-Seacoast system is used to identify future capital improvement projects and/or operational enhancements which may be required in order to achieve and maintain these goals.

3 Outages by Cause

This section provides a breakdown of all outages by cause code experienced during 2020. Charts 4, 5, and 6 list the number of interruptions, the number of customer interruptions, and total customer-minutes of interruption due to each cause respectively. Only the causes contributing 3% or greater of the total are labeled. Table 1 shows the number of interruptions for the top three trouble causes for the previous five years.

Chart 4
Number of Interruptions by Cause

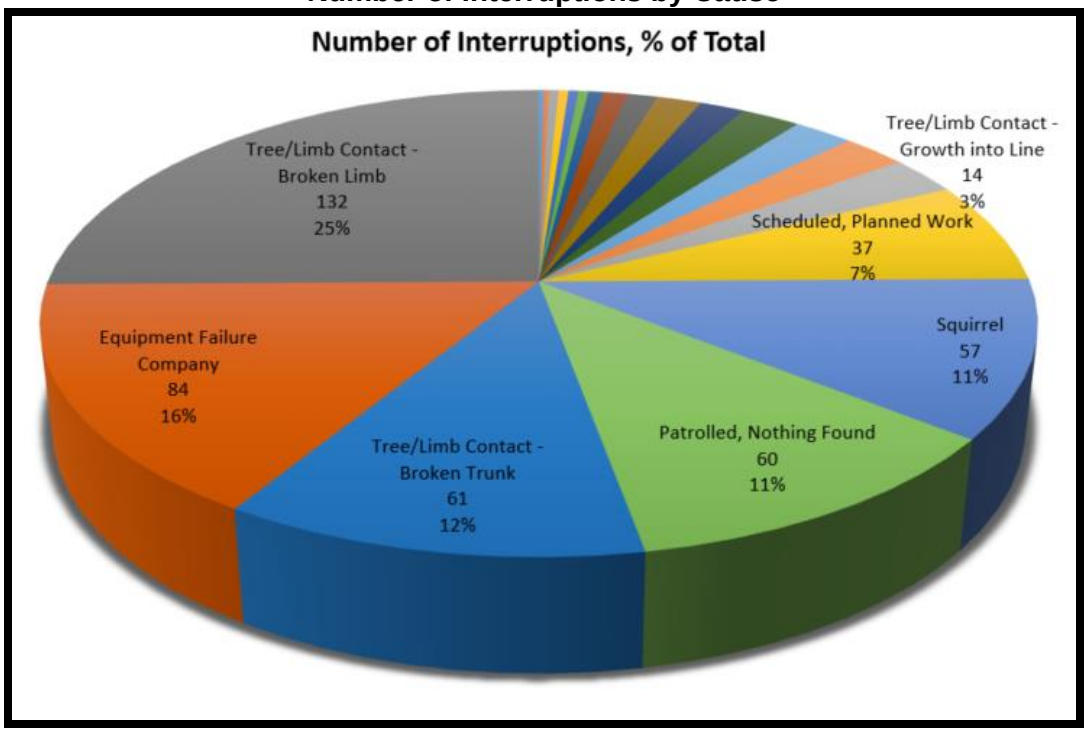


Chart 5
Number of Customer Interruptions by Cause

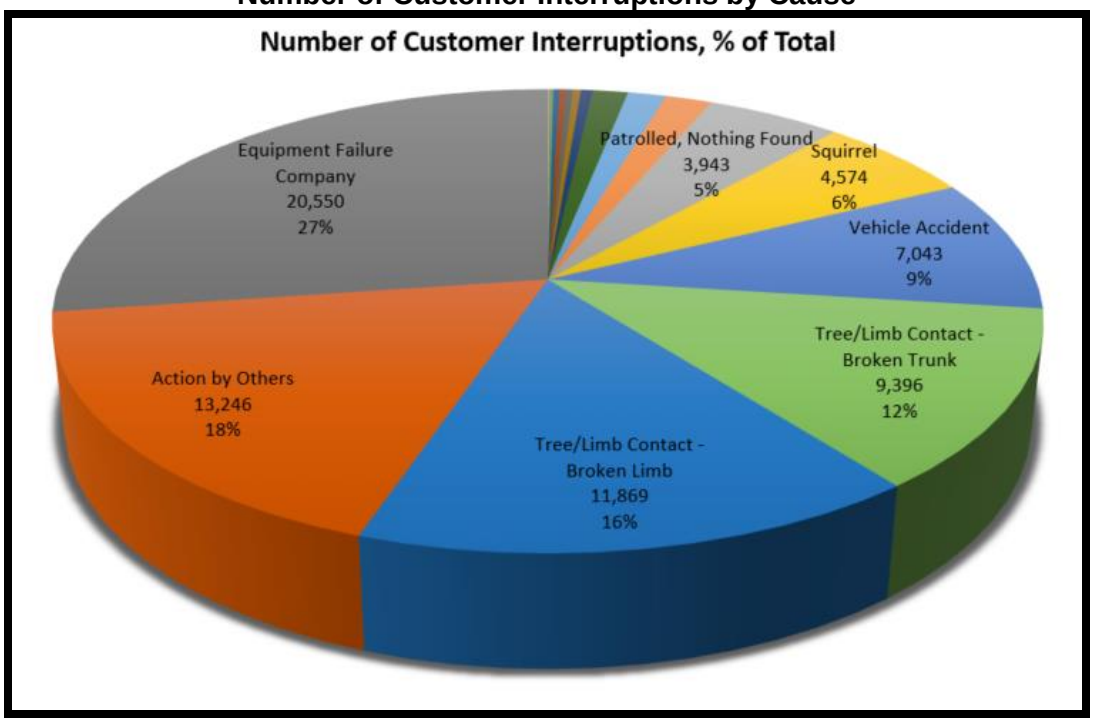


Chart 6
Percent of Customer-Minutes of Interruption by Cause

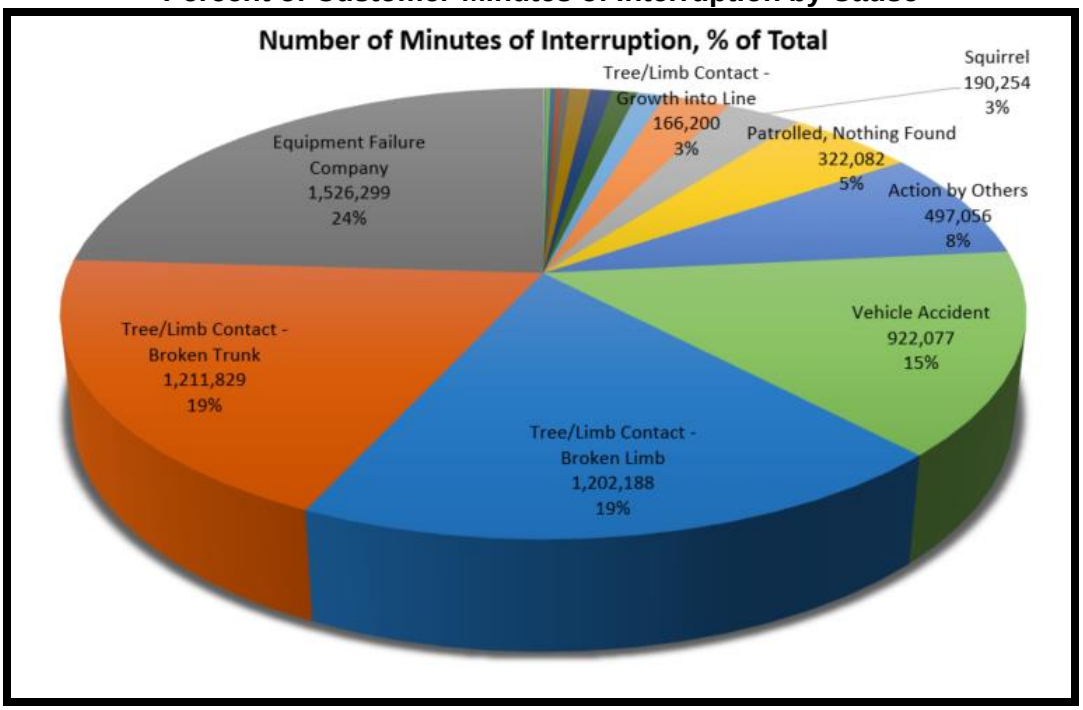


Table 1
Five-Year History of the Number of
Interruptions for the Worst Three Trouble Causes

Year	# of Interruptions Per Trouble Cause		
	Tree/Limb Contact - Broken Limb	Equipment Failure Company	Tree/Limb Contact - Broken Trunk
2020	132	84	61
2019	88	69	68
2018	179	93	57
2017	121	79	46
2016	147	79	51

4 10 Worst Distribution Outages

The ten worst distribution outages ranked by customer-minutes of interruption during the time period from January 1, 2020 through December 31, 2020 are summarized in Table 2 below.

Table 2
Worst Ten Distribution Outages

Circuit	Date/Cause	Customer Interruptions	Cust-Min of Interruption	SAIDI	SAIFI
E51X1	08/14/2020 Vehicle Accident	1,036	319,175	6.69	0.022
E15X1	06/16/2020 Vehicle Accident	3,926	294,340	6.17	0.082
E21W2	12/05/2020 Tree/Limb Contact - Broken Trunk	1,128	263,087	5.51	0.024
E19X3	02/19/2020 Vehicle Accident	906	160,912	3.37	0.019
E6W2	04/13/2020 Tree/Limb Contact - Growth into Line	987	133,015	2.79	0.021
E51X1	09/30/2020 Tree/Limb Contact - Broken Limb	838	125,681	2.63	0.018
E51X1	04/13/2020 Tree/Limb Contact - Broken Limb	838	108,345	2.27	0.018
E22X1	02/07/2020 Tree/Limb Contact - Broken Limb	927	106,103	2.22	0.019
E47X1	05/09/2020 Tree/Limb Contact - Broken Limb	1,485	86,735	1.82	0.031
E21W1	07/28/2020 Equipment Failure Company	1,371	83,905	1.76	0.029

5 Sub-transmission and Substation Outages

This section describes the contribution of sub-transmission line and substation outages on the UES-Seacoast system.

All substation and sub-transmission outages ranked by customer-minutes of interruption during the time period from January 1, 2020 through December 31, 2020 are summarized in Table 3 below.

Table 4 shows the substations that have been affected by sub-transmission line and substation outages. The table illustrates the contribution of customer minutes of interruption for each circuit affected.

In aggregate, sub-transmission line and substation outages accounted for 29% of the total customer-minutes of interruption for UES-Seacoast.

Table 3
Sub-transmission and Substation Outages

Line / Substation	Date/Cause	Customer Interruptions	Cust-Min of Interruption	SAIDI	SAIFI	Number of Outages in Prior Four Years
3353 Line	01/23/2020 Action by Others	7,920	207,418	4.35	0.166	0

High Street Substation	02/24/2020 Squirrel	2,656	40,608	0.85	0.056	0
3362 Line	04/20/2020 Action by Others	5,262	284,148	5.96	0.110	0
3359 Line	04/29/2020 Equipment Failure Company	6,025	557,923	11.69	0.126	1
3348/3350/3359 Line	06/05/2020 Equipment Failure Company	6,021	334,708	7.02	0.126	1
3359 Line	07/31/2020 Equipment Failure Company	6,018	391,170	8.20	0.126	1

Table 4
Affected Substations

Substation/Tap	Substation / Transmission Line Outage	Customer Interruptions	Cust-Min of Interruption	Number of Events
Brazonics Tap	3353 Line	2	52	1
Hampton	3353 Line	1,200	32,015	1
Hampton Beach	3353 Line	3,189	82,595	1
Hampton Sewer Tap	3353 Line	1	26	1
High St	High St, 3353 Line	2,655	69,959	2
Winnacunnet Rd	3353 Line	873	22,771	1
Exeter	3362 Line	894	48,276	1
Gilman Lane	3362 Line	4,368	235,872	1
Cemetary Lane	3359 Line, 3348/3350/3359 Line	6,023	377,509	3
Mill Lane	3359 Line, 3348/3350/3359 Line	2,862	172,674	3
Seabrook	3359 Line, 3348/3350/3359 Line	6,059	545,367	2
Stard Rd Tap	3359 Line, 3348/3350/3359 Line	3,120	188,251	3

6 Worst Performing Circuits

This section compares the reliability of the worst performing circuits using various performance measures.

6.1 Worst Performing Circuits in Past Year (1/1/20 – 12/31/20)

A summary of the worst performing circuits during the time period between January 1, 2020 and December 31, 2020 is included in the tables below.

Table 5 shows the ten worst circuits ranked by the total number of Customer-Minutes of interruption. The SAIFI and CAIDI for each circuit are also listed in this table.

Table 6 provides detail on the major causes of the outages on each of these circuits. Customer-Minutes of interruption are given for the six most prevalent causes during 2020.

Circuits having one outage contributing more than 80% of the Customer-Minutes of interruption were excluded from this analysis.

Table 5
Worst Performing Circuits Ranked by Customer-Minutes

Circuit	Customer Interruptions	Worst Event (% of CI)	Cust-Min of Interruption	Worst Event (% of CMI)	SAIDI	SAIFI	CAIDI
E51X1	4,845	21%	722,611	44%	370.76	2.486	149.15
E21W2	1,696	66%	345,066	76%	219.48	1.079	203.43
E21W1	4,006	34%	329,126	25%	240.24	2.924	82.16
E19X3	2,182	41%	317,837	51%	89.58	0.615	145.66
E15X1	3,586	84%	282,917	79%	283.77	3.597	78.89
E58X1	2,183	25%	232,320	16%	103.21	0.97	106.42
E6W2	2,078	47%	222,582	60%	225.28	2.103	107.11
E22X1	1,652	55%	211,532	50%	153.4	1.198	128.05
E6W1	1,324	28%	146,767	44%	166.78	1.505	110.85
E18X1	2,000	60%	143,156	41%	78.91	1.103	71.58

Note: all percentages and indices are calculated on a circuit basis

Table 6
Circuit Interruption Analysis by Cause

Circuit	Customer-Minutes of Interruption / # of Outages					
	Tree/Limb Contact - Broken Limb	Tree/Limb Contact - Broken Trunk	Equipment Failure Company	Squirrel	Patrolled, Nothing Found	Loose/Failed Connection
E51X1	3,719 / 4	3,388 / 3	348,167 / 14	320,346 / 2	0 / 0	3,053 / 1
E21W2	0 / 0	263,127 / 2	22,138 / 7	10,075 / 1	0 / 0	7,510 / 2
E21W1	85,451 / 4	73,676 / 3	89,080 / 7	0 / 0	155 / 1	54,823 / 7
E19X3	6,910 / 3	6,309 / 2	33,629 / 5	187,583 / 3	0 / 0	25,089 / 2
E15X1	10,807 / 2	21,283 / 2	0 / 0	224,424 / 1	0 / 0	7,350 / 6
E58X1	1,732 / 3	122,212 / 7	60,390 / 11	37,435 / 1	1,035 / 2	690 / 2
E6W2	2,013 / 3	1,574 / 1	17,195 / 6	15,799 / 1	0 / 0	32,797 / 2
E22X1	34,214 / 2	30,598 / 1	131,460 / 8	0 / 0	0 / 0	13,312 / 3
E6W1	151 / 1	103,951 / 5	140 / 1	0 / 0	0 / 0	17,039 / 3
E18X1	5,412 / 5	76,081 / 1	3,416 / 2	0 / 0	0 / 0	58,241 / 2

6.2 Worst Performing Circuits of the Past Five Years (2016 – 2020)[1]

The annual performance of the ten worst circuits in terms of SAIDI and SAIFI for each of the past five years is shown in the tables below. Table 7 lists the ten worst performing circuits ranked by SAIFI and Table 8 lists the ten worst performing circuits ranked by SAIDI. Table 9 lists the ten worst circuits in terms of SAIFI and SAIDI for the past five years.

The data used in this analysis includes all system outages except those outages that occurred during the IEEE MEDs in 2016 through 2020.

Table 7
Circuit SAIFI

Circuit Ranking (1=worst)	2020		2019		2018		2017		2016	
	Circuit	SAIFI	Circuit	SAIFI	Circuit	SAIFI	Circuit	SAIFI	Circuit	SAIFI
1	E15X1	3.597	E3W1	2.062	E7W1	6.569	E6W1	4.096	E43X1	2.945
2	E21W1	2.924	E6W1	1.991	E6W1	3.257	E22X1	2.606	E3H2	2.867
3	E51X1	2.486	E22X1	1.758	E54X2	2.949	E15X1	2.536	E21W2	2.641
4	E6W2	2.103	E51X1	1.693	E21W1	2.519	E54X2	2.271	E17W2	2.309
5	E13X3	2.000	E23X1	1.677	E6W2	2.334	E19H1	2.012	E21W1	2.198
6	E19H1	2.000	E11X1	1.356	E54X1	2.115	E23X1	1.527	E58X1	2.107
7	E17W2	1.518	E21W1	1.290	E21W2	2.053	E59X1	1.496	E22X1	1.922
8	E6W1	1.505	E18X1	1.261	E13W2	1.777	E43X1	1.481	E27X1	1.917
9	E56X1	1.484	E17W2	0.998	E43X1	1.465	E18X1	1.414	E54X1	1.892
10	E2H1	1.223	E6W2	0.901	E22X1	1.458	E19X2	1.387	E6W1	1.772

Table 8
Circuit SAIDI

Circuit Ranking (1=worst)	2020		2019		2018		2017		2016	
	Circuit	SAIDI	Circuit	SAIDI	Circuit	SAIDI	Circuit	SAIDI	Circuit	SAIDI
1	E51X1	370.76	E6W1	459.13	E7W1	520.93	E54X2	275.94	E3H2	463.53
2	E13X3	335.64	E51X1	354.92	E54X2	338.40	E6W1	269.71	E7W1	375.29
3	E15X1	283.77	E21W1	176.68	E21W1	285.58	E19H1	254.56	E3H3	255.03
4	E21W1	240.24	E22X1	170.09	E54X1	221.90	E22X1	238.10	E54X2	249.35
5	E6W2	225.28	E11X1	167.39	E22X1	209.94	E5H1	200.60	E6W1	241.11
6	E21W2	219.48	E15X1	116.15	E6W1	205.87	E15X1	192.52	E43X1	226.55
7	E6W1	166.78	E17W2	115.43	E13W2	196.23	E51X1	158.75	E21W2	214.57
8	E22X2	154.73	E13W1	113.60	E2H1	192.59	E58X1	134.36	E17W2	210.69
9	E22X1	153.40	E23X1	112.91	E23X1	176.73	E59X1	125.01	E58X1	203.82
10	E19H1	147.89	E6W2	93.03	E58X1	167.86	E22X2	117.33	E54X1	196.61

[1] 2020 SAIDI and SAIFI numbers do not include sub-transmission outages

Table 9
Worst Performing Circuits in Past Five Years

SAIDI			SAIFI		
Circuit Ranking (1=worst)	**Circuit**	**# of Times in Worst 10**	**Circuit Ranking (1=worst)**	**Circuit**	**# of Times in Worst 10**
1	E6W1	5	**1**	E6W1	5
2	E51X1	3	**2**	E21W1	4
3	E7W1	2	**3**	E22X1	4
4	E21W1	3	**4**	E7W1	1
5	E22X1	4	**5**	E15X1	2
6	E54X2	3	**6**	E6W2	3
7	E58X1	3	**7**	E21W2	2
8	E15X1	3	**8**	E43X1	3
9	E21W2	2	**9**	E51X1	2
10	E6W2	2	**10**	E54X2	2

6.3 System Reliability Improvements (2020 and 2021)

Vegetation management projects completed in 2020 or planned for 2021 that are expected to improve the reliability of the 2020 worst performing circuits are included in Table 10 below. Table 11 below details electric system upgrades scheduled to be completed in 2021 or completed in 2020 to improve system reliability of the 2020 worst performing circuits.

Table 10
Vegetation Management Projects Worst Performing Circuits

Circuit(s)	Year of Completion	Project Description
E51X1	2020	Hazard Tree Mitigation
	2021	Cycle Pruning Hazard Tree Mitigation
E21W1	2020	Hazard Tree Mitigation
	2021	Storm Resiliency Pruning
E6W2	2020	Cycle Pruning
E6W1	2020	Cycle Pruning
E15X1	2021	Mid-Cycle Pruning
E21W2	2020	Hazard Tree Mitigation
E22X1	2020	Cycle Pruning

Circuit(s)	Year of Completion	Project Description
		Hazard Tree Mitigation
E13X3	2021	Mid-Cycle Pruning
E58X1	2021	Mid-Cycle Pruning Hazard Tree Mitigation
E56X1	2020	Hazard Tree Mitigation
E19X3	2021	Cycle Pruning Hazard Tree Mitigation
E17W2	2020	Reliability Trimming
	2021	Mid-Cycle Pruning
E22X2	2020	Cycle Pruning
E2H1	2021	Mid-Cycle Pruning
3346 Line[1]	2020	Sub-Transmission Clearing
3347 Line[2]	2021	Sub-Transmission Clearing
3341/3352 Line[3]	2020/2021	Sub-Transmission Clearing
3342/3353 Line[4]	2020	Sub-Transmission Clearing
3351/3362 Line[5]	2021	Sub-Transmission Clearing

Table 11
Electric System Improvements Performed to Improve Reliability

Circuit(s)	Year of Completion	Project Description
Various	2021	Porcelain Cutout Replacements
E21W1	2021	Install set of sectionalizers
E6W2	2020/2021	Fuse changes to address/improve device coordination
E6W1	2020	Install two reclosers

[1] The 3346 line is the normal feed for the High Street (#17) Substation
[2] The 3347 line is the normal feed for the Guinea Road (#47) Substation
[3] The 3341 and 3352 lines are the normal and alternate feeds for the Gilman Lane (#19) Substation
[4] The 3342 and 3353 lines are the normal and alternate feeds for the Hampton (#2) Substation. They also feed the 3346 line which feeds the High Street (#17) Substation
[5] The 3351 and 3362 lines are the normal and alternate feeds for the Winnicutt Road (#51) Substation. They also feed the 3347 line which feeds the Guinea Road (#47) Substation. They also feed the 3341 and 3352 lines which feed the Gilman Lane (#19) Substation

Circuit(s)	Year of Completion	Project Description
	2021	Fuse changes to address/improve device coordination
E15X1	2020	Fuse changes to address/improve device coordination
E56X1	2020	Fuse changes to address/improve device coordination
E18X1	2020	Fuse changes to address/improve device coordination
E19X3	2020/2021	Fuse changes to address/improve device coordination
3343/3354 Lines[1]	2020	Install Two Electronically Controlled Reclosers

7 Tree Related Outages in Past Year

This section summarizes the worst performing circuits by tree related outage during the time period between January 1, 2020 and December 31, 2020.

Table 12 shows the ten worst circuits ranked by the total number of Customer-Minutes of interruption. The number of customer-interruptions and number of outages are also listed in this table.

All streets on the UES-Seacoast system with three or more tree related outages are shown in Table 13 below. The table is sorted by number of interruptions and customer-minutes of interruption.

Table 12
Worst Performing Circuits – Tree Related Outages

Circuit	Customer Minutes of Interruption	Number of Customers Interrupted	No. of Interruptions
E51X1	351,854	3,279	19
E21W2	285,265	1,317	9
E58X1	190,669	1,590	20
E21W1	163,757	1,556	12
E22X1	162,058	1,256	9
E6W2	152,256	1,263	10
E6W1	104,202	769	7
E47X1	90,868	1,511	3
E56X1	86,817	924	10
E18X1	79,498	758	3

[1] The 3343 and 3354 lines are the normal and alternate feeds for the East Kingston (#6) Substation

Table 13
Multiple Tree Related Outages by Street

Circuit(s)	Street, Town	# Outages	Customer-Minutes of Interruption	Number of Customer Interruptions
E51X1	Winnicut Rd, Stratham	7	331,500	3,112
E13W2, E58X1, E54X1	Main St, Newton	6	102,145	964
E28X1	Exeter Rd, Hampton Falls	6	3,470	23
E58X1, E21W2	Main St, Atkinson	4	275,938	1,236
E56X1	Hunt Rd, Kingston	4	64,229	781
E13W1	North Main St, Plaistow	4	38,762	371
E43X1, E6W1	Willow Rd, East Kingston	4	393	5
E58X1, E5X3	Sweet Hill Rd, Plaistow	3	62,998	391
E58X1	Forest St, Plaistow	3	52,471	222
E59X1	Stard Rd, Hampton Falls	3	47,562	263
E2X3, E27X1	Drinkwater Rd, Hampton Falls	3	29,370	135
E58X1, E21W1	Sawyer Ave, Atkinson	3	22,405	151
E58X1	Newton Rd, Plaistow	3	20,853	356
E56X1	Hillside Rd, Kingston	3	7,804	31

8 Failed Equipment

This section is intended to clearly show all equipment failures throughout the study period from January 1, 2020 through December 31, 2020. Chart 7 shows all equipment failures throughout the study period. Chart 8 shows each equipment failure as a percentage of the total failures within this same study period. The number of equipment failures in each of the top three categories of failed equipment for the past five years are shown below in Chart 9.

Chart 7
Equipment Failure Analysis by Cause

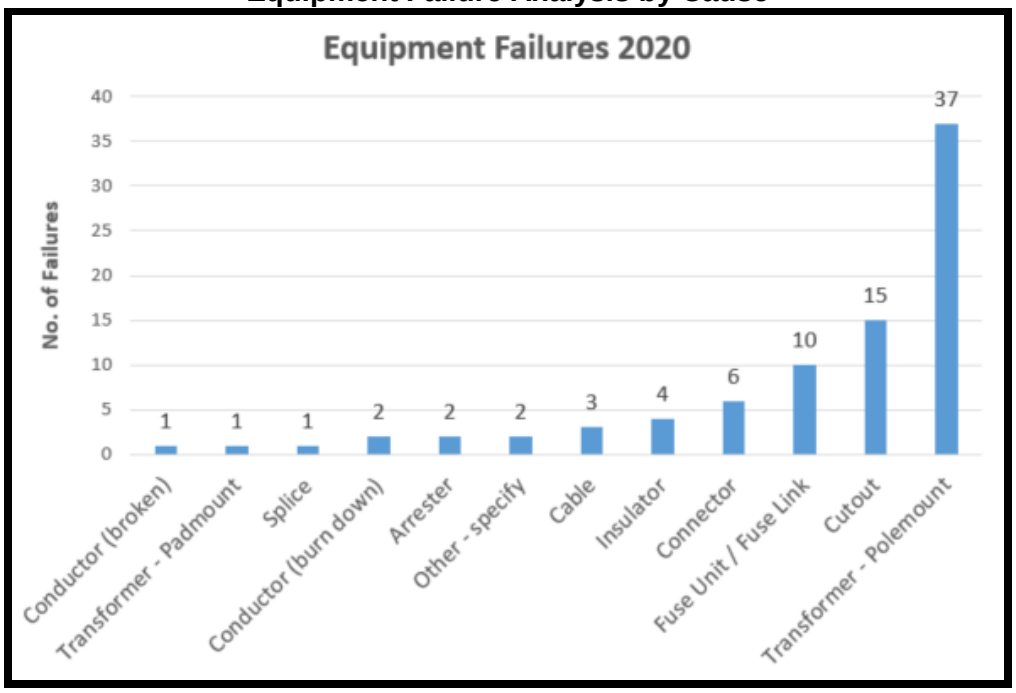


Chart 8
Equipment Failure Analysis by Percentage of Total Failures

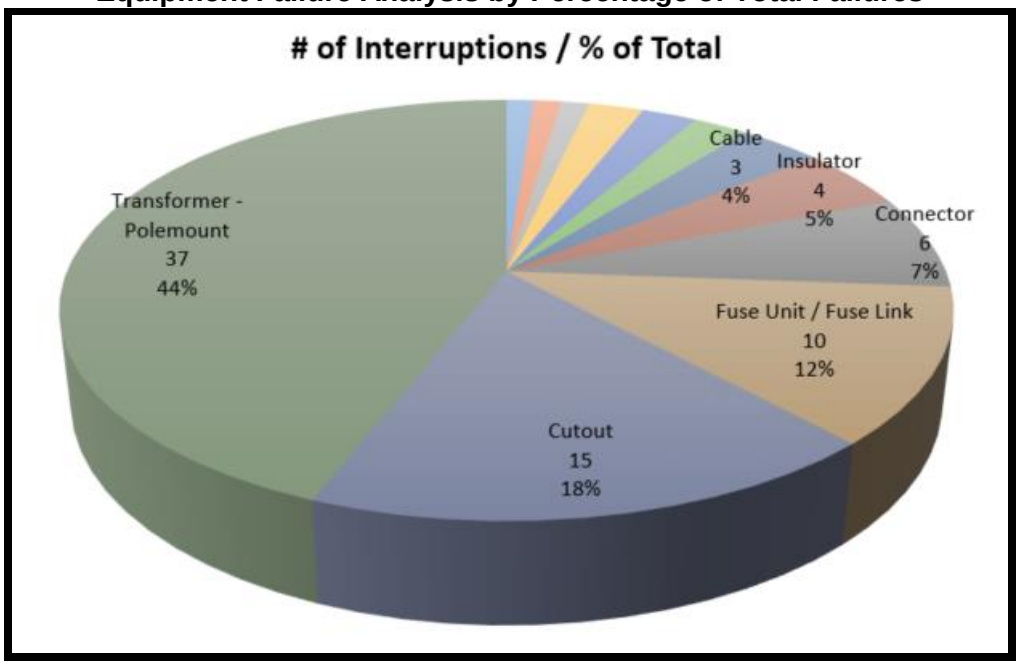
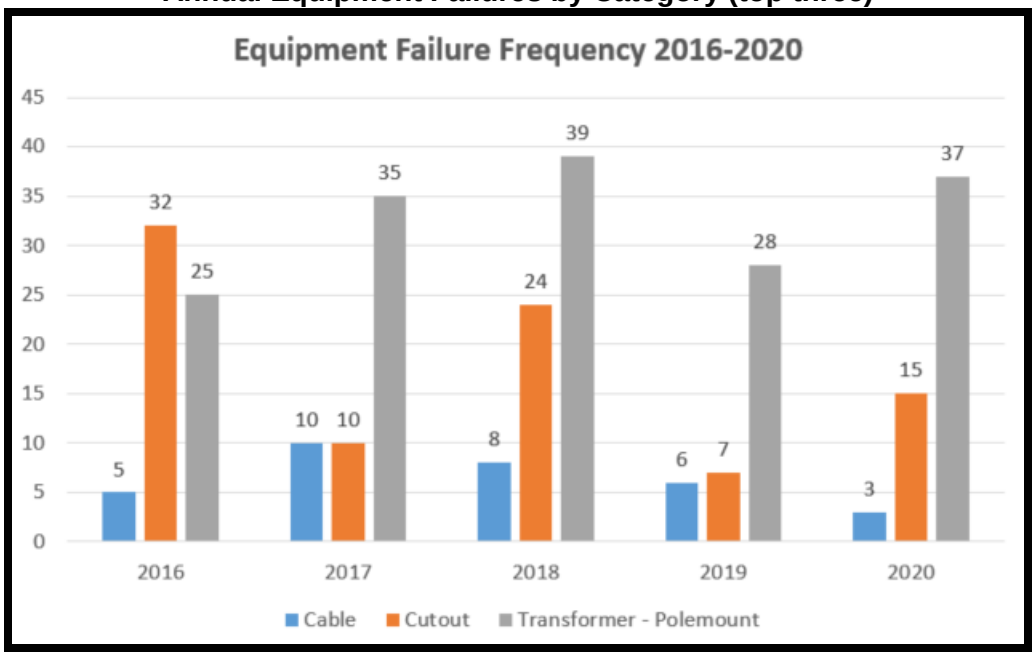


Chart 9
Annual Equipment Failures by Category (top three)



9 Multiple Device Operations and Streets with Highest Number of Outages

A summary of the devices that have operated three or more times from January 1, 2020 to December 31, 2020 is included in Table 14 below. Refer to section 11.6 for recommendations to address some of the areas identified that have experienced recurring outages in 2020.

A summary of the streets on the UES-Seacoast system that had customers with 7 or more non-exclusionary outages in 2020 is included in Table 15 below. The table is sorted by circuit and then the maximum number of outages seen by a single customer on that street.

Table 14
Multiple Device Operations

Circuit	Number of Operations	Device	Customer Minutes	Customer Interruptions	# of Times on List in Previous 4 Years
E13W1	4	Fuse, Pole 1, Crown Hill Rd, Atkinson	11,058	88	0
E22X1	4	Fuse, Pole 7, Sandown Rd, Danville	43,809	186	0
E15X1	4	Transformer Fuse, Pole 93, Lafayette Rd, Seabrook	3,067	28	0
E51X1	4	Recloser, Pole 63, Winnicut Rd, Stratham	292,589	2,268	0
E21W1	3	Fuse, Pole 2, Lisheen Dr, Atkinson	1,975	36	0
E21W2	3	Fuse, Pole 62, Maple Ave, Atkinson	49,716	225	0
E21W1	3	Recloser, Pole 4, Meditation Ln, Atkinson	178,008	1,900	0
E21W1	3	Fuse, Pole 1, Woodlawn Ave, Atkinson	10,762	75	0
E6W1	3	Recloser, Pole 2, South Rd, East Kingston	116,923	901	1
E43X1	3	Fuse, Pole 29, Willow Rd, East Kingston	196	3	0
E13W1	3	Transformer Fuse, Pole 8, Culver St, Plaistow	415	3	0
E13W1	3	Fuse, Pole 54, North Main St, Plaistow	38,501	366	1
E13X3	3	Fuse, Pole 11, Old County Rd, Plaistow	31,580	321	0

Table 15
Streets with the Highest Number of Outages

Circuit	Street	Max Number of Outages Seen by a Single Customer	Number of Times on List in Previous 4 Years
E15X1	Smiths Ln, Seabrook	9	0
E15X1	Pine St, Seabrook	7	1
E15X1	Ayer Cir, Seabrook	7	0
E59X1	Crank Rd, Hampton Falls	8	0
E51X1	Benjamin Rd, Stratham	7	0
E51X1	Spring Creek Ln, Stratham	7	0
E7W1	Ocean Dr, Seabrook	7	0

10 Recommendations

This following section describes recommendations on circuits, sub-transmission lines and substations to improve overall system reliability. The recommendations listed below will be compared to the other proposed reliability projects on a system-wide basis. A cost benefit analysis will determine the priority ranking of projects for the 2022 capital budget. All project costs are shown without general construction overheads.

10.1 Miscellaneous Circuit Improvements to Reduce Recurring Outages

10.1.1 Forestry Review

Table 13 of this report; Multiple Tree Related Outages by Street indicates that there were fourteen streets that experienced three or more tree related outages in 2020.

It is recommended that a forestry review of the areas identified in Table 13 be performed in 2021 in order to identify and address any growth or hazard tree problems.

10.2 Circuit 51X1 – Install Sectionalizers on Winnicutt Rd

10.2.1 Identified Concerns

Circuit 51X1 was the worst performing circuit in terms of SAIDI and the third worst performing circuit in terms of SAIFI in 2020. It has also been one of the 10 worst performing circuits in terms of both SAIFI and SAIDI for the Seacoast system in the past 5 years.

10.2.2 Recommendation

This project will consist of installing three cutouts and three cutout-mounted sectionalizers at Winnicutt Rd Pole 22.

Customer Exposure = 192 customers

The projected average annual savings for this project is 7,529 customer minutes of interruptions and 94 customer interruptions.

Estimated Project Cost: $15,000

10.3 Circuit 21W1 – Install FuseSaver on Main St

10.3.1 Identified Concerns

Circuit 21W1 was the second worst performing circuit in terms of SAIFI and the fourth worst performing circuit in terms of SAIDI in 2020. It has also been one of the 10 worst performing circuits in terms of both SAIFI and SAIDI for the Seacoast system in the past 5 years.

10.3.2 Recommendation

This project will consist of installing a Siemens FuseSaver at Main St, Atkinson Pole 96.

Customer Exposure = 64 customers

The projected average annual savings for this project is 740 customer minutes of interruptions and 9 customer interruptions.

Estimated Project Cost: $7,000

10.4 Circuit 21W1 – Install FuseSaver on East Rd

10.4.1 Identified Concerns

Circuit 21W1 was the second worst performing circuit in terms of SAIFI and the fourth worst performing circuit in terms of SAIDI in 2020. It has also been one of the 10 worst performing circuits in terms of both SAIFI and SAIDI for the Seacoast system in the past 5 years.

10.4.2 Recommendation

This project will consist of installing a Siemens FuseSaver at East Rd, Atkinson Pole 23 toward the Coventry Rd lateral tap.

Customer Exposure = 57 customers

The projected average annual savings for this project is 1,421 customer minutes of interruptions and 18 customer interruptions.

Estimated Project Cost: $7,000

10.5 Circuit 22X1 – Install FuseSavers on Sandown Rd

10.5.1 Identified Concerns

Circuit 22X1 was the ninth worst performing circuit in terms of SAIDI in 2020. It has also been one of the 10 worst performing circuits in terms of both SAIFI and SAIDI for the Seacoast system in the past 5 years. The fuses at Sandown Rd, Danville Pole 7 operated four times in 2020. Three of these operations were due to patrolled nothing found.

10.5.2 Recommendation

This project will consist of installing three Siemens FuseSavers at Sandown Rd, Danville Pole 7.

Customer Exposure = 71 customers

The projected average annual savings for this project is 927 customer minutes of interruptions and 11 customer interruptions.

Estimated Project Cost: $16,000

10.6 Circuits 15X1 and 59X1 – Install Reclosers and Implement Distribution Automation

10.6.1 Identified Concerns

Circuit 15X1 was the worst performing circuit in terms of SAIFI in 2020. It has also been one of the 10 worst performing circuits in terms of both SAIFI and SAIDI for the Seacoast system in the past 5 years.

10.6.2 Recommendation

This project will consist of installing two G&W Viper reclosers along circuit 15X1 and 59X1.

One of the reclosers will replace the solid blades at Stard Rd, Seabrook Pole 1. The 15X1J59X1-2 tie switch at Mill Rd Pole 31 will also be replaced with a recloser.

Once installed, a distribution automation scheme will be implemented between the new reclosers and the existing 15X1R1 recloser. The intent of the scheme is to have 15X1 and 59X1 automatically reconfigure for permanent faults on the mainline of either circuit.

- Fault between 15X1 and 15X1R1 – 15X1 and 15X1R1 lockout and 15X1J59X1-2 closes.
- Fault between 59X1 and new recloser at Stard Rd Pole 1 – 59X1 and new recloser lockout and 15X1J59X1-2 closes.

Customer Exposure = 1,222 customers

The projected average annual savings for this project is 148,156 customer minutes of interruptions and 1,465 customer interruptions.

Estimated Project Cost: $146,000

10.7 Circuit 6W2 – Install Recloser on Main St

10.7.1 Identified Concerns

Circuit 6W2 was the fourth worst performing circuit in terms of SAIFI and the fifth worst performing circuit in terms of SAIDI in 2020. It has also been one of the 10 worst performing circuits in terms of both SAIFI and SAIDI for the Seacoast system in the past 5 years.

10.7.2 Recommendation

This project will consist of replacing the fuses at Main St, Kingston Pole 75 with a G&W Viper recloser. It will also involve replacing the fuses at Main St Pole 82-2 with two sectionalizers and adding two fuses at Rockrimmon Rd Pole 19.

Customer Exposure = 662 customers

The projected average annual savings for this project is 22,495 customer minutes of interruptions and 273 customer interruptions.

Estimated Project Cost: $72,000

11 Conclusion

The annual electric service reliability of the UES-Seacoast system has seen trending improvement over the last ten years after discounting MEDs. 2019 was Seacoast's best year on record in regards to SAIDI and SAIFI. However, because 2019 was such an outstanding year, some level of regression could have been expected in 2020 due to mean reversion. In actuality, 2020 ended up being Seacoast's worst reliability year since 2012. Much of the overall improvement trend in reliability can be attributed to an aggressive vegetation management program; however, the most significant risk to reliability of the electric system continues to be vegetation.

The recommendations in this report focus on addressing equipment concerns as well as increasing the flexibility of the system to facilitate quicker restoration of customers that can be isolated from faulted sections of the system. This includes upgrading equipment and adding additional circuit sectionalizing points and protection where it will be most effective. This report is also intended to assist Unitil Forestry in identifying areas of the system that are being frequently affected by tree related outages to allow proactive measure to be taken.