THE STATE OF NEW HAMPSHIRE
BEFORE THE
PUBLIC UTILITIES COMMISSION

Unitil Energy Systems, Inc.

RELIABILITY PROGRAM AND VEGETATION MANAGEMENT PROGRAM ANNUAL REPORT – FISCAL YEAR 2018

1. Introduction

Pursuant to the Settlement Agreement approved by the New Hampshire Public Utilities Commission ("Commission") in Docket No. DE 10-055[1] , Unitil Energy Systems, Inc. ("UES" or "Company") is submitting the results of the Reliability Enhancement Plan ("REP") and Vegetation Management Plan ("VMP") for Fiscal Year 2018 ("FY 2018"), report the period, January 1, 2018 – December 31, 2018.

The Settlement Agreement provides that on or before the last day of February of each year following approval, Unitil will provide an annual report to the Commission, Staff and OCA showing actual REP and VMP activities and costs for the previous calendar year, and its planned activities and costs for the current calendar year. Actual and planned REP and VMP costs shown in the report will be reconciled along with the revenue requirements associated with the actual and planned capital additions and expenses. This report includes the following information:

(A) A description of Unitil's VMP;
(B) A comparison of FY2018 actual to budgeted spending on O&M activities related to the VMP
(C) Detail on the O&M spending related to the FY2019 VMP estimated expenditures and work to be completed;
(D) A summary of the reliability performance tracking for pruning, hazard tree and storm pilot program components;
(E) A summary of the Vegetation Management Storm Hardening Pilot Program results;
(F) Detail on the O&M spending related to Exacter Inspection survey;
(G) Detail on the O&M spending related to Enhanced Tree Trimming;
(H) Detail on the reliability capital spending for 2017 and 2018 budget; and

[1] Order 25,214 dated April 26, 2011

(I) Reliability performance of the UES Capital and UES Seacoast systems.

2. Vegetation Management Plan

The VMP is based upon the recommended program provided in the report of Unitil's consultant Environmental Consultants, Inc. ("ECI")[2], modified to incorporate a 5-year prune cycle with 10-foot side and 15-foot top prune zones.

2.1. Plan Description

Unitil's VMP is comprised of five components; 1) circuit pruning; 2) hazard tree mitigation; 3) mid-cycle review; 4) forestry reliability assessment; and 5) storm resiliency work. This program is designed to support favorable reliability performance, reduce damage to lines and equipment, as well as provide a measure of public safety. The main benefits and risks addressed by these programs are reliability, regulatory, efficiency, safety and customer satisfaction.

2.1.1.Circuit Pruning

Vegetation maintenance pruning is done on a cyclical schedule by circuit. The optimal cycle length was calculated by balancing five important aspects: 1) clearance to be created at time of pruning; 2) growth rates of predominant species; 3) risk to system performance; 4) aesthetics / public acceptance of pruning; and 5) cost to implement. For New Hampshire, this optimal cycle length was calculated as 5 years for all lines.

2.1.2.Hazard Tree Mitigation

The Hazard Tree Mitigation program ("HTM") consolidates tree removal activities into a formalized program with risk tree assessment. This program is aimed at developing a more resistant electrical system that is more resilient under the impacts of typical wind, rain and snow events. The intention is to accomplish this through minimizing the incidence and resulting damage of large tree and limb failures from above and alongside the conductors through removal of biologically unhealthy or structurally unstable trees and limbs.

[2]A copy of the ECI reliability report, originally provided in response to data request Staff 1-29 (Confidential), was made part of the record in DE 10-055, UES's 2010 base rate case, as a Confidential Exhibit, accompanied by a public redacted version, during the hearing before the Commission.

HTM circuits are identified and prioritized through reliability assessment risk ranking, identification as a worst performing circuit, field problem identification, and time since last worked. Once circuits are identified they are scheduled in two ways: 1) while the circuit is undergoing cycle pruning; or 2) scheduled independently of cycle pruning. In New Hampshire, HTM circuit selection corresponds closely with cycle pruning, as both pruning and HTM are on a 5 year cycle.

In order to produce the greatest reliability impact quickly and cost effectively, HTM circuit hazard tree assessment and removal is focused primarily on the three phase only, with most emphasis on the portion of the circuit from the substation to the first protection device. In circuits that have undergone storm resiliency work, the HTM focus also includes single phase circuitry.

2.1.3.Mid-Cycle Review

The mid-cycle review program targets circuits for inspection and pruning based on time since last circuit pruning and forecasted next circuit pruning. The aim of this program is to address the fastest growing tree species that will grow into the conductors prior to the next cyclic pruning, potentially causing reliability, restoration and safety issues. As the first full circuit pruning cycle is underway, mid-cycle review will be used to address only 13.8kV and above, three-phase portions of selected circuits. Circuit selection is based on number of years since last prune and field assessment.

2.1.4.Forestry Reliability Assessment

The Forestry Reliability Assessment program targets circuits for inspection, pruning, and hazard tree removal based on recent historic reliability performance. The goal of this program is to allow reactive flexibly to address immediate reliability issues not addressed by the scheduled maintenance programs. Using recent historic interruption data, poor performing circuits are selected for analysis of tree related interruptions. Circuits or portions of circuits showing a high number of tree related events per mile, customers interrupted per event, and/or customer minutes interrupted per event are selected for field assessment. After field assessment, suitable circuits are scheduled and a forestry work prescription is written for selected circuits or areas.

2.1.5. Storm Resiliency Work

The SRP targets critical sections of circuits for tree exposure reduction by removing all overhanging vegetation or pruning "ground to sky", as well as performing intensive hazard tree review and removal along these critical sections and the remaining three phase of the circuit. The goal of this program is to reduce tree related incidents and resulting customers interrupted along these portions in minor and major weather events. In turn, the aim is to reduce the overall cost of storm preparation and response, and improve restoration.

2.2. 2018 Actual Expenditures and Work Completed

Table 1 depicts the 2018 VMP expenditures by activity in relation to the anticipated budget expenditures. As the program progressed in 2018, there were some deviations in the anticipated expenditures. In the VMP spending, the Cycle Pruning and the Police/Flagging work activities had the most deviation in spending relative to anticipated costs. Cycle Pruning had spending above anticipated levels by $131,765, while Police/Flagging work activity was $124,549 less than anticipated. As shown in the table below, the Program Total was right on budget, at only $10,161 under budget with only minor work carryover (hazard tree) into 2019 due to vendor delays from workforce availability. The work spending for the SRP was well below the anticipated level. Unfortunately, even with all the work planning completed on-time, multiple circuits will carry over into 2019 because of the unavailability of vendors to complete the work. This was due to a lack of workforce available to perform the work, a growing concern for the region. As shown in the table below, total spending for all VMP and SRP components was below the budget by $457,364.

Table 1

2018 VMP O&M Activities		
VM Activity	**2018 Cost Proposal**	**2018 Actual Cost**
Cycle Prune	$ 1,163,894	$ 1,295,659
Hazard Tree Mitigation	$ 800,000	$ 780,697
Forestry Reliability Work	$ 24,857	$ 22,475
Mid-Cycle Review	$ 112,000	$ 124,275
Police / Flagger	$ 573,600	$ 449,051
Core Work	$ 150,000	$ 198,324
VMP Planning	$ -	$ -
Distribution Total	**$ 2,824,351**	**$ 2,870,480**
Sub-T	$ 626,521	$ 572,832
Substation Spraying	$ 10,700	$ 10,172
VM Staff	$ 314,657	$ 312,494
Program Total	**$ 3,776,139**	**$ 3,765,978**
Storm Resiliency Program	$ 1,423,000	$ 975,797
Grand Total	**$ 5,199,139**	**$ 4,741,775**

The following tables detail the 2018 VMP work completed by activity. Table 2 details the cycle pruning work. A total of 216.4 miles of cycle pruning was completed in 2018.

Table 2

2018 VMP Planned Cycle Pruning Details				
District	**Feeder**	**Overhead Miles**	**Scheduled Miles**	**Completed Miles**
Capital	C13W2	18.0	18.0	18.0
Capital	C13W3	82.7	69.3	69.3
Capital	C24H1	2	2	2
Capital	C24H2	2	2	2
Capital	C33X4	2	2	2
Capital	C34X4	0.2	0.2	0.2
Seacoast	E13W2	29.0	29.0	29.0
Seacoast	E13X3	3.9	3.9	3.9
Seacoast	E56X2	2.4	2.4	2.4
Seacoast	E58X1	31.0	31.0	31.0
Seacoast	E5H1	2.4	2.4	2.4
Seacoast	E5H2	4.9	4.9	4.9
Seacoast	E5X3	2.2	2.2	2.2
Seacoast	E15X1	9.7	9.7	9.7
Seacoast	E17X1	8.9	8.9	8.9
Seacoast	E17W2	4.8	4.8	4.8
Seacoast	E2H1	2.3	2.3	2.3
Seacoast	E27X1	16.1	14.1	14.1
Seacoast	E27X2	8.7	7.3	7.3
Total			**216.4**	**216.4**

Table 3 details the hazard tree mitigation work. A total of 111.4 miles of line across 23 circuits were mitigated for hazard tree risk. Unitil had estimated approximately 2,229 hazard tree removals in the budget. The actual results indicate 2,156 total hazard trees were removed on these circuits and various other circuits as found through the course of work over the year.

Table 3

2018 VMP Completed Hazard Tree Mitigation Details

District	Feeder	Overhead Miles	Scheduled Miles	Completed Miles	# of Removals
Capital	C4X1	23.7	16.1	16.1	141
Capital	C8X3	105.5	8.9	8.9	390
Capital	C15W1	16.8	8.2	8.2	122
Capital	C15W2	5.8	4.4	4.4	36
Capital	C7W3	23.2	14.8	14.8	275
Capital	C13W2	18.0	3.7	3.7	167
Capital	C24H1	2.0	1.0	0.3	2*
Capital	C24H2	2.0	1.6	0.3	1*
Capital	C33X4	2.0	0.1	0.1	17
Capital	*Various*				202
Seacoast	E54X1	21.5	3.0	3.0	55
Seacoast	E22X1	51.1	11.9	11.9	119
Seacoast	E23X1	23.8	6.9	6.9	187
Seacoast	E6W1	27.0	10.7	10.7	93
Seacoast	E6W2	19.2	7.2	5.0	15*
Seacoast	E13W2	29.0	10.7	7.7	50*
Seacoast	E13X3	3.9	2.5	2.5	5
Seacoast	E56X2	2.4	2.1	0.5	16*
Seacoast	E58X1	31.0	7.8	1.5	22*
Seacoast	E5H1	2.4	0.7	0.7	3
Seacoast	E5H2	4.9	2.6	2.6	7
Seacoast	E5X3	2.2	0.6	0.6	4
Seacoast	E15X1	9.7	6.3	0.5	8*
Seacoast	E17X1	8.9	3.5	0	0*
Seacoast	E17W2	4.8	2.0	0.5	7*
Seacoast	E2H1	2.3	1.4	0	0*
Seacoast	*Various*				212
Total			**138.5**	**111.4**	**2,156**

* All hazard trees identified, marked, and approved for removal but not yet completed in the field – removals to carry over to 2019

Tables 4 and 5 detail the forestry reliability work and mid-cycle work respectively. A total of 7.7 miles of line underwent forestry reliability work and 65.6 miles of line were completed for mid-cycle work.

Table 4

2018 VMP Completed Reliability Analysis Details				
District	**Feeder**	**Overhead Miles**	**Scheduled Miles**	**Completed Miles**
Capital	C15W1	16.8	3.6	3.6
Capital	C13W1	33.6	1.3	1.3
Capital	C4W4	13.3	1.1	1.1
Capital	C4W3	18.6	1.7	1.7
Total			**7.7**	**7.7**

Table 5

2018 VMP Completed Mid-Cycle Review Details				
District	**Feeder**	**Overhead Miles**	**Scheduled Miles**	**Completed Miles**
Capital	C4X1	23.7	7.6	7.6
Capital	C7W4	7.4	4.2	4.2
Capital	C8H2	4.6	2.8	2.8
Capital	C8X5	7.4	6.8	6.8
Capital	C15W2	5.8	4.4	4.4
Capital	C7W3	23.2	14.8	14.8
Seacoast	E22X1	51.1	25.0	25.0
Total			**65.6**	**65.6**

Table 6 details the sub-transmission right-of-way clearing work. A total of 17.7 linear miles of right-of-way floor were cleared.

Table 6

2018 Sub Transmission Clearing Details			
District	**Feeder**	**Scheduled Miles**	**Completed Miles**
Capital	35	4.4	4.4
Capital	34	2.3	2.3
Seacoast	3358	1.1	1.1
Seacoast	3343/3354	9.9	9.9
Total		**17.7**	**17.7**

Additionally, the sub-transmission right-of-way that was cleared in both Capital and Seacoast in 2017 underwent the integrated vegetation management (IVM) program's low-volume foliar herbicide application work in 2018. A total of approximately 141 acres were managed with IVM chemical control.

2.3. 2019 VMP Estimated Expenditures and Work To Be Completed

Table 7 depicts the 2019 VMP expenditures by activity and the proposed VMP activity details. Unitil proposes to spend $3,764,417 on VMP activities and another $1,690,556 on vegetation storm resiliency, explained in more detail below, for a total of $5,454,973.

Table 7

2019 VMP O&M Activities Cost Proposal		
VM Activity		**2018 Cost Proposal**
Cycle Prune	$	1,163,000
Hazard Tree Mitigation	$	800,000
Forestry Reliability Work	$	24,857
Mid-Cycle Review	$	112,000
Brush Control	$	-
Police / Flagger	$	557,000
Core Work	$	150,000
Distribution Total	**$**	**2,807,751**
Sub-T	$	626,521
Substation Spraying	$	10,700
VM Staff	$	322,876
Program Total	**$**	**3,764,417**
Storm Resiliency Program (SRP)	$	1,690,556
Grand Total	**$**	**5,454,973**

Tables 8 through 12 provide more detail on each of the VMP activities planned for 2019. The activities include 225 miles of cycle pruning (Table 8), 128.3 miles of hazard tree mitigation (Table 9) which estimates 2,225 hazard tree removals, 7.4 miles of forestry reliability work (Table 10), 59.8 miles of mid-cycle pruning (Table 11), and 18.1 miles of sub-transmission clearing.

Table 8

2019 VMP Planned Cycle Pruning Details			
District	**Feeder**	**Overhead Miles**	**Scheduled Miles**
Capital	C13W1	33.6	33.6
Capital	C22W1	4.4	4.4
Capital	C22W2	0.9	0.9
Capital	C38	8.3	8.3
Capital	C4W4	14.3	14.3
Capital	C4X1	24.0	24.0
Capital	C7W4	7.4	7.4
Capital	C8H1	1.2	1.2
Capital	C8H2	4.6	4.6
Capital	C8X5	7.4	7.4
Seacoast	E13W1	18.5	18.5
Seacoast	E18X1	18.4	14.7
Seacoast	E19H1	4.7	4.7
Seacoast	E21W1	29.7	29.7
Seacoast	E21W2	21.6	21.6
Seacoast	E47X1	14.7	14.7
Seacoast	E7X2	19.3	15.0
Total			**225**

Table 9

2019 VMP Planned Hazard Tree Mitigation Details			
District	**Feeder**	**Overhead Miles**	**Scheduled Miles**
Capital	C24H1	2.0	0.7*
Capital	C24H2	2.0	1.3*
Capital	C18W2	34.0	5.0
Capital	C6X3	15.2	4.7
Capital	C37X1	6.8	1.2
Capital	C4W3	18.6	7.5
Capital	C13W1	33.6	6.2
Capital	C4W4	14.3	4.0
Capital	C4X1	24.0	7.9
Seacoast	E6W2	19.2	2.2*
Seacoast	E13W2	29.0	3.0*
Seacoast	E56X2	2.4	1.6*
Seacoast	E58X1	31.0	6.3*
Seacoast	E15X1	9.7	5.8*
Seacoast	E17X1	8.9	3.5*
Seacoast	E17W2	4.8	1.5*
Seacoast	E2H1	2.3	1.4*
Seacoast	E19X3	38.7	16.0
Seacoast	E43X1	30.8	7.8
Seacoast	E51X1	30.1	10.3

Seacoast	E59X1	15.4	7.3
Seacoast	E13W1	18.5	4.7
Seacoast	E21W1	29.7	9.9
Seacoast	E21W2	21.6	8.5
Total			**128.3**

*carry-over

Table 10

2019 VMP Planned Reliability Analysis Details			
District	**Feeder**	**Overhead Miles**	**Scheduled Miles**
Capital	C22W3	40.1	2.7
Capital	C8X3	105.8	4.7
Total			**7.4**

Table 11

2019 VMP Planned Mid-Cycle Review Details			
District	**Feeder**	**Overhead Miles**	**Scheduled Miles**
Capital	C18W2	34.0	5.0
Capital	C37X1	6.8	1.2
Capital	C4W3	18.6	7.5
Capital	C6X3	15.2	4.7
Seacoast	E19X3	38.7	16.0
Seacoast	E43X1	30.8	7.8
Seacoast	E51X1	30.1	10.3
Seacoast	E59X1	15.4	7.3
Total			**59.8**

Table 12

2019 Sub Transmission Planned Clearing Details		
District	**Feeder**	**Scheduled Miles**
Capital	37	4.1
Capital	34/36	2.2
Seacoast	3359	7.5
Seacoast	3348/3350	4.3
Total		**18.1**

2.4. 2018 Vegetation Management Storm Resiliency Program Results

In 2018, Unitil continued the SRP, targeting the resiliency efforts in communities in the Seacoast area. This program, now through its seventh year, has been very successful. As in previous program years, the 2018 circuits were selected through analysis of tree related reliability performance. The 2018

circuits are shown below in Table 13. In 2018, 33.5 miles of critical three phase line were worked planned for hazard tree removals and ground-to-sky pruning, but only 14.4 miles were mitigated by year end with 1,875 hazard trees were removed along these portions of line.

Table 13

2018 Storm Program Work Details			
Circuit	**Scheduled Miles**	**Completed Miles**	**# of Removals**
E6W1	5.8	5.8	1,103
E6W2	4.9	4.9	375
E23X1	10.1	0*	0
E27X1	4.7	2.3*	205
E27X2	1.4	1.4	192
E7X2	6.6	0*	0
Total	**33.5**	**14.4**	**1,875**

* carry-over

Even though work planning and hazard tree identification were done on these circuits, work was not able to be completed by year-end. Due to workforce restrictions in the region, bidder interest in the program work was low. After discussing possible alternatives and work schedules with qualified vendors, the Company had no alternative but to choose a vendor that could complete the most amount of work in 2018 and carry some work over into 2019. Those circuits carrying over into 2019 are marked with an asterisk in the table above. For this reason, total expenditures for the SRP program were below the estimated budget with final expenditures totaling $975,797 which is $447,203 under the $1,423,000 budget estimate.

Again in 2018, Unitil continued tree growth regulator application, an additional measure to improve the health of the adjacent trees along the overhead electric line corridor. Trees remaining and being pruned were treated with the tree growth regulator chemical in order to reduce the resulting tree growth after pruning and positively affect the tree's health. The Cambistat tree growth regulator treatment creates other plant growth effects that are beneficial for tree health including increased root density, improved drought and heat resistance, and higher tolerance to insects and diseases.[3] 1,000 trees along the 2018 SRP corridor were treated with the tree growth regulator.

[3] 2014 Rainbow Treecare Scientific Advancements, Cambistat Customer Literature

Due to the varying nature of storm resiliency work and traffic control, as well as the lack of workforce availability, the Company expects costs may continue to experience minor variances, with final annual costs being slightly above or below the estimated budget. Even with yearly fluctuations, the average cost for the SRP program has remained close to the original estimate.

The Company did experience an elevated number of major storms again in 2018, compared to the absence of major storms seen in 2016. The largest tree related event was the March 7th through 9th nor'easter event. The Company believes that the SRP program contributed significantly to the swift restoration times and shortened duration of the event. It is evident from these most recent results, the October 2017 wind event, the results of the 2015 Plaistow microburst, the 2014 Thanksgiving storm, and favorable results of the 2012 and 2013 storm resiliency pilot circuits over the last seven years, that the Storm Resiliency work has the ability to and was successful at preventing tree related failures and subsequent electric incidents. This reduction in incidents reduces damage to the electric infrastructure and the need for crews to respond, which reduces the overall storm costs and expedites the restoration.

2.5. 2019 Vegetation Management Storm Resiliency Program Planned

For 2019, storm resiliency work on 40 miles of line in the Seacoast service area is proposed, at a total cost of $1,690,556. This total is the $267,556 required to complete the remaining 9 miles of carry-over work, plus the $1,423,000 annual planned for the 31 miles designated for 2019. These planned circuits, shown in Table 14 (a), were chosen for their recent historic reliability performance, number of customers served, field conditions, and location.

Table 14 (a)

2019 SRP Planned Work Details		
Circuit	**Overhead Miles**	**Scheduled Miles**
E27X1	16.1	2.4*
E7X2	19.2	6.6*
E23X1	23.8	10.1
E59X1	15.4	7.3
E11X1	11.9	4.3
E18X1	18.4	9.3
Total		**40.0**

*** carry-over**

The Company is hopeful that due to the carry over work, there will be no lag in work implementation and a reduced effect of workforce issues to the SRP program. Ideally, crews can transition from completing the 2018 carry-over work to the 2019 work and have the capacity to complete the carry-over plus the normal 2019 SRP amount.

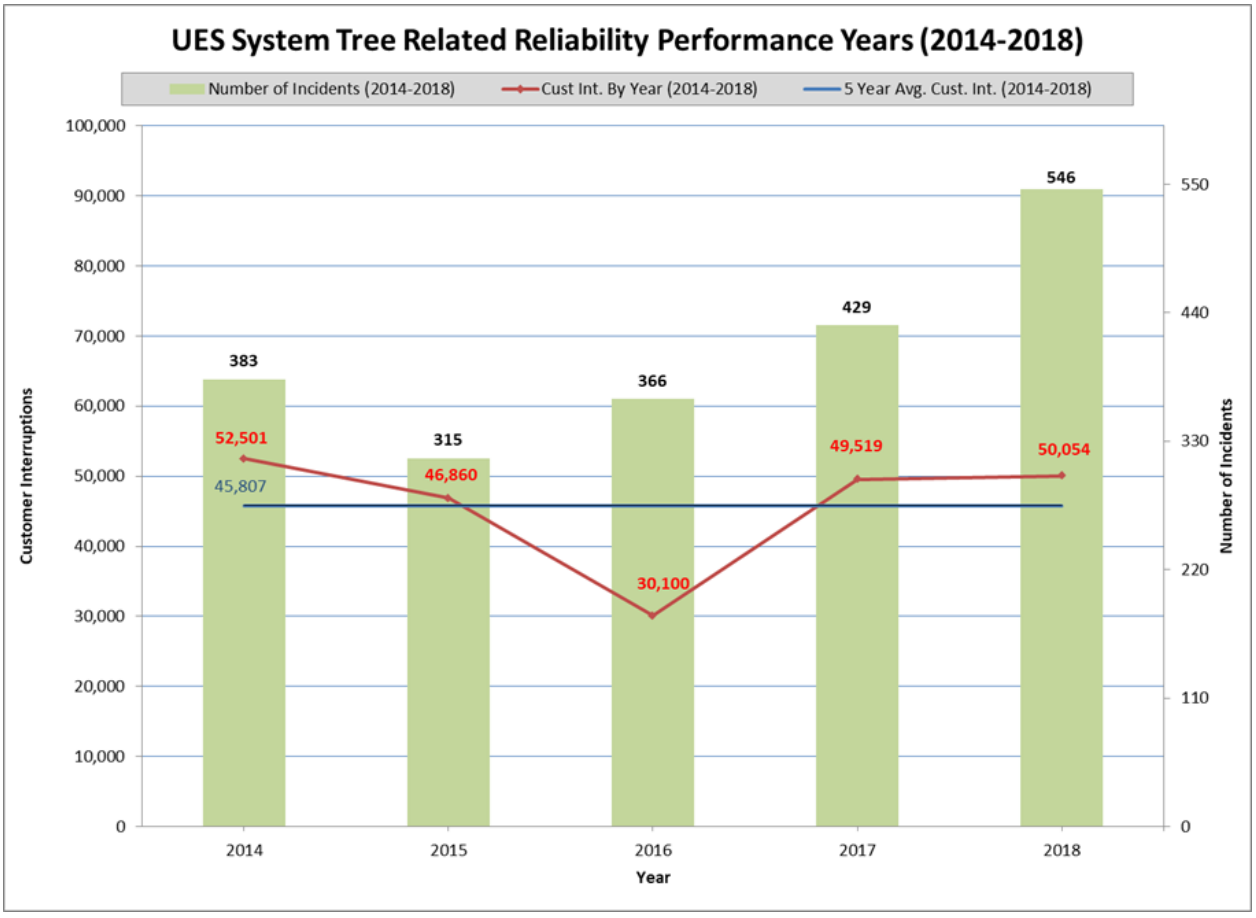
1.1. 2.6 Vegetation Management Reliability Performance Tracking

As the VMP progresses through its second five-year prune and hazard tree cycle, the effects of these programs on reliability have been shown over the last few years. The overall New Hampshire system tree related reliability performance was reviewed. Chart 1, shown below, displays the number of tree related incidents per year as well as the number of customers interrupted from tree related incidents from 2014 to 2018 against the 5 year average of tree related incidents during the same time period. The data used for this comparison excludes all major storm events identified by the NH PUC definition of a major storm in effect prior to 2015. The data for 2015 through 2018 uses IEEE 1366 methodology for identifying major event days. There were no major event days during 2015 and 2016 that excluded tree related interruptions. In 2017 there were 6 events that met the criteria for a major event day. In 2018 there were

3 events that met the criteria for a major event day. They can be seen in more detail in Section 4.2 "Summary of 2018 Performance".

Related to the obvious declining trend in tree related outages demonstrated from 2014 to 2016, Chart 1 shows a slight declining trend in customers interrupted from 2014 through 2018, even though the customers interrupted rose slightly from 2017 to 2018. This can be seen in the five year average , which declined from 54,236 in 2016 to 46,705 in 2017 and to 45,807 in 2018. The fluctuation in number of outages can be attributed to the increased weather events in 2017 and 2018. While trees are dynamic and susceptible to damage, drought, disease and other sources of decline, tree related outages will always fluctuate on the system. The VM program has the largest influence on the effect of tree related outages on the system, shown in the relationship between the number of tree related events and the customers interrupted. The fact that the number of incidents rose to its highest level in five years, but the number of customers interrupted stayed near the five year average indicates that the VM program is producing positive results. This can be seen by looking at the total customers interrupted per event. In 2018, the customers interrupted per event was 91.67 CI/ Event while the average of the CI/Event for 2014 to 2017 was greater at 120.87 CI/Event. While tree related outages are still occurring, they are occurring in areas that do not affect the largest amount of people, and events on the mainline, where most people are affected, are decreasing.

Chart 1


UES System Tree Related Reliability Performance Years (2014-2018)
Number of Incidents (2014-2018)
Cust Int. By Year (2014-2018)
5 Year Avg. Cust. Int. (2014-2018)
Customer Interruptions
Number of Incidents
Year
2014
2015
2016
2017
2018
383
315
366
429
546
52,501
46,860
30,100
49,519
50,054
45,807
100,000
90,000
80,000
70,000
60,000
50,000
40,000
30,000
20,000
10,000
0
550
440
330
220
110
0

2. Reliability Planning and Performance

The Company approved total spending of $2,355,966 in the 2018 annual budget on capital reliability projects and $300,000 in reliability O&M expenditures.

The Reliability Program covers capital and O&M activities and projects intended to maintain or improve the reliability of the electric system including: (1) system hardening measures, i.e., equipment upgrades; installation of additional fuses, sectionalizers and reclosers; SCADA and automation projects; improvements to lightning protection; installation of animal guards; and other activities to mitigate the specific causes of outages; and (2) reliability-based inspections and maintenance, which will include enhanced inspection methods to detect and mitigate outage causes before they occur, including surveys using new or improved technology such as thermography (IR) and radiofrequency (RF) sensor technology to identify and mitigate failing electrical equipment, as well as software applications to better manage inspection, maintenance, and reliability programs and data.

2.1. Annual Studies

Each year the Company completes an annual distribution planning study and reliability study in each of the operation areas. Both of these studies incorporate analysis to improved system reliability.

2.1.1. Distribution Planning Study

The Company conducts distribution planning studies on an annual basis. The purpose of this study is to identify when system load growth is likely to cause main elements of the distribution system to reach their operating limits, and to preliabilityare plans for the most cost-effective system improvements.

Circuit analysis provides the basis for the distribution planning study. Circuit analysis is completed on a three year rotating cycle with the objective to review one-third of the entire system each year. The Milsoft WindMil software application is used to perform circuit analysis to identify potential problem areas and to evaluate available alternatives for system improvements. Circuit analysis includes the following: 1) update of circuit model from GIS; 2) circuit diagnostics; 3) load allocation; 4) voltage drop and overload analysis; 5) fault current and protection device coordination analysis. Engineering work requests are initiated for any apparent miscoordination identified during this analysis.

In addition to the fuse coordination completed as part of circuit analysis, the Company reviews trouble interruption reliabilityorts on a daily basis. Any outage in which the fuse did not appear to

operate correctly is further analyzed to determine the cause. Engineering Work Requests are issued to implement upgrades or changes on the system identified by the circuit analysis or an evaluation of an outage.

2.1.2.Reliability Studies

Each year, Unitil completes annual reliability studies for each of its operating areas. The purpose of these studies is to reporton the overall reliability performance of the electric systems from January 1 through December 31 of the previous year (12 months total). The scope of this report also evaluates substation, subtransmission (34.5kV system generally off road and serving one or more substations or circuit taps) and individual circuit reliability performance over the same time period. The analysis also identifies common trends or themes based upon type of outage (i.e. tree, equipment failure, etc.). The Annual Reliability Analysis and Recommendations report for the UES Capital Operating Area and UES Seacoast Operating Area are attached to this report as Attachment 2 and Attachment 3 respectively.

The recommendations provided in the study are focused on improving the worst performing circuits as well as the overall system reliability. These recommendations are provided for budget consideration and will be further developed with the intention of incorporation into the capital budget development process.

There are several common solutions which can improve reliability depending upon the circumstance: 1) installation of reclosers or sectionalizers; 2) addition of fusing locations; 3) tree trimming; 4) installation of tree wire or spacer cable; and 5) implementation of automatic restoration schemes. These solutions are recommended most commonly; however, other solutions are also recommended for specific situations.

2.2. Reliability O&M Expenditures

The Company has allocated $300,000 to Reliability O&M expenditures, split between reliability centered maintenance and inspection and enhanced tree trimming. The Enhanced Tree Trimming funding of $80,000 is intended to target “problem” areas identified through engineering analysis, while $220,000 is allocated to the Exacter® inspection program.

The Company recently completed a review of equipment failure trends since the inception of the Exactor® inspection program. Because this analysis has not demonstrated improved outage performance with respect to failed equipment, the Company will discontinue this inspection program in 2019 and

beyond. Instead, the $300,000 Reliability O&M expeditures will be spent entirely on enhanced tree trimming. The Company will continue to evaluate alternmative inspection technologies and may introduce a new program at some time in the future.

Table 15 below lists the amount of operation and maintenance expenditures budgeted for 2019 and past five years on Enhanced Tree Trimming and reliability centered inspection and maintenance programs.

Table 15

Reliability O&M Category	**Budgeted Spending Amounts**					
	2014	**2015**	**2016**	**2017**	**2018**	**2019**
Enhanced Tree Trimming	$200,000	$80,000	$80,000	$80,000	$80,000	$300,000
Reliability Inspection and Maintenance	$ 100,000	$220,000	$220,000	$220,000	$220,000	$0
Totals	$300,000	$300,000	$300,000	$300,000	$300,000	$300,000

2.2.1. Enhanced Tree Trimming

Each year, the Company completes reliability analysis on the distribution and subtransmission system. The reliability analysis identifies areas of the system which have experienced an abnormal or increasing amount of tree related outages in the previous year. Distribution Engineering provides the System Arborist a prioritized list of recommended subtransmission lines and/or distribution circuits which would benefit the most from enhanced tree trimming.

In 2018, Distribution Engineering recommended the sub-transmission 3346 and 3347 lines in the UES – Seacoat area to receive enhanced tree trimming. In total, $94,883 was spent on Enhanced Tree Trimming. On these lines, 240 hazard tree removals were completed along with sideline clearing on selected portions. In addition to this enhanced tree trimming, the Company also collecting imagery and LiDAR for a small portion of the distribution system in order to pilot a reliability enchancemnet solution which would more accurately determine areas that have the potential to cause outages and should be pruned in 2019.

For 2019, Distribution Engineering is recommending a thorough review of all sub-transmission lines that experienced a tree related outage in 2018 and enhanced tree trimming/ hazard tree removal

and/or ROW widening be performed on these lines, where appropriate. The work is budgeted not to exceed $300,000 in 2019.

2.2.2. Reliability Inspection and Maintenance

In 2018, Unitil continued to inspect our distribution facilities utilizing Exacter® technology as described in the Unitil Energy Systems, Inc. Reliability Enhancement Program and Vegetation Management Report 2013. The scope of the 2018 program included Davey Resource Group performing field survey work and analysis, and providing the company with a report of their findings. In 2018, the Company spent $220,000 in O&M expenditures and $80,778 in capital dollars to replace equipment identified by the survey as possibly failing in the near future.

As described in the previous section, Unitil has decided to discontinue this inspection program and will begin evaluating alternative technologies for possible implementation in future years.

2.2.2.1. Exacter Overview

As explained in our initial 2013 reliability report, Exacter® technology is deployed by electric utilities to locate overhead distribution equipment showing signs of degradation and possible failure, thereby increasing overall system reliability by preventing failures before they occur.

2.2.2.2. Project Overview and Results

Unitil continued the inspection and survey program and completed a survey of all our overhead, three-phase circuitry, or a total of 419 pole miles of line, as well as a small portion of single-phase circuitry serving large numbers of customers. We believe this methodology provides the greatest impact to customers as a failure of equipment along these circuits would affect the greatest amount of customers and therefore have the greatest impact on system reliability, i.e. SAIDI.

The circuit survey performed in 2018 identified 108 pieces of equipment that displayed the immanent failure signature and required reliabilityair or reliabilitylacement. As was the case in prior years, the types of facilities identified included transformers, insulators, lightning arrestors, bushings, and cutouts.

Utilizing Unitil's Outage Management System (OMS) which details customer counts and protective devices, we are able to develop potential system reliability impacts. The 2018 program

identified a reliability repair every 3.9 miles, and an average of 568 customers impacted by each failure event if it occurred. The estimated number of customers impacted by potential failures of all identified locations is 61,313. The estimated customer minutes of interruption would be 5,267,660, calculated using 2018 customer counts. The total opportunity for avoided system SAIDI is 67.9 minutes, which represents 48.5% of UES' most recent 10-year average annual SAIDI of 140.0 minutes.

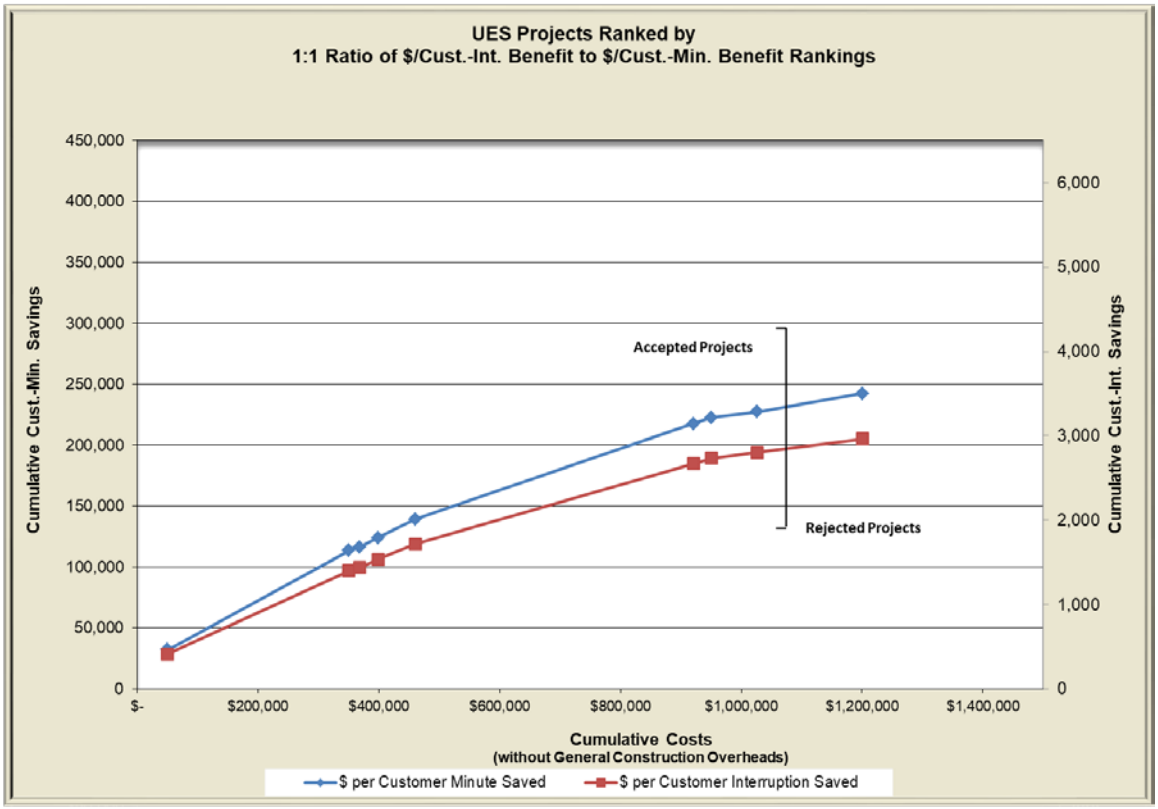
2.3. Reliability Capital Expenditures

As described in section 3.1.2 above, in addition to the annual pole inspection and replacement program, each year Unitil completes annual reliability studies for each of its operating areas. The recommendations provided in the study are focused on improving the worst performing circuits, as well as the overall system reliability. These reliability projects count for the majority or all of the "System Hardening/Reliability" spending for each year.

The reliability projects recommended for the budget include a project scope, construction cost estimate and estimated reliability improvements (annualized saved customer minutes and saved customer interruptions). All of the recommended projects are ranked against each other based upon two cost benefit comparisons (cost per saved customer minute and cost per saved customer interruption).

An overall project rank is derived from the sum of these two cost benefit rankings. In general, projects with low construction cost and high saved customer minutes or high saved customer interruptions are ranked highest on the list while those projects with high construction cost and low saved customer minutes or saved customer interruptions are ranked low on the list. Another way these projects are analyzed by Distribution Engineering is shown in Chart 2 below. This chart displays the cumulative project cost compared to the anticipated reliability benefits of all projects. Each data point pair reliabilityresents a specific project and its associated reliability benefits (saved customer minutes and saved customer interruptions). This chart is used to compare the relative return of reliability benefits associated with project cost between all projects. The projects to the left of the cutoff line are those that are entered into the annual Capital Budget for approval. Those to the right have been rejected.

Chart 2



The reliability projects for 2098 presented in Table 16 below provide an illustration of the process used to identify reliability projects. Table 16 is a listing of reliability projects recommended by Distribution Engineering as part of the 2018 annual reliability studies for the UES system which have been accepted into the 2019 Capital Budget. This project-listing details the overall project ranking, scope, cost, and anticipated reliability benefits.

Table 16

Project Ranking	Budget No.	Description	Project Cost	Cumulative Cost	Customer Interruptions Saved Annually	Customer Minutes Saved Annually
1	**DRBC01**	**Animal Protection**	**$50,000**	**$50,000**	**412**	**32,241**
2	**DRBE06**	**19X2 DA**	**$199,086**	**$349,984**	**992**	**81,473**
3	**DRBE05**	**13W1 FuseSaver**	**$9,009**	**$368,351**	**35**	**2,840**
4	**DRBE04**	**17W2 - Little River Rd**	**$30,000**	**$398,351**	**95**	**7,687**
5	**DRBC03**	**396X1 Tap Recloser**	**$62,404**	**$460,755**	**186**	**15,272**
6	**DRBE01**	**43X1 Reconductor Willow Rd**	**$450,000**[4]	**$920,788**	**950**	**78,052**
7	**DRBE03**	**17W1 Install Devices N. Shore Rd**	**$30,000**	**$950,788**	**63**	**5,153**
8	**DRBC02**	**18W2 Recloser South**	**$47,368**	**$1,026,343**	**71**	**4,616**
PROPOSED NH RELIABILITY PROJECTS			$877,867		2,840	227,334

Recommended 2019 Reliability Based Projects

Note the project list in the table above has been sorted by project rank in ascending order beginning with the project having the best composite cost benefit ranking. This list is used by Distribution Engineering as a guide for recommending projects to be included in the Capital Budget as reliability projects. The projects listed above are those projects that were accepted into the 2019 capital budget. However, it should be noted other projects were identified in the annual reliability analysis and were not accepted in the Capital Budget as providing adequate reliability compared to the cost. The Capital Budget process approves the amount of spending for reliability projects and allows for changes of projects, if it is later determined that there are better or more practical projects.

2.3.1. 2018 Actual Reliability Expenditures

[4] Total Project Cost – 2019/20

The capital expenditures of reliability project construction for the Company in 2018, totaled $2,355,966[5]. This total includes the annual pole replacement project in addition to the projects recommended as part of the 2017 annual reliability analysis. .

Attachment 4 details the budgeted costs and actual expenditures of all capital reliability projects. This list includes the projects that were originally budgeted and those that were actually constructed. There were a few projects that were budgeted and then were replaced by other projects due to practicality of completing the construction.

[5] Refer to Attachment 3 for reliability project spending

3. 2018 Reliability Performance

3.1. Historical Performance (2014-2018)

The historical reliability performance for the UES system for the time period from 2013-2017 is outlined in Charts 3-5 below. These charts display annual SAIDI and SAIFI for the combined UES systems as well as separate charts for each of the UES-Capital and UES-Seacoast service territories.

Chart 3

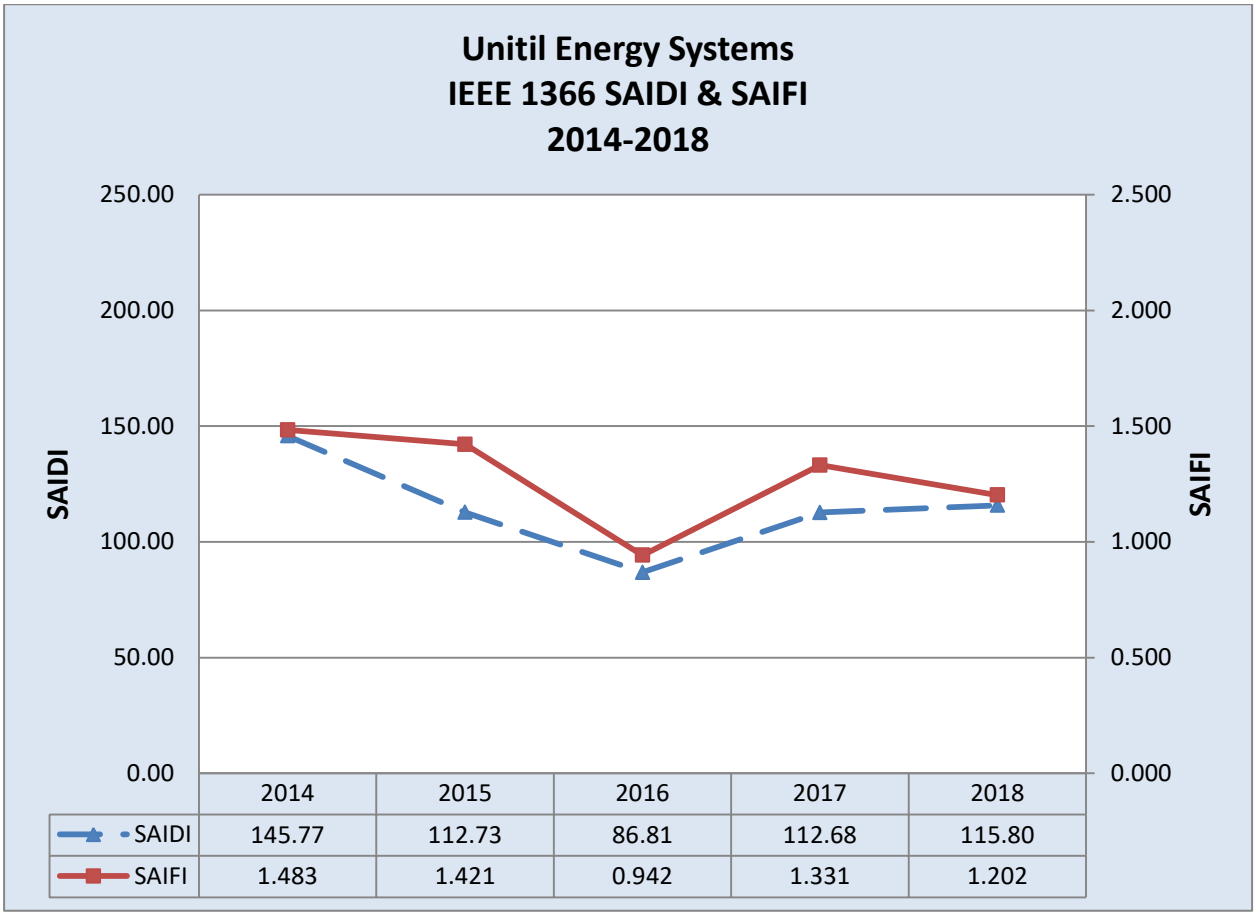


Chart 4

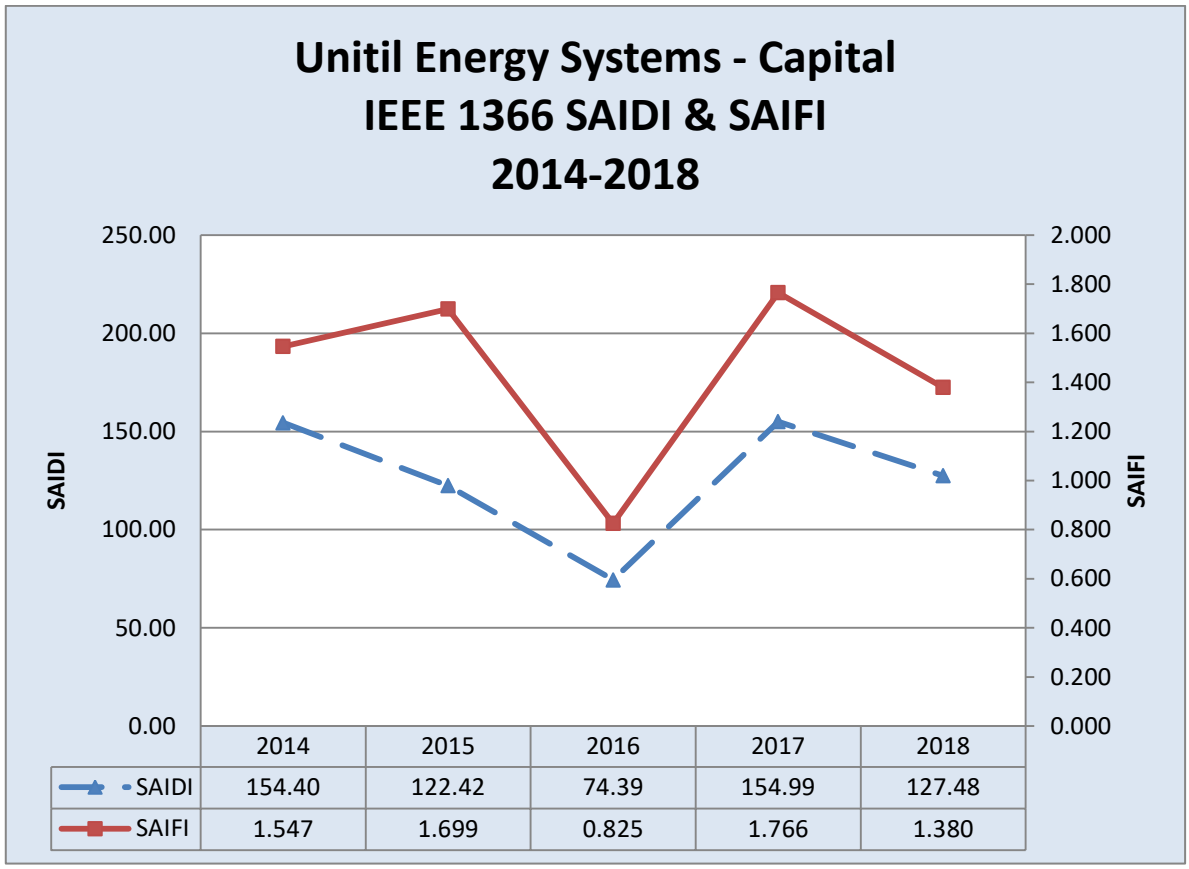
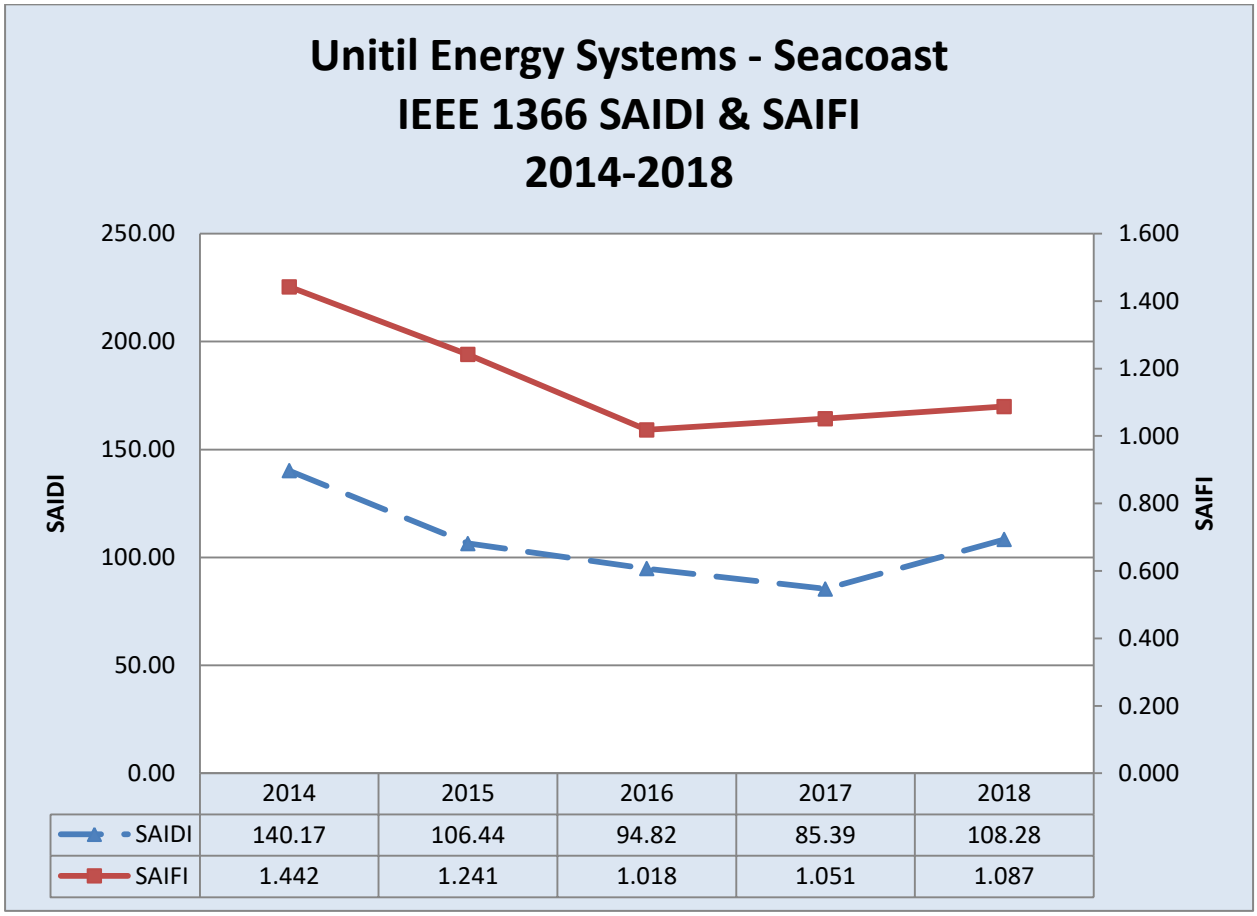

Unitil Energy Systems - Capital
IEEE 1366 SAIDI & SAIFI
2014-2018
SAIDI
SAIFI
250.00
200.00
150.00
100.00
50.00
0.00
2.000
1.800
1.600
1.400
1.200
1.000
0.800
0.600
0.400
0.200
0.000
2014 2015 2016 2017 2018
SAIDI 154.40 122.42 74.39 154.99 127.48
SAIFI 1.547 1.699 0.825 1.766 1.380

Chart 5



NOTE: Only those events causing an outage to 1 or more customers and lasting more than 5 minutes in duration are included in the calculation of these indices. In addition, events meeting any of the following criteria have also been excluded from these calculations:

- PUC Major Storm: All outages occurring in any day classified as an IEEE-1366 Major Event Day
- Interruptions/outages involving the failure of customer owned equipment
- Off system power supply interruptions

3.2. Summary of 2018 Performance

The reliabilityorted reliability performance of the UES systems in 2018 (based on IEEE-1366) was the third best performance in the last five years in terms of SAIDI. The combined UES system SAIDI of 115.80 minutes is roughly the same as the 5 year average of 114.76 minutes. The UES

combined system SAIFI for 2018 was 1.202 interruptions which was the second best performance in the last five years. The system SAIFI is approximately the same as the 5 year average of 1.276. The total number of interruption events recorded in 2017 was 1,093.

In 2018, there were five events that met the IEEE -1366 criteria for a Major Event Day which were therefore not included in the calculation of UES system SAIDI and SAIFI. These Major Event Days are listed below:

- March 7th, 8th, and 9th – Wind Event (Seacoast Region
- May 4th – Wind Event (Capital Region)
- June 18th – Lightning & Rain Storm (Captial Region)

Table 17 below shows a breakdown of the reliability performance of the UES system by individual cause codes.

Table 17

Cause of Outage	No of Troubles	Cust Int	Cust Hrs	SAIDI	% Total	SAIFI	% Total
Action by Others	15	481	1,574	1.22	1.1%	0.006	0.5%
Animal - Other	2	6	7	0.01	0.0%	0.000	0.0%
Bird	21	3,188	1,498	1.16	1.0%	0.041	3.4%
Civil Emergency (fire,flood,etc.)	1	9	8	0.01	0.0%	0.000	0.0%
Corrosion/Contamination/Decay	1	1	1	0.00	0.0%	0.000	0.0%
Equipment Failure Company	162	15,965	29,408	22.74	19.6%	0.206	17.1%
Equipment Failure Customer	3	19	39	0.03	0.0%	0.000	0.0%
Improper Installation	1	1	1	0.00	0.0%	0.000	0.0%
Lightning Strike	6	463	643	0.50	0.4%	0.006	0.5%
Loose/Failed Connection	9	398	557	0.43	0.4%	0.005	0.4%
Operator Error/System Malfunction	2	2,175	559	0.43	0.4%	0.028	2.3%
Other	12	255	305	0.24	0.2%	0.003	0.3%
Overload	6	80	119	0.09	0.1%	0.001	0.1%
Patrolled, Nothing Found	97	9,334	12,000	9.28	8.0%	0.120	10.0%
Scheduled, Planned Work	85	1,460	1,280	0.99	0.9%	0.019	1.6%
Squirrel	125	3,471	3,531	2.73	2.4%	0.045	3.7%
Tree/Limb Contact - Broken Limb	313	31,294	46,848	36.22	31.3%	0.403	33.6%
Tree/Limb Contact - Broken Trunk	160	13,599	28,187	21.80	18.8%	0.175	14.6%
Tree/Limb Contact - Growth into Line	34	1,230	1,841	1.42	1.2%	0.016	1.3%
Tree/Limb Contact - Uprooted Tree	28	3,406	9,453	7.31	6.3%	0.044	3.7%
Tree/Limb Contact - Vines	11	525	954	0.74	0.6%	0.007	0.6%
Vehicle Accident	40	5,906	10,946	8.46	7.3%	0.076	6.3%
Totals	**1134**	**93,266**	**149,760**	**115.80**	**100.00%**	**1.202**	**100.00%**

As observed from the preceding table, tree related outages had the greatest impact on the UES system reliability in terms of both SAIDI and SAIFI performance in 2018. Tables 18 and 19 below shows how the top three causes during 2017 have trended over the last three years[6].

Table 18

	SAIDI (% Total)		
Cause	**2018**	**2017**	**2016**
Tree Related	65%	54%	38%
Equipment Failure	20%	18%	17%
Patrolled, Nothing Found	8%	6%	9%

Table 19

	SAIFI (% Total)		
Cause	**2018**	**2017**	**2016**
Tree Related	62%	48%	42%
Equipment Failure	17%	19%	11%
Patrolled, Nothing Found	10%	5%	10%

[6] Percentages based on reliability data after removing exclusionary events based on the PUC exclusionary criteria in effect for the respective year.