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PUBLIC UTILITIES  
COMMISSION

The Honorable Chair and Members of the  
Hawai'i Public Utilities Commission  
Kekuanaoa Building  
465 South King Street, First Floor  
Honolulu, Hawai'i 96813

Dear Commissioners:

Subject: Hawaiian Electric Companies Annual Service Reliability Reports for 2015

Hawaiian Electric Company, Inc., Hawai'i Electric Light Company, Inc., and Maui Electric Company, Limited respectfully submit a copy of its Annual Service Reliability Report for the year 2015. (See Attachments 1, 2, and 3, respectively.)

Sincerely,

Daniel G. Brown  
Manager, Regulatory Non-Rate Proceedings

Attachments

c: Division of Consumer Advocacy (with Attachments)

**HAWAIIAN ELECTRIC COMPANY, INC.**  
**ANNUAL SERVICE RELIABILITY REPORT**  
**2015**

Prepared by  
System Operation Department

March 15, 2016

## **INTRODUCTION**

This is the 2015 annual service reliability report of the Hawaiian Electric Company. The year-end average number of electric customers increased from 300,722 in 2014 to 302,499 in 2015 (a 0.60% increase). The 2015 peak demand for the system was 1,246 MW (evening peak), 45 MW higher than the peak demand in 2014; the highest system peak demand remains at 1,327 MW set on the evening of October 12, 2004.

The system interruption summary for 2015 (Attachments A and B) and the system reliability indices for the five prior years are presented to depict the quality of service provided to the electrical energy consumer. Attachment C contains the definition of terms and the reliability indices explanations and equations.

Indices measure reliability in terms of the overall availability of electrical service (Average Service Availability Index or ASAI), the frequency or number of times Hawaiian Electric Company's customers experience an outage during the year (System Average Interruption Frequency Index or SAIFI), the average length of time an interrupted customer is out of power (Customer Average Interruption Duration Index or CAIDI), and the average length of time Hawaiian Electric Company's customers are out of power during the year (System Average Interruption Duration Index or SAIDI). SAIDI is an indication of overall system reliability because it is the product of SAIFI and CAIDI and incorporates the impact of frequency and duration of outages on Hawaiian Electric Company's total customer base (in this case 302,499 customers).

## **ANALYSIS**

This analysis of the annual system reliability for Hawaiian Electric Company is for the year 2015. To determine the relative level of reliability, the statistics for five prior years, 2010 through 2014, are used for comparison.

The reliability indices are calculated using the data from all sustained<sup>1</sup> system outages except customer maintenance outages. If data normalization is required, it is done using the guidelines specified in the report on reliability that was prepared for the Public Utilities Commission, titled "Methodology for Determining Reliability Indices for HECO Utilities," dated December 1990. The guidelines indicate that normalization is allowed for "abnormal" situations such as hurricanes, tsunamis, earthquakes, floods, catastrophic equipment failures, and single outages that cascade into a loss of load greater than 10% of the system peak load. These normalizations are made in calculating the reliability indices because good engineering design takes into account safety, reliability, utility industry standards, and economics, and cannot always plan for catastrophic events.

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<sup>1</sup>An electrical service interruption of more than one minute. (The majority of peer companies in the Edison Electric Institute association use a threshold of five minutes to identify sustained interruptions.)

## **2015 RESULTS**

### **Annual Service Reliability Indices**

The annual service reliability result for 2015 was ranked the best for CAIDI in the past 6 years. The reliability results for 2015 and five prior years are shown below in Table 1: Annual Service Reliability Indices – All Events and Table 2: Annual Service Reliability Indices – with Normalizations. Tables 3-8 break out the events into three groups, Transmission and Distribution, Generation – Hawaiian Electric, and Generation – Other [non-utility] for all events and with normalization. No outage events were normalized in 2015. All subsequent graphic comparisons and discussion are based on the normalized data.

**Table 1: Annual Service Reliability Indices - All Events**

	2010	2011*	2012	2013	2014	2015
Number of Customers	295,637	296,679	297,598	298,920	300,722	302,499
Customer Interruptions	361,334	502,253	407,197	409,516	447,048	642,380
Customer-Hours Interrupted	564,424.3	1,257,349.4	563,806.5	605,965	541,434.6	770,215.47
SAIDI (Minutes)	114.55	254.28	113.67	121.63	108.03	152.77
CAIDI (Minutes)	93.72	150.21	83.08	88.78	72.67	71.94
SAIFI (Occurrences)	1.222	1.693	1.368	1.370	1.487	2.124
ASAI (Percent)	99.978%	99.952%	99.978%	99.977%	99.979%	99.971%

**Table 2: Annual Service Reliability Indices - with Normalization**

	2010	2011*	2012	2013	2014	2015
Number of Customers	295,637	296,679	297,598	298,920	300,722	302,499
Customer Interruptions	361,334	408,327	407,197	409,516	447,048	642,380
Customer-Hours Interrupted	564,424.3	1,044,915.7	563,806.5	605,965	541,434.6	770,215.47
SAIDI (Minutes)	114.55	211.32	113.67	121.63	108.03	152.77
CAIDI (Minutes)	93.72	153.54	83.08	88.78	72.67	71.94
SAIFI (Occurrences)	1.222	1.376	1.368	1.370	1.487	2.124
ASAI (Percent)	99.978%	99.960%	99.978%	99.977%	99.979%	99.971%

**NOTE:**

2011\* Data normalized to exclude the 03/04/11 Labor Work Stoppage  
Data normalized to exclude the 05/02/11 – 05/03/11 Lightning Storm

**Table 3: Transmission & Distribution Events**

	2010	2011	2012	2013	2014	2015
Number of Customers	295,637	296,679	297,598	298,920	300,722	302,499
Customer Interruptions	361,334	477,798	341,118	341,930	382,867	459,546
Customer-Hours Interrupted	564,424.3	1,238,615.1	524,554	576,305.6	524,146.1	723,679.42
SAIDI (Minutes)	114.55	250.50	105.76	115.68	104.58	143.54
CAIDI (Minutes)	93.72	155.54	92.26	101.13	82.14	94.49
SAIFI (Occurrences)	1.222	1.610	1.146	1.144	1.273	1.519
ASAI (Percent)	99.978%	99.952%	99.980%	99.978%	99.980%	99.973%

**Table 4: Generation Events – Hawaiian Electric**

	2010	2011	2012	2013	2014	2015
Number of Customers	295,637	296,679	297,598	298,920	300,722	302,499
Customer Interruptions	0	24,455	0	0	0	26,914
Customer-Hours Interrupted	0	18,734.3	0	0	0	18,772.23
SAIDI (Minutes)	0.00	3.79	0.00	0.00	0.00	3.72
CAIDI (Minutes)	0.00	45.96	0.00	0.00	0.00	41.85
SAIFI (Occurrences)	0.000	0.082	0.000	0.000	0.000	0.089
ASAI (Percent)	100.000%	99.999%	100.000%	100.000%	100.000%	99.999%

**Table 5: Generation Events – Other [non-utility]**

	2010	2011	2012	2013	2014	2015
Number of Customers	295,637	296,679	297,598	298,920	300,722	302,499
Customer Interruptions	3	0	66,079	67,586	64,181	155,920
Customer-Hours Interrupted	4.9	0	39,252.5	29,659.4	17,288.5	27,763.82
SAIDI (Minutes)	0.00	0.00	7.91	5.95	3.45	5.51
CAIDI (Minutes)	98.00	0.00	35.64	26.33	16.16	10.68
SAIFI (Occurrences)	0.000	0.000	0.222	0.226	0.213	0.515
ASAI (Percent)	100.000%	100.000%	99.998%	99.999%	99.999%	99.999%

**Table 6: Transmission & Distribution Events with Normalization**

	2010	2011*	2012	2013	2014	2015
Number of Customers	295,637	296,679	297,598	298,920	300,722	302,499
Customer Interruptions	361,334	383,872	341,118	341,930	382,867	459,546
Customer-Hours Interrupted	564,424.3	1,026,181.4	524,554	576,305.6	524,146.1	723,679.42
SAIDI (Minutes)	114.55	207.53	105.76	115.68	104.58	143.54
CAIDI (Minutes)	93.72	160.39	92.26	101.13	82.14	94.49
SAIFI (Occurrences)	1.222	1.294	1.146	1.144	1.273	1.519
ASAI (Percent)	99.978%	99.961%	99.980%	99.978%	99.980%	99.973%

**Table 7: Generation Events – Hawaiian Electric with Normalization**

	2010	2011	2012	2013	2014	2015
Number of Customers	295,637	296,679	297,598	298,920	300,722	302,499
Customer Interruptions	0	24,455	0	0	0	26,914
Customer-Hours Interrupted	0	18,734.3	0	0	0	18,772.23
SAIDI (Minutes)	0.00	3.79	0.00	0.00	0.00	3.72
CAIDI (Minutes)	0.00	45.96	0.00	0.00	0.00	41.85
SAIFI (Occurrences)	0.000	0.082	0.000	0.000	0.000	0.089
ASAI (Percent)	100.000%	99.999%	100.000%	100.000%	100.000%	99.999%

**Table 8: Generation Events – Other [non-utility] with Normalization**

	2010	2011	2012	2013	2014	2015
Number of Customers	295,637	296,679	297,598	298,920	300,722	302,499
Customer Interruptions	3	0	66,079	67,586	64,181	155,920
Customer-Hours Interrupted	4.9	0	39,252.5	29,659.4	17,288.5	27,763.82
SAIDI (Minutes)	0.00	0.00	7.91	5.95	3.45	5.51
CAIDI (Minutes)	98.00	0.00	35.64	26.33	16.16	10.68
SAIFI (Occurrences)	0.000	0.000	0.222	0.226	0.213	0.515
ASAI (Percent)	100.000%	100.000%	99.998%	99.999%	99.999%	99.999%

**Figure 1: System Average Interruption Duration Index (SAIDI)**

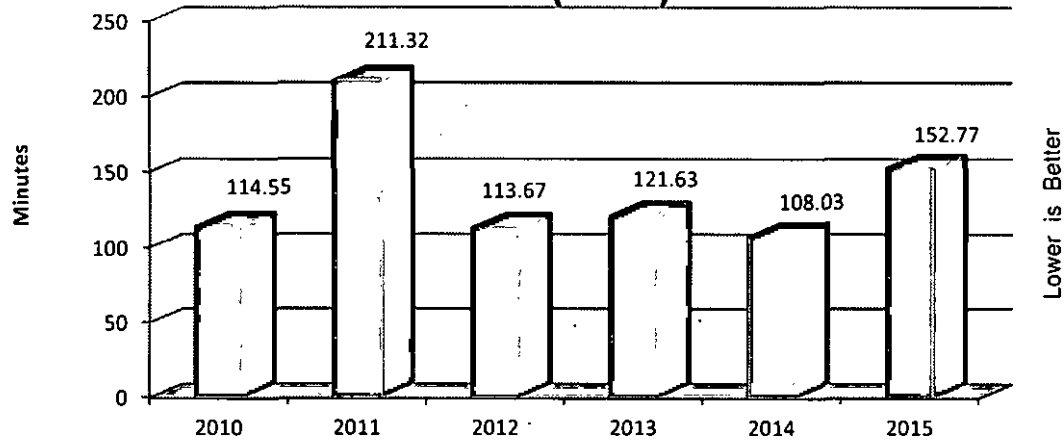


Figure 4 shows the System Average Interruption Duration Indices (SAIDI) for the past six years. The 2015 SAIDI is 152.77 minutes, a 41% increase compared to the 2014 SAIDI, and resulted as the second worst SAIDI performance in the last six years. The increase in 2015 is due to the largest amount of customer interruptions in the last 6 years also reflected in SAIFI. SAIDI is not the worst in the 6 year period due to excellent restoration times in 2015 also reflected in CAIDI. The SAIDI is the composite of both the SAIFI and CAIDI indices and produces a broader benchmark of system reliability by combining both the duration and the number of customer interruptions during a given period of time.

**Figure 2: Customer Average Interruption Duration Index (CAIDI)**

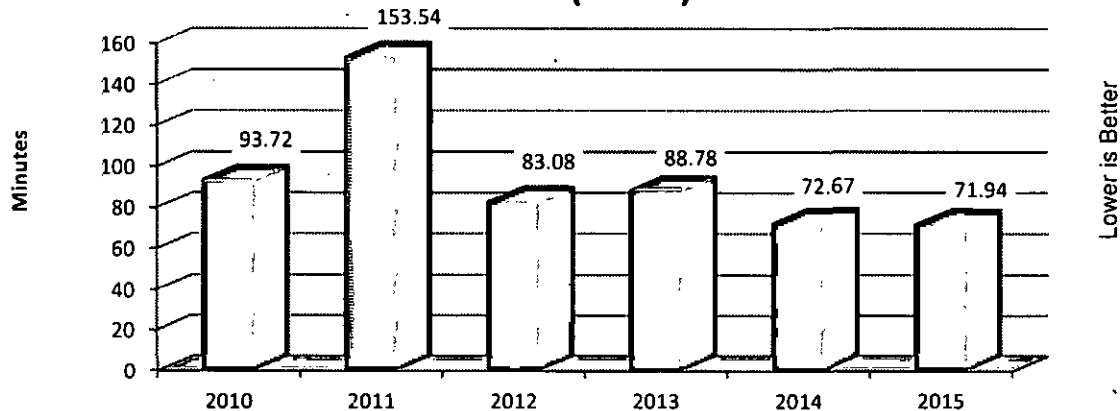


Figure 1 shows the Customer Average Interruption Duration Indices (CAIDI) for the past six years. The 2015 CAIDI of 71.94 minutes, is an 1% decrease compared to the 2014 CAIDI, making it the best CAIDI result in the last six years.

This continued performance improvement and noticeable downward trend is a result of our increasing grid modernization initiatives. DA (distribution automation) and SCADA (supervisory control and data acquisition) apparatuses are strategically placed smart grid devices to aide in circuit fault detection which enables quicker isolation of the problem resulting in quicker power restoration. Fundamentally, the grid modernization provides immediate alarms to the System Operation Control Center (SOCC), enabling and alerting the SOCC personnel to assess and respond to deploy field crews effectively and efficiently, and allowing more remote controllability to restore customers as well.

Three major events impacting the 2015 CAIDI results were:

1. January 2, 2015 (Friday) – High winds caused overhead conductors to fall in Mililani Tech Park in Mililani affecting 2,864 customers causing a momentary interruption for some customers and a sustained interruption lasting up to 38 hours and 49 minutes to others. This incident added 1.86 minutes to the annual 2015 CAIDI.
2. February 14, 2015 (Saturday) – Conductor broke near Kaluapuni Neighborhood Park in Kaneohe affecting 2,517 customers with an outage lasting 7 hours and 1 minute. This event added 1.37 minutes to the annual 2015 CAIDI.
3. February 14, 2015 (Saturday) – High winds caused overhead conductor to fall near Schofield in Wahiawa affecting 577 customers with some customers seeing a momentary interruption and others experiencing an outage lasting 17 hours and 19 minutes. This event added 0.82 minutes to the annual 2015 CAIDI.

**Figure 3: System Average Interruption Frequency Index (SAIFI)**

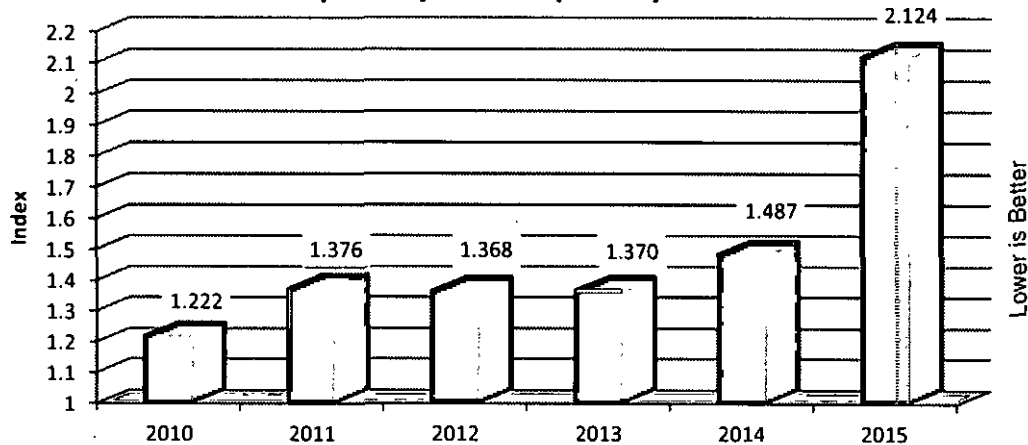


Figure 2 illustrates the System Average Interruption Frequency Index (SAIFI) for the past six years. The 2015 SAIFI of 2.124 had the most customer interruption occurrences of the past six years, increasing 43% from the 2014 SAIFI of 1.487. The total number of customer interruptions in 2015 was 642,380 compared to 447,048 interruptions in 2014.

This result is an indication that as we continue to make improvements in certain causes of outages (e.g., equipment deterioration) storms and other weather incidents continue to have a large impact on the system reliability. As was pointed out in the discussion regarding the CAIDI results, the three significant interruptions were during severe weather related conditions, particularly the high winds in January and February, also contributed to the overall SAIFI as large numbers of customers were affected by these outages.

In 2015, there were seven events that resulted in the loss of more than 10,000 customers:

1. July 22, 2015 (Wednesday), Oahu experienced an under frequency load shedding (UFLS) event due to the loss of the island's largest generating unit at the AES facility. This event caused a series of interruptions to 55,516 customers or 18% of our customers with outage durations ranging from a momentary interruption to 1 hours and 43 minutes.
2. July 23, 2015 (Thursday), Oahu experienced an under frequency load shedding (UFLS) event due to the loss of the island's largest generating unit at the AES facility. This event caused a series of interruptions to 55,498 customers or 18% of our customers with outage durations ranging from a momentary interruption to 1 hours and 19 minutes.

3. January 12, 2015 (Monday), Oahu generation was not able to support the forecasted evening peak load demand as a result the company executed manual load shedding affected 26,914 customers or 9% of our customers with outage durations from 23 minutes to 1 hour and 2 minutes.
4. February 14, 2015 (Saturday), Oahu experienced an under frequency load shedding (UFLS) event due to the loss of the island's largest generating unit at the AES facility. This event caused a series of interruptions to 22,751 customers or 8% of our customers with outage durations ranging from a momentary interruption to 13 minutes.
5. September 2, 2015 (Wednesday), a company switching error outage in Puunui Substation affected 21,784 customers or 7% of our customers with outage durations ranging from a momentary interruption to 3 hours and 42 minutes.
6. January 3, 2015 (Saturday), high winds caused two 138KV lines to trip consequently de-energized Wahiawa Substation. This affected 16,938 customers or 6% of our customers with outage durations ranging from a momentary interruption to 1 hour and 1 minute.
7. February 19, 2015 (Thursday), high winds caused two 46KV lines to trip consequently de-energized Hawaii Kai and sections of Waimanalo. This affected 13,169 customers or 4% of our customers with outage durations ranging from a momentary interruption to 1 hour and 58 minutes.

**Figure 4: Average Service Availability Index  
(ASAI)**

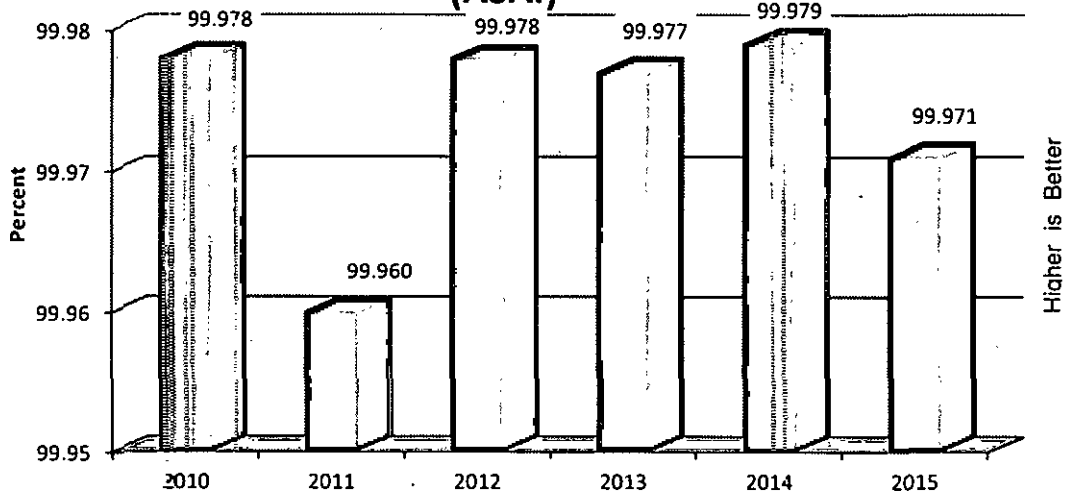
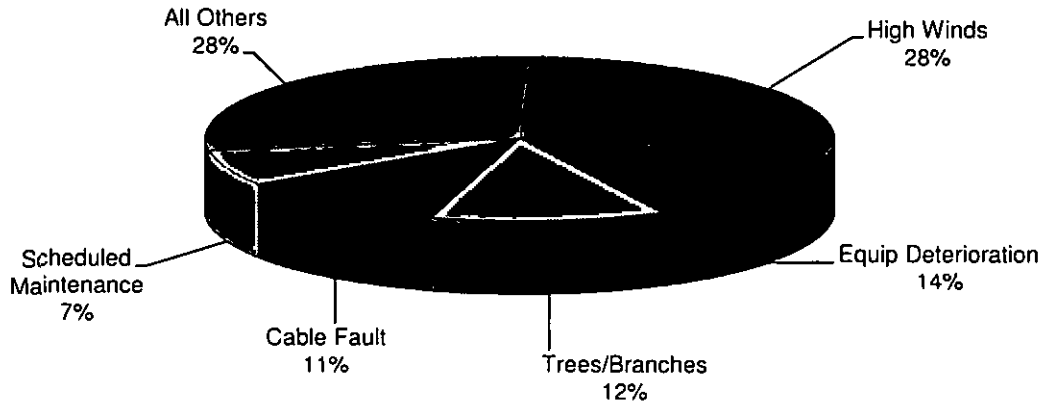


Figure 3 shows that the 2015 Average Service Availability is the second lowest in the last six years, higher is better, decreasing .008% from 2014. The ability to restore power quicker resulted in the best performance for CAIDI, yet 2015 experienced the highest amount of customer interruptions (SAIFI) for the last six years, therefore causing SAIDI to be the second worst performance in the period. With a customer base increase of 1,777 over 2014, the difference of availability equates to approximately 51 more hours of availability per customer for 2015, ranking ASAI second worst performance in the last six years

**Figure 5: Outage Categories**



The Top 5 Outage Categories, by SAIDI, as illustrated in Figure 5, equates to about 72% of the total SAIDI in 2015.

These top outage causes are:

<u>Outage Category</u>	<u>Sample Causes</u>
1. High Winds	Direct wind force on any electrical equipment
2. Equipment Deterioration	Failed, broken, corroded equipment
3. Trees/Branches	Contact by vegetation regardless of what caused it to make contact
4. Cable Faults	Underground equipment failures
5. Scheduled Maintenance	Planned maintenance

The top five major cause factors for 2015 remained the same as 2014 in a varied ranking order. High winds outage cause is now ranked first from fifth with a 419% increase of customer interruption hours from 2014 with 41,062.65 hours to 213,075.3 hours in 2015. Trees/Branches remained in third place yet had a 38% increase of customer interruption hours from 2014 with 67,573.97 hours to 93,318.12 hours in 2015. The severe El Nino weather affects in 2015 are reflected in the increase in both of these outage cause codes. Equipment deterioration fell from first to second with a 0.50% decrease of customer interruption hours from 2014 with 108,772.65 hours to 108,233.3 hours in 2015. Cable faults saw the greatest improvement moving from second place to fourth with a 12% decrease of customer interruption hours from 2014 with 97,504.37 hours to 85,489.52 hours in 2015. Lastly, scheduled maintenance moved from fourth to fifth with an 11% decrease of customer interruption hours from 2014 with 56,762.85 hours to 50,684.22 hours in 2015.

## Hawaiian Electric Company Normalized Sustained Interruption Summary

From: January 1, 2015

To: December 31, 2015

Outage Cause	Customer Hours	Customer Interruptions	SAIFI	SAIDI	CAIDI
HIGH WINDS	213,075.28	121,947	0.403	42.26	104.84
EQUIP DETERIORATION	108,233.28	53,901	0.178	21.47	120.48
TREES/BRANCHES IN LINES	93,318.12	46,992	0.155	18.51	119.15
CABLE FAULT	85,489.52	66,607	0.220	16.96	77.01
SCHEDULED MAINTENANCE	50,684.22	13,689	0.045	10.05	222.15
AUTO ACCIDENT	31,957.57	26,469	0.088	6.34	72.44
FORCED MAINTENANCE	28,982.03	26,273	0.087	5.75	66.19
AUTO UF LOADSHED	27,754.75	155,919	0.515	5.51	10.68
COMPANY SWITCHING ERROR	22,556.75	33,372	0.110	4.47	40.56
MANUAL UF LOADSHED	18,772.23	26,914	0.089	3.72	41.85
OVERGROWN VEGETATION	15,964.77	9,414	0.031	3.17	101.75
UNKNOWN	15,051.62	10,687	0.035	2.99	84.50
LIGHTNING	14,533.03	10,355	0.034	2.88	84.21
ANIMAL IN LINES	8,855.90	6,028	0.020	1.76	88.15
FAULTY EQUIP OPERATION	7,348.95	9,034	0.030	1.46	48.81
TRANSFORMER FAILURE	5,117.47	992	0.003	1.02	309.52
FIRE	4,673.05	7,129	0.024	0.93	39.33
FLASHOVER	3,817.83	3,240	0.011	0.76	70.70
CONSTRUCTION ACCIDENT	3,651.43	2,682	0.009	0.72	81.69
COMPANY PERSONNEL ERROR	3,119.90	5,528	0.018	0.62	33.86
MYLAR BALLOON	2,486.60	1,764	0.006	0.49	84.58
CUSTOMER EQUIP	1,734.30	561	0.002	0.34	185.49
FOREIGN OBJECT IN LINES	974.82	587	0.002	0.19	99.64
VANDALISM	455.30	1,195	0.004	0.09	22.86
TRANSFORM OVERLOAD	425.13	238	0.001	0.08	107.18
EQUIP OVERLOAD	405.57	314	0.001	0.08	77.50
MOVING EQUIP ACCIDENT	400.30	286	0.001	0.08	83.98
OTHER	240.62	196	0.001	0.05	73.66
EQUIP ROT OR TERMITES	135.13	67	0.000	0.03	121.01
SYSTEM LOAD MAINTENANCE	0.00	0	0.000	0.00	0.00
SWITCH LOAD MAINTENANCE	0.00	0	0.000	0.00	0.00
MANUFACTURER EQUIP DEFECT	0.00	0	0.000	0.00	0.00
IPP EQUIP FAILURE	0.00	0	0.000	0.00	0.00
CONTAMINATION FLASHOVER	0.00	0	0.000	0.00	0.00
NATURAL DISASTER	0.00	0	0.000	0.00	0.00
LANDSLIDE/FLOODING	0.00	0	0.000	0.00	0.00
MAN IN LINES	0.00	0	0.000	0.00	0.00
OTHER-GENERATION	0.00	0	0.000	0.00	0.00
TRANSFER LOAD MAINTENANCE	0.00	0	0.000	0.00	0.00
CUSTOMER MAINTENANCE "	0.00	0	0.000	0.00	0.00

## Hawaiian Electric Company Normalized Sustained Interruption Summary

From: January 1, 2015

To: December 31, 2015

Outage Cause	Customer Hours	Customer Interruptions	SAIFI	SAIDI	CAIDI
<b>Total</b>	770,215.47	642,380	2.124	152.77	71.94
AVERAGE SYSTEM AVAILABILITY =			99.971%		
NUMBER OF CUSTOMERS FOR THE PERIOD =			302,499		
24 MONTH ANNUALIZED SAIDI AVERAGE FOR THE PERIOD 1/1/2014 - 12/31/2015 =			130.46		
24 MONTH AVERAGE NUMBER OF CUSTOMERS FOR THE PERIOD 1/1/2014 - 12/31/2015 =			301,611		

SAIFI = SYSTEM AVERAGE INTERRUPTION FREQUENCY INDEX

SAIDI = SYSTEM AVERAGE INTERRUPTION DURATION INDEX (MINUTES)

CAIDI = CUSTOMER AVERAGE INTERRUPTION DURATION INDEX (MINUTES)

**NOTES:** Outage causes are listed in order of SAIFI.

Outages with zero customer hours or due to customer maintenance are not included in the report.

## Hawaiian Electric Company Normalized Sustained Interruption Summary

From: January 1, 2015

To: December 31, 2015

Outage Cause	<u>Interruptions</u>		<u>Customer Hours</u>	
	Number	% of Total	Number	% of Total
<b><u>ACCIDENT</u></b>	<b>50</b>	<b>1.64</b>	<b>35,009.30</b>	<b>4.68</b>
AUTO ACCIDENT	32	1.05	31,957.5	4.15
CONSTRUCTION ACCIDENT	15	0.49	3,651.43	0.47
MOVING EQUIP ACCIDENT	3	0.10	400.30	0.05
<b><u>CABLE FAULT</u></b>	<b>537</b>	<b>17.56</b>	<b>85,489.52</b>	<b>11.10</b>
CABLE FAULT	537	17.56	85,489.52	11.10
<b><u>COMPANY ERROR</u></b>	<b>44</b>	<b>1.44</b>	<b>25,676.65</b>	<b>3.33</b>
COMPANY SWITCHING ERROR	27	0.88	22,556.75	2.93
COMPANY PERSONNEL ERROR	17	0.56	3,119.90	0.41
<b><u>EQUIPMENT</u></b>	<b>400</b>	<b>13.08</b>	<b>117,857.23</b>	<b>15.30</b>
EQUIP DETERIORATION	344	11.25	108,233.28	14.05
FAULTY EQUIP OPERATION	21	0.69	7,348.95	0.95
CUSTOMER EQUIP	26	0.85	1,734.30	0.23
EQUIP OVERLOAD	6	0.20	405.57	0.05
EQUIP ROT OR TERMITES	3	0.10	135.13	0.02
IPP EQUIP FAILURE	0	0.00	0.00	0.00
I. MANUFACTURER EQUIP DEFECT	0	0.00	0.00	0.00
<b><u>FIRE</u></b>	<b>4</b>	<b>0.13</b>	<b>4,673.05</b>	<b>0.61</b>
FIRE	4	0.13	4,673.05	0.61
<b><u>FLASHOVER</u></b>	<b>12</b>	<b>0.39</b>	<b>3,817.83</b>	<b>0.50</b>
FLASHOVER	11	0.36	3,817.83	0.50
CONTAMINATION FLASHOVER	1	0.03	0.00	0.00
<b><u>GENERATION</u></b>	<b>124</b>	<b>4.05</b>	<b>46,526.98</b>	<b>6.04</b>
AUTO UF LOADSHED	120	3.92	27,754.75	3.60
MANUAL UF LOADSHED	4	0.13	18,772.23	2.44
OTHER-GENERATION	0	0.00	0.00	0.00
<b><u>MAINTENANCE</u></b>	<b>1,340</b>	<b>43.82</b>	<b>79,666.25</b>	<b>10.34</b>
SCHEDULED MAINTENANCE	1,115	36.46	50,684.22	6.58
FORCED MAINTENANCE	225	7.36	28,982.03	3.76
SYSTEM LOAD MAINTENANCE	0	0.00	0.00	0.00
CUSTOMER MAINTENANCE	0	0.00	0.00	0.00
TRANSFER LOAD MAINTENANCE	0	0.00	0.00	0.00
SWITCH LOAD MAINTENANCE	0	0.00	0.00	0.00

## Hawaiian Electric Company Normalized Sustained Interruption Summary

From: January 1, 2015

To: December 31, 2015

	<u>Interruptions</u>		<u>Customer Hours</u>	
<b><u>OBJECT IN LINES OR EQUIP</u></b>	<b>36</b>	<b>1.18</b>	<b>12,317.32</b>	<b>1.60</b>
ANIMAL IN LINES	24	0.78	8,855.90	1.15
MYLAR BALLOON	10	0.33	2,486.60	0.32
FOREIGN OBJECT IN LINES	2	0.07	974.82	0.13
MAN IN LINES	0	0.00	0.00	0.00
<b><u>OTHER</u></b>	<b>3</b>	<b>0.10</b>	<b>240.62</b>	<b>0.03</b>
OTHER	3	0.10	240.62	0.03
<b><u>TRANSFORMER</u></b>	<b>85</b>	<b>2.78</b>	<b>5,542.60</b>	<b>0.72</b>
TRANSFORMER FAILURE	71	2.32	5,117.47	0.66
TRANSFORM OVERLOAD	14	0.46	425.13	0.06
<b><u>UNKNOWN</u></b>	<b>79</b>	<b>2.58</b>	<b>15,051.62</b>	<b>1.95</b>
UNKNOWN	79	2.58	15,051.62	1.95
<b><u>VANDALISM</u></b>	<b>2</b>	<b>0.07</b>	<b>455.30</b>	<b>0.06</b>
VANDALISM	2	0.07	455.30	0.06
<b><u>VEGETATION</u></b>	<b>157</b>	<b>5.13</b>	<b>109,282.89</b>	<b>14.19</b>
TREES/BRANCHES IN LINES	130	4.25	93,318.12	12.12
OVERGROWN VEGETATION	27	0.88	15,964.77	2.07
<b><u>WEATHER</u></b>	<b>185</b>	<b>6.05</b>	<b>227,608.31</b>	<b>29.55</b>
HIGH WINDS	106	3.47	213,075.28	27.66
LIGHTNING	79	2.58	14,533.03	1.89
LANDSLIDE/FLOODING	0	0.00	0.00	0.00
NATURAL DISASTER	0	0.00	0.00	0.00
<b>Total:</b>	<b>3058</b>		<b>770,215.47</b>	

**NOTES:** Outages with zero customer hours or due to customer maintenance are not included in the report.

## **DEFINITION OF TERMS**

### **OUTAGE**

The state of a component when it is not available to perform its intended function due to some event directly associated with that component. An outage may or may not cause an interruption of service to consumers depending on the system configuration.

### **INTERRUPTION**

The loss of service to one or more consumers and is a result of one or more component outages.

### **INTERRUPTION DURATION**

The period from the initiation of an interruption to a consumer until service has been restored to that consumer.

### **MOMENTARY INTERRUPTION**

An interruption that has a duration limited to the period required to restore service by automatic or supervisory-controlled switching operations or by manual switching at locations where an operator is immediately available. Such switching operations must be completed in a specific time not to exceed one minute. Previous issues of this report indicated that a momentary interruption has a duration not to exceed five minutes. A December 1990 report, "Methodology for Determining Reliability Indices for HECO Utilities" indicated that momentary interruptions will have a duration of less than one minute.

### **SUSTAINED INTERRUPTION**

Any interruption not classified as a momentary interruption. Only this type of interruption is included in the reliability indices within this report. In conformance with the guidelines established in the report, "Methodology for Determining Reliability Indices for HECO Utilities," dated December 1990, a sustained interruption has a duration of one minute or longer.

### **CUSTOMER INTERRUPTION**

One interruption of one customer.

NOTE: Interruptions to customers at their request (e.g., customer maintenance) are not considered.

## **RELIABILITY INDICES**

Reliability indices used in this report conform to standards proposed by both the Edison Electric Institute (EEI) and the Institute of Electrical and Electronics Engineers (IEEE) unless otherwise indicated in the above definitions. Four reliability indices that convey a meaningful representation of the level of reliability were selected and are presented in this report. These reliability indices are as follows:

### **AVERAGE SERVICE AVAILABILITY INDEX (ASAI)**

Total customer hours actually served as a percentage of total customer hours possible during the year. This indicates the extent to which electrical service was available to all customers. This index has been commonly referred to as the "Index of Reliability." A customer-hour is calculated by multiplying the number of customers by the number of hours in the period being analyzed.

$$ASA = \frac{\sum \text{No. of Customer Hours Actually Served during the year}}{\sum \text{No. of Customer Hours Possible during the year}} \times 100\%$$

### **SYSTEM AVERAGE INTERRUPTION FREQUENCY INDEX (SAIFI)**

The number of customer interruptions per customer served during the year. This index indicates the average number of sustained interruptions experienced by all customers serviced on the system.

$$SAIF = \frac{\sum \text{No. of Customer Interruptions Experienced during the year}}{\text{Average No. of Customers served during the year}}$$

### **CUSTOMER AVERAGE INTERRUPTION DURATION INDEX (CAIDI)**

The interruption duration per customer interrupted during the year. This index indicates the average duration of an interruption for those customers affected by a sustained interruption.

$$CAID = \frac{\sum \text{Duration of Interruption} \times \text{No. of Customers affected}}{\sum \text{No. of Customer Interruptions Experienced for the year}}$$

### **SYSTEM AVERAGE INTERRUPTION DURATION INDEX (SAIDI)**

The interruption duration per customer served during the year. This index indicates the average interruption time experienced by all customers serviced on the system.

$$SAID = \frac{\sum \text{Duration of Interruption} \times \text{No. of Customers Affected}}{\text{Average No. of Customers Served during the year}}$$

# **HAWAI'I ELECTRIC LIGHT COMPANY, INC.**

## **ANNUAL SERVICE RELIABILITY REPORT**

**2015**

Prepared by

Operations, Distribution Department

September 16, 2016

## **INTRODUCTION**

This is the 2015 annual service reliability report of the Hawai'i Electric Light Company (HAWAI'I ELECTRIC LIGHT). The year-end average number of electric customers increased from 82,872 in 2014 to 83,622 in 2015 (a 0.91% increase). The 2015 peak demand for the system was 191.5 MW (evening peak), 3.7 MW higher than the peak demand of 187.8 MW in 2014.

The system interruption summaries (Attachment A) for the past year and the system reliability indices for the five prior years are presented to depict the quality of service provided to the electrical energy consumer.

Attachment B contains the definition of terms and the reliability indices explanations and equations.

Indices measure reliability in terms of the overall availability of electrical service (ASAI), the frequency or number of times HAWAI'I ELECTRIC LIGHT's customers experience an outage during the year (SAIFI), the average length of time an interrupted customer is out of power (CAIDI), and the average length of time HAWAI'I ELECTRIC LIGHT's customers are out of power during the year (SAIDI). SAIDI is an indication of overall system reliability because it is the product of SAIFI and CAIDI and incorporates the impact of frequency and duration of outages on HAWAI'I ELECTRIC LIGHT's total customer base (in this case 83,622 customers).

## **ANALYSIS**

This analysis of the annual system reliability for HAWAI'I ELECTRIC LIGHT is for the year 2015. To determine the relative level of reliability, the statistics for five prior years, 2010 through 2014, are used for comparison.

The reliability indices are calculated using the data from all sustained<sup>1</sup> system outages except Customer Maintenance outages. If data normalization is required, it is done using the guidelines specified in the report on reliability that was prepared for the Public Utilities Commission, titled "Methodology for Determining Reliability Indices for HAWAI'I ELECTRIC LIGHT Utilities," dated December 1990. The guidelines indicate that normalization is allowed for "abnormal" situations such as hurricanes, tsunamis, earthquakes, floods, catastrophic equipment failures, and single outages that cascade into a loss of load greater than 10% of the system peak load. These normalizations are made in calculating the reliability indices because good engineering design takes into account safety, reliability, utility industry standards, and economics, and cannot always plan for catastrophic events.

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<sup>1</sup>An electrical service interruption of more than one minute. (The majority of peer companies in the Edison Electric Institute association use a threshold of five minutes to identify sustained interruptions.)

**2015 RESULTS****Annual Service Reliability Indices**

The reliability results for 2015 and five prior years are shown below in Table 1: Annual Service Reliability Indices – All Events and Table 2: Annual Service Reliability Indices – with Normalizations. Tables 3 - 8 break out the events into three groups, Transmission and Distribution, Generation – Hawaiian Electric Light, and Generation – Other [non-utility] for all events and with normalization. Four outage events were normalized in 2015, including two T&D and two Generation related events. All subsequent comparisons and discussion are based on the normalized data.

**Table 1: Annual Service Reliability Indices - All Events**

Year	2010	2011	2012	2013	2014	2015
Number of Customers	80,171	80,800	81,537	82,068	82,872	83,622
Customer Interruptions	300,528	289,448	229,461	377,561	405,362	432,794
Customer-Hour Interruptions	209,919	245,465	191,973	277,087	1,320,024	668,864
SAID	157.10	182.28	141.27	202.58	955.7	479.92
CAID	41.91	50.88	50.2	44.03	195.38	92.73
SAIF	3.749	3.582	2.814	4.601	4.891	5.176
ASA	99.965	99.964	99.973	99.961	99.811	99.908

**Table 2: Annual Service Reliability Indices - with Normalization**

Year	2010*	2011*	2012	2013*	2014*	2015*
Number of Customers	80,171	80,800	81,537	82,068	82,872	83,622
Customer Interruptions	176,252	235,520	229,461	239,369	281,467	228,540
Customer-Hours Interrupted	170,798	235,894	191,973	155,975	222,297	209,464
SAID	127.83	175.17	141.27	114.03	160.94	150.29
CAID	58.14	60.1	50.2	39.1	47.39	54.99
SAIF	2.198	2.915	2.814	2.917	3.396	2.733
ASA	99.970	99.966	99.973	99.978	99.962	99.971

**NOTE:**

2010\*      Data normalized to exclude 1/26, Puna Plant UFLS  
               Data normalized to exclude 4/9 and 7/3, Keahole CT5 UFLS  
               Data normalized to exclude 10/27, Keahole CT4 UFLS

Hawai'i Electric Light Company, Inc.  
Annual Service Reliability Report 2015

- 2011\* Data normalized to exclude 6/30, Keahole CT4 UFLS  
Data normalized to exclude 7/16, Keahole CT5 and ST7 UFLS  
Data normalized to exclude 8/2, HEP UFLS
- 2013\* Data normalized to exclude 1/25, 7600 Line fault  
Data normalized to exclude 3/2, Keahole CT4 UFLS  
Data normalized to exclude 3/13, 6500 Line fault  
Data normalized to exclude 6/27, 8/14 Waimea Sub upgrade  
Data normalized to exclude 7/29, Wind Storm  
Data normalized to exclude 10/26, 12/30 PGV UFLS  
Data normalized to exclude 11/25, Hill 6 UFLS  
Data normalized to exclude 12/30, Lightning Storm
- 2014\* Data normalized to exclude 1/22, Wind Storm  
Data normalized to exclude 4/12, Keahole CT 5 UFLS  
Data normalized to exclude 8/7, Hurricane Iselle
- 2015\* Data normalized to exclude 1/2, Wind Storm  
Data normalized to exclude 2/13, Wind Storm  
Data normalized to exclude 5/6, Keahole CT 5 UFLS  
Data normalized to exclude 6/25, Keahole CT 4 UFLS

**Table 3: Transmission & Distribution Events**

Year	2010	2011	2012	2013	2014	2015
Number of Customers	80,171	80,800	81,537	82,068	82,872	83,622
Customer Interruptions	87,951	178,277	146,243	189,384	232,992	293,259
CID	161,749.1	230,936.3	184,668.8	256,892.7	1,294,789.2	648,887.9
SAID	121.05	171.49	135.89	187.81	937.44	465.59
CAID	110.34	77.72	75.77	81.39	333.43	132.76
SAIF	1.097	2.206	1.794	2.308	2.811	3.507

**Table 4: Generation Events – Hawai'i Electric Light**

Year	2010	2011	2012	2013	2014	2015
Number of Customers	80,171	80,800	81,537	8,2068	82,872	83,622
Customer Interruptions	160,866	57,396	31,421	117,362	118,641	128,579
CID	32,265.7	6,272.8	2,714.8	13,785	15,257.9	18,946.4
SAID	24.15	4.66	2.00	10.08	11.05	13.59
CAID	12.03	6.56	5.18	7.05	7.72	8.84
SAIF	2.007	0.71	0.385	1.43	1.432	1.538

Hawai'i Electric Light Company, Inc.  
Annual Service Reliability Report 2015**Table 5: Generation Events – Other (non-utility)**

Year	2010	2011	2012	2013	2014	2015
Number of Customers	80,171	80,800	81,537	82,068	82,872	83,622
Customer Interruptions	51,711	53,775	51,797	70,815	53,729	10,956
CID	15,903.8	8,255.7	4,589.8	6,409.7	9,976.5	1,029.5
SAID	11.9	6.13	3.38	4.69	7.22	0.74
CAID	18.45	9.21	5.32	5.43	11.14	5.64
SAIF	0.645	0.666	0.635	0.863	0.648	0.131

**Table 6: Transmission & Distribution Events with Normalization**

Year	2010	2011	2012	2013	2014	2015
Number of Customers	80,171	80,800	81,537	82,068	82,872	83,622
Customer Interruptions	87,951	178,277	14,6243	125,999	141,684	130,329
CID	161,749.1	230,936.3	184,668.8	146,321.3	204,185.5	196,347.1
SAID	121.05	171.49	135.89	106.98	147.83	140.88
CAID	110.34	77.72	75.77	69.68	86.47	90.39
SAIF	1.097	2.206	1.794	1.535	1.710	1.559

**Table 7: Generation Events – Hawai'i Electric Light with Normalization**

Year	2010	2011	2012	2013	2014	2015
Number of Customers	80,171	80,800	81,537	82,068	82,872	83,622
Customer Interruptions	71,993	29,754	31,421	71,236	86,054	87,255
CID	7,733.5	3,061.3	2,714.8	6,375	8,134.9	12,087.2
SAID	5.79	2.27	2.00	4.66	5.89	8.67
CAID	6.45	6.17	5.18	5.37	5.67	8.31
SAIF	0.898	0.368	0.385	0.868	1.038	1.043

**Table 8: Generation Events – Other (non-utility) with Normalization**

Year	2010	2011	2012	2013	2014	2015
Number of Customers	80,171	8,0800	81,537	82,068	82,872	83,622
Customer Interruptions	16,308	27,489	51,797	42,134	53,729	10,956
CID	1,315	1,896	4,589.8	3,278.5	9,976.5	1,029.5
SAID	0.98	1.41	3.38	2.4	7.22	0.74
CAID	4.84	4.14	5.32	4.67	11.14	5.64
SAIF	0.203	0.340	0.635	0.513	0.648	0.131

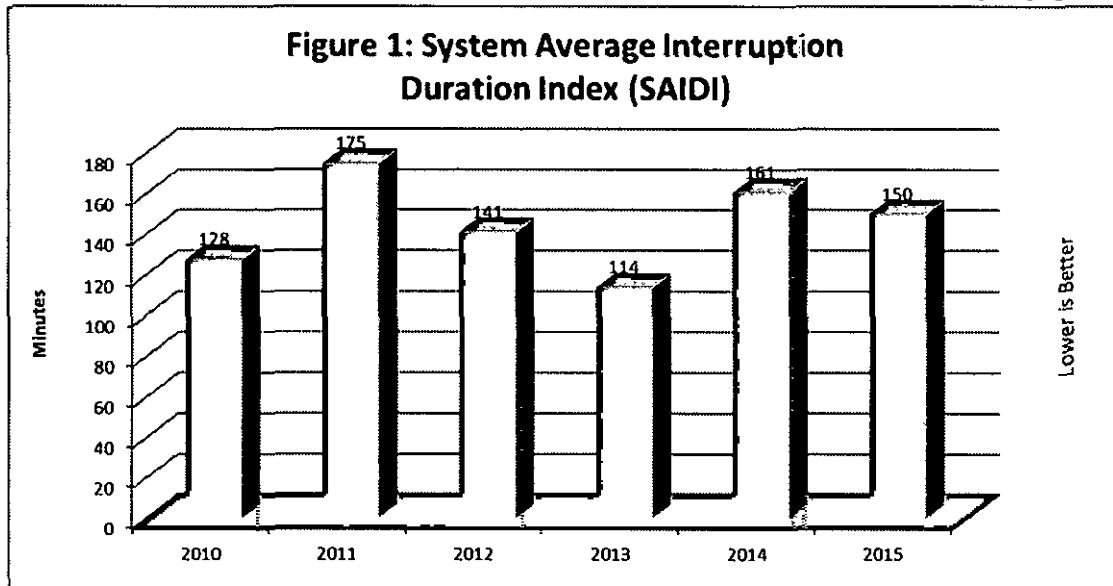


Figure 1 shows the System Average Interruption Duration Indices (SAIDI) for the past six years. It shows that the 2015 SAIDI is 150 minutes, a 6.8% decrease compared to the 2014 SAIDI result of 161 minutes. The SAIDI is the composite of both the SAIFI and CAIDI indices and produces a broader benchmark of system reliability by combining both the duration and the number of customer interruptions during a given period of time.

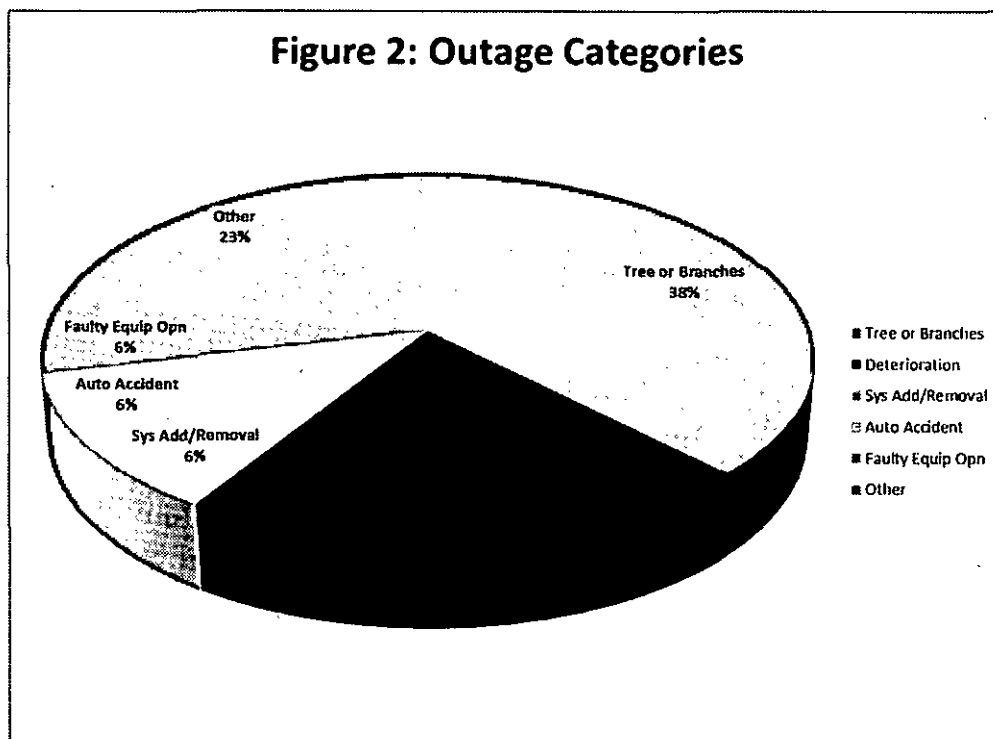
In 2015, there were 8 sustained outages that resulted in the loss of more than 5,000 customers:

1. **January 20, 2015:** Underfrequency load shed event occurred when Hill 6 tripped offline, affecting 10,956 customers for up to 15 minutes.
2. **January 25, 2015:** Underfrequency load shed event occurred when Keahole CT5 tripped offline, affecting 10,956 customers for up to 15 minutes.
3. **January 25, 2015:** Underfrequency load shed event occurred when Puna Plant tripped offline, affecting 5,935 customers for up to 5 minutes.
4. **January 26, 2015:** Underfrequency load shed event occurred when Hamakua Energy Partners tripped offline, affecting 10,956 customers for up to 10 minutes.
5. **May 3, 2015:** Underfrequency load shed event occurred when Keahole CT5 tripped offline, affecting 17,116 customers for up to 8 minutes.
6. **May 4, 2015:** Underfrequency load shed event occurred when Keahole CT5 and ST7 tripped offline, affecting 15,414 customers for up to 49 minutes.

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7. **November 6, 2015:** Underfrequency load shed event occurred when Keahole CT4 tripped offline, affecting 7,007 customers for up to 44 minutes.
8. **November 9, 2015:** Underfrequency load shed event occurred when Hill 5 tripped offline, affecting 7,007 customers for up to 6 minutes.

**Figure 2: Outage Categories**



The Top 5 Outage Categories, by number of customer interruption hours affected, as illustrated in Figure 2, equates to about 80% of the total Customer hours in 2015. These top outage causes are:

<u>Outage Category</u>	<u>Sample Causes</u>
1. Trees/Branches	Contact by vegetation regardless of what caused it to make contact
2. Deterioration	Failed, broken corroded equipment
3. Automobile Accidents	
4. System Add/Removal	System Upgrades/Improvements
5. Faulty Equipment Operation	HAWAII ELECTRIC LIGHT generation load shedding

The top two major cause factors for 2015 were exactly the same as 2014. The top 3<sup>rd</sup>, 4<sup>th</sup> and 5<sup>th</sup> major causes for 2015 were nearly the same in value and varied somewhat from 2014, whereas Automobile Accidents, Lightning and Cable Faults" were replaced by "System Add/Removal, Automobile Accidents and Faulty Equipment Operation."

A total of 228,540 Customer Interruptions were recorded for a total of 209,464 Customer Hours of Interruptions. The System Average Interruption Frequency (SAIF) index was 2.733 and the Customer Average Interruption Duration (CAID) was 54.99 minutes.

**Figure 3: Customer Average Interruption Duration Index (CAIDI)**

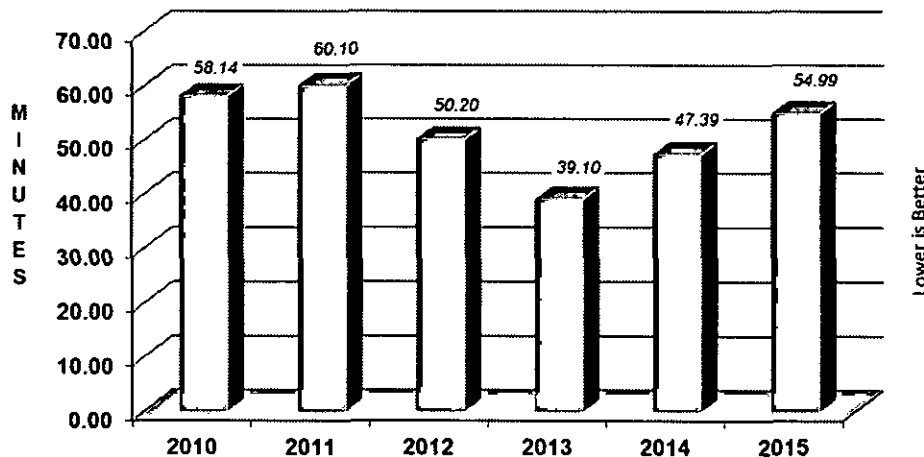


Figure 3 shows the Customer Average Interruption Duration Indices (CAIDI) for the past six years. The CAIDI for 2015 is 54.99 minutes, an 16% increase compared to the 2014 CAIDI result of 47.39 minutes. In the six year period, 2015 was the second highest year for CAIDI.

The largest contributing factor for the increase in the annual 2015 CAIDI was longer sustained outages due to trees and branches. In 2014, CAIDI caused by trees and branches was 95.92 minutes as compared to 104.70 minutes in 2015.

Three major events affecting the 2015 CAIDI results were:

1. July 30, 2015 – Tree bark was found on a 69kV insulator affecting 1,666 customers along the Hamakua coast area and caused a sustained outage of 4 hours and 12 minutes, since a crew had to be called out to remove bark. This incident added 1.44 minutes to the annual 2015 CAIDI.
2. November 11, 2015 – Hawi substation transformer was upgraded which

affected 983 customers in North Kohala and caused a sustained outage of 5 hours and 10 minutes. This incident added 1.36 minutes to the annual 2015 CAIDI.

3. May 25, 2015 – Broken strain insulator due to deterioration affected 1,385 customers in the Pahoa – Kalapana area and caused a sustained outage of 5 hours and 49 minutes. This incident added 1.11 minutes to the annual 2015 CAIDI.

**Figure 4: System Average Interruption  
Frequency Index (SAIFI)**

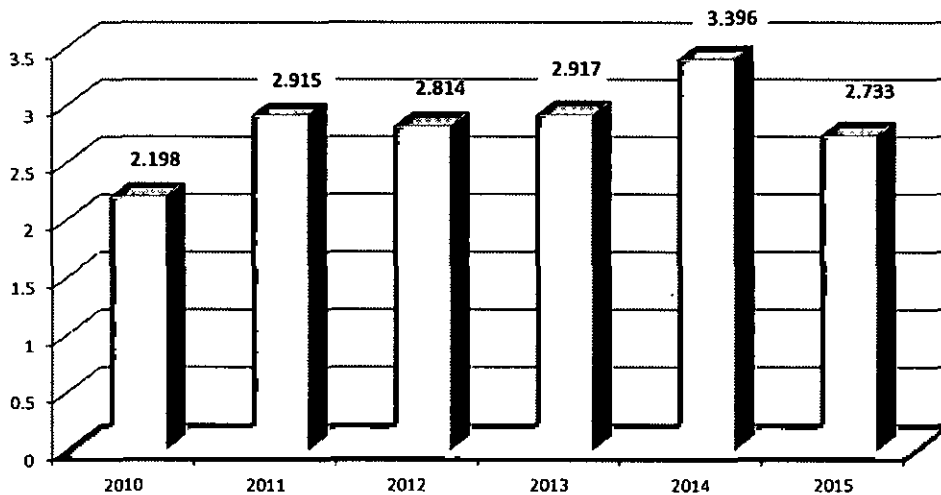


Figure 4 shows the System Average Interruption Frequency Index (SAIFI) decreased from 3.396 in 2014 to 2.733 in 2015. 2015 had the second lowest customer interruption occurrences of the past six years.

While underfrequency load shed events continue to be the leading cause of customer interruptions, the largest contributing factors for the annual 2015 SAIFI was the number of interruptions due to trees and branches. 2014 saw 48,949 customer interruptions related to trees and branches, compared to a decrease to 45,046 in 2015.

**Figure 5: Average Service Availability Index (ASAI)**

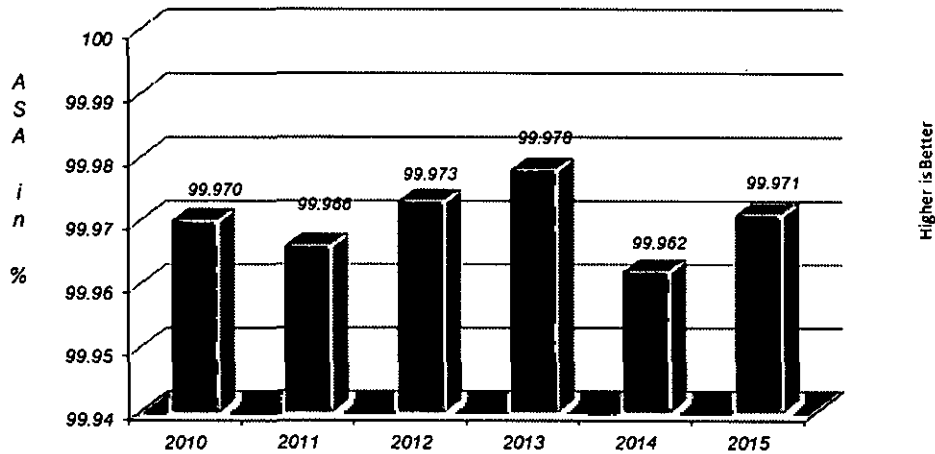


Figure 5 shows that the 2015 Average Service Availability Index was the third highest when compared to the prior five years. A decrease of customer-hour interruptions in 2015 shows a direct relationship to the increase of the ASAI in 2015. The top two SAIDI causes (as shown in above Figure 2), trees and branches, and deterioration, also account for the top two causes of customer-hour interruptions.

### 2015 SERVICE RELIABILITY SUMMARY Normalized

Cause of Outage	CUST-HRS	CUST-INT	SAIF	SAID	CAID	MAIF	SAID Rank
Faulty Equip Opn	12674.7	87781	1.050	9.09	8.66	0.031	5
Tree or Branches	78607.5	45046	0.539	56.40	104.70	0.509	1
Deterioration	44800.4	29134	0.348	32.15	92.26	0.218	2
Customer Equip	1108.6	10989	0.131	0.80	6.05	0.000	15
Lightning	12638.3	9646	0.115	9.07	78.61	0.909	6
Man or Animal	8878.1	8768	0.105	6.37	60.75	0.053	7
Auto Accident	12873.5	8616	0.103	9.24	89.65	0.155	4
Cable Fault	7844.2	4155	0.050	5.63	113.27	0.007	8
Other Persnl Err	1825.3	3914	0.047	1.31	27.98	0.000	13
Unknown	3810.0	3848	0.046	2.73	59.41	0.262	10
Opn or Sw Error	811.6	3640	0.044	0.58	13.38	0.000	16
Fire	1870.3	3196	0.038	1.34	35.11	0.031	12
Equip Failure	2002.9	2984	0.036	1.44	40.27	0.000	11
Sys Add/Removal	13027.3	2444	0.029	9.35	319.82	0.000	3
High Wind	1630.9	1893	0.023	1.17	51.69	0.000	14
Scheduled Maint	4146.3	1721	0.021	2.98	144.56	0.000	9
Tsf Failure	685.5	614	0.007	0.49	66.99	0.000	17
Forced Maint	35.3	35	0.000	0.03	60.57	0.000	20
Balloon/Kite	16.0	33	0.000	0.01	29.00	0.000	24
Balance Load	0.7	20	0.000	0.00	2.00	0.033	26
Equip Contact	26.0	19	0.000	0.02	82.11	0.010	22
Loose Connection	60.6	19	0.000	0.04	191.26	0.000	18
Excavate Constr	45.3	15	0.000	0.03	181.27	0.000	19
Transfer Load	27.0	6	0.000	0.02	270.00	0.000	21
Vandalism	16.4	3	0.000	0.01	327.00	0.000	23
Flood Tsunami	0.9	1	0.000	0.00	56.00	0.000	25
Foreign Objects	0.0	0	0.000	0.00	0.00	0.032	27
Flashover	0.0	0	0.000	0.00	0.00	0.000	28
Tsf Overload	0.0	0	0.000	0.00	0.00	0.000	29
Equip Overload	0.0	0	0.000	0.00	0.00	0.000	30
Customer Maint	0.0	0	0.000	0.00	0.00	0.000	31
<b>TOTALS</b>	<b>209463.8</b>	<b>228540</b>	<b>2.733</b>	<b>150.29</b>	<b>54.99</b>	<b>2.248</b>	

NUMBER OF CUSTOMERS FOR THE PERIOD = 83622

ASA = 99.971%

SAIF = SYSTEM AVERAGE INTERRUPTION FREQUENCY

SAID = SYSTEM AVERAGE INTERRUPTION DURATION

CAID = CUSTOMER AVERAGE INTERRUPTION DURATION

MAIF = MOMENTARY AVERAGE INTERRUPTION FREQUENCY

THE OUTAGE CAUSES ARE LISTED IN ORDER OF ITS SAIF

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## 2015 SYSTEM INTERRUPTION CAUSE REPORT Normalized

CAUSE		No. of Interruptions		Customer Hours	
<b>NON-CONNECTED SYSTEM</b>	(Totals)	641	30.51%	103470.3	49.40%
Tree or Branches		501	23.85%	78607.5	37.53%
Auto Accident		49	2.33%	12873.5	6.15%
Man or Animal		33	1.57%	8878.1	4.24%
Fire		20	0.95%	1870.3	0.89%
Customer Equip		19	0.90%	1108.6	0.53%
Excavate Constr		7	0.33%	45.3	0.02%
Equip Contact		5	0.24%	26.0	0.01%
Balloon/Kite		2	0.10%	16.0	0.01%
Vandalism		2	0.10%	16.4	0.01%
Balance Load		1	0.05%	0.7	0.00%
Transfer Load		1	0.05%	27.0	0.01%
Flood Tsunami		1	0.05%	0.9	0.00%
Foreign Objects		0	0.00%	0.0	0.00%
<b>ERROR</b>	(Totals)	34	1.62%	2636.9	1.26%
Other Persnl Err		26	1.24%	1825.3	0.87%
Opn or Sw Error		8	0.38%	811.6	0.39%
<b>WEATHER</b>	(Totals)	215	10.23%	14269.2	6.81%
Lightning		185	8.81%	12638.3	6.03%
High Wind		30	1.43%	1630.9	0.78%
<b>EQUIPMENT FAILURE</b>	(Totals)	486	23.13%	67382.8	32.17%
Deterioration		238	11.33%	44800.4	21.39%
Cable Fault		126	6.00%	7844.2	3.74%
Faulty Equip Opn		106	5.05%	12674.7	6.05%
Equip Failure		8	0.38%	2002.9	0.96%
Loose Connection		8	0.38%	60.6	0.03%
Flashover		0	0.00%	0.0	0.00%
Equip Overload		0	0.00%	0.0	0.00%
<b>TRANSFORMER FAILURE</b>	(Totals)	50	2.38%	685.5	0.33%
Tsf Failure		50	2.38%	685.5	0.33%
Tsf Overload		0	0.00%	0.0	0.00%
<b>UNKNOWN AFTER TESTS AND INSPECTIONS</b>	(Totals)	44	2.09%	3810.0	1.82%
Unknown		44	2.09%	3810.0	1.82%
<b>MAINTENANCE</b>	(Totals)	529	25.18%	4181.7	2.00%
Scheduled Maint		519	24.70%	4146.3	1.98%

## ATTACHMENT 2

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Hawai'i Electric Light Company, Inc.  
Annual Service Reliability Report 2015

Attachment A- Summaries

Forced Maint		10	0.48%	35.3	0.02%
<b>SYSTEM ADDITIONS OR REMOVALS</b>	(Totals)	102	4.85%	13027.3	6.22%
Sys Add/Removal		102	4.85%	13027.3	6.22%
TOTALS		2101		209463.8	

NOTES: OUTAGES WITH ZERO CUSTOMER HOURS OR DUE TO CUSTOMER MAINTENANCE ARE NOT INCLUDED IN THE REPORT.

## **DEFINITION OF TERMS**

### **OUTAGE**

The state of a component when it is not available to perform its intended function due to some event directly associated with that component. An outage may or may not cause an interruption of service to consumers depending on the system configuration.

### **INTERRUPTION**

The loss of service to one or more consumers and is a result of one or more component outages.

### **INTERRUPTION DURATION**

The period from the initiation of an interruption to a consumer until service has been restored to that consumer.

### **MOMENTARY INTERRUPTION**

An interruption that has a duration limited to the period required to restore service by automatic or supervisory-controlled switching operations or by manual switching at locations where an operator is immediately available. Such switching operations must be completed in a specific time not to exceed one minute. Previous issues of this report indicated that a momentary interruption has a duration not to exceed five minutes. A December 1990 report, "Methodology for Determining Reliability Indices for HAWAI'I ELECTRIC LIGHT Utilities" indicated that momentary interruptions will have duration of less than one minute.

### **SUSTAINED INTERRUPTION**

Any interruption not classified as a momentary interruption. Only this type of interruption is included in the reliability indices within this report. In conformance with the guidelines established in the report, "Methodology for Determining Reliability Indices for HAWAI'I ELECTRIC LIGHT Utilities," dated December 1990, a sustained interruption has duration of one minute or longer.

### **CUSTOMER INTERRUPTION**

One interruption of one customer.

NOTE: Interruptions to customers at their request (e.g., Customer Maintenance) are not considered.

Reliability indices used in this report conform to standards proposed by both the Edison Electric Institute (EEI) and the Institute of Electrical and Electronics Engineers (IEEE) unless otherwise indicated in the above definitions. Four reliability indices that convey a meaningful representation of the level of reliability were selected and are presented in this report. These reliability indices are as follows:

**RELIABILITY INDICES****AVERAGE SERVICE AVAILABILITY INDEX (ASA)**

Total customer hours actually served as a percentage of total customer hours possible during the year. This indicates the extent to which electrical service was available to all customers. This index has been commonly referred to as the "Index of Reliability." A customer-hour is calculated by multiplying the number of customers by the number of hours in the period being analyzed.

$$ASA = \frac{\sum \text{No. of Customer Hours Actually Served during the year}}{\sum \text{No. of Customer Hours Possible during the year}} \times 100\%$$

**SYSTEM AVERAGE INTERRUPTION FREQUENCY INDEX (SAIFI)**

The number of customer interruptions per customer served during the year. This index indicates the average number of sustained interruptions experienced by all customers serviced on the system.

$$SAIF = \frac{\sum \text{No. of Customer Interruptions Experienced during the year}}{\text{Average No. of Customers served during the year}}$$

**CUSTOMER AVERAGE INTERRUPTION DURATION INDEX (CAIDI)**

The interruption duration per customer interrupted during the year. This index indicates the average duration of an interruption for those customers affected by a sustained interruption.

$$CAID = \frac{\sum \text{Duration of Interruption} \times \text{No. of Customers affected}}{\sum \text{No. of Customer Interruptions Experienced for the year}}$$

**SYSTEM AVERAGE INTERRUPTION DURATION INDEX (SAIDI)**

The interruption duration per customer served during the year. This index indicates the average interruption time experienced by all customers serviced on the system.

$$SAID = \frac{\sum \text{Duration of Interruption} \times \text{No. of Customers Affected}}{\text{Average No. of Customers Served during the year}}$$

**MAUI ELECTRIC COMPANY, LIMITED**  
**ANNUAL SERVICE RELIABILITY REPORT**  
**2015**

Prepared by  
System Operations Department

August 18, 2016

## **INTRODUCTION**

This is the 2015 annual service reliability report for Maui Electric Company, Limited (MECO). The year-end average number of electric customers increased from 69,825 in 2014 to 70,303 in 2015 (a 0.68% increase). The 2015 peak demand for the system was 206.6 MW (gross) set on September 1, 2015, at 7:22pm, 11.7 MW higher than the peak demand of 194.9 MW (gross) set in 2014; the highest system peak demand remains at 210.9 MW (gross) set on October 11, 2004, at approximately 6:45 p.m.

The system interruption summaries (Attachments A and B) for the past year and the system reliability indices for the five prior years are presented to depict the quality of service provided to the electrical energy consumer.

Attachment C, contains the definition of terms and the reliability indices explanations and equations.

Indices measure reliability in terms of the overall availability of electrical service (ASAI), the frequency or number of times MECO's customers experience an outage during the year (SAIFI), the average length of time an interrupted customer is out of power (CAIDI), and the average length of time MECO's customers are out of power during the year (SAIDI). SAIDI is an indication of overall system reliability because it is the product of SAIFI and CAIDI and incorporates the impact of frequency and duration of outages on MECO's total customer base (in this case 70,303 customers).

## **ANALYSIS**

This analysis of the annual system reliability for MECO is for the year 2015. To determine the relative level of reliability, the statistics for five prior years, 2010 through 2014, are used for comparison.

The reliability indices are calculated using the data from all sustained<sup>1</sup> system outages except customer maintenance outages. If data normalization is required, it is done using the guidelines specified in the report on reliability that was prepared for the Public Utilities Commission, titled "Methodology for Determining Reliability Indices for HECO Utilities," dated December 1990. The guidelines indicate that normalization is allowed for "abnormal" situations such as hurricanes, tsunamis, earthquakes, floods, catastrophic equipment failures, and single outages that cascade into a loss of load greater than 10% of the system peak load. These normalizations are made in calculating the reliability indices because good engineering design takes into account safety, reliability, utility industry standards, and economics, and cannot always plan for catastrophic events.

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<sup>1</sup> An electrical service interruption of more than one minute (The majority of peer companies in the Edison Electric Institute association use a threshold of five minutes to identify sustained interruptions.)

## **2015 RESULTS**

### **Annual Service Reliability Indices**

The annual service reliability for 2015 was ranked last for SAIDI, CAIDI, SAIFI and ASA in comparison to the prior 5 years in terms of the indices for all events. The reliability results for all events in 2015 and five prior years are shown below in Table 1 through Table 4. The normalized reliability results in 2015 and five prior years are shown below in Table 5 through Table 8. The reliability results comparing T&D and generation related outages with all events in 2015 and five prior years are shown below in Table 9 through Table 16. The normalized reliability results comparing T&D and generation related outages in 2015 and five prior years are shown below in Table 17 through Table 24.

**Table 1: Annual Service Reliability Indices – All Islands with All Events**

	2010	2011	2012	2013	2014	2015
Number of Customers	67,405	68,010	68,575	69,303	69,825	70,303
Customer Interruptions	131,294	170,379	195,618	138,480	179,256	230,381
Customer-Hours Interrupted	103,416.1	210,185.7	248,500.5	221,000.3	219,243.8	534,259.8
SAIDI (Minutes)	92.05	185.43	217.43	191.33	188.39	455.96
CAIDI (Minutes)	47.26	74.02	76.22	95.75	73.38	139.14
SAIFI (Occurrence)	1.948	2.505	2.853	1.998	2.567	3.277
ASA (Percent)	99.9824%	99.9646%	99.9586%	99.9635%	99.9641%	99.9130%

**Table 2: Annual Service Reliability Indices – Maui with All Events**

	2010	2011	2012	2013	2014	2015
Number of Customers	62,640	63,225	63,745	64,397	64,909	65,390
Customer Interruptions	110,350	156,145	181,244	100,316	145,117	206,126
Customer-Hours Interrupted	70,072.9	194,603.0	199,620.7	171,316.7	167,244.6	505,698.0
SAIDI (Minutes)	67.12	184.68	187.89	159.62	154.60	464.01
CAIDI (Minutes)	38.10	74.78	66.08	102.47	69.15	147.20
SAIFI (Occurrence)	1.762	2.470	2.843	1.558	2.236	3.152
ASA (Percent)	99.9872%	99.9648%	99.9643%	99.9695%	99.9705%	99.9115%

**Table 3: Annual Service Reliability Indices – Molokai with All Events**

	2010	2011	2012	2013	2014	2015
Number of Customers	3,145	3,161	3,187	3,205	3,191	3,193
Customer Interruptions	18,473	8,018	12,171	33,224	21,114	18,192
Customer-Hours Interrupted	31,258.9	7,022.2	47,466.7	44,162.1	35,756.2	23,109.6
SAIDI (Minutes)	596.35	133.29	893.63	826.75	672.32	434.26
CAIDI (Minutes)	101.53	52.55	234.00	79.75	101.61	76.22
SAIFI (Occurrence)	5.874	2.537	3.819	10.366	6.617	5.697
ASA (Percent)	99.8862%	99.9746%	99.8300%	99.8423%	99.8717%	99.9172%

**Table 4: Annual Service Reliability Indices – Lanai with All Events**

	2010	2011	2012	2013	2014	2015
Number of Customers	1,621	1,624	1,643	1,702	1,724	1,720
Customer Interruptions	2,471	6,216	2,203	4,940	13,025	6,063
Customer-Hours Interrupted	2,084.3	8,560.4	1,413.1	5,521.5	16,243.1	5,452.1
SAIDI (Minutes)	77.15	316.27	51.60	194.65	565.30	190.19
CAIDI (Minutes)	50.61	82.63	38.49	67.06	74.82	53.95
SAIFI (Occurrence)	1.524	3.828	1.341	2.902	7.555	3.525
ASA (Percent)	99.9853%	99.9397%	99.9902%	99.9629%	99.8922%	99.9637%

**Table 5: Annual Service Reliability Indices - All Islands with Normalization**

	2010*	2011*	2012*	2013*	2014*	2015*
Number of Customers	67,405	68,010	68,575	69,303	69,825	70,303
Customer Interruptions	67,481	101,268	81,428	71,894	107,847	112,984
Customer-Hours Interrupted	60,006.6	145,710.8	125,836.1	108,360.7	120,684.7	177,063.2
SAIDI (Minutes)	53.41	128.55	110.10	93.81	103.70	151.11
CAIDI (Minutes)	53.35	86.33	92.72	90.43	67.14	94.03
SAIFI (Occurrence)	1.001	1.489	1.187	1.037	1.545	1.607
ASA (Percent)	99.9898%	99.9755%	99.9791%	99.9821%	99.9802%	99.9712%

**Table 6: Annual Service Reliability Indices - Maui with Normalization**

	2010*	2011*	2012*	2013*	2014*	2015*
Number of Customers	62,640	63,225	63,745	64,397	64,909	65,390
Customer Interruptions	65,654	99,729	77,968	64,459	102,328	104,287
Customer-Hours Interrupted	55,954.1	144,404.5	119,045.4	101,098.4	114,071.1	165,638.5
SAIDI (Minutes)	53.60	137.04	112.05	94.20	105.44	151.99
CAIDI (Minutes)	51.14	86.88	91.61	94.10	66.89	95.30
SAIFI (Occurrence)	1.048	1.577	1.223	1.001	1.576	1.595
ASA (Percent)	99.9898%	99.9739%	99.9787%	99.9820%	99.9799%	99.9710%

**Table 7: Annual Service Reliability Indices - Molokai with Normalization**

	2010*	2011*	2012*	2013*	2014*	2015*
Number of Customers	3,145	3,161	3,187	3,205	3,191	3,193
Customer Interruptions	1,498	1,252	3,229	6,180	4,064	8,159
Customer-Hours Interrupted	3,800.1	1,218.5	6,338.9	5,942.2	4,870.6	10,901.8
SAIDI (Minutes)	72.50	23.13	119.34	111.24	91.58	204.86
CAIDI (Minutes)	152.21	58.39	117.79	57.69	71.91	80.17
SAIFI (Occurrence)	0.476	0.396	1.013	1.928	1.274	2.555
ASA (Percent)	99.9862%	99.9956%	99.9773%	99.9788%	99.9825%	99.9609%

**Table 8: Annual Service Reliability Indices - Lanai with Normalization**

	2010*	2011*	2012*	2013*	2014*	2015*
Number of Customers	1,621	1,624	1,643	1,702	1,724	1,720
Customer Interruptions	329	287	231	1,255	1,455	538
Customer-Hours Interrupted	252.4	87.8	451.7	1,320.1	1,742.9	522.9
SAIDI (Minutes)	9.34	3.24	16.50	46.54	60.66	18.24
CAIDI (Minutes)	46.04	18.36	117.33	63.11	71.87	58.32
SAIFI (Occurrence)	0.203	0.177	0.141	0.737	0.844	0.313
ASA (Percent)	99.9982%	99.9994%	99.9969%	99.9911%	99.9884%	99.9965%

**NOTE:**

2010*	Data normalized to exclude the 03/28/10 – 04/01/2010 High Winds Data normalized to exclude the 06/7/10 Flashover Data normalized to exclude the 12/9/10 – 12/10/10 Kona Storm Data normalized to exclude various equipment failures and faults on Lanai and Molokai
2011*	Data normalized to exclude the 01/10/11 High Winds Data normalized to exclude the 01/12/11 – 01/14/11 High Winds and Lightning Storm Data normalized to exclude the 12/24/11 High Winds Data normalized to exclude various equipment failures and faults on Lanai and Molokai
2012*	Data normalized to exclude the 02/7/12 – 02/08/12 High Winds Data normalized to exclude the 09/5/12 Operator Error Data normalized to exclude the 11/6/12 Flashover Data normalized to exclude the 12/4/12 Substation Fire Data normalized to exclude various equipment failures and faults on Lanai and Molokai
2013*	Data normalized to exclude the 01/2/13 Trees in Transmission Lines Data normalized to exclude the 07/29/13 – 07/30/13 Tropical Storm Flossie Data normalized to exclude various equipment failures and faults on Lanai and Molokai
2014*	Data normalized to exclude the 5/9/14 Flashover on the Maalaea/Kihei 69KV Line Data normalized to exclude the 08/7/14 – 08/9/13 Tropical Storm Iselle Data normalized to exclude the 10/7/14 Equipment failure Data normalized to exclude various equipment failures and faults on Lanai and Molokai
2015*	Data normalized to exclude the 01/2/16 – 01/4/16 Kona Storm Data normalized to exclude the 02/13/16 - 02/15/16 Valentine's Day Storm Data normalized to exclude the 04/18/16 Equipment Failure Data normalized to exclude the 12/18/16 Equipment Failure Data normalized to exclude various equipment failures and faults on Lanai and Molokai

**T&D vs. Generation – All Events**

**Table 9: Annual Service Reliability Indices for All Islands – T&D**

	2010	2011	2012	2013	2014	2015
Number of Customers	67,405	68,010	68,575	69,303	69,825	70,303
Customer Interruptions	89,347	129,554	120,420	88,944	155,067	202,029
Customer-Hours Interrupted	82,311.0	188,364.0	182,315.6	186,857.1	198,535.5	516,408.0
SAIDI (Minutes)	73.27	166.18	159.52	161.77	170.60	440.73
CAIDI (Minutes)	55.28	87.24	90.84	126.05	76.82	153.37
SAIFI (Occurrence)	1.326	1.905	1.756	1.283	2.221	2.874
ASA (Percent)	99.9860%	99.9683%	99.9697%	99.9691%	99.9675%	99.9159%

**Table 10: Annual Service Reliability Indices for All Islands - Generation**

	2010	2011	2012	2013	2014	2015
Number of Customers	67,405	68,010	68,575	69,303	69,825	70,303
Customer Interruptions	41,947	40,825	75,198	49,536	24,189	28,352
Customer-Hours Interrupted	21,105.1	21,821.7	66,185.0	34,143.2	20,708.3	17,851.8
SAIDI (Minutes)	18.79	19.25	57.91	29.56	17.79	15.24
CAIDI (Minutes)	30.19	32.07	52.81	41.36	51.37	37.78
SAIFI (Occurrence)	0.622	0.600	1.097	0.715	0.346	0.403
ASA (Percent)	99.9964%	99.9963%	99.9890%	99.9944%	99.9966%	99.9971%

**Table 11: Annual Service Reliability Indices for Maui – T&D**

	2010	2011	2012	2013	2014	2015
Number of Customers	62,640	63,225	63,745	64,397	64,909	65,390
Customer Interruptions	80,270	121,962	109,200	73,357	131,670	185,303
Customer-Hours Interrupted	62,462.0	179,049.6	134,348.7	159,261.0	159,909.0	494,145.2
SAIDI (Minutes)	59.83	169.92	126.46	148.39	147.82	453.41
CAIDI (Minutes)	46.69	88.08	73.82	130.26	72.87	160.00
SAIFI (Occurrence)	1.281	1.929	1.713	1.139	2.029	2.834
ASA (Percent)	99.9886%	99.9676%	99.9759%	99.9717%	99.9718%	99.9135%

**Table 12: Annual Service Reliability Indices for Maui - Generation**

	2010	2011	2012	2013	2014	2015
Number of Customers	62,640	63,225	63,745	64,397	64,909	65,390
Customer Interruptions	30,080	34,183	72,044	26,959	13,447	20,823
Customer-Hours Interrupted	7,610.9	15,553.4	65,272.0	12,055.7	7,335.6	11,552.9
SAIDI (Minutes)	7.29	14.76	61.44	11.23	6.78	10.60
CAIDI (Minutes)	15.18	27.30	54.36	26.83	32.73	33.29
SAIFI (Occurrence)	0.48	0.541	1.130	0.419	0.207	0.318
ASA (Percent)	99.9986%	99.9972%	99.9883%	99.9979%	99.9987%	99.9980%

**Table 13: Annual Service Reliability Indices for Molokai – T&D**

	2010	2011	2012	2013	2014	2015
Number of Customers	3,145	3,161	3,187	3,205	3,191	3,193
Customer Interruptions	7,914	3,261	10,338	12,730	18,190	14,373
Customer-Hours Interrupted	19,294.9	2,753.4	47,081.8	23,428.8	32,789.8	19,414.8
SAIDI (Minutes)	368.11	52.26	886.38	438.60	616.54	364.82
CAIDI (Minutes)	146.28	50.66	273.25	110.43	108.16	81.05
SAIFI (Occurrence)	2.516	1.032	3.244	3.972	5.700	4.501
ASA (Percent)	99.9298%	99.9900%	99.8314%	99.9163%	99.8824%	99.9304%

**Table 14: Annual Service Reliability Indices for Molokai - Generation**

	2010	2011	2012	2013	2014	2015
Number of Customers	3,145	3,161	3,187	3,205	3,191	3,193
Customer Interruptions	10,559	4,757	1,833	20,494	2,924	3,819
Customer-Hours Interrupted	11,964.0	4,268.9	385.0	20,733.4	2,966.4	3,694.9
SAIDI (Minutes)	228.25	81.03	7.25	388.14	55.78	69.43
CAIDI (Minutes)	67.98	53.84	12.60	60.70	60.87	58.05
SAIFI (Occurrence)	3.357	1.505	0.575	6.394	0.916	1.196
ASA (Percent)	99.9565%	99.9845%	99.9986%	99.9259%	99.9894%	99.9868%

**Table 15: Annual Service Reliability Indices for Lanai – T&D**

	2010	2011	2012	2013	2014	2015
Number of Customers	1,621	1,624	1,643	1,702	1,724	1,720
Customer Interruptions	1,163	4,331	882	2,857	5,207	2,353
Customer-Hours Interrupted	554.1	6,561.0	885.1	4,167.4	5,836.8	2,848.0
SAIDI (Minutes)	20.51	242.40	32.32	146.91	203.14	99.35
CAIDI (Minutes)	28.59	90.89	60.21	87.52	67.26	72.62
SAIFI (Occurrence)	0.717	2.667	0.537	1.679	3.020	1.368
ASA (Percent)	99.9961%	99.9538%	99.9939%	99.9720%	99.9612%	99.9810%

**Table 16: Annual Service Reliability Indices for Lanai - Generation**

	2010	2011	2012	2013	2014	2015
Number of Customers	1,621	1,624	1,643	1,702	1,724	1,720
Customer Interruptions	1,308	1,885	1,321	2,083	7,818	3,710
Customer-Hours Interrupted	1,530.1	1,999.5	528.0	1,354.1	10,406.3	2,604.1
SAIDI (Minutes)	56.64	73.87	19.28	47.74	362.17	90.84
CAIDI (Minutes)	70.19	63.64	23.98	39.00	79.86	42.11
SAIFI (Occurrence)	0.807	1.161	0.804	1.224	4.535	2.157
ASA (Percent)	99.9892%	99.9859%	99.9963%	99.9909%	99.9309%	99.9827%

**T&D vs. Generation – With Normalization**

**Table 17: Normalized Annual Service Reliability Indices for All Islands – T&D**

	2010*	2011*	2012*	2013*	2014*	2015*
Number of Customers	67,405	68,010	68,575	69,303	69,825	70,303
Customer Interruptions	44,699	92,997	53,218	59,404	94,451	110,133
Customer-Hours Interrupted	53,754.4	139,223.9	111,142.1	101,339.0	113,310.1	172,681.4
SAIDI (Minutes)	47.85	122.83	97.24	87.74	97.37	147.37
CAIDI (Minutes)	72.16	89.82	125.31	102.36	71.98	94.08
SAIFI (Occurrence)	0.663	1.435	0.776	0.857	1.353	1.567
ASA (Percent)	99.9909%	99.9766%	99.9815%	99.9833%	99.9814%	99.9719%

**Table 18: Normalized Annual Service Reliability Indices for All Islands – Generation**

	2010*	2011*	2012*	2013*	2014*	2015*
Number of Customers	67,405	68,010	68,575	69,303	69,825	70,303
Customer Interruptions	22,782	8,271	28,210	12,490	13,396	2,851
Customer-Hours Interrupted	6,252.2	6,486.9	14,694.0	7,021.7	7,374.6	4,381.8
SAIDI (Minutes)	5.57	5.72	12.86	6.08	6.34	3.74
CAIDI (Minutes)	16.47	47.06	31.25	33.73	33.03	92.22
SAIFI (Occurrence)	0.338	0.054	0.411	0.180	0.192	0.041
ASA (Percent)	99.9989%	99.9989%	99.9976%	99.9988%	99.9988%	99.9993%

**Table 19: Normalized Annual Service Reliability Indices for Maui – T&D**

	2010*	2011*	2012*	2013*	2014*	2015*
Number of Customers	62,640	63,225	63,745	64,397	64,909	65,390
Customer Interruptions	42,938	91,828	50,306	54,680	89,101	101,454
Customer-Hours Interrupted	49,743.3	137,980.4	104,638.8	96,167.0	106,764.9	161,264.7
SAIDI (Minutes)	47.65	130.94	98.49	89.60	98.69	147.97
CAIDI (Minutes)	69.51	90.16	124.80	105.52	71.89	95.37
SAIFI (Occurrence)	0.685	1.452	0.789	0.849	1.373	1.552
ASA (Percent)	99.9909%	99.9800%	99.9813%	99.9829%	99.9812%	99.9718%

**Table 20: Normalized Annual Service Reliability Indices for Maui – Generation**

	2010*	2011*	2012*	2013*	2014*	2015*
Number of Customers	62,640	63,225	63,745	64,397	64,909	65,390
Customer Interruptions	22,716.0	7,901.0	27,662.0	9,779	13,227	2,833
Customer-Hours Interrupted	6,210.7	6,424.1	14,406.7	4,931.4	7,306.3	4,373.9
SAIDI (Minutes)	5.95	6.10	13.56	4.59	6.75	4.01
CAIDI (Minutes)	16.40	48.78	31.25	30.26	33.14	92.63
SAIFI (Occurrence)	0.363	0.125	0.434	0.152	0.204	0.043
ASA (Percent)	99.9989%	99.9988%	99.9974%	99.9991%	99.9987%	99.9992%

**Table 21: Normalized Annual Service Reliability Indices for Molokai – T&D**

	2010*	2011*	2012*	2013*	2014*	2015*
Number of Customers	3,145	3,161	3,187	3,205	3,191	3,193
Customer Interruptions	1,498	1,102	2,752	3,487	4,064	8,159
Customer-Hours Interrupted	3,800.1	1,163.5	6,067.0	3,856.5	4,870.6	10,901.8
SAIDI (Minutes)	72.50	22.08	114.22	72.20	91.58	204.86
CAIDI (Minutes)	152.21	63.35	132.27	66.36	71.91	80.17
SAIFI (Occurrence)	0.476	0.349	0.864	1.088	1.274	2.555
ASA (Percent)	99.9862%	99.9958%	99.9783%	99.9862%	99.9825%	99.9609%

**Table 22: Normalized Annual Service Reliability Indices for Molokai – Generation**

	2010*	2011*	2012*	2013*	2014*	2015*
Number of Customers	3,145	3,161	3,187	3,205	3,191	3,193
Customer Interruptions	0	150	477	2,693	0	0
Customer-Hours Interrupted	0.0	55.0	272.0	2,085.7	0.0	0.0
SAIDI (Minutes)	0.00	1.04	5.12	39.05	0.00	0.00
CAIDI (Minutes)	0.00	22.00	34.21	46.47	0.00	0.00
SAIFI (Occurrence)	0.000	0.047	0.150	0.840	0.000	0.000
ASA (Percent)	100.0000%	99.9998%	99.9990%	99.9926%	100.0000%	100.0000%

**Table 23: Normalized Annual Service Reliability Indices for Lanai – T&D**

	2010*	2011*	2012*	2013*	2014*	2015*
Number of Customers	1,621	1,624	1,643	1,702	1,724	1,720
Customer Interruptions	263	67	160	1,237	1,286	520
Customer-Hours Interrupted	211.0	80.0	436.3	1,315.6	1,674.7	515.0
SAIDI (Minutes)	7.81	2.96	15.93	46.38	58.28	17.96
CAIDI (Minutes)	48.13	71.66	163.61	63.81	78.13	59.42
SAIFI (Occurrence)	0.162	0.041	0.097	0.727	0.746	0.302
ASA (Percent)	99.9985%	99.9994%	99.9970%	99.9912%	99.9889%	99.9966%

**Table 24: Normalized Annual Service Reliability Indices for Lanai – Generation**

	2010*	2011*	2012*	2013*	2014*	2015*
Number of Customers	1,621	1,624	1,643	1,702	1,724	1,720
Customer Interruptions	66	220	71	18	169	18
Customer-Hours Interrupted	41.5	7.8	15.4	4.5	68.3	8.0
SAIDI (Minutes)	1.53	0.29	0.56	0.16	2.38	0.28
CAIDI (Minutes)	37.70	2.13	13.03	15.00	24.24	26.50
SAIFI (Occurrence)	0.041	0.135	0.043	0.011	0.098	0.010
ASA (Percent)	99.9997%	99.9999%	99.9999%	100.0000%	99.9995%	99.9999%

**Figure 1: System Average Interruption Duration Index (SAIDI)**

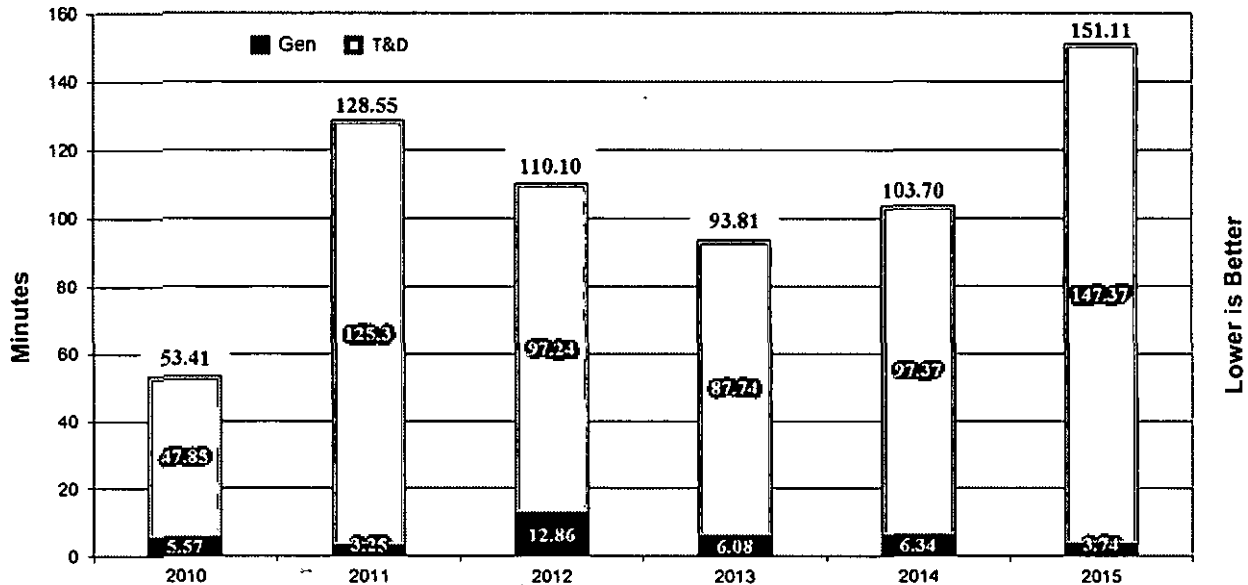


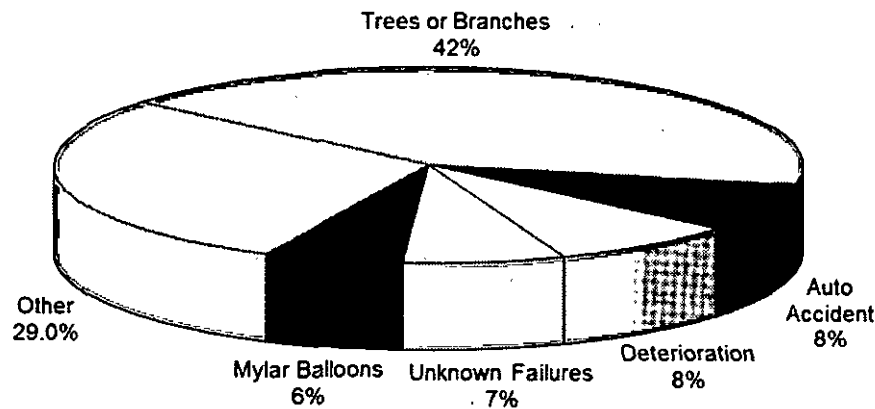
Figure 1 shows the System Average Interruption Duration Indices (SAIDI) for 2015 and the past five years. It shows that the 2015 SAIDI is 151.11 minutes, a 45.72% increase compared to the 2014 SAIDI result of 103.70 minutes. The SAIDI is a composite of both the SAIFI and CAIDI indices and produces a broader benchmark of system reliability by combining both the duration and the number of customer interruptions during a given period of time. The higher SAIDI result for 2015 was due to an increase in both the number of customer interruptions and the duration of the customer interruptions.

In 2015, there were five sustained outages that resulted in the loss of more than 5,000 customers:

1. **February 24, 2015:** Maui experienced a major outage event when the Hana 23KV line tripped due to a broken guy wire contacting the 23KV conductor affecting 7,221 customers for up to 2 hours 23 minutes.
2. **February 24, 2015:** Maui experienced a major outage event when the Hana 23KV line tripped due to a broken guy wire contacting the 23KV conductor affecting 6,651 customers for up to 58 minutes.
3. **September 26, 2015:** Maui experienced a major outage event when a Mylar balloon contacted primary conductors causing the Kihei Transformer #2 fuses to blow affecting 6,000 customers for up to 1 hour 21 minutes.
4. **November 20, 2015:** Maui experienced a major outage event when a vehicle struck and downed the pole for the Hana 23KV transmission line affecting 6,564 customers for up to 9 hours 3 minutes.
5. **November 22, 2015:** Maui experienced a major outage event due to bamboo falling on the conductors for the Hana 23KV transmission line affecting 6,564 customers for up to 1 hour 12 minutes.

These five events increased the 2015 SAIDI by 29.87 minutes.

**Figure 2: Top 5 Outage Categories**



The top 5 outage categories, by number of customer interruption hours, as illustrated in Figure 2, equates to about 71% of the total customer interruption hours in 2015; these causes are:

<u>Outage Category</u>	<u>Sample Causes</u>
1. Trees or Branches in Lines	Trees falling or contacting overhead lines
2. Automobile Accidents	Downed poles due to vehicles accidents
3. Deterioration, Rot, Corrosion, Termites	Failed or broken equipment due to corrosion
4. Unknown Failures	Outages without apparent cause
5. Mylar Balloons	Mylar balloons contacting conductors

The top 5 major cause factors for 2015, based on customer interruption hours, varied in comparison to 2014. While "Trees and Branches in Lines", "Automobile Accidents" and "Deterioration, Rot, Corrosion, Termites" remained in the top 5 causes, "Foreign Objects in Lines or Equipment" and "Equipment Failures" were replaced by "Unknown Failures" and "Mylar Balloons". The total number of customer interruption hours increased in 2015, which was 177,063.2 hours, compared with 120,684.7 hours in 2014. 2015 also had the highest number of customer interruption hours in the six year period.

The number of customer interruption hours for two major causes did decrease in 2015. These causes were "Automobile Accidents" and "Deterioration, Rot, Corrosion, Termites". The number of customer interruption hours due to "Automobile Accidents" decreased from 17,124.1 hours in 2014 to 13,393.8 hours in 2015 and the number of customer interruptions hours due to "Deterioration, Rot, Corrosion, Termites" decreased from 17,630.9 hours in 2014 to 13,320.0 hours in 2015.

However, the number of customer interruption hours for three major causes did increase in 2015. These causes were "Trees and Branches in Lines", "Unknown Failures" and "Mylar Balloons". The number of customer interruption hours due to "Trees and Branches in Lines" increased from 37,342.0 hours in 2014 to 73,417.3 hours in 2015, the number of customer interruption hours due to "Unknown Failures" increased from 5,465.6 hours in 2014 to 12,740.3 hours in 2015 and the number of customer interruption hours due to "Mylar Balloons" increased from 1.4 hours in 2014 to 11,171.8 hours in 2015.

**Figure 3: Customer Average Interruption Duration Index (CAIDI)**

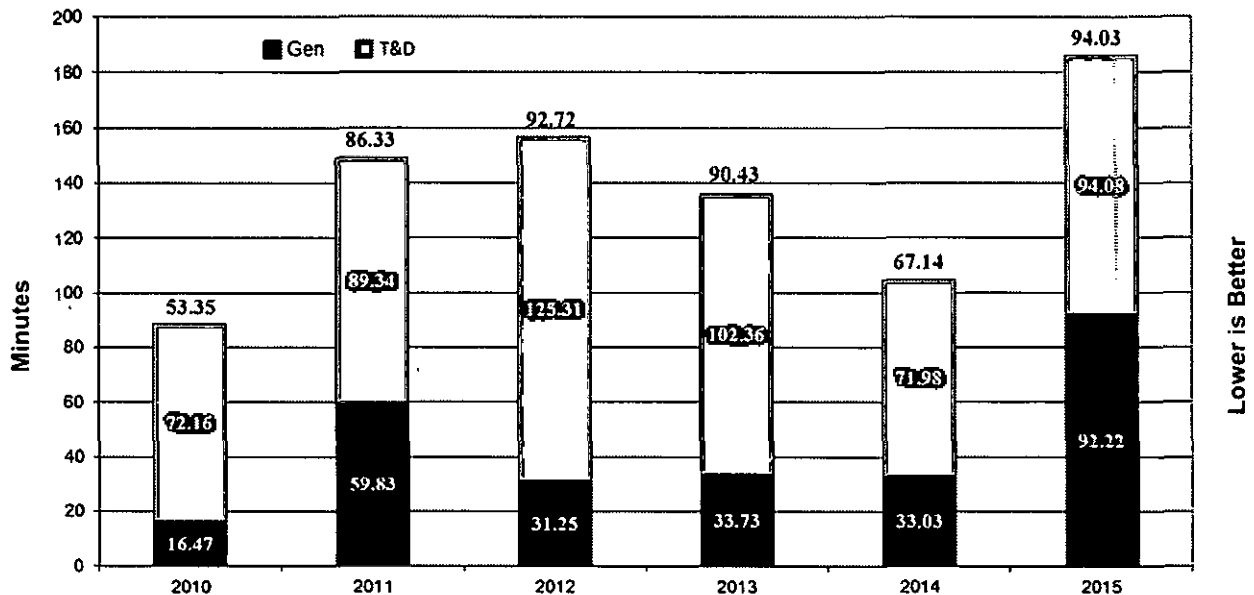


Figure 3 shows the Customer Average Interruption Duration Indices (CAIDI) for 2015 and the past five years. It shows that the average duration of a customer's outage (CAIDI) for 2015 is 94.03 minutes, a 40.05% increase compared to the 2014 CAIDI result of 67.14 minutes. In the six year period, 2015 was the worst performing year for CAIDI.

The contributing factor to the increase of the CAIDI index from 2014 was a greater number of customers being affected by longer outage durations related to interruptions due to "Trees or Branches in Lines", "Scheduled Maintenance" and "Mylar Balloons". The CAIDI for "Trees or Branches in Lines" increased in 2015, which incurred 149.68 minutes, as compared to 81.25 minutes in 2014. The CAIDI for "Scheduled Maintenance" increased in 2015, which incurred 189.94 minutes, as compared to 130.17 minutes in 2014 and the CAIDI for "Mylar Balloons" also increased in 2015, which incurred 83.69 minutes, as compared to 28.00 minutes in 2014.

The five major events affecting the 2015 CAIDI results were:

1. **May 31, 2015:** A Mylar balloon made contact with primary conductors affecting approximately 1,000 customers for 2 hours 58 minutes.
2. **September 14, 2015:** A prearranged outage on the Hana 23KV transmission line to replace various poles affecting 600 customers for 5 hours 53 minutes.
3. **October 5, 2015:** During a period of heavy rain, a tree fell onto the primary conductors affecting 1,910 customers for up to 14 hours 18 minutes.
4. **November 19, 2015:** During a period of heavy rain, tree branches made contact with the primary conductors affecting 1,473 customers for 7 hours 27 minutes.
5. **November 20, 2015:** During a period of heavy rain, tree branches made contact with the primary conductors affecting 2,289 customers for up to 11 hours 7 minutes.

These five events increased the 2015 CAIDI by 11.13 minutes.

**Figure 4: System Average Interruption Frequency Index (SAIFI)**

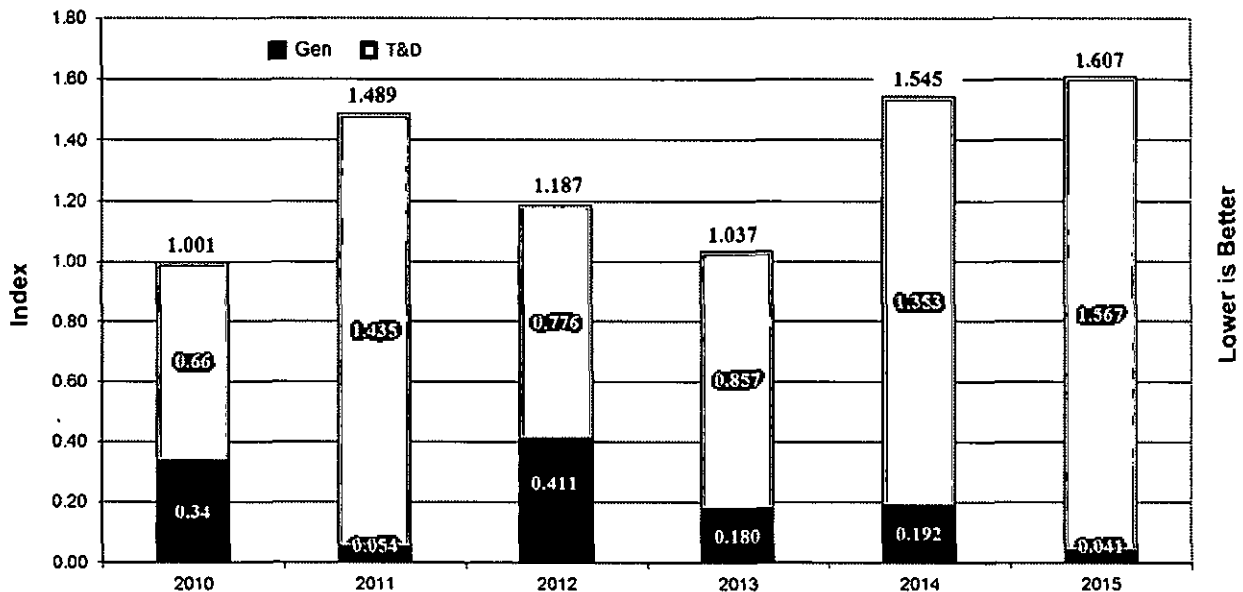


Figure 4 shows the System Average Interruption Frequency Index (SAIFI) for 2015 and the past five years. It shows that the 2015 SAIFI was 1.607, an increase of 4.01% compared to the 2014 SAIFI result of 1.545. The number of customer interruptions in 2015 was 112,984 as compared to 107,847 customer interruptions in 2014. In the past six years, 2015 had the most customer interruptions and was the worst performing year for SAIFI.

Maui Electric did see a decrease in customer interruptions due to outages caused by "Automobile Accidents", "Foreign Objects in Lines or Equipment" and "Equipment Failures", but these decreases were offset by higher customer interruptions due to other causes. The contributing factor to the increase of the 2015 SAIFI index from 2014 was from the rise in the number of customer interruptions especially related to "Unknown Failures", "Mylar Balloons" and "High Winds".

The number of customer interruptions due to "Unknown Failures" increased in 2015, which incurred 15,297 customer interruptions, as compared to 8,478 customer interruptions in 2014. The number of customer interruptions due to "Mylar Balloons" increased in 2015, which incurred 8,009 customer interruptions, as compared to 3 customer interruptions in 2014. The number of customer interruptions due to "High Winds" also increased in 2015, which incurred 10,224 customer interruptions, as compared to 3,035 customer interruptions in 2014.

**Figure 5: Average Service Availability Index (ASAI)**

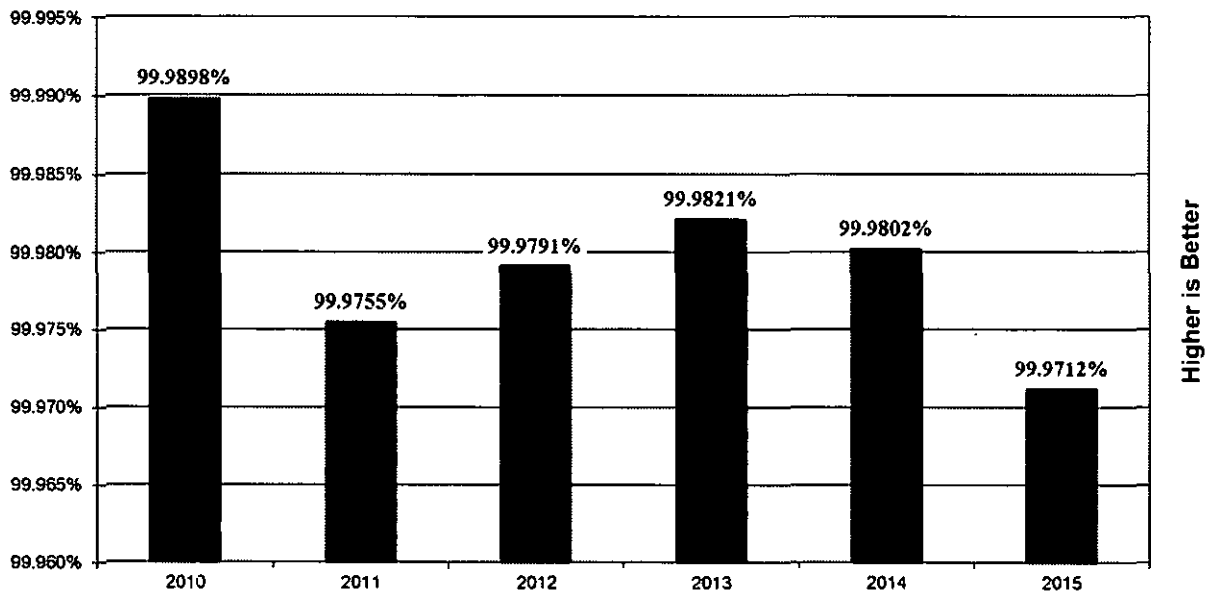


Figure 5 shows that the 2015 Average Service Availability Index decreased as compared to the 2014 results. It shows that the 2015 ASAI was 99.9712%, a decrease of 0.9181% compared to the 2014 ASAI result of 99.9802%. In the six year period, 2015 was the worst performing year for ASAI.

The ASAI is a percentage of the total number of customer hours that service was available to customers during the year compared to the total customer hours possible and produces a generalized standard of system reliability by combining both the durations and the number of customers affected. The contributing factor to the decrease of the ASAI in 2015 was an increase of both the number of customers interrupted and the durations of the interruptions. The total number of customer hour interruptions in 2015 was 177,063.2 hours as compared to 120,684.7 hours in 2014, an increase of 46.72%.

Attachment-A

**Maui Electric Company**  
**Normalized Sustained Interruption Summary – System Total**

FROM: JANUARY 1, 2015

TO: DECEMBER 31, 2015

Outage Cause	Customer Hours	Customer Interruptions	SAIFI	SAIDI	CAIDI
TREES OR BRANCHES IN LINES	73,417.3	29,429	0.419	62.66	149.68
AUTOMOBILE ACCIDENT	13,393.8	9,094	0.129	11.43	88.37
DETERIORATION, ROT, CORROSION, TERMITES	13,320.0	9,902	0.141	11.37	80.71
UNKNOWN FAILURE	12,740.3	15,297	0.218	10.87	49.97
MYLAR BALLOONS	11,171.8	8,009	0.114	9.53	83.69
HIGH WIND	10,540.8	10,224	0.145	9.00	61.86
CABLE FAULT	8,369.6	5,246	0.075	7.14	95.73
MAINTENANCE – SCHEDULED ON EXISTING SERVICE	8,265.5	2,611	0.037	7.05	189.94
MAINTENANCE - UNSCHEDULED ON EXISTING SERVICE	6,847.5	4,313	0.061	5.84	95.26
LIGHTNING	3,859.6	3,687	0.052	3.29	62.81
FLASHOVER	2,712.3	1,516	0.022	2.31	107.35
EQUIPMENT FAILURE	2,541.4	4,239	0.060	2.17	35.97
FOREIGN OBJECTS IN LINES OR EQUIPMENT	1,641.7	1,582	0.023	1.40	62.26
FAILURE OF CUSTOMER'S ELECTRICAL EQUIPMENT	1,513.0	1,396	0.020	1.29	65.03
EQUIPMENT OVERLOAD	1,483.4	748	0.011	1.27	118.99
OTHER COMPANY PERSONNEL ERROR	1,399.1	1,580	0.022	1.19	53.13
TRANSFORMER FAILURE OTHER THAN OVERLOAD	1,251.7	295	0.004	1.07	254.59
MAN OR ANIMALS IN LINES OR EQUIPMENT	1,219.3	698	0.010	1.04	104.81
CONTACT BY MOVING EQUIPMENT	1,156.9	1,626	0.023	0.99	42.69
NECESSARY INTERRUPTION TO BALANCE LOAD OR SYSTEM CONVERSION	106.6	814	0.012	0.09	7.86
OPERATOR OR SWITCHING ERROR	47.8	65	0.001	0.04	44.08
SYSTEM ADDITIONS OR REMOVALS ON NEW SERVICE/CUSTOMER	18.6	4	0.000	0.02	279.00
EXCAVATION AND CONSTRUCTION	13.6	12	0.000	0.01	68.00
NECESSARY INTERRUPTION TO TRANSFER LOAD (OUT OF PHASE)	9.4	566	0.008	0.01	1.00
TRANSFORMER OVERLOAD	8.9	10	0.000	0.01	53.50
FAULTY OPERATION OF EQUIPMENT	6.4	16	0.000	0.01	24.00
LOOSE CONNECTION	5.6	3	0.000	0.00	111.67
FIRE	1.4	2	0.000	0.00	42.00
VANDALISM	0.0	0	0.000	0.00	0.00
TSUNAMI, EARTHQUAKE, OR FLOODING	0.0	0	0.000	0.00	0.00
TOTAL	177,063.2	112,984	1.607	151.11	94.03

AVERAGE SYSTEM AVAILABILITY = 99.9712%  
NUMBER OF CUSTOMERS FOR THE PERIOD = 70,303  
24 MONTH ANNUALIZED SAIDI AVERAGE FOR THE PERIOD 1/1/2014 - 12/31/2015 = 127.41  
24 MONTH AVERAGE NUMBER OF CUSTOMERS FOR THE PERIOD 1/1/2014 - 12/31/2015 = 70,064  
SAIFI = SYSTEM AVERAGE INTERRUPTION FREQUENCY INDEX  
SAIDI = SYSTEM AVERAGE INTERRUPTION DURATION INDEX (MINUTES)  
CAIDI = CUSTOMER AVERAGE INTERRUPTION DURATION INDEX (MINUTES)

NOTES: OUTAGE CAUSES ARE LISTED IN ORDER OF SAIDI.  
OUTAGES WITH ZERO CUSTOMER HOURS OR DUE TO CUSTOMER MAINTENANCE ARE NOT INCLUDED IN THE REPORT.

Attachment-A

**Maui Electric Company**  
**Normalized Sustained Interruption Summary – Maui**

FROM: JANUARY 1, 2015

TO: DECEMBER 31, 2015

Outage Cause	Customer Hours	Customer Interruptions	SAIFI	SAIDI	CAIDI
TREES OR BRANCHES IN LINES	72,492.5	28,864	0.441	66.52	150.69
AUTOMOBILE ACCIDENT	12,752.4	8,952	0.137	11.70	85.47
UNKNOWN FAILURE	11,451.1	14,254	0.218	10.51	48.20
MYLAR BALLOONS	11,171.8	8,009	0.122	10.25	83.69
DETERIORATION, ROT, CORROSION, TERMITES	11,032.5	8,662	0.132	10.12	76.42
HIGH WIND	9,301.9	9,773	0.149	8.54	57.11
MAINTENANCE – SCHEDULED ON EXISTING SERVICE	8,211.9	2,590	0.040	7.54	190.24
CABLE FAULT	7,066.8	4,063	0.062	6.48	104.36
MAINTENANCE - UNSCHEDULED ON EXISTING SERVICE	6,780.3	4,144	0.063	6.22	98.17
LIGHTNING	3,859.6	3,687	0.056	3.54	62.81
FLASHOVER	2,712.3	1,516	0.023	2.49	107.35
EQUIPMENT FAILURE	2,516.4	4,218	0.065	2.31	35.79
FOREIGN OBJECTS IN LINES OR EQUIPMENT	1,528.8	1,440	0.022	1.40	63.70
EQUIPMENT OVERLOAD	1,479.3	740	0.011	1.36	119.95
FAILURE OF CUSTOMER'S ELECTRICAL EQUIPMENT	1,284.1	1,254	0.019	1.18	61.44
TRANSFORMER FAILURE OTHER THAN OVERLOAD	1,251.7	295	0.005	1.15	254.59
CONTACT BY MOVING EQUIPMENT	223.2	164	0.003	0.20	81.65
OTHER COMPANY PERSONNEL ERROR	213.7	112	0.002	0.20	114.49
NECESSARY INTERRUPTION TO BALANCE LOAD OR SYSTEM CONVERSION	106.6	814	0.012	0.10	7.86
MAN OR ANIMALS IN LINES OR EQUIPMENT	95.2	67	0.001	0.09	85.21
OPERATOR OR SWITCHING ERROR	42.4	56	0.001	0.04	45.43
SYSTEM ADDITIONS OR REMOVALS ON NEW SERVICE/CUSTOMER	18.6	4	0.000	0.02	279.00
EXCAVATION AND CONSTRUCTION	13.6	12	0.000	0.01	68.00
NECESSARY INTERRUPTION TO TRANSFER LOAD (OUT OF PHASE)	9.4	566	0.009	0.01	1.00
TRANSFORMER OVERLOAD	8.9	10	0.000	0.01	53.50
FAULTY OPERATION OF EQUIPMENT	6.4	16	0.000	0.01	24.00
LOOSE CONNECTION	5.6	3	0.000	0.01	111.67
FIRE	1.4	2	0.000	0.00	42.00
VANDALISM	0.0	0	0.000	0.00	0.00
TSUNAMI, EARTHQUAKE, OR FLOODING	0.0	0	0.000	0.00	0.00
TOTAL	165,638.5	104,287	1.595	151.99	95.30

AVERAGE SYSTEM AVAILABILITY = 99.9710%  
NUMBER OF CUSTOMERS FOR THE PERIOD = 65,390  
24 MONTH ANNUALIZED SAIDI AVERAGE FOR THE PERIOD 1/1/2014 - 12/31/2015 = 81.10  
24 MONTH AVERAGE NUMBER OF CUSTOMERS FOR THE PERIOD 1/1/2014 - 12/31/2015 = 65,150  
SAIFI = SYSTEM AVERAGE INTERRUPTION FREQUENCY INDEX  
SAIDI = SYSTEM AVERAGE INTERRUPTION DURATION INDEX (MINUTES)  
CAIDI = CUSTOMER AVERAGE INTERRUPTION DURATION INDEX (MINUTES)

NOTES: OUTAGE CAUSES ARE LISTED IN ORDER OF SAIDI.  
OUTAGES WITH ZERO CUSTOMER HOURS OR DUE TO CUSTOMER MAINTENANCE ARE NOT INCLUDED IN THE REPORT.

Attachment-A

**Maui Electric Company**  
**Normalized Sustained Interruption Summary – Molokai**

FROM: JANUARY 1, 2015

TO: DECEMBER 31, 2015

Outage Cause	Customer Hours	Customer Interruptions	SAIFI	SAIDI	CAIDI
DETERIORATION, ROT, CORROSION, TERMITES	2,263.7	1,225	0.384	42.54	110.87
UNKNOWN FAILURE	1,257.4	1,012	0.317	23.63	74.55
HIGH WIND	1,238.9	451	0.141	23.28	164.82
OTHER COMPANY PERSONNEL ERROR	1,176.4	1,462	0.458	22.11	48.28
MAN OR ANIMALS IN LINES OR EQUIPMENT	1,109.5	618	0.194	20.85	107.71
CABLE FAULT	988.3	921	0.288	18.57	64.38
CONTACT BY MOVING EQUIPMENT	933.7	1,462	0.458	17.54	38.32
TREES OR BRANCHES IN LINES	924.8	565	0.177	17.38	98.21
AUTOMOBILE ACCIDENT	641.4	142	0.044	12.05	271.00
FAILURE OF CUSTOMER'S ELECTRICAL EQUIPMENT	228.8	142	0.044	4.30	96.69
FOREIGN OBJECTS IN LINES OR EQUIPMENT	112.8	142	0.044	2.12	47.68
EQUIPMENT FAILURE	22.4	12	0.004	0.42	112.00
EQUIPMENT OVERLOAD	3.8	5	0.002	0.07	46.00
FIRE	0.0	0	0.000	0.00	0.00
EXCAVATION AND CONSTRUCTION	0.0	0	0.000	0.00	0.00
LIGHTNING	0.0	0	0.000	0.00	0.00
LOOSE CONNECTION	0.0	0	0.000	0.00	0.00
FLASHOVER	0.0	0	0.000	0.00	0.00
TRANSFORMER FAILURE OTHER THAN OVERLOAD	0.0	0	0.000	0.00	0.00
TRANSFORMER OVERLOAD	0.0	0	0.000	0.00	0.00
VANDALISM	0.0	0	0.000	0.00	0.00
FAULTY OPERATION OF EQUIPMENT	0.0	0	0.000	0.00	0.00
OPERATOR OR SWITCHING ERROR	0.0	0	0.000	0.00	0.00
TSUNAMI, EARTHQUAKE, OR FLOODING	0.0	0	0.000	0.00	0.00
NECESSARY INTERRUPTION TO TRANSFER LOAD (OUT OF PHASE)	0.0	0	0.000	0.00	0.00
NECESSARY INTERRUPTION TO BALANCE LOAD OR SYSTEM CONVERSION	0.0	0	0.000	0.00	0.00
MAINTENANCE – SCHEDULED ON EXISTING SERVICE	0.0	0	0.000	0.00	0.00
MAINTENANCE - UNSCHEDULED ON EXISTING SERVICE	0.0	0	0.000	0.00	0.00
SYSTEM ADDITIONS OR REMOVALS ON NEW SERVICE/CUSTOMER	0.0	0	0.000	0.00	0.00
MYLAR BALLOONS	0.0	0	0.000	0.00	0.00
TOTAL	10,901.8	8,159	2.555	204.86	80.17

AVERAGE SYSTEM AVAILABILITY = 99.9609%  
NUMBER OF CUSTOMERS FOR THE PERIOD = 3,193  
24 MONTH ANNUALIZED SAIDI AVERAGE FOR THE PERIOD 1/1/2014 - 12/31/2015 = 148.22  
24 MONTH AVERAGE NUMBER OF CUSTOMERS FOR THE PERIOD 1/1/2014 - 12/31/2015 = 3,192  
SAIFI = SYSTEM AVERAGE INTERRUPTION FREQUENCY INDEX  
SAIDI = SYSTEM AVERAGE INTERRUPTION DURATION INDEX (MINUTES)  
CAIDI = CUSTOMER AVERAGE INTERRUPTION DURATION INDEX (MINUTES)

NOTES: OUTAGE CAUSES ARE LISTED IN ORDER OF SAIDI.  
OUTAGES WITH ZERO CUSTOMER HOURS OR DUE TO CUSTOMER MAINTENANCE ARE NOT INCLUDED IN THE REPORT.

Attachment-A

**Maui Electric Company  
Normalized Sustained Interruption Summary – Lanai**

**FROM:** JANUARY 1, 2015

**TO:** DECEMBER 31, 2015

<b>Outage Cause</b>	<b>Customer Hours</b>	<b>Customer Interruptions</b>	<b>SAIFI</b>	<b>SAIDI</b>	<b>CAIDI</b>
CABLE FAULT	314.5	262	0.152	10.97	72.03
MAINTENANCE - UNSCHEDULED ON EXISTING SERVICE	67.2	169	0.098	2.35	23.87
MAINTENANCE – SCHEDULED ON EXISTING SERVICE	53.6	21	0.012	1.87	153.10
UNKNOWN FAILURE	31.9	31	0.018	1.11	61.74
DETERIORATION, ROT, CORROSION, TERMITES	23.9	15	0.009	0.83	95.53
MAN OR ANIMALS IN LINES OR EQUIPMENT	14.7	13	0.008	0.51	67.62
OTHER COMPANY PERSONNEL ERROR	9.0	6	0.003	0.31	90.00
OPERATOR OR SWITCHING ERROR	5.4	9	0.005	0.19	35.67
EQUIPMENT FAILURE	2.6	9	0.005	0.09	17.33
EQUIPMENT OVERLOAD	0.2	3	0.002	0.01	4.00
AUTOMOBILE ACCIDENT	0.0	0	0.000	0.00	0.00
FOREIGN OBJECTS IN LINES OR EQUIPMENT	0.0	0	0.000	0.00	0.00
FIRE	0.0	0	0.000	0.00	0.00
CONTACT BY MOVING EQUIPMENT	0.0	0	0.000	0.00	0.00
EXCAVATION AND CONSTRUCTION	0.0	0	0.000	0.00	0.00
TREES OR BRANCHES IN LINES	0.0	0	0.000	0.00	0.00
LIGHTNING	0.0	0	0.000	0.00	0.00
HIGH WIND	0.0	0	0.000	0.00	0.00
LOOSE CONNECTION	0.0	0	0.000	0.00	0.00
FLASHOVER	0.0	0	0.000	0.00	0.00
TRANSFORMER FAILURE OTHER THAN OVERLOAD	0.0	0	0.000	0.00	0.00
TRANSFORMER OVERLOAD	0.0	0	0.000	0.00	0.00
VANDALISM	0.0	0	0.000	0.00	0.00
FAULTY OPERATION OF EQUIPMENT	0.0	0	0.000	0.00	0.00
FAILURE OF CUSTOMER'S ELECTRICAL EQUIPMENT	0.0	0	0.000	0.00	0.00
TSUNAMI, EARTHQUAKE, OR FLOODING	0.0	0	0.000	0.00	0.00
NECESSARY INTERRUPTION TO TRANSFER LOAD (OUT OF PHASE)	0.0	0	0.000	0.00	0.00
NECESSARY INTERRUPTION TO BALANCE LOAD OR SYSTEM CONVERSION	0.0	0	0.000	0.00	0.00
SYSTEM ADDITIONS OR REMOVALS ON NEW SERVICE/CUSTOMER	0.0	0	0.000	0.00	0.00
MYLAR BALLOONS	0.0	0	0.000	0.00	0.00
<b>TOTAL</b>	<b>522.9</b>	<b>538</b>	<b>0.313</b>	<b>18.24</b>	<b>58.32</b>

AVERAGE SYSTEM AVAILABILITY = 99.9965%  
 NUMBER OF CUSTOMERS FOR THE PERIOD = 1,720  
 24 MONTH ANNUALIZED SAIDI AVERAGE FOR THE PERIOD 1/1/2014 - 12/31/2015 = 39.45  
 24 MONTH AVERAGE NUMBER OF CUSTOMERS FOR THE PERIOD 1/1/2014 - 12/31/2015 = 1,722  
 SAIFI = SYSTEM AVERAGE INTERRUPTION FREQUENCY INDEX  
 SAIDI = SYSTEM AVERAGE INTERRUPTION DURATION INDEX (MINUTES)  
 CAIDI = CUSTOMER AVERAGE INTERRUPTION DURATION INDEX (MINUTES)

**NOTES:** OUTAGE CAUSES ARE LISTED IN ORDER OF SAIDI.  
 OUTAGES WITH ZERO CUSTOMER HOURS OR DUE TO CUSTOMER MAINTENANCE ARE NOT INCLUDED IN THE REPORT.

Attachment-B

**Maui Electric Company**  
**Normalized Sustained Interruption Summary – System Total**

FROM: JANUARY 1, 2015 TO: DECEMBER 31, 2015

Outage Cause	Interruptions		Customer Hours	
	Number	% of Total	Number	% of Total
<u>NON-CONNECTED SYSTEM EMERGENCY</u>	187	23.23%	103528.7	58.5%
FOREIGN OBJECTS IN LINES OR EQUIPMENT	5	0.62%	1641.7	0.9%
CONTACT BY MOVING EQUIPMENT	6	0.75%	1156.9	0.7%
EXCAVATION AND CONSTRUCTION	1	0.12%	13.6	0.0%
FIRE	1	0.12%	1.4	0.0%
AUTOMOBILE ACCIDENT	12	1.49%	13393.8	7.6%
MAN OR ANIMAL IN LINES	13	1.61%	1219.3	0.7%
TREES OR BRANCHES IN LINES	140	17.39%	73417.3	41.5%
VANDALISM	0	0.00%	0.0	0.0%
FAILURE OF CUSTOMER'S ELECTRICAL EQUIPMENT	4	0.50%	1513.0	0.9%
MYLAR BALLOONS	5	0.62%	11171.8	6.3%
<u>ERROR</u>	10	1.24%	1446.9	0.8%
OPERATOR OR SWITCHING ERROR	4	0.50%	47.8	0.0%
OTHER COMPANY PERSONNEL ERROR	6	0.75%	1399.1	0.8%
<u>WEATHER</u>	40	4.97%	14400.4	8.1%
LIGHTNING	20	2.48%	3859.6	2.2%
HIGH WIND	20	2.48%	10540.8	6.0%
TSUNAMI, EARTHQUAKE OR FLOODING	0	0.00%	0.0	0.0%
<u>NON-TRANSFORMER EQUIPMENT FAILURE</u>	206	25.59%	28438.7	16.1%
LOOSE CONNECTION	2	0.25%	5.6	0.0%
FLASHOVER	4	0.50%	2712.3	1.5%
EQUIPMENT FAILURE	16	1.99%	2541.4	1.4%
CABLE FAULT	83	10.31%	8369.6	4.7%
EQUIPMENT OVERLOAD	4	0.50%	1483.4	0.8%
DETERIORATION, CORROSION OR TERMITES	96	11.93%	13320.0	7.5%
FAULTY OPERATION OF EQUIPMENT	1	0.12%	6.4	0.0%
<u>TRANSFORMER</u>	29	3.60%	1260.6	0.7%
TRANSFORMER OVERLOAD	2	0.25%	8.9	0.0%
TRANSFORMER FAILURE	27	3.35%	1251.7	0.7%
<u>SWITCHING</u>	4	0.50%	116.0	0.1%
NECESSARY INTERRUPTION TO TRANSFER LOAD (OUT OF PHASE)	1	0.12%	9.4	0.0%
NECESSARY INTERRUPTION TO BALANCE LOAD OR SYSTEM CONVERSION	3	0.37%	106.6	0.1%
<u>UNKNOWN</u>	41	5.09%	12740.3	7.2%
<u>MAINTENANCE</u>	287	35.65%	15113.0	8.5%
SCHEDULED ON EXISTING SERVICE	244	30.31%	8265.5	4.7%
UNSCHEDULED ON EXISTING SERVICE	43	5.34%	6847.5	3.9%
<u>SYSTEM ADDITIONS OR REMOVALS ON NEW SERVICE/CUSTOMER</u>	1	0.12%	18.6	0.0%
<u>TOTALS</u>	805		177063.2	

NOTES: OUTAGES WITH ZERO CUSTOMER HOURS OR DUE TO CUSTOMER MAINTENANCE ARE NOT INCLUDED IN THE REPORT.

Attachment-B

**Maui Electric Company**  
**Normalized Sustained Interruption Summary – Maui**

FROM: JANUARY 1, 2015 TO: DECEMBER 31, 2015

Outage Cause	Interruptions		Customer Hours	
	Number	% of Total	Number	% of Total
<u>NON-CONNECTED SYSTEM EMERGENCY</u>	176	23.53%	99563.1	60.1%
FOREIGN OBJECTS IN LINES OR EQUIPMENT	4	0.53%	1528.8	0.9%
CONTACT BY MOVING EQUIPMENT	5	0.67%	223.2	0.1%
EXCAVATION AND CONSTRUCTION	1	0.13%	13.6	0.0%
FIRE	1	0.13%	1.4	0.0%
AUTOMOBILE ACCIDENT	11	1.47%	12752.4	7.7%
MAN OR ANIMAL IN LINES	9	1.20%	95.2	0.1%
TREES OR BRANCHES IN LINES	137	18.32%	72492.5	43.8%
VANDALISM	0	0.00%	0.0	0.0%
FAILURE OF CUSTOMER'S ELECTRICAL EQUIPMENT	3	0.40%	1284.1	0.8%
MYLAR BALLOONS	5	0.67%	11171.8	6.7%
<u>ERROR</u>	7	0.94%	256.1	0.2%
OPERATOR OR SWITCHING ERROR	3	0.40%	42.4	0.0%
OTHER COMPANY PERSONNEL ERROR	4	0.53%	213.7	0.1%
<u>WEATHER</u>	38	5.08%	13161.5	7.9%
LIGHTNING	20	2.67%	3859.6	2.3%
HIGH WIND	18	2.41%	9301.9	5.6%
TSUNAMI, EARTHQUAKE OR FLOODING	0	0.00%	0.0	0.0%
<u>NON-TRANSFORMER EQUIPMENT FAILURE</u>	183	24.47%	24819.3	15.0%
LOOSE CONNECTION	2	0.27%	5.6	0.0%
FLASHOVER	4	0.53%	2712.3	1.6%
EQUIPMENT FAILURE	13	1.74%	2516.4	1.5%
CABLE FAULT	79	10.56%	7066.8	4.3%
EQUIPMENT OVERLOAD	2	0.27%	1479.3	0.9%
DETERIORATION, CORROSION OR TERMITES	82	10.96%	11032.5	6.7%
FAULTY OPERATION OF EQUIPMENT	1	0.13%	6.4	0.0%
<u>TRANSFORMER</u>	29	3.88%	1260.6	0.8%
TRANSFORMER OVERLOAD	2	0.27%	8.9	0.0%
TRANSFORMER FAILURE	27	3.61%	1251.7	0.8%
<u>SWITCHING</u>	4	0.53%	116.0	0.1%
NECESSARY INTERRUPTION TO TRANSFER LOAD (OUT OF PHASE)	1	0.13%	9.4	0.0%
NECESSARY INTERRUPTION TO BALANCE LOAD OR SYSTEM CONVERSION	3	0.40%	106.6	0.1%
<u>UNKNOWN</u>	31	4.14%	11451.1	6.9%
<u>MAINTENANCE</u>	279	37.30%	14992.2	9.1%
SCHEDULED ON EXISTING SERVICE	240	32.09%	8211.9	5.0%
UNSCHEDULED ON EXISTING SERVICE	39	5.21%	6780.3	4.1%
<u>SYSTEM ADDITIONS OR REMOVALS ON NEW SERVICE/CUSTOMER</u>	1	0.13%	18.6	0.0%
<u>TOTALS</u>	748		165638.5	

NOTES: OUTAGES WITH ZERO CUSTOMER HOURS OR DUE TO CUSTOMER MAINTENANCE ARE NOT INCLUDED IN THE REPORT.

Attachment-B

**Maui Electric Company**  
**Normalized Sustained Interruption Summary – Molokai**

FROM: JANUARY 1, 2015 TO: DECEMBER 31, 2015

Outage Cause	Interruptions		Customer Hours	
	Number	% of Total	Number	% of Total
<u>NON-CONNECTED SYSTEM EMERGENCY</u>	9	27.27%	3951.0	36.2%
FOREIGN OBJECTS IN LINES OR EQUIPMENT	1	3.03%	112.8	1.0%
CONTACT BY MOVING EQUIPMENT	1	3.03%	933.7	8.6%
EXCAVATION AND CONSTRUCTION	0	0.00%	0.0	0.0%
FIRE	0	0.00%	0.0	0.0%
AUTOMOBILE ACCIDENT	1	3.03%	641.4	5.9%
MAN OR ANIMAL IN LINES	2	6.06%	1109.5	10.2%
TREES OR BRANCHES IN LINES	3	9.09%	924.8	8.5%
VANDALISM	0	0.00%	0.0	0.0%
FAILURE OF CUSTOMER'S ELECTRICAL EQUIPMENT	1	3.03%	228.8	2.1%
MYLAR BALLOONS	0	0.00%	0.0	0.0%
<u>ERROR</u>	1	3.03%	1176.4	10.8%
OPERATOR OR SWITCHING ERROR	0	0.00%	0.0	0.0%
OTHER COMPANY PERSONNEL ERROR	1	3.03%	1176.4	10.8%
<u>WEATHER</u>	2	6.06%	1238.9	11.4%
LIGHTNING	0	0.00%	0.0	0.0%
HIGH WIND	2	6.06%	1238.9	11.4%
TSUNAMI, EARTHQUAKE OR FLOODING	0	0.00%	0.0	0.0%
<u>NON-TRANSFORMER EQUIPMENT FAILURE</u>	15	45.45%	3278.2	30.1%
LOOSE CONNECTION	0	0.00%	0.0	0.0%
FLASHOVER	0	0.00%	0.0	0.0%
EQUIPMENT FAILURE	1	3.03%	22.4	0.2%
CABLE FAULT	3	9.09%	988.3	9.1%
EQUIPMENT OVERLOAD	1	3.03%	3.8	0.0%
DETERIORATION, CORROSION OR TERMITES	10	30.30%	2263.7	20.8%
FAULTY OPERATION OF EQUIPMENT	0	0.00%	0.0	0.0%
<u>TRANSFORMER</u>	0	0.00%	0.0	0.0%
TRANSFORMER OVERLOAD	0	0.00%	0.0	0.0%
TRANSFORMER FAILURE	0	0.00%	0.0	0.0%
<u>SWITCHING</u>	0	0.00%	0.0	0.0%
NECESSARY INTERRUPTION TO TRANSFER LOAD (OUT OF PHASE)	0	0.00%	0.0	0.0%
NECESSARY INTERRUPTION TO BALANCE LOAD OR SYSTEM CONVERSION	0	0.00%	0.0	0.0%
<u>UNKNOWN</u>	6	18.18%	1257.4	11.5%
<u>MAINTENANCE</u>	0	0.00%	0.0	0.0%
SCHEDULED ON EXISTING SERVICE	0	0.00%	0.0	0.0%
UNSCHEDULED ON EXISTING SERVICE	0	0.00%	0.0	0.0%
<u>SYSTEM ADDITIONS OR REMOVALS ON NEW SERVICE/CUSTOMER</u>	0	0.00%	0.0	0.0%
<u>TOTALS</u>	33		10901.8	

NOTES: OUTAGES WITH ZERO CUSTOMER HOURS OR DUE TO CUSTOMER MAINTENANCE ARE NOT INCLUDED IN THE REPORT.

Attachment-B

**Maui Electric Company**  
**Normalized Sustained Interruption Summary – Lanai**

FROM: JANUARY 1, 2015 TO: DECEMBER 31, 2015

Outage Cause	Interruptions		Customer Hours	
	Number	% of Total	Number	% of Total
<u>NON-CONNECTED SYSTEM EMERGENCY</u>	2	8.33%	14.7	2.8%
FOREIGN OBJECTS IN LINES OR EQUIPMENT	0	0.00%	0.0	0.0%
CONTACT BY MOVING EQUIPMENT	0	0.00%	0.0	0.0%
EXCAVATION AND CONSTRUCTION	0	0.00%	0.0	0.0%
FIRE	0	0.00%	0.0	0.0%
AUTOMOBILE ACCIDENT	0	0.00%	0.0	0.0%
MAN OR ANIMAL IN LINES	2	8.33%	14.7	2.8%
TREES OR BRANCHES IN LINES	0	0.00%	0.0	0.0%
VANDALISM	0	0.00%	0.0	0.0%
FAILURE OF CUSTOMER'S ELECTRICAL EQUIPMENT	0	0.00%	0.0	0.0%
MYLAR BALLOONS	0	0.00%	0.0	0.0%
<u>ERROR</u>	2	8.33%	14.4	2.7%
OPERATOR OR SWITCHING ERROR	1	4.17%	5.4	1.0%
OTHER COMPANY PERSONNEL ERROR	1	4.17%	9.0	1.7%
<u>WEATHER</u>	0	0.00%	0.0	0.0%
LIGHTNING	0	0.00%	0.0	0.0%
HIGH WIND	0	0.00%	0.0	0.0%
TSUNAMI, EARTHQUAKE OR FLOODING	0	0.00%	0.0	0.0%
<u>NON-TRANSFORMER EQUIPMENT FAILURE</u>	8	33.33%	341.2	65.3%
LOOSE CONNECTION	0	0.00%	0.0	0.0%
FLASHOVER	0	0.00%	0.0	0.0%
EQUIPMENT FAILURE	2	8.33%	2.6	0.5%
CABLE FAULT	1	4.17%	314.5	60.1%
EQUIPMENT OVERLOAD	1	4.17%	0.2	0.0%
DETERIORATION, CORROSION OR TERMITES	4	16.67%	23.9	4.6%
FAULTY OPERATION OF EQUIPMENT	0	0.00%	0.0	0.0%
<u>TRANSFORMER</u>	0	0.00%	0.0	0.0%
TRANSFORMER OVERLOAD	0	0.00%	0.0	0.0%
TRANSFORMER FAILURE	0	0.00%	0.0	0.0%
<u>SWITCHING</u>	0	0.00%	0.0	0.0%
NECESSARY INTERRUPTION TO TRANSFER LOAD (OUT OF PHASE)	0	0.00%	0.0	0.0%
NECESSARY INTERRUPTION TO BALANCE LOAD OR SYSTEM CONVERSION	0	0.00%	0.0	0.0%
<u>UNKNOWN</u>	4	16.67%	31.9	6.1%
<u>MAINTENANCE</u>	8	33.33%	120.8	23.1%
SCHEDULED ON EXISTING SERVICE	4	16.67%	53.6	10.2%
UNSCHEDULED ON EXISTING SERVICE	4	16.67%	67.2	12.9%
<u>SYSTEM ADDITIONS OR REMOVALS ON NEW SERVICE/CUSTOMER</u>	0	0.00%	0.0	0.0%
<u>TOTALS</u>	24		522.9	

NOTES: OUTAGES WITH ZERO CUSTOMER HOURS OR DUE TO CUSTOMER MAINTENANCE ARE NOT INCLUDED IN THE REPORT.

Attachment-C

## **DEFINITION OF TERMS**

### **OUTAGE**

The state of a component when it is not available to perform its intended function due to some event directly associated with that component. An outage may or may not cause an interruption of service to consumers depending on the system configuration.

### **INTERRUPTION**

The loss of service to one or more consumers and is a result of one or more component outages.

### **INTERRUPTION DURATION**

The period from the initiation of an interruption to a consumer until service has been restored to that consumer.

### **MOMENTARY INTERRUPTION**

An interruption that has a duration limited to the period required to restore service by automatic or supervisory-controlled switching operations or by manual switching at locations where an operator is immediately available. Such switching operations must be completed in a specific time not to exceed one minute. Previous issues of this report indicated that a momentary interruption has a duration not to exceed five minutes. A December 1990 report, "Methodology for Determining Reliability Indices for HECO Utilities" indicated that momentary interruptions will have duration of less than one minute.

### **SUSTAINED INTERRUPTION**

Any interruption not classified as a momentary interruption. Only this type of interruption is included in the reliability indices within this report. In conformance with the guidelines established in the report, "Methodology for Determining Reliability Indices for HECO Utilities," dated December 1990, a sustained interruption has duration of one minute or longer.

### **CUSTOMER INTERRUPTION**

One interruption of one customer.

NOTE: Interruptions to customers at their request (e.g., customer maintenance) are not considered.

Attachment-C

Reliability indices used in this report conform to standards proposed by both the Edison Electric Institute (EEI) and the Institute of Electrical and Electronics Engineers (IEEE) unless otherwise indicated in the above definitions. Five reliability indices that convey a meaningful representation of the level of reliability were selected and are presented in this report. These reliability indices are as follows:

## **RELIABILITY INDICES**

### **AVERAGE SERVICE AVAILABILITY INDEX (ASA)**

Total customer hours actually served as a percentage of total customer hours possible during the year. This indicates the extent to which electrical service was available to all customers. This index has been commonly referred to as the "Index of Reliability." A customer-hour is calculated by multiplying the number of customers by the number of hours in the period being analyzed.

$$ASA = \frac{\sum \text{No. of Customer Hours Actually Served during the year}}{\sum \text{No. of Customer Hours Possible during the year}} \times 100\%$$

### **SYSTEM AVERAGE INTERRUPTION FREQUENCY INDEX (SAIFI)**

The number of customer interruptions per customer served during the year. This index indicates the average number of sustained interruptions experienced by all customers serviced on the system.

$$SAIF = \frac{\sum \text{No. of Customer Interruptions Experienced during the year}}{\text{Average No. of Customers served during the year}}$$

### **CUSTOMER AVERAGE INTERRUPTION DURATION INDEX (CAIDI)**

The interruption duration per customer interrupted during the year. This index indicates the average duration of an interruption for those customers affected by a sustained interruption.

$$CAID = \frac{\sum \text{Duration of Interruption} \times \text{No. of Customers affected}}{\sum \text{No. of Customer Interruptions Experienced for the year}}$$

### **SYSTEM AVERAGE INTERRUPTION DURATION INDEX (SAIDI)**

The interruption duration per customer served during the year. This index indicates the average interruption time experienced by all customers serviced on the system.

$$SAID = \frac{\sum \text{Duration of Interruption} \times \text{No. of Customers Affected}}{\text{Average No. of Customers Served during the year}}$$