



May 11, 2022

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

Dear Commissioners:

Subject: Hawaiian Electric Annual Service Reliability Reports for 2021

Hawaiian Electric Company, Inc., Hawai'i Electric Light Company, Inc., and Maui Electric Company, Limited<sup>1</sup> respectfully submit a copy of its Annual Service Reliability Report for the year 2021. (See Attachments 1, 2, and 3, respectively.)

Sincerely,

/s/ Kevin M. Katsura

Kevin M. Katsura  
Director, Regulatory Non-Rate Proceedings

Enclosures

c: Division of Consumer Advocacy

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<sup>1</sup> Hawaiian Electric Company, Inc., Maui Electric Company, Limited, and Hawai'i Electric Light Company, Inc. are each doing business as "Hawaiian Electric" and have jointly registered "Hawaiian Electric" as a trade name with the State of Hawai'i Department of Commerce and Consumer Affairs, as evidenced by Certificate of Registration No. 4235929, dated December 20, 2019.

# **HAWAIIAN ELECTRIC COMPANY, INC.**

## **ANNUAL SERVICE RELIABILITY REPORT**

**2021**

May 11, 2022

## **INTRODUCTION**

This is Hawaiian Electric Company, Inc.'s 2021 annual service reliability report.

The service reliability indices provided in this report are commonly used in the electric power utility industry as a method of measuring system reliability performance. These include overall availability of electrical service during a given period of time (Average Service Availability Index or ASAI), the average frequency or number of times customers experience a sustained interruption of service during a given period of time (System Average Interruption Frequency Index or SAIFI), the average length of time an interrupted customer is without power during a given period of time (Customer Average Interruption Duration Index or CAIDI), and the average length of time customers are without power during a given period of time (System Average Interruption Duration Index or SAIDI). SAIDI is an indication of overall system reliability because it incorporates the impact of frequency and duration of outages on the total customer base. The Appendix contains definitions, explanations, and equations for the reliability indices.

## **METHODOLOGY**

For the period prior to and including March 31, 2021, the reliability indices provided in this report were calculated using the Institute of Electrical and Electronics Engineers (IEEE) Standard 1366<sup>TM</sup>-2012 methodology. For the period April 1, 2021 and forward, indices are calculated using an adjusted IEEE 1366 methodology.<sup>1</sup> Indices reported on a normalized basis exclude Major Event Days (MEDs). MEDs are defined as days in which the daily system SAIDI exceeds the MED threshold value (T<sub>MED</sub>). Statistically, days having a daily system SAIDI greater than T<sub>MED</sub> indicate days on which the energy delivery system experienced stresses beyond that normally expected (such as during severe weather).<sup>2</sup> In calculating daily system SAIDI, any interruption that spans multiple calendar days is accrued to the day on which the interruption began.

## **RESULTS**

The following tables provide reliability index results on unnormalized and normalized bases for generation, transmission, and distribution outages and separately for 1) transmission and distribution outages, 2) utility generation outages, and 3) non-utility generation outages. Results are as of January 7, 2022. Subsequent findings may result in changes to data.

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<sup>1</sup> Docket No. 2019-0110, Decision and Order No. 37600, issued on February 2, 2021.

<sup>2</sup> IEEE Std 1366<sup>TM</sup>-2012: IEEE Guide for Electric Power Distribution Reliability Indices

### Annual Service Reliability Indices

The following days in 2021 were determined to be MEDs and are therefore excluded from the normalized indices.

- 2/3/21 due to weather-related outages affecting various parts of O'ahu
- 3/10/21 due to weather-related outages affecting various parts of O'ahu
- 8/21/21 due to bird in conductors and faulty equipment operation
- 12/5/21 due to weather-related outages affecting various parts of O'ahu
- 12/6/21 due to weather-related outages affecting various parts of O'ahu

**Table 1: Generation, Transmission, and Distribution Outages – Unnormalized**

	<u>2016</u>	<u>2017</u>	<u>2018</u>	<u>2019</u>	<u>2020</u>	<u>2021</u>
<b>Number of Customers</b>	303,732	304,359	304,965	305,627	306,243	307,691
<b>Customer Interruptions</b>	394,758	426,050	404,503	449,341	360,868	496,291
<b>Customer-Hours Interrupted</b>	553,427	703,324	627,251	890,903	612,894	796,684
<b>SAIDI (minutes)</b>	109.33	138.65	123.41	174.90	120.08	155.35
<b>CAIDI (minutes)</b>	84.12	99.05	93.04	118.96	101.90	96.32
<b>SAIFI (interruptions)</b>	1.300	1.400	1.326	1.470	1.178	1.613
<b>ASAI (percentage)</b>	99.979%	99.974%	99.977%	99.967%	99.977%	99.970%

**Table 2: Transmission and Distribution Outages – Unnormalized**

	<u>2016</u>	<u>2017</u>	<u>2018</u>	<u>2019</u>	<u>2020</u>	<u>2021</u>
<b>Number of Customers</b>	303,732	304,359	304,965	305,627	306,243	307,691
<b>Customer Interruptions</b>	328,474	397,604	404,502	445,204	340,731	468,260
<b>Customer-Hours Interrupted</b>	506,993	699,880	627,238	890,348	609,039	784,014
<b>SAIDI (minutes)</b>	100.15	137.97	123.41	174.79	119.32	152.88
<b>CAIDI (minutes)</b>	92.61	105.61	93.04	119.99	107.25	100.46
<b>SAIFI (interruptions)</b>	1.081	1.306	1.326	1.457	1.113	1.522
<b>ASAI (percentage)</b>	99.981%	99.974%	99.977%	99.967%	99.977%	99.971%

**Table 3: Utility Generation Outages – Unnormalized**

	<u>2016</u>	<u>2017</u>	<u>2018</u>	<u>2019</u>	<u>2020</u>	<u>2021</u>
<b>Number of Customers</b>	303,732	304,359	304,965	305,627	306,243	307,691
<b>Customer Interruptions</b>	66,284	17,341	0	3,646	2,892	2,000
<b>Customer-Hours Interrupted</b>	46,434	1,776	0	425	924	2,835
<b>SAIDI (minutes)</b>	9.17	0.35	0.00	0.08	0.18	0.55
<b>CAIDI (minutes)</b>	42.03	6.14	0.00	7.00	19.16	85.04
<b>SAIFI (interruptions)</b>	0.218	0.057	0.000	0.012	0.009	0.007
<b>ASAI (percentage)</b>	99.998%	100.000%	100.000%	100.000%	100.000%	100.000%

**Table 4: Non-Utility Generation Outages – Unnormalized**

	<u>2016</u>	<u>2017</u>	<u>2018</u>	<u>2019</u>	<u>2020</u>	<u>2021</u>
<b>Number of Customers</b>	303,732	304,359	304,965	305,627	306,243	307,691
<b>Customer Interruptions</b>	0	11,105	1	491	17,245	26,031
<b>Customer-Hours Interrupted</b>	0	1,668	13	130	2,931	9,836
<b>SAIDI (minutes)</b>	0.00	0.33	0.00	0.03	0.57	1.92
<b>CAIDI (minutes)</b>	0.00	9.01	753.00	15.92	10.20	22.67
<b>SAIFI (interruptions)</b>	0.000	0.036	0.000	0.002	0.056	0.085
<b>ASAI (percentage)</b>	100.000%	100.000%	100.000%	100.000%	100.000%	100.000%

**Table 5: Generation, Transmission, and Distribution Outages – Normalized<sup>3</sup>**

	<u>2016</u>	<u>2017</u>	<u>2018</u>	<u>2019</u>	<u>2020</u>	<u>2021</u>
<b>Number of Customers</b>	303,732	304,359	304,965	305,627	306,243	307,691
<b>Customer Interruptions</b>	304,466	350,078	382,106	337,799	279,813	379,271
<b>Customer-Hours Interrupted</b>	421,384	489,908	568,968	530,394	416,577	547,663
<b>SAIDI (minutes)</b>	83.24	96.58	111.94	104.13	81.62	106.79
<b>CAIDI (minutes)</b>	83.04	83.97	89.34	94.21	89.33	86.64
<b>SAIFI (interruptions)</b>	1.002	1.150	1.253	1.105	0.914	1.233
<b>ASAI (percentage)</b>	99.984%	99.982%	99.979%	99.980%	99.985%	99.980%

<sup>3</sup> Exclusions include:

- 3/25/16 due to underfrequency load shed due to a lightning storm
- 7/24/16 due to flooding at Iwilei Substation and surrounding area
- 10/4/16 due to switching error and abnormal system configuration
- 1/21/17 due to trees/branches and high winds
- 1/22/17 due to high winds
- 2/5/17 due to high winds and vegetation
- 8/24/18 due to effects of Hurricane Lane
- 9/12/18 due to effects of Tropical Storm Olivia and equipment deterioration
- 2/10/19 due to effects of winter storm/high winds, vegetation, equipment deterioration, and flashover
- 10/30/19 due to vegetation and company personnel error
- 12/25/19 due to high winds and vegetation
- 1/3/20 due to faulty equipment operation and unknown causes
- 2/9/20 due to vegetation and equipment deterioration during high winds
- 2/10/20 due to high winds, vegetation, and equipment deterioration
- 2/18/20 due to cable fault and faulty equipment operation
- 12/26/20 due to substation equipment-related fire
- 2/3/21 due to weather-related outages affecting various parts of O'ahu
- 3/10/21 due to weather-related outages affecting various parts of O'ahu
- 8/21/21 due to bird in conductors and faulty equipment operation
- 12/5/21 due to weather-related outages affecting various parts of O'ahu
- 12/6/21 due to weather-related outages affecting various parts of O'ahu



The following charts and discussion are based on the annual reliability index results for generation, transmission, and distribution outages on a normalized basis (data from Table 5, above).

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

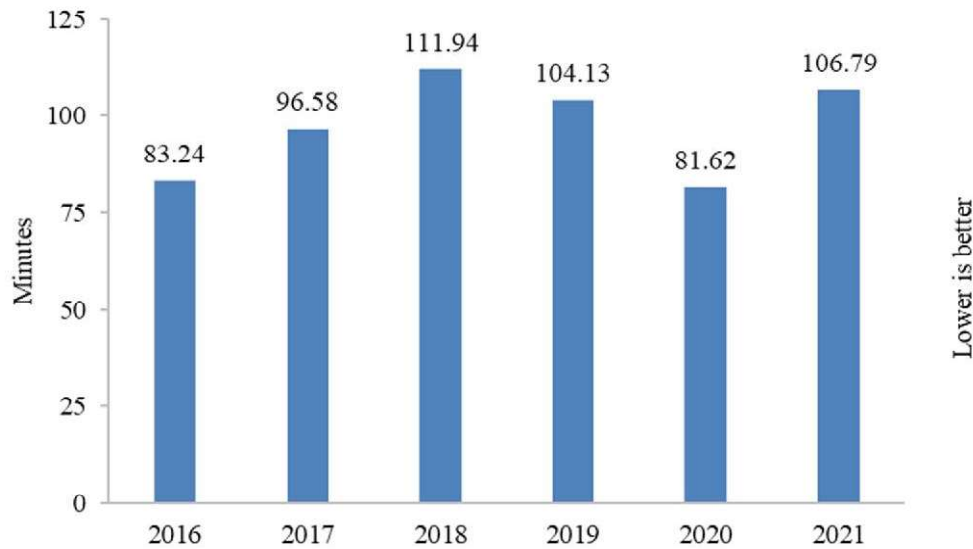


Figure 1 shows the SAIDI values for 2016 to 2021.

The 2021 SAIDI of 106.79 minutes is about a 31% increase compared to the 2020 SAIDI of 81.62 minutes. The customer hours interrupted was 547,663 hours in 2021 compared to 416,577 hours in 2020.

The following events significantly impacted the 2021 SAIDI results:

1. January 18, 2021 (Monday) – Weather-related outages affecting various parts of O‘ahu. This resulted in a sustained interruption to 13,216 customers for up to 25 hours and 14 minutes and contributed 3.76 minutes to the annual SAIDI.
2. December 14, 2021 (Tuesday) – A switch vault flashed over. This resulted in a sustained interruption to 5,084 customers for up to 3 hours and 52 minutes and contributed 3.06 minutes to the annual SAIDI.
3. April 16, 2021 (Friday) – The control rod for a switch broke during operation and fell onto substation equipment. This resulted in a sustained interruption to 22,896 customers for up to 37 minutes and contributed 2.70 minutes to the annual SAIDI.

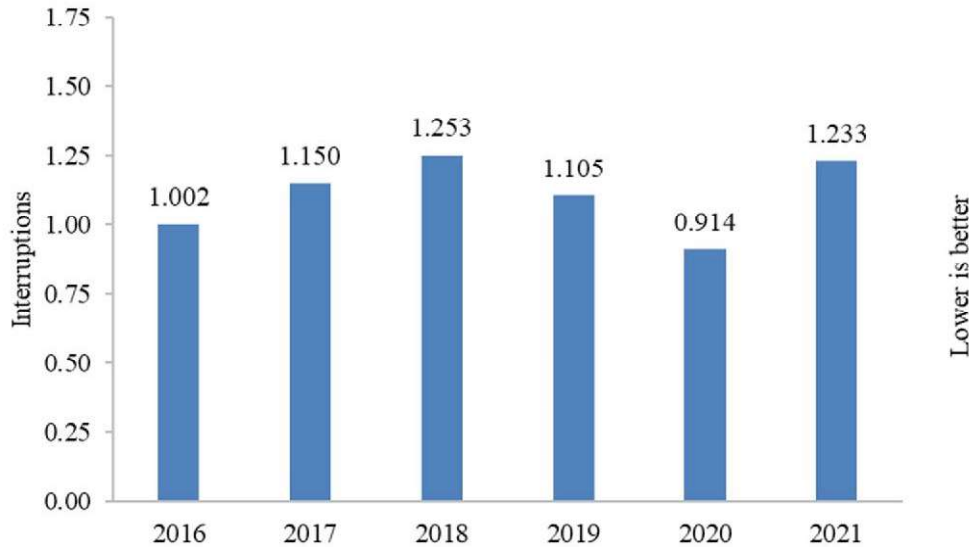
**Figure 2: Normalized System Average Interruption Frequency Index (SAIFI)**

Figure 2 shows the SAIFI values for 2016 to 2021.

The 2021 SAIFI of 1.233 interruptions is about a 35% increase compared to the 2020 SAIFI of 0.914 interruptions. The number of customer interruptions was 379,271 in 2021 compared to 279,813 in 2020.

The following events significantly impacted the 2021 SAIFI results:

1. September 24, 2021 (Friday) – Underfrequency load shed due to an Independent Power Producer’s (IPP) generating equipment tripping offline. This resulted in a sustained interruption to 26,031 customers for up to 5 hours and 5 minutes and contributed 0.085 interruptions to the annual SAIFI.
2. March 31, 2021 (Wednesday) – A new substation transformer failed upon energizing. This resulted in a sustained interruption to 24,799 customers for up to 11 minutes and contributed 0.081 interruptions to the annual SAIFI.
3. April 16, 2021 (Friday) – The control rod for a switch broke during operation and fell onto substation equipment. This resulted in a sustained interruption to 22,896 customers for up to 37 minutes and contributed 0.074 interruptions to the annual SAIFI.



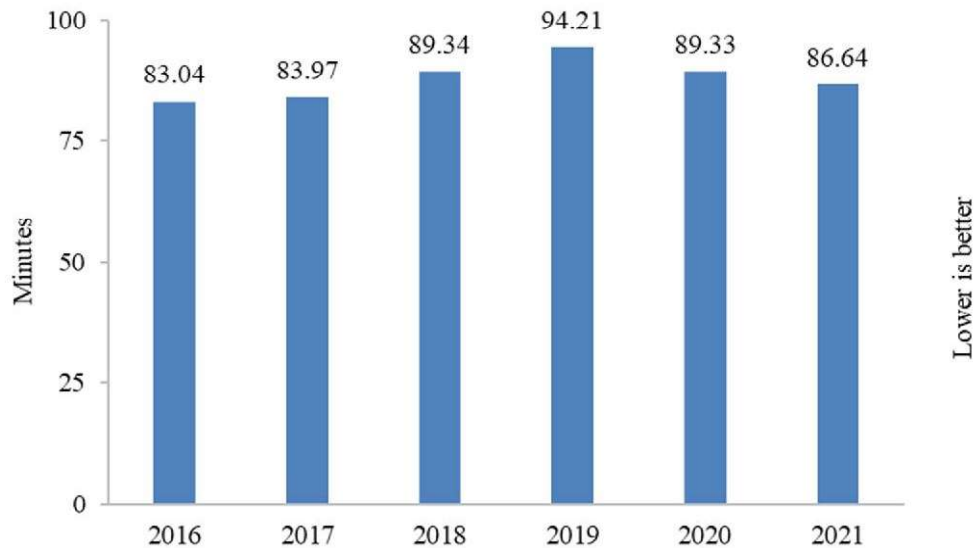
**Figure 3: Normalized Customer Average Interruption Duration Index (CAIDI)**

Figure 3 shows the CAIDI values for 2016 to 2021.

The 2021 CAIDI of 86.64 minutes is about a 3% decrease compared to the 2020 CAIDI of 89.33 minutes.

The following events significantly affected the 2021 CAIDI results:

1. December 14, 2021 (Tuesday) – A switch vault flashed over. This resulted in a sustained interruption to 5,084 customers for up to 3 hours and 52 minutes and contributed 1.34 minutes to the annual CAIDI.
2. March 21, 2021 (Sunday) – Vegetation in conductors. This resulted in a sustained interruption to 2,450 customers for up to 14 hours and 10 minutes and contributed 1.32 minutes to the annual CAIDI.
3. August 7, 2021 (Saturday) – A switch vault moved off the concrete pad due to a motor vehicle accident. This resulted in a sustained interruption to 1,774 customers for up to 6 hours and 37 minutes and contributed 1.31 minutes to the annual CAIDI.

**Figure 4: Normalized Average System Availability Index (ASAI)**

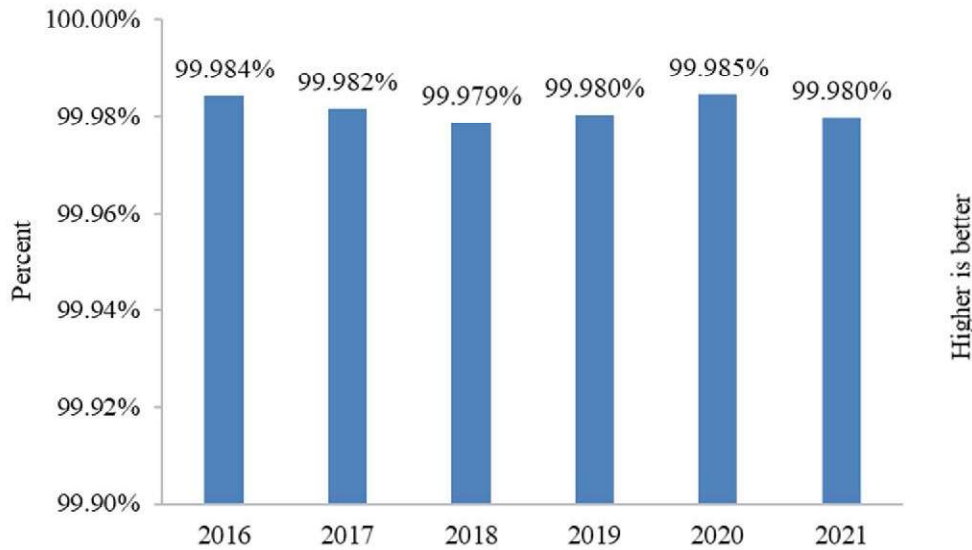
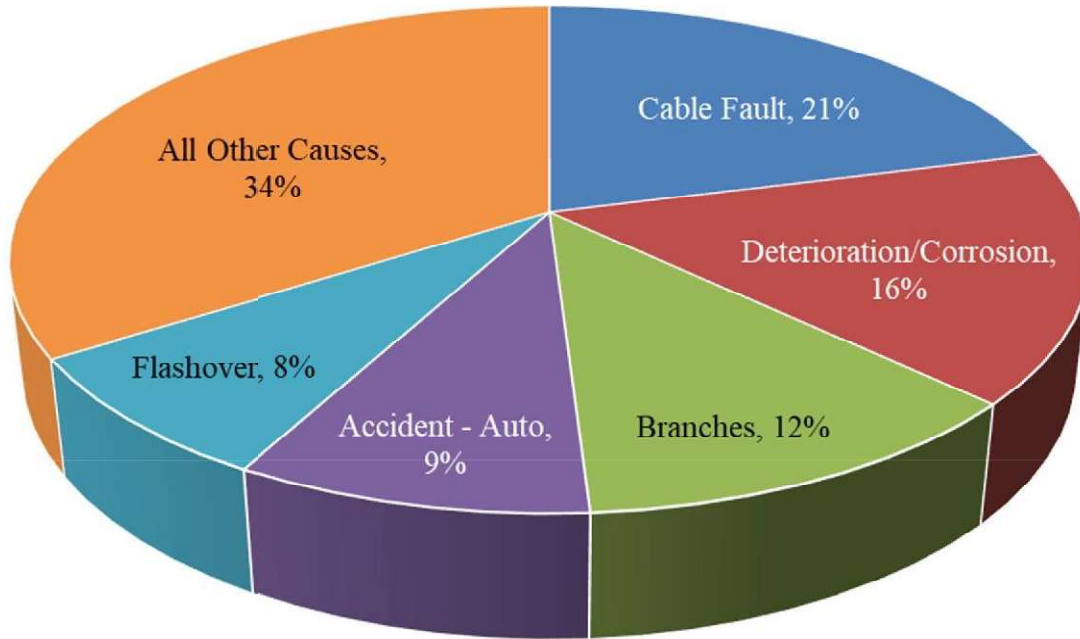


Figure 4 shows the ASAI values for 2016 to 2021.

The 2021 ASAI of 99.980% is a 0.005% decrease compared to the 2020 ASAI of 99.985%. The customer hours interrupted was 547,663 hours in 2021 compared to 416,577 hours in 2020.

**Figure 5: Outage Causes for 2021**



The top five outage causes by customer hours interrupted, as illustrated in Figure 5, accounted for about 66% of the total customer hours interrupted in 2021. These include:

<u>Outage Cause</u>	<u>Description</u>
1. Cable Fault	Failure of underground cable or cable component
2. Deterioration/Corrosion	Equipment breakdown from natural causes
3. Branches <sup>4</sup>	Disconnected portion of vegetation contacts/damages equipment
4. Accident - Auto	Non-utility vehicle collision with equipment
5. Flashover	Abnormal electrical discharge that directly results in an interruption

From 2020 to 2021, Cable Fault replaced Deterioration/Corrosion as the top outage cause. Deterioration/Corrosion is now the 2<sup>nd</sup> top outage cause. Branches and Flashover remained as the 3<sup>rd</sup> and 5<sup>th</sup> top outage causes, respectively. Accident – Auto replaced Scheduled as the 4<sup>th</sup> top outage cause.

<sup>4</sup> Prior to and including November 28, 2021, the Branches cause includes contributions due to entire downed trees. From November 29, 2021 and forward, outages due to entire downed trees are coded to a separate Tree cause.

**Hawaiian Electric Company, Inc.**  
**Normalized Sustained Interruption Summary**

From: January 1, 2021      To: December 31, 2021

<b>Outage Cause</b>	<b>Customer Hours Interrupted</b>	<b>Customer Interruptions</b>	<b>SAIFI (interruptions)</b>	<b>SAIDI (minutes)</b>	<b>CAIDI (minutes)</b>
Cable Fault	112,738.1	77,273	0.251	21.98	87.54
Deterioration/Corrosion	86,913.7	52,646	0.171	16.95	99.05
Branches	65,413.3	39,996	0.130	12.76	98.13
Accident - Auto	51,972.2	21,771	0.071	10.13	143.23
Flashover	42,537.6	38,755	0.126	8.29	65.86
Unknown	38,038.5	25,502	0.083	7.42	89.50
Scheduled	33,449.2	8,969	0.029	6.52	223.77
High Winds	17,746.4	7,082	0.023	3.46	150.35
Faulty Operation	15,432.4	10,324	0.034	3.01	89.69
Object in Line - Animal	14,557.5	10,486	0.034	2.84	83.30
Auto UFLS	9,836.4	26,031	0.085	1.92	22.67
Transformer - Failure	8,867.9	25,743	0.084	1.73	20.67
Accident - Construction	8,809.8	1,980	0.006	1.72	266.96
Lightning	6,835.5	2,479	0.008	1.33	165.44
Object in Line - Foreign Object	5,859.9	6,123	0.020	1.14	57.42
Object in Line - Balloon	4,908.5	6,110	0.020	0.96	48.20
Customer - Equipment	4,670.4	3,390	0.011	0.91	82.66
Other	4,612.8	1,789	0.006	0.90	154.70
Other Company Personnel	3,930.5	3,922	0.013	0.77	60.13
Overgrown	2,967.2	536	0.002	0.58	332.15
Overload	2,634.5	3,070	0.010	0.51	51.49
Switching	1,562.5	4,085	0.013	0.30	22.95
Tree	1,493.5	195	0.001	0.29	459.54
Accident - Other	817.5	562	0.002	0.16	87.27
Fire	688.0	210	0.001	0.13	196.56
Transformer - Overload	294.1	175	0.001	0.06	100.83
Vandalism	62.6	62	0.000	0.01	60.61
Failure/Defect	12.8	5	0.000	0.00	153.00
Flooding	0.0	0	0.000	0.00	0.00
Heavy Rain	0.0	0	0.000	0.00	0.00
Landslide	0.0	0	0.000	0.00	0.00
Manual Load Shed	0.0	0	0.000	0.00	0.00
Natural Disaster/Tsunami/Earthquake	0.0	0	0.000	0.00	0.00
Object in Line - Man	0.0	0	0.000	0.00	0.00
System Change	0.0	0	0.000	0.00	0.00
<b>Total</b>	<b>547,662.9</b>	<b>379,271</b>	<b>1.233</b>	<b>106.79</b>	<b>86.64</b>

Average System Availability =	99.980%
Number of customers for the period =	307,691
24-month annual SAIDI (minutes) average for the period 1/1/2020 - 12/31/2021 =	94.21
24-month average number of customers for the period 1/1/2020 - 12/31/2021 =	306,967

**Notes:** Outage causes are listed in descending order of SAIDI. Outages due to customer requests are not included in the service reliability indices. The Forced cause, which was used in previous reports, has been discontinued; outages are coded to the event's root cause. Prior to and including November 28, 2021, the Branches cause includes contributions due to entire downed trees. From November 29, 2021 and forward, outages due to entire downed trees are coded to a separate Tree cause.

**Hawaiian Electric Company, Inc.**  
**Normalized Sustained Interruption Summary**

From: January 1, 2021      To: December 31, 2021

<b>Outage Cause Category/Cause</b>	<b>Interruption Count</b>	<b>% of Total</b>	<b>Customer Hours Interrupted</b>	<b>% of Total</b>
<b><u>Equipment</u></b>	<b>1,035</b>	<b>46.6%</b>	<b>269,431.0</b>	<b>49.2%</b>
Cable Fault	538	24.2%	112,738.1	20.6%
Deterioration/Corrosion	336	15.1%	86,913.7	15.9%
Flashover	26	1.2%	42,537.6	7.8%
Faulty Operation	19	0.9%	15,432.4	2.8%
Transformer - Failure	70	3.2%	8,867.9	1.6%
Overload	28	1.3%	2,634.5	0.5%
Transformer - Overload	17	0.8%	294.1	0.1%
Failure/Defect	1	0.0%	12.8	0.0%
<b><u>Error</u></b>	<b>24</b>	<b>1.1%</b>	<b>5,493.0</b>	<b>1.0%</b>
Other Company Personnel	10	0.5%	3,930.5	0.7%
Switching	14	0.6%	1,562.5	0.3%
<b><u>Generation</u></b>	<b>19</b>	<b>0.9%</b>	<b>9,836.4</b>	<b>1.8%</b>
Auto UFLS	19	0.9%	9,836.4	1.8%
Manual Load Shed	0	0.0%	0.0	0.0%
Other	0	0.0%	0.0	0.0%
<b><u>Maintenance</u></b>	<b>631</b>	<b>28.4%</b>	<b>33,449.2</b>	<b>6.1%</b>
Scheduled	631	28.4%	33,449.2	6.1%
System Change	0	0.0%	0.0	0.0%
<b><u>Other</u></b>	<b>16</b>	<b>0.7%</b>	<b>4,612.8</b>	<b>0.8%</b>
Other	16	0.7%	4,612.8	0.8%
<b><u>Public (Non-Utility)</u></b>	<b>162</b>	<b>7.3%</b>	<b>92,346.3</b>	<b>16.9%</b>
Accident - Auto	40	1.8%	51,972.2	9.5%
Object in Line - Animal	30	1.4%	14,557.5	2.7%
Accident - Construction	13	0.6%	8,809.8	1.6%
Object in Line - Foreign Object	6	0.3%	5,859.9	1.1%
Object in Line - Balloon	7	0.3%	4,908.5	0.9%
Customer - Equipment	44	2.0%	4,670.4	0.9%
Accident - Other	4	0.2%	817.5	0.1%
Fire	16	0.7%	688.0	0.1%
Vandalism	2	0.1%	62.6	0.0%
Object in Line - Man	0	0.0%	0.0	0.0%
<b><u>Unknown</u></b>	<b>151</b>	<b>6.8%</b>	<b>38,038.5</b>	<b>6.9%</b>
Unknown	151	6.8%	38,038.5	6.9%
<b><u>Vegetation</u></b>	<b>154</b>	<b>6.9%</b>	<b>69,874.0</b>	<b>12.8%</b>
Branches	131	5.9%	65,413.3	11.9%
Overgrown	15	0.7%	2,967.2	0.5%
Tree	8	0.4%	1,493.5	0.3%
<b><u>Weather</u></b>	<b>30</b>	<b>1.4%</b>	<b>24,581.9</b>	<b>4.5%</b>
High Winds	27	1.2%	17,746.4	3.2%
Lightning	3	0.1%	6,835.5	1.2%
Flooding	0	0.0%	0.0	0.0%
Heavy Ram	0	0.0%	0.0	0.0%
Landslide	0	0.0%	0.0	0.0%
Natural Disaster/Tsunami/Earthquake	0	0.0%	0.0	0.0%
<b>Total</b>	<b>2,222</b>		<b>547,662.9</b>	

**Note:** Outage causes are listed in descending order of Customer Hours Interrupted within each Cause Category. Outages due to customer requests are not included in the service reliability indices. The Forced cause, which was used in previous reports, has been discontinued. Outages are coded to the event's root cause. Prior to and including November 28, 2021, the Branches cause includes contributions due to entire downed trees. From November 29, 2021 and forward, outages due to entire downed trees are coded to a separate Tree cause.

# **APPENDIX**

## ANNUAL SERVICE RELIABILITY REPORT

2021

May 11, 2022

**DEFINITION OF TERMS**

**CUSTOMER INTERRUPTION**

One interruption of one customer.

**INTERRUPTION**

The loss of service to one or more customers as a result of one or more component outages.

**INTERRUPTION DURATION**

The time period from the initiation of an interruption until service has been restored to the affected customers.

**MOMENTARY INTERRUPTION**

An interruption having a duration of five minutes or less, typically limited to the period required to restore service by an interrupting device.

**OUTAGE**

The loss of ability of a component to deliver power. An outage may or may not cause an interruption of service to customers, depending on the system configuration.

**SUSTAINED INTERRUPTION**

Any interruption not classified as a momentary interruption. That is, any interruption that lasts more than five minutes.

Note: Interruptions to customers at their request are not included.

Reliability indices are based on the standards defined by the Institute of Electrical and Electronics Engineers (IEEE). Four indices that convey a meaningful representation of the level of reliability are as follows:

### **RELIABILITY INDICES**

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

ASAI indicates the fraction of time that the average customer received service during a predefined period of time. Customer hours service demand is determined by multiplying the total number of customers served by the number of hours in the period.

$$ASAI = \frac{\sum \text{Customer Hours Service Availability}}{\sum \text{Customer Hours Service Demand}} \times 100\%$$

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

CAIDI indicates the average time required to restore service during a predefined period of time.

$$CAIDI = \frac{\sum(\text{Duration of Interruption} \times \text{No. of Sustained Customer Interruptions})}{\sum \text{No. of Sustained Customer Interruptions}} = \frac{SAIDI}{SAIFI}$$

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

SAIDI indicates the total sustained interruption duration for the average customer during a predefined period of time. It is commonly measured in minutes or hours of interruption.

$$SAIDI = \frac{\sum(\text{Duration of Interruption} \times \text{No. of Sustained Customer Interruptions})}{\text{Total No. of Customers Served}}$$

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

SAIFI indicates how often the average customer experiences a sustained interruption during a predefined period of time.

$$SAIFI = \frac{\sum \text{No. of Sustained Customer Interruptions}}{\text{Total No. of Customers Served}}$$



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

## **ANNUAL SERVICE RELIABILITY REPORT 2021**

May 11, 2022

## **INTRODUCTION**

This is Hawai'i Electric Light Company, Inc.'s 2021 annual service reliability report.

The service reliability indices provided in this report are commonly used in the electric power utility industry as a method of measuring system reliability performance. These include overall availability of electrical service during a given period of time (Average Service Availability Index or ASAI), the average frequency or number of times customers experience a sustained interruption of service during a given period of time (System Average Interruption Frequency Index or SAIFI), the average length of time an interrupted customer is without power during a given period of time (Customer Average Interruption Duration Index or CAIDI), and the average length of time customers are without power during a given period of time (System Average Interruption Duration Index or SAIDI). SAIDI is an indication of overall system reliability because it incorporates the impact of frequency and duration of outages on the total customer base. The Appendix contains definitions, explanations, and equations for the reliability indices.

## **METHODOLOGY**

For the period prior to and including March 31, 2021, the reliability indices provided in this report were calculated using the Institute of Electrical and Electronics Engineers (IEEE) Standard 1366<sup>TM</sup>-2012 methodology. For the period April 1, 2021 and forward, indices are calculated using an adjusted IEEE 1366 methodology.<sup>1</sup> Indices reported on a normalized basis exclude Major Event Days (MEDs). MEDs are defined as days in which the daily system SAIDI exceeds the MED threshold value ( $T_{MED}$ ). Statistically, days having a daily system SAIDI greater than  $T_{MED}$  indicate days on which the energy delivery system experienced stresses beyond that normally expected (such as during severe weather).<sup>2</sup> In calculating daily system SAIDI, any interruption that spans multiple calendar days is accrued to the day on which the interruption began.

## **RESULTS**

The following tables provide reliability index results on unnormalized and normalized bases for generation, transmission, and distribution outages and separately for 1) transmission and distribution outages, 2) utility generation outages, and 3) non-utility generation outages. Results are as of January 10, 2022. Subsequent findings may result in changes to data.

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<sup>1</sup> Docket No. 2019-0110, Decision and Order No. 37600, issued on February 2, 2021.

<sup>2</sup> IEEE Std 1366<sup>TM</sup>-2012: IEEE Guide for Electric Power Distribution Reliability Indices.

**Annual Service Reliability Indices**

The following days in 2021 were determined to be MEDs and are therefore excluded from the normalized indices.

- 7/29/21 due to scheduled interruption to replace multiple poles on a transmission circuit
- 12/5/21 due to tree-related outages affecting various parts of Hawai'i Island during high winds
- 12/6/21 due to tree-related outages affecting various parts of Hawai'i Island during high winds
- 12/16/21 due to a tree fell on transmission circuit conductors

**Table 1: Generation, Transmission, and Distribution Outages – Unnormalized**

	<u>2016</u>	<u>2017</u>	<u>2018</u>	<u>2019</u>	<u>2020</u>	<u>2021</u>
<b>Number of Customers</b>	84,367	85,041	85,408	86,068	86,826	87,558
<b>Customer Interruptions</b>	196,249	151,681	216,840	263,410	157,964	277,662
<b>Customer-Hours Interrupted</b>	247,641	263,828	328,406	362,225	186,333	697,585
<b>SAIDI (minutes)</b>	176.12	186.14	230.71	252.52	128.76	478.03
<b>CAIDI (minutes)</b>	75.71	104.36	90.87	82.51	70.78	150.74
<b>SAIFI (interruptions)</b>	2.326	1.784	2.539	3.060	1.819	3.171
<b>ASAI (percentage)</b>	99.967%	99.965%	99.956%	99.952%	99.976%	99.909%

**Table 2: Transmission and Distribution Outages – Unnormalized**

	<u>2016</u>	<u>2017</u>	<u>2018</u>	<u>2019</u>	<u>2020</u>	<u>2021</u>
<b>Number of Customers</b>	84,367	85,041	85,408	86,068	86,826	87,558
<b>Customer Interruptions</b>	118,879	120,857	137,897	230,102	95,278	179,448
<b>Customer-Hours Interrupted</b>	227,989	259,368	297,702	357,482	176,156	682,997
<b>SAIDI (minutes)</b>	162.14	182.99	209.14	249.21	121.73	468.03
<b>CAIDI (minutes)</b>	115.07	128.76	129.53	93.21	110.93	228.37
<b>SAIFI (interruptions)</b>	1.409	1.421	1.615	2.673	1.097	2.049
<b>ASAI (percentage)</b>	99.969%	99.965%	99.960%	99.953%	99.977%	99.911%

**Table 3: Utility Generation Outages – Unnormalized**

	<u>2016</u>	<u>2017</u>	<u>2018</u>	<u>2019</u>	<u>2020</u>	<u>2021</u>
<b>Number of Customers</b>	84,367	85,041	85,408	86,068	86,826	87,558
<b>Customer Interruptions</b>	58,077	22,253	28,948	14,302	42,257	28,466
<b>Customer-Hours Interrupted</b>	16,766	2,728	16,346	1,782	6,047	3,855
<b>SAIDI (minutes)</b>	11.92	1.92	11.48	1.24	4.18	2.64
<b>CAIDI (minutes)</b>	17.32	7.36	33.88	7.48	8.59	8.12
<b>SAIFI (interruptions)</b>	0.688	0.262	0.339	0.166	0.487	0.325
<b>ASAI (percentage)</b>	99.998%	100.000%	99.998%	100.000%	99.999%	99.999%

**Table 4: Non-Utility Generation Outages – Unnormalized**

	<u>2016</u>	<u>2017</u>	<u>2018</u>	<u>2019</u>	<u>2020</u>	<u>2021</u>
<b>Number of Customers</b>	84,367	85,041	85,408	86,068	86,826	87,558
<b>Customer Interruptions</b>	19,293	8,571	49,995	19,006	20,429	69,748
<b>Customer-Hours Interrupted</b>	2,886	1,731	14,357	2,961	4,130	10,733
<b>SAIDI (minutes)</b>	2.05	1.22	10.09	2.06	2.85	7.36
<b>CAIDI (minutes)</b>	8.97	12.12	17.23	9.35	12.13	9.23
<b>SAIFI (interruptions)</b>	0.229	0.101	0.585	0.221	0.235	0.797
<b>ASAI (percentage)</b>	100.000%	100.000%	99.998%	100.000%	99.999%	99.999%

**Table 5: Generation, Transmission, and Distribution Outages – Normalized<sup>3</sup>**

	<u>2016</u>	<u>2017</u>	<u>2018</u>	<u>2019</u>	<u>2020</u>	<u>2021</u>
<b>Number of Customers</b>	84,367	85,041	85,408	86,068	86,826	87,558
<b>Customer Interruptions</b>	185,013	128,861	216,840	160,467	157,964	201,285
<b>Customer-Hours Interrupted</b>	204,049	191,415	328,406	236,484	186,333	235,769
<b>SAIDI (minutes)</b>	145.12	135.05	230.71	164.86	128.76	161.56
<b>CAIDI (minutes)</b>	66.17	89.13	90.87	88.42	70.78	70.28
<b>SAIFI (interruptions)</b>	2.193	1.515	2.539	1.864	1.819	2.299
<b>ASAI (percentage)</b>	99.972%	99.974%	99.956%	99.969%	99.976%	99.969%

**Table 6: Transmission and Distribution Outages – Normalized<sup>3</sup>**

	<u>2016</u>	<u>2017</u>	<u>2018</u>	<u>2019</u>	<u>2020</u>	<u>2021</u>
<b>Number of Customers</b>	84,367	85,041	85,408	86,068	86,826	87,558
<b>Customer Interruptions</b>	107,643	98,037	137,897	127,159	95,278	103,071
<b>Customer-Hours Interrupted</b>	184,397	186,955	297,702	231,741	176,156	221,181
<b>SAIDI (minutes)</b>	131.14	131.90	209.14	161.55	121.73	151.57
<b>CAIDI (minutes)</b>	102.78	114.42	129.53	109.35	110.93	128.75
<b>SAIFI (interruptions)</b>	1.276	1.153	1.615	1.477	1.097	1.177
<b>ASAI (percentage)</b>	99.975%	99.975%	99.960%	99.969%	99.977%	99.971%

<sup>3</sup> Exclusions include:

- 7/23/16 due to effects of Tropical Storm Darby
- 9/21/17 due to scheduled substation maintenance
- 12/5/17 due to high winds
- 2/10/19 due to effects of winter storm/high winds
- 7/8/19 due to remnants of Tropical Storm Barbara
- 7/29/21 due to scheduled interruption to replace multiple poles on a transmission circuit
- 12/5/21 due to tree-related outages affecting various parts of Hawai'i Island during high winds
- 12/6/21 due to tree-related outages affecting various parts of Hawai'i Island during high winds
- 12/16/21 due to a tree fell on transmission circuit conductors

**Table 7: Utility Generation Outages – Normalized<sup>3</sup>**

	<u>2016</u>	<u>2017</u>	<u>2018</u>	<u>2019</u>	<u>2020</u>	<u>2021</u>
<b>Number of Customers</b>	84,367	85,041	85,408	86,068	86,826	87,558
<b>Customer Interruptions</b>	58,077	22,253	28,948	14,302	42,257	28,466
<b>Customer-Hours Interrupted</b>	16,766	2,728	16,346	1,782	6,047	3,855
<b>SAIDI (minutes)</b>	11.92	1.92	11.48	1.24	4.18	2.64
<b>CAIDI (minutes)</b>	17.32	7.36	33.88	7.48	8.59	8.12
<b>SAIFI (interruptions)</b>	0.688	0.262	0.339	0.166	0.487	0.325
<b>ASAI (percentage)</b>	99.998%	100.000%	99.998%	100.000%	99.999%	99.999%

**Table 8: Non-Utility Generation Outages – Normalized<sup>3</sup>**

	<u>2016</u>	<u>2017</u>	<u>2018</u>	<u>2019</u>	<u>2020</u>	<u>2021</u>
<b>Number of Customers</b>	84,367	85,041	85,408	86,068	86,826	87,558
<b>Customer Interruptions</b>	19,293	8,571	49,995	19,006	20,429	69,748
<b>Customer-Hours Interrupted</b>	2,886	1,731	14,357	2,961	4,130	10,733
<b>SAIDI (minutes)</b>	2.05	1.22	10.09	2.06	2.85	7.36
<b>CAIDI (minutes)</b>	8.97	12.12	17.23	9.35	12.13	9.23
<b>SAIFI (interruptions)</b>	0.229	0.101	0.585	0.221	0.235	0.797
<b>ASAI (percentage)</b>	100.000%	100.000%	99.998%	100.000%	99.999%	99.999%

The following charts and discussion are based on the annual reliability index results for generation, transmission, and distribution outages on a normalized basis (data from Table 5, above).

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

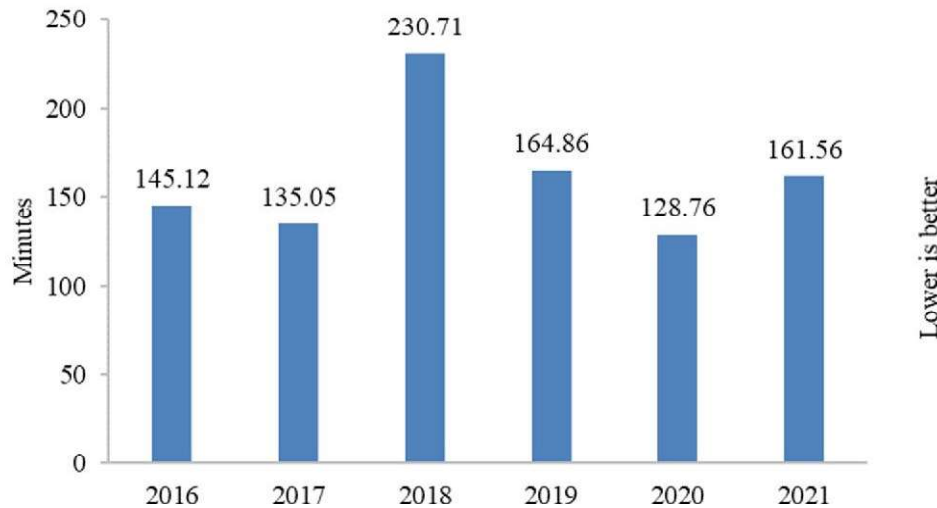


Figure 1 shows the SAIDI values for 2016 to 2021.

The 2021 SAIDI of 161.56 minutes is about a 25% increase compared to the 2020 SAIDI of 128.76 minutes. The customer hours interrupted was 235,769 hours compared to 186,333 hours in 2020.

The following events significantly impacted the 2021 SAIDI results:

1. October 22, 2021 (Friday) – A tree fell on transmission conductors. This resulted in a sustained interruption to 2,923 customers for up to 11 hours and 22 minutes and contributed 8.99 minutes to the annual SAIDI.
2. February 28, 2021 (Sunday) – A tree leaned on transmission conductors. This resulted in a sustained interruption to 2,923 customers for up to 4 hours and 13 minutes and contributed 7.18 minutes to the annual SAIDI.
3. February 2, 2021 (Tuesday) – A tree fell on distribution conductors. This resulted in a sustained interruption to 1,578 customers for up to 5 hours and 56 minutes and contributed 6.05 minutes to the annual SAIDI.

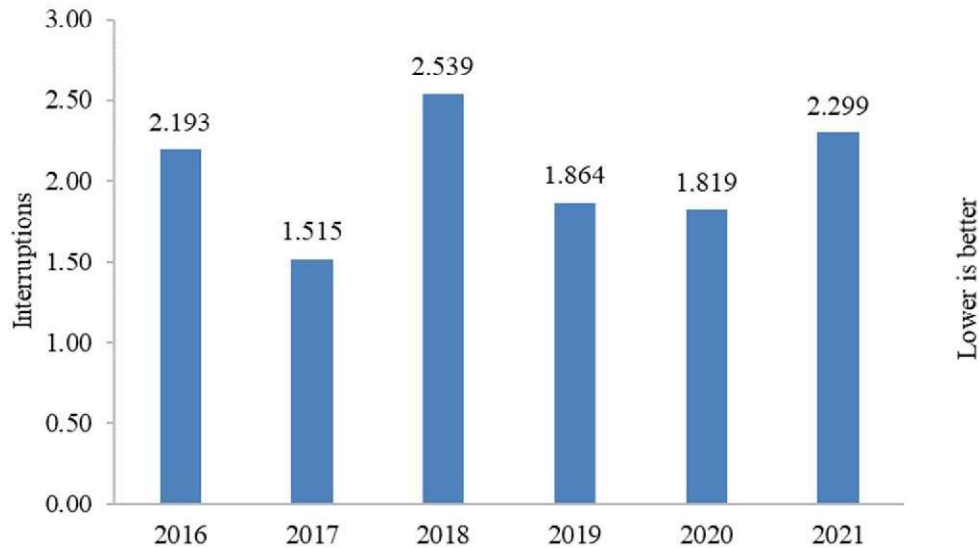
**Figure 2: Normalized System Average Interruption Frequency Index (SAIFI)**

Figure 2 shows the SAIFI values for 2016 to 2021.

The 2021 SAIFI of 2.299 interruptions is about a 26% increase compared to the 2020 SAIFI of 1.819 interruptions. The number of customer interruptions was 201,285 in 2021 compared to 157,964 in 2020.

The following events significantly impacted the 2021 SAIFI results:

1. June 24, 2021 (Thursday) – Underfrequency load shed due to an Independent Power Producer’s (IPP) generating equipment tripping offline. This resulted in a sustained interruption to 16,773 customers for up to 13 minutes and contributed 0.192 interruptions to the annual SAIFI.
2. June 21, 2021 (Monday) – Underfrequency load shed due to an IPP’s generating equipment tripping offline. This resulted in a sustained interruption to 11,971 customers for up to 27 minutes and contributed 0.137 interruptions to the annual SAIFI.
3. July 4, 2021 (Sunday) – Underfrequency load shed due to an IPP’s output dropping to minimum generation. This resulted in a sustained interruption to 11,635 customers for up to 11 minutes and contributed 0.133 interruptions to the annual SAIFI.

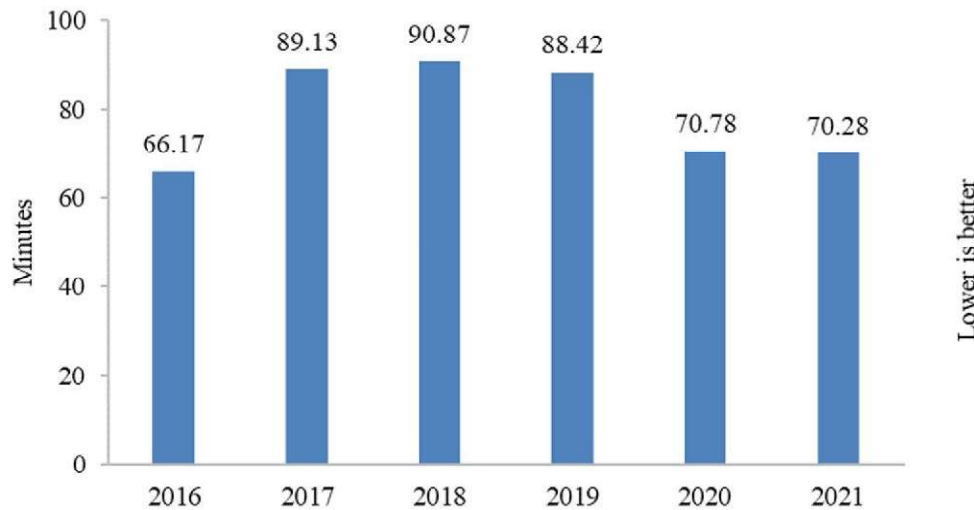
**Figure 3: Normalized Customer Average Interruption Duration Index (CAIDI)**

Figure 3 shows the CAIDI values for 2016 to 2021.

The 2021 CAIDI of 70.28 minutes is about a 1% decrease compared to the 2020 CAIDI of 70.78 minutes.

The following events significantly impacted the 2021 CAIDI results:

1. October 22, 2021 (Friday) – A tree fell on transmission conductors. This resulted in a sustained interruption to 2,923 customers for up to 11 hours and 22 minutes and contributed 2.93 minutes to the annual CAIDI.
2. February 28, 2021 (Sunday) – A tree leaned on transmission conductors. This resulted in a sustained interruption to 2,923 customers for up to 4 hours and 13 minutes and contributed 2.14 minutes to the annual CAIDI.
3. December 7, 2021 (Tuesday) – Tree-related outages affecting various parts of Hawai'i Island during high winds. This resulted in a sustained interruption to 115 customers for up to 126 hours and 7 minutes and contributed 2.10 minutes to the annual CAIDI.



**Figure 4: Normalized Average System Availability Index (ASAI)**

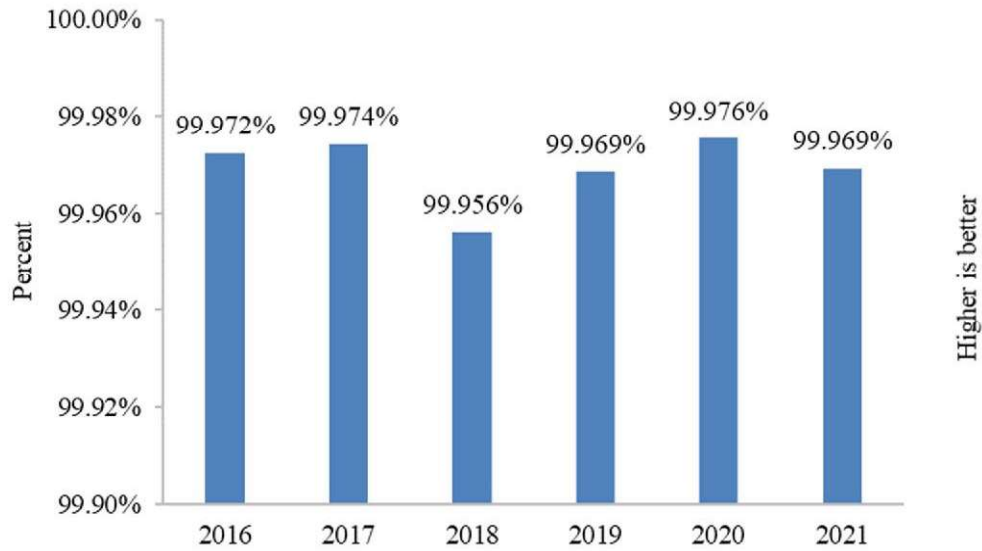
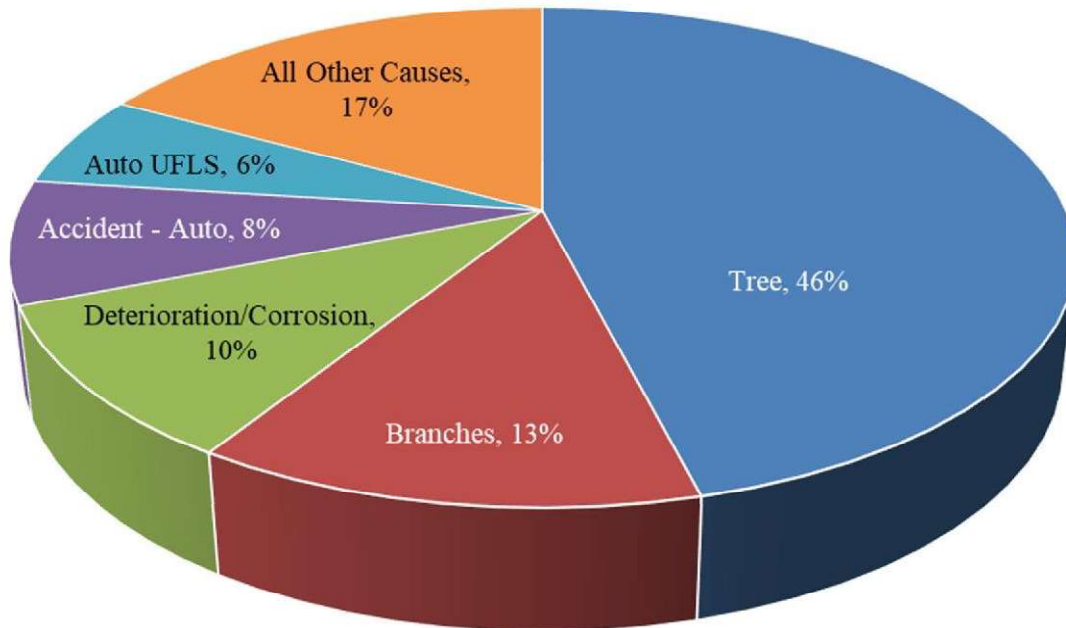


Figure 4 shows the ASAI values for 2016 to 2021.

The 2021 ASAI of 99.969% is a 0.007% decrease from the 2020 ASAI of 99.976%. The customer hours interrupted was 235,769 hours in 2021 compared to 186,333 hours in 2020.

**Figure 5: Outage Causes for 2021**



The top five outage causes by customer hours interrupted, as illustrated in Figure 5, accounted for about 83% of the total customer hours interrupted in 2021. These include:

<u>Outage Cause</u>	<u>Description</u>
1. Tree	Entire downed tree contacts/damages equipment
2. Branches	Disconnected portion of vegetation contacts/damages equipment
3. Deterioration/Corrosion	Equipment breakdown from natural causes
4. Accident – Auto	Non-utility vehicle collision with equipment
5. Auto UFLS	Controlled automatic load shed to recover from underfrequency conditions

From 2020 to 2021, Tree remained the top outage cause. Branches replaced Deterioration/Corrosion as the 2<sup>nd</sup> top outage cause. Deterioration/Corrosion is now the 3<sup>rd</sup> top outage cause. Accident – Auto and Auto UFLS replaced High Winds and Overgrown as the 4<sup>th</sup> and 5<sup>th</sup> top outage causes, respectively.

**Hawai'i Electric Light Company, Inc.**  
**Normalized Sustained Interruption Summary**

From: January 1, 2021      To: December 31, 2021

<b>Outage Cause</b>	<b>Customer Hours Interrupted</b>	<b>Customer Interruptions</b>	<b>SAIFI (interruptions)</b>	<b>SAIDI (minutes)</b>	<b>CAIDI (minutes)</b>
Tree	108,777.9	34,859	0.398	74.54	187.23
Branches	30,740.9	21,286	0.243	21.07	86.65
Deterioration/Corrosion	24,163.4	13,405	0.153	16.56	108.15
Accident - Auto	18,047.0	6,264	0.072	12.37	172.86
Auto UFLS	14,588.1	98,214	1.122	10.00	8.91
Unknown	6,439.8	3,100	0.035	4.41	124.64
Failure/Defect	5,164.8	2,698	0.031	3.54	114.86
Overgrown	4,768.3	6,479	0.074	3.27	44.16
Cable Fault	4,034.0	1,472	0.017	2.76	164.43
Scheduled	2,707.4	909	0.010	1.86	178.71
High Winds	2,612.2	2,333	0.027	1.79	67.18
Accident - Construction	2,420.2	724	0.008	1.66	200.57
Transformer - Failure	2,198.7	384	0.004	1.51	343.54
Fire	1,933.0	1,708	0.020	1.32	67.90
Lightning	1,733.1	726	0.008	1.19	143.23
Other Company Personnel	1,208.7	392	0.004	0.83	185.01
Other	1,130.8	879	0.010	0.77	77.19
Faulty Operation	1,072.6	1,155	0.013	0.73	55.72
Flashover	878.9	279	0.003	0.60	189.00
Object in Line - Animal	700.7	716	0.008	0.48	58.72
Switching	200.6	2,036	0.023	0.14	5.91
Overload	104.1	1,203	0.014	0.07	5.19
Heavy Rain	82.3	20	0.000	0.06	247.00
Customer - Equipment	45.0	30	0.000	0.03	90.00
Natural					
Disaster/Tsunami/Earthquake	10.6	3	0.000	0.01	212.00
Vandalism	6.3	11	0.000	0.00	34.36
Accident - Other	0.0	0	0.000	0.00	0.00
Flooding	0.0	0	0.000	0.00	0.00
Landslide	0.0	0	0.000	0.00	0.00
Manual Load Shed	0.0	0	0.000	0.00	0.00
Object in Line - Balloon	0.0	0	0.000	0.00	0.00
Object in Line - Foreign Object	0.0	0	0.000	0.00	0.00
Object in Line - Man	0.0	0	0.000	0.00	0.00
System Change	0.0	0	0.000	0.00	0.00
Transformer - Overload	0.0	0	0.000	0.00	0.00
<b>Total</b>	<b>235,769.4</b>	<b>201,285</b>	<b>2.299</b>	<b>161.56</b>	<b>70.28</b>

Average System Availability =	99.969%
Number of customers for the period =	87,558
24-month annual SAIDI (minutes) average for the period 1/1/2020 - 12/31/2021 =	145.16
24-month average number of customers for the period 1/1/2020 - 12/31/2021 =	87,192

**Notes:** Outage causes are listed in descending order of SAIDI. Outages due to customer requests are not included in the service reliability indices. The Forced cause, which was used in previous reports, has been discontinued; outages are coded to the event's root cause.

**Hawai'i Electric Light Company, Inc.**  
**Normalized Sustained Interruption Summary**

From: January 1, 2021      To: December 31, 2021

Outage Cause Category/Cause	Interruption Count	% of Total	Customer Hours Interrupted	% of Total
<b><u>Equipment</u></b>	<b>193</b>	<b>20.3%</b>	<b>37,616.4</b>	<b>16.0%</b>
Deterioration/Corrosion	102	10.7%	24,163.4	10.2%
Failure/Defect	13	1.4%	5,164.8	2.2%
Cable Fault	27	2.8%	4,034.0	1.7%
Transformer - Failure	46	4.8%	2,198.7	0.9%
Faulty Operation	2	0.2%	1,072.6	0.5%
Flashover	1	0.1%	878.9	0.4%
Overload	2	0.2%	104.1	0.0%
Transformer - Overload	0	0.0%	0.0	0.0%
<b><u>Error</u></b>	<b>5</b>	<b>0.5%</b>	<b>1,409.3</b>	<b>0.6%</b>
Other Company Personnel	3	0.3%	1,208.7	0.5%
Switching	2	0.2%	200.6	0.1%
<b><u>Generation</u></b>	<b>11</b>	<b>1.2%</b>	<b>14,588.1</b>	<b>6.2%</b>
Auto UFLS	11	1.2%	14,588.1	6.2%
Manual Load Shed	0	0.0%	0.0	0.0%
Other	0	0.0%	0.0	0.0%
<b><u>Maintenance</u></b>	<b>156</b>	<b>16.4%</b>	<b>2,707.4</b>	<b>1.1%</b>
Scheduled	156	16.4%	2,707.4	1.1%
System Change	0	0.0%	0.0	0.0%
<b><u>Other</u></b>	<b>19</b>	<b>2.0%</b>	<b>1,130.8</b>	<b>0.5%</b>
Other	19	2.0%	1,130.8	0.5%
<b><u>Public (Non-Utility)</u></b>	<b>95</b>	<b>10.0%</b>	<b>23,152.1</b>	<b>9.8%</b>
Accident - Auto	33	3.5%	18,047.0	7.7%
Accident - Construction	25	2.6%	2,420.2	1.0%
Fire	2	0.2%	1,933.0	0.8%
Object in Line - Animal	31	3.3%	700.7	0.3%
Customer - Equipment	1	0.1%	45.0	0.0%
Vandalism	3	0.3%	6.3	0.0%
Accident - Other	0	0.0%	0.0	0.0%
Object in Line - Balloon	0	0.0%	0.0	0.0%
Object in Line - Foreign Object	0	0.0%	0.0	0.0%
Object in Line - Man	0	0.0%	0.0	0.0%
<b><u>Unknown</u></b>	<b>104</b>	<b>10.9%</b>	<b>6,439.8</b>	<b>2.7%</b>
Unknown	104	10.9%	6,439.8	2.7%
<b><u>Vegetation</u></b>	<b>326</b>	<b>34.2%</b>	<b>144,287.1</b>	<b>61.2%</b>
Tree	176	18.5%	108,777.9	46.1%
Branches	105	11.0%	30,740.9	13.0%
Overgrown	45	4.7%	4,768.3	2.0%
<b><u>Weather</u></b>	<b>43</b>	<b>4.5%</b>	<b>4,438.2</b>	<b>1.9%</b>
High Winds	8	0.8%	2,612.2	1.1%
Lightning	33	3.5%	1,733.1	0.7%
Heavy Rain	1	0.1%	82.3	0.0%
Natural Disaster/Tsunami/Earthquake	1	0.1%	10.6	0.0%
Flooding	0	0.0%	0.0	0.0%
Landslide	0	0.0%	0.0	0.0%
<b>Total</b>	<b>952</b>		<b>235,769.4</b>	

**Note:** Outage causes are listed in descending order of Customer Hours Interrupted within each Cause Category. Outages due to customer requests are not included in the service reliability indices. The Forced cause, which was used in previous reports, has been discontinued. Outages are coded to the event's root cause.

# **APPENDIX**

## ANNUAL SERVICE RELIABILITY REPORT

2021

May 11, 2022

**DEFINITION OF TERMS**

**CUSTOMER INTERRUPTION**

One interruption of one customer.

**INTERRUPTION**

The loss of service to one or more customers as a result of one or more component outages.

**INTERRUPTION DURATION**

The time period from the initiation of an interruption until service has been restored to the affected customers.

**MOMENTARY INTERRUPTION**

An interruption having a duration of five minutes or less, typically limited to the period required to restore service by an interrupting device.

**OUTAGE**

The loss of ability of a component to deliver power. An outage may or may not cause an interruption of service to customers, depending on the system configuration.

**SUSTAINED INTERRUPTION**

Any interruption not classified as a momentary interruption. That is, any interruption that lasts more than five minutes.

Note: Interruptions to customers at their request are not included.

Reliability indices are based on the standards defined by the Institute of Electrical and Electronics Engineers (IEEE). Four indices that convey a meaningful representation of the level of reliability are as follows:

### **RELIABILITY INDICES**

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

ASAI indicates the fraction of time that the average customer received service during a predefined period of time. Customer hours service demand is determined by multiplying the total number of customers served by the number of hours in the period.

$$ASAI = \frac{\sum \text{Customer Hours Service Availability}}{\sum \text{Customer Hours Service Demand}} \times 100\%$$

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

CAIDI indicates the average time required to restore service during a predefined period of time.

$$CAIDI = \frac{\sum(\text{Duration of Interruption} \times \text{No. of Sustained Customer Interruptions})}{\sum \text{No. of Sustained Customer Interruptions}} = \frac{SAIDI}{SAIFI}$$

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

SAIDI indicates the total sustained interruption duration for the average customer during a predefined period of time. It is commonly measured in minutes or hours of interruption.

$$SAIDI = \frac{\sum(\text{Duration of Interruption} \times \text{No. of Sustained Customer Interruptions})}{\text{Total No. of Customers Served}}$$

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

SAIFI indicates how often the average customer experiences a sustained interruption during a predefined period of time.

$$SAIFI = \frac{\sum \text{No. of Sustained Customer Interruptions}}{\text{Total No. of Customers Served}}$$

# **MAUI ELECTRIC COMPANY, LIMITED**

## **ANNUAL SERVICE RELIABILITY REPORT**

**2021**

May 11, 2022



## **INTRODUCTION**

This is Maui Electric Company, Limited's 2021 annual service reliability report.

The service reliability indices provided in this report are commonly used in the electric power utility industry as a method of measuring system reliability performance. These include overall availability of electrical service during a given period of time (Average Service Availability Index or ASAI), the average frequency or number of times customers experience a sustained interruption of service during a given period of time (System Average Interruption Frequency Index or SAIFI), the average length of time an interrupted customer is without power during a given period of time (Customer Average Interruption Duration Index or CAIDI), and the average length of time customers are without power during a given period of time (System Average Interruption Duration Index or SAIDI). SAIDI is an indication of overall system reliability because it incorporates the impact of frequency and duration of outages on the total customer base. The Appendix contains definitions, explanations, and equations for the reliability indices.

## **METHODOLOGY**

For the period prior to and including March 31, 2021, the reliability indices provided in this report were calculated using the Institute of Electrical and Electronics Engineers (IEEE) Standard 1366<sup>TM</sup>-2012 methodology. For the period April 1, 2021 and forward, indices are calculated using an adjusted IEEE 1366 methodology.<sup>1</sup> Indices reported on a normalized basis exclude Major Event Days (MEDs). MEDs are defined as days in which the daily system SAIDI exceeds the MED threshold value ( $T_{MED}$ ). Statistically, days having a daily system SAIDI greater than  $T_{MED}$  indicate days on which the energy delivery system experienced stresses beyond that normally expected (such as during severe weather).<sup>2</sup> In calculating daily system SAIDI, any interruption that spans multiple calendar days is accrued to the day on which the interruption began.

## **RESULTS**

The following tables provide reliability index results on unnormalized and normalized bases for generation, transmission, and distribution outages and separately for 1) transmission and distribution outages, 2) utility generation outages, and 3) non-utility generation outages. Results are as of January 19, 2022. Subsequent findings may result in changes to data.

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<sup>1</sup> Docket No. 2019-0110, Decision and Order No. 37600, issued on February 2, 2021.

<sup>2</sup> IEEE Std 1366<sup>TM</sup>-2012: IEEE Guide for Electric Power Distribution Reliability Indices

### Annual Service Reliability Indices

The following days in 2021 were determined to be MEDs and are therefore excluded from the normalized indices.

- 4/24/21 due to mylar balloon in conductors on Lānaʻi
- 5/29/21 due to underfrequency load shed (UFLS) when a generator tripped offline on Lānaʻi
- 11/29/21 due to transmission and distribution (T&D) equipment failure on Maui
- 12/5/21 due to weather-related outages affecting various parts of Maui
- 12/7/21 due to T&D equipment failure on Maui

\* Previously reported information has been revised based on updated data.

**Table 1: Generation, Transmission, and Distribution Outages – All Islands, Unnormalized**

	<u>2016</u>	<u>2017</u>	<u>2018</u>	<u>2019</u>	<u>2020*</u>	<u>2021</u>
Number of Customers	70,745	71,049	71,671	72,265	73,007	73,735
Customer Interruptions	141,555	248,291	241,217	195,561	138,816	147,004
Customer-Hours Interrupted	220,337	984,239	569,222	348,169	287,853	609,474
SAIDI (minutes)	186.87	831.18	476.53	289.08	236.57	495.94
CAIDI (minutes)	93.39	237.84	141.59	106.82	124.42	248.76
SAIFI (interruptions)	2.001	3.495	3.366	2.706	1.901	1.994
ASAI (percentage)	99.965%	99.842%	99.909%	99.945%	99.955%	99.906%

**Table 2: Transmission and Distribution Outages – All Islands, Unnormalized**

	<u>2016</u>	<u>2017</u>	<u>2018</u>	<u>2019</u>	<u>2020*</u>	<u>2021</u>
Number of Customers	70,745	71,049	71,671	72,265	73,007	73,735
Customer Interruptions	134,247	244,444	173,292	185,205	113,267	141,693
Customer-Hours Interrupted	213,140	979,851	527,947	342,971	256,870	603,472
SAIDI (minutes)	180.77	827.48	441.98	284.76	211.11	491.06
CAIDI (minutes)	95.26	240.51	182.79	111.11	136.07	255.54
SAIFI (interruptions)	1.898	3.441	2.418	2.563	1.551	1.922
ASAI (percentage)	99.966%	99.843%	99.916%	99.946%	99.960%	99.907%

**Table 3: Utility Generation Outages – All Islands, Unnormalized**

	<u>2016</u>	<u>2017</u>	<u>2018</u>	<u>2019</u>	<u>2020</u>	<u>2021</u>
Number of Customers	70,745	71,049	71,671	72,265	73,007	73,735
Customer Interruptions	7,305	3,667	23,563	10,356	25,549	5,311
Customer-Hours Interrupted	7,185	4,296	17,010	5,198	30,982	6,002
SAIDI (minutes)	6.09	3.63	14.24	4.32	25.46	4.88
CAIDI (minutes)	59.01	70.29	43.31	30.12	72.76	67.80
SAIFI (interruptions)	0.103	0.052	0.329	0.143	0.350	0.072
ASAI (percentage)	99.999%	99.999%	99.997%	99.999%	99.995%	99.999%

**Table 4: Non-Utility Generation Outages – All Islands, Unnormalized**

	<u>2016</u>	<u>2017</u>	<u>2018</u>	<u>2019</u>	<u>2020</u>	<u>2021</u>
<b>Number of Customers</b>	70,745	71,049	71,671	72,265	73,007	73,735
<b>Customer Interruptions</b>	3	180	44,362	0	0	0
<b>Customer-Hours Interrupted</b>	13	92	24,264	0	0	0
<b>SAIDI (minutes)</b>	0.01	0.08	20.31	0.00	0.00	0.00
<b>CAIDI (minutes)</b>	255.00	30.71	32.82	0.00	0.00	0.00
<b>SAIFI (interruptions)</b>	0.000	0.003	0.619	0.000	0.000	0.000
<b>ASAI (percentage)</b>	100.000%	100.000%	99.996%	100.000%	100.000%	100.000%

**Table 5: Generation, Transmission, and Distribution Outages – Maui, Unnormalized**

	<u>2016</u>	<u>2017</u>	<u>2018</u>	<u>2019*</u>	<u>2020*</u>	<u>2021</u>
<b>Number of Customers</b>	65,799	66,107	66,701	67,267	68,001	68,711
<b>Customer Interruptions</b>	118,080	230,067	214,637	181,075	122,467	126,542
<b>Customer-Hours Interrupted</b>	177,695	860,210	462,804	321,110	240,043	563,958
<b>SAIDI (minutes)</b>	162.03	780.74	416.31	286.42	211.80	492.46
<b>CAIDI (minutes)</b>	90.29	224.34	129.37	106.40	117.60	267.40
<b>SAIFI (interruptions)</b>	1.795	3.480	3.218	2.692	1.801	1.842
<b>ASAI (percentage)</b>	99.969%	99.851%	99.921%	99.946%	99.960%	99.906%

**Table 6: Transmission and Distribution Outages –Maui, Unnormalized**

	<u>2016</u>	<u>2017</u>	<u>2018</u>	<u>2019*</u>	<u>2020*</u>	<u>2021</u>
<b>Number of Customers</b>	65,799	66,107	66,701	67,267	68,001	68,711
<b>Customer Interruptions</b>	118,077	230,067	152,495	176,151	103,870	126,542
<b>Customer-Hours Interrupted</b>	177,682	860,210	426,968	318,362	223,632	563,958
<b>SAIDI (minutes)</b>	162.02	780.74	384.08	283.97	197.32	492.46
<b>CAIDI (minutes)</b>	90.29	224.34	167.99	108.44	129.18	267.40
<b>SAIFI (interruptions)</b>	1.795	3.480	2.286	2.619	1.527	1.842
<b>ASAI (percentage)</b>	99.969%	99.851%	99.927%	99.946%	99.963%	99.906%

**Table 7: Utility Generation Outages – Maui, Unnormalized**

	<u>2016</u>	<u>2017</u>	<u>2018</u>	<u>2019</u>	<u>2020</u>	<u>2021</u>
<b>Number of Customers</b>	65,799	66,107	66,701	67,267	68,001	68,711
<b>Customer Interruptions</b>	0	0	17,960	4,924	18,597	0
<b>Customer-Hours Interrupted</b>	0	0	11,658	2,748	16,411	0
<b>SAIDI (minutes)</b>	0.00	0.00	10.49	2.45	14.48	0.00
<b>CAIDI (minutes)</b>	0.00	0.00	38.95	33.48	52.95	0.00
<b>SAIFI (interruptions)</b>	0.000	0.000	0.269	0.073	0.273	0.000
<b>ASAI (percentage)</b>	100.000%	100.000%	99.998%	100.000%	99.997%	100.000%

**Table 8: Non-Utility Generation Outages – Maui, Unnormalized**

	<u>2016</u>	<u>2017</u>	<u>2018</u>	<u>2019</u>	<u>2020</u>	<u>2021</u>
<b>Number of Customers</b>	65,799	66,107	66,701	67,267	68,001	68,711
<b>Customer Interruptions</b>	3	0	44,182	0	0	0
<b>Customer-Hours Interrupted</b>	13	0	24,178	0	0	0
<b>SAIDI (minutes)</b>	0.01	0.00	21.75	0.00	0.00	0.00
<b>CAIDI (minutes)</b>	255.00	0.00	32.83	0.00	0.00	0.00
<b>SAIFI (interruptions)</b>	0.000	0.000	0.662	0.000	0.000	0.000
<b>ASAI (percentage)</b>	100.000%	100.000%	99.996%	100.000%	100.000%	100.000%

**Table 9: Generation, Transmission, and Distribution Outages – Moloka'i, Unnormalized**

	<u>2016</u>	<u>2017</u>	<u>2018</u>	<u>2019*</u>	<u>2020</u>	<u>2021</u>
<b>Number of Customers</b>	3,212	3,209	3,232	3,250	3,259	3,272
<b>Customer Interruptions</b>	17,610	12,700	20,101	9,441	13,893	16,517
<b>Customer-Hours Interrupted</b>	38,058	32,315	99,544	23,938	42,964	41,433
<b>SAIDI (minutes)</b>	710.85	604.19	1847.88	441.98	791.07	759.86
<b>CAIDI (minutes)</b>	129.67	152.67	297.13	152.13	185.55	150.51
<b>SAIFI (interruptions)</b>	5.482	3.958	6.219	2.905	4.263	5.048
<b>ASAI (percentage)</b>	99.865%	99.885%	99.648%	99.916%	99.850%	99.855%

**Table 10: Transmission and Distribution Outages – Moloka'i, Unnormalized**

	<u>2016</u>	<u>2017</u>	<u>2018</u>	<u>2019*</u>	<u>2020</u>	<u>2021</u>
<b>Number of Customers</b>	3,212	3,209	3,232	3,250	3,259	3,272
<b>Customer Interruptions</b>	15,259	10,952	17,177	7,226	7,719	12,492
<b>Customer-Hours Interrupted</b>	34,985	29,132	96,584	23,036	28,848	36,476
<b>SAIDI (minutes)</b>	653.46	544.68	1792.93	425.33	531.16	668.95
<b>CAIDI (minutes)</b>	137.57	159.60	337.37	191.28	224.23	175.20
<b>SAIFI (interruptions)</b>	4.750	3.413	5.314	2.224	2.369	3.818
<b>ASAI (percentage)</b>	99.876%	99.896%	99.659%	99.919%	99.899%	99.873%

**Table 11: Utility Generation Outages – Moloka'i, Unnormalized**

	<u>2016</u>	<u>2017</u>	<u>2018</u>	<u>2019</u>	<u>2020</u>	<u>2021</u>
<b>Number of Customers</b>	3,212	3,209	3,232	3,250	3,259	3,272
<b>Customer Interruptions</b>	2,351	1,748	2,924	2,215	6,174	4,025
<b>Customer-Hours Interrupted</b>	3,073	3,183	2,960	902	14,116	4,957
<b>SAIDI (minutes)</b>	57.40	59.51	54.94	16.65	259.92	90.91
<b>CAIDI (minutes)</b>	78.42	109.26	60.74	24.42	137.19	73.89
<b>SAIFI (interruptions)</b>	0.732	0.545	0.905	0.682	1.895	1.230
<b>ASAI (percentage)</b>	99.989%	99.989%	99.990%	99.997%	99.951%	99.983%

**Table 12: Non-Utility Generation Outages – Moloka'i, Unnormalized**

	<u>2016</u>	<u>2017</u>	<u>2018</u>	<u>2019</u>	<u>2020</u>	<u>2021</u>
<b>Number of Customers</b>	3,212	3,209	3,232	3,250	3,259	3,272
<b>Customer Interruptions</b>	0	0	0	0	0	0
<b>Customer-Hours Interrupted</b>	0	0	0	0	0	0
<b>SAIDI (minutes)</b>	0.00	0.00	0.00	0.00	0.00	0.00
<b>CAIDI (minutes)</b>	0.00	0.00	0.00	0.00	0.00	0.00
<b>SAIFI (interruptions)</b>	0.000	0.000	0.000	0.000	0.000	0.000
<b>ASAI (percentage)</b>	100.000%	100.000%	100.000%	100.000%	100.000%	100.000%

**Table 13: Generation, Transmission, and Distribution Outages – Lāna'i, Unnormalized**

	<u>2016</u>	<u>2017</u>	<u>2018</u>	<u>2019</u>	<u>2020</u>	<u>2021</u>
<b>Number of Customers</b>	1,733	1,733	1,738	1,749	1,747	1,752
<b>Customer Interruptions</b>	5,865	5,524	6,479	5,045	2,456	3,945
<b>Customer-Hours Interrupted</b>	4,584	91,714	6,874	3,121	4,846	4,083
<b>SAIDI (minutes)</b>	158.66	3176.26	237.27	107.10	166.39	139.78
<b>CAIDI (minutes)</b>	46.89	996.17	63.65	37.12	118.38	62.09
<b>SAIFI (interruptions)</b>	3.383	3.188	3.727	2.885	1.406	2.251
<b>ASAI (percentage)</b>	99.970%	99.396%	99.955%	99.980%	99.968%	99.973%

**Table 14: Transmission and Distribution Outages – Lāna'i, Unnormalized**

	<u>2016</u>	<u>2017</u>	<u>2018</u>	<u>2019</u>	<u>2020</u>	<u>2021</u>
<b>Number of Customers</b>	1,733	1,733	1,738	1,749	1,747	1,752
<b>Customer Interruptions</b>	911	3,425	3,620	1,828	1,678	2,659
<b>Customer-Hours Interrupted</b>	472	90,510	4,395	1,572	4,390	3,038
<b>SAIDI (minutes)</b>	16.35	3134.53	151.71	53.95	150.76	104.01
<b>CAIDI (minutes)</b>	31.10	1585.57	72.85	51.61	156.99	68.55
<b>SAIFI (interruptions)</b>	0.526	1.977	2.083	1.045	0.960	1.517
<b>ASAI (percentage)</b>	99.997%	99.404%	99.971%	99.990%	99.971%	99.980%

**Table 15: Utility Generation Outages – Lāna'i, Unnormalized**

	<u>2016</u>	<u>2017</u>	<u>2018</u>	<u>2019</u>	<u>2020</u>	<u>2021</u>
<b>Number of Customers</b>	1,733	1,733	1,738	1,749	1,747	1,752
<b>Customer Interruptions</b>	4,954	1,919	2,679	3,217	778	1,286
<b>Customer-Hours Interrupted</b>	4,112	1,113	2,392	1,549	455	1,045
<b>SAIDI (minutes)</b>	142.32	38.53	82.58	53.15	15.63	35.77
<b>CAIDI (minutes)</b>	49.80	34.79	53.58	28.89	35.10	48.74
<b>SAIFI (interruptions)</b>	2.858	1.108	1.541	1.840	0.445	0.734
<b>ASAI (percentage)</b>	99.973%	99.993%	99.984%	99.990%	99.997%	99.993%

**Table 16: Non-Utility Generation Outages – Lānaʻi, Unnormalized**

	<u>2016</u>	<u>2017</u>	<u>2018</u>	<u>2019</u>	<u>2020</u>	<u>2021</u>
<b>Number of Customers</b>	1,733	1,733	1,738	1,749	1,747	1,752
<b>Customer Interruptions</b>	0	180	180	0	0	0
<b>Customer-Hours Interrupted</b>	0	92	86	0	0	0
<b>SAIDI (minutes)</b>	0.00	3.19	2.98	0.00	0.00	0.00
<b>CAIDI (minutes)</b>	0.00	30.71	28.75	0.00	0.00	0.00
<b>SAIFI (interruptions)</b>	0.000	0.104	0.104	0.000	0.000	0.000
<b>ASAI (percentage)</b>	100.000%	99.999%	99.999%	100.000%	100.000%	100.000%

**Table 17: Generation, Transmission, and Distribution Outages – All Islands, Normalized<sup>3</sup>**

	<u>2016</u>	<u>2017</u>	<u>2018</u>	<u>2019</u>	<u>2020</u>	<u>2021</u>
<b>Number of Customers</b>	70,745	71,049	71,671	72,265	73,007	73,735
<b>Customer Interruptions</b>	113,783	117,429	181,037	148,205	125,931	99,226
<b>Customer-Hours Interrupted</b>	159,383	178,350	272,398	190,802	202,513	192,587
<b>SAIDI (minutes)</b>	135.18	150.62	228.04	158.42	166.43	156.71
<b>CAIDI (minutes)</b>	84.05	91.13	90.28	77.25	96.49	116.45
<b>SAIFI (interruptions)</b>	1.608	1.653	2.526	2.051	1.725	1.346
<b>ASAI (percentage)</b>	99.974%	99.971%	99.957%	99.970%	99.968%	99.970%

<sup>3</sup> Exclusions include:

- 4/3/16 due to motor vehicle accident on Maui
- 7/2/16 due to West Maui Mountains wildfire on Maui
- 12/18/16 due to trees or branches in lines during high winds on Maui
- 1/21/17 due to high winds on Lānaʻi
- 3/2/17 due to UFLS on Maui
- 10/24/17 due to an island-wide outage on Maui
- 11/26/17 due to UFLS and a fault caused by tree branch on Maui
- 8/23/18 due to effects of Hurricane Lane on Maui
- 8/24/18 due to effects of Hurricane Lane on Maui
- 9/12/18 due to effects of Tropical Storm Olivia on Maui
- 10/20/18 UFLS due to rapid drop in as-available generation on Maui
- 2/10/19 due to effects of winter storm/high winds, vegetation, and flashover on Maui
- 2/12/19 due to effects of winter storm/high winds on Maui
- 11/22/19 due to high winds on Maui
- 12/26/20 due to weather and vegetation-related outages during high winds and rain on Maui
- 4/24/21 due to mylar balloon in conductors on Lānaʻi
- 5/29/21 due to UFLS when a generator tripped offline on Lānaʻi
- 11/29/21 due to T&D equipment failure on Maui
- 12/5/21 due to weather-related outages affecting various parts of Maui
- 12/7/21 due to T&D equipment failure on Maui

**Table 18: Transmission and Distribution Outages – All Islands, Normalized<sup>3</sup>**

	<u>2016</u>	<u>2017</u>	<u>2018</u>	<u>2019</u>	<u>2020</u>	<u>2021</u>
Number of Customers	70,745	71,049	71,671	72,265	73,007	73,735
Customer Interruptions	106,475	113,582	135,488	137,849	100,382	95,195
Customer-Hours Interrupted	152,185	173,962	248,682	185,604	171,531	187,625
SAIDI (minutes)	129.07	146.91	208.19	154.10	140.97	152.67
CAIDI (minutes)	85.76	91.90	110.13	80.79	102.53	118.26
SAIFI (interruptions)	1.505	1.599	1.890	1.908	1.375	1.291
ASAI (percentage)	99.976%	99.972%	99.960%	99.971%	99.973%	99.971%

**Table 19: Utility Generation Outages – All Islands, Normalized<sup>3</sup>**

	<u>2016</u>	<u>2017</u>	<u>2018</u>	<u>2019</u>	<u>2020</u>	<u>2021</u>
Number of Customers	70,745	71,049	71,671	72,265	73,007	73,735
Customer Interruptions	7,305	3,667	23,563	10,356	25,549	4,031
Customer-Hours Interrupted	7,185	4,296	17,010	5,198	30,982	4,961
SAIDI (minutes)	6.09	3.63	14.24	4.32	25.46	4.04
CAIDI (minutes)	59.01	70.29	43.31	30.12	72.76	73.85
SAIFI (interruptions)	0.103	0.052	0.329	0.143	0.350	0.055
ASAI (percentage)	99.999%	99.999%	99.997%	99.999%	99.995%	99.999%

**Table 20: Non-Utility Generation Outages – All Islands, Normalized<sup>3</sup>**

	<u>2016</u>	<u>2017</u>	<u>2018</u>	<u>2019</u>	<u>2020</u>	<u>2021</u>
Number of Customers	70,745	71,049	71,671	72,265	73,007	73,735
Customer Interruptions	3	180	21,986	0	0	0
Customer-Hours Interrupted	13	92	6,706	0	0	0
SAIDI (minutes)	0.01	0.08	5.61	0.00	0.00	0.00
CAIDI (minutes)	255.00	30.71	18.30	0.00	0.00	0.00
SAIFI (interruptions)	0.000	0.003	0.307	0.000	0.000	0.000
ASAI (percentage)	100.000%	100.000%	99.999%	100.000%	100.000%	100.000%

**Table 21: Generation, Transmission, and Distribution Outages – Maui, Normalized<sup>3</sup>**

	<u>2016</u>	<u>2017</u>	<u>2018</u>	<u>2019*</u>	<u>2020</u>	<u>2021</u>
Number of Customers	65,799	66,107	66,701	67,267	68,001	68,711
Customer Interruptions	90,308	100,952	154,457	133,719	109,582	80,807
Customer-Hours Interrupted	116,740	143,751	165,980	163,742	154,703	148,603
SAIDI (minutes)	106.45	130.47	149.31	146.05	136.50	129.76
CAIDI (minutes)	77.56	85.44	64.48	73.47	84.71	110.34
SAIFI (interruptions)	1.372	1.527	2.316	1.988	1.611	1.176
ASAI (percentage)	99.980%	99.975%	99.972%	99.972%	99.974%	99.975%

**Table 22: Transmission and Distribution Outages – Maui, Normalized<sup>3</sup>**

	<u>2016</u>	<u>2017</u>	<u>2018</u>	<u>2019*</u>	<u>2020</u>	<u>2021</u>
Number of Customers	65,799	66,107	66,701	67,267	68,001	68,711
Customer Interruptions	90,305	100,952	114,691	128,795	90,985	80,807
Customer-Hours Interrupted	116,728	143,751	147,702	160,995	138,293	148,603
SAIDI (minutes)	106.44	130.47	132.86	143.60	122.02	129.76
CAIDI (minutes)	77.56	85.44	77.27	75.00	91.20	110.34
SAIFI (interruptions)	1.372	1.527	1.719	1.915	1.338	1.176
ASAI (percentage)	99.980%	99.975%	99.975%	99.973%	99.977%	99.975%

**Table 23: Utility Generation Outages – Maui, Normalized<sup>3</sup>**

	<u>2016</u>	<u>2017</u>	<u>2018</u>	<u>2019</u>	<u>2020</u>	<u>2021</u>
Number of Customers	65,799	66,107	66,701	67,267	68,001	68,711
Customer Interruptions	0	0	17,960	4,924	18,597	0
Customer-Hours Interrupted	0	0	11,658	2,748	16,411	0
SAIDI (minutes)	0.00	0.00	10.49	2.45	14.48	0.00
CAIDI (minutes)	0.00	0.00	38.95	33.48	52.95	0.00
SAIFI (interruptions)	0.000	0.000	0.269	0.073	0.273	0.000
ASAI (percentage)	100.000%	100.000%	99.998%	100.000%	99.997%	100.000%

**Table 24: Non-Utility Generation Outages – Maui, Normalized<sup>3</sup>**

	<u>2016</u>	<u>2017</u>	<u>2018</u>	<u>2019</u>	<u>2020</u>	<u>2021</u>
Number of Customers	65,799	66,107	66,701	67,267	68,001	68,711
Customer Interruptions	3	0	21,806	0	0	0
Customer-Hours Interrupted	13	0	6,620	0	0	0
SAIDI (minutes)	0.01	0.00	5.96	0.00	0.00	0.00
CAIDI (minutes)	255.00	0.00	18.22	0.00	0.00	0.00
SAIFI (interruptions)	0.000	0.000	0.327	0.000	0.000	0.000
ASAI (percentage)	100.000%	100.000%	99.999%	100.000%	100.000%	100.000%

**Table 25: Generation, Transmission, and Distribution Outages – Moloka'i, Normalized<sup>3</sup>**

	<u>2016</u>	<u>2017</u>	<u>2018</u>	<u>2019*</u>	<u>2020</u>	<u>2021</u>
Number of Customers	3,212	3,209	3,232	3,250	3,259	3,272
Customer Interruptions	17,610	12,700	20,101	9,441	13,893	16,517
Customer-Hours Interrupted	38,058	32,315	99,544	23,938	42,964	41,433
SAIDI (minutes)	710.85	604.19	1847.88	441.98	791.07	759.86
CAIDI (minutes)	129.67	152.67	297.13	152.13	185.55	150.51
SAIFI (interruptions)	5.482	3.958	6.219	2.905	4.263	5.048
ASAI (percentage)	99.865%	99.885%	99.648%	99.916%	99.850%	99.855%



**Table 26: Transmission and Distribution Outages – Moloka'i, Normalized<sup>3</sup>**

	<u>2016</u>	<u>2017</u>	<u>2018</u>	<u>2019*</u>	<u>2020</u>	<u>2021</u>
Number of Customers	3,212	3,209	3,232	3,250	3,259	3,272
Customer Interruptions	15,259	10,952	17,177	7,226	7,719	12,492
Customer-Hours Interrupted	34,985	29,132	96,584	23,036	28,848	36,476
SAIDI (minutes)	653.46	544.68	1792.93	425.33	531.16	668.95
CAIDI (minutes)	137.57	159.60	337.37	191.28	224.23	175.20
SAIFI (interruptions)	4.750	3.413	5.314	2.224	2.369	3.818
ASAI (percentage)	99.876%	99.896%	99.659%	99.919%	99.899%	99.873%

**Table 27: Utility Generation Outages – Moloka'i, Normalized<sup>3</sup>**

	<u>2016</u>	<u>2017</u>	<u>2018</u>	<u>2019</u>	<u>2020</u>	<u>2021</u>
Number of Customers	3,212	3,209	3,232	3,250	3,259	3,272
Customer Interruptions	2,351	1,748	2,924	2,215	6,174	4,025
Customer-Hours Interrupted	3,073	3,183	2,960	902	14,116	4,957
SAIDI (minutes)	57.40	59.51	54.94	16.65	259.92	90.91
CAIDI (minutes)	78.42	109.26	60.74	24.42	137.19	73.89
SAIFI (interruptions)	0.732	0.545	0.905	0.682	1.895	1.230
ASAI (percentage)	99.989%	99.989%	99.990%	99.997%	99.951%	99.983%

**Table 28: Non-Utility Generation Outages – Moloka'i, Normalized<sup>3</sup>**

	<u>2016</u>	<u>2017</u>	<u>2018</u>	<u>2019</u>	<u>2020</u>	<u>2021</u>
Number of Customers	3,212	3,209	3,232	3,250	3,259	3,272
Customer Interruptions	0	0	0	0	0	0
Customer-Hours Interrupted	0	0	0	0	0	0
SAIDI (minutes)	0.00	0.00	0.00	0.00	0.00	0.00
CAIDI (minutes)	0.00	0.00	0.00	0.00	0.00	0.00
SAIFI (interruptions)	0.000	0.000	0.000	0.000	0.000	0.000
ASAI (percentage)	100.000%	100.000%	100.000%	100.000%	100.000%	100.000%

**Table 29: Generation, Transmission, and Distribution Outages – Lāna'i, Normalized<sup>3</sup>**

	<u>2016</u>	<u>2017</u>	<u>2018</u>	<u>2019</u>	<u>2020</u>	<u>2021</u>
Number of Customers	1,733	1,733	1,738	1,749	1,747	1,752
Customer Interruptions	5,865	3,777	6,479	5,045	2,456	1,902
Customer-Hours Interrupted	4,584	2,284	6,874	3,121	4,846	2,550
SAIDI (minutes)	158.66	79.10	237.27	107.10	166.39	87.32
CAIDI (minutes)	46.89	36.28	63.65	37.12	118.38	80.46
SAIFI (interruptions)	3.383	2.180	3.727	2.885	1.406	1.085
ASAI (percentage)	99.970%	99.985%	99.955%	99.980%	99.968%	99.983%

**Table 30: Transmission and Distribution Outages – Lāna‘i, Normalized<sup>3</sup>**

	<u>2016</u>	<u>2017</u>	<u>2018</u>	<u>2019</u>	<u>2020</u>	<u>2021</u>
Number of Customers	1,733	1,733	1,738	1,749	1,747	1,752
Customer Interruptions	911	1,678	3,620	1,828	1,678	1,896
Customer-Hours Interrupted	472	1,079	4,395	1,572	4,390	2,546
SAIDI (minutes)	16.35	37.38	151.71	53.95	150.76	87.17
CAIDI (minutes)	31.10	38.59	72.85	51.61	156.99	80.57
SAIFI (interruptions)	0.526	0.969	2.083	1.045	0.960	1.082
ASAI (percentage)	99.997%	99.993%	99.971%	99.990%	99.971%	99.983%

**Table 31: Utility Generation Outages – Lāna‘i, Normalized<sup>3</sup>**

	<u>2016</u>	<u>2017</u>	<u>2018</u>	<u>2019</u>	<u>2020</u>	<u>2021</u>
Number of Customers	1,733	1,733	1,738	1,749	1,747	1,752
Customer Interruptions	4,954	1,919	2,679	3,217	778	6
Customer-Hours Interrupted	4,112	1,113	2,392	1,549	455	4
SAIDI (minutes)	142.32	38.53	82.58	53.15	15.63	0.15
CAIDI (minutes)	49.80	34.79	53.58	28.89	35.10	44.00
SAIFI (interruptions)	2.858	1.108	1.541	1.840	0.445	0.003
ASAI (percentage)	99.973%	99.993%	99.984%	99.990%	99.997%	100.000%

**Table 32: Non-Utility Generation Outages – Lāna‘i, Normalized<sup>3</sup>**

	<u>2016</u>	<u>2017</u>	<u>2018</u>	<u>2019</u>	<u>2020</u>	<u>2021</u>
Number of Customers	1,733	1,733	1,738	1,749	1,747	1,752
Customer Interruptions	0	180	180	0	0	0
Customer-Hours Interrupted	0	92	86	0	0	0
SAIDI (minutes)	0.00	3.19	2.98	0.00	0.00	0.00
CAIDI (minutes)	0.00	30.71	28.75	0.00	0.00	0.00
SAIFI (interruptions)	0.000	0.104	0.104	0.000	0.000	0.000
ASAI (percentage)	100.000%	99.999%	99.999%	100.000%	100.000%	100.000%

The following charts and discussion are based on the annual reliability index results for generation, transmission, and distribution outages on a normalized basis (data from Table 17, above).

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

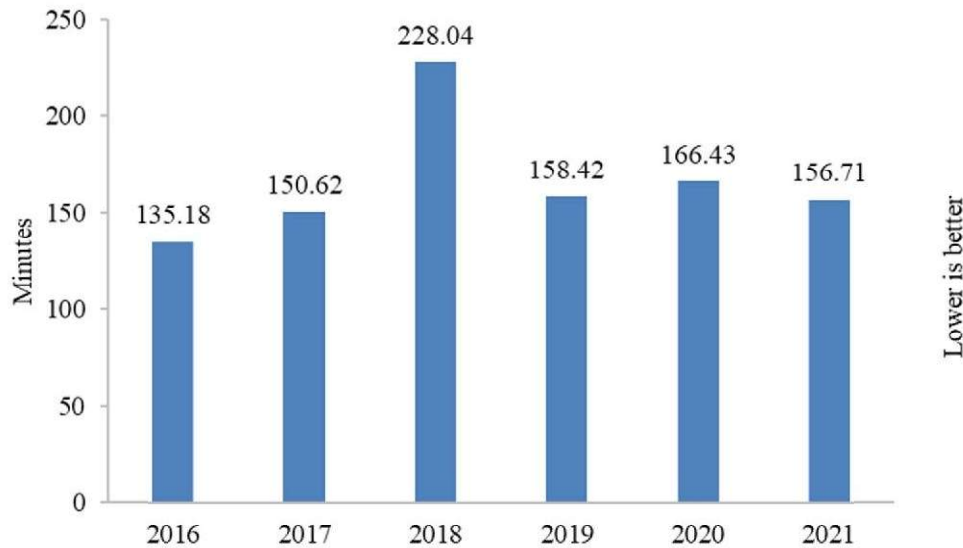


Figure 1 shows the SAIDI values for 2016 to 2021.

The 2021 SAIDI of 156.71 minutes is about a 6% decrease compared to the 2020 SAIDI of 166.43 minutes. The customer hours interrupted was 192,587 hours in 2021 compared to 202,513 hours in 2020.

The following events significantly impacted the 2021 SAIDI result:

1. September 6, 2021 (Monday) – T&D equipment failure on Maui. This resulted in a sustained interruption to 7,169 customers for up to 7 hours and 23 minutes and contributed 10.25 minutes to the annual SAIDI.
2. December 6, 2021 (Monday) – Weather-related outages affecting various parts of Maui. This resulted in a sustained interruption to 1,516 customers for up to 23 hours and 44 minutes and contributed 9.48 minutes to the annual SAIDI.
3. November 1, 2021 (Monday) – A switch flashed over on Maui. This resulted in a sustained interruption to 4,000 customers for up to 9 hours and 47 minutes and contributed 9.07 minutes to the annual SAIDI.

**Figure 2: Normalized System Average Interruption Frequency Index (SAIFI)**

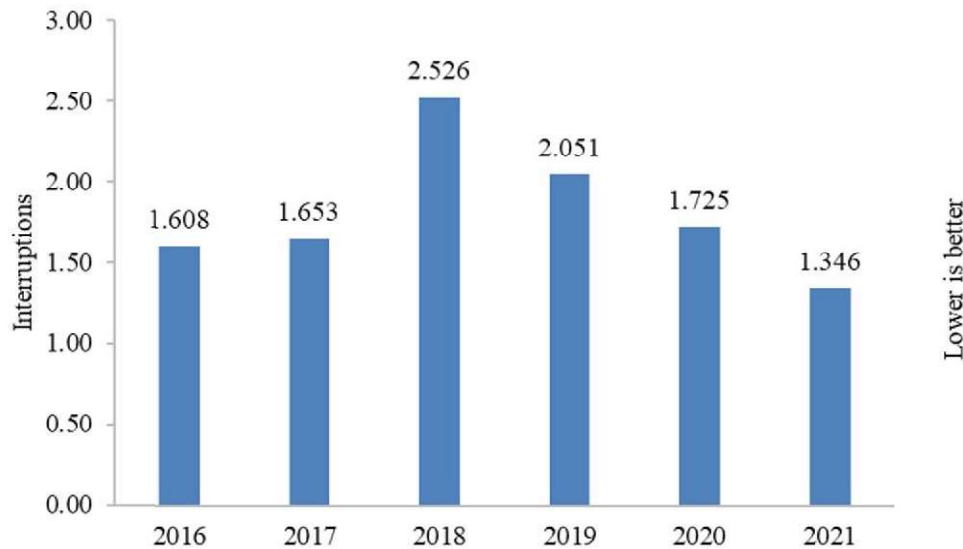


Figure 2 shows the SAIFI values for 2016 to 2021.

The 2021 SAIFI of 1.346 interruptions is about a 22% decrease compared to the 2020 SAIFI of 1.725 interruptions. The number of customer interruptions in 2021 was 99,226 compared to 125,931 in 2020.

The following events significantly impacted the 2021 SAIFI result:

1. September 6, 2021 (Monday) – T&D equipment failure on Maui. This resulted in a sustained interruption to 7,169 customers for up to 7 hours and 23 minutes and contributed 0.097 interruptions to the annual SAIFI.
2. December 6, 2021 (Monday) – Faulty T&D equipment operation during rain on Maui. This resulted in a sustained interruption to 6,917 customers for up to 1 hour and 23 minutes and contributed 0.094 interruptions to the annual SAIFI.
3. December 8, 2021 (Wednesday) – T&D equipment failure on Maui. This resulted in a sustained interruption to 6,347 customers for up to 5 hours and 16 minutes and contributed 0.086 interruptions to the annual SAIFI.

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



Figure 3 shows the CAIDI values for 2016 to 2021.

The 2021 CAIDI of 116.45 minutes is about a 21% increase compared to the 2020 CAIDI of 96.49 minutes.

The following events significantly affected the 2021 CAIDI results:

1. December 6, 2021 (Monday) – Vegetation-related outages and unknown causes affecting various parts of Maui during severe weather. This resulted in a sustained interruption to 1,516 customers for up to 23 hours and 44 minutes and contributed 5.35 minutes to the annual CAIDI.
2. July 1 and 2, 2021 (Thursday, Friday) – Unknown cause affecting a portion of Moloka‘i. This resulted in a sustained interruption to 822 customers for up to 12 hours and 16 minutes and contributed 2.74 minutes to the annual CAIDI.
3. February 3, 2021 (Wednesday) – Weather and vegetation-related outages affecting various parts of Maui and Moloka‘i during high winds and heavy rain. This resulted in a sustained interruption to 1,527 customers for up to 18 hours and 6 minutes and contributed 2.47 minutes to the annual CAIDI.

**Figure 4: Normalized Average System Availability Index (ASAI)**

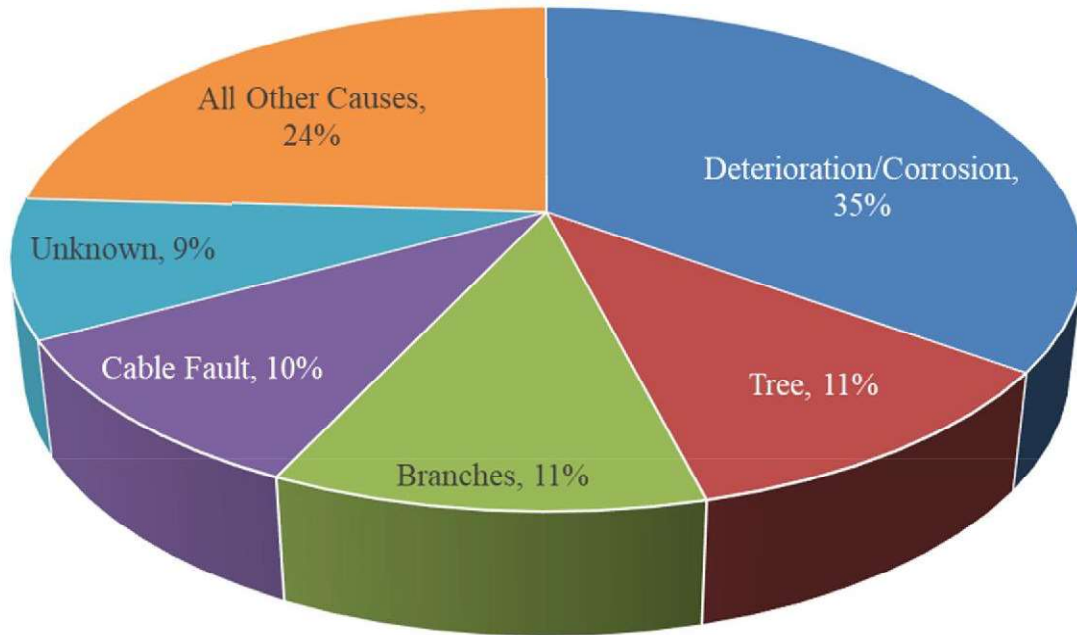


Figure 4 shows the ASAI values for 2016 to 2021.

The 2021 ASAI of 99.970% is a 0.002% increase compared to the 2020 ASAI of 99.968%. The customer hours interrupted was 192,587 hours in 2021 compared to 202,513 hours in 2020.



**Figure 5: Outage Causes for 2021**



The top five outage causes by customer hours interrupted, as illustrated in Figure 5, accounted for about 76% of the total customer hours interrupted in 2021. These include:

<u>Outage Cause</u>	<u>Description</u>
1. Deterioration/Corrosion	Equipment breakdown from natural causes
2. Tree	Entire downed tree contacts/damages equipment
3. Branches	Disconnected portion of vegetation contacts/damages equipment
4. Cable Fault	Failure of underground cable or cable component
5. Unknown	Definitive cause cannot be determined after investigation

From 2020 to 2021, Deterioration/Corrosion replaced Branches as the top outage cause. Tree and Branches are the 2<sup>nd</sup> and 3<sup>rd</sup> top outage causes, respectively. Cable Fault remained as the 4<sup>th</sup> top outage cause and Unknown replaced Auto UFLS as the 5<sup>th</sup> top outage cause.

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

From: January 1, 2021      To: December 31, 2021

Outage Cause	Customer Hours Interrupted	Customer Interruptions	SAIFI (interruptions)	SAIDI (minutes)	CAIDI (minutes)
Deterioration/Corrosion	66,780.2	37,211	0.505	54.34	107.68
Tree	21,844.9	5,459	0.074	17.78	240.10
Branches	20,629.6	6,617	0.090	16.79	187.06
Cable Fault	18,342.7	12,076	0.164	14.93	91.14
Unknown	18,285.7	6,186	0.084	14.88	177.36
Faulty Operation	8,826.9	10,713	0.145	7.18	49.44
Accident - Auto	8,194.3	2,191	0.030	6.67	224.40
Flashover	6,182.8	3,745	0.051	5.03	99.06
Auto UFLS	4,961.4	4,031	0.055	4.04	73.85
Scheduled	4,606.9	4,105	0.056	3.75	67.34
High Winds	4,219.4	523	0.007	3.43	484.07
Failure/Defect	2,061.4	679	0.009	1.68	182.16
Object in Line - Animal	1,895.0	1,383	0.019	1.54	82.21
Object in Line - Foreign Object	1,607.4	496	0.007	1.31	194.44
Heavy Rain	1,533.3	315	0.004	1.25	292.05
Overload	516.6	358	0.005	0.42	86.58
Transformer - Failure	502.9	165	0.002	0.41	182.87
Accident - Construction	428.9	204	0.003	0.35	126.13
Switching	424.9	1,968	0.027	0.35	12.95
Other	230.7	557	0.008	0.19	24.85
Flooding	212.8	7	0.000	0.17	1,824.14
Lightning	102.2	41	0.001	0.08	149.54
Other Company Personnel	75.5	129	0.002	0.06	35.11
Object in Line - Balloon	48.0	30	0.000	0.04	96.00
Accident - Other	31.3	25	0.000	0.03	75.00
Overgrown	27.1	8	0.000	0.02	203.25
Customer - Equipment	14.1	4	0.000	0.01	210.75
Fire	0.0	0	0.000	0.00	0.00
Landslide	0.0	0	0.000	0.00	0.00
Manual Load Shed	0.0	0	0.000	0.00	0.00
Natural Disaster: Tsunami/Earthquake	0.0	0	0.000	0.00	0.00
Object in Line - Man	0.0	0	0.000	0.00	0.00
System Change	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
<b>Total</b>	<b>192,586.5</b>	<b>99,226</b>	<b>1.346</b>	<b>156.71</b>	<b>116.45</b>

Average System Availability =	99.970%
Number of customers for the period =	73,735
24-month annual SAIDI (minutes) average for the period 1/1/2020 - 12/31/2021 =	161.57
24-month average number of customers for the period 1/1/2020 - 12/31/2021 =	73,371

**Notes:** Outage causes are listed in descending order of SAIDI. Outages due to customer requests are not included in the service reliability indices. The Forced cause, which was used in previous reports, has been discontinued: outages are coded to the event's root cause.



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

From: January 1, 2021      To: December 31, 2021

Outage Cause	Customer Hours Interrupted	Customer Interruptions	SAIFI (interruptions)	SAIDI (minutes)	CAIDI (minutes)
Deterioration/Corrosion	58,382.9	33,729	0.491	50.98	103.86
Tree	20,479.0	5,175	0.075	17.88	237.44
Branches	16,595.7	4,892	0.071	14.49	203.54
Cable Fault	15,887.7	11,403	0.166	13.87	83.60
Unknown	10,122.3	3,919	0.057	8.84	154.97
Faulty Operation	8,826.9	10,713	0.156	7.71	49.44
Flashover	5,689.7	3,436	0.050	4.97	99.35
Accident - Auto	3,870.3	983	0.014	3.38	236.23
Scheduled	2,752.3	2,663	0.039	2.40	62.01
Failure/Defect	1,949.3	528	0.008	1.70	221.51
High Winds	1,575.6	121	0.002	1.38	781.31
Switching	424.9	1,968	0.029	0.37	12.95
Accident - Construction	417.5	196	0.003	0.36	127.81
Transformer - Failure	304.6	60	0.001	0.27	304.55
Object in Line - Foreign Object	276.0	100	0.001	0.24	165.60
Other	230.5	556	0.008	0.20	24.87
Flooding	212.8	7	0.000	0.19	1,824.14
Overload	192.3	119	0.002	0.17	96.95
Object in Line - Animal	137.2	40	0.001	0.12	205.78
Lightning	102.2	41	0.001	0.09	149.54
Other Company Personnel	70.1	110	0.002	0.06	38.22
Object in Line - Balloon	48.0	30	0.000	0.04	96.00
Overgrown	27.1	8	0.000	0.02	203.25
Customer - Equipment	14.1	4	0.000	0.01	210.75
Heavy Rain	14.0	6	0.000	0.01	140.00
Accident - Other	0.0	0	0.000	0.00	0.00
Auto UFLS	0.0	0	0.000	0.00	0.00
Fire	0.0	0	0.000	0.00	0.00
Landslide	0.0	0	0.000	0.00	0.00
Manual Load Shed	0.0	0	0.000	0.00	0.00
Natural Disaster: Tsunami/Earthquake	0.0	0	0.000	0.00	0.00
Object in Line - Man	0.0	0	0.000	0.00	0.00
System Change	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
<b>Total</b>	<b>148,602.7</b>	<b>80,807</b>	<b>1.176</b>	<b>129.76</b>	<b>110.34</b>

Average System Availability =	99.975%
Number of customers for the period =	68,711
24-month annual SAIDI (minutes) average for the period 1/1/2020 - 12/31/2021 =	133.13
24-month average number of customers for the period 1/1/2020 - 12/31/2021 =	68,356

**Notes:** Outage causes are listed in descending order of SAIDI. Outages due to customer requests are not included in the service reliability indices. The Forced cause, which was used in previous reports, has been discontinued: outages are coded to the event's root cause.

**Maui Electric Company, Limited**  
**Normalized Sustained Interruption Summary – Moloka‘i**

From: January 1, 2021      To: December 31, 2021

Outage Cause	Customer Hours Interrupted	Customer Interruptions	SAIFI (interruptions)	SAIDI (minutes)	CAIDI (minutes)
Deterioration/Corrosion	8,386.8	3,464	1.059	153.81	145.27
Unknown	8,116.4	2,237	0.684	148.85	217.70
Auto UFLS	4,957.0	4,025	1.230	90.91	73.89
Accident - Auto	4,324.1	1,208	0.369	79.30	214.77
Branches	3,701.0	1,500	0.458	67.87	148.04
High Winds	2,643.8	402	0.123	48.49	394.60
Cable Fault	2,455.0	673	0.206	45.02	218.87
Heavy Rain	1,519.3	309	0.094	27.86	295.00
Tree	1,365.9	284	0.087	25.05	288.57
Object in Line - Foreign Object	1,331.4	396	0.121	24.42	201.72
Scheduled	1,289.3	1,127	0.344	23.64	68.64
Flashover	493.1	309	0.094	9.04	95.75
Overload	324.3	239	0.073	5.95	81.41
Transformer - Failure	198.4	105	0.032	3.64	113.34
Object in Line - Animal	170.9	51	0.016	3.13	201.10
Failure/Defect	112.2	151	0.046	2.06	44.56
Accident - Other	31.3	25	0.008	0.57	75.00
Accident - Construction	11.3	8	0.002	0.21	85.00
Other Company Personnel	2.0	3	0.001	0.04	39.00
Other	0.2	1	0.000	0.00	10.00
Customer - Equipment	0.0	0	0.000	0.00	0.00
Faulty Operation	0.0	0	0.000	0.00	0.00
Fire	0.0	0	0.000	0.00	0.00
Flooding	0.0	0	0.000	0.00	0.00
Landslide	0.0	0	0.000	0.00	0.00
Lightning	0.0	0	0.000	0.00	0.00
Manual Load Shed	0.0	0	0.000	0.00	0.00
Natural Disaster/Tsunami/Earthquake	0.0	0	0.000	0.00	0.00
Object in Line - Balloon	0.0	0	0.000	0.00	0.00
Object in Line - Man	0.0	0	0.000	0.00	0.00
Overgrown	0.0	0	0.000	0.00	0.00
Switching	0.0	0	0.000	0.00	0.00
System Change	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
<b>Total</b>	<b>41,433.4</b>	<b>16,517</b>	<b>5.048</b>	<b>759.86</b>	<b>150.51</b>

Average System Availability =	99.855%
Number of customers for the period =	3,272
24-month annual SAIDI (minutes) average for the period 1/1/2020 - 12/31/2021 =	775.46
24-month average number of customers for the period 1/1/2020 - 12/31/2021 =	3,265

**Notes:** Outage causes are listed in descending order of SAIDI. Outages due to customer requests are not included in the service reliability indices. The Forced cause, which was used in previous reports, has been discontinued; outages are coded to the event's root cause.

**Maui Electric Company, Limited**  
**Normalized Sustained Interruption Summary – Lāna‘i**

From: January 1, 2021 To: December 31, 2021

<b>Outage Cause</b>	<b>Customer Hours Interrupted</b>	<b>Customer Interruptions</b>	<b>SAIFI (interruptions)</b>	<b>SAIDI (minutes)</b>	<b>CAIDI (minutes)</b>
Object in Line - Animal	1,586.9	1,292	0.737	54.33	73.69
Scheduled	565.3	315	0.180	19.36	107.68
Branches	332.9	225	0.128	11.40	88.78
Unknown	47.0	30	0.017	1.61	94.00
Deterioration/Corrosion	10.5	18	0.010	0.36	35.00
Auto UFLS	4.4	6	0.003	0.15	44.00
Other Company Personnel	3.5	16	0.009	0.12	13.00
Accident - Auto	0.0	0	0.000	0.00	0.00
Accident - Construction	0.0	0	0.000	0.00	0.00
Accident - Other	0.0	0	0.000	0.00	0.00
Cable Fault	0.0	0	0.000	0.00	0.00
Customer - Equipment	0.0	0	0.000	0.00	0.00
Failure/Defect	0.0	0	0.000	0.00	0.00
Faulty Operation	0.0	0	0.000	0.00	0.00
Fire	0.0	0	0.000	0.00	0.00
Flashover	0.0	0	0.000	0.00	0.00
Flooding	0.0	0	0.000	0.00	0.00
Heavy Rain	0.0	0	0.000	0.00	0.00
High Winds	0.0	0	0.000	0.00	0.00
Landslide	0.0	0	0.000	0.00	0.00
Lightning	0.0	0	0.000	0.00	0.00
Manual Load Shed	0.0	0	0.000	0.00	0.00
Natural Disaster: Tsunami/Earthquake	0.0	0	0.000	0.00	0.00
Object in Line - Balloon	0.0	0	0.000	0.00	0.00
Object in Line - Foreign Object	0.0	0	0.000	0.00	0.00
Object in Line - Man	0.0	0	0.000	0.00	0.00
Other	0.0	0	0.000	0.00	0.00
Overgrown	0.0	0	0.000	0.00	0.00
Overload	0.0	0	0.000	0.00	0.00
Switching	0.0	0	0.000	0.00	0.00
System Change	0.0	0	0.000	0.00	0.00
Transformer - Failure	0.0	0	0.000	0.00	0.00
Transformer - Overload	0.0	0	0.000	0.00	0.00
Tree	0.0	0	0.000	0.00	0.00
Vandalism	0.0	0	0.000	0.00	0.00
<b>Total</b>	<b>2,550.5</b>	<b>1,902</b>	<b>1.085</b>	<b>87.32</b>	<b>80.46</b>

Average System Availability = 99.983%  
Number of customers for the period = 1,752  
24-month annual SAIDI (minutes) average for the period 1/1/2020 - 12/31/2021 = 126.86  
24-month average number of customers for the period 1/1/2020 - 12/31/2021 = 1,750

**Notes:** Outage causes are listed in descending order of SAIDI. Outages due to customer requests are not included in the service reliability indices. The Forced cause, which was used in previous reports, has been discontinued; outages are coded to the event's root cause.

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

From: January 1, 2021 To: December 31, 2021

<b>Outage Cause Category/Cause</b>	<b>Interruption Count</b>	<b>% of Total</b>	<b>Customer Hours Interrupted</b>	<b>% of Total</b>
<b><u>Equipment</u></b>	<b>216</b>	<b>31.2%</b>	<b>103,213.5</b>	<b>53.6%</b>
Deterioration/Corrosion	112	16.2%	66,780.2	34.7%
Cable Fault	56	8.1%	18,342.7	9.5%
Faulty Operation	3	0.4%	8,826.9	4.6%
Flashover	7	1.0%	6,182.8	3.2%
Failure/Defect	22	3.2%	2,061.4	1.1%
Overload	7	1.0%	516.6	0.3%
Transformer - Failure	9	1.3%	502.9	0.3%
Transformer - Overload	0	0.0%	0.0	0.0%
<b><u>Error</u></b>	<b>9</b>	<b>1.3%</b>	<b>500.4</b>	<b>0.3%</b>
Switching	2	0.3%	424.9	0.2%
Other Company Personnel	7	1.0%	75.5	0.0%
<b><u>Generation</u></b>	<b>3</b>	<b>0.4%</b>	<b>4,961.4</b>	<b>2.6%</b>
Auto UFLS	3	0.4%	4,961.4	2.6%
Manual Load Shed	0	0.0%	0.0	0.0%
Other	0	0.0%	0.0	0.0%
<b><u>Maintenance</u></b>	<b>165</b>	<b>23.8%</b>	<b>4,606.9</b>	<b>2.4%</b>
Scheduled	165	23.8%	4,606.9	2.4%
System Change	0	0.0%	0.0	0.0%
<b><u>Other</u></b>	<b>7</b>	<b>1.0%</b>	<b>230.7</b>	<b>0.1%</b>
Other	7	1.0%	230.7	0.1%
<b><u>Public (Non-Utility)</u></b>	<b>51</b>	<b>7.4%</b>	<b>12,218.8</b>	<b>6.3%</b>
Accident - Auto	25	3.6%	8,194.3	4.3%
Object in Line - Animal	8	1.2%	1,895.0	1.0%
Object in Line - Foreign Object	5	0.7%	1,607.4	0.8%
Accident - Construction	7	1.0%	428.9	0.2%
Object in Line - Balloon	1	0.1%	48.0	0.0%
Accident - Other	1	0.1%	31.3	0.0%
Customer - Equipment	4	0.6%	14.1	0.0%
Fire	0	0.0%	0.0	0.0%
Object in Line - Man	0	0.0%	0.0	0.0%
Vandalism	0	0.0%	0.0	0.0%
<b><u>Unknown</u></b>	<b>60</b>	<b>8.7%</b>	<b>18,285.7</b>	<b>9.5%</b>
Unknown	60	8.7%	18,285.7	9.5%
<b><u>Vegetation</u></b>	<b>158</b>	<b>22.8%</b>	<b>42,501.5</b>	<b>22.1%</b>
Tree	68	9.8%	21,844.9	11.3%
Branches	88	12.7%	20,629.6	10.7%
Overgrown	2	0.3%	27.1	0.0%
<b><u>Weather</u></b>	<b>23</b>	<b>3.3%</b>	<b>6,067.7</b>	<b>3.2%</b>
High Winds	11	1.6%	4,219.4	2.2%
Heavy Rain	2	0.3%	1,533.3	0.8%
Flooding	2	0.3%	212.8	0.1%
Lightning	8	1.2%	102.2	0.1%
Landslide	0	0.0%	0.0	0.0%
Natural Disaster/Tsunami/Earthquake	0	0.0%	0.0	0.0%
<b>Total</b>	<b>692</b>		<b>192,586.5</b>	

**Note:** Outage causes are listed in descending order of Customer Hours Interrupted within each Cause Category. Outages due to customer requests are not included in the service reliability indices. The Forced cause, which was used in previous reports, has been discontinued; outages are coded to the event's root cause.

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

From: January 1, 2021 To: December 31, 2021

<b>Outage Cause Category/Cause</b>	<b>Interruption Count</b>	<b>% of Total</b>	<b>Customer Hours Interrupted</b>	<b>% of Total</b>
<b><u>Equipment</u></b>	<b>187</b>	<b>32.1%</b>	<b>91,233.3</b>	<b>61.4%</b>
Deterioration/Corrosion	98	16.8%	58,382.9	39.3%
Cable Fault	48	8.2%	15,887.7	10.7%
Faulty Operation	3	0.5%	8,826.9	5.9%
Flashover	6	1.0%	5,689.7	3.8%
Failure/Defect	20	3.4%	1,949.3	1.3%
Transformer - Failure	6	1.0%	304.6	0.2%
Overload	6	1.0%	192.3	0.1%
Transformer - Overload	0	0.0%	0.0	0.0%
<b><u>Error</u></b>	<b>7</b>	<b>1.2%</b>	<b>495.0</b>	<b>0.3%</b>
Switching	2	0.3%	424.9	0.3%
Other Company Personnel	5	0.9%	70.1	0.0%
<b><u>Generation</u></b>	<b>0</b>	<b>0.0%</b>	<b>0.0</b>	<b>0.0%</b>
Auto UFLS	0	0.0%	0.0	0.0%
Manual Load Shed	0	0.0%	0.0	0.0%
Other	0	0.0%	0.0	0.0%
<b><u>Maintenance</u></b>	<b>120</b>	<b>20.6%</b>	<b>2,752.3</b>	<b>1.9%</b>
Scheduled	120	20.6%	2,752.3	1.9%
System Change	0	0.0%	0.0	0.0%
<b><u>Other</u></b>	<b>6</b>	<b>1.0%</b>	<b>230.5</b>	<b>0.2%</b>
Other	6	1.0%	230.5	0.2%
<b><u>Public (Non-Utility)</u></b>	<b>37</b>	<b>6.3%</b>	<b>4,763.0</b>	<b>3.2%</b>
Accident - Auto	21	3.6%	3,870.3	2.6%
Accident - Construction	6	1.0%	417.5	0.3%
Object in Line - Foreign Object	2	0.3%	276.0	0.2%
Object in Line - Animal	3	0.5%	137.2	0.1%
Object in Line - Balloon	1	0.2%	48.0	0.0%
Customer - Equipment	4	0.7%	14.1	0.0%
Accident - Other	0	0.0%	0.0	0.0%
Fire	0	0.0%	0.0	0.0%
Object in Line - Man	0	0.0%	0.0	0.0%
Vandalism	0	0.0%	0.0	0.0%
<b><u>Unknown</u></b>	<b>54</b>	<b>9.3%</b>	<b>10,122.3</b>	<b>6.8%</b>
Unknown	54	9.3%	10,122.3	6.8%
<b><u>Vegetation</u></b>	<b>152</b>	<b>26.1%</b>	<b>37,101.8</b>	<b>25.0%</b>
Tree	66	11.3%	20,479.0	13.8%
Branches	84	14.4%	16,595.7	11.2%
Overgrown	2	0.3%	27.1	0.0%
<b><u>Weather</u></b>	<b>20</b>	<b>3.4%</b>	<b>1,904.6</b>	<b>1.3%</b>
High Winds	9	1.5%	1,575.6	1.1%
Flooding	2	0.3%	212.8	0.1%
Lightning	8	1.4%	102.2	0.1%
Heavy Rain	1	0.2%	14.0	0.0%
Landslide	0	0.0%	0.0	0.0%
Natural Disaster/Tsunami/Earthquake	0	0.0%	0.0	0.0%
<b>Total</b>	<b>583</b>		<b>148,602.7</b>	

**Note:** Outage causes are listed in descending order of Customer Hours Interrupted within each Cause Category. Outages due to customer requests are not included in the service reliability indices. The Forced cause, which was used in previous reports, has been discontinued. Outages are coded to the event's root cause.

**Maui Electric Company, Limited**  
**Normalized Sustained Interruption Summary – Moloka'i**

From: January 1, 2021 To: December 31, 2021

<b>Outage Cause Category/Cause</b>	<b>Interruption Count</b>	<b>% of Total</b>	<b>Customer Hours Interrupted</b>	<b>% of Total</b>
<b><u>Equipment</u></b>	<b>28</b>	<b>34.6%</b>	<b>11,969.7</b>	<b>28.9%</b>
Deterioration/Corrosion	13	16.0%	8,386.8	20.2%
Cable Fault	8	9.9%	2,455.0	5.9%
Flashover	1	1.2%	493.1	1.2%
Overload	1	1.2%	324.3	0.8%
Transformer - Failure	3	3.7%	198.4	0.5%
Failure/Defect	2	2.5%	112.2	0.3%
Faulty Operation	0	0.0%	0.0	0.0%
Transformer - Overload	0	0.0%	0.0	0.0%
<b><u>Error</u></b>	<b>1</b>	<b>1.2%</b>	<b>2.0</b>	<b>0.0%</b>
Other Company Personnel	1	1.2%	2.0	0.0%
Switching	0	0.0%	0.0	0.0%
<b><u>Generation</u></b>	<b>2</b>	<b>2.5%</b>	<b>4,957.0</b>	<b>12.0%</b>
Auto UFLS	2	2.5%	4,957.0	12.0%
Manual Load Shed	0	0.0%	0.0	0.0%
Other	0	0.0%	0.0	0.0%
<b><u>Maintenance</u></b>	<b>25</b>	<b>30.9%</b>	<b>1,289.3</b>	<b>3.1%</b>
Scheduled	25	30.9%	1,289.3	3.1%
System Change	0	0.0%	0.0	0.0%
<b><u>Other</u></b>	<b>1</b>	<b>1.2%</b>	<b>0.2</b>	<b>0.0%</b>
Other	1	1.2%	0.2	0.0%
<b><u>Public (Non-Utility)</u></b>	<b>11</b>	<b>13.6%</b>	<b>5,869.0</b>	<b>14.2%</b>
Accident - Auto	4	4.9%	4,324.1	10.4%
Object in Line - Foreign Object	3	3.7%	1,331.4	3.2%
Object in Line - Animal	2	2.5%	170.9	0.4%
Accident - Other	1	1.2%	31.3	0.1%
Accident - Construction	1	1.2%	11.3	0.0%
Customer - Equipment	0	0.0%	0.0	0.0%
Fire	0	0.0%	0.0	0.0%
Object in Line - Balloon	0	0.0%	0.0	0.0%
Object in Line - Man	0	0.0%	0.0	0.0%
Vandalism	0	0.0%	0.0	0.0%
<b><u>Unknown</u></b>	<b>5</b>	<b>6.2%</b>	<b>8,116.4</b>	<b>19.6%</b>
Unknown	5	6.2%	8,116.4	19.6%
<b><u>Vegetation</u></b>	<b>5</b>	<b>6.2%</b>	<b>5,066.9</b>	<b>12.2%</b>
Branches	3	3.7%	3,701.0	8.9%
Tree	2	2.5%	1,365.9	3.3%
Overgrown	0	0.0%	0.0	0.0%
<b><u>Weather</u></b>	<b>3</b>	<b>3.7%</b>	<b>4,163.1</b>	<b>10.0%</b>
High Winds	2	2.5%	2,643.8	6.4%
Heavy Rain	1	1.2%	1,519.3	3.7%
Flooding	0	0.0%	0.0	0.0%
Landslide	0	0.0%	0.0	0.0%
Lightning	0	0.0%	0.0	0.0%
Natural Disaster/Tsunami/Earthquake	0	0.0%	0.0	0.0%
<b>Total</b>	<b>81</b>		<b>41,433.4</b>	

**Note:** Outage causes are listed in descending order of Customer Hours Interrupted within each Cause Category. Outages due to customer requests are not included in the service reliability indices. The Forced cause, which was used in previous reports, has been discontinued; outages are coded to the event's root cause.

**Maui Electric Company, Limited**  
**Normalized Sustained Interruption Summary – Lāna‘i**

From: January 1, 2021 To: December 31, 2021

<b>Outage Cause Category/Cause</b>	<b>Interruption Count</b>	<b>% of Total</b>	<b>Customer Hours Interrupted</b>	<b>% of Total</b>
<b><u>Equipment</u></b>	<b>1</b>	<b>3.6%</b>	<b>10.5</b>	<b>0.4%</b>
Deterioration/Corrosion	1	3.6%	10.5	0.4%
Cable Fault	0	0.0%	0.0	0.0%
Failure/Defect	0	0.0%	0.0	0.0%
Faulty Operation	0	0.0%	0.0	0.0%
Flashover	0	0.0%	0.0	0.0%
Overload	0	0.0%	0.0	0.0%
Transformer - Failure	0	0.0%	0.0	0.0%
Transformer - Overload	0	0.0%	0.0	0.0%
<b><u>Error</u></b>	<b>1</b>	<b>3.6%</b>	<b>3.5</b>	<b>0.1%</b>
Other Company Personnel	1	3.6%	3.5	0.1%
Switching	0	0.0%	0.0	0.0%
<b><u>Generation</u></b>	<b>1</b>	<b>3.6%</b>	<b>4.4</b>	<b>0.2%</b>
Auto UFLS	1	3.6%	4.4	0.2%
Manual Load Shed	0	0.0%	0.0	0.0%
Other	0	0.0%	0.0	0.0%
<b><u>Maintenance</u></b>	<b>20</b>	<b>71.4%</b>	<b>565.3</b>	<b>22.2%</b>
Scheduled	20	71.4%	565.3	22.2%
System Change	0	0.0%	0.0	0.0%
<b><u>Other</u></b>	<b>0</b>	<b>0.0%</b>	<b>0.0</b>	<b>0.0%</b>
Other	0	0.0%	0.0	0.0%
<b><u>Public (Non-Utility)</u></b>	<b>3</b>	<b>10.7%</b>	<b>1,586.9</b>	<b>62.2%</b>
Object in Line - Animal	3	10.7%	1,586.9	62.2%
Accident - Auto	0	0.0%	0.0	0.0%
Accident - Construction	0	0.0%	0.0	0.0%
Accident - Other	0	0.0%	0.0	0.0%
Customer - Equipment	0	0.0%	0.0	0.0%
Fire	0	0.0%	0.0	0.0%
Object in Line - Balloon	0	0.0%	0.0	0.0%
Object in Line - Foreign Object	0	0.0%	0.0	0.0%
Object in Line - Man	0	0.0%	0.0	0.0%
Vandalism	0	0.0%	0.0	0.0%
<b><u>Unknown</u></b>	<b>1</b>	<b>3.6%</b>	<b>47.0</b>	<b>1.8%</b>
Unknown	1	3.6%	47.0	1.8%
<b><u>Vegetation</u></b>	<b>1</b>	<b>3.6%</b>	<b>332.9</b>	<b>13.1%</b>
Branches	1	3.6%	332.9	13.1%
Overgrown	0	0.0%	0.0	0.0%
Tree	0	0.0%	0.0	0.0%
<b><u>Weather</u></b>	<b>0</b>	<b>0.0%</b>	<b>0.0</b>	<b>0.0%</b>
Flooding	0	0.0%	0.0	0.0%
Heavy Rain	0	0.0%	0.0	0.0%
High Winds	0	0.0%	0.0	0.0%
Landslide	0	0.0%	0.0	0.0%
Lightning	0	0.0%	0.0	0.0%
Natural Disaster/Tsunami/Earthquake	0	0.0%	0.0	0.0%
<b>Total</b>	<b>28</b>		<b>2,550.5</b>	

**Note:** Outage causes are listed in descending order of Customer Hours Interrupted within each Cause Category. Outages due to customer requests are not included in the service reliability indices. The Forced cause, which was used in previous reports, has been discontinued. Outages are coded to the event's root cause.

# **APPENDIX**

## ANNUAL SERVICE RELIABILITY REPORT

2021

May 11, 2022



**DEFINITION OF TERMS**

**CUSTOMER INTERRUPTION**

One interruption of one customer.

**INTERRUPTION**

The loss of service to one or more customers as a result of one or more component outages.

**INTERRUPTION DURATION**

The time period from the initiation of an interruption until service has been restored to the affected customers.

**MOMENTARY INTERRUPTION**

An interruption having a duration of five minutes or less, typically limited to the period required to restore service by an interrupting device.

**OUTAGE**

The loss of ability of a component to deliver power. An outage may or may not cause an interruption of service to customers, depending on the system configuration.

**SUSTAINED INTERRUPTION**

Any interruption not classified as a momentary interruption. That is, any interruption that lasts more than five minutes.

Note: Interruptions to customers at their request are not included.

Reliability indices are based on the standards defined by the Institute of Electrical and Electronics Engineers (IEEE). Four indices that convey a meaningful representation of the level of reliability are as follows:

### **RELIABILITY INDICES**

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

ASAI indicates the fraction of time that the average customer received service during a predefined period of time. Customer hours service demand is determined by multiplying the total number of customers served by the number of hours in the period.

$$ASAI = \frac{\sum \text{Customer Hours Service Availability}}{\sum \text{Customer Hours Service Demand}} \times 100\%$$

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

CAIDI indicates the average time required to restore service during a predefined period of time.

$$CAIDI = \frac{\sum(\text{Duration of Interruption} \times \text{No. of Sustained Customer Interruptions})}{\sum \text{No. of Sustained Customer Interruptions}} = \frac{SAIDI}{SAIFI}$$

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

SAIDI indicates the total sustained interruption duration for the average customer during a predefined period of time. It is commonly measured in minutes or hours of interruption.

$$SAIDI = \frac{\sum(\text{Duration of Interruption} \times \text{No. of Sustained Customer Interruptions})}{\text{Total No. of Customers Served}}$$

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

SAIFI indicates how often the average customer experiences a sustained interruption during a predefined period of time.

$$SAIFI = \frac{\sum \text{No. of Sustained Customer Interruptions}}{\text{Total No. of Customers Served}}$$

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