

City of Bellevue

Overview of 2015 Electrical System Reliability

This summary provides an overview of the electrical system reliability in Bellevue for 2015 as support for follow-up activities to the annual reliability workshop between the City of Bellevue (Bellevue) and Puget Sound Energy (PSE) in August 2016. The topics included in this overview are:

- Electric System Reliability
- Reliability Projects Assessment

This summary is based primarily on information provided in the annual reliability reports prepared by PSE for the City and for the Washington Utilities and Transportation Council (WUTC).

1. Electric System Reliability

The reliability assessment is performed by reviewing the overall PSE system as well as Bellevue specific circuits as measured by outage frequency and duration. The reliability assessment is performed by reviewing the following information:

- Reliability metrics
- Bellevue circuit trends
- Outage trends
- Reliability benchmarks

PSE provides reliability information on all outage events, including storm outages. This allows for a review of system reliability from both a normal operations perspective and an overall major event perspective.

Reliability Metrics (Excluding Major Events)

The reliability of the electrical system is reviewed by assessing the reliability metrics that indicate the performance of the system relative to planned and unplanned outages. Electric system reliability is measured by standard industry metrics of System Average Interruption Frequency Index (SAIFI) and System Average Interruption Duration Index (SAIDI). SAIFI measures the number of outages an average customer experiences in a year and SAIDI reflects the amount of outage time an average customer experiences during a year. PSE has provided specific outage data for Bellevue and this information is used to determine the reliability metrics excluding major events.

Figures 1 and 2 provide the historical view of the reliability metrics for the overall PSE system and for Bellevue. The metrics are based on the information in the WUTC annual reliability reports and the Bellevue reliability reports prepared by PSE. For this analysis, the SAIDI and SAIFI information is provided on an annual basis. PSE also reports SAIDI information on a 5-

year average basis, but for consistency with the past reviews, the annual basis was selected for the charts below.

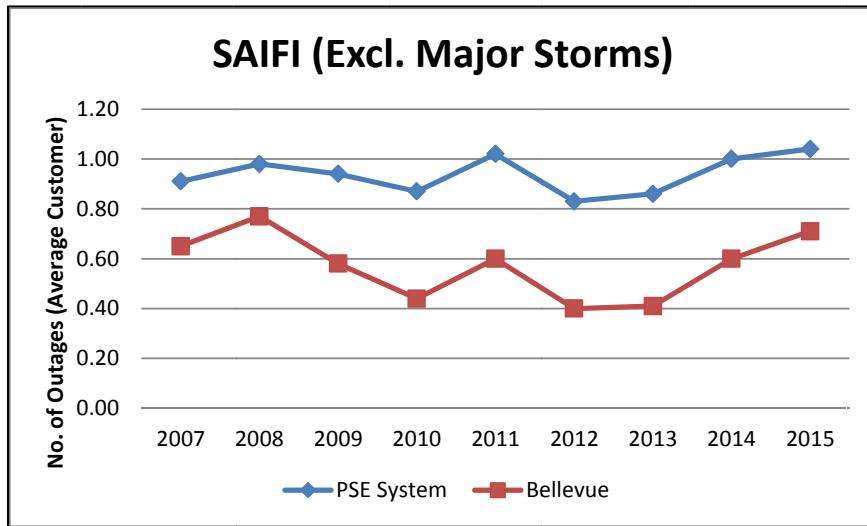


Figure 1: SAIFI Metric for Planned and Unplanned Outages (Excluding major events) for Bellevue and PSE

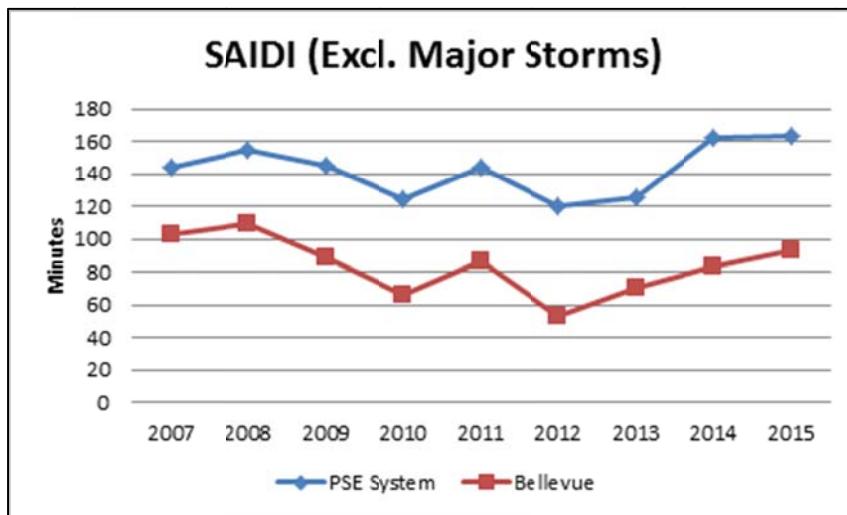


Figure 2: SAIDI Metric for Planned and Unplanned Outages (Excluding major events) for Bellevue and PSE

Based on the information above, both the overall PSE system and Bellevue have experienced an increase in outage frequency and duration over the past three years. Bellevue's performance over time mirrors that of the overall system reliability. However, on average Bellevue continues to experience better reliability performance than the overall system average. The 2015 SAIFI metric indicates that on average 7 out of 10 customers in Bellevue experienced an outage the past year. Similarly, the average customer had electric outages of about 93 minutes in 2015, which is an increase over the previous few years. [Note that PSE uses a 5-year rolling average for reporting Bellevue SAIDI and the information in the graph are determined based on annual basis using the planned and unplanned outage information for Bellevue.]

Reliability Metrics (Including Major Events)

Another view of reliability is to examine reliability performance including the impact of major events, which for Bellevue is the impact of major storm events. The reporting of reliability indices typically excludes major events. However, PSE has provided reliability data including major storms in its annual reliability report to the WUTC. PSE also includes information on all outage events in Bellevue and this information can be used to determine SAIDI and SAIFI associated with all outages including major storms. PSE system and Bellevue reliability indices including major events is shown in Figures 3 and 4.

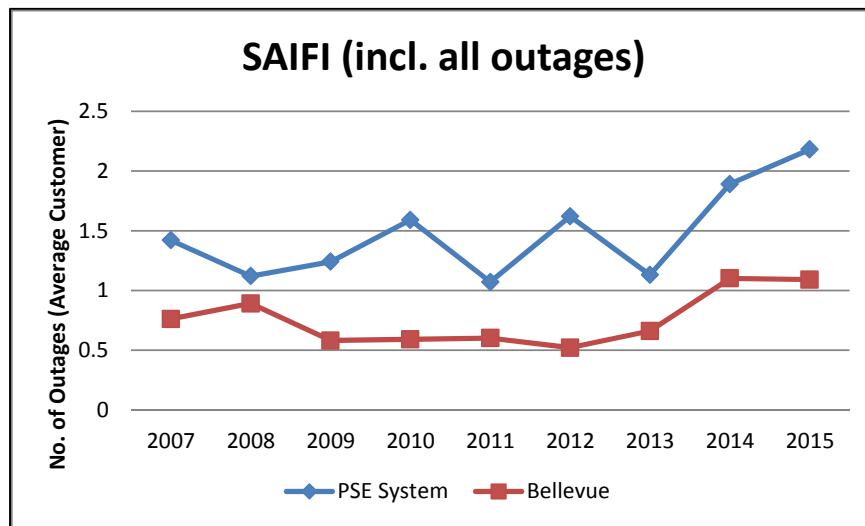


Figure 3: SAIFI Metric for Planned and Unplanned Outages (Including major events) for Bellevue and PSE

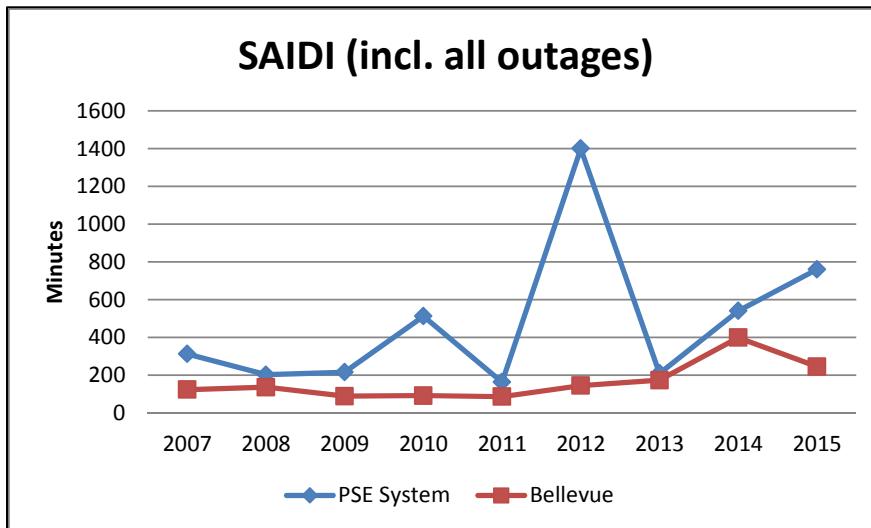


Figure 4: SAIDI Metric for Planned and Unplanned Outages (Including major events) for Bellevue and PSE

There were several major storm events reported in 2013 through 2015. PSE reported that 3, 6, and 7 major storms occurred in 2013, 2014, and 2015, respectively. Therefore, there can be major changes in the reliability metrics when including major storm events and annual comparisons are difficult. However, Bellevue experiences better reliability performance overall than the system average.

Bellevue Circuit Trends

PSE reports on the 50 least reliability circuits throughout its system in its annual reliability reports to the WUTC. There are no Bellevue circuits on the list of these 50 circuits over the past three years. PSE also reports in the annual Bellevue reliability report on circuits in Bellevue that experience outage frequency or duration above the PSE system average or PSE targets. Figure 5 shows the number of circuits in Bellevue that exceed these PSE benchmarks.

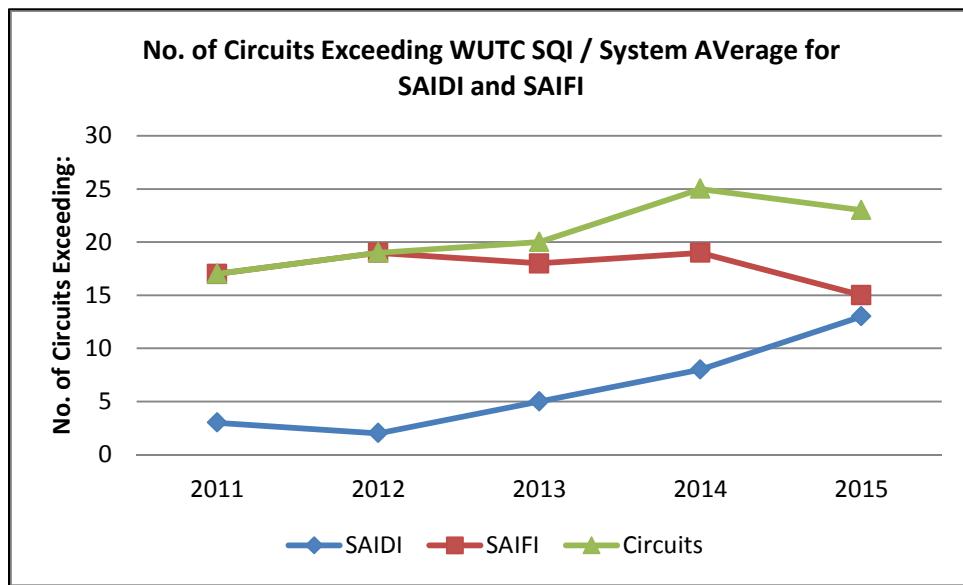


Figure 5: Bellevue Circuit Performance

Based on the information above, the number of circuits above the system average has increased over the past three years. The major change over the past few years has been the increase in the number of stations above the PSE benchmarks for SAIDI impact. However, there have been an increased number of major storm events in King County over the last three years that has likely resulted in an increased number of outages due to major storms.

Outage Trends

Figures 6 and 7 provide information on outages including major events. Relative to unplanned outages including major event, Figures 6 and 7 indicate that the number of outages and the duration of outages have increased over the past three years. Also, these figures indicate that there has been increased major storm activity over the past few years.

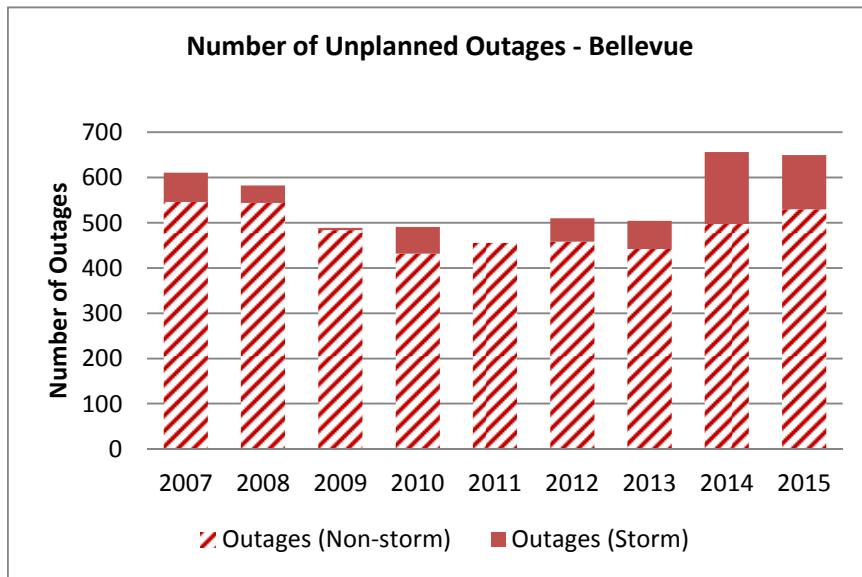


Figure 6: Unplanned Outages in Bellevue

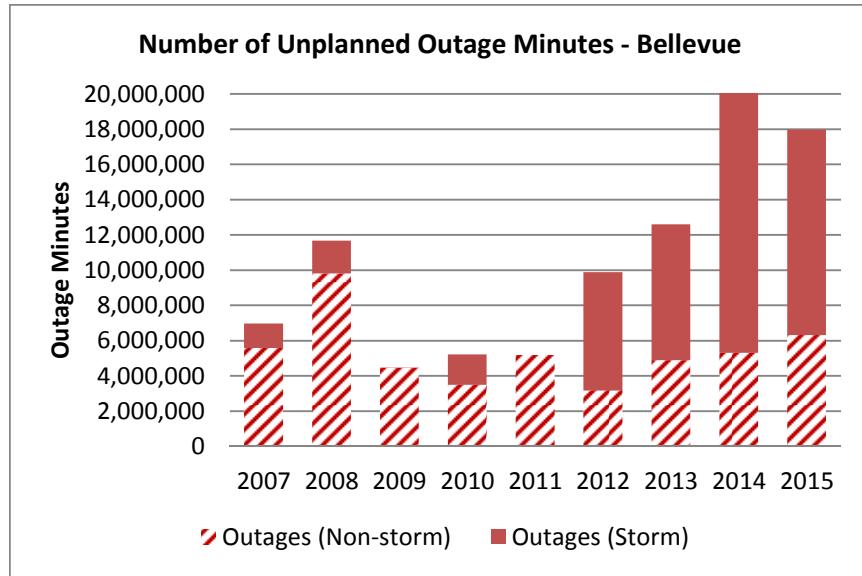


Figure 7: Unplanned Outage Duration in Bellevue

Reliability Benchmarks

There are several benchmarks available to evaluate the electrical system performance in Bellevue.

PSE participates in an Institute of Electrical and Electronics Engineers (IEEE) survey that reviews the reliability performance of many utilities in the United States and identifies reliability performance against peer companies. PSE reports the results of this survey in their annual

reliability report to the WUTC. PSE reported that it was 2nd quartile in SAIFI and 3rd quartile in SAIDI among participating utilities in both 2013 and 2014 (with 1st quartile being the highest reliability). PSE's place in the survey is based on the metrics for their entire system. The reliability performance of the City is in the 1st quartile for both SAIFI and SAIDI based on 2014 results. The IEEE data is provided in the Table 1.

Table 1: IEEE Reliability Results

Quartile	2013		2014	
	SAIFI	SAIDI	SAIFI	SAIDI
1st / 2nd quartile break	0.90	85	0.86	86
2nd / 3rd quartile break	1.10	115	1.07	115
3rd / 4th quartile break	1.40	158	1.33	159

Selected Utility Comparison

Typically, states require utilities to report reliability metrics based on IEEE criteria. Information from 2013-2015 for selected utilities in the western United States was reviewed to provide a second benchmark for reliability performance in Bellevue. These results are presented in Table 2 for SAIDI and SAIFI excluding major events. It should be noted that utilities use slightly different methods to calculate their reliability metrics so this comparison only provides a relative review of performance.

Table 2: Reliability Metric Benchmark

Company	2013		2014		2015	
	SAIFI	SAIDI	SAIFI	SAIDI	SAIFI	SAIDI
Puget Sound Energy (WA)	0.86	125	1.00	154	1.04	163
Avista (WA)	1.05	138	1.11	139	1.05	163
Pacific Power (WA)	0.79	113	0.79	122	0.85	100
Seattle City Light (WA)	0.90	69	0.90	70	0.50	63
Pacific Power (OR)	0.91	103	1.15	123	0.94	120
Portland General Electric (OR)	0.45	61	0.70	95	0.48	75
Idaho Power (OR)	2.01	277	1.58	190	1.74	216

The reliability results in Bellevue compare favorably with the utility benchmarks.

2. Reliability Project Assessment

The review of the reliability projects being implemented by PSE requires an assessment of the outage causes and trends. There are five categories of outage information reviewed that have been shown to impact electrical system reliability in Bellevue:

- Equipment-related outage causes and trends
- Tree-related outage trends
- Bird and animal-related outage trends
- Overhead and underground outage trends
- Transmission and substation outage trends

The evaluation of outage trends is based on unplanned outages and excludes major events. The major storm events are addressed later in this report. Figures 8 and 9 provide information on the causes of outages for the five categories.

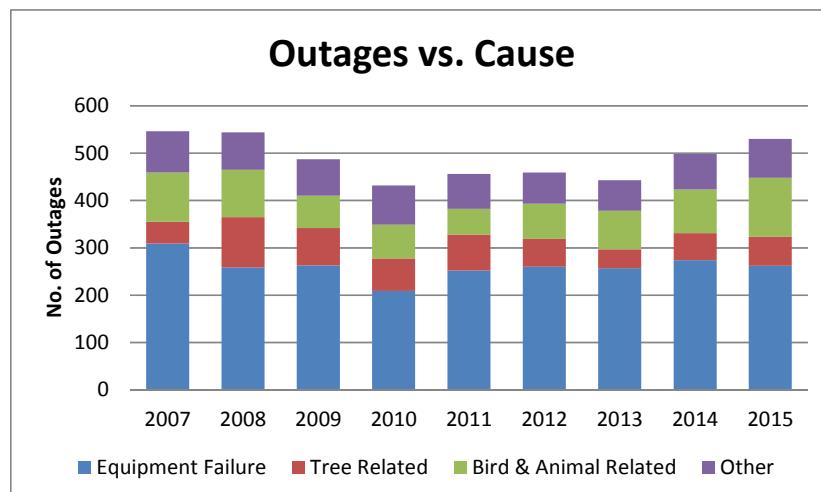


Figure 8: Outages vs. Cause

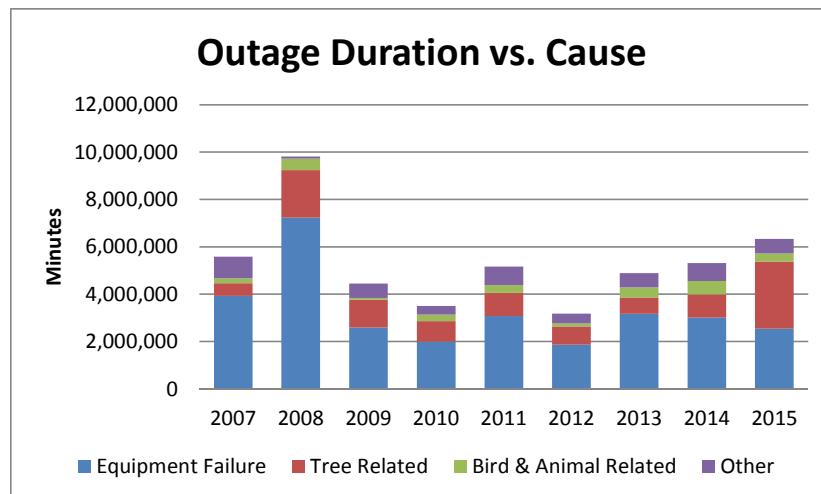


Figure 9: Outage Duration vs. Cause

Based on the results above, the number and duration of outages (excluding major storms) has increased over the past few years. Specific discussion of each outage category follows.

Equipment-Related Outage Causes and Trends

The updated equipment failure outage information is shown Figure 10. The number of equipment outages has remained relative constant over the past three years and the duration of these outages has shown improvement in the past year. These results indicate that the maintenance and inspection programs have been consistent.

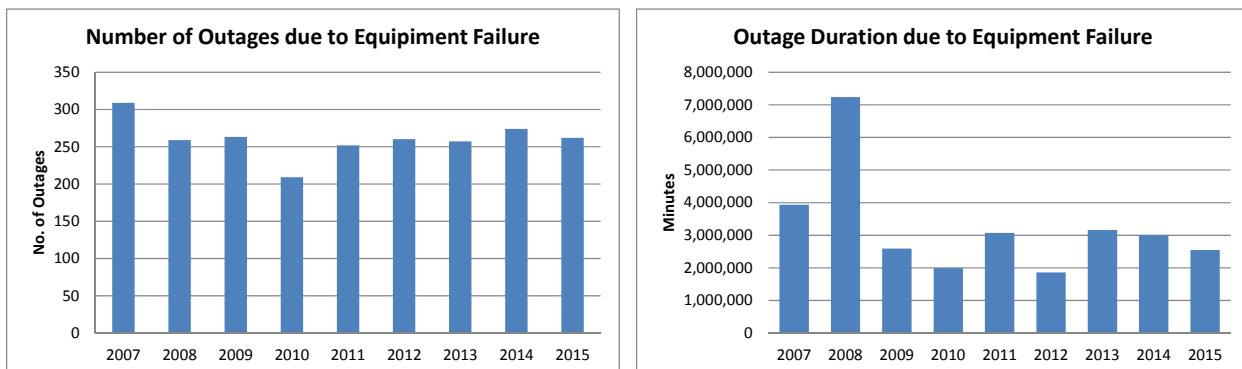


Figure 10: Outage Data for Bellevue for Equipment Failure (Excluding Major Events)

A review of the outages relative to equipment item is shown in Figure 11. This figure provides a Pareto analysis of the outages caused by equipment type for 2015.

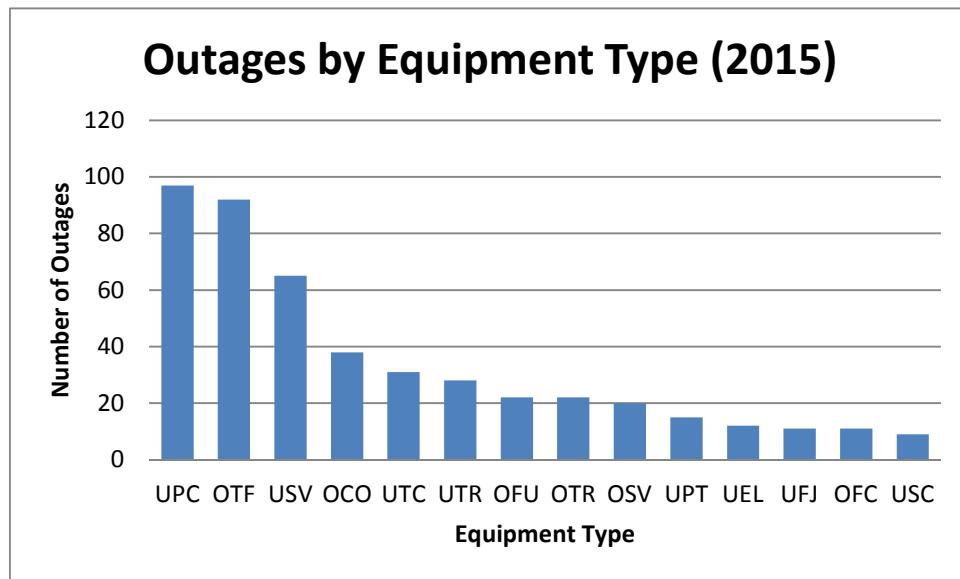


Figure 11: Outages by Equipment Type (Excluding Major Events)

Underground primary cable (UPC), overhead transformer fuse (OTF), underground services (USV) are the top equipment failure causes in 2015, which is similar to previous years.

PSE has continued their program for underground cable remediation and replacement to improve overall reliability of the underground system. PSE also indicates that a majority of the transformer fuse outages are related to protection of the system from faults on the lines, which is the desired function of this equipment.

Tree-Related Outage Trends

The updated tree-related outage information is shown in Figure 12.

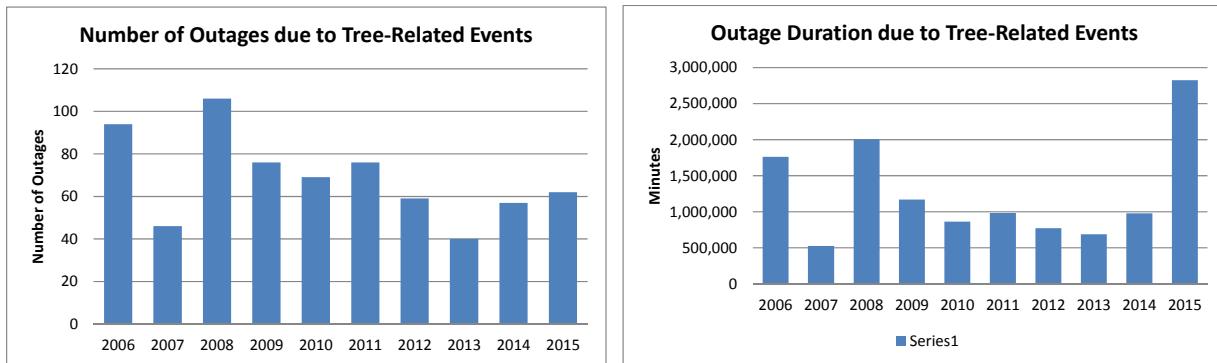


Figure 12: Outages for Tree-Related Events (Excluding Major Events)

The data indicates that the non-storm tree-related events have decreased over time, except for 2015. There were several tree-related, large substation and transmission outages that occurred in 2015. These events were caused by tree damage to transmission lines and a substation transformer. These outages account for about 70% of the 2015 outage minutes. With these events removed, there would be approximately 700 outage minutes, which is comparable to past years. The impact of these events would also have resulted in improvements in the overall SAIDI and SAIFI results for 2015.

PSE is continuing programs related to tree-wire installations, vegetation management, and circuit specific projects to drive improved reliability on its overhead circuits.

Bird and Animal-Related Outage Trends

The updated bird and animal-related outage information is shown in Figure 13.

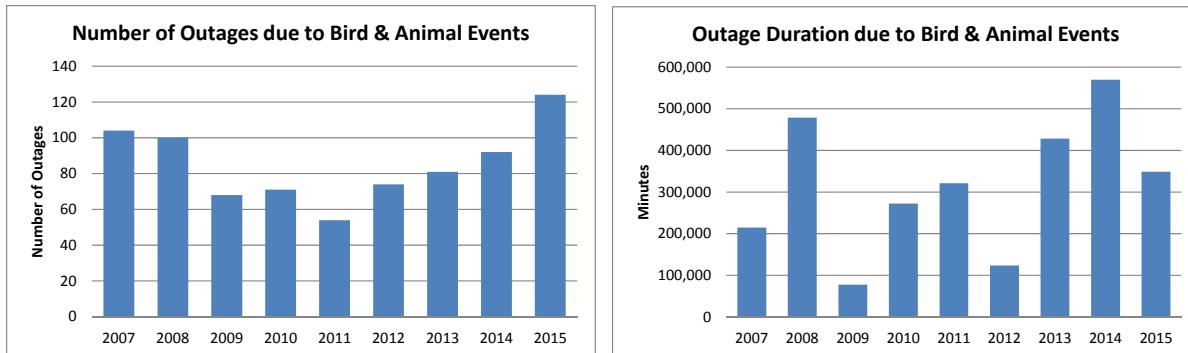


Figure 13: Outages for Bird and Animal-Related Events (Excluding Major Events)

There is an increase in bird and animal related events over the past several years. PSE reports an increased number of events both in Bellevue and system-wide. PSE has an on-going program to install bushing covers, cutout covers and jumper covers on equipment poles when performing maintenance to reduce the number of bird and animal events.

Overhead and Underground Outage Trends

The outage statistics for the overhead and underground equipment are shown in Figure 14 for unplanned outages excluding major events.

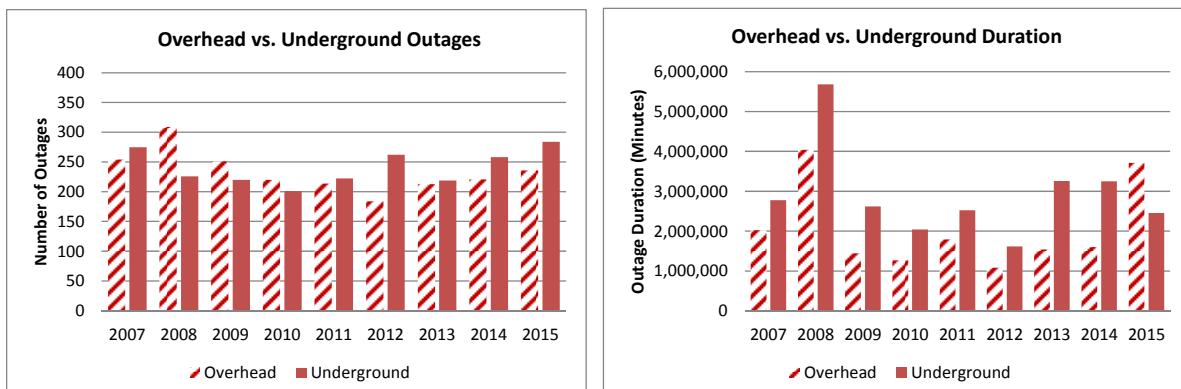


Figure 14: Outage Data for Overhead and Underground Systems (Excluding Major Events)

The results show a relatively similar mix of overhead and underground events with the underground events having longer durations except for 2015. In 2015, as discussed previously, several tree-related events on the overhead system drove higher overhead outage duration in 2015. However, since locating faults on the underground system and repair of the underground assets typically take a longer time, these results are expected.

Figure 15 shows the information for the major events only. As expected, the overhead system is the major asset affected during these major storms. Generally, tree-related events during storms are the driver of outages.

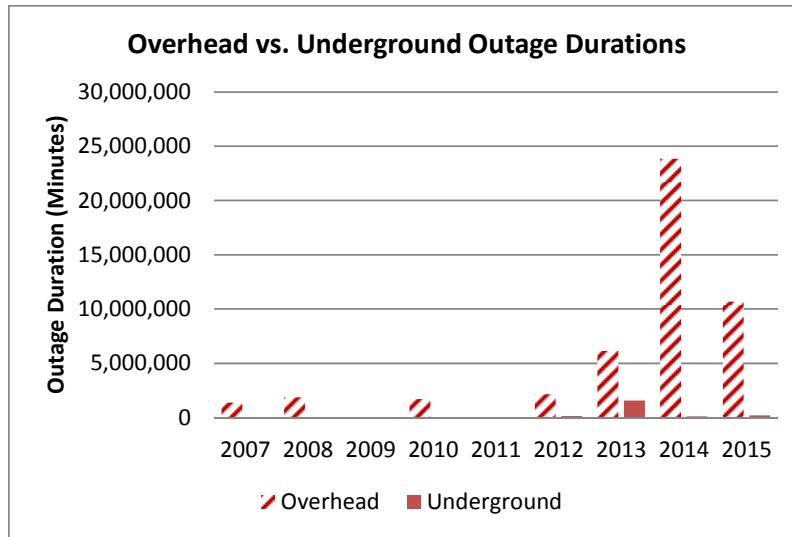


Figure 15: Outage Duration for Overhead and Underground Systems (Major Storms Only)

Circuits / Issues Assessment

Each year, PSE evaluates the circuits which exceed the system average and provides actions taken or to-be-taken to address these circuits. In reviewing the circuits of concern included in 2015 Bellevue electric reliability report, PSE has completed action on 17 of the 23 circuits identified and has identified future projects for six circuits.

There are three circuits that have remained on this circuit list for 4 of the last 5 years. These circuits are Bridle Trails 22, Lake Hills 22 and Evergreen 23. Actions for these circuits include:

- For the Bridle Trails 22 circuit, PSE is developing a project to underground portions of the system subject to low reliability and to install tree wire on the remaining overhead portions. This project will enhance the reliability of the circuit by both preventing tree damage in the underground portion and reducing the number of tree contact outages on the overhead line.
- For Lake Hills 22, PSE is installing tree wire on two feeders and is permitting a new transmission line between Phantom Lake and Lake Hills substations to provide greater redundancy on this circuit and to improve outage restoration.
- PSE is currently monitoring the Evergreen 23 circuit performance.

Over the past three years, PSE has performed projects related to substation equipment replacement, installation of animal guards, underground cable replacement, and switch replacements, which are all focused on the improvement of reliability of the circuits in Bellevue. In addition, PSE routinely performs the following activities related to maintaining reliability:

- On-going vegetation management to reduce the risks to the system from tree damage. However, this will be an on-going challenge based on the presence of tall trees along the overhead system rights-of-way. In 2015, vegetation

management at the Northrup substation introduced lower growing screening trees at the substation to reduce the risk of tree-caused outages.

- Installation of tree wire along overhead distribution circuits that are subject to significant tree-related damage.
- Installation of sectionalizing devices on distribution circuits to provide for quicker outage restoration
- Installation of SCADA switches in the Bellevue Downtown to allow for better visibility and control of the system. This effort is a major distribution automation improvement.
- On-going underground cable remediation and replacement
- Improvements in the aging overhead infrastructure to replace older wires with smaller diameters

These on-going efforts along with system maintenance programs provide for improvements in circuit and system reliability.

3. Summary

Reliability is affected by the impacts of planned outages, unplanned outages (non-storm) and unplanned outages (major events) on the system. The number of unplanned (non-storm) outages on Bellevue circuits has increased over the past three years, such that SAIDI and SAIFI are higher. The results in Bellevue mirrored the overall PSE system during this time, and continue to be more reliable than the overall PSE system.

There were significant major storms in the past two years so that there has been an increase in the overall increase in outage frequency and duration when including these storm events. Storm related outages due to tree-related events continue to be a challenge.

In general, the outage causes and on-going PSE programs are consistent with past performance. PSE is continuing their efforts with their general reliability programs and also with specific circuit projects.

4. References

1. 2007-2015 Bellevue Electric Service Reliability Reports (by PSE)
2. PSE 2007-2015 SQ Program and Electric Service Reliability Filings; Attachment A: Annual PSE SQI and Electric Service Reliability Report