City of Bellevue
Overview of 2016 Electrical System Reliability

This summary provides an overview of the electrical system reliability in Bellevue for 2016 as support for follow-up activities to the annual reliability workshop between the City of Bellevue (Bellevue) and Puget Sound Energy (PSE) in August 2017. 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 report prepared by PSE for the City.

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 PSE system and for Bellevue. The metrics are based on the information in the annual reliability reports prepared by PSE for the City of Bellevue[1]. For this analysis, the SAIDI and SAIFI information is provided on

[1] The WUTC has not yet uploaded the annual electric reliability reports for 2016 from the Washington State regulated utilities so that updated information is not provided for the overall PSE system for 2016.

an annual basis[2]. 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.

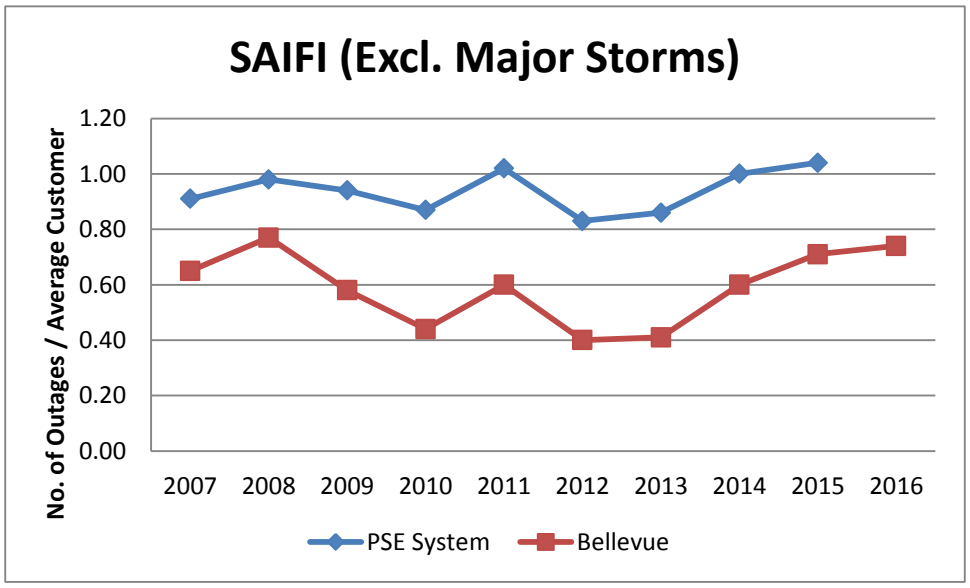


Figure 1: SAIFI Metric for Planned and Unplanned Outages (Excluding major events) for Bellevue and PSE[1]

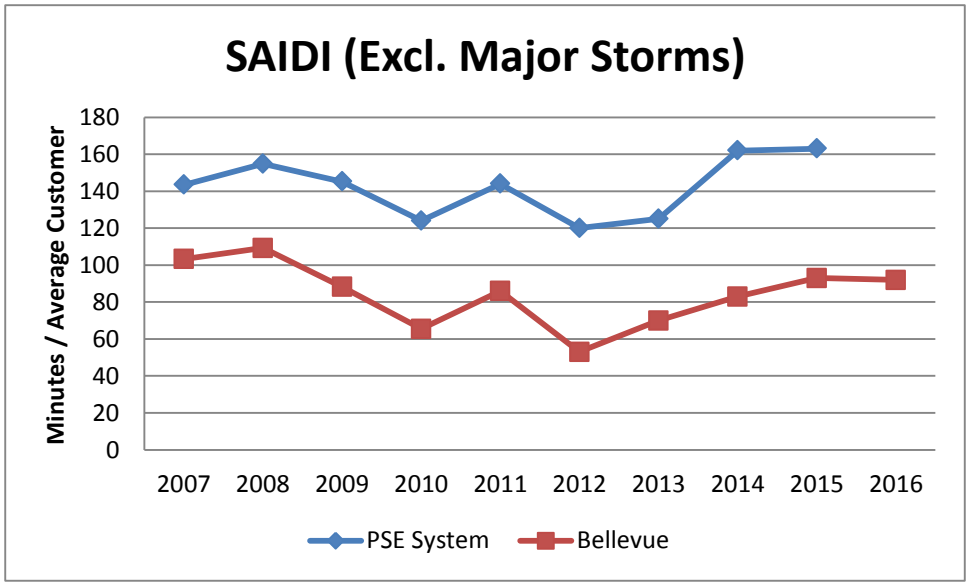


Figure 2: SAIDI Metric for Planned and Unplanned Outages (Excluding major events) for Bellevue and PSE[1]

[2] The outage information provided by PSE in the Annual Reliability Reports for Bellevue is used to calculate the SAIDI and SAIFI information for Bellevue. The information is reported on an annual basis. PSE has reported in several formats over the years and has now converted to use of the IEEE 3666 methodology which reports on an annual basis.

Based on the information above, Bellevue has experienced similar reliability performance in 2016 as 2015. Additionally, based on the 2016 Bellevue reliability report, it appears that the PSE system performance improved in 2016 relative to the past few years[3]. Bellevue's performance over time continues to mirror that of the overall system reliability and Bellevue continues to experience better reliability performance than the overall system average. The 2016 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 92 minutes in 2016, from non-storm related outages.

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. PSE has provided reliability data including major storms in its annual reliability report to the Bellevue and included information on all outage events in Bellevue. 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.

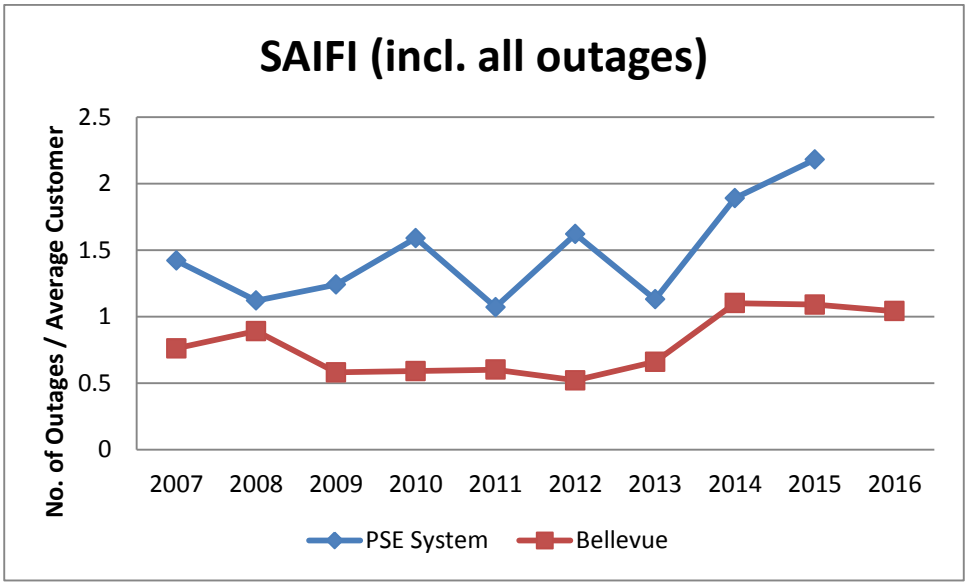


Figure 3: SAIFI Metric for Planned and Unplanned Outages (Including major events) for Bellevue and PSE[1]

[3] The reported SAIFI and SAIDI results on the overall PSE system have improved with reductions in both metrics from the prior year.

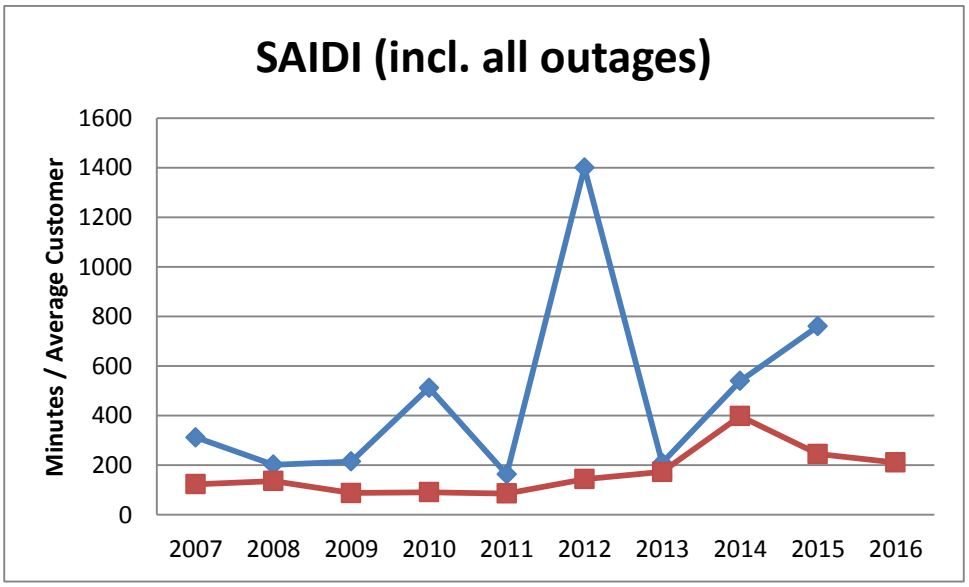


Figure 4: SAIDI Metric for Planned and Unplanned Outages (Including major events) for Bellevue and PSE[1]

There is a reduction in the metrics including storm events during 2016. There are 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 in the annual Bellevue reliability report on circuits in Bellevue that experience outage frequency or duration above the PSE system average or PSE targets[4]. Figure 5 shows the number of circuits in Bellevue that exceed these PSE benchmarks.

4 PSE reports on the 50 circuits system-wide that have the greatest reliability concerns in their annual report to the WUTC. The WUTC has not yet uploaded the reports for 2016 and therefore, there is no update on this information. For 2015, Bellevue had no circuits in this list.

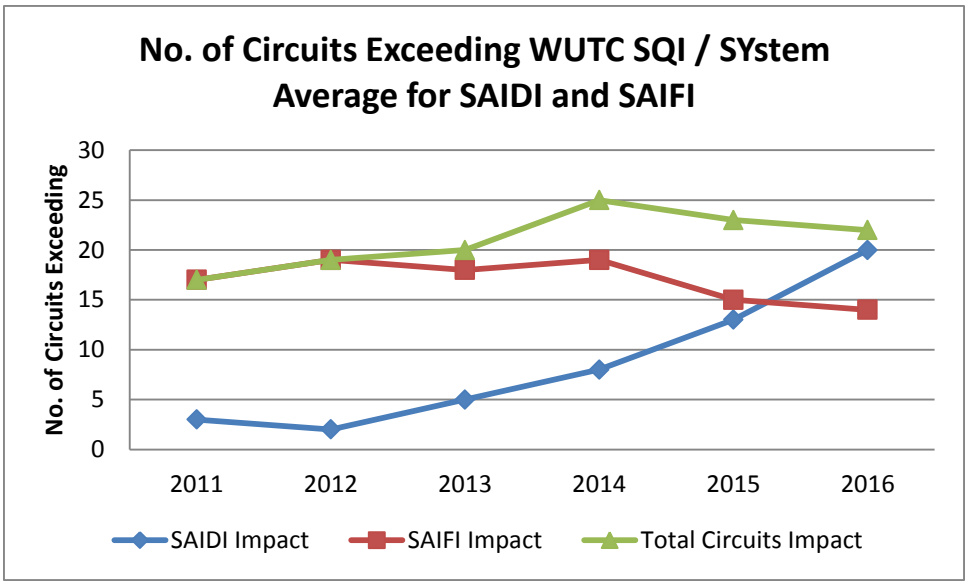


Figure 5: Bellevue Circuit Performance

Based on the information above, the number of circuits above the system average has decreased over the past year. The trend continues with more circuits being impacted by return to service after outages (i.e. circuits impacted by SAIDI). It should also be noted that the number of circuits exceeding the SAIFI thresholds continues to drop. PSE indicates that most of these circuits have received some type of corrective action or pending corrective action to address the cause of the outages on these circuits that contribute to their inclusion on this list.

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 been relatively constant over the past three years, excluding storms.

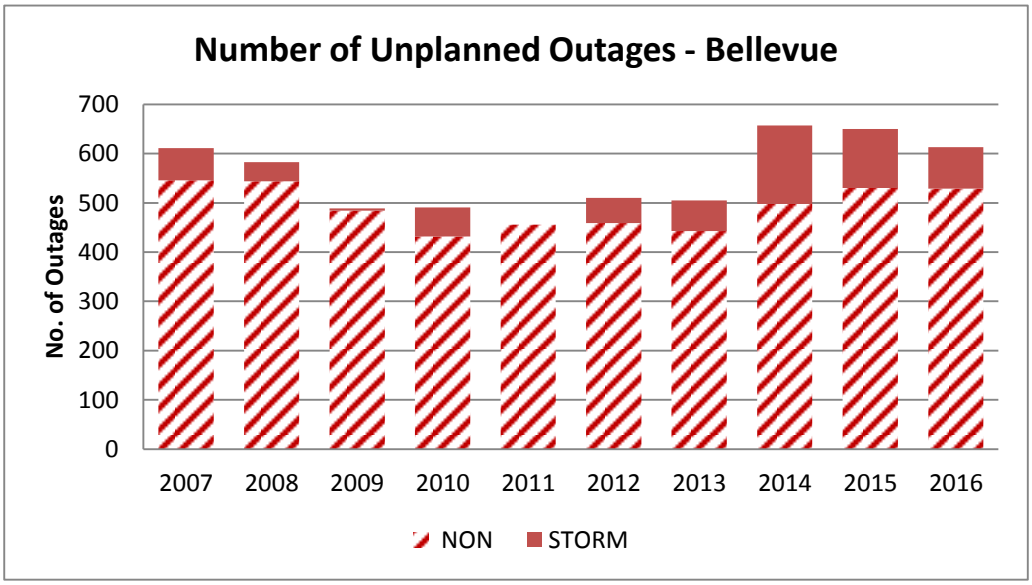


Figure 6: Unplanned Outages in Bellevue

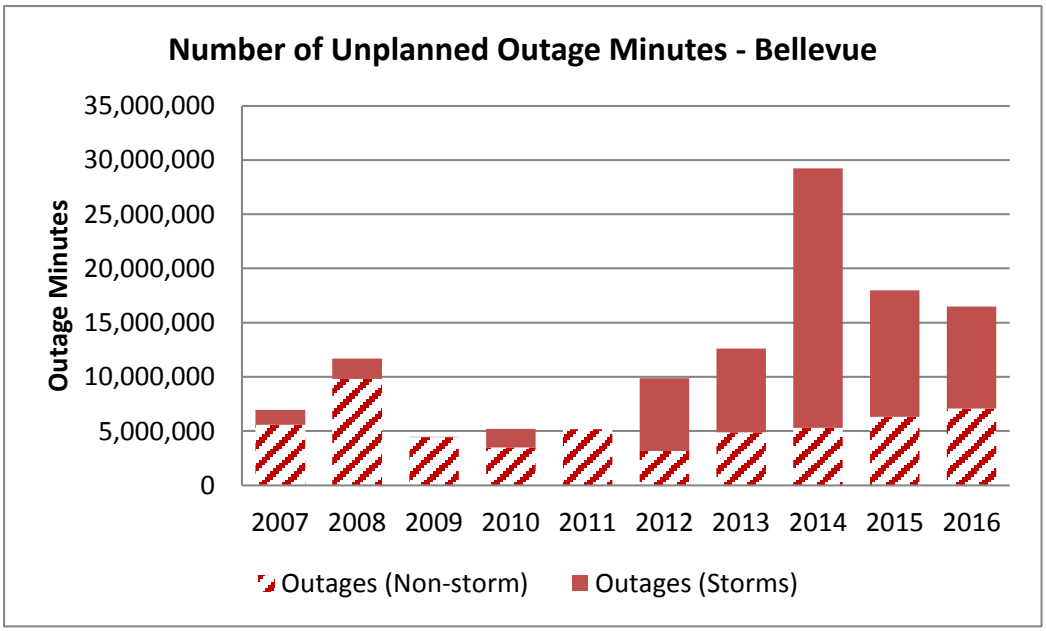


Figure 7: Unplanned Outage Duration in Bellevue

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. [Note: The WUTC has not yet posted reliability results for 2016. However, PSE has reported reliability for their system and Bellevue in the Annual Report for Bellevue.] The reliability performance of the City is in the 1st quartile for SAIFI and SAIDI based on 2016 results. The SAIDI calculated for Bellevue from the outage data indicates 92 minutes, excluding storms; and the SAIFI metric is 0.74 outages per average customer. The IEEE data is provided in the Table 1.

Table 1: IEEE Reliability Results[5]

	2015		2016	
Quartile	SAIFI	SAIDI (minutes)	SAIFI	SAIDI (minutes)
1st / 2nd quartile break	0.86	81	0.91	97
2nd / 3rd quartile break	1.04	115	1.10	124
3rd / 4th quartile break	1.32	166	1.33	155

Selected Utility Comparison

The WUTC has not yet posted 2016 reliability reports for the Washington regulated utilities so updated information is not available here.

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.

[5] IEEE Presentation "2017 General Meeting Distribution Reliability Working Group: Results for 2016 Data"

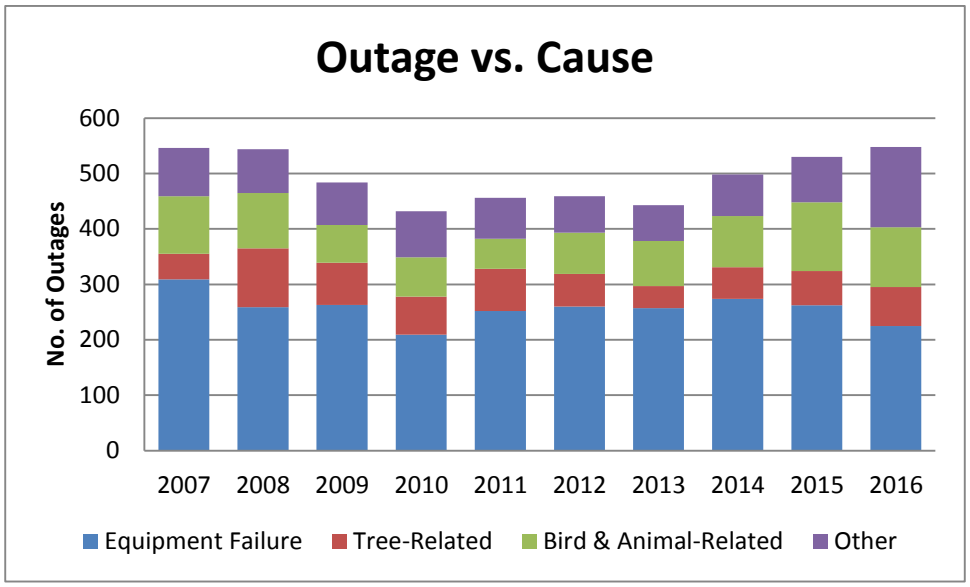


Figure 8: Outages vs. Cause

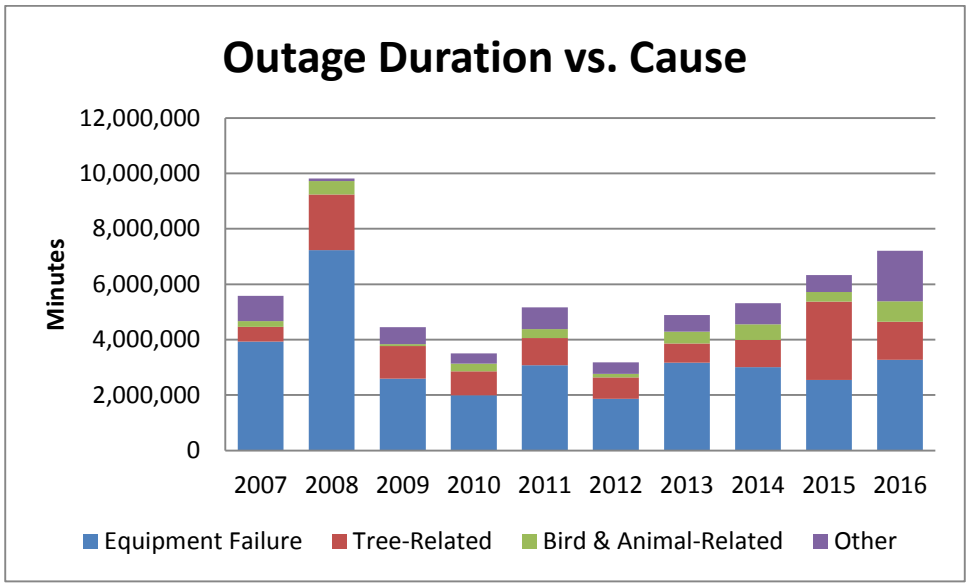
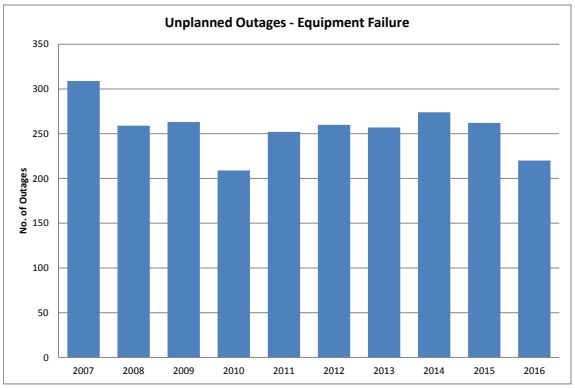


Figure 9: Outage Duration vs. Cause

Based on the results above, the number and duration of outages (excluding major storms) has increased slightly over the past few years. However, the other causes consist of items that are somewhat outside the control of the utility and are often related to third-party events. If the other category is removed, then performance between 2015 and 2016 are comparable. 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 decreased over the past three years and with the duration of these outages remaining about the same. These results indicate that the maintenance and inspection programs are generally consistent each year in achieving this level of performance.



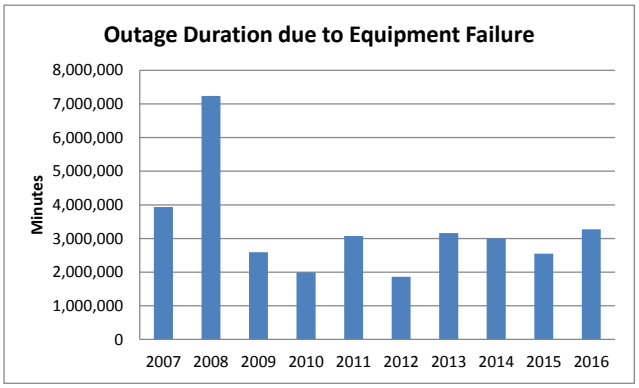


Figure 10: Outage Data for Bellevue for Equipment Failure (Excluding Major Events)

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.

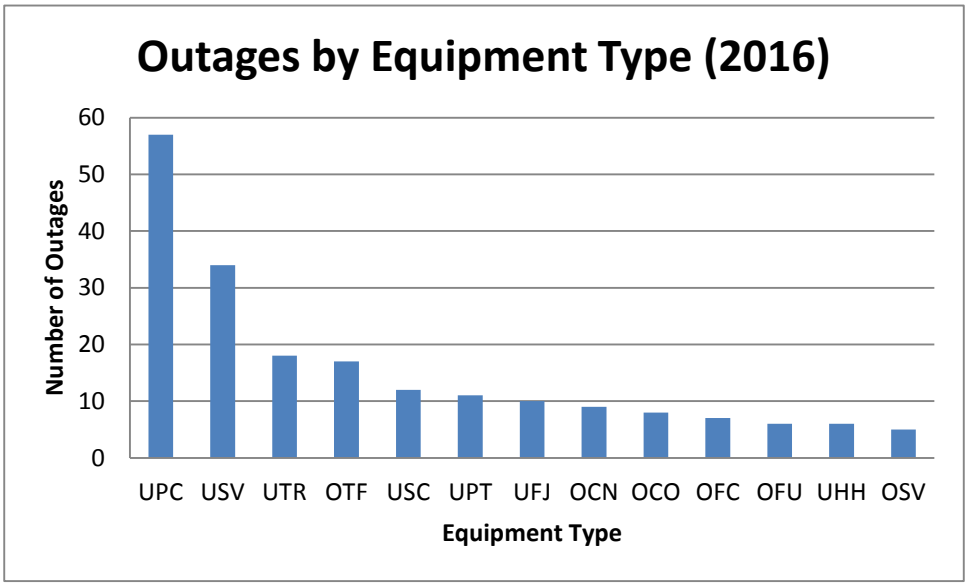


Figure 11: Outages by Equipment Type (Excluding Major Events)

Underground primary cable (UPC) and underground services (USV) are the top equipment failure causes in 2016. This trend is consistent with past years in that the underground equipment failures tending to be the top causes. PSE has continued their program for underground cable remediation and replacement to improve overall reliability of the underground system.

Tree-Related Outage Trends

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

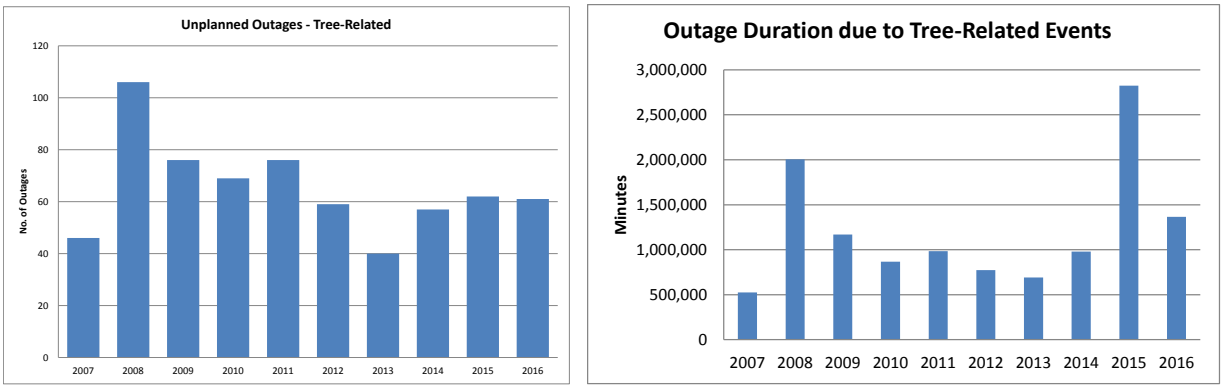


Figure 12: Outages for Tree-Related Events (Excluding Major Events)

The data indicates that the non-storm tree-related events have remained relatively constant over the past three years. There were several tree-related, large substation and transmission outages that occurred in 2015. These results indicate that the inspection and vegetation management programs are generally consistent each year in achieving this level of performance. 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.

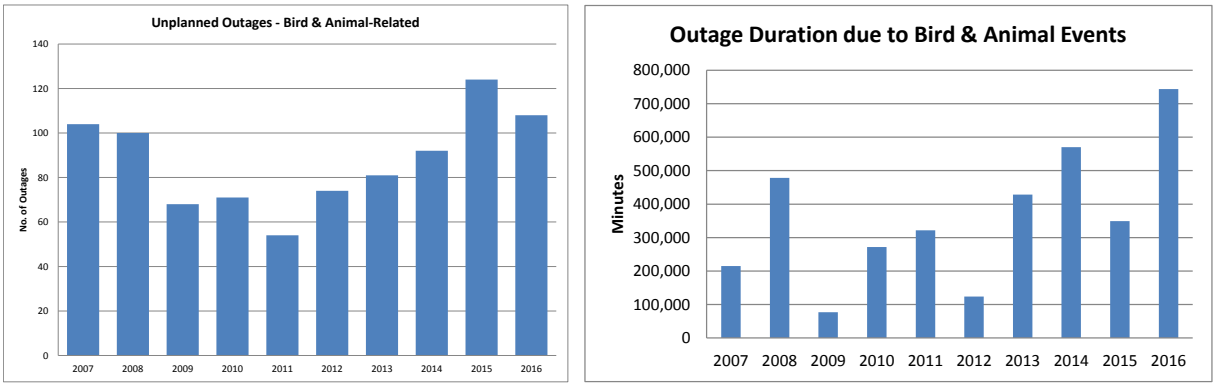


Figure 13: Outages for Bird and Animal-Related Events (Excluding Major Events)

Bird and animal outage events continue to be about 20% of the unplanned outages on the electric system in Bellevue. PSE has previously reported in 2015 that there was an increased number of events both in Bellevue and system-wide due to weather related activities. 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.

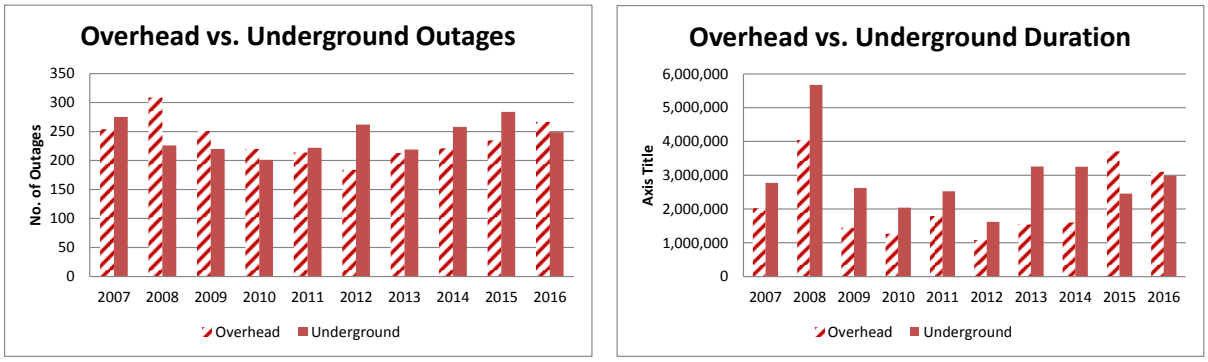


Figure 14: Outage Data for Overhead and Underground Systems (Excluding Major Events)

The results continue to show a relatively similar mix of overhead and underground events. Again, the results indicate a consistency in maintenance and inspection to achieve the current level of performance.

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.

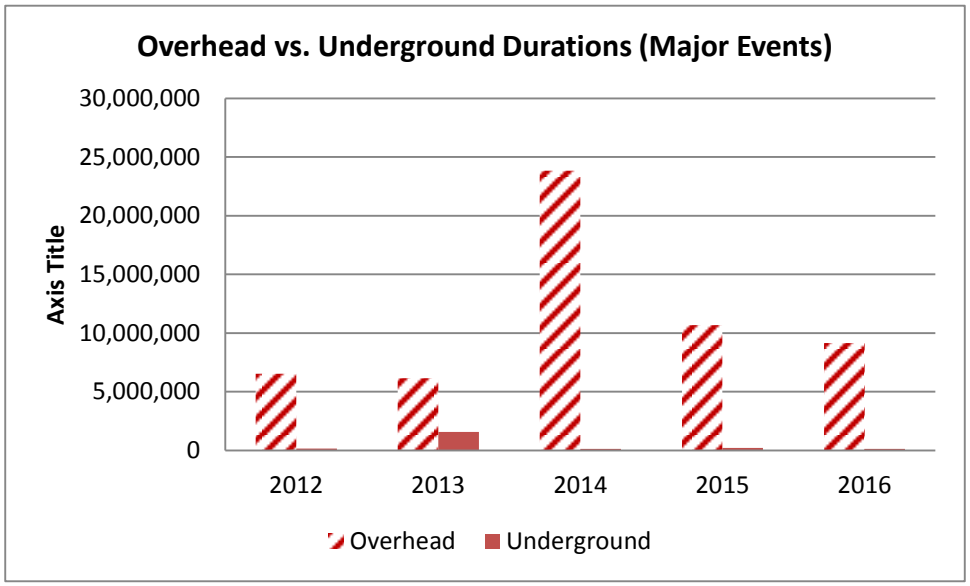


Figure 15: Outage Duration for Overhead and Underground Systems (Major Storms Only)

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 16 of the 22 circuits identified and has identified future projects for 5 circuits and no required action for one circuit.

In 2015, there were three circuits that had remained on this circuit list for 4 of the last 5 years. These circuits are Bridle Trails 22, Lake Hills 22 and Evergreen 23. Only Evergreen 23 was on the list in 2016 with reliability below the threshold. For Evergreen 23, three switches and arrestors on this circuit that were the cause of the outage have been replaced. In addition, Bridle Trails 22 had 4 of 5 years on this list, but it was within reliability thresholds for 2016 and no corrective actions were identified.

PSE is continuing to perform 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.
- 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
- On-going underground cable remediation and replacement

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. Reliability performance in Bellevue has been relatively consistent over the past three years. This indicates that current maintenance and inspection programs are being consistently applied. Bellevue also continues to be more reliable than the overall PSE system.

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. 2007-2016 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