Bainbridge Island Electric System Needs Assessment

Bainbridge Island, WA

Strategic System Planning
July 2019

PUGET SOUND ENERGY

Bainbridge Island Electric System Needs Assessment

Prepared By:

Chad Larson, PE, *Strategic System Planning*
Rachit Arora, PE, *Strategic System Planning*

Reviewed By:

Stephanie Imamovic, PE, *Supervisor - Strategic System Planning*

Approved By:

7/31/19

Jens Nedrud, PE *Date*
System Planning, Manager

7/31/19

Cathy Koch, PE *Date*
System Planning, Director

Strategic System Planning
July 2019

Table of Contents

List of Figures

List of Tables

Executive Summary

A transmission and distribution system needs assessment was performed for Bainbridge Island. The detailed technical analysis determined that there are reliability, system capacity and aging infrastructure needs during the 10-year planning horizon.

Bainbridge Island is home to a population of 24,400 residents and Washington State Ferries Eagle Harbor Maintenance Facility and Ferry Terminal. Puget Sound Regional Council has identified Bainbridge Island as an urban area for the Growth Management Act.

Bainbridge Island receives electric power via two 115,000 volt (115 kV) transmission lines extending south onto the island. Approximately 12,400 island electric customers are served from three distribution substations – Port Madison, Murden Cove and Winslow. The two supply transmission lines connect at Port Madison, and then split into single radial transmission lines, also referred to as "taps", to bring power to Murden Cove and Winslow substations. From the three substations, distribution lines deliver power to island homes and businesses.

Transmission Needs and Concerns

Transmission Reliability Need

Key findings from the reliability assessment for the five year period (2013 to 2017) identified reliability needs on Bainbridge Island.

Customers on Bainbridge Island, in particular those served by the Winslow substation, experienced longer and more frequent outages in comparison to Kitsap County and PSE company-wide. Excluding storm related outages, Bainbridge Island 5-year average SAIDI[1] was 2 times PSE service quality index of 155 customer minutes of service interruption a year. Bainbridge Island 5-year average SAIFI[2] was 75 percent higher than PSE service quality index of 1.3 customer service interruptions a year.

Transmission outages contributed to nearly 50 percent of the total customer minutes of service interruption to Bainbridge Island over the past 5 years. In comparison, across PSE's service territory, transmission outages contributed an average of 10 percent to the total customer minutes of service interruption.

Nearly 70 percent of the transmission customer minutes of service interruption on Bainbridge Island were from outages to the Winslow Tap transmission line. The remaining transmission customer minutes of service interruption were caused by island-wide outages due to loss of both transmission supply lines outside of the island.

The Winslow Tap transmission corridor has cross country sections with limited access and difficult terrain for patrol, which results in prolonged restoration times for many of the Winslow tap outages.

Winslow substation experienced a significant number of outages, 21 over the five-year period, averaging 4 outages a year, primarily caused by loss of Winslow Tap transmission line from tree related events.

---

[1] SAIDI (System Average Interruption Duration Index): Reliability metric calculated for an area or PSE company-wide to measure average outage duration impacting customers in minutes per year. Outages longer than 5 minutes are considered.

[2] SAIFI (System Average Interruption Frequency Index): Reliability metric calculated for an area or PSE company-wide to measure average outage frequency impacting customers in interruptions per year. Interruptions longer than 1 minute are considered.

Transmission Aging Infrastructure Need

The Winslow Tap transmission line was built in 1960 with wishbone crossarm construction. PSE has started to see wishbone crossarms of similar vintage failing in other parts of PSE service area and considers this type of construction to be a reliability risk. An inspection of this transmission line in early 2019 indicated that nearly half of the wishbone crossarms will require replacement.

Transmission Operating Flexibility Concern

Operational flexibility is related to the ability to transfer load to support routine maintenance and outage management. Winslow and Murden Cove substations are on radial transmission taps with no operating flexibility at the transmission level, meaning there is no transmission backup supply to power these substations. In absence of transmission backup, for managing a transmission outage to a substation, PSE switches customers of the affected substation to adjacent substations over distribution ties. Such switching can be time taking and complex dependent on the area loading. During winter when customer demand is highest, some customers on the affected transmission line and its substation may not be transferred and can experience an outage[3].

Transmission Service Concern - Load shedding, Low Voltage and Island-wide Outage Events[4]

Bainbridge Island and the North Kitsap County substations are at the end of the transmission system serving Kitsap Peninsula. PSE transmission planners studied various contingencies in compliance with federal reliability requirements and found that certain multiple contingencies on the transmission system off-island on Kitsap peninsula may cause low voltage or overloading of the transmission lines on the peninsula. Under such contingencies, PSE may be forced to shed load by de-energizing some or all of Bainbridge Island substations. These concerns will be addressed separately under PSE's solution for Kitsap Transmission System Needs. PSE rebuilt the 2 transmission supply lines in North Kitsap in 2016 and expects the line upgrades to improve reliability of the two supply lines and mitigate possibilities of island-wide outages.

Distribution Needs and Concerns

Distribution Substation Group Capacity Need

An additional substation group capacity of 14.6 MW is needed on Bainbridge Island over the next 10 years starting in 2019/20 to support general load growth and the planned 10 MW load addition of WSDOT electric ferry, and keep the island's projected load within PSE's distribution planning guidelines.

Distribution Feeder Group Capacity Concern

The distribution feeder capacity needs are for distribution circuit group of five feeders supplying the Downtown Winslow area. With the electrification of Bainbridge to Seattle Ferry currently planned by Washington State Ferries, load would exceed N-1 (one element out of service) feeder capacity in the area leaving some customers in this commercial area at risk for long duration outages. A dedicated new feeder will be required to supply the ferry load under their tentative rate schedule. This additional dedicated feeder will eliminate the feeder group capacity concern in the Downtown Winslow area.

---

[3] PSE limits routine equipment maintenance to summer months when loading is light and backup is available from the distribution system. An unplanned or emergency transmission repair situation in winter can lead to outages for some customers due to lack of operating flexibility.

[4] For this document, the definition of Island wide outage is the simultaneous loss of electric service to all customers on Bainbridge Island.

Distribution Reliability Concern

There are reliability needs with Port Madison and Winslow substations feeders - PMA-12 and WIN-13 feeders respectively. These two circuits continue to have SAIDI and SAIFI scores significantly worse than PSE's average values. However, reliability projects are currently planned to eliminate these reliability needs.

Conclusion

The system needs and concerns identified for Bainbridge Island are summarized below. Potential solutions must address all of the system needs identified in this study, while also considering the identified concerns. The system needs and concerns for Bainbridge Island are:

- **Transmission Reliability need:** A reliability improvement need was identified to improve the performance of transmission service to Winslow substation.
- **Transmission Aging Infrastructure need:** An infrastructure replacement need was identified for the Winslow Tap transmission line support structures that are nearing end of useful life and could potentially fail leading to unplanned outages and emergency repairs.
- **Substation Capacity need:** A distribution substation group capacity need of 14.6 MW was identified on Bainbridge Island within the 10 year planning horizon (2018-2027) to support general load growth of 4.6 MW and planned 10 MW load addition of WSDOT electric ferry.
- **Transmission Operating Flexibility concern:** Concerns related to ability to transfer load to support routine maintenance and outage management on the radial transmission lines feeding Winslow and Murden Cove substations.

1 Introduction

This document reports the results of a needs assessment performed for the transmission and distribution systems serving Bainbridge Island to identify current and future needs of the electric systems.

1.1 Study Objective

The study objective was to assess the capability of existing transmission and distribution infrastructure within Puget Sound Energy's (PSE's) Bainbridge Island service area. (See Figure 1-1 for study area)

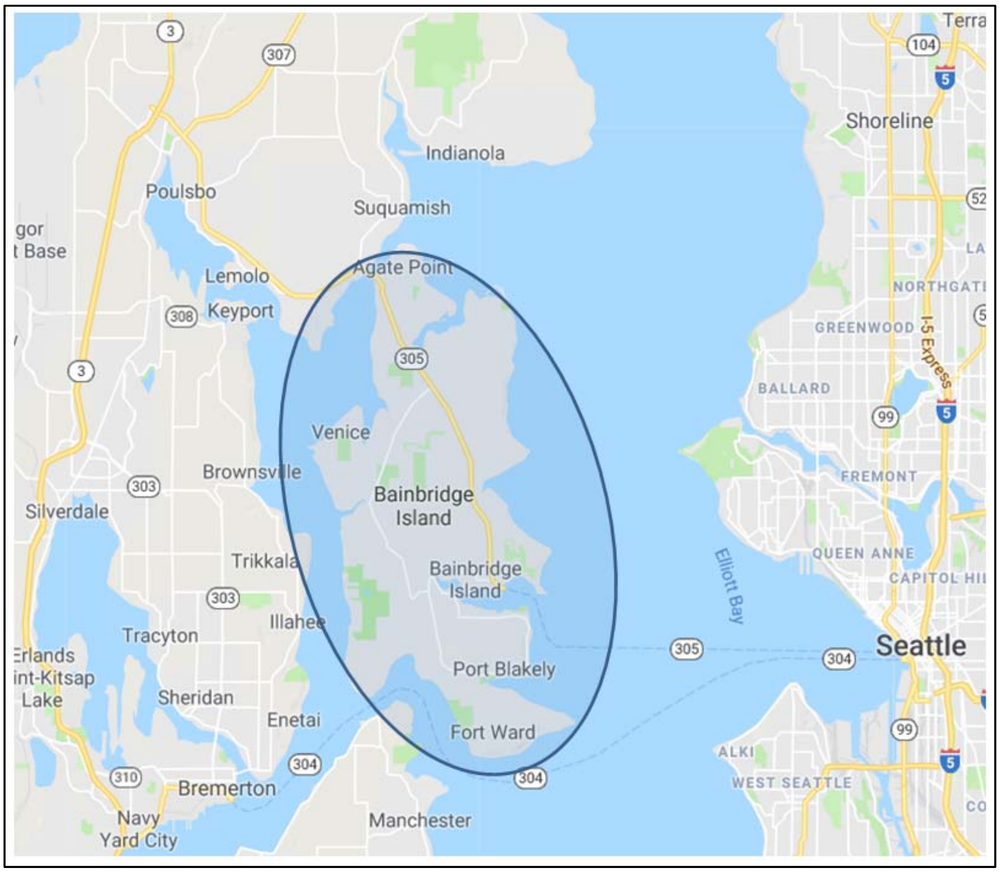


Figure 1-1: Bainbridge Island Study Area

Transmission Assessment includes:

- Analysis of transmission capacity to serve Bainbridge Island load over the next 10 years (2018-2027), as forecasted under the F2017 PSE Load Forecast (See Appendix A-1). The transmission system was analyzed for a range of planning contingencies as per the North American Electric Reliability Corporation (NERC) Transmission Planning Standard (TPL-001-4).
- Reliability assessment of the transmission lines serving Bainbridge Island
- Analysis of operational concerns of the transmission system serving Bainbridge Island.

Distribution Assessment includes:

- Analysis of distribution capacity to serve Bainbridge Island load over the next 10 years (2018-2027). Analysis includes all elements in service (N-0) and one element out of service (N-1) contingencies.
- Review of historical reliability performance
- Analysis of operational concerns for all the circuits and substations on Bainbridge Island.

2 Background

2.1 Background Information

Reliability issues were first identified for Bainbridge Island in 1993. At the time, PSE proposed to construct a new parallel 115 kV transmission line via Bainbridge Island from Bremerton to Foss Corner switching station in Poulsbo. The proposed West Sound Transmission Reliability project was later revised to implement one of the alternate solutions: to improve tree trimming and to re-build Port Madison (PMA) substation with four 115 kV breakers. This project was completed in 2000.

In 2006, PSE completed a reliability and capacity study of the Island, which resulted in proposed infrastructure solutions and community conversations about the proposed solutions from 2008-2010. After input from the community, PSE agreed to a three-year "stay out" period where the community would attempt to reduce its energy demand; any load growth above 58 MW peak demand (Winslow and Murden Cove combined) would require additional substation capacity. PSE also clarified that providing the community with a three-year window to reduce its energy demand would only address the capacity challenges – reliability problems would not be addressed. A peak combined demand of 54.8 MW was experienced on February 7, 2014. Ferry electrification would require a 10 MW load connection to either Winslow or Murden resulting in exceeding the 58 MW.

PSE conducted a residential Demand Reduction Pilot (DRP) project from October 2009 through September 2011, as part of an effort to work with the residents of Bainbridge Island to reduce their load in an attempt to defer a need for additional substation capacity. During the pilot, PSE used special equipment to monitor and reduce residential household energy use on peak load days. One of the goals of the pilot project was to determine the potential peak electric demand reduction achievable on Bainbridge Island through the control of residential space and water heating equipment. Approximately 8% of the target customers participated in the pilot and an average aggregate demand reduction of 683 kW were realized in the target area.

With growing reliability challenges and expected increases in demand, PSE initiated this needs analysis in 2017.

2.2 Area Description

The City of Bainbridge Island is an urban growth area separated from the Kitsap Peninsula by the Agate Pass waterway and bridge and is home to a population of 24,400 residents, a unique downtown area, and Washington State Ferries Eagle Harbor Maintenance Facility and Ferry Terminal. In 2017, an average customer meter count of 12,400. Two-thirds of the population is located at the south end of the island.

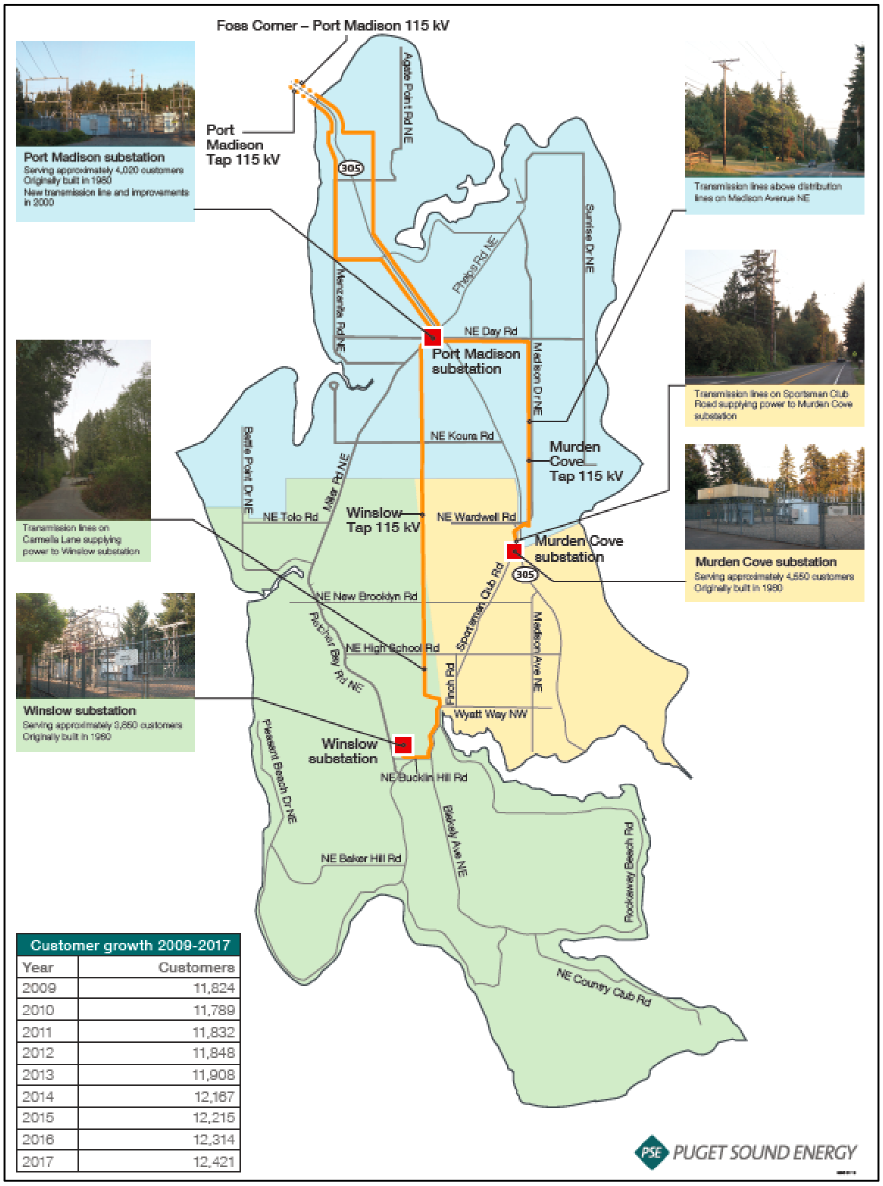
Bainbridge Island customers are served from three distribution substations, Port Madison, Murden Cove and Winslow, with an aggregate peak winter 2016/17 electric load of 77 megawatts (MW) and a peak summer 2017 of 26 MW[5]. Two 115 kilovolt (kV) transmission supply lines bring power to the Port Madison substation on Bainbridge Island. From Port Madison, there are two separate radial 115 kV transmission lines that serve Murden Cove and Winslow substations respectively.

---

[5] Peak winter and summer loads coincident with system peak

The Bainbridge Island study area is served primarily by electric energy as there is no natural gas service to the island, though some customers use propane gas for heating. In winter, electricity usage is higher than is typical in other PSE service areas, due to a large amount of electric heating loads. Bainbridge Island has mainly residential electric customers and relatively few commercial and industrial customers. The peak load occurs in the winter and is typically 2.5 to 3 times the summer peak load.

Figure 2-1 illustrates the Transmission System and Distribution Substations serving Bainbridge Island.



Customer growth 2009-2017	
Year	Customers
2009	11,824
2010	11,789
2011	11,832
2012	11,848
2013	11,908
2014	12,167
2015	12,215
2016	12,314
2017	12,421

Figure 2-1: 115 kV Transmission System and Distribution Substations Serving Bainbridge Island

2.3 Existing Transmission System

As shown in Figure 2-1, Bainbridge Island receives power from 2-115 kV lines, the Foss Corner-Port Madison 115 kV line and the Port Madison Tap of the Foss Corner-Keyport 115 kV line. The two 115 kV transmission lines terminate at Port Madison 115 kV switching station. Two separate 115 kV radial transmission lines – the Winslow Tap 115 kV and Murden Cove Tap 115 kV, tap off the Port Madison 115 kV bus and serve Murden Cove and Winslow distribution substations.

The Murden Cove Tap 115 kV transmission line is 3 miles long and consists of 795 ACSR Tern conductor. The Winslow Tap 115 kV transmission line is 4.5 miles long and consists of 4/0 ACSR conductor. Both transmission lines are radial from the Port Madison transmission bus. This means if there's an outage anywhere on the transmission line, the substation at the end of the line has an outage (either Winslow or Murden Cove). If the substation is out, then all customers served by it have an outage, too.

2.4 Existing Distribution System

Bainbridge Island is generally served from four feeders from the Port Madison substation (PMA-12, PMA-13, PMA-15, PMA-16), four feeders from the Murden Cove substation (MUR-13, MUR-15, MUR-16, MUR-17), and four feeders from the Winslow substation (WIN-12, WIN-13, WIN-15, WIN-16). All three substations utilize the PSE standard 115-12 kV 25 MVA distribution transformers.

Table 2-1 summarizes the customer count and feeder system conductor type for each circuit on Bainbridge Island during normal system configuration (N-0).

Table 2-1: Study Area Feeder System Conductor Type by Mile

Circuit	2017 Average Customer Count	Overhead Bare	Overhead Tree Wire	Underground
PMA-12	993	3.8	-	.1
PMA-13	893	.4	2.3	.5
PMA-15	1290	3.0	.9	.5
PMA-16	843	1.3	.9	.1
PMA Total	**4019**	**8.5**	**4.1**	**1.2**
WIN-12	1158	1.7	3.1	.1
WIN-13	1247	1.2	2.0	.3
WIN-15	727	.8	3.2	1.5
WIN-16	720	.1	-	1.1
WIN Total	**3852**	**3.8**	**8.3**	**3**
MUR-13	1493	1.7	2.5	2.0
MUR-15	751	1.0	-	1.9
MUR-16	601	2.4	-	.1
MUR-17	1705	1.4	.3	2.2
MUR Total	**4550**	**6.5**	**2.8**	**6.2**
Total (Study Area)	**12421**	**18.8**	**15.2**	**10.4**

3 Forecasted Load

The PSE F2017 Kitsap County area load forecast was utilized for modeling of PSE's Kitsap peninsula load outside of Bainbridge Island. The Bainbridge Island Load Forecast was used for modeling loads for analysis of transmission and distribution system on Bainbridge Island.

3.1 Kitsap County Corporate Load Forecast

PSE's F2017 Corporate Load Forecast shows a slightly declining load growth profile for Kitsap County winter peak demand over the 10 year period 2018-2027. The Kitsap County normal winter peak load has an average annual load growth (decline) of minus 0.4% per year over next 10 years (2018-2027), with 100% conservation. With 0% conservation, the County winter peak demand grows at an average annual load growth of 0.9% per year.

Figure 3-1 shows the PSE normal winter peak load forecast for Kitsap County over the 10 year period 2018-2027 with 100% and 0% level of conservation. As shown in the forecast, conservation offsets the growth in electric demand over the 10 year period. With no conservation, Kitsap County normal winter demand is expected to grow from 512 MW in 2018 to 560 MW in 2027. PSE's conservation measures of up to 79 MW over the 10 year period, offset (reduce) the electrical demand for the county to a declining trend – 560 MW to 481 MW in 2027.

The PSE F2017 Kitsap County area load forecast was utilized for modeling of PSE's Kitsap peninsula load outside of Bainbridge Island, for analysis of PSE's transmission system on Kitsap peninsula. The proposed Bainbridge Island ferry electrification load information was not available at the time of release of the F2017 corporate load forecast. Therefore, the Ferry load was included separately in the analysis.

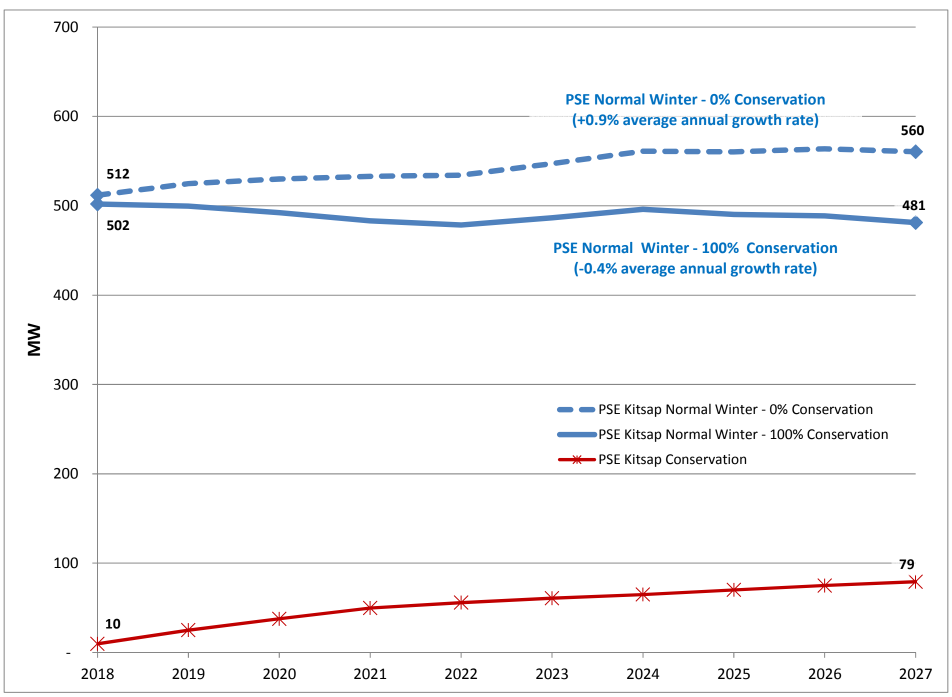


Figure 3-1: Kitsap County – PSE Normal Winter Peak F2017 Load Forecast (2018-2027) without/with Conservation

Appendix A and Appendix B provide the PSE F2017 Kitsap County peak load forecast for normal winter and normal summer conditions.

The PSE F2017 corporate load forecast is a 20 year[6] (2018-2037) load projection of peak winter and summer demand; however the study utilized the initial 10 years of the load forecast for the Bainbridge needs assessment for the 10 year planning horizon of 2018-2027. Peak winter load forecast is provided for "normal" winter conditions at 23°F. Peak summer load forecast is provided for "normal" summer conditions at 89.5 °F. Load forecast is also provided with respect to PSE's implementation of conservation at 100% and 0% level.

PSE uses the "normal" weather load forecast at 100% conservation for planning PSE's system; however 0% conservation was used for as a sensitivity study in transmission analysis to verify system performance at higher loading level.

The PSE F2018 load forecast became available in July of 2018 after substantial completion of this needs assessment. The PSE F2018 load forecast utilizes the same county level conservation values as the F2017 forecast as the conservation forecasts values are updated every 2 years. Appendix C details the F2018 normal winter forecast.

In comparison the F2018 normal winter load forecast has a slightly higher load projection than F2017, due to following reasons:

- More than 50% of difference in load forecast from 2017 to 2018 for the first 3 years comes from 2018 updated block load assumptions for new block load additions in Kitsap County. These load additions in the first 3 years (2018 to 2020) included 36 MW of new block loads such as the Bainbridge Island Ferry terminal (10 MW), Kingston Ferry terminal (10 MW), Harrison Hospital expansion (6 MW), Bitcoin (3 MW) and Clearwater Casino expansion (2 MW).
- The 2018 load forecast is higher in the long term due to updated economic and demographic forecast assumptions in 2018.

3.2 Bainbridge Island Load Forecast

PSE generated a 10 year *Bainbridge Island Load Forecast* (2018-2027) for normal winter and normal summer conditions using the following methodology:

Navigant Consulting developed a bottom-up winter load forecast for Bainbridge Island. The "bottom-up" forecast is detailed in Appendix D of the Bainbridge Island Electric System Solutions Report, Bainbridge Island Non-Wires Alternative Analysis, Navigant Consulting, page 3. Navigant relied on "the refined "bottom-up" calculation of load net of planned DSM[7] programs, which includes zip code-specific cost-effective EE savings, and recalculation of demand-side management (DSM) capacity savings based on local substation load shapes, line losses, and power factor." This bottom-up winter load forecast was used as the Bainbridge Island Load Forecast for winter. This bottom-up winter load forecast used the historical winter peak demand for Bainbridge Island 3-substation group in the past 5 year period 2013-2017, as the starting load. The historic peak load was grown at annual load growth rates from PSE F2017 county level forecast, and included the 2021 anticipated ferry block load addition. The bottom-up

[6] Forecast Horizon is for 20 years, however the assessment period is for the first ten years. Years 11-20 is included in distribution assessment for use in developing solutions.

[7] DSM as used by Navigant Consulting is synonymous with Conservation

demand savings calculated for Bainbridge Island zip code were then applied to generate the net bottom-up normal winter load forecast with conservation.

The summer load forecast for the *Bainbridge Island Load Forecast* was generated with similar methodology, except that the bottom-up calculation of demand savings was not used. This is because the impact of efficiency measures on summer loading is minimal.

Figure 3-2 shows the Bainbridge Island Load Forecast for normal winter and summer conditions for the 3 substation group that includes Port Madison, Murden Cove and Winslow substations and the ferry load addition in 2021. Bainbridge Island winter peak load grows at an average annual load growth of 1.8 percent a year over the 10 year period 2018-2027, as compared to a declining minus 0.4 percent for the rest of Kitsap County.

Appendix D details the Bainbridge Island local area load forecast for normal winter and normal summer conditions.

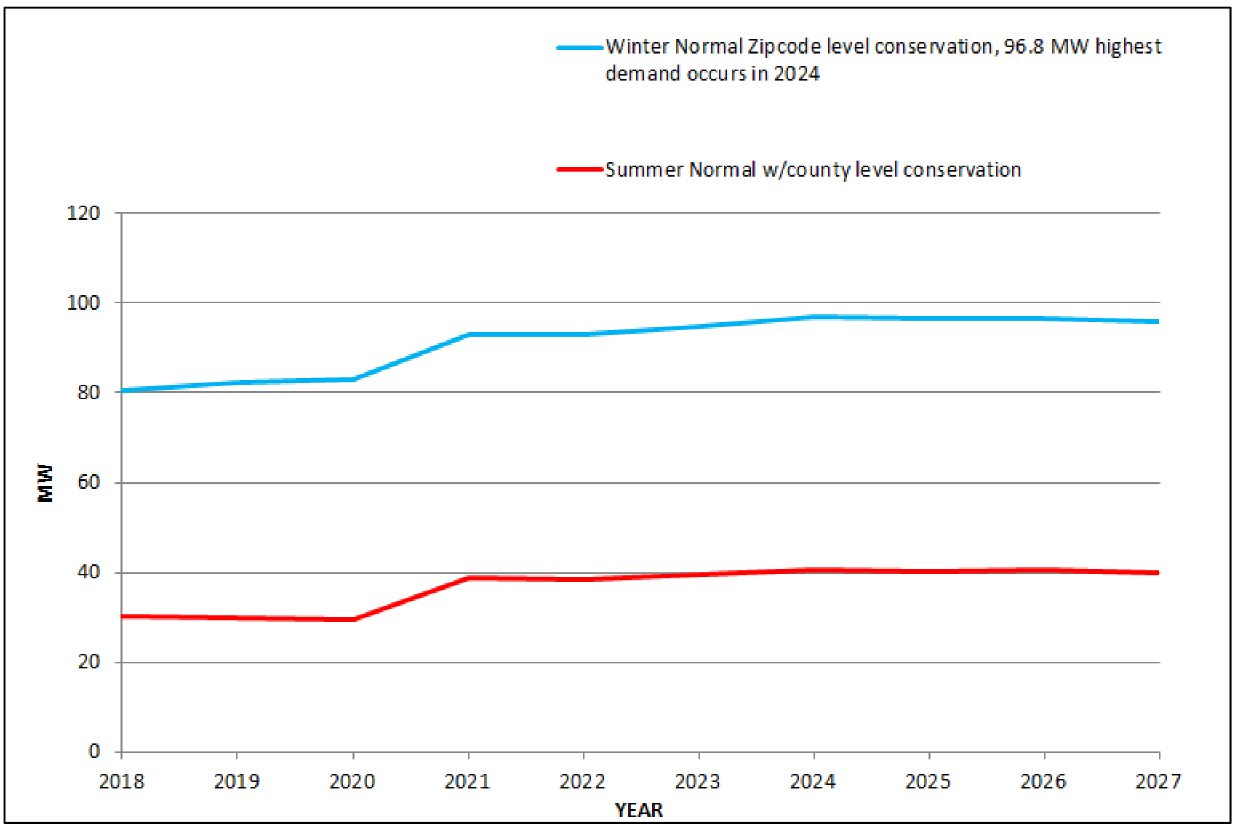


Figure 3-2: Bainbridge Island Load Forecast – Normal Winter and Normal Summer

4 Transmission Needs Assessment

This section assesses the transmission system needs for Bainbridge Island over the 10 year planning horizon (2018-2027). The transmission system needs assessment utilized the PSE F2017 corporate load forecast and PSE's Bainbridge Island local area load forecast for projecting Kitsap County and Bainbridge Island load for the 10 year period.

4.1 Transmission Study Assumptions

Following are the major assumptions utilized in the transmission needs assessment for Bainbridge Island:

- The load levels for Bainbridge Island for the 10 year planning horizon 2018-2027 normal winter load forecast at 23°F are from the Bainbridge Island Load Forecast detailed in section 3.2.
- The load levels for entire Kitsap County are from the PSE F2017 corporate load forecast for Kitsap County for the 10 year planning horizon 2018-2027.
- A base case was modeled for normal winter load with 100% conservation using the Bainbridge Island Load Forecast at the maximum winter loading of 96.8 MW for Bainbridge Island in 2024 during the 10 year planning horizon 2018-2027.
- A sensitivity case was developed to study impact of greater electrical loading under 0% conservation over the 10 year planning horizon 2018-2027, at a maximum winter loading of 99 MW for Bainbridge Island in 2026.

4.2 Transmission Capacity AssessmentMethodology

PSE follows the NERC and WECC planning standards[8] for transmission capacity assessment. The assessment involves review of the transmission system for any thermal overloads or voltage violations for forecasted load, under normal system state (N-0) and abnormal system state involving different types of contingencies (N-1, N-1-1, bus). The contingencies are categorized under TPL-001-4 as P0 through P7. PSE plans for load forecasted at winter peak at 23°F and summer peak at 89.5°F.

4.2.2 Performance Criteria for Thermal Overload and Voltage Limits

PSE has thermal operating limits for normal and emergency operation, which are temperature based limits the equipment can operate under without failing. Normal operating limit is a specific electric loading that a facility can support through the daily demand cycles. The emergency limit is a higher than normal loading that the facility can support for a finite period. PSE's transmission assessment utilizes the normal facility rating for normal state (no contingencies) and emergency facility rating for abnormal system state involving a contingency.

The TPL-001-WECC CRT-3criterion requires PSE to operate the transmission system within 95% to 105% of nominal voltage for normal conditions (P0), and 90% to 110% of nominal voltage during contingencies (P1 through P7). Voltage deviation is not allowed to exceed 8% for single contingency events (P1).

[8] TPL-001-4 (*https://www.nerc.com/files/TPL-001-4.pdf*) *and TPL-001-WECC CRT-3 (https://www.wecc.biz/reliability/tpl-001-wecc-crt-3.pdf)*

4.2.3 Transmission Assessment Results

Transmission assessment for Bainbridge Island was performed over the following range of contingencies (P0 through P7):

P0: No Contingencies (Normal System)

The existing transmission system on the island can carry the projected loads over the 10 year planning horizon (2018-2027) with no overloading or voltage violations under a normal system configuration, i.e. no contingencies.

P1: Single Contingency (Loss of one transmission line)

Bainbridge Island is supplied by 2-115 kV transmission lines from Foss Corner switching station in North Kitsap – the Foss Corner – Port Madison line and Port Madison Tap off the Bremerton – Foss Corner line. Either supply transmission line will carry the projected load for Bainbridge Island for the 10 year planning horizon (2018-2027).

There are two radial transmission lines that originate from Port Madison substation - Winslow Tap (Port Madison to Winslow substation) and Murden Cove Tap (Port Madison to Murden Cove substation). Under loss of either radial transmission line, the de-energized substation load may be switched to other substations on the island using distribution ties, in the summer; PSE is extremely limited on switching ability in the winter months. For example, for a loss of Murden Cove substation, the load may be switched over to Winslow, Port Madison or both substations.

The single transmission contingencies studied on Bainbridge Island were the loss of the either transmission tap line. The loss of the Murden Cove Tap transmission line results in an outage of the Murden Cove substation, and it is assumed that all of Murden Cove substation load is switched to Winslow substation over distribution ties. The Winslow Tap transmission line feeding Winslow substation will then carry the load of Winslow substation, Murden Cove substation and the 10 MW ferry load. This is a conservative assumption since the distribution system under peak loading does not support switching the de-energized Murden Cove substation customers entirely to Winslow substation, (see the distribution system capacity Section 5.3.2), However such assumption tests the transmission capacity of the Winslow Tap transmission line for an emergency measure such as installing a mobile substation off the Winslow Tap transmission line, to pick Murden Cove customers for the loss of Murden Cove Tap transmission line.

The Winslow Tap line conductor of 4/0 ACSR has sufficient transmission capacity to support the Murden Cove Tap contingency with no overloads or voltage violations in the studied base cases and the sensitivity case of 0% conservation.

The loss of the Winslow Tap transmission line results in an outage of the Winslow Substation, and it is assumed that all of Winslow substation load is switched to Murden Cove substation over distribution ties except during peak demand.

The Murden Cove Tap line conductor of Tern 795 ACSR has sufficient transmission capacity to support the Winslow Tap contingency with no overloads or voltage violations in the studied base cases and the sensitivity case of 0% conservation.

P2: Single Contingency (Opening of one transmission line without fault, bus section fault etc.)

Results for P2 single contingencies on transmission lines are same as P1, described above. Results for single contingencies involving bus outage are covered under P4 below.

P3: Multiple Contingency (Loss of generator unit followed by loss of another transmission element)

P3 contingencies do not apply to the study area as there are no generators connected to the transmission system on Bainbridge Island.

P4: Multiple Contingency (Bus Outage)

A bus contingency on the island does not result in any overloads or voltage violations in the studied base cases and the sensitivity case of 0% conservation. No violations of the NERC TPL-001-4 were found due to a P4 contingency.

However, bus configuration is a reliability concern that a single bus contingency event at a switching station could cause an island-wide outage until PSE could perform manual switching to restore power. Outage restoration might take 3 to 4 hours to perform. The loss of load for the P4 contingency is allowed under the NERC TPL-001-4 planning standard.

P5: Multiple Contingency (Fault plus relay failure to operate)

Results for P5 contingency are same as P4 contingencies.

P6: Multiple Contingency (Loss of two transmission elements in succession)

Bainbridge Island is supplied by two transmission lines. Loss of both transmission supply lines will de-energize all substations on the island, resulting in an island-wide outage. Loss of connected load for a multiple contingency (P6) is considered a consequential loss of load, and is allowed under the NERC TPL-001-4 planning standard.

The Bainbridge Island winter peak load is projected in the range of 80 MW to 97 MW over the 10 year period 2018-2027 (see Figure 3-2). Per PSE Transmission Planning Guidelines, the load served by two transmission sources is recommended in the range of 100 MW to 150 MW or a maximum of 4 distribution substations. Therefore, Bainbridge Island projected load over the next 10 years is adequately served by two transmission sources.

Bainbridge Island is served at the end of PSE’s transmission system on Kitsap peninsula. As such, certain contingencies on Kitsap peninsula will impact service to Bainbridge Island.

P7: Multiple Contingency (Loss of two transmission elements simultaneously)

There are no two transmission elements on common structure on Bainbridge Island or the north Kitsap County transmission loop serving Bainbridge Island, therefore no contingencies needed to be studied in this category.

4.3 Transmission Reliability Assessment

This section discusses reliability performance of Bainbridge Island over the 5 year period 2013 to 2017 and provides an assessment of reliability of the transmission system serving Bainbridge Island.

Figure 4-1 and Figure 4-2 show reliability performance[9] of Bainbridge Island (all three substations – Port Madison, Winslow and Murden Cove) and Winslow substation, over a 5 year period – 2013 to 2017, in comparison to PSE Kitsap County and PSE company-wide service area in terms of observed SAIDI and SAIFI. Winslow substation was included in isolation for comparison, as it had the highest count and duration of outages of the 3 island substations. The outage data excludes storm related events for comparison to established PSE non-storm Service Quality Indices (SQIs). Reliability metrics were reported with transmission and distribution outage components.

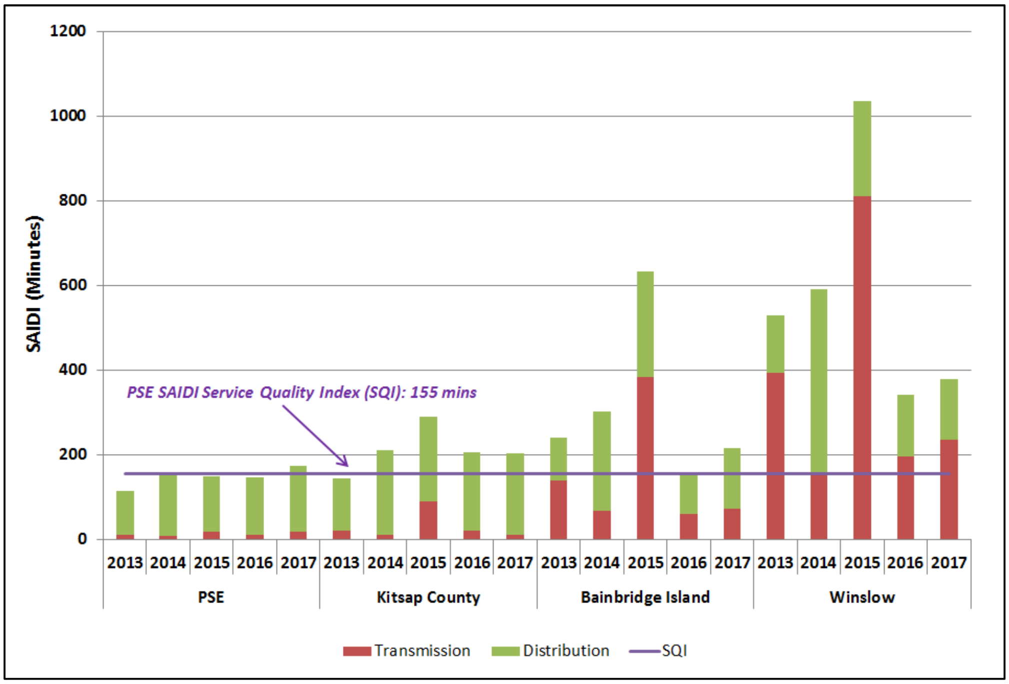


Figure 4-1: Comparison of Non-Storm SAIDI Performance for Bainbridge Island (average customer outage minutes from 2013 to 2017)

[9] Reliability metrics of SAIDI and SAIFI were evaluated for each subset of customer base considered – PSE company-wide, Kitsap County, Bainbridge Island and Winslow substation, from 5 years of non-storm outage data (2013-2017).

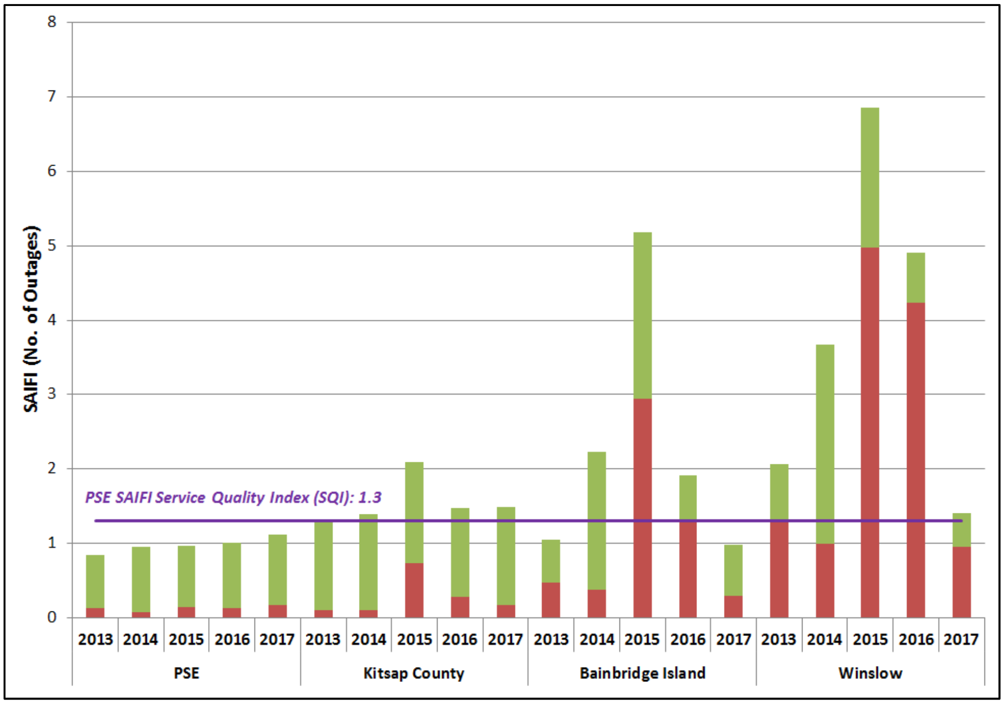


Figure 4-2: Comparison of Non-Storm SAIFI Performance for Bainbridge Island (average number of outages from 2013 to 2017)

Reliability metrics show that customers on Bainbridge Island, in particular Winslow substation, experienced longer and more frequent outages in comparison to Kitsap County and PSE company-wide over the 5 year period 2013-2017.

Excluding storms, Bainbridge Island 5-year average SAIDI for 2013-2017 was 310 customer minutes of service interruption a year or 2 times the PSE service quality index of 155 customer minutes of service interruption a year. Bainbridge Island 5-year average SAIFI for 2013-2017 was 2.27 customer service interruptions a year or approximately 75 percent more service interruptions than the PSE service quality index of 1.3 customer service interruptions a year.

Winslow substation customers had the lowest service reliability on Bainbridge Island. Winslow customer's 5-year average SAIDI for 2013-2017 was 576 customer minutes of service interruption a year or nearly 4 times PSE service quality index of 155 customer minutes of service interruption a year. The Winslow 5-year average SAIFI for 2013-2017 was 3.78 customer service interruptions a year or nearly 3 times the PSE service quality index of 1.3 customer service interruptions a year.

Transmission outages are a significant proportion of customer outages experienced on Bainbridge Island. For 2013-2017, transmission outages contributed an average 47% of customer minutes of service interruption a year for Bainbridge Island, and an average 63% of customer minutes of service interruption a year to Winslow substation - in comparison to an average 10% transmission outage contribution to PSE company-wide customer minutes of service interruption.

4.3.1 Transmission Reliability Analysis

The transmission system analyzed includes the two 115 kV transmission supply lines, the Foss Corner – Port Madison line and the Foss Corner – Keyport line, as well as two radial 115 kV transmission lines of Winslow Tap and Murden Cove Tap.

Figure 4-3 shows a timeline of sustained outages to Bainbridge Island distribution substations over the 5 year period 2013-2017, due to outages on the transmission system.

Figure 4-4 shows a corresponding timeline of transmission line outages that resulted in sustained and momentary outages to Bainbridge Island substations. Outages involving island-wide events are outlined in red.

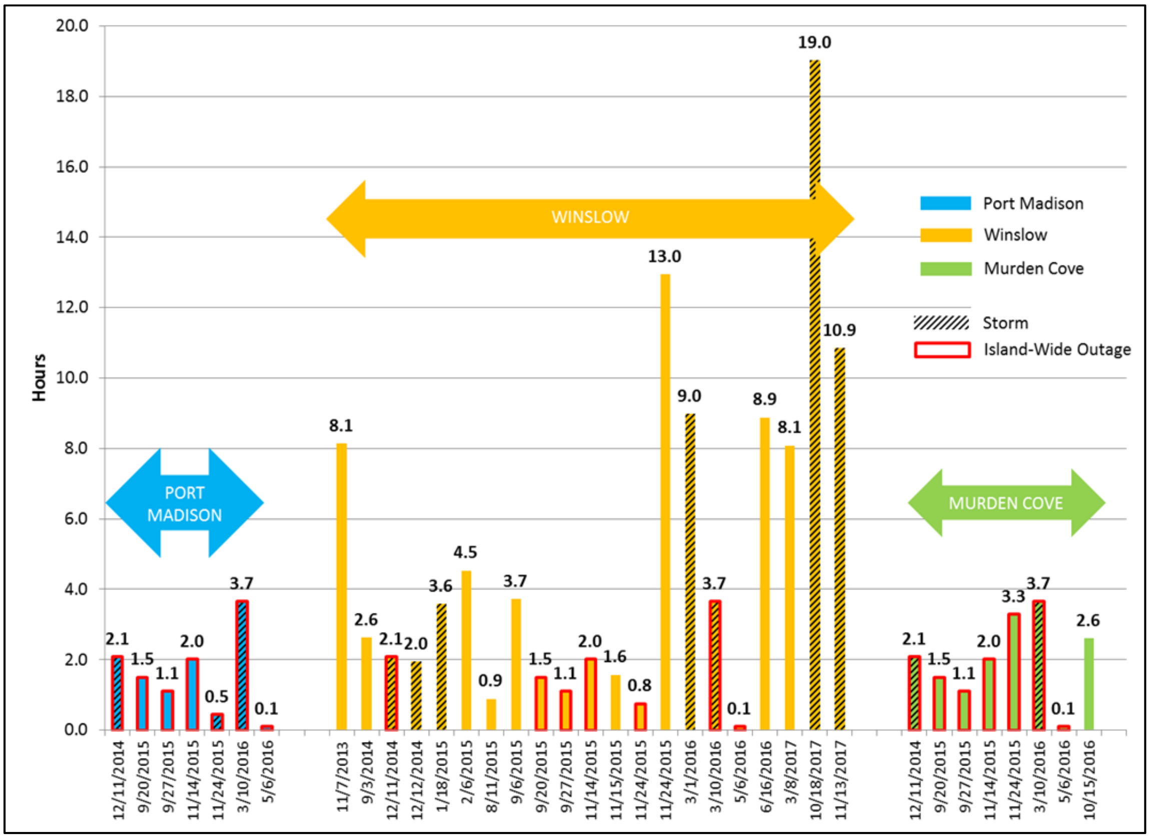


Figure 4-3: Bainbridge Island Substation Outages 2013-2017 on Loss of Transmission

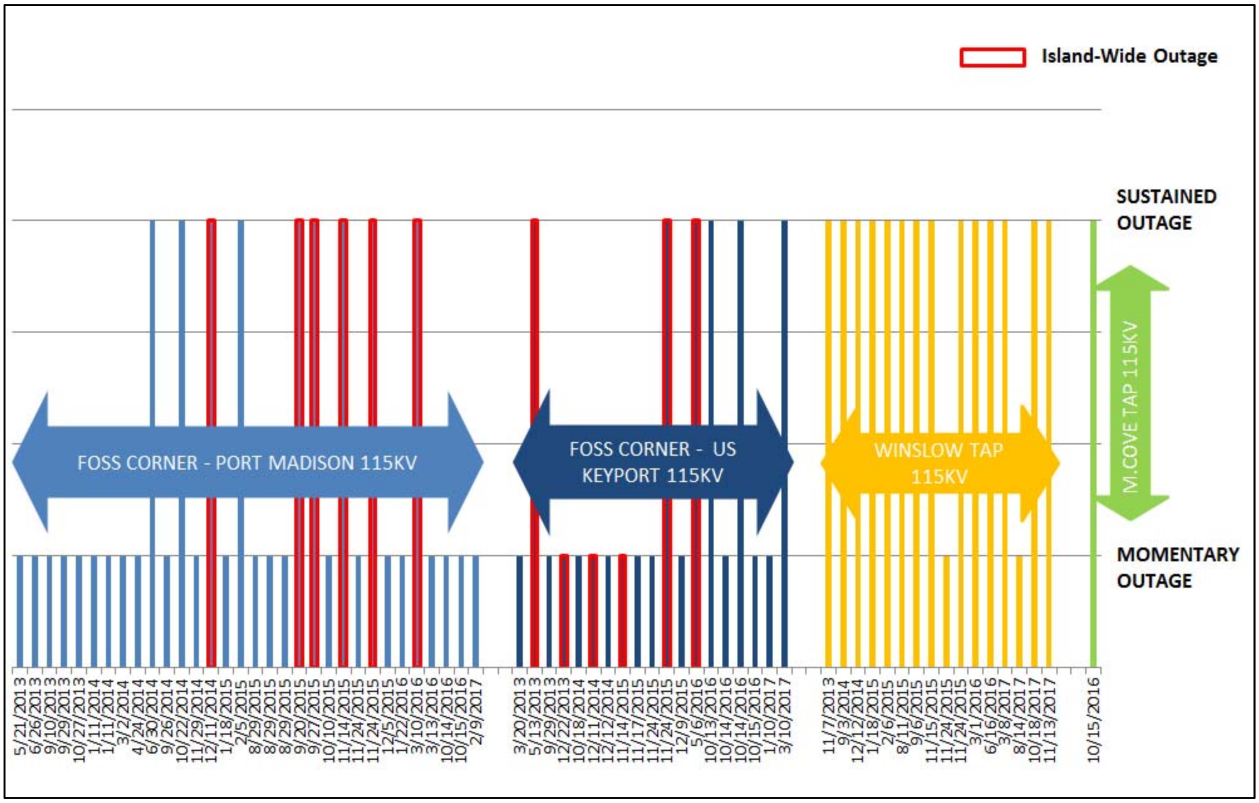


Figure 4-4: Bainbridge Transmission Line Outages (2013-2017) – Sustained and Momentary

Table 4-1 provides a summary of Bainbridge Island substation outages due to contingencies on the transmission system, as shown in Figure 4-3.

Table 4-2 provides a summary of transmission line outage data shown in Figure 4-4.

Table 4-1: Bainbridge Island Substation Outage Summary 2013-2017 – Due to Loss of Transmission

Substation	Island-Wide Outages	Individual Substation Outages	Total Substation Outages
Port Madison	7	0	7
Winslow	7	14	21
Murden Cove	7	1	8
TOTAL	21	15	36

Table 4-2: Bainbridge Island Transmission Line Outage Summary (2013-2017)

Transmission Line	Sustained Outages	Momentary Outages	Total Outages
Foss Corner – Port Madison	9	26	35
Foss Corner – Keyport	6	15	21
Port Madison – Winslow Tap	14	1	15
Port Madison – Murden Cove Tap	1	0	1

Table 4-3 provides a breakdown of Bainbridge Island transmission line outages (2013-2017) by cause.

Table 4-3: Bainbridge Island Transmission Line Outage Summary by Cause (2013-2017)

Transmission Line	Total Outages	Trees/ Vegetation	Equipment	Unknown
Foss Corner – Port Madison	35	19	0	16
Foss Corner – Keyport	21	12	1	8
Port Madison – Winslow Tap	15	14	1	0
Port Madison – Murden Cove Tap	1	1	0	0
TOTAL	73	47	2	24

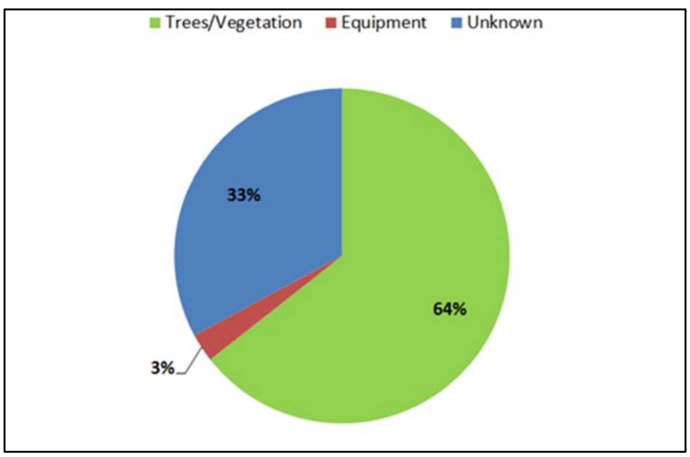


Figure 4-5: Bainbridge Island Transmission Outages by Cause (2013-2017)

Appendix E provides further details regarding Winslow Tap transmission outages and the factors responsible for the longer outage restoration time for Winslow Tap outages.

4.3.2 Reliability Analysis Summary

There were a total of 36 sustained outages to Bainbridge Island substations over the 5 year period 2013-2017, ranging from 6 minutes to 19 hours, due to outages on the transmission system. Twenty one of the 36 Bainbridge substation outages involved 7 island-wide outage events due to loss of both 115 kV transmission supply lines to the island. These events resulted in simultaneous outage to all three Bainbridge substations. The remaining 15 substation outages involved loss of radial transmission taps serving Winslow (14 transmission tap outages) and Murden Cove (1 transmission tap outage).

Winslow substation had the highest count of substation outages on Bainbridge Island, with 21 outages over the 5 year period or on average 4 outages a year. Fourteen of the 21 or nearly 70% of Winslow substation outages were caused by Winslow Tap transmission outages. The other 7 Winslow substation outages were part of island-wide outage events impacting entire Bainbridge Island. Restoration time of the Winslow Tap transmission line ranged from 0.9 hours to 19 hours. Outage restoration on the Winslow tap has been reported by PSE crews as difficult and time consuming, due to poor access on some cross-country sections of the transmission line.

Trees were a major cause of the transmission line outages impacting Bainbridge Island, comprising 64% of total transmission outages, as shown in Figure 4-5. A large proportion of outages (33%) were reported with unknown cause, most of which are suspected to be tree-related.

4.3.3 Island-Wide Outages Assessment

Island-wide outage events constituted a significant proportion (nearly 60%) of substation outages to Bainbridge Island.

- There were 7 island-wide outage events impacting Bainbridge Island over the 5 year period (2013-2017), ranging from 6 minutes to 3.7 hours.
- 3 out of the 7 island-wide outage events (9/20/2015, 9/27/2015 and 5/6/2016) happened when one of the transmission supply lines feeding Bainbridge was taken out of service for construction.
- 6 out of the 7 island-wide outages were caused by tree-related events.

The recurrence of island-wide outage events in 2013-2017 demonstrates vulnerability of transmission service to Bainbridge Island from two 115 kV transmission supply lines. However, 3 of the 7 island-wide outage events happened when PSE had taken one of the transmission supply lines, Foss Corner – Port Madison 115 KV, out of service to support construction for capacity upgrade. With the capacity upgrade of the supply line completed in 2016, PSE expects an improvement in reliability of the transmission supply lines to Bainbridge Island and reduced risk of island-wide outages.

4.4 Transmission Operations Assessment

The following issues were identified by PSE Operations departments:

Transmission Operating Flexibility:

There is no operating flexibility at the transmission level between the radial transmission taps to Winslow and Murden Cove substations. During winter months of peak electric demand on the island, if PSE has to perform emergency repair of equipment on the radial transmission tap to Winslow or Murden Cove substation, then some customers served by the affected substation might experience outage as there is no backup transmission line to feed either substation, and the distribution system on the island does not have enough capacity to backup all customers of the affected substation.

Access to the Winslow 115 kV Tap Transmission Line for Repair and Maintenance:

PSE line crews have poor access to cross country sections of the Winslow 115 kV tap. A transmission line outage on 10-18-2017 caused by broken transmission wishbone crossarm took PSE crews 19 hours to repair due to poor access to the failed crossarm location.

Transmission Capacity Deficiency on Kitsap Peninsula:

PSE performs week-ahead transmission operations planning analysis for the PSE transmission system and recommend operating plans to mitigate system violations that may occur under contingencies. During peak winter conditions, multiple contingencies involving certain 115 kV transmission lines or bulk transformers on the Kitsap peninsula can overload the transmission system and cause low voltage, impacting Bainbridge Island. PSE's operating plan to mitigate the transmission system overloads and low voltage under such contingencies is to reduce (shed) load in North Kitsap County and Bainbridge Island. Shedding load to mitigate line overloads is not a preferred practice at PSE, but may need to be adhered to as an interim measure until transmission capacity upgrades are implemented on the Kitsap Peninsula. PSE's Kitsap transmission needs assessment identified transmission capacity deficiencies on the Kitsap Peninsula and a separate transmission project will address Kitsap Peninsula needs.

4.5 Transmission Equipment Condition Assessment

4.5.1 Aging Infrastructure

Winslow Tap Transmission Line Aging Infrastructure:

The Winslow Tap transmission line was installed in 1960 at the time of energization of Winslow substation. The 4.5 mile transmission line consists of 4/0 ACSR conductor with wishbone crossarm construction. PSE has concerns about the condition of the wishbone crossarms that were installed in 1960s and 1970s. The transmission outage on Winslow 115 kV tap on 10-18-2017 was caused by failure of a transmission wishbone crossarm.

PSE conducted a line inspection of the Winslow tap in early 2019.

Key findings of the 2019 Winslow Tap inspection were:

- Nearly 50% of the line crossarms (39 out of 79) were in "reject" condition
- All poles (except 1 out of 79) met PSE pole strength criteria

PSE inspects transmission lines on a 10 year cycle. The PSE transmission line inspection criterion considers equipment status of "reject" as failing but non-critical condition and recommends replacement within 3 years. A “priority reject” is considered critical condition and requires replacement in 1 to 3 months.

Given the high proportion (50%) of cross arms on the line in reject condition, PSE considers replacing the reject crossarms in the next 1 to 3 years as a system need, as this need lies in the 10 year planning horizon of the needs assessment.

4.6 Transmission Needs and Concerns

The transmission assessment identified needs and concerns for the existing transmission system serving Bainbridge Island in Kitsap County.

4.6.1 Transmission Needs

The transmission needs for Bainbridge Island are summarized below.

Transmission Reliability Need:

- Customers on Bainbridge Island, in particular customers served from Winslow substation, experienced longer and more frequent outages in comparison to Kitsap County and PSE company-wide over the 5 year period (2013-2017). Excluding storms, Bainbridge Island 5-year average SAIDI for 2013 to 2017 was 2 times PSE service quality index of 155 customer minutes of service interruption a year. Bainbridge Island 5-year average SAIFI was 75% higher than PSE service quality index of 1.3 customer service interruptions a year.
- Transmission outages are a significant proportion of customer outages experienced on Bainbridge Island. In 2013-2017, transmission outages contributed on average 47% of customer minutes of service interruption a year for Bainbridge Island, in comparison to an average 10% transmission outage contribution to PSE company-wide customer minutes of service interruption.
- Nearly 70% of transmission-related customer minutes of service interruption on Bainbridge Island were caused by outages on the Winslow 115 kV tap. The remaining 30% of Bainbridge customer minutes of service interruption were attributed to island-wide outage events due to loss of both transmission supply lines to the island.
- Winslow substation, served radially by the Winslow 115 kV tap, had 21 outages over the 5 year period (2013-2017), an average of nearly 4 substation outages per year. Nearly 70% of the Winslow substation outages were caused by the loss of Winslow Tap transmission line due to tree related events. The remaining 30% Winslow substation outages were part of island-wide outage events.

Transmission Aging Infrastructure Need on Winslow Tap:

Majority of the Winslow Tap 115 kV line design is wishbone crossarm construction identified by PSE as a reliability risk. PSE’s field inspection of the Winslow tap in 2019 found 50% of the Winslow tap crossarms were in “reject” condition needing replacement within 3 years. Given the high proportion (50%) of the wishbone crossarms requiring replacement, PSE considers the aging infrastructure on the Winslow Tap as a system need.

4.6.2 Transmission Concerns

This section summarizes the concerns with the transmission system. These concerns are not required to be addressed, however solutions that eliminate concerns should be evaluated as an added benefit.

Transmission Operating Flexibility:

There is no operating flexibility at the transmission level between the radial transmission taps to Winslow and Murden Cove substations. During winter months of peak electric demand on the island, if PSE has to perform emergency equipment repair on the radial transmission tap to Winslow or Murden Cove substation, then some customers served by the affected substation might experience outage as there is no backup transmission line to feed either substation, and the distribution system on the island does not have enough capacity to backup all customers of the affected substation.

Potential Load Shedding and Low Voltage:

Under certain multiple contingencies on Kitsap peninsula, the transmission system faces overloading on transmission lines and bulk transformers and low voltage, which impacts Bainbridge Island. These concerns will be addressed under PSE's solution for Kitsap transmission system needs.

Potential Island-Wide Outage:

Overlapping outages on the two transmission supply lines feeding Bainbridge Island will result in de-energization of all 3 substations on Bainbridge Island simultaneously. There were 7 such island-wide outage events affecting Bainbridge Island in the 5 year period 2013-2017, ranging from 6 minutes to nearly 4 hours. The recurrence of island-wide outage events over the 5 years, primarily caused by tree related events, is indicative of the vulnerability of the 2 transmission lines supply system serving Bainbridge Island, to tree related incidents. However, PSE rebuilt the 2 transmission supply lines in North Kitsap in 2016 and expects the line upgrades to improve reliability of the two supply lines and mitigate possibilities of island-wide outages.

5 Distribution Needs Assessment

This section assesses the distribution system needs for Bainbridge Island over the 10 year planning horizon (2018-2027). The distribution system needs assessment utilized the Bainbridge Island local area load forecast described in Section 3.2 for projecting Bainbridge Island load for the 10 year period.

5.1 Distribution Study Assumptions

The following key assumptions were adopted in this assessment:

- PSE Distribution Planning Guidelines were used for the performance criteria in this study
- The needs study period is for the 10 year period of 2018 through 2027
- Reliability and outage data are considered in the assessment
- There are no PSE DER's (Distributed Energy Resources) on the feeders
- There is 606 kW of interconnected net metering generation capacity on Murden Cove feeders MUR-13 126 kW, MUR-15 82 kW, MUR-16 52 kW, MUR-17 346 kW
- There is 815kW of interconnected net metering generation capacity on Winslow feeders WIN-12 134 kW, WIN-13 196 kW, WIN-15 356 kW, WIN-16 129 kW
- There is 307 kW of interconnected net metering generation capacity on Port Madison feeders PMA-12 87 kW, PMA-12 22 kW, PMA-12 142 kW, PMA-12 56 kW
- MW Load Forecast converted to MVA for capacity analysis using historic .978 Power Factor at peak

5.2 Distribution Capacity Assessment

PSE's Planning Department monitors the electrical loads in all areas throughout our service territory in anticipation of meeting future system needs and to correct deficiencies in the electrical system.

5.2.1 Distribution Substation Group Capacity

When the loads in an area reach 85% of existing substation capacity for a study group of 3 substations or more, the need to add additional substation capacity is triggered to maintain operational flexibility. The Bainbridge Island study area consists of a three substation grouping of Port Madison, Murden Cove, and Winslow. Each of these substations has a nameplate rating of 25 MVA and can be utilized to 132% of that value in the winter and 108% in the summer, resulting in a winter group capacity of 99 MVA and a summer group capacity of 81 MVA. The 85% trigger for additional group capacity under N-0 is 84 MVA winter and 69 MVA summer.

Table 5-1summarizes the N-0 and the N-1 capacity limits for PSE's standard 25 MVA distribution substation transformers.

Single Distribution Subsbstation Capacity Limits (25 MVA Nameplate)			
(N-0)		(N-1)	
Winter 132%	Summer 108%	Winter 144%	Summer 116%
33 MVA	27 MVA	36 MVA	29 MVA

Table 5-1: Substation Capacity Limits

5.2.2 Distribution Feeder Capacity

When the loads in an area reach approximately **83%** of existing capacity for either overhead (OH) or underground (UG) feeder sections for an individual feeder or Distribution Feeder Group under N-0 system operating conditions the planning need to study adding additional feeder capacity is triggered. These capacity limits are shown in Table 2-1 and Table 5-3. This trigger allows for solutions to be studied and put in place before conductor capacity limits are reached and allows for operational flexibility.

Distribution Feeder Group Capacity is the collective capacity of all feeders serving a particular area. These consists of 2-5 feeders that serve load that can be realistically be used to support the study area and facilitate sharing of load. Feeder grouping should be considered in urban and suburban areas or when there are existing adjacent feeders in rural locations.

Table 5-2 summarizes the N-0 and N-1 capacity limits for PSE's standard overhead feeder conductor (either 336 AAC or 397 ACSR tree wire at the PSE standard 12.47 kV system voltage) per PSE Standards and Operating Limits. Added load above these capacity limits would require additional feeder capacity to serve new load. Table 5-2 applies to the entire overhead feeder portion of the twelve feeders in this study that includes, MUR-13, 15, 16, and 17, WIN-12, 13, 15, and 16, and PMA-12, 13, 15, and 16. All of these circuits contain underground feeder sections that are more limiting than its overhead feeder sections.

Overhead Feeder Conductor Limits (Amps)				
Conductor	Winter (23F)		Summer (86F)	
	(N-0)	(N-1)	(N-0)	(N-1)
4/0 ACSR	503	519	410	432
336 ACSR T/W	600	650	542	573
397 AAC	600	650	597	631

Table 5-2: Distribution Overhead Feeder Capacity Limits

Underground (UG) Feeder Capacity: Under N-0 and depending on the number of feeder runs in the trench, the capacity limit is 394-552 Amps per PSE Standard. Added load above the corresponding capacity limit would require additional feeder capacity. For UG feeders the N-0 capacity limit is the same as the N-1 planning limit. In this study all feeders have UG portions that parallel another feeder so the ratings for two feeder runs in a trench were used in the capacity analysis.

Table 5-3 summarizes the N-0 capacity and the N-1 emergency capacity for PSE's standard underground feeder conductor 750 MCM Al per PSE Standards at the standard system voltage of 12.47 kV. Table 5-3 applies to all underground feeder sections for the twelve distribution feeders in the Bainbridge Island study area.

Rating Type	Feeder Runs in Trench			
	One	Two	Three	Four
Operational Load (N-0) Planning Trigger, 83% Utilization	458 A	403 A	359 A	327 A
Emergency Load (N-1) Planning Trigger and (N-0) Capacity Limit, 100% Utilization	552 A	486 A	433 A	394 A

Table 5-3: Distribution Underground Feeder Capacity Triggers and Capacity Limit

5.3 Distribution Capacity Results

5.3.1 Distribution Substation Group Capacity (N-0)

Figure 5-1 illustrates forecasted demand for the Bainbridge Island load forecast for the distribution substation group of MUR-1, WIN-1, and PMA-1, with load included for ferry electrification. This figure also illustrates the N-0 capacity limit of the station group.

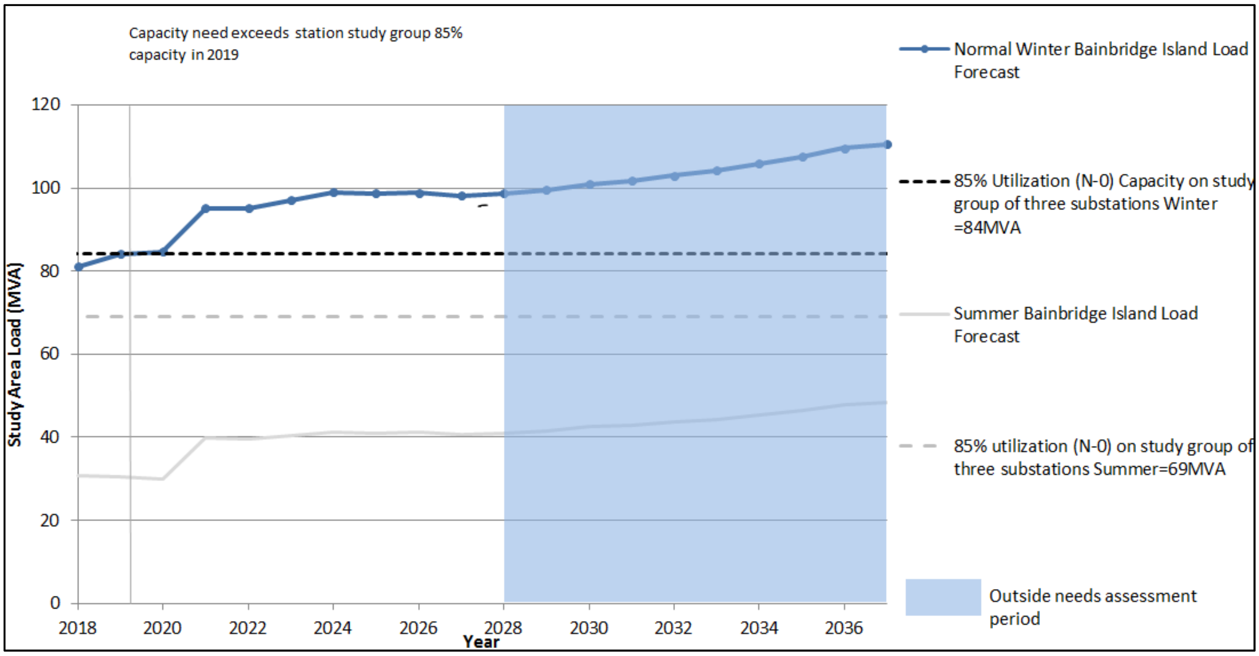


Figure 5-1: Distribution Substation Group N-0 Loading and Capacity

Table 5-4 shows the anticipated station group loading, N-0 group capacity need and the percentage over the need by year through the study period. Red indicates values over capacity.

The need to add N-0 station capacity to this study group is in 2019.

Table 5-4: Distribution Substation Group N-0 Capacity Need Overview by Year

Normal Winter	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
Bainbridge Island Load Forecast w/DSM (MW)	80.7	82.4	83.0	93.2	93.1	94.9	96.8	96.5	96.7	96.0
Forecasted Load w/DSM (MVA) .978PF	82.4	84.3	84.8	95.2	95.2	97.0	99.0	98.7	98.9	98.1
N-0 Group Capacity (85%)	84	84	84	84	84	84	84	84	84	84
% Loading of Group Capacity Limit	98.1%	100.3%	101.0%	113.4%	113.3%	115.5%	117.9%	117.4%	117.7%	116.8%

5.3.2 Distribution Substation Group Capacity (N-1)

Substation group capacity under loss of one substation is a distribution planning concern. This study highlights a concern that N-1 capacity is deficient and some load could not be served during peak loading with a substation out until a mobile substation could be put in place temporarily.

Figure 5-2 illustrates the N-1 capacity limits of the station group with ferry load. Without improvements 24.8 MVA (Year 2024) is at risk of needing to be dropped under N-1 condition during periods of peak demand.

N-1 station capacity to the study group is currently deficient. On February 12th 2018 at 07:15 AM while MUR-1 was off line for an emergency replacement due to transformer failure, load levels on adjacent substations reached 37.6 MVA at Winslow and 39.6 MVA at Port Madison. The combined coincident load at the time was 77.2 MVA, 5.2 MVA above the N-1 planning guideline limit of 144% utilization of available capacity. The 144% utilization threshold prevents an unacceptable loss of life risk to the transformer due to accelerated aging from heat stress. Load shedding would have been required if loading would have persisted. Fortunately, MUR-1 was restored and picked up load at 10:00 AM. An N-1 load loss at peak historic demand of 79.7 MVA would require a 7.7 MVA load shed to reach the acceptable 144% N-1 utilization.

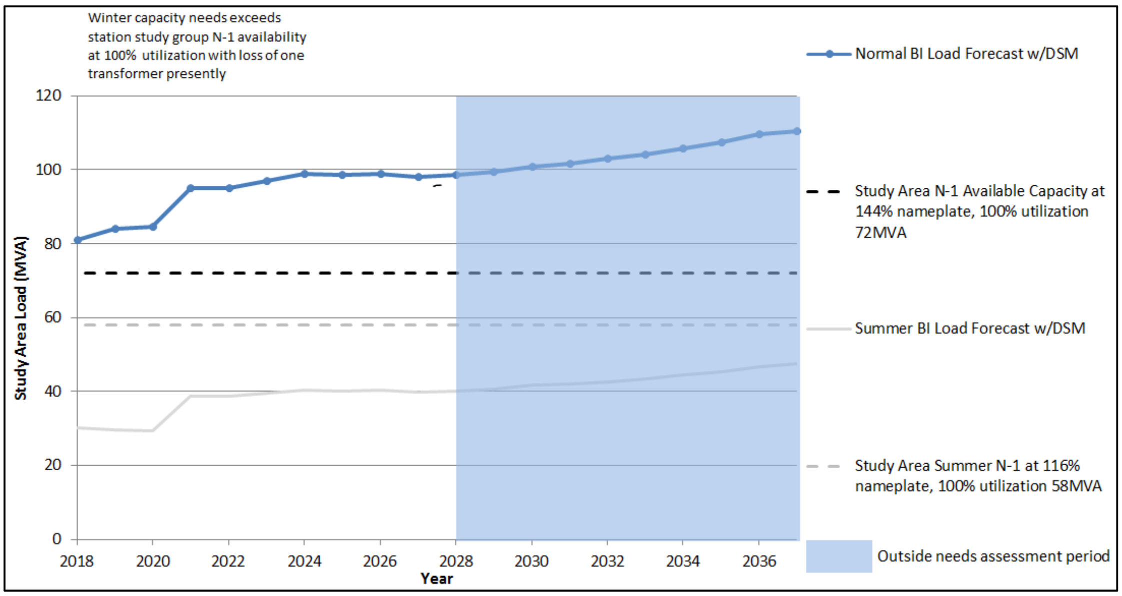


Figure 5-2: Distribution Substation Group N-1 Loading and Capacity Concern

5.3.3 Distribution Feeder Group Capacity - Winslow Downtown Area

Figure 5-3 illustrates the feeder group serving the Winslow downtown area which also includes service to the Winslow Ferry Terminal. This feeder group consists of WIN-15, WIN-16, MUR-13, MUR-16, and MUR-17. This group was studied with electrification of the Bainbridge to Seattle ferry in 2021.

Feeder capacity in this group is determined by the limiting feeder section which is the underground sections that share a common trench with one other feeder section.

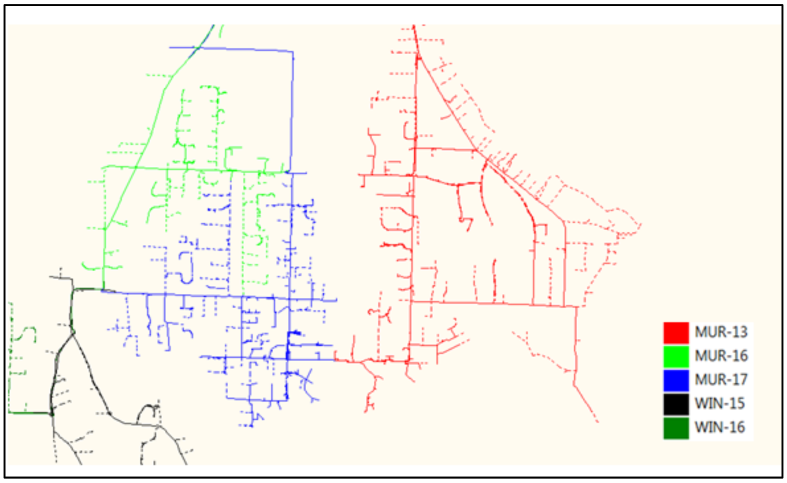


Figure 5-3: Graphical Representation of Feeder Group in Winslow Downtown Area

5.3.3.1 Distribution Feeder Group Analysis - Winslow Downtown Area

Table 5-5 summarizes forecasted demand and limits for the downtown Winslow feeder group and individual feeders with the ferry electrification load. The yellow highlighted cells indicate when the individual feeder or the group of feeders exceeds 83% utilization that is a trigger to add capacity to maintain operation flexibility and red indicates the year in which capacity is exceeded. Figure 5-4 illustrates graphically the feeder group loading.

Table 5-5: Distribution Feeder Group Forecast in Winslow Downtown Area and Capacity Limits with Ferry Load

Feeder 83% Utilization	403	Amps								
Feeder 100% Utilization	486	Amps								
Feeder Group 83% Utilization	2017	Amps								
Feeder Group 100% Utilization	2430	Amps								
W/Ferry WDSM	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
WIN-15	433.0	436.0	437.2	436.7	446.2	456.3	454.4	455.8	451.8	454.5
WIN-16	28.6	28.8	28.9	493.8	494.5	495.1	495.0	495.1	494.8	495.0
MUR-16	240.0	241.7	242.3	242.0	247.3	252.9	251.9	252.6	250.4	251.9
MUR-17	395.3	398.0	399.1	398.6	407.3	416.5	414.8	416.0	412.4	414.8
MUR-13	419.8	422.6	423.8	423.3	432.5	442.3	440.5	441.8	438.0	440.6
Group	1516.7	1527.1	1531.3	1994.4	2027.8	2063.1	2056.6	2061.3	2047.4	2056.8
Group Utilization	62%	63%	63%	82%	83%	85%	85%	85%	84%	85%

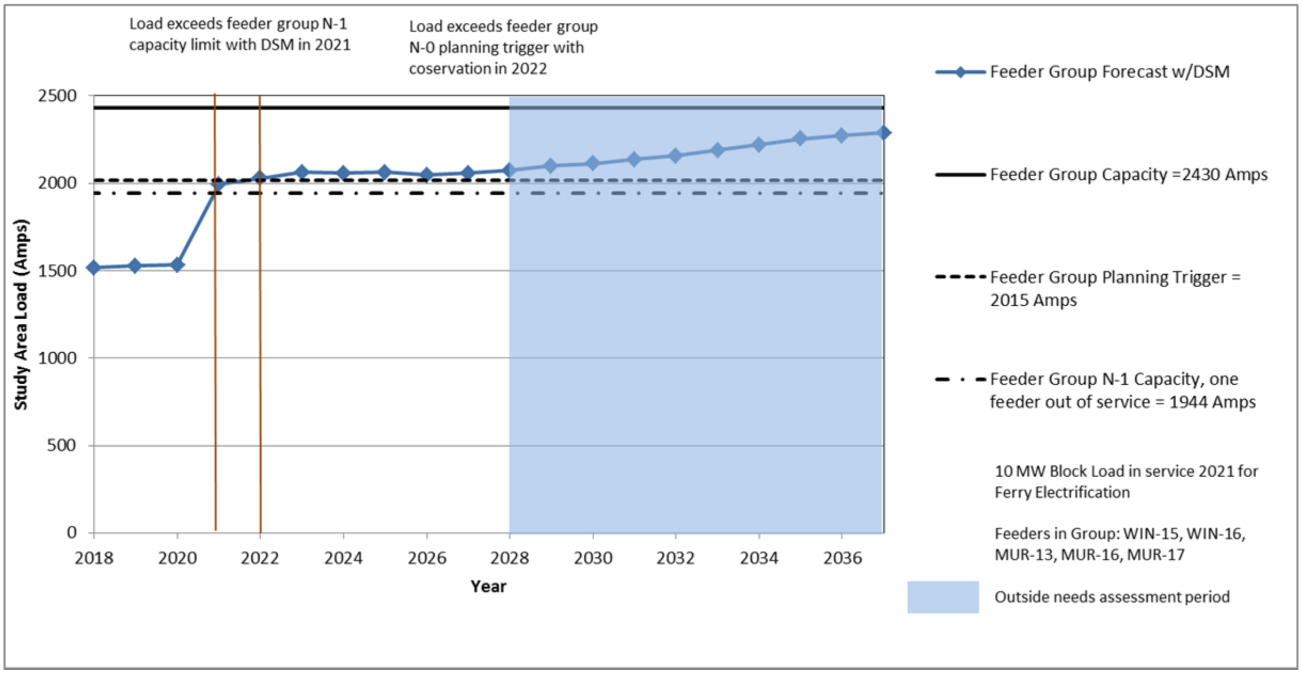


Figure 5-4: Distribution Feeder Group Winslow Downtown Area Loading and Capacity with Ferry Electrification

Additional feeder capacity is needed in the downtown Winslow area if the ferry electrification load is added to existing feeder group; however, Washington State Ferries is planning on utilizing a rate schedule that will require them to install a dedicated feeder to serve their load. With installation of the dedicated feeder the feeder load forecast is represented in Table 5-6. Yellow represents where loading exceeds the 83% Utilization of an individual feeder or group. No capacity limit is exceeded however loading on WIN-15, WIN-17, and MUR-13 is a concern.

Table 5-6: Group and Individual Feeders Loading in Downtown Winslow Area

Feeder 83% Utilization	403	Amps								
Feeder 100% Utilization	486	Amps								
Feeder Group 83% Utilization	2017	Amps								
Feeder Group 100% Utilization	2430	Amps								
W/o Ferry W/DSM	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
WIN-15	433.0	436.0	437.2	436.7	446.2	456.3	454.4	455.8	451.8	454.5
WIN-16	28.6	28.8	28.9	28.8	29.5	30.1	30.0	30.1	29.8	30.0
MUR-16	240.0	241.7	242.3	242.0	247.3	252.9	251.9	252.6	250.4	251.9
MUR-17	395.3	398.0	399.1	398.6	407.3	416.5	414.8	416.0	412.4	414.8
MUR-13	419.8	422.6	423.8	423.3	432.5	442.3	440.5	441.8	438.0	440.6
Group Amps	1516.7	1527.1	1531.3	1529.4	1562.8	1598.1	1591.6	1596.3	1582.4	1591.8
Group Utilization	62%	63%	63%	63%	64%	66%	65%	66%	65%	66%

5.3.4 Individual Distribution Feeder Capacity Outside Downtown Winslow Area

Load forecasts for each feeder that exceeds the planning study trigger on the rest of the Bainbridge Island study area are shown in Table 5-7. No capacity need exists within this study period; however, should be monitored to ensure 100% utilization will not be exceeded in future.

Table 5-7: Individual Feeders That Exceed 85%[10] Utilization in Study Period

Feeder 83% Utilization			403	Amps							
Feeder 100% Utilization			486	Amps							
		2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
WIN-13		389	392	393	392	401	410	408	410	406	408
PMA-15		423	426	427	426	436	446	444	445	441	444

5.4 Distribution Reliability Assessment

5.4.1 Distribution Reliability Background

Some areas in Kitsap County are challenged by frequent outages with many occurring for a long duration. This is primarily due to trees falling and exposure to storms from the peninsula geography and corridors that are difficult to access for maintenance and vegetation management.

At PSE, reliability performance of the electric system is evaluated through the SAIFI and SAIDI metrics. PSE's Planning Department monitors the outage frequency and durations, specific to each of the approximately 1100 circuits in its entire service territory. Of those circuits a worst performing list is maintained to help identify circuits in need of reliability improvements. The criteria for a circuit's placement onto the worst performing list are summarized in Section 5.4.2. Circuits identified on this list are targeted for reliability improvements to enhance performance to reduce the primary driver metric for placement on the list by 50%.

5.4.2 Distribution Reliability Circuit Criteria

PSE uses the following performance data for all circuits for the years 2013-2015[11] to identify circuits which need attention. Circuits are identified if any of the following criteria is met:

1) Customer Minutes Interrupted (CMI) – Any circuit with more than 3,000,000 CMI on non-Major Event Day (MED) over three years.
2) CMI - Any circuit with at least two out of three years with CMI > 750,000 non-MED customer minutes (750,000 is roughly ½ of 1 percent of companywide CMI).
3) SAIDI - At least two out of three years with circuit SAIDI > 300 minutes (non-MED). Circuits with fewer than 50 customers are excluded.
4) SAIFI - At least two out of three years with circuit SAIFI > 2 (non-MED).
5) Circuits in the top 50 worst of the averaged positions in any of the annual rankings for the years 2011-2015 for all-in CMI (includes MED).

The above list is ranked in order of primary driver for inclusion on the list from highest (line 1) to lowest (line 5). If a circuit meets multiple of the above criteria, the highest driver met is the primary driver. The primary driver is used for determining improvement targets discussed in Section 5.4.1.

[10] Ratings based on two feeders in common trench

[11] Circuits needing attention list was based on performance data for 2013-2015. List is not updated every year as it takes multiple years to plan and construct some reliability projects.

5.4.3 Historical Distribution Reliability Performance Data (2013-2015) and Analysis

There are two circuits on Bainbridge Island, PMA-12 and WIN-13 that have reliability concerns.

Table 5-8 through Table 5-10 summarize the outage data for circuits PMA-12 and WIN-13. Values in red are shown if above the criteria as described in section 5.4.2. WIN-13 is on the worst performing list due to Criteria 5 in which WIN-13 was among the top 50 worst of the averaged positions from 2011-2013.

Table 5-8: SAIDI Performance (2013-2015)

	Non-MED SAIDI (IEEE, T_{MED} adj for catastrophic storm) (Minutes)			
	YEAR			
Circuit	**2013**	**2014**	**2015**	**Avg SAIDI (2013-2015)**
PMA-12	71	351	301	241
WIN-13	272	618	127	339

Table 5-9: SAIFI Performance Criteria (2013-2015)

	Non-MED SAIFI (IEEE, T_{MED} adj for catastrophic storm) (Interruptions)			
	YEAR			
Circuit	**2013**	**2014**	**2015**	**Avg SAIFI (2013-2015)**
PMA-12	0.49	5.72	2.85	3.02
WIN-13	1.33	4.90	1.38	2.54

Table 5-10: CMI Performance (2013-2015)

	Non-MED CMI (IEEE, T_{MED} adj for catastrophic storm) (Minutes)			
	YEAR			
Circuit	**2013**	**2014**	**2015**	**Total (2013-2015)**
PMA-12	71,158	349,753	301,190	722,101
WIN-13	334,219	761,003	156,295	1,251,517

The annual SAIDI reliability performance data of PMA-12 and WIN-13 for 2013-2015 is summarized in

Table 5-8. PSE System SAIDI average from 2013-2015 is 143 minutes. All data is MED excluded. Both PMA-12 and WIN-13 have significantly higher than system average values:

- 2013-15 Average SAIDI for PMA-12 customers is 241 minutes (169% of system average)
- 2013-15 Average SAIDI for WIN-13 customers is 339 minutes (237% of system average)

Annual SAIFI reliability performance data for PMA-12 and WIN-13 for 2013-2015 is summarized in Table 5-9. System SAIFI average from 2013-2015 is 0.94 interruptions per customer. All data is MED excluded. Both PMA-12 and WIN-13 have significantly higher than system average values:

- 2013-15 Average SAIFI for PMA-12 customers is 3.02 interruptions per customer (321% of system average)
- 2013-15 Average SAIFI for WIN-13 customers is 2.54 interruptions per customer (270% of system average)

PSE's planning group target is to reduce the top driver for placement on the worst performing list by 50%.

The primary driver for PMA-12 is SAIDI > 300 minutes non-MED, 2 out of 3 years. PMA-12 had SAIDI values for 2013 of 71, 2014 of 351, and 2015 of 301. Reduction of just 2 annual minutes each would have prevented this from being a driver for inclusion by dropping the 2015 value below 300. Applying a 50% annual reduction to the average 2013-15 non-MED SAIDI value of 241 would result in a goal to reduce the annual average by 120 minutes. Recently completed and planned projects will accomplish this reduction.

Recently completed and planned reliability improvement projects in the study area are shown at https://psebainbridge.com/completed-projects and https://psebainbridge.com/current-projects.

The primary driver for WIN-13 is CMI (Includes MED) for the years 2011-2015. The 50% reduction of primary driver goal is not applicable for this driver. Improvements to average SAIDI and SAIFI could be considered to move performance of this circuit towards system averages.

5.5 Distribution Operations

5.5.1 Circuit Voltage

PSE's Distribution Planning Guideline targets a minimum of 119 volts and maximum of 126 volts at the primary side of all distribution service transformers under N-0 (no segment of the system is out of service) conditions. The 119 volt minimum is to allow for up to a 5 volt drop across the service transformer and service conductor to deliver 114 volts minimum at the customer meter or point of service per PSE Standard. A minimum of 113 volts is required at the primary side of all distribution service transformers under N-1 (one segment of the system is out of service) conditions to deliver 108 volts minimum at the customer meter or point of service.

System modeling using loading levels projected for winter has identified areas near 119 volts that is a concern that should be monitored to ensure service voltage above 114 volts.

5.5.2 Phase Balance

Distribution Planning Guidelines recommends that phase imbalance should be no greater that 100 amps between any two phases. Circuits with imbalance greater than 100 amps at system peak in 2012-2016 are summarized in Table 5-11.

Table 5-11: Historic Circuit Imbalance Greater Than 100 Amps

Circuit	Year	Phases	Magnitude	Phases	Magnitude
PMA-12	2016	B-A	165	C-A	196
PMA-12	2015	B-A	127	C-A	179
PMA-12	2014	B-A	16*	C-A	8*
PMA-12	2013	B-A	110	C-A	128
PMA-12	2012	-	-	C-A	110
PMA-13	2016	A-B	147	-	-
PMA-13	2015	A-B	109	-	-
PMA-13	2014	A-B	113	-	-
PMA-13	2013	A-B	113	-	-
PMA-15	2013	A-B	107	-	-
PMA-16	2016	-	-	C-A	176
PMA-16	2015	-	-	C-A	115
PMA-16	2014	-	-	C-A	182
PMA-16	2013	-	-	C-A	190
PMA-16	2012	-	-	C-A	134

*System was abnormal configuration at time of reading

5.5.3 Cold Load Pickup

Cold Load Pickup is the period when loads are coming back on line after extended outages. In areas without a high gas penetration, demands during cold load pickup can be 2-3 times higher than the peak demands. When loading is close to capacity, circuit breakers can operate and/or fuses can melt and open without operational intervention to bypass, which slows restoration time.

Circuits MUR-13, MUR-17, WIN-15, and PMA-15 are heavily loaded, especially during the winter due to primarily electric heating. Extended outages on these circuits require operations intervention to prevent circuit breakers from opening as cold load is picked up.

5.5.4 Operational Flexibility

Operational flexibility on Bainbridge Island is limited by loading that is not evenly distributed between substations and circuits. Distribution sources are essentially limited to the 3 existing substations on the island. Geography limits the available and potential electrical ties between the existing substations and leads to a greater possibility of longer outages when outages do occur. Recently completed improvements and improvements scheduled for 2019-20 creates a feeder tie network as shown in Figure 5-5. Although the tie possibilities are robust, feeder loading at peak demand will limit ability to pick up all customers under scenarios that tie two heavily loaded circuits.

A loss of a substation transformer under peak winter demand exceeds the capacity limit (144% of available nameplate) of the other transformers that remain in service. The overloading of Port Madison and Winslow occurred when Murden Cove was offline as detailed in Section 5.3.3. In the event of a loss of a transformer at peak loading it is estimated it would take a minimum of 24 hours to evaluate the outage, transport, set up and energize a mobile substation in order to restore customers. A mobile was not used in the recent loss of Murden Cove as the transformer replacement was within three hours of energizing.

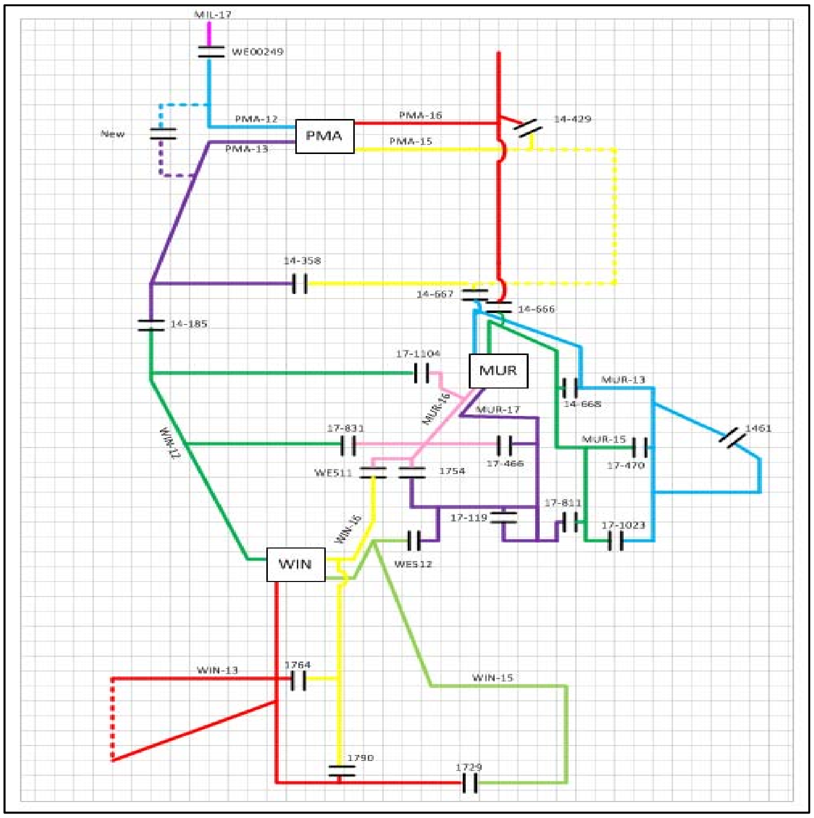


Figure 5-5: Distribution Feeder Tie Points (After Planned Projects through 2020)

5.6 Distribution Substation Equipment

5.6.1 Distribution Station Equipment Condition

Murden Cove: The 115-12kV bank was recently replaced due to transformer failure. The transformer is a PSE standard 25MVA bank and was placed in service in February 2018.

The distribution getaway cables on MUR-13 and MUR-15 are 1970's vintage Yellow Jacket cables. These cables have a distinct yellow outer layer that makes them easily identifiable. Yellow Jacket cables have been identified as more likely to fail than other vintage cable sand PSE replaces this type of getaway cable when the opportunity exists, such as when other work and/or outage can be leveraged to justify replacement. There is not currently a replacement program to eliminate yellow jacket cables.

Winslow: The 115-12kV 25MVA station transformer is a PSE standard and was placed in service in 1982. As of December 2017, the health of the transformer is good and has an estimated life expectancy of 2030.

Port Madison: The 115-12kV 25MVA station transformer is a PSE standard and was placed in service in 1981. As of December 2017, the health of the transformer is good and has an estimated life expectancy of 2027. Transformers can continue to operate well past expectant life estimates and regular maintenance and tests will be used to determine when replacement becomes necessary.

The distribution getaway cables are 1970's vintage Yellow Jacket cables.

All three transformers see numerous faults due to heavy trees and windy weather on Bainbridge Island which creates vegetation outages of the existing transmission lines. According to IEEE Standard C57.91, conditions which over work the transformers may cause early aging of the infrastructure.

5.7 Distribution Needs and Concerns

There are needs and concerns on the existing distribution system for Bainbridge Island in Kitsap County.

5.7.1 Distribution Needs

The following distribution needs for Bainbridge Island have been identified through this assessment.

Substation Group Capacity:

Additional substation group capacity is needed on Bainbridge Island over the next 10 years starting in 2019 due to native load growth and continuing through study period due to native load growth and load associated with electrification of the Seattle-Bainbridge ferry expected in 2021, to keep the island's projected load within PSE's distribution planning guidelines. The highest magnitude of capacity need is forecasted in 2026 with a magnitude of 14.5 MW.

Distribution Reliability:

Both PMA-12 and WIN-13 have much higher than average values for SAIDI and SAIFI as compared to the entire system. Reliability improvements are needed in this study area to improve these values closer to system averages. PSE's planning group targets to reduce the top driver for placement by 50%. To accomplish the 50% reduction of the primary driver on PMA-12 a reduction of 120 average annual non-MED SAIDI minutes would be required.

The primary driver for WIN-13 is CMI (Includes MED) for the years 2011-2015. The 50% reduction of primary driver goal is not applicable for this driver. Improvements to average SAIDI and SAIFI could be considered to move performance of this circuit towards system averages. Average annual SAIDI reduction of 198 minutes and average annual SAIFI reduction of 1.6 interruptions would bring WIN-13 to average annual system level.

There are completed and planned projects on PMA-12 and WIN-13 to improve the reliability; therefore no additional reliability projects on these circuits are necessary.

Distribution Operations:

The following are distribution operation's needs:

- PMA-12 feeder imbalance is 96 Amps over guideline recommended 100 Amp imbalance limit.
- PMA-13 feeder imbalance is 47 Amps over guideline recommended 100 Amp imbalance limit.
- PMA-16 feeder imbalance is 76 Amps over guideline recommended 100 Amp imbalance limit.
- Voltage needs to be maintained at 119 volts minimum and 126 volts maximum under normal system configurations per planning guidelines.
- Areas of voltage less than 119V under present peak demands exist in the study area.

Phase imbalance is a need but can be addressed independently of other need solutions through changing lateral taps in the field.

5.7.2 Distribution Concerns

This section summarizes the concerns with the distribution system. Finding solutions that eliminate concerns should be evaluated as an added benefit.

Substation Capacity:

Substation capacity is presently deficient for the loss of a substation transformer in the study area. At historical peak load level, 7.7MVA of load is at risk to be dropped under N-1 conditions.

Feeder Capacity:

The distribution feeder capacity needs are for the circuit group of five feeders supplying the Downtown Winslow area. With the electrification of Bainbridge to Seattle Ferry currently planned by Washington State Ferries load would exceed N-1 (one element out of service) feeder capacity in the area leaving some customers in this commercial area at risk for long duration outages. There is also a distribution feeder capacity need as no individual existing feeder could accommodate the ferry block load addition. A dedicated new feeder will be required supply the ferry load under their tentative rate schedule. This additional dedicated feeder will eliminate the feeder group capacity need in the Downtown Winslow area.

Cold Load Pickup:

Due to primarily electric heating and heavy loading presently on MUR-13, MUR-17, PMA-15 and WIN-15 cold load pickup is a concern for the system and requires operations intervention to mitigate bringing loads back on after extended outages.

Feeder Capacity:

For individual feeders outside the Downtown Winslow feeder group, the following capacity concerns exist or will at expected peak demands.

- WIN-12 N-0 planning trigger as early as 2024 depending on level of conservation achieved.
- WIN-13 N-0 planning trigger as early as 2019 depending on level of conservation achieved.
- PMA-15 N-0 planning trigger already exists

Operations:

Areas of less than 119 volts at peak demand. These areas are a concern as service voltage needs to be monitored to ensure service voltage at the meter does not fall below 114 volts.

6 Conclusion

The Bainbridge Island Electric System Needs Assessment examined the island's transmission and distribution system for the 10-year planning horizon (2018-2027). PSE's planners assessed the island's future capacity needs based on the PSE F2017 corporate load forecast and PSE's Bainbridge Island Load Forecast. In addition, planners reviewed the transmission and distribution system's historical reliability performance to identify areas needing improvement.

As a result of this study, PSE identified that:

- Bainbridge Island customers experience more frequent and longer outages than the average PSE customer, and nearly half of those outage minutes are due to issues with the transmission system.
- Customers served by the Winslow substation have the worst reliability on the island, and secondarily Murden Cove substation. Nearly 70 percent of transmission customer minutes of service interruptions were from the Winslow Tap transmission line that feeds the Winslow substation.
- Demand for electricity is growing on the island due to anticipated population growth and ferry electrification.
- Some transmission and distribution issues are being addressed through other projects.[12]

The system needs and concerns for Bainbridge Island are summarized as follows:

- **Transmission Reliability need:** A reliability improvement need was identified to improve the performance of transmission service to Winslow substation.
- **Transmission Aging Infrastructure need:** An infrastructure replacement need was identified for the Winslow tap transmission line support structures that are nearing end of useful life and could potentially fail leading to unplanned outages and emergency repairs.
- **Substation Capacity need:** A distribution substation group capacity need of 14.5 MW was identified on Bainbridge Island within the 10 year study period to support general load growth of 4.5 MW and planned 10 MW load addition of WSDOT electric ferry.
- **Transmission Operating Flexibility concern:** Concerns related to ability to transfer load to support routine maintenance and outage management on the radial transmission lines feeding Winslow and Murden Cove substations.

Potential solutions must address all of the system needs identified in this study, while also considering the identified concerns.

[12] Off-island transmission issues are being addressed in the 2018 Kitsap Transmission Needs Assessment Report. Distribution reliability projects for PMA-12 and WIN-13 have been or have existing projects to address them.

Appendix A F2017 Kitsap County "Normal" Winter Load Forecast 2018-2037

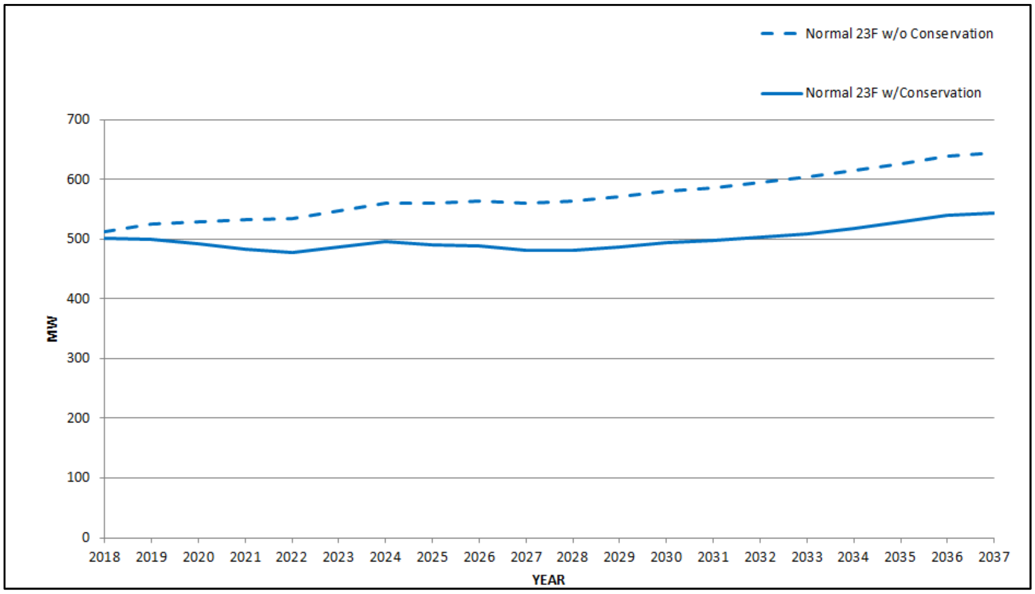


Figure A-1: Year End F2017 Kitsap County Winter Load Forecast

Table A-1: Annual Growth Rates F2017 for 2018-2037

F2017 Load Forecast w/Conservation			F2017 Load Forecast w/o Conservation		
December "Normal" Peak: 23 Degrees			December "Normal" Peak: 23 Degrees		
Year	Kitsap (MW)	Annual Rate	Year	MW	Annual Rate
2018	502		2018	512	
2019	500	-0.47%	2019	525	2.53%
2020	492	-1.47%	2020	530	1.02%
2021	483	-1.88%	2021	533	0.53%
2022	478	-0.97%	2022	534	0.25%
2023	486	1.70%	2023	547	2.45%
2024	496	1.97%	2024	561	2.52%
2025	490	-1.17%	2025	560	-0.11%
2026	489	-0.35%	2026	564	0.57%
2027	481	-1.51%	2027	560	-0.56%
2028	482	0.15%	2028	565	0.75%
2029	487	1.07%	2029	571	1.20%
2030	495	1.58%	2030	581	1.68%
2031	497	0.48%	2031	586	0.86%
2032	504	1.35%	2032	595	1.54%
2033	510	1.13%	2033	604	1.40%
2034	519	1.80%	2034	615	1.85%
2035	529	1.98%	2035	626	1.80%
2036	540	2.08%	2036	638	2.02%
2037	544	0.82%	2037	645	0.99%
Avg 10 year (2018-2027)		-0.4%	Avg 10 year (2018-2027)		0.9%
Avg 20 year (2018-2037)		0.4%	Avg 20 year (2018-2037)		1.2%

Appendix B F2017 Kitsap County "Normal" Summer Load Forecast 2018-2037

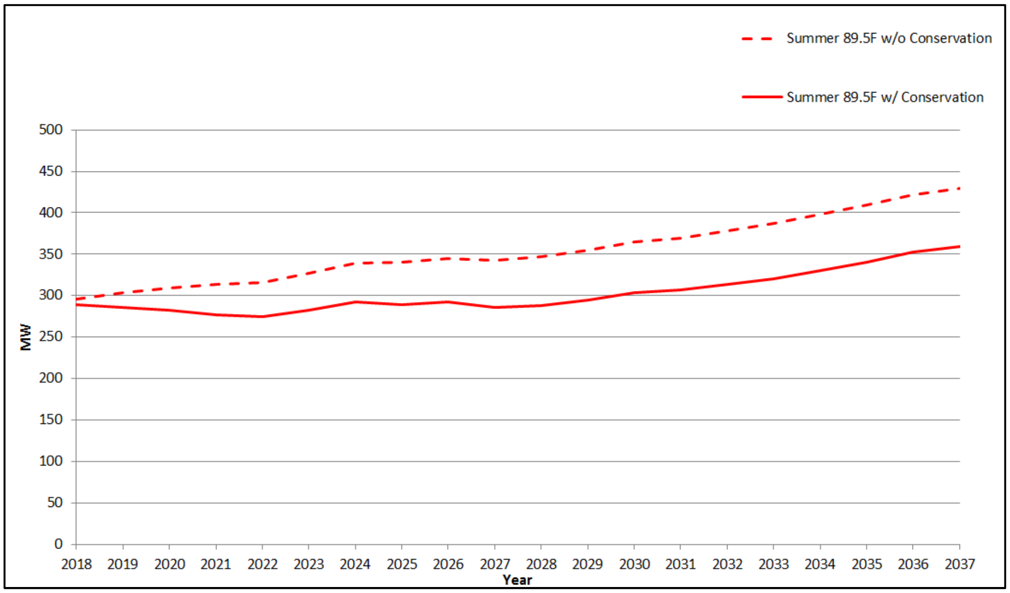


Figure B-1: Year End F2017 Kitsap County Summer Load Forecast

Table B-1: Annual Growth Rates F2017 for 2018-2037

F2017 Load Forecast w/Conservation			F2017 Load Forecast w/o Conservation		
Summer Peak: 89.5 Degrees			Summer Peak: 89.5 Degrees		
Year	MW	Annual Rate	Year	MW	Annual Rate
2018	289		2018	296	
2019	286	-1.06%	2019	304	2.71%
2020	282	-1.23%	2020	310	1.84%
2021	277	-1.80%	2021	313	1.19%
2022	275	-0.84%	2022	315	0.69%
2023	282	2.81%	2023	327	3.73%
2024	292	3.41%	2024	339	3.65%
2025	290	-0.81%	2025	340	0.21%
2026	292	0.81%	2026	345	1.58%
2027	286	-2.03%	2027	342	-0.91%
2028	288	0.62%	2028	347	1.41%
2029	294	2.33%	2029	355	2.31%
2030	303	3.06%	2030	365	2.78%
2031	306	0.97%	2031	369	1.17%
2032	313	2.21%	2032	378	2.37%
2033	321	2.33%	2033	388	2.55%
2034	330	3.00%	2034	399	2.84%
2035	340	3.00%	2035	409	2.59%
2036	352	3.61%	2036	421	3.02%
2037	359	2.02%	2037	429	1.84%
Avg 10 year (2018-2027)		-0.1%	Avg 10 year (2018-2027)		1.5%
Avg 20 year (2018-2037)		1.1%	Avg 20 year (2018-2037)		1.9%

Appendix C F2018 Kitsap County "Normal" Winter Load Forecast 2019-2038

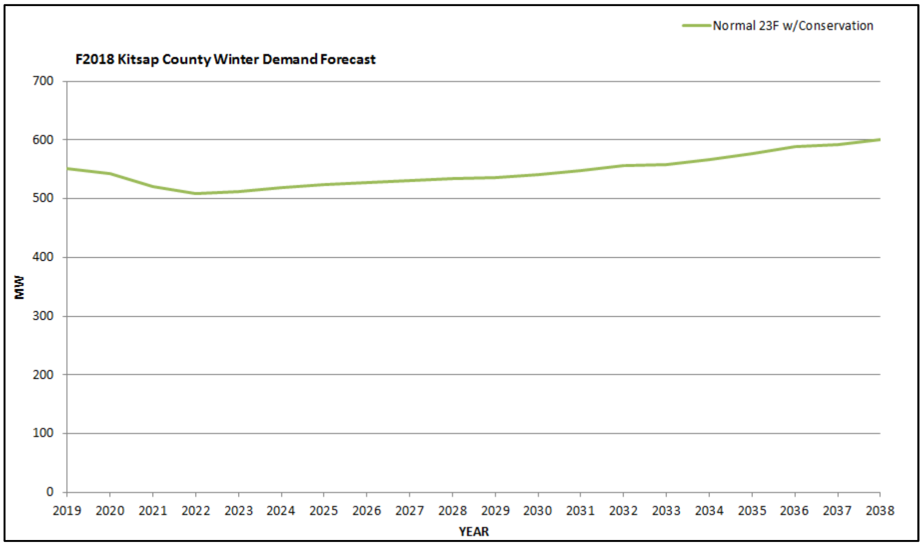


Figure C-1: F2018 Load Forecast Summary Winter Normal Kitsap w/Conservation

F2018 Load Forecast w/Conservation		
December "Normal" Peak: 23 Degrees		
Year	Kitsap (MW)	Annual Rate
2018	530	
2019	551	3.81%
2020	543	-1.36%
2021	520	-4.21%
2022	509	-2.12%
2023	512	0.46%
2024	519	1.48%
2025	523	0.75%
2026	528	0.86%
2027	530	0.45%
2028	535	0.93%
2029	535	0.10%
2030	541	1.01%
2031	547	1.13%
2032	556	1.60%
2033	559	0.55%
2034	566	1.34%
2035	577	1.92%
2036	588	1.97%
2037	592	0.60%
2038	600	1.29%
Avg 10 year (2019-2028)		0.1%
Avg 20 year (2019-2038)		0.6%

Table C-1: Annual Growth Rates F2018 for 2019-2038

Appendix D Bainbridge Island Load Forecast

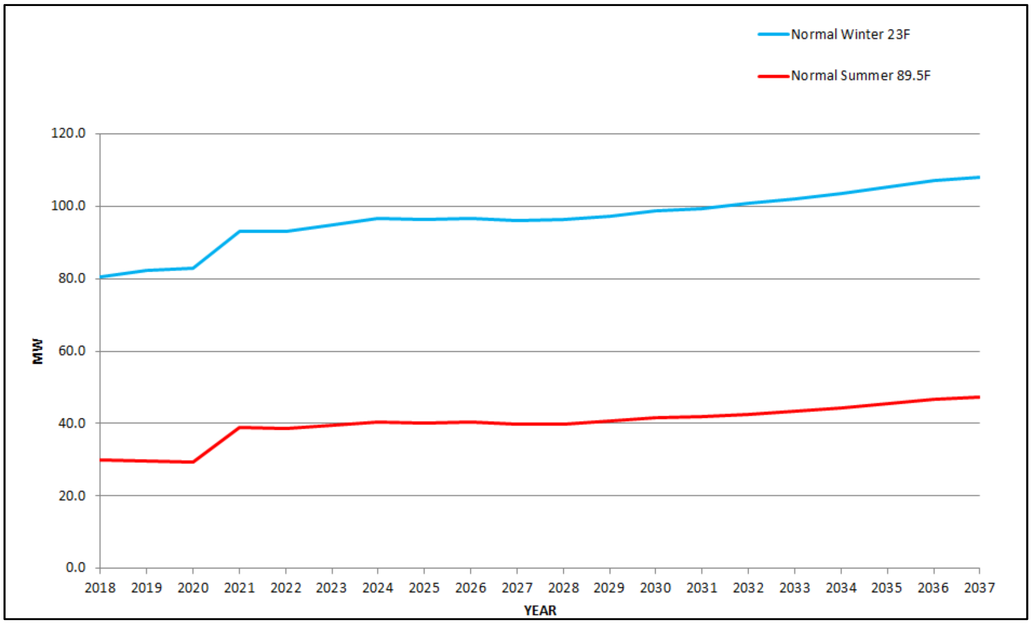


Figure D-1: Bainbridge Island Load Forecast

Table D-1: Annual Growth Rates Bainbridge Island Load Forecast

Bainbridge Island Load Forecast			Bainbridge Island Load Forecast		
December "Normal" Peak: 23 Degrees F			Summer Peak: 89.5 Degrees		
		Bainbridge			Bainbridge
Year	Bainbridge (MW)	Annual Rate	Year	Bainbridge (MW)	Annual Rate
2018	80.7		2018	30.1	
2019	82.4	2.1%	2019	29.7	-1.1%
2020	83.0	0.7%	2020	29.4	-1.2%
2021	93.2	12.3%	2021	38.8	32.2%
2022	93.1	-0.1%	2022	38.6	-0.6%
2023	94.9	1.9%	2023	39.4	2.1%
2024	96.8	2.0%	2024	40.4	2.5%
2025	96.5	-0.4%	2025	40.2	-0.6%
2026	96.7	0.3%	2026	40.4	0.6%
2027	96.0	-0.8%	2027	39.8	-1.5%
2028	96.5	0.5%	2028	40.0	0.5%
2029	97.4	1.0%	2029	40.7	1.7%
2030	98.8	1.4%	2030	41.6	2.3%
2031	99.5	0.7%	2031	41.9	0.7%
2032	100.8	1.3%	2032	42.6	1.7%
2033	102.0	1.2%	2033	43.4	1.8%
2034	103.6	1.6%	2034	44.4	2.3%
2035	105.3	1.6%	2035	45.4	2.3%
2036	107.2	1.8%	2036	46.7	2.8%
2037	108.2	0.9%	2037	47.4	1.6%
Avg 10 year (2018-2027)		1.8%	Avg 10 year (2018-2027)		2.8%
Avg 20 year (2018-2037)		1.5%	Avg 20 year (2018-2037)		2.3%

Appendix E Transmission Reliability Needs Addendum

This section describes in greater detail specific aspects of transmission reliability need on Bainbridge Island.

As described in the Bainbridge Needs Assessment report, 47% (or nearly 50%) of outage minutes on Bainbridge were caused by transmission outages. A significant proportion (70%) of the transmission outages were on the Winslow Tap transmission line. The Winslow Tap is a 4.5 mile radial[13] transmission line from Port Madison substation to Winslow substation.

Key observations regarding Winslow Tap transmission outages over past 5 years (2013 through 2017):

- Outages are long (from 1-2 hours to 13 hours per year)
- Outages are frequent (from 1 to 5 outages per year)
- During storms, reliability is worse

Reasons for poor reliability of the Winslow Tap:

- Heavy vegetation along Winslow Tap
- Difficult terrain and poor access along the line
- Limited distribution substation capacity for backup of Winslow substation

Heavy Vegetation along Winslow Tap

There is heavy vegetation along majority of Winslow Tap transmission corridor. The PSE transmission corridor is limited to 30 FT width or less, and has tall trees in the vicinity of the line. The vegetation is dense in a 1.6 mile cross country section of the line (from Lovgreen Rd to Paulanna Rd). Outside the cross country section, the vegetation exposure is less dense but remains in close proximity to the line.

Figure A-7 shows an aerial map of outages over past 5 years (2013 to 2017). The cross country section of line is outlined. As shown, outages are spread along the line demonstrating that tree related vegetation contact is possible on the entire line route.

Of the 15 Winslow Tap outages (2013 to 2017), 8 out of 15 or nearly 50% outages were in the cross country section of the line and the other 50% outages spread along the remainder of the line. PSE maintains a 3 year vegetation management cycle for the Winslow Tap. Due to heavy vegetation exposure and close proximity of the line to significant trees (tight corridor) for Winslow Tap, PSE standard vegetation management practice has not been successful in mitigating transmission outages on the Winslow Tap.

---

[13] A radial transmission line has a single source. The Winslow Tap transmission line is a radial line with source at Port Madison substation. A substation served by a radial transmission line loses power on outage of the radial line. A looped transmission line has two sources. A substation served from a looped transmission line does not lose power on loss of one source, and can be served by the second source.

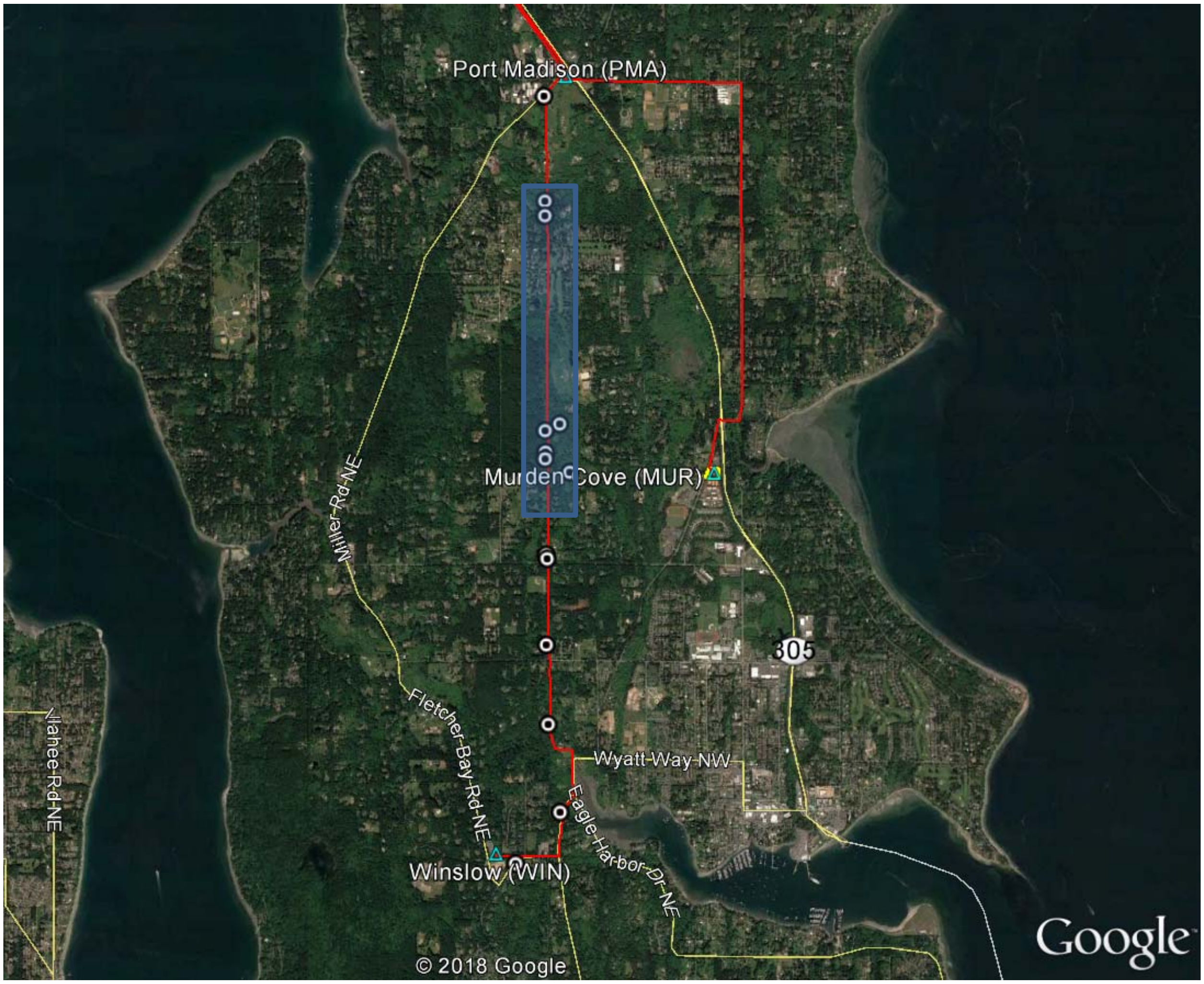


Figure E-1: Aerial map of Winslow Tap Transmission Outages (2013-2017)

Difficult terrain and limited access along Winslow Tap

A1.6 mile cross country section of Winslow Tap has dense vegetation, significant grade variation (of up to 40 feet), rocks, drainage channels and ground patches that remain wet throughout the year. PSE crews have 3 to 4 access identified points along the line to get to different poles. Some of the access points run through private property and require PSE to seek permission before mobilizing crews and equipment. The line along some non-cross country sections have a public or private road nearby but not in the immediate vicinity of the line, requiring crew to work through vegetation to get to the transmission line.

Key findings regarding access to the line:

- Winslow Tap cannot be patrolled for night-time outages due to difficult terrain and lack of a patrol path along the corridor. Helicopter patrols have been used during storms.
- Wet conditions and limited access along the corridor prolong outage repair times and restoration of transmission line. The conditions are worse during wet winter months such as the 36-hour storm outage on February 11, 2019 and 19-hour storm outage on October 18, 2018.

- PSE requires access through private property to mobilize crews and equipment to reach affected areas on the line, causing further delays.

Limited distribution substation capacity for backup of Winslow substation

During Winslow Tap transmission outages, PSE switches Winslow substation customers to the neighboring distribution substations (Murden Cove and Port Madison) over distribution ties. Due to high loading in winter months and limited distribution substation capacity on the island, switching customers over distribution ties for a transmission outage is involved and time-taking, as it requires more switching operations by the crews.

Key findings on distribution capacity backup:

- During high loading (winter months), for a Winslow Tap transmission outage, Winslow substation customers may remain without power until system load drops to a manageable level and Winslow substation load may be transferred to neighboring substations.
- Distribution backup of Winslow substation for scheduled transmission outages for planned maintenance activities is possible only during light load conditions (non-winter months).

Appendix F Ferry Electrification Plan

Sustainability and resilience

+ Design future vessels and terminals to be more environmentally friendly and flexible in design to accommodate new technology, changing transportation modes and increased passenger ridership.

WSF is the largest consumer of diesel fuel in Washington State, burning more than 18 million gallons each year. Because of this, WSF's operations generate the most carbon and other greenhouse gas emissions within the state transportation system. The Plan recommends that WSF leverage the need for new vessels to meet and exceed carbon dioxide emissions reduction requirements under state law. To cut fuel consumption, the Plan recommends building new vessels to use hybrid propulsion technology instead of full diesel engines. The use of this propulsion technology has benefits of reduced engine noise and vibration, potentially lessening effects on orcas and other marine life.

In April 2018, Governor Inslee approved $600,000 in funding to study conversion of WSF's three Jumbo Mark II Class vessels to plug-in electric-hybrid propulsion with charging connections at the terminals. These three vessels account for the highest fuel consumption and emissions in the fleet. Completing these conversions will reduce the carbon emissions from the current fleet by 25 percent.

Once WSF implements the capital investments in vessel and terminal infrastructure identified in the Plan, by 2040 the agency will have replaced 13 existing diesel vessels with electric-hybrid vessels and will have converted six vessels to plug-in hybrid. All hybrid vessels will be capable of charging at the terminal to realize the maximum benefit of hybrid propulsion. With the installation of terminal charging equipment, some vessels will be capable of full electric operation on shorter routes and others will use the plug-in hybrid system to supplement onboard engines. The following table shows the planned fleet composition over time. During the development of new vessel contracting requirements, the Plan recommends that a design charrette be held with technical design experts and departments within WSF to outline design elements of a future vessel to be most efficient and environmentally friendly.

Why electrify vessels?

The electrification of the WSF fleet provides measurable benefits in fuel/energy cost savings over the 20-year planning horizon and beyond. More importantly, measureable benefits in the CO_2 emissions into the atmosphere are projected at below 2050 reduction targets by 2034. That means moving more people in and around our region with less impact on our environment.

Figure F-1: Ferry Electrification Excerpt (Page 98) from WSF 2040 Long Range Plan (January 2019)

Sustainability and resilience

Planned fleet composition

	2019	2023	2030	2040
Plug-in Hybrid	0	4	12	22
Diesel	23	18	13	4
Total Fleet Size	23	22	25	26

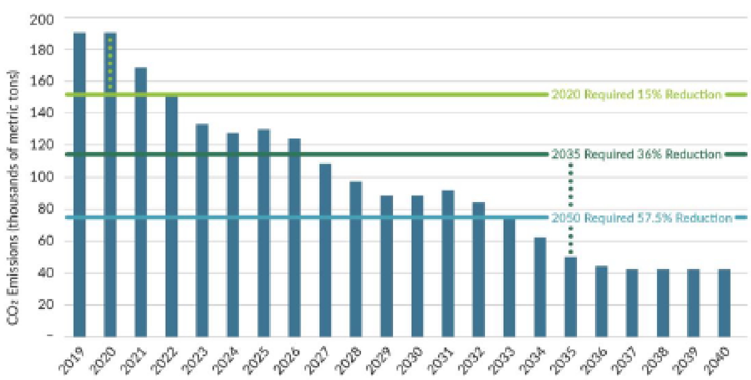
With this new, greener composition, the WSF fleet would achieve a 50 percent reduction in emissions and annual fuel consumption compared to today's fleet, from approximately 19 million gallons consumed in 2018 to approximately 9.5 million gallons consumed in 2040. Not only does this have significant positive effects on the environment, but also tremendous cost savings, as discussed in more detail in the Implementation, Investments and Financial Outlook section of the Plan.

2018 fuel consumption
19 million gallons

2040 fuel consumption
9.5 million gallons

The figure below shows the corresponding change in carbon emissions, which include meeting and exceeding state law requirements of a 36 percent reduction to 2005 emissions by 2035 and a 57.5 percent reduction by 2050. The Jumbo Mark II Class vessel conversions represent an initial 25 percent reduction in emissions upon the completion in 2023.

Annual CO_2 emissions and RCW 70.235.050 reduction requirements



While vessel fuel consumption, emissions and noise are central to the Plan's strategies and investments related to vessels, other smaller endeavors will make a difference. WSF should also consider waste management and waste diversion, the practice of trying to divert as much waste as possible out of the landfill by recycling and composting. This would be particularly relevant in the context of WSF's vendor contracts—for instance, galley service providers onboard vessels or other food service providers at terminals.

Figure F-2: Ferry Electrification Excerpt (Page 99) from WSF 2040 Long Range Plan (January 2019)

Appendix G Glossary

Term	Definition
Term	Definition
Block load	A large expected increase in electric energy demand from an existing or new customer.
Circuit	A circuit is the electric equipment associated with serving all customers under normal configuration from a specific distribution circuit breaker at a substation.
Concern	A "concern" is a non-critical issue that impacts system operations but is not required to be addressed by a solution; a solution that addresses an identified concern provides additional benefit.
Conservation	Measures to improve efficiency of customer's electric loads reducing energy use and reducing peak demand.
Consumption	Consumption is the amount of electricity that customers use over the course of a year and it's measured in kilowatt hours.
Contingency	Contingencies are a set of transmission system failure modes, when elements are taken out of service (e.g., loss of equipment).
Curtailable	A load that may be interrupted to reduce load on system during peak periods. Curtailable customers are on a different rate schedule than non-curtailable (firm) customers.
Demand	The amount of power being required by customers at any given moment, and it's measured in kilowatts.
DR- Demand response	Flexible, price-responsive loads, which may be curtailed or interrupted during system emergencies or when wholesale market prices exceed the utility's supply cost. Demand response is also the voluntary reduction of electricity demand during periods of peak electricity demand or high electricity prices. Demand response provides incentives to customers to temporarily lower their demand at a specific time in exchange for reduced energy costs.
Distributed generation	Small-scale electricity generators, like rooftop solar panels, located close to the source of the customer's load.
Distribution line	A distribution line is a medium-voltage (12.5 kV-35 kV) line that carries electricity from a substation to customers. Roughly half of PSE's distribution lines are underground. Distribution voltage is stepped down to service voltage through smaller transformers located along distribution lines. Distribution lines differ from feeder as it includes the large feeder wire and smaller wire laterals.
Distribution System	A distribution system is the medium-voltage (12.5 kV-35 kV) infrastructure that carries electricity from a substation to customers and includes the substation transformer. System is the collective of all of this infrastructure in an entire study area.

Term	Definition
EPRI- The Electric Power Research Institute	The Electric Power Research Institute conducts research, development, and demonstration projects for the benefit of the public in the United States and internationally. As an independent, nonprofit organization for public interest energy and environmental research, they focus on electricity generation, delivery, and use.
Feeder	A feeder is the largest conductor section of a circuit and generally
Institute of Electrical and Electronics Engineers (IEEE)	A professional association, promoting the development and application of electro-technology and allied sciences for the benefit of humanity, the advancement of the profession, and the well-being of our members.
Integrated Resource Plan (IRP)	The Integrated Resource Plan (IRP) is a forecast of conservation resources and supply-side resource additions that appear to be cost effective to meet the growing needs of our customers over the next 20 years. Every two years, utilities are required to update integrated resource plans to reflect changing needs and available information.
Interim Operating Plan (IOP)	A temporary plan to address a transmission system deficiency and meet performance requirements, until a solution takes effect. An IOP may consist of a series of operational steps to radially operate the system, run generation or implement load shedding.
Kilovolt (kV)	A kilovolt (kV) is equal to 1,000 volts of electric energy. PSE uses kilovolts as a standard measurement when discussing things like distribution lines and the energy that reaches our customers.
Load	The total of customer demand plus planning margins and operating reserve obligations.
Load forecast	A load forecast is a projection of how much power PSE's customers will use in future years. The forecast allows PSE to plan upgrades to its electric system to ensure that current and future customers continue to have reliable power. Federal regulations require that utilities plan a reliable system based on forecasted loads. When developing a load forecast, PSE takes multiple factors into account like current loads, economic and population projections, building permits, conservation goals, and weather events.
Load shedding	Load shedding is when a utility intentionally causes outages to customers because demand for electricity is exceeding the capacity of the electric grid. Load shedding is the option of last resort and is conducted to protect the integrity of the electric grid components in order to avoid a larger blackout. This is not a practice that PSE endorses as a long-term solution to meet mandatory performance requirements.
Major Event Day (MED)	Any day in which the daily system SAIDI exceeds the annual threshold value. Outages on those days are excluded from the SAIDI performance calculation.

Term	Definition
Megawatt (MW)	A megawatt (MW) is equal to 1,000,000 watts of electric energy. PSE uses megawatts as a standard measurement when discussing things like system load and peak demand. MW differs from MVA in that it is generally always lower and translates as energy that performs work. The amount of MW vs MVA is determined by load characteristics. Motor loads generally have a lower power factor (PF) than heating loads for example and as a result. MW=MVA*PF
Mega Volt-Amp (MVA)	A MVA is equal to 1,000,000 (Volt*Amps). MVA is generally slightly higher than MW. Equipment ratings are in MVA as the equipment heat rise is determined by actual MVA.
N-0	This is a planning term describing that the electric grid is operating in a normal condition and no components have failed.
N-1	This is a planning term describing an outage condition when one system component has failed or has been taken out of service for construction or maintenance.
N-1-1	This is a planning term describing outage conditions where two failures occur one after another with a time delay between them.
N-2	This is a planning term describing outage conditions where two failures occur nearly simultaneously.
Native Load Growth	Load growth associated with existing customers or new customers less than 1 MW.
Need	A constraint or limitation on the delivery system in providing safe and reliable electric supply to customers. A need is a “must-have” that is required to be addressed for the system in a timely manner (by a certain Need Date, as determined in a needs assessment)
Non-wires alternatives	Alternatives that are not traditional poles, wires and substations. These alternatives can include demand reduction technologies, battery energy storage systems, and distributed generation.
NERC- North American Electric Reliability Corporation	NERC establishes the reliability standards for the North American grid. NERC is a not-for-profit international regulatory authority whose mission is to ensure the reliability of the bulk power system in North America, as certified by FERC. NERC develops and enforces Reliability Standards and annually assesses seasonal and long-term reliability. PSE is required to meet the Reliability Standards and is subject to fines if noncompliant.
Peak demand	Customers’ highest demand for electricity at any given time, and it’s measured in megawatts.
Proven technology	Technology that has successfully operated with acceptable performance and reliability within a set of predefined criteria. It has a documented track record for a defined environment, meaning there are multiple examples of installations with a history of reliable operations. Such documentation shall provide confidence in the technology from practical operations, with respect to the ability of the technology to meet the specified requirements.

Term	Definition
Reasonable project cost	Reasonable project cost means holistically comparing costs and benefits to project alternatives. This includes dollar costs, as well as duration of the solution, risk to the electric system associated with the type of solution (e.g., is the solution an untested technology), and impacts to the community.
Right of way	A corridor of land on which electric lines may be located. PSE may own the land in fee, own an easement, or have certain franchise, prescription, or license rights to construct and maintain lines.
Sensitivities	Sensitivities are circumstances or stressors under which the contingencies are tested (e.g., forecasted demand levels, interchange, various generation configurations).
Substation	A substation is a vital component of electricity distribution systems, containing utility circuit protection, voltage regulation and equipment that steps down higher-voltage electricity to a lower voltage before reaching your home or business.
Substation group	A grouping of 2-5 substation transformers that are situated close enough to each other that loads in the study area can be switched from one station to an adjacent station for maintenance, construction, or permanent load shifting. For Bainbridge Island, the substation group includes 3 distribution substations – Port Madison, Murden Cove and Winslow.
Substation group capacity	The aggregate distribution transformer capacity of the substation group for winter and summer rating, calculated in MVA. Example: Winter/Summer ratings of distribution transformers at Port Madison (33 MVA/28 MVA), Murden Cove (33 MVA/28 MVA) and Winslow (33 MVA/28 MVA); Substation Group Capacity for Bainbridge Island (Winter/Summer): 99 MVA/84 MVA.
SAIDI- System Average Interruption Duration Index	SAIDI is the length of non-major-storm power outages per year, per customer. SAIDI is commonly used as a reliability indicator by electric power utilities. Outages longer than 5 minutes are included.
SAIFI- System Average Interruption Frequency Index	SAIFI is the frequency of non-major-storm power outages per year, per customer. SAIFI is commonly used as a reliability indicator by electric power utilities. Interruptions longer than 1 minute are included.
Transformer	A transformer is a device that steps electricity voltage down from a higher voltage, or steps it up to a higher voltage, depending on use. On the distribution system, transformers typically step the voltage down from a distribution voltage (12.5 kV) to 120 to 240 volts for customers' residential use. Transformers are the green boxes in some residences' front yard or the barrel-like canisters on utility poles.
Transmission line	Transmission lines are high-voltage lines that carry electricity from generation plants to substations or from substation to substation. Transformers at the substation "step down" the electricity's transmission voltage (55 to 230 kilovolts) to our primary distribution voltage (12.5 kV).