Bainbridge Island Electric System Solutions Report

Bainbridge Island, WA

Strategic System Planning
July 2019

PUGET SOUND ENERGY

Bainbridge Island Electric System Solutions Report

Prepared By:

Chad Larson, PE, *Strategic System Planning*
Kelly Kozdras, 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

After completion of the Bainbridge Island Electric System Needs Assessment, Puget Sound Energy (PSE) and industry experts conducted analyses of traditional alternatives (wires) and non-wires alternatives (NWAs) to determine a cost-effective solution that addresses the identified system needs for Bainbridge Island over the 10 year planning horizon.

The City of Bainbridge Island (Bainbridge Island) is separated from the Kitsap Peninsula by the Agate Pass waterway and bridge. Puget Sound Regional Council has identified Bainbridge Island as an urban area for the Growth Management Act. The island is home to a population of 24,400 residents and Washington State Ferries Eagle Harbor Maintenance Facility and Ferry Terminal.

PSE's System Planning department regularly assesses electrical system needs to ensure PSE can reliably serve residents and businesses over a 10-year planning horizon. The Bainbridge Island Electric System Needs Assessment determined the island's grid has reliability, capacity, and aging infrastructure needs during the 10-year planning horizon on both the transmission and distribution systems.

PSE's proposed solution for Bainbridge Island is a combination of a new 115 kilovolt (kV) transmission line, battery storage, distributed energy resources, and replacement of aging infrastructure. Together these solutions will meet growing demand and improve reliability for Bainbridge Island customers.

Bainbridge Island Electric Needs

The Bainbridge Island Electric System Needs Assessment report identified needs and concerns[1] for PSE's transmission and distribution system on Bainbridge Island, which are briefly described below.

System needs and concerns for Bainbridge Island are:

- **Transmission Reliability need:** A reliability improvement need was identified to improve the performance of the Winslow Tap transmission line that feeds Winslow substation. Nearly 70 percent of the transmission related customer minutes of service interruption[2] on Bainbridge Island were from outages to the Winslow Tap transmission line.
- **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 for the new ferry electrification charging load. The anticipated capacity need is expected to grow to 16.6 MW by 2030 due to general load growth increase by 2 MW. Per the PSE Solution criteria a solution must last 10 years. The Needs Assessment shows that additional

[1] PSE defines "need" as a system deficiency that is required to be addressed by a solution, preferably by the identified date of need. 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.

[2] Outages considered over the past 5 year period 2013-2017. Refer to Bainbridge Island Electric System Needs Assessment Report – Transmission Reliability Assessment, Section 4.3.

substation capacity is needed by 2020. Therefore, the need of 16.6 MW is the ultimate need for a viable solution to last until 2030.

- **Transmission Operating Flexibility concern:** Concerns related to ability to transfer load to support routine maintenance[3] and outage management. Winslow and Murden Cove substations are on radial transmission taps (single transmission source) with no transmission backup. Customers served from these two substations have potential for outage in the event of an unplanned transmission outage or emergency transmission equipment repair situation due to lack of transmission backup.

Alternatives Analyzed

PSE, along with Navigant Consulting (Navigant) and Quanta Technology (Quanta), studied various alternatives for meeting the needs identified for the Bainbridge Island transmission and distribution system. This solutions report details conventional wires and non-wires alternatives considered to solve the aforementioned needs. Various alternatives were screened for viability using the solutions criteria detailed in Section 1.2.

PSE studied conventional wires alternatives, while Navigant and Quanta were contracted to review these alternatives, analyze non-wires alternatives (NWA), and analyze hybrids of wires and non-wires alternatives. The goal of their analyses was to consider the technical and economic feasibility of potential alternatives which could meet Bainbridge Island needs.

PSE studied various wires alternatives, and determined the top-wires alternative to include:

- New transmission line (loop) between Winslow and Murden Cove substations
- New substation with new feeders
- Winslow Tap transmission line rebuild[4]

Navigant considered a NWA consisting of both battery energy storage and distributed energy resources (DERs). A DER is defined as “a resource sited close to customers that can provide all or some of their immediate electric and power needs and can also be used by the system to reduce system demand (such as energy efficiency) or provide supply to satisfy the energy, capacity, or ancillary service needs of the distribution grid. The resources, if providing electricity or thermal energy, are small in scale, connected to the distribution system, and close to load”.[5] Quanta considered the feasibility of a non-wires alternative consisting of entirely battery energy storage systems.

<u>Navigant’s Non-wires Alternatives Analysis</u>

Navigant’s Non-wires Alternatives Analysis reviewed and analyzed three approaches:

1. Traditional wires scenario
2. Exclusive non-wires scenario
3. Hybrid non-wires scenario

[3] PSE limits routine equipment maintenance to summer months when loading is light and backup is available from the distribution system.

[4] Rebuild of the Winslow Tap transmission line involves replacing transmission poles, support structures and line conductor.

[5] National Association of Regulatory Utility Commissioners. "NARUC Manual on Distributed Energy Resources Rate Design and Compensation." November 2016. http://pubs.naruc.org/pub/19FDF48B-AA57-5160-DBA1-BE2E9C2F7EA0

Key takeaways from Navigant's study:

- A hybrid alternative comprising of wires and non-wires components to meet the reliability and capacity needs is "technically feasible and economically-preferable to the wired solution."[6]
- An exclusive non-wires alternative would be "technically possible but not realistic"[7] due to the area needed and cost of battery storage needed at various locations, the need for aggressive tree-trimming and removal[8], and the ability to meet the timeframe to meet the island's needs.
- PSE could delay the need for investment in a new distribution substation by focusing on battery storage, DERs, and block load curtailment (if Washington State Ferries chooses to connect the new ferry electrification charging load as a curtailable resource).

Navigant's analysis is described in Section 4.3.1 and available in full in Appendix D.

<u>Quanta's Battery Storage Analysis</u>

Quanta evaluated an all-battery storage alternative to potentially address both the transmission system reliability and distribution system capacity needs. Quanta reviewed the conventional solutions, assessed the siting and sizing of battery storage to meet reliability and capacity needs, considered potential locations for utility-scale battery energy storage, and conducted a comparative analysis of costs.

Quanta's analysis concluded that:

- An alternative with only battery energy storage would require large grid-scale energy storage sites at five locations on the island. Each site would include between one and up to 35 shipping containers, and four of the locations would be new sites not associated with a substation.
- At minimum, an all-battery storage solution would cost at least $20 million more than the conventional wires alternative; this alternative's cost will increase due to interconnection costs and siting of the batteries.[9]

Quanta's analysis is described at length in Appendix E and is summarized in Section 3.3.2.

<u>Hybrid Alternatives Analysis</u>

PSE further assessed the hybrid solution suggested by Navigant by identifying a location for their recommended battery. Based on power flow analysis completed in the Quanta Technology report, PSE assessed that the most appropriate location for this approximately 3.3 MW battery is likely at Murden Cove Substation.

---

[6] Appendix D, Bainbridge Island Non-Wires Alternative Analysis, Navigant Consulting, page 1

[7] Appendix D, Bainbridge Island Non-Wires Alternative Analysis, Navigant Consulting, page 2

[8] PSE defines "aggressive" vegetation management (e.g., tree trimming and removal) as a substantial distance beyond our standard practices. In some cases, the vegetation management area may be equal to the height of the surrounding trees from the edge of the wire zone.

[9] While one battery could be located at substation property, the four other large batteries would need to be located around the island. Locations of those potential sites were not considered, but if additional land needed to be purchased this would also increase the differential between the wired alternative and the all-battery storage alternative.

Top Alternatives Analysis

PSE then further evaluated the estimated costs of the top reliability, capacity and aging infrastructure alternatives, which is shown in the table below.

Table 0-1: Summary of Top Alternatives[10] [11] [12] [13]

	Top Wires Alternative	Top Non-Wires Alternative (All BESS)	Top Hybrid Alternative
Primary Need: Winslow Tap Transmission Reliability	Transmission Loop (Winslow to Murden Cove)	TOTAL BESS: 25.1 MW/79.2 MWH MUR: 13.7 MW/34.8 MWH MUR-15: 0.4 MW/0.4 MWH, PMA-13/WIN-12: 3.2 MW/9 MWH, MUR-17/WIN-15: 3.4 MW/15 MWH WIN-13: 4.4 MW/20 MWH	Transmission Loop (Winslow to Murden Cove)
Primary Need: Substation Group Capacity	New Distribution Substation		Ferry Curtailment: 10 MW up to 182 hours 50% BESS@MUR: 3.3 MW/5 MWH 50% DER: 3.3 MW
Primary Need: Winslow Tap Aging Infrastructure	Rebuild Transmission Line-Replace Poles & Wire, Improve Corridor Access, Acquire Necessary Rights & Veg Mgmt	Rebuild Transmission Line-Replace Poles & Wire, Improve Corridor Access, Acquire Necessary Rights & Veg Mgmt	Rebuild Transmission Line-Replace Poles & Wire, Improve Corridor Access, Acquire Necessary Rights & Veg Mgmt
Total Cost Estimate Range (Base to High)	$42.5 million to $85 million	$66 million to $132 million	$38 million to $76 million
Decision Factors	- Expertise - Long term solution - High reliability	- 10 year solution - Add with growth - New operational strategies needed - High cost	- 10 year solution - Add with growth - New operational strategies needed - Local EE and DR

Solution for Improving Bainbridge Island Reliability

PSE determined that a hybrid alternative presents the best solution for cost-effectively meeting Bainbridge Island electric transmission and distribution system needs. This alternative also provides an opportunity to assess the viability of energy storage and distributed energy resources to allow deferral of traditional distribution system infrastructure additions. A hybrid solution is consistent with both our

[10] Costs are estimate based on similar past projects in other areas of PSE service territory. Does not include site-specific engineering.

[11] The costs shown for the wires portions of all alternatives are capital investment costs.

[12] Costs shown for battery storage systems in Top Non-Wires Alternative (all-BESS) are from the Quanta Technology Report, Appendix E, Table 7.1, Storage-Only Solution (Option), Total Capital Investment cost ($37.7M). A 25% cost estimating contingency is added to the cost in that report to be consistent with how other costs in this table are shown. The capital investment cost is shown to be consistent with the presentation of the wires alternative.

[13] Costs shown for Top Hybrid Alternative, Primary Need: Substation Group Capacity are from the Navigant Consulting Report, Appendix D, page 24 which notes a portfolio cost between $4.5M (including DR) and $5.5M (excluding DR). The higher portfolio cost of $5.5M is used here to remain conservative. A 25% cost estimating contingency is added to the cost in that report to be consistent with how other costs in this table are shown. The costs and benefits for the measures of this portfolio are from the PSE 2017 IRP. These costs and benefits are in present value terms and are levelized to be consistent with the PSE 2017 IRP. Further discussion of this is in Appendix D, Section 3.1.

customers' expectations to lead us into the future and policy direction from the Washington Utilities and Transportation Commission (WUTC).

The hybrid solution:

- Invests in traditional transmission infrastructure to replace aging equipment and improve reliability.
- Deploys battery storage and DERs to support the island's electric load growth and ferry electrification without the need for additional substation infrastructure.
- Adds a transmission loop that improves reliability and supports future technologies.
- Provides cost savings as compared to the conventional wires alternative.

<u>Specifically, the proposed hybrid solution:</u>

- Improves transmission and distribution reliability by building approximately 3.5 miles of new overhead transmission line between Murden Cove and Winslow substations that will create a transmission "loop". The loop will also improve operating flexibility on the transmission system to both Winslow and Murden Cove substations.
- Addresses the aging infrastructure need for the Winslow Tap transmission line by rebuilding the line and improving the corridor for maintainability and operability of the line.
- Addresses Bainbridge Island's distribution capacity need with:
  - Connecting the new ferry electrification charging load (10 MW) as a curtailable resource.
  - Installing an approximately 3.3 MW/5 MWh battery storage system (planned for Murden Cove substation).
  - Implementing an approximately 3.3 MW DER portfolio on Bainbridge Island, with customer-side resources such as energy efficiency, renewable distributed generation, and potential of demand response.

See Figure 0-1 for an illustration of the proposed solution.

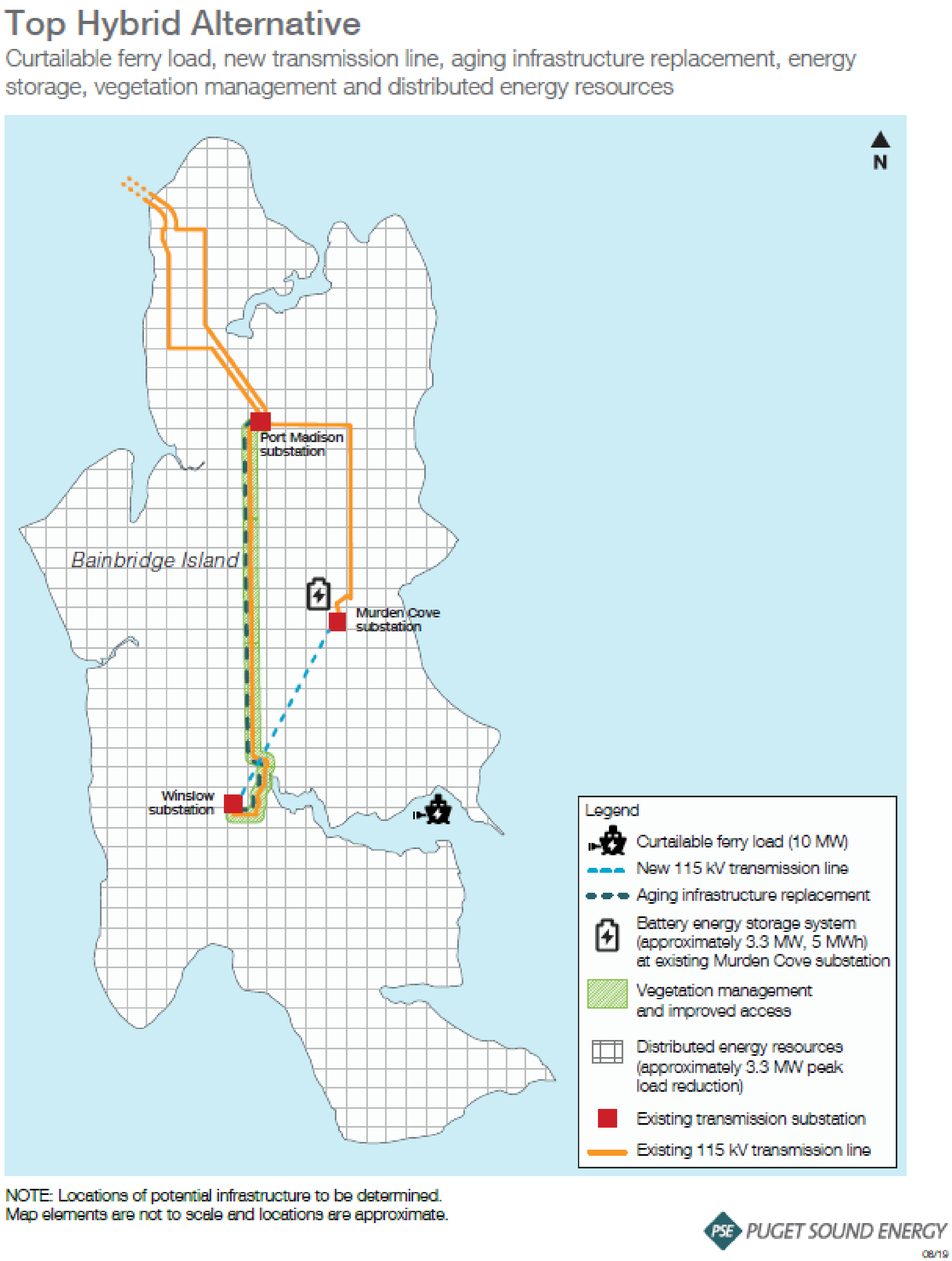


Figure 0-1: Proposed Solution - Hybrid Alternative 1

1 Introduction, Methodology and Key Assumptions

After completion of the Bainbridge Island Electric System Needs Assessment, PSE and industry experts conducted analyses of traditional alternatives (wires) and non-wires alternatives (NWAs) to determine a cost-effective solution that addresses the identified system needs for Bainbridge Island over the 10 year planning horizon.

1.1 Methodology

This solutions study used the following process:

1. Step one: Brainstorm potential solution types to solve the identified system needs, including conventional wires type, non-wires type like batteries, energy efficiency and distributed energy resources (DERs), and hybrid type that involved combination of wires and non-wires components.
2. Step two: Identify possible alternatives for each solution type. PSE studied conventional wires alternatives, Navigant studied various non-wires alternatives, and Quanta studied an all-battery storage alternative.
3. Step three: Assess the most promising alternatives using the solutions criteria for system performance in terms of capacity, reliability, asset life and constructability; and determine “viable” alternatives. An alternative was considered “viable” if it met all identified system needs and the solutions criteria.
4. Step four: Identify and compare the most viable alternatives.
5. Step five: Compare the top alternatives in terms of cost, benefits, drawbacks and risks to identify the proposed solution.

Figure 1-1 shows the process flow for the solutions study methodology.

PSE started the analysis with many conventional wires alternatives (as shown in Appendix A) and then shortlisted the alternatives to viable alternatives that met Bainbridge Island needs and the solutions criteria. The viable wires alternatives were compared in terms of cost, benefits, drawbacks and risks to generate the top-wires alternative. The top-wires alternative was used as a reference for development of non-wires and hybrid alternatives. As a final step, the top alternatives for the wires, non-wires and hybrid categories were compared to determine the proposed solution that best met Bainbridge Island needs.

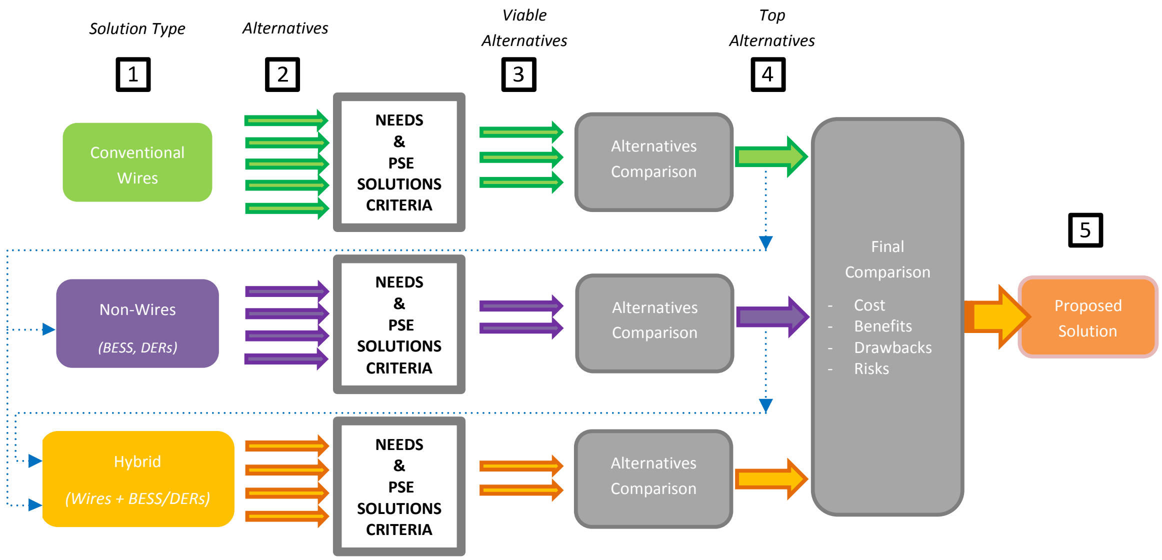


Figure 1-1: PSE Solutions Study Methodology

1.2 Solution Criteria

PSE evaluates alternatives with electrical and non-electrical criteria. These criteria are based on federal requirements, PSE planning guidelines, and industry standards, as well as project implementation considerations.

A proposed alternative is considered viable if it addresses all identified system *needs* and meets the solutions criteria. A viable alternative is not required to but may also address identified *concerns*, if deemed prudent or advantageous to include in the project scope.

Technical Criteria:

1. Must meet all performance criteria:

   - Address needs identified within the ten year study period (2018-2027)
   - Does not re-trigger any of the needs identified in the Needs Assessment for 10 years or more after the solution is in service
   - Normal winter peak load forecast with 100% conservation
   - Normal summer peak load forecast with 100% conservation

   Transmission:

   - Applicable transmission planning standards including mandatory North American Electric Reliability Corporation (NERC) and Western Electricity Coordinating Council (WECC) standards (e.g., NERC TPL-001-4 and WECC TPL-001-WECC-CRT-3.1)
   - Applicable PSE Transmission Planning Guidelines as follows:
     - o Transmission planning guideline for upgrading existing infrastructure in radial transmission line configuration when load served exceeds 15 to 20 MW
   - ≤ 100% of Planning's normal limit for lines and transformers for NERC TPL-001-4 P0-P7 contingencies for the 10-year planning horizon

- Take into account planned transmission system improvement projects that are expected to be in-service within study period
- No load shedding
- No interim operating plans

Distribution:

- Applicable PSE Distribution Planning Guidelines as follows:
  - Individual substation utilization in study area ≤ 100% of capacity
  - Total utilization of all substations in study group ≤ 85% of capacity
  - ≤ 100% of overhead individual feeder limits for N-0 and applicable N-1 scenarios
  - ≤ 100% of underground individual feeder limits for N-0 and applicable N-1 scenarios

Reliability:

- For areas with high non-MED[14] SAIDI[15] or non-MED SAIFI[16], solution must reduce non-MED SAIDI and non-MED SAIFI.

Aging Infrastructure:

- Addresses all major equipment with less than 10 years of useful life
- Addresses key infrastructure impacted by aging infrastructure replacements

Design Requirements:

- Must meet applicable Institute of Electrical and Electronics Engineers (IEEE) and NERC standards
- Must meet Washington Administrative Code (WAC) and National Electrical Safety Code (NESC) safety codes
- Must use PSE standard equipment as applicable and be consistent with the PSE Major Equipment Committee's spare equipment strategy
- Must meet PSE best practices for operations and maintenance

2. Must address all relevant PSE equipment overloads and voltage violations identified in the Needs Assessment.
3. Must address all relevant needs identified in the Needs Assessment Report.
4. Must not cause any adverse impacts to the reliability or operating characteristics of PSE's or neighboring utility system.

<u>Non-technical Criteria</u>:

1. Feasible permitting
2. Reasonable project cost

---

[14] MED (Major Event Day): See definition in Glossary

[15] SAIDI (System Average Interruption Duration Index): See definition in Glossary

[16] SAIFI (System Average Interruption Frequency Index): See definition in Glossary

3. Uses proven technology that may be adopted at a system level
4. Constructible within reasonable timeframe

1.3 Study Assumptions

For this solutions study, the following key assumptions were used:

- The 10-year planning horizon for the solutions study is from 2018 to 2027.
- Solution study horizon will be extended, if necessary, to accommodate solution criteria that states the solution must meet the need for at least 10 years.
- The study used the PSE corporate county level load forecast to project Kitsap County load; and PSE's Bainbridge Island load forecast[17] for specifically projecting Bainbridge Island load for the solution window.
- For alternatives involving battery energy storage system (BESS):
  - An 8 hour backup for transmission outages was considered sufficient duration for PSE to repair and restore most transmission line outages[18].
  - For outages that can exceed the assumed repair duration time, PSE System Operations and crews will have enough time margin, with the BESS backup, to manage area loads and switch the outaged load (or portion of the outaged load) to available capacity. This approach was considered reasonable and practical for sizing BESS alternatives.
- With regards to the ferry electrification charging load addition:
  - Anticipated as early as 2021.
  - PSE considered the load as curtailable. As of 2019, WSF has elected to pursue a curtailable rate schedule that allows PSE to interrupt service to the ferry charging load for up to 182 hours in a year.
- The estimated cost of acquiring land rights was included in each alternative.

[17] See Bainbridge Island Electric System Needs Assessment report for details on load forecast for Bainbridge Island

[18] Excludes storm related outages which can take longer duration for restoration. 8-hour battery backup covered 90% of transmission outages affecting Bainbridge Island in the past 5 year period 2013-2017

2 Needs Summary

PSE performed a needs assessment for Bainbridge Island's transmission and distribution system. The needs assessment determined that over the 10-year planning horizon, the needs and concerns were primarily in these areas – service reliability, system capacity, aging infrastructure, and operating flexibility. This is summary of the needs. For the complete needs assessment, refer to the Bainbridge Island Electric System Needs Assessment report.

2.1 Needs and Concerns

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. 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 interruptions than the average PSE customer, and nearly half of those interruptions minutes are due to issues with the transmission system.
- 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.[19]

The system needs and concerns[20] for Bainbridge Island are summarized as follows:

- **Transmission Reliability need:** The Winslow Tap transmission line feeding Winslow substation has experienced longer and more frequent outages in comparison to Kitsap County and PSE company-wide.
- **Transmission Aging Infrastructure need:** The Winslow Tap transmission line support structures 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 study period to support general load growth of 4.6 MW and planned 10 MW load addition for the new ferry electrification charging load.
- **Transmission Operating Flexibility concern**[21] – Concerns related to 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.

---

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

[20] A *need* is defined as 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 the Needs Assessment study for a planning horizon and defined in the Solutions Criteria. A *concern* is a non-critical issue that impacts system operations but may be overcome with alternate work plans. Concerns if unattended for long period manifest into needs, and may then require attention. A solution is required to address all identified system needs and may or may not address concerns.

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

[21] Operational flexibility relates to the ability to transfer load to support routine maintenance and outage management. PSE limits equipment maintenance to non-winter months when loading is light and backup is available from the distribution system. Since there is no transmission backup for Winslow or Murden Cove substations, an unplanned or emergency transmission repair event in winter can lead to outages for some customers.

3 Top Alternatives Analysis

PSE, Navigant and Quanta studied a variety of wires and non-wires options, which are listed below for reference. Alternatives were developed to meet all identified needs of Bainbridge Island through a combination of the various potential wires and non-wires options. The alternatives were classified in 3 categories – wires, non-wires, and hybrid that included both wires and non-wires options. This section of the report discusses and compares the top alternatives for the wires, non-wires and hybrid categories.

Alternatives consisted of a combination of the following options that were considered:

- Wires options
  - Replace aging infrastructure on Winslow Tap
  - Rebuild Winslow Tap
  - Add a new substation
  - Add additional transformer in an existing substation
  - Replace existing substation transformers with larger transformers to add capacity
  - Add a new 115 kV transmission line between Winslow and Murden Cove substations
  - Add a submarine transmission line to connect to Winslow substation from Bremerton
- Non-wires options
  - Standard vegetation management[22]
  - Aggressive vegetation management
  - Battery storage
  - Distributed energy resources (DERs)

Appendix A describes the full range of specific wires, non-wires and hybrid alternatives that were considered in the evaluation. Some alternatives were eliminated and deemed *non-viable* as they did not meet the PSE solution criteria as defined in Section 1.2. Alternatives that met all Bainbridge Island needs and the PSE solution criteria were deemed *viable* and considered for further evaluation. Viable alternatives for each category were compared to determine the top alternative for the category.

3.1 No Action Alternative

PSE considered a scenario where no action is taken to improve the transmission reliability and distribution capacity needs; however, the aging infrastructure need of the Winslow Tap will be addressed for safety and overall reliability considerations.

Under this alternative, PSE would continue to operate and maintain the system as is done now with little expectation for service reliability improvement. Expected island electric load growth demand could exacerbate this situation.

Specifically, the substation group capacity planning guideline may be exceeded as early as 2019/2020, which limits operational system flexibility resulting in longer duration outages. Addition of expected WSF ferry electrification charging load as early as 2021 would further limit system operation. Flexibility

[22] PSE defines standard vegetation management as trimming and removal that is based on an analysis of our internal standards and local conditions by our vegetation management team. For Bainbridge Island, our existing corridor standard is 60 feet.

is also needed to properly maintain systems and perform required system maintenance. Without needed flexibility customers will be subject to scheduled outages for system maintenance and repairs.

This option also does not address the transmission reliability need of the Winslow Tap. Customers fed from that station will continue to see a high frequency of interruptions from the transmission source. With the limited group capacity operating flexibility this load cannot be shifted to other substations resulting in lengthy outages.

It is important to note that due to the potential safety risk, the replacement of Winslow Tap aging infrastructure is included in the no action alternative. Failure of aging infrastructure dictates that PSE replace equipment and rebuild the existing transmission line.[23]

3.2 Top Wires Alternative

PSE's top wires alternative is detailed below, other wires alternatives considered but not selected are summarized in Appendix A.

Top Wires Alternative (see Figure 3-1):

- Construct a 115 kV transmission line from Murden Cove substation to Winslow substation to create a looped transmission system to improve transmission reliability for Bainbridge Island (notably for Winslow substation and also beneficial for Murden Cove substation).
- Construct a new 25 MVA substation in south Bainbridge Island to address the substation group capacity need.

The top wires alternative was selected over the other viable wires alternatives because of the reliability benefit. Reliability would be improved both by the looped transmission line (decreased transmission outages and outage durations) and by the decrease in number of customers served by any one substation (decreased customer outages) for Winslow and Murden Cove substations with the addition of a new 25 MVA substation.

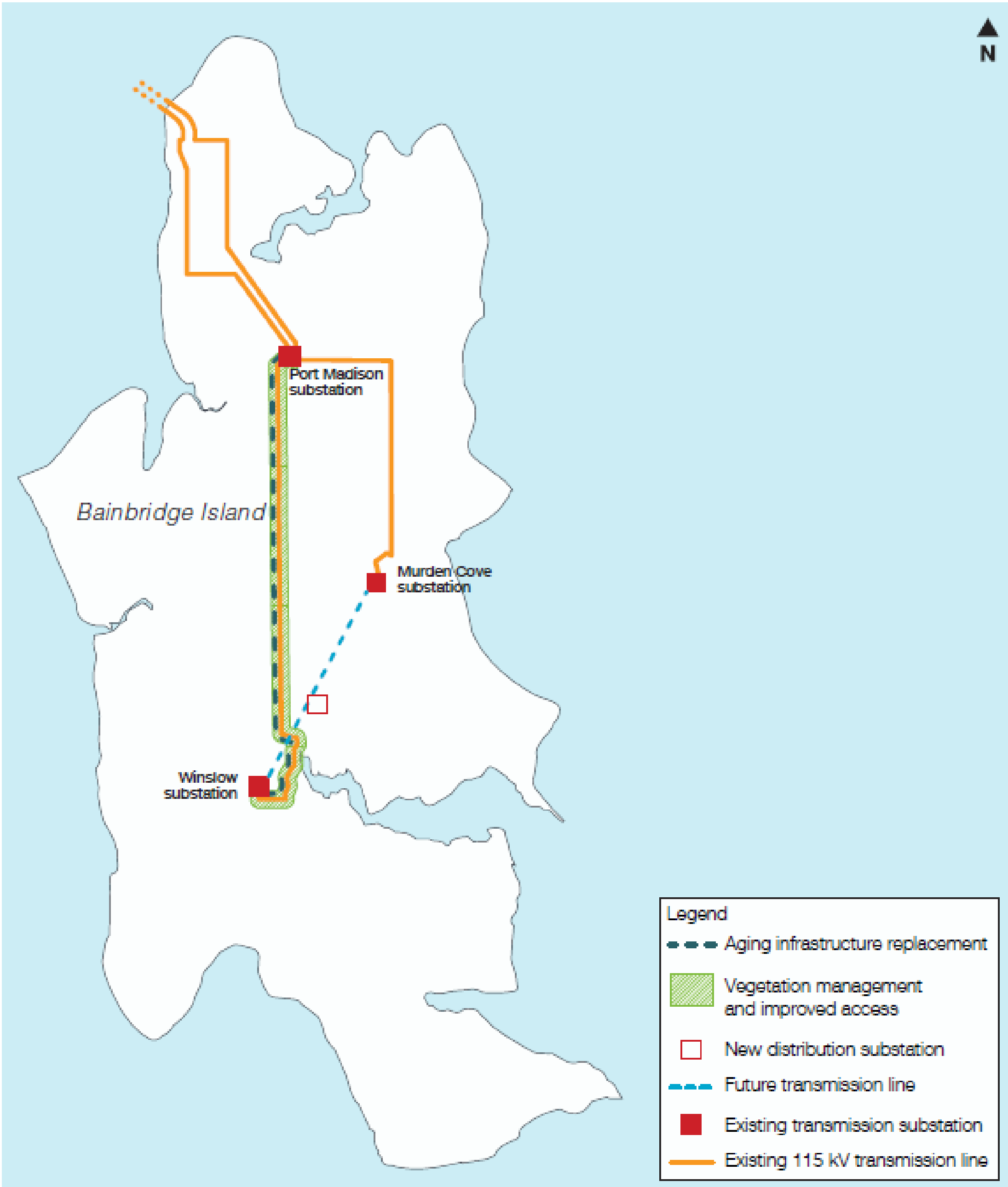
This option provides the best feeder configurations and facilitates future distribution automation implementation. Distribution automation isolates failed distribution equipment and restores service to as many customers as possible with automatic switching.

The new substation would ideally be in a location with relatively easy access to transmission lines and would minimize the construction of new distribution feeders to integrate the new substation into the existing distribution system.

[23] Refer to Appendix C "Addressing Transmission Aging Infrastructure Need" to see further explanation of PSE's assessment of options for corridor improvement.

Top Wires Alternative

New distribution substation, new transmission line, aging infrastructure replacement and vegetation management



NOTE: Locations of potential infrastructure to be determined.
Map elements are not to scale and locations are approximate.

PUGET SOUND ENERGY
08/19

Figure 3-1: Top Wires Alternative

3.3 Top Non-Wires Alternatives

PSE contracted two consultants to perform non-wires analysis. Both considered the technical and economic feasibility of an alternative that consists entirely of non-wires alternatives (NWAs). Navigant considered alternatives consisting of both energy storage and other distributed energy resources (DERs), while Quanta considered the feasibility of an alternative consisting entirely of energy storage.

3.3.1 Energy Storage and Distributed Energy Resource Analysis by Navigant Consulting

Navigant reviewed whether energy storage and DERs could meet the needs of Bainbridge Island. The DERs that were included in the analysis for Bainbridge are energy efficiency (EE), demand response (DR), solar photovoltaic (PV), and renewable combined heat and power (CHP). These items as well as the resources that were considered but not included in the Bainbridge analysis are detailed in Table 1 of Appendix D.

Navigant's Non-wires Alternatives Analysis reviewed and analyzed three approaches:

1. **Traditional wires scenario**: Navigant reviewed the traditional wires alternative developed by PSE to meet Bainbridge Island needs and concerns. This alternative included a new 115 kV transmission line, expansion of the Winslow and Murden Cove substations, a new substation and new distribution feeders, and a rebuild of the Winslow Tap transmission line.
2. **Exclusively non-wires scenario:** Navigant analyzed a range of NWAs, which included energy efficiency, energy storage, renewable distributed generation like solar and renewable combined heat and power, and demand response[24]. In addition, Navigant considered vegetation management in their overall assessment but not in their detailed analysis.
3. **Hybrid non-wires scenario:** Navigant combined a new 115kV transmission line loop, battery storage, distributed energy resources, connection of the new ferry electrification charging load (10MW) as a curtailable resource, and rebuilding of the Winslow Tap transmission line.

In order to evaluate whether the needs on Bainbridge Island could be met exclusively with NWAs, Navigant considered both the narrow set of NWAs defined above as well as items not typically considered as NWAs, such as vegetation management, as discussed in Section 1.3.1 of Appendix D. They deconstructed the challenges on Bainbridge Island by two dimensions – the specific identified project need and the grid elements. The two purposes of this were to define the specific challenge being considered as well as identify where that challenge fits in the overall picture of Bainbridge Island needs. The deconstruction is done this way in order to cover the entire potential range of alternatives—wires and non-wires. The deconstruction into grid elements was divided into transmission and distribution components to be consistent with the existing grid architectural structure. This deconstruction, as well as the assessment of whether the project need can be met by NWAs, is referred to as a "Decision Tree" and is shown in Figure 2 of Appendix D**.**

Navigant concluded that NWAs would not aid transmission aging infrastructure or transmission operational flexibility on Bainbridge Island. However, NWAs could provide distribution capacity, some additional distribution reliability, and potentially distribution operational flexibility.

---

[24] As defined by the Northwest Power and Conservation Council, demand response is "the voluntary and temporary reduction in consumers' use of electricity when the power system is stressed". https://www.nwcouncil.org/energy/energy-topics/demand-response

Navigant also considered whether a broader definition of NWAs to include vegetation management could meet the Bainbridge Island needs. Navigant noted that some of the needs "would be extremely hard to meet with NWAs. For example, addressing transmission reliability without the Winslow 115 kV Tap rebuild and without addressing some of the aging infrastructure needs is a significant challenge."[25]

Key findings from Navigant's study:

- A hybrid alternative of wire and non-wires alternatives to meet the reliability and capacity needs is "technically feasible and economically-preferable to the wired solution."[26]
- PSE could delay the investment in a new distribution substation by focusing on battery storage, DERs, and working with WSF to have the ferry electrification charging connected as a curtailable load.
- Navigant concluded that while an all-NWA is technically possible, it is not a practical alternative.

With regards to the all-NWA options, Navigant specifically noted that, "considering the likely need for significant additional electric storage at various locations on the island, the need for aggressive tree-trimming and removal (counter to community values on Bainbridge Island), and the roll-out timeframe necessary to meet the full set of defined needs with an exclusively NWA solution, Navigant does not think such a solution could be realistically achieved."[25]

Navigant further noted that, "to provide similar levels of operational flexibility and reliability as the traditional solution, additional batteries would be needed to provide grid support for four to eight hours. These batteries would be needed in addition to the batteries and other measures needed to meet the growing capacity needs. Navigant estimated that the costs for these additional batteries would be considerably more than the costs of the traditional solution related to grid flexibility and reliability."[25] The detailed analysis that was undertaken by Quanta Technology did evaluate the cost of an alternative consisting entirely of batteries and is documented in the next section.

3.3.2 Energy Storage Analysis by Quanta Technology

Quanta analyzed whether multiple battery energy storage systems could meet the defined needs on Bainbridge Island. They ran power flow studies and analyzed optimal locations for battery siting and sizing to meet the defined needs on Bainbridge Island. The conditions and assumptions under which they conducted their analysis included the use of load shifting and feeder switching and are detailed further in Section 2 of Appendix E.

The results of Quanta's analysis yielded an alternative consisting of five batteries with a total combined rating of 28.2 MW/91.2 MWh. The batteries would be distributed throughout the island at locations shown in Table 3-1 and in Figure 3-2 along circuits or at a substation.

One of the five batteries could be located at substation property, while the four other large batteries would be at locations determined around the island on specific circuits and not at a substation. At minimum, an all battery storage alternative would cost at least $20 million more than the conventional wire alternative as documented further in Section 5; this alternative's cost will increase due to interconnection costs and siting of the batteries.

---

[25] Appendix D, Bainbridge Island Non-Wires Alternative Analysis, Navigant Consulting, page 11

[26] Appendix D, Bainbridge Island Non-Wires Alternative Analysis, Navigant Consulting, page 1

Table 3-1: Battery Sizes and Locations

Location	Battery Storage System Size
Circuit WIN-13	4.4 MW/20 MWH
Circuit MUR-17/WIN-15	3.4 MW/15 MWH
Circuit PMA-13/WIN-12	3.2 MW/9 MWH
Circuit MUR-15	0.4 MW/0.4 MWH
Murden Cove Distribution Substation	13.7 MW/34.8 MWH
Total	**25.1 MW/79.2 MWH**

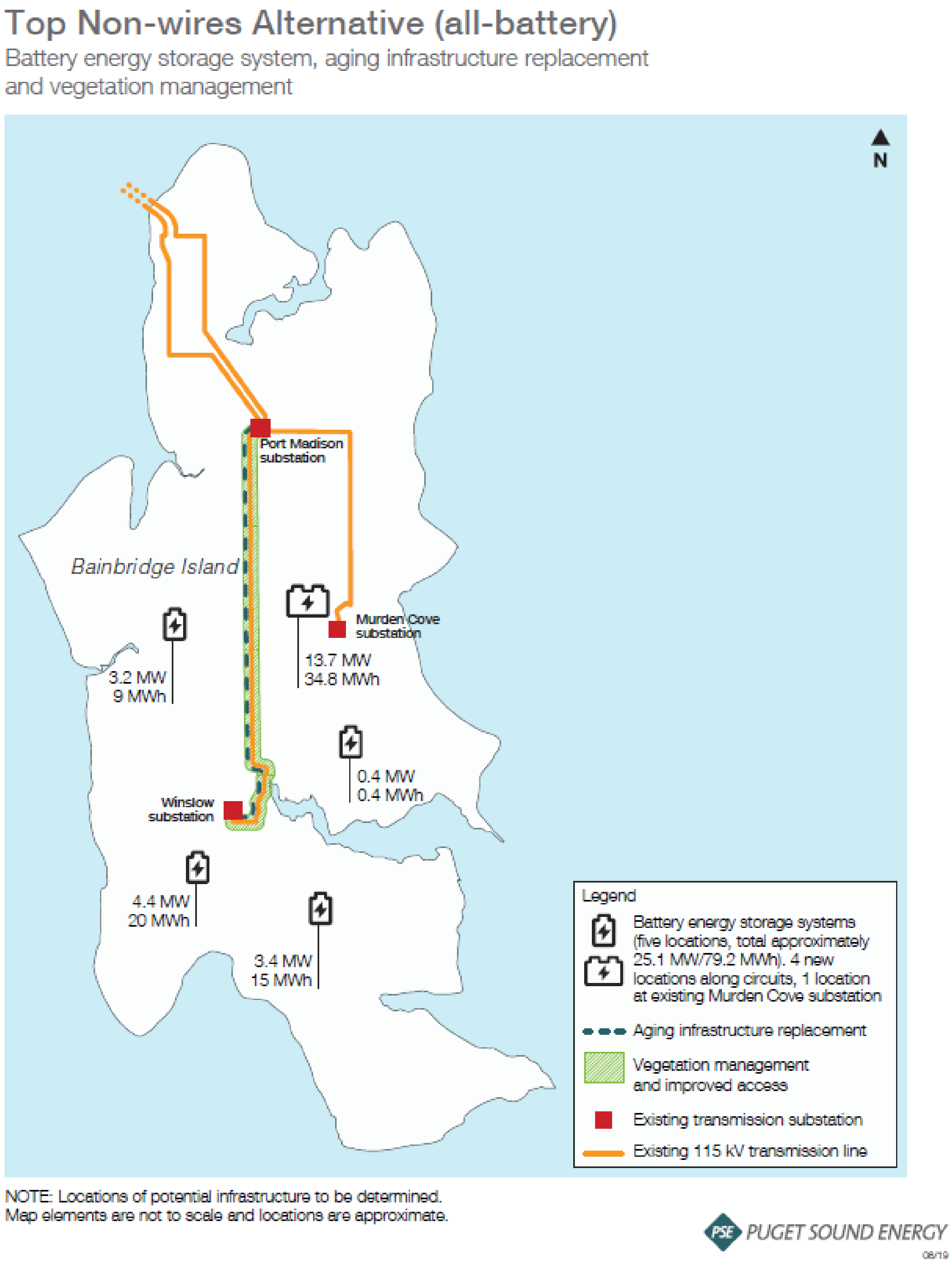


Figure 3-2: All BESS Alternative

3.4 Top Hybrid Alternative

Upon noting the high cost and challenges of a full non-wires alternative, PSE asked Navigant to consider the potential hybrid alternatives that would include both traditional wires components and other needs met through NWAs. The review of key system elements was made in the "Decision Tree" discussed in the previous section and shown in Figure 2 of Appendix D with a detailed explanation of their analysis procedure noted in Section 3.3.1 of this report.

Navigant's analysis concluded that an exclusively non-wire alternative was impractical for solving the island's needs; however, a combination of non-wires and traditional components could. Their analysis indicated potential to meet capacity needs for the distribution component of the alternative. Navigant recommended connecting the ferry as an interruptible load, as previously discussed in Section 3.3.1. More detailed analysis focused on identifying the potential of DERs to address the remaining distribution capacity needs.

The method that Navigant used for determining the achievable technical potential to meet these distribution capacity needs was to consider the incremental potential available beyond the "business as-usual" procurement that PSE already does for demand-side resources (with discussion of this incremental potential analysis in Section 2.1 of Appendix D). **"**To include storage and other DERs into a single optimal portfolio, Navigant developed a levelized cost of capacity (LCOC) calculation. This allows comparison of resources based on the present value of the net costs for providing local capacity deferral."[27] This method is detailed in Section 3 of Appendix D.

The results of this technical potential and economic analysis concluded that:

- A "NWA portfolio including energy efficiency (EE), [battery] storage, renewable distributed generation (DG), and the option of demand response (DR), has the potential to cost-effectively defer the wired alternative until 2030 given current load forecasts."[28] The portion of the wires alternative that could be deferred is the distribution substation.
- Navigant recommended sizing the storage to meet 50% of the capacity needs in 2030 with their analysis indicating that "a 3.3 MW, 5 MWh battery would provide sufficient flexibility for PSE to study and pilot targeted DR and EE programs to meet the other 3.3 MW of need before DSM resources become absolutely necessary to meet the need"[29].

Based on power flow analysis completed in the Quanta report (Section 6.1.2 of Appendix E), PSE has assessed that the likely most appropriate location for this 3.3 MW battery is Murden Cove substation.

In order to confirm the size and resource mix noted above, Navigant recommended launching a pre-implementation NWA analysis to validate the DSM portion of the results. For the storage portion of the alternative, these results help to provide an indicative value of storage for consideration in planning. PSE is undertaking the suggested validation of the DSM portion of the results, and based on the results of that investigation the size of the approximately 3.3MW/5MWh could adjust so that between the battery and the DSM portion of the alternative the entire 6.6 MW capacity need is met.

---

[27] Appendix D, Bainbridge Island Non-Wires Alternative Analysis, Navigant Consulting, page 21

[28] Appendix D, Bainbridge Island Non-Wires Alternative Analysis, Navigant Consulting, page 3

[29] Appendix D, Bainbridge Island Non-Wires Alternative Analysis, Navigant Consulting, page 4

In conclusion, Navigant's recommended hybrid alternative includes the following features:

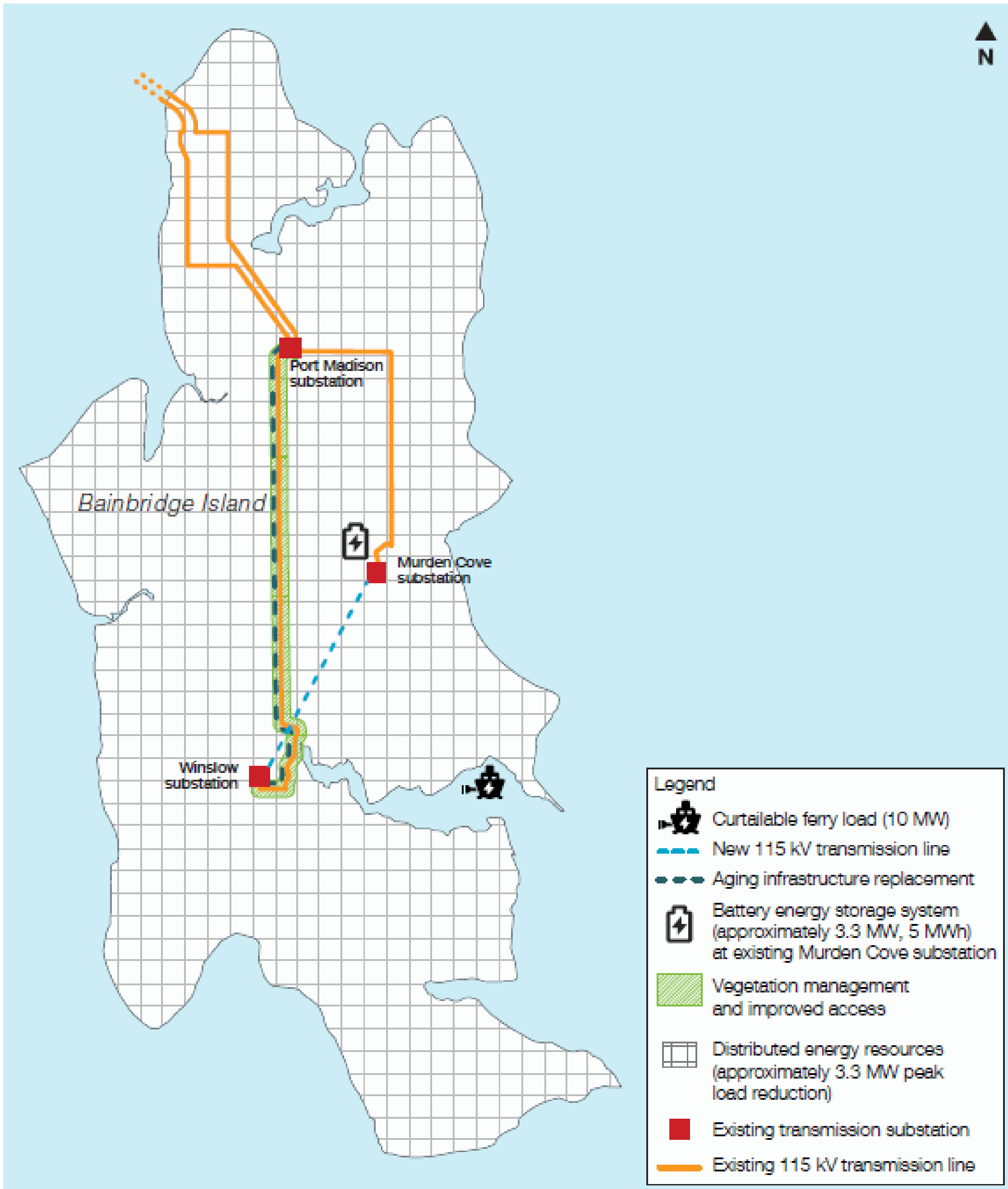
- Addresses reliability with a conventional transmission "loop" to connect substations. A new overhead transmission line between Murden Cove and Winslow substations would ensure each substation will be connected to two transmission lines. If one line goes out, the other line will still feed the substation and provide power to customers.
    - Targeted vegetation management supplements the transmission reliability benefits that the transmission loop provides.
- Addresses distribution capacity through a three-pronged non-wires alternative approach, which defers the wires alternative of a distribution substation until at least 2030.
    - Connecting the new ferry electrification charging load (10 MW) as a curtailable resource.
    - A NWA portfolio including energy efficiency, energy storage, renewable distributed generation, and the option of demand response.
    - A battery sized to meet 50 percent of the capacity needs in 2030. "Navigant's analysis indicates that an approximately 3.3 MW / 5 MWh battery would provide sufficient flexibility for PSE to study and pilot targeted DR and EE programs to meet the other 3.3 MW of need before these demand side management (DSM) resources become absolutely necessary to meet the need."[30]
- Addresses aging infrastructure need for the Winslow Tap transmission line by rebuilding the line. PSE's plan for this is discussed in Appendix C.

All of the potential hybrid alternatives that arose from the analysis in Navigant's report are presented in Appendix A with descriptions of why the other considered alternatives are not the top hybrid alternative.

[30] Appendix D, Bainbridge Island Non-Wires Alternative Analysis, Navigant Consulting, page 4

Top Hybrid Alternative

Curtailable ferry load, new transmission line, aging infrastructure replacement, energy storage, vegetation management and distributed energy resources



NOTE: Locations of potential infrastructure to be determined.
Map elements are not to scale and locations are approximate.

PUGET SOUND ENERGY

08/19

Figure 3-3: Top Hybrid Alternative

3.5 Top Alternatives Comparison

The top wires, non-wires, and hybrid alternatives were described in Section 3. The key aspects of each of these alternatives are shown below in Table 3. In addition, the project costs for each potential alternative are noted and include a 25% cost estimating contingency. The hybrid and full wires alternative are closer in cost, but the all battery energy storage system (BESS) alternative is significantly more expensive. The potential benefits, drawbacks and risks of each alternative are discussed following the summary table.

Table 3-2 Summary of Top Alternatives and Costs[31] [32] [33] [34]

	Top Wires Alternative	Top Non-Wires Alternative (All BESS)	Top Hybrid Alternative
Primary Need: Winslow Tap Transmission Reliability	Transmission Loop (Winslow to Murden Cove)	TOTAL BESS: 25.1 MW/79.2 MWH MUR: 13.7 MW/34.8 MWH MUR-15: 0.4 MW/0.4 MWH, PMA-13/WIN-12: 3.2 MW/9 MWH, MUR-17/WIN-15: 3.4 MW/15 MWH WIN-13: 4.4 MW/20 MWH	Transmission Loop (Winslow to Murden Cove)
Primary Need: Substation Group Capacity	New Distribution Substation		Ferry Curtailment: 10 MW up to 182 hours 50% BESS@MUR: 3.3 MW/5 MWH 50% DER: 3.3 MW
Primary Need: Winslow Tap Aging Infrastructure	Rebuild Transmission Line-Replace Poles & Wire, Improve Corridor Access, Acquire Necessary Rights & Veg Mgmt	Rebuild Transmission Line-Replace Poles & Wire, Improve Corridor Access, Acquire Necessary Rights & Veg Mgmt	Rebuild Transmission Line-Replace Poles & Wire, Improve Corridor Access, Acquire Necessary Rights & Veg Mgmt
Total Cost Estimate Range (Base to High)	$42.5 million to $85 million	$66 million to $132 million	$38 million to $76 million
Decision Factors	- Expertise - Long term solution - High reliability	- 10 year solution - Add with growth - New operational strategies needed - High cost	- 10 year solution - Add with growth - New operational strategies needed - Local EE and DR

[31] Costs are estimate based on similar past projects in other areas of PSE service territory. Does not include site-specific engineering.

[32] The costs shown for the wires portions of all alternatives are capital investment costs.

[33] Costs shown for battery storage systems in Top Non-Wires Alternative (all-BESS) are from the Quanta Technology Report, Appendix E, Table 7.1, Storage-Only Solution (Option), Total Capital Investment cost ($37.7M). A 25% cost estimating contingency is added to the cost in that report to be consistent with how other costs in this table are shown. The capital investment cost is shown to be consistent with the presentation of the wires alternative.

[34] Costs shown for Top Hybrid Alternative, Primary Need: Substation Group Capacity are from the Navigant Consulting Report, Appendix D, page 24 which notes a portfolio cost between $4.5M (including DR) and $5.5M (excluding DR). The higher portfolio cost of $5.5M is used here to remain conservative. A 25% cost estimating contingency is added to the cost in that report to be consistent with how other costs in this table are shown. The costs and benefits for the measures of this portfolio are from the 2017 IRP. These costs and benefits are in present value terms and are levelized to be consistent with the 2017 IRP. Further discussion of this is in Appendix D, Section 3.1.

3.5.1 Decision Factors - Wires Alternative

When considering the top wires alternative, there are clear benefits and potential drawbacks and risk.

A clear benefit is that the option presents a longer term alternative as typical wires infrastructure is in service for 30 plus years. The wires alternative has an advantage that PSE has strong expertise and experience in building wires solutions to address its electrical system needs.

A drawback is that the alternative is more capital intensive upfront and requires the building of a new substation that the hybrid alternative does not require. A risk of building this longer-term alternative is possibly over-building capacity. Bainbridge Island needs 6.6 MW[35] of capacity, while a substation would add 33 MVA (winter) of distribution capacity which exceeds what is needed.

3.5.2 Decision Factors - Non-wires and Hybrid Alternatives

The full non-wires or hybrid alternatives have some benefits, drawbacks, and risks that are similar between them.

As a benefit, both alternatives allow for deferral of the distribution substation. However, both alternatives involve some non-wires elements that are scoped to be a 10 year solution. The lifespan for non-wires elements that is shorter than typical wired alternative can be seen as both a drawback (perhaps PSE needs to do additional work after 10 years) but potentially a risk-laden benefit (maybe PSE does not need the substation at 10 years and so constructing it may be over-building). Rather than the potential for over-building, PSE can instead add with growth as it occurs.

As discussed in Section 3.3, the full non-wires alternative was deemed not reasonable by both consultants (Navigant and Quanta) that performed analysis in the area as well as by PSE. Navigant's review noted that this alternative would be "technically possible but not realistic".[36] More specifically they note that, "considering the likely need for significant additional electric storage at various locations on the island (at considerable cost), the need for aggressive tree-trimming and vegetation management (counter to community values on Bainbridge Island), and the roll-out timeframe necessary to meet the full set of defined needs with an exclusively NWA solution, Navigant does not think such a solution could be realistically achieved."[37] Navigant further elaborates on this considerable cost as "to provide similar levels of operational flexibility and reliability as the traditional solution, additional batteries would be needed to provide grid support for four to eight hours. These batteries would be needed in addition to the batteries and other measures needed to meet the growing capacity needs. Navigant estimated that the costs for these additional batteries would be considerably more than the costs of the traditional solution related to grid flexibility and reliability."[37]

Quanta's analysis indicates that five batteries would be required and would be distributed throughout Bainbridge Island along circuits and at a substation. While one battery could be located at substation property, locations for the four other batteries would need to be determined around the island. The cost of this is estimated to be at least $20 million more than the traditional wires alternative. Quanta did not include interconnection costs in their estimates, however PSE has included a very conservative interconnection cost estimate (included in Table 3-2). Given that these are conservative estimates it is

---

[35] Per Navigant Bainbridge Island assessment, Bainbridge Island has distribution capacity need of 6.6 MW with the addition of electric ferry service as a curtailable load.

[36] Appendix B, Bainbridge Island Non-Wires Alternative Analysis, Navigant Consulting, page 2

[37] Appendix B, Bainbridge Island Non-Wires Alternative Analysis, Navigant Consulting, page 11

reasonable that the differential between the wires alternative and the all-battery storage alternative that Quanta developed would only increase. Additionally, locations of the potential battery storage sites were not considered, but if additional land is needed to be purchased this would only increase the differential between the wires alternative and the all-battery storage alternative that Quanta developed. This eliminates the consideration of the full non-wires alternative and narrows the alternative possibilities down to the proposed wires alternative and hybrid alternative.

As displayed in Table 3-2, the hybrid alternative presents the opportunity to adapt and operate new technologies – energy storage and DERs – to meet electric system needs. It is consistent with both our customers' expectations to lead us into the future and the Washington Utilities and Transportation Commission policy statement of October 2017 (Docket UE-151069 and U-161024). In addition, adopting this new technology allows us to gain further operational experience in energy storage and DERs. Incorporating the transmission loop as part of the alternative enables future technologies by providing a reliable transmission backbone which is important for customers to be able to enjoy the benefits of enabling more flexible grid technologies (such as distribution automation). It also provides some cost savings as compared to the wires alternative.

Given these reasons, the top hybrid alternative incorporating traditional wired investment for the transmission needs and a combination of energy storage and DERs for distribution capacity needs is PSE's proposed solution.

4 Proposed Solution

The top alternatives were presented in Section 3. Other alternatives that were considered are presented in Appendix A.

Based on the alternatives analysis, the proposed solution is the top hybrid alternative that is shown in Figure 3-3. The hybrid alternative:

- Invests in traditional transmission infrastructure to replace aging equipment and improve reliability.
- Deploys battery storage and DERs to support the island’s electric load growth and ferry electrification without the need for additional substation infrastructure.
- Adds a transmission loop that improves reliability and supports future technologies.
- Provides cost savings as compared to the conventional wires alternative.

The primary needs being addressed and the components of the proposed hybrid solution are:

- Improves transmission and distribution reliability by building approximately 3.5 miles of new overhead transmission line between Murden Cove and Winslow substations that will create a transmission “loop”. The loop will also improve operating flexibility on the transmission system to both Winslow and Murden Cove substations.
- Addresses the aging infrastructure need for the Winslow Tap transmission line by rebuilding the line and improving the corridor for maintainability and operability of the line.
- Address Bainbridge Island’s distribution capacity need by:
  - Connecting the new ferry electrification charging load (10 MW) as a curtailable resource.
  - Installing an approximately 3.3 MW/5 MWh battery storage system (planned for Murden Cove substation)
  - Implementing an approximately 3.3 MW DER portfolio on Bainbridge Island, with customer-side resources such as energy efficiency, renewable distributed generation, and the potential for demand response.

Appendix A Alternatives Considered

Appendix A summarizes the alternatives considered while developing the preferred solution. An alternative is considered viable if it meets all system needs and the solutions criteria; otherwise it is deemed non-viable and eliminated from further consideration.

The following table format is utilized in this section to describe the alternatives considered, and the determination of viability of these alternatives.

NAME STATUS	SCOPE SUMMARY	DECISION FACTORS (N) Indicates criteria not met but could be met with cost sharing (X) Indicates criteria not met (Y) Indicates criteria met	

NAME – Name of Alternative

STATUS – Viable or Eliminated

SCOPE SUMMARY – High level description of scope of alternative considered

DECISION FACTORS – N, X or Y (as described above)

Wires Alternatives w/o Transmission Loop (No Loop (NL))

This section describes the wires alternatives that do not include a transmission loop between Murden Cove and Winslow Substations as part of the alternative, referred to as the No Loop (NL) alternatives.

Table A-1: Alternative Comparison: No Loop Wires Alternatives

NAME STATUS	SCOPE SUMMARY	DECISION FACTORS	
NL-1 ELIMINATED	Winslow Tap rebuild with widened transmission corridor	Meets all technical criteria • Does not meet PSE Transmission Planning guideline with load levels exceeding recommended limit of 15-20 MW for radial lines – Winslow Tap and Murden Cove Tap • Does not add needed substation capacity Feasible permitting Reasonable project cost Uses proven technology Constructible within reasonable timeframe	X Y Y Y Y
NL-2 ELIMINATED	Install new substation and Winslow Tap rebuild with widened transmission corridor	Meets all technical criteria • Does not meet PSE Transmission Planning guideline with load levels exceeding recommended limit of 15-20 MW for radial lines – Winslow Tap and Murden Cove Tap • Does not meet PSE Transmission Planning guideline with more than 1 distribution transformer on a radial line Feasible permitting Reasonable project cost Uses proven technology Constructible within reasonable timeframe	X Y Y Y Y

NAME STATUS	SCOPE SUMMARY	DECISION FACTORS	
NL-3 ELIMINATED	Double bank Winslow sub and Winslow Tap rebuild with widened transmission corridor	Meets all technical criteria • Does not meet PSE Transmission Planning guideline with more than 1 distribution transformer on a radial line Feasible permitting Reasonable project cost Uses proven technology Constructible within reasonable timeframe	X Y Y Y Y
NL-4 ELIMINATED	Double bank Murden Cove sub and Winslow Tap rebuild with widened transmission corridor	Meets all technical criteria • Does not meet PSE Transmission Planning guideline with more than 1 distribution transformer on a radial line Feasible permitting Reasonable project cost Uses proven technology Constructible within reasonable timeframe	X Y Y Y Y
NL-5 ELIMINATED	Add a 115 kV line underground from Port Madison to loop Winslow, double bank Winslow and Winslow Tap rebuild	Meets all technical criteria Feasible permitting Reasonable project cost • Underground transmission cost is much greater than overhead option • Would require community cost sharing[38] Uses proven technology Constructible within reasonable timeframe	Y Y N Y Y
NL-6 ELIMINATED	Underground portions of existing Winslow 115 kV tap (in areas of heavy vegetation)	Meets all technical criteria • Does not meet PSE Transmission Planning guideline with load levels exceeding recommended limit of 15-20 MW for radial lines – Winslow Tap and Murden Cove Tap • Does not add needed substation capacity Feasibility of permitting Reasonable project cost • Would require community cost sharing Uses proven technology Constructible within reasonable timeframe	X N N Y Y

[38] Because there is a technically viable overhead transmission line route, PSE will not consider an underground option as viable overall. However, that does not eliminate underground transmission lines as an option **if** the community is interested and willing to invest in undergrounding the transmission lines pursuant to Schedule 80. State regulations require PSE to first consider building overhead transmission lines because of their combination of reliability and affordability, both of which are important to our customers.

NAME STATUS	SCOPE SUMMARY	DECISION FACTORS	
NL-7 ELIMINATED	Replace existing 25 MVA transformers at Murden Cove and Winslow subs with 40 MVA transformers and vegetation management with Winslow Tap rebuild	Meets all technical criteria • Does not meet PSE Transmission Planning guideline with load levels exceeding recommended limit of 15-20 MW for radial lines – Winslow Tap and Murden Cove Tap • Does not meet PSE standard equipment requirement Feasibility of permitting Reasonable project cost Uses proven technology Constructible within reasonable timeframe	X Y Y Y Y
NL-8 ELIMINATED	Submarine 115 kV, and new overhead 115 kV line on either side of water, double bank Winslow sub and vegetation management with Winslow Tap rebuild	Meets all technical criteria Feasibility of permitting Reasonable project cost Uses proven technology Constructible within reasonable timeframe	Y X X Y X

Wires Alternatives w/ Transmission Loop (With Loop (WL))

This section describes the wires alternatives that include a transmission loop as part of the alternative referred to as With Loop (WL) alternatives.

Table A-2: Alternative Comparison: With Loop Wires Alternatives

NAME STATUS	SCOPE SUMMARY	DECISION FACTORS	
WL-1 VIABLE	New substation and looped overhead transmission line (Winslow to Murden Cove) and Winslow Tap rebuild	Meets all technical criteria Feasibility of permitting Reasonable project cost Uses proven technology Constructible within reasonable timeframe	Y Y Y Y Y
WL-2 VIABLE	Looped overhead transmission line (Winslow to Murden Cove), double bank Winslow sub and Winslow Tap rebuild	Meets all technical criteria Feasibility of permitting Reasonable of project cost Uses proven technology Constructible within reasonable timeframe	Y Y Y Y Y
WL-3 VIABLE	Looped overhead transmission line (Winslow to Murden Cove), double bank Murden Cove sub and Winslow Tap rebuild	Meets all technical criteria Feasibility of permitting Reasonable project cost Uses proven technology Constructible within reasonable timeframe	Y Y Y Y Y
WL-4 ELIMINATED	Looped overhead transmission line (Winslow to Murden Cove), replace existing 25 MVA transformers with 40 MVA transformers and Winslow Tap rebuild	Meets all technical criteria • Does not use PSE standard equipment Feasibility of permitting Reasonable project cost Uses proven technology Constructible within reasonable timeframe	X Y Y Y Y

NAME STATUS	SCOPE SUMMARY	DECISION FACTORS	
WLU-1, WLU-2, WLU-3 ELIMINATED	Same alternatives as WL-1 through WL-3 except transmission loop is underground	Meets all technical criteria Feasibility of permitting Reasonable project cost • Would require community cost sharing Uses proven technology Constructible within reasonable timeframe	Y Y N Y Y
WLU-4 ELIMINATED	Same alternatives as WL-4 except transmission loop is underground	Meets all technical criteria • Does not use PSE standard equipment Feasibility of permitting Reasonable project cost • Would require community cost sharing Uses proven technology Constructible within reasonable timeframe	X Y N Y Y
WL-5 ELIMINATED	Loop overhead transmission line (Winslow to Murden Cove) and Winslow Tap rebuild	Meets all technical criteria • Does not add needed substation capacity Feasibility of permitting Reasonable project cost Uses proven technology Constructible within reasonable timeframe	X Y Y Y Y
WLU-5 ELIMINATED	Same alternative as WL-5 except transmission loop is underground	Meets all technical criteria • Does not add needed substation capacity Feasibility of permitting Reasonable project cost • Would require community cost sharing Uses proven technology Constructible within reasonable timeframe	X Y N Y Y
WL-6 ELIMINATED	Submarine 115kV cable and new overhead 115 kV transmission lines on either side of water, with looped transmission line, double bank Winslow sub and Winslow Tap rebuild	Meets all technical criteria Feasibility of permitting Reasonable project cost Uses proven technology Constructible within reasonable timeframe	Y X X Y X

Table A-3: Viable Alternatives Comparison: With Loop (WL) Wires Alternatives[39] [40]

	Alternative WL-1	Alternative WL-2	Alternative WL-3
	Scope	**Scope**	**Scope**
Primary Need: Winslow Tap Transmission Reliability	Transmission Loop (Winslow to Murden Cove)	Transmission Loop (Winslow to Murden Cove)	Transmission Loop (Winslow to Murden Cove)
Primary Need: Substation Group Capacity	New Distribution Substation	Double Bank- Winslow	Double Bank - Murden Cove
Primary Need: Winslow Tap Aging Infrastructure	Rebuild Transmission Line- Replace Poles & Wire, Improve Corridor Access, Acquire Necessary Rights & Veg Mgmt	Rebuild Transmission Line- Replace Poles & Wire, Improve Corridor Access, Acquire Necessary Rights & Veg Mgmt	Rebuild Transmission Line- Replace Poles & Wire, Improve Corridor Access, Acquire Necessary Rights & Veg Mgmt
Additional Costs - Land (ROW, Property)	Sub. property available, 25 FT wide ROW for loop	25 FT wide ROW for loop	25 FT wide ROW for loop
Total Cost Estimate Range (Base to High)	$42.5 million to $85 million	$42.5 million to $85 million	$40.2 million to $80.4 million
Decision factors	-Long term solution (20-30 years) -Ferry load may not need to be curtailed -High Cost	-Long term solution (20-30 years) -Ferry load may not need to be curtailed -High Cost	-Long term solution (20-30 years) -Ferry load may not need to be curtailed -High Cost

[39] Costs are estimate based on similar past projects in other areas of PSE service territory. Does not include site-specific engineering.

[40] The costs shown for the wires portions of all alternatives are capital investment costs.

All-Battery Alternatives (AB)

This section describes an all-battery alternative.

Table A-4: Alternative Comparison: All-Battery Alternative

NAME STATUS	SCOPE SUMMARY	DECISION FACTORS	
AB-1 ELIMINATED	Total BESS size: 25.1 MW/79.2 MWH Murden Cove Sub: 13.7 MW/34.8 MWH Circuit MUR-15: 0.4 MW/0.4 MWH Circuit PMA-13/WIN-12: 3.2 MW/9 MWH Circuit MUR-17/WIN-15: 3.4 MW/15 MWH WIN-13: 4.4 MW/20 MWH	Meets all technical criteria Feasibility of permitting Reasonable project cost Uses proven technology Constructible within required timeframe	Y Y X X Y

Hybrid Alternatives (HA)

This section describes hybrid alternatives which are a combination of wires and non-wires alternatives.

Table A-5: Alternative Comparison: Hybrid Alternatives

NAME STATUS	SCOPE SUMMARY	DECISION FACTORS	
HA-1 VIABLE	Looped overhead transmission line (Winslow to Murden Cove), 3.3 MW battery at Murden Cove sub, 3.3 MWs distributed energy resources (DERs), connect new ferry electrification load (10 MW) as a curtailable resource, and Winslow Tap rebuild	Meets all technical criteria Feasibility of permitting Reasonable project cost Uses proven technology Constructible within required timeframe	Y Y Y Y Y
HA-2 VIABLE	Looped overhead transmission line (Winslow to Murden Cove), 6.6 MW battery at Murden Cove sub, connect new ferry electrification load (10 MW) as a curtailable resource, and Winslow Tap rebuild	Meets all technical criteria Feasibility of permitting Reasonable of project cost Uses proven technology Constructible within required timeframe	Y Y Y Y Y
HA-3 ELIMINATED	Winslow Tap rebuild with widened transmission corridor, 6.6 MW battery at Murden Cove sub, and connect new ferry electrification load (10 MW) as a curtailable resource	Meets all technical criteria • Does not meet PSE Transmission Planning guideline with load levels exceeding recommended limit of 15-20 MW for radial lines – Winslow Tap and Murden Cove Tap Feasibility of permitting Reasonable project cost Uses proven technology Constructible within required timeframe	X X Y Y X

NAME STATUS	SCOPE SUMMARY	DECISION FACTORS	
HA-4 ELIMINATED	Winslow Tap rebuild with widened transmission corridor, 3.3 MWs distributed energy resources (DERs), and 3.3 MW battery at Murden Cove sub, and connect new ferry electrification load (10 MW) as a curtailable resource	Meets all technical criteria • Does not meet PSE Transmission Planning guideline with load levels exceeding recommended limit of 15-20 MW for radial lines – Winslow Tap and Murden Cove Tap Feasibility of permitting Reasonable project cost Uses proven technology Constructible within required timeframe	X X Y Y X

Table A-6: Viable Alternative Comparison: Hybrid Alternatives[41] [42]

	Alternative HA-1	Alternative HA-2
	Scope	**Scope**
Primary Need: Winslow Tap Transmission Reliability	Transmission Loop (Winslow to Murden Cove)	Transmission Loop (Winslow to Murden Cove)
Primary Need: Substation Group Capacity	Ferry Curtailment: 10MW up to 182 hours 50% BESS@MUR: 3.3 MW/5 MWH 50% DER: 3.3MW	Ferry Curtailment: 10MW up to 182 hours 100% BESS@MUR: 6.6 MW/12.9 MWH
Primary Need: Winslow Tap Aging Infrastructure	Rebuild Transmission Line-Replace Poles & Wire, Improve Corridor Access, Acquire Necessary Rights & Veg Mgmt	Rebuild Transmission Line-Replace Poles & Wire, Improve Corridor Access, Acquire Necessary Rights & Veg Mgmt
Total Cost Estimate Range (Base to High)	$38.1 million to $76.2 million	$41.8 million to $83.6 million
Decision factors	- 10 year solution - Add with growth - New operational strategies needed - Local EE and DR	- 10 year solution - Add with growth - New operational strategies needed

[41] Costs are estimate based on similar past projects in other areas of PSE service territory. Does not include site-specific engineering.

[42] The costs shown for the wires portions of all alternatives are capital investment costs.

Appendix B Addressing Transmission Reliability Need

This section describes PSE's recommended approach to address the Bainbridge Island transmission reliability need, specifically the Winslow Tap transmission outages, by building a new transmission line (loop) that connects Winslow and Murden Cove substations. This section describes the looped transmission configuration for Bainbridge Island and its benefits in greater detail.

As described in the Bainbridge Island Electric System 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[43] transmission line from Port Madison substation to Winslow substation.

Key observations regarding Winslow Tap transmission outages over the 5 year period between 2013 and 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[44]
- Limited distribution substation capacity for backup of Winslow substation

Figure B-1 shows an aerial map of the Winslow Tap transmission line outages over the 5 year period 2013-2017, and outlines the cross country section of line with difficult terrain and poor access. As shown in the figure, outages are spread across the entire line due to vegetation exposure on the entire line route.

[43] A radial transmission line has a single source. The Winslow Tap is a radial transmission line with source at Port Madison substation. A substation served by a radial transmission line loses power when there is an 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 B-1: Aerial Map of Winslow Tap Transmission Outages (2013-2017)

Applicable Transmission Planning Guidelines – Looped Transmission

PSE Transmission Planning Guidelines state *"a radial transmission line should only be used to serve a single bank substation when conditions are such that load can be picked up by surrounding substations through distribution switching to accommodate forced or planned outages. The load should be no more than 15 to 20 MW. The load should be mostly residential in rural areas where lines built along public rights-of-way…."*

PSE recommends a transmission system upgrade for Bainbridge Island in accordance with its Transmission Planning Guidelines, from the existing radial transmission lines to a looped transmission system by building a new transmission line (loop) connecting Winslow and Murden Cove substations.

The existing radial transmission lines to Winslow and Murden Cove substations do not meet PSE's Transmission Planning Guidelines for the following reasons:

- Peak load served from Winslow and Murden Cove substations has reached 24 MW and 28 MW respectively, which exceeds the planning guideline load threshold of 15 to 20 MW for radial transmission service.

- Both substations cannot be offloaded to surrounding substations for a forced or planned transmission outage (on radial line) during high loading in winter months.
- Per the guideline, radial transmission lines should serve mostly rural residential loads. Winslow and Murden Cove substations serve an urban customer base with significant commercial and industrial loads such as the Bainbridge Ferry terminal in downtown Winslow area.
- A significant portion (35 percent) of the Winslow Tap radial transmission line is not along public rights-of-way but on cross country corridor with poor access and difficult terrain that results in longer outage restoration time.

The transmission system upgrade will significantly improve transmission reliability on Bainbridge Island (notably for Winslow Substation) and provide operating flexibility for the transmission system on the island. A looped transmission system is recommended for the following reasons:

- The looped transmission system is routinely utilized by PSE to serve urban areas in other parts of its service territory and is a significant improvement in reliability over a radial transmission system.
- A looped transmission system provides transmission service for a substation in the event of loss of one of the two transmission sources for a substation, and provides operating flexibility on the transmission system to take out one transmission source for planned maintenance. The probability of both transmission sources going out concurrently is low, but possible.

Recommendation – Build Looped Transmission Configuration

The looped transmission alternative builds 3 to 3.5 miles of new transmission line connecting Winslow substation to Murden Cove substation and creates a transmission loop. Figure B-2 shows an electrical one line diagram comparing the existing radial transmission system on Bainbridge Island to a looped transmission system.

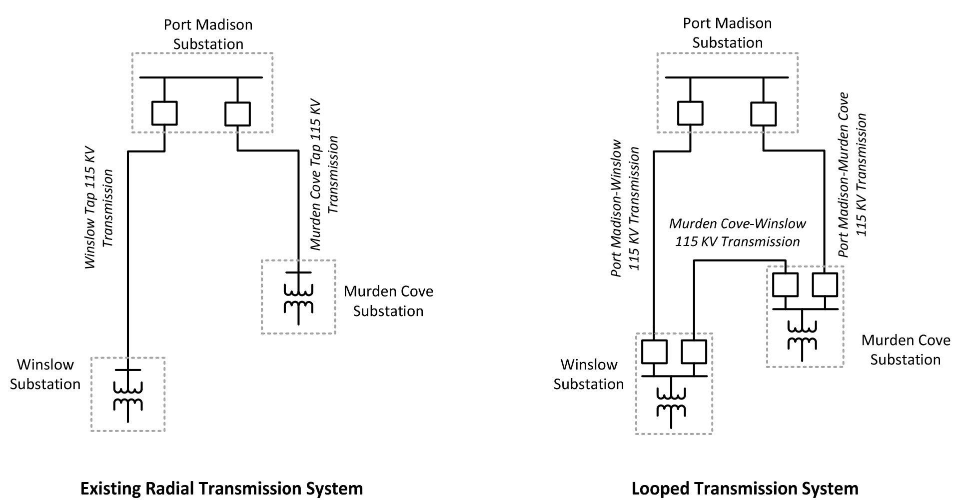


Figure B-2: Looped Transmission System Upgrade for Bainbridge Island

Benefits of a looped transmission system for Bainbridge Island:

- The looped transmission system will bring a second transmission source to Winslow substation besides the existing Winslow Tap. In this case, loss of the existing Winslow Tap will not cause outage to Winslow Substation, as it will remain energized from the second transmission source (new line from Murden Cove substation) and maintain service to Winslow customers.

- The looped transmission system provides reliable transmission service for both Winslow and Murden Cove Substations.
- The looped transmission system provides operating flexibility on the transmission system for planned transmission outages without impacting customers.
- PSE will plan good access for the new transmission line (loop) from Murden Cove Substation to Winslow Substation and therefore, this new line will be superior to the Winslow Tap in terms of access; and may be quickly put back in service if taken out by an unplanned outage.

Appendix C Addressing Transmission Aging Infrastructure Need

This section describes PSE's recommended approach to address Bainbridge Island's transmission aging infrastructure need, specifically for the Winslow Tap transmission line, by rebuilding the Winslow Tap transmission line in its existing corridor. This section describes the options analyzed and considerations in reaching the recommendation for the line rebuild.

The Winslow Tap transmission line was built in 1960 and constructed with wishbone type crossarm design. PSE considers the wishbone crossarms of 1960s-70s vintage a reliability risk because they have started to fail in other parts of PSE service territory. Because of these concerns, PSE contracted Osmose Utilities Services to conduct a field inspection on the Winslow Tap transmission line in January 2019.

Key findings of the 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 requires replacement in 1 to 3 years. A "priority reject" is considered critical condition and requires emergency replacement in 1 to 3 months.

Options Analyzed

PSE considered different options to address the Winslow Tap aging infrastructure need, such as:

- Reframe poles (50% of line crossarms)
- Replace and reframe poles (50% of line poles and crossarms)
- Replace and reframe all poles and crossarms (100% of line poles and crossarms)
- Fully rebuild Winslow Tap by replacing poles, crossarms and line conductor

The analysis of these options required consideration to different factors such as cost effectiveness, asset life, engineering design and construction, and customer and environmental impact. These considerations are discussed below.

Cost effectiveness:

PSE determined that, although the wishbone crossarm is the failing element on the Winslow Tap, reframing an aged pole to replace a reject wishbone crossarm was not cost effective. This is because reframing a transmission pole requires much of the same rigor of permitting, engineering design, construction access, line shutdown, vegetation management, site restoration and customer outreach as would be needed for replacement of the pole and its attachments (crossarms, guys, insulators). The incremental cost of pole replacement was marginal and PSE considered full pole replacement a cost-effective measure to address a reject wishbone crossarm, and results in longer asset life.

Asset Life:

The 2019 Winslow Tap line inspection indicated that 50% of the line crossarms that were of wishbone construction design were in reject condition and nearing end of useful life. PSE pole replacement guidelines require replacement of pole equipment in reject condition within 3 years. PSE strongly believes that a greater number of poles and crossarms could be added to reject status and become new candidates for replacement by the next 10 year inspection cycle (2028). This is for the following reasons:

- Uniform age of equipment on the line (mostly 1960 vintage) and similar field conditions in the transmission corridor will likely lead to other equipment previously deemed to be in acceptable condition to start failing in a similar manner in the near term.
- PSE has seen a noticeable increase in the number of *reject* and *priority reject* poles on lines that are older than 60 years. Based on the age of Winslow Tap line (mostly 1960 vintage) and observed equipment failure data, it is likely that Winslow Tap non-reject poles and arms will deteriorate to reject or priority reject status by the next inspection cycle.
- The 2019 Winslow Tap inspection was a visual inspection of crossarms from ground level. There is possibility of additional wishbone crossarms with internal decay or decay unidentified due to limitations of a visual inspection, especially one from ground level.
- The wishbone crossarm is not a standard construction for PSE since the 1980s. A reject wishbone crossarm replacement to current PSE standard transmission framing can require a taller pole and potentially impact neighboring structures, leading to greater number of pole replacements.

PSE also believes that some poles may be in worse condition near the crossarm level than that reported from strength testing at ground level. Due to limited access and no corridor pathway to bring a bucket truck, most of Winslow Tap transmission poles need to be climbed by crew to work on the line. Given the age of these poles, the crew may find some of these aging poles unsafe to climb and require pole replacement.

PSE does not have an age criteria for line conductors, however some utility research publications recommend a mean useful life of 70 years for existing older ACSR[45] conductors for planning purposes. The Winslow Tap 4/0 ACSR conductor is 1960 vintage and will reach its expected useful life of 70 years after the 10 year planning horizon (in 2030).

Engineering design and construction

PSE determined that the engineering design and construction will be most efficient with a single stage full line rebuild. Replacing only the existing identified reject condition crossarms will be a short term measure and will not address replacement of remaining wishbone crossarms or other line equipment that are expected to fail in the near future. PSE believes that rebuilding the Winslow Tap in multiple phases will not be cost effective due to reworking multiple tasks in preparation of the upgrades – project management, customer outreach, project permitting, vegetation management, site restoration, coordinating line shutdowns and mobilizing crews to the corridor for construction.

[45] Aluminum conductor steel reinforced (ACSR) is a type of high strength stranded conductor with a central steel core surrounded with one or more layers of aluminum strands

Customer and Environmental Impact

PSE believes that multiple phases of construction to replace Winslow Tap aging infrastructure will not be favorable to customers and will have a greater impact to the environment. A single stage full rebuild of the Winslow Tap provides a comprehensive solution that will replace all aged infrastructure – poles, crossarms and conductors and extends life of Winslow Tap transmission line for the long term.

Recommendation

Based on the considerations discussed above, PSE recommends a complete rebuild of the Winslow Tap transmission line to replace all poles, structures and line conductor. This will address aging infrastructure need and provide enhanced reliability for customers. A high level scope for the improvements includes:

- Replace 100% of poles and structures on the line. Replace line conductor with bigger conductor.
- Review and acquire rights along the corridor as necessary to expand the Winslow Tap transmission corridor in the cross-country section to current PSE rights-of-way standard and clear vegetation on the corridor.
- Create a graveled access road along the transmission corridor in the cross country section to facilitate a patrol pathway.

Appendix D Navigant Consulting Report

See *Bainbridge Island Non-Wires Alternative Analysis,* Navigant Consulting, July 9, 2019.

Appendix E Quanta Technology Report

See *Energy Storage Planning to Support Bainbridge Island, Final Report,* Quanta Technology, April 23, 2019, Version 4.

Appendix F 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).