Case Study: Seattle Waterfront Networked Microgrid Evaluation

INTRODUCTION

Many ports and waterfronts are evaluating alternative electrification efforts, including electrification of passenger and vehicle ferries. In Seattle, the Washington State Department of Transportation, in conjunction with Seattle City Light (the local utility) and the Port of Seattle, are working to deploy a hybrid electric ferry and provide charging at Seattle's Colman dock. As part of this ferry electrification effort, Seattle City Light is considering including a large battery energy storage system (BESS) to help "buffer" the ferry charging. The "buffer" provides energy arbitrage and spreads out the large amount of power needed to recharge the ferry to times when the ferry is out of the dock – rather than one very large peak for 15 minutes, the battery storage allows it to be a smaller power value over a longer duration. This initial BESS concept served as the jumping off point to explore an expanded microgrid concept via a notional test system that incorporates additional distributed energy resources (DER) and infrastructure upgrades to the local distribution infrastructure at the Seattle Waterfront and neighboring Port of Seattle properties. This case study examined the potential for secondary use of the BESS within a networked microgrid during the scenario of a large-scale power outage, such as a natural disaster.

OVERVIEW

To enable the transition from a traditionally fossil-fueled ferry to a hybrid electric version, a charging connection for the ferry and the capability to source approximately 25 MW of peak power for charging is needed at Seattle's Colman dock. The first ferry route using the hybrid-electric powertrain has a recharge dwell time (where it is in dock unloading and loading passengers and vehicles before the next run) of only around 20 minutes. To level out the charging power demand, Seattle City Light (SCL) is exploring the deployment of a large BESS to reduce the magnitude of the additional utility grid power required during charging. This battery allows the power draw to the grid to be a lower value over a longer duration, rather than the 25 MW charging peak power over a shorter duration. This helps to not only mitigate some infrastructure upgrades to serve the ferry charging load, but also helps SCL avoid peak demand charges from the serving transmission authority, the Bonneville Power Administration.

Ferry charging represents the "blue sky" condition; that is, the typical every-day use case of the BESS – reducing peak power requirements by smoothing out the peaky/intermittent load of the hybrid ferry charging between service runs. However, the BESS is also an asset that could be deployed during a significant power outage event, such as a power outage associated with a large earthquake. In a Cascadia Subduction Zone event (large earthquake), there may be significant damage to the bulk power system serving the Seattle area, as well as damage to the interstate and intrastate transportation infrastructure. In this scenario, the waterfront and Port of Seattle would be a significant asset, providing a viable route for delivering disaster relief, recovery supplies, and emergency response personnel. This study examined if a networked microgrid could be formed, utilizing the BESS and other resources on the Seattle Waterfront and nearby Port of Seattle, to serve critical loads and emergency supply delivery operations, and what considerations may be involved in that emergency mode of operation. For information on networked microgrids, please see the “Types of Microgrids” section in the Port Electrification Handbook.

Figure 1 shows a notional version of the test system composed of electrical loads, different types of switchgear to connect/disconnect parts of the system, and any generation devices like a BESS, a fuel-based generator, or photovoltaic array. Light magenta shading represents the networked microgrid examined for this study – this is composed of multiple individual microgrids, which are represented by the dashed magenta boundary lines. It is important to note that while this test system is based off the Seattle Waterfront, Port of Seattle, and Seattle City Light infrastructure, it includes many speculative upgrades and DER deployments – many of these are still speculative, although some may be in the design or approval stages of development. Some connections, like the additional submarine cables in the bottom of the figure, are purely conceptual, resulting from broad discussions about potential upgrades/changes to the current waterfront and Port of Seattle systems. In the test system, the BESS (at figure location T-N) is connected through the existing distribution system to ship-to-shore cranes at figure locations T-K-1, T-J, T-B, and T-C. Other electrical generators are also included in the microgrid design: connections to photovoltaic (PV) arrays at figure locations T-J and T-B, electric vehicle charging with potential vehicle to grid (V2G) operation at figure location T-J, and biodiesel generators at figure location T-C. The PV and biodiesel generators are especially important because they not only provide additional power to supply critical loads and relief operations, but also provide power to charge the BESS with any excess generation. The ability to recharge the BESS means it can be used as a power source at night (when the PV is not generating), or as a voltage and frequency regulation device on the networked microgrid.

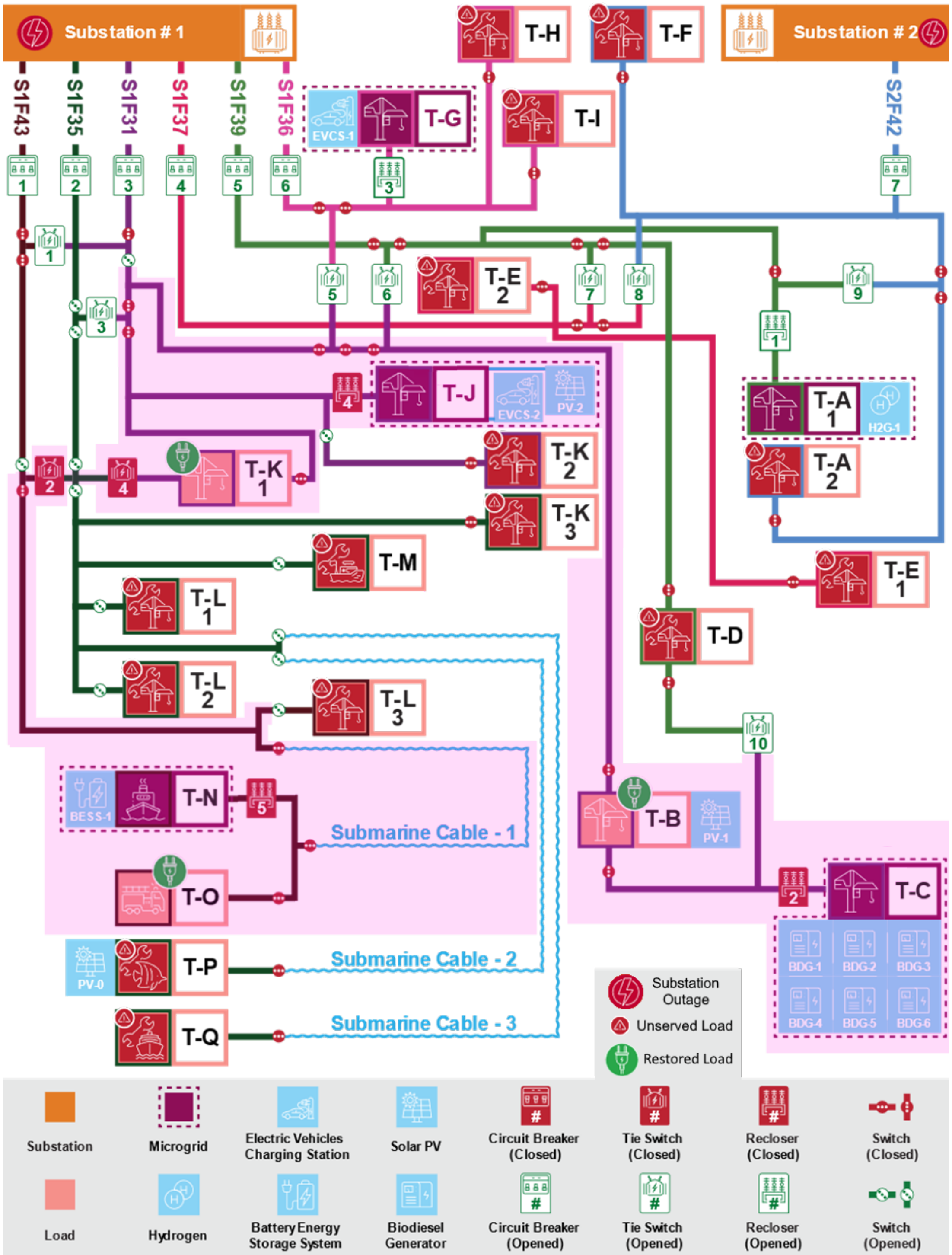

Figure 1 – Notional Seattle Waterfront and Port of Seattle test system configured for a networked microgrid. Red and magenta icons represent the type of load connected at that location. Dark red icons (with the "Unserved Load" icon) represent loads that are disconnected and not functioning in the current configuration. Line colors represent the primary feeder circuit associated with that line (e.g., black = S1F43).

The test system in Figure 1 was evaluated for different load scenarios (such as various large ship-to-shore cranes picking and dropping loads) and different system configurations (such as various combinations of generators operating and switch positions). The detailed transient system response was analyzed to examine if the connected test system could successfully operate, and whether any load scenarios or system configurations required adjustments.

It's important to point out that the networked microgrid test system presented here assessed only the electrical and physical responses of the system. Use of the utility electrical distribution system, numerous metering connections and crossing of "fencelines" would be necessary to implement this system in the real world. This would require several authorities holding jurisdiction to either enact new regulations to allow power to cross boundaries or be exchanged by non-utilities, or grant exemptions to their current regulations. Compensation mechanisms for the owners or operators of the different assets would also likely be necessary. The system in Figure 1 assumes all assets want to participate for the good of the community and aiding in recovery, but compensation would be a key element to further incentivize the various individual owners to participate in this networked microgrid structure.

LESSONS LEARNED

- ✓ DER assets deployed for other purposes during normal mode operation and/or individual microgrids can be joined to a networked microgrid to enable larger operations during emergency mode operation.
- ✓ Detailed electrical analysis revealed the different assets can coexist on the electrically-connected study test system with no poor interactions.
- ✓ Networked microgrid connections of many different assets are physically and electrically possible, but many regulatory and protective elements need to be addressed before this could be deployed practically.
- ✓ Secondary use of a BESS in a microgrid can provide backup power capability to nearby assets, but will be of limited value if there is no way to recharge the BESS during longer grid power outages.
- ✓ The test system networked microgrid could provide power to several ship-to-shore crane groups, but could not operate all four groups/terminals of the networked microgrid simultaneously. More generation would be needed to operate the microgrid for extended periods, as the energy storage augments the deployed generation on the system and needs way to recharge itself.

PROJECT CONSIDERATIONS

Potential Planning Steps:

- Catalog the loads and usage patterns (load profiles) that require backup power to maintain port operations.
- Assess opportunities for everyday operational ("blue sky operations") use of the microgrid elements to provide additional benefit or cost savings to system operations, beyond the backup power benefit.

- Determine if additional switchgear is needed to make the connections between distant assets to form a networked microgrid at the proposed location.
- Engage the local utility to understand all requirements for grid interconnection of the microgrid assets, including any limits on operation or restrictions on power transfer.
- Engage other stakeholders (e.g., local fire marshal, city council, port tenants) to determine any legal restrictions or stakeholder considerations for deploying a networked microgrid at the proposed location.
- Evaluate the design operating duration for the networked microgrid and determine if additional generation or fuel sources are needed to meet this operating duration.

Potential Implementation Steps:

- Assemble the project team, likely to include sustainability, maintenance, operations, legal staff, and external collaborators such as utility representatives, fire department, and the environmental assessment office.
- Engage local utility to evaluate protective devices and if they need advanced control schemes or multiple settings groups to handle the connection of the networked microgrid assets.
- Develop scope, schedule, budget accounting for funding requirements, equipment availability, utility timelines, and required stakeholder coordination.

Potential Iteration Steps:

- Evaluate if additional electrical generation resources are needed to improve disaster recovery operations, and whether they can be connected to the networked microgrid.
- Evaluate if adjustments to the device control to adjust generator runtimes (for maintenance and fuel use) and generator interactions are necessary.
- Evaluate performance of deployed generation, energy management, and switching equipment, including improved uptime for operations, emissions impacts, outage or large infrastructure costs deferred, efficiency impacts, and other lessons learned.