Energy Storage Control Design and Valuation for Puget Sound Energy Microgrids

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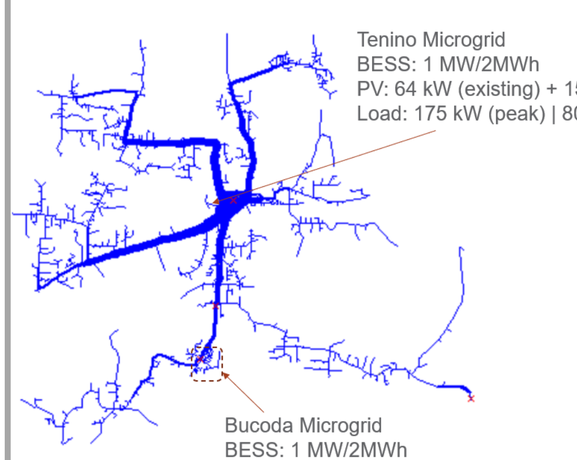
ABSTRACT

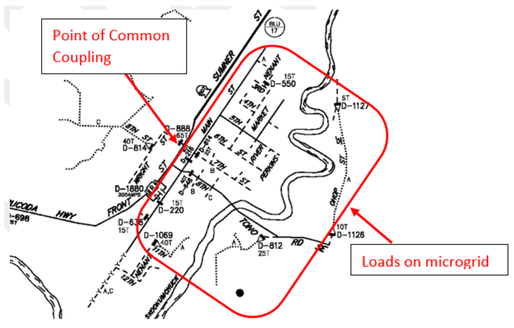
As part of the third round of funding from the Washington State Clean Energy Fund (CEF), the Washington State Department of Commerce granted $2.7 million to Puget Sound Energy (PSE) to design, deploy, and test utility-scale microgrids. PNNL has worked with PSE to evaluate different design options for the two microgrids at the Tenino school district and Bucoda residential area. For the Tenino microgrid, PSE plans to install a 150 kW in addition to a 64 kW existing photovoltaic (PV) generation system paired with a lithium-ion battery energy storage system (BESS). For the Bucoda microgrid, only BESS is considered. To better understand the potential benefits and cost-effectiveness of the two microgrids, comprehensive techno-economic assessments have been performed considering different BESS sizing options and stacked value streams. A detailed power flow and hosting capacity analysis is performed to understand the impacts of deployments on PSE's system. Moreover, a risk-aware control strategy for BESS is under development for both microgrids.

MICROGRID OVERVIEW

Locations and Specifications of Microgrids

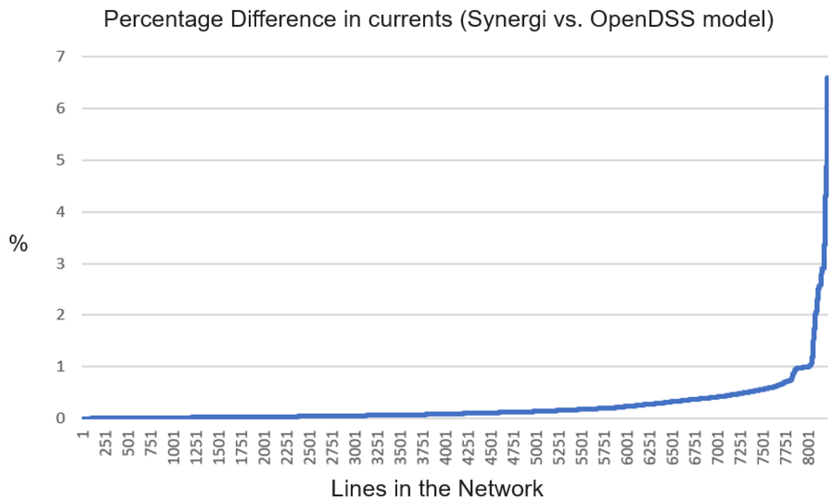


Bucoda Circuit Map



NETWORK CONVERSION, VALIDATION AND HOSTING CAPACITY

- **Model Conversion**: CIMHub used to convert Synergi model into OpenDSS and GridLAB-D models
- **Model validation:** Performed using power flow results provided by PSE as the baseline
- **Hosting Capacity Analysis**:
  - Holistic analysis to determine voltage and thermal violations caused by BESS and PV.
  - No network violations for proposed PV and BESS sizes. Violations found for higher power outputs from PV and BESS

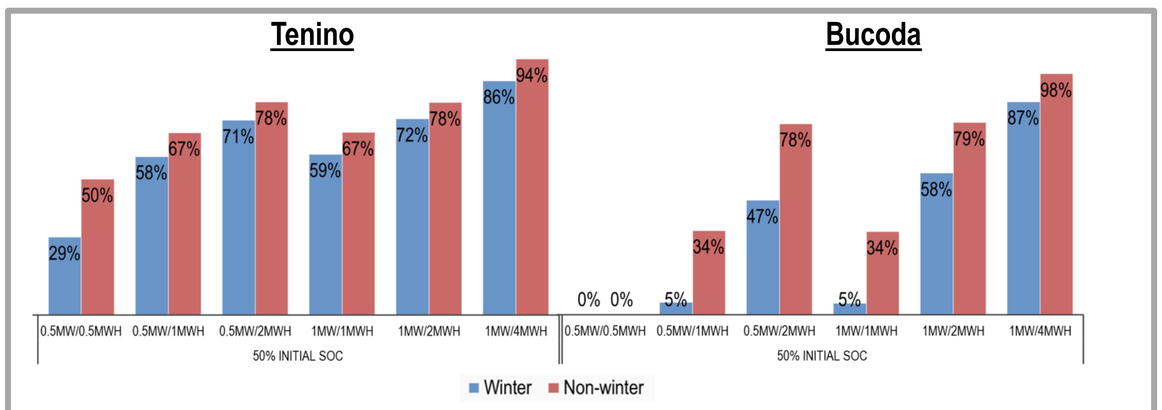


TECHNO-ECONOMIC ASSESSMENT

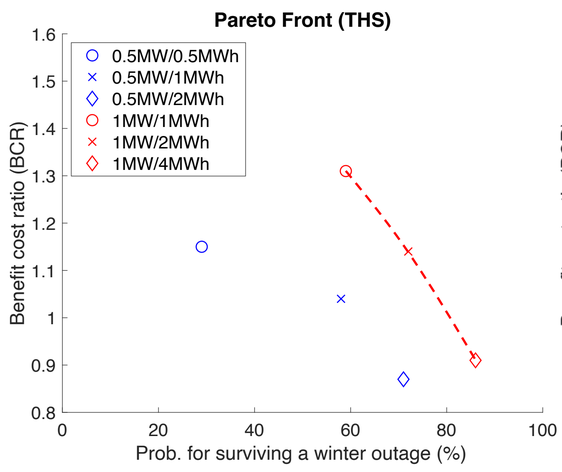
Assumptions and Input Parameters:

- Project life: 10 years
- Discount rate: 7.5%
- Insurance rate: 0.48%
- Property tax rate: 0.56%
- Income tax rate: 24.9%
- Tax credit for PV: 26%

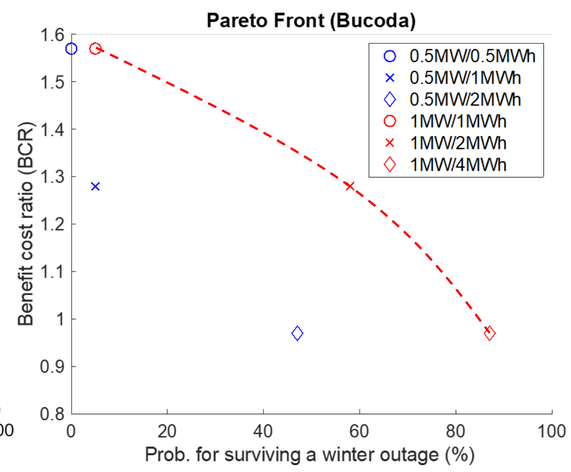
- Microgrid's resilience is quantified by survivability, the probability to survive random outages.
- Scenarios analyzed with different initial SOCs, BESS durations, and winter/summer seasons (we evaluated 1000 random trials for each scenario).



Tenino Microgrid



Bucoda Microgrid

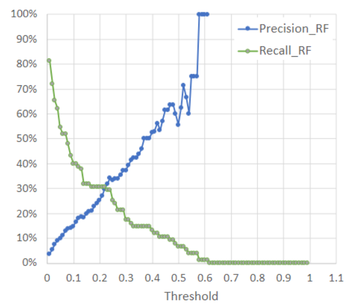


- Benefits are largely driven by frequency response (49%) and capacity value (26%).
- The net benefits and benefit-cost ratio (BCR) decrease with increased BESS duration.
- The survivability against a random outage increases with increased BESS duration.

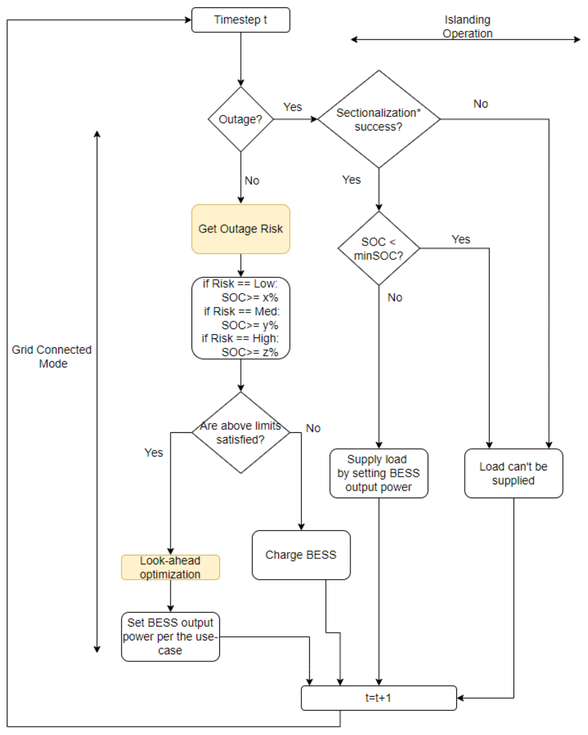
RISK-AWARE CONTROL DESIGN

- A risk-aware control framework is under development for BESS at Tenino and Bucoda Microgrids
- Resiliency is considered the primary use case whereas energy shifting is the secondary use case
- Using learning-based methods, an outage risk quantification model has been developed to inform real-time BESS operation
- Economic and resilience metrics are used to quantify control performance

Outage risk model - Precision vs Recall



High-level Control Flow



CONCLUSIONS AND FUTURE WORK

- With a proper design, the microgrid systems can be cost-effective for bundling grid services while improving distribution resilience by supporting the local load during grid outages.
- A risk-aware control can help improve resilience and economic performance compared to traditional methods using static energy reserve.

Acknowledgements

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