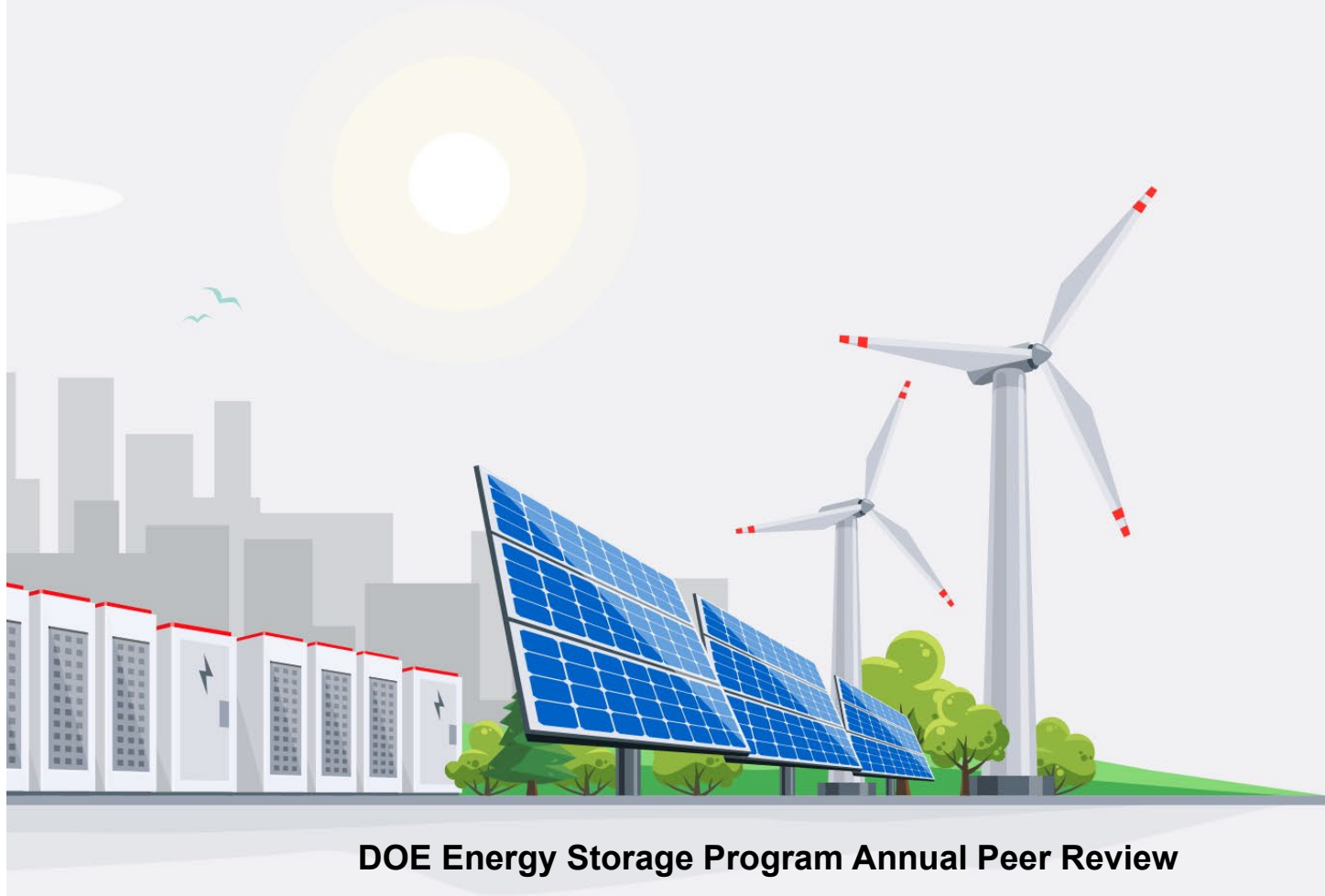
Pacific Northwest
NATIONAL LABORATORY

Supporting Grid Deployments and Field Validations of Energy Storage at PNNL

Presented by

Diane Baldwin

Project Manager – Renewables Integration



DOE Energy Storage Program Annual Peer Review

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U.S. DEPARTMENT OF ENERGY BATTELLE

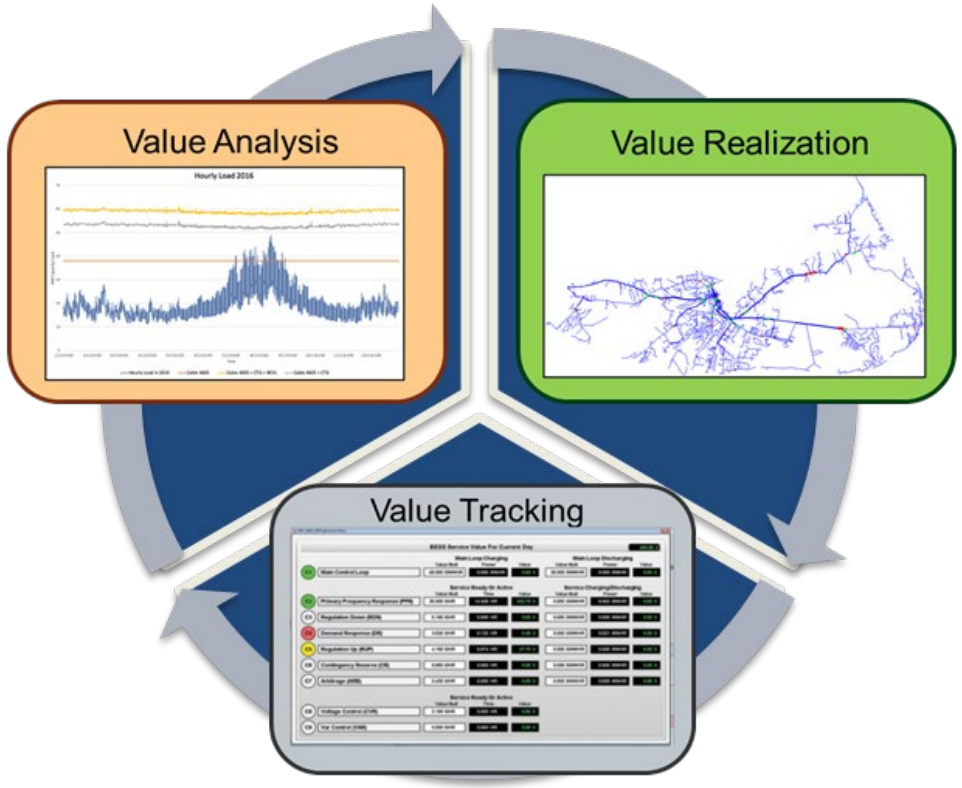
PNNL is operated by Battelle for the U.S. Department of Energy

Themes

- Innovation Takes Many Forms in Deployment
- Testing Provides Key Insights
- Looking Ahead – Utilities Explore Energy Storage and Energy Equity
- Acknowledgements

Innovations in the Grid Deployments and Field Validations Program at PNNL

- Microgrids of increasing interest
  - resiliency and investment deferral
  - community benefits
- Battery technologies
- Energy storage as workforce development
- Sharing benefits between utilities and customers



PNNL GD & FV Program Actively Supports the Energy Storage Value Chain

Credit: Jan Alam et al, 2021

Small Island Co-op Utility Explores Microgrid Solution

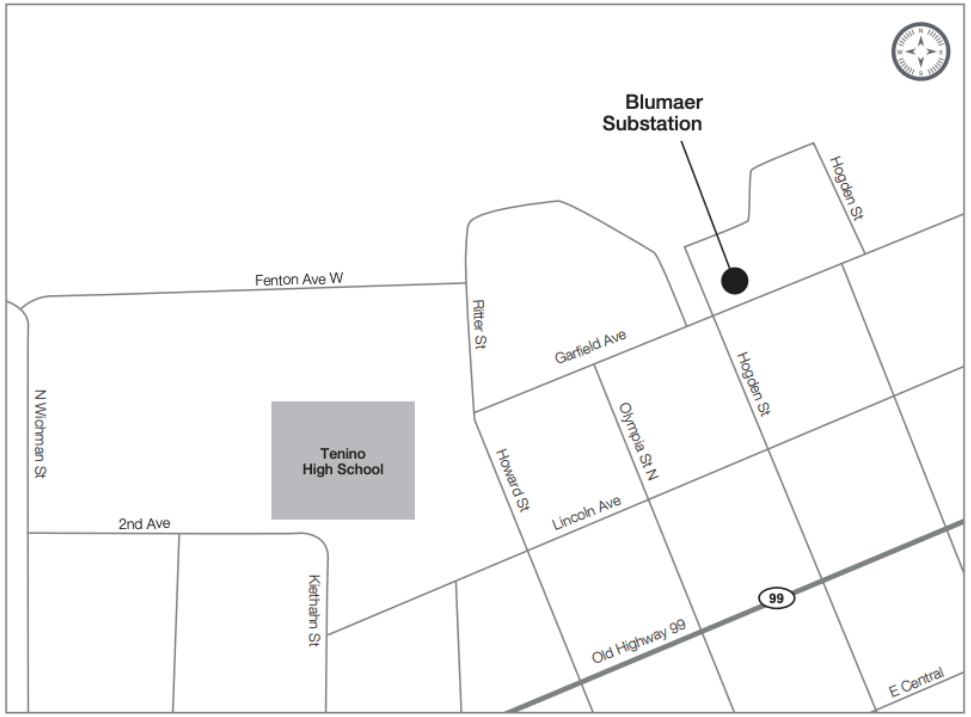
- OPALCO BESS/PV at Decatur Island
- ESS sized at 1MW / 2.6 MWh co-located with PV sized at 504 kW (DC)
- Utility objectives include
  - Demand charge reduction
  - Load shaping
  - Submarine cable upgrade deferral
  - Outage mitigation
- PNNL focus in FY22 - testing
  - Baseline testing
  - Use case testing
  - Validation of the techno-economic analysis
- Lessons learned – vendor controls do not support stacked values

Technical Team: Alasdair Crawford, Di Wu, Vish Viswanathan, and Diane Baldwin

Large Investor-Owned Utility Commits to Multiple Microgrids

- Puget Sound Energy: Tenino High School and Bucoda Microgrids
- ESS sized at 1 MW / 2 MWh for both systems; Tenino HS paired with PV (214 kW)
- Utility objectives include
  - Resilience improvements “end of the line”
  - Solar integration
- PNNL focus in FY22 – distribution system modeling and economic assessment
  - Distribution modeling and initial hosting capacity analysis (HCA)
  - HCA automation alternatives explored
  - Completed economic analysis in the base case
  - Completed resilience analysis
  - Sensitivity analysis
- Lessons learned – the human resources are the “supply chain” most constrained

TENINO HIGH SCHOOL
LEARNING TODAY, LEADING TOMORROW



Technical Team: Di Wu, Bilal Bhatti, Xu Ma, Tom McDermott, Yanyan Zhu, Tao Fu, and Jason Hou

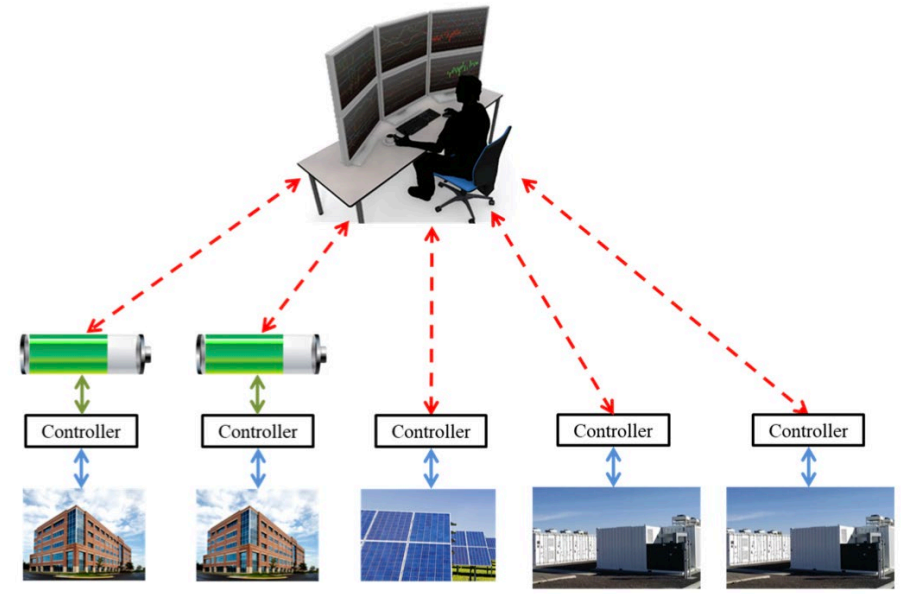
Energy Storage Workforce Development

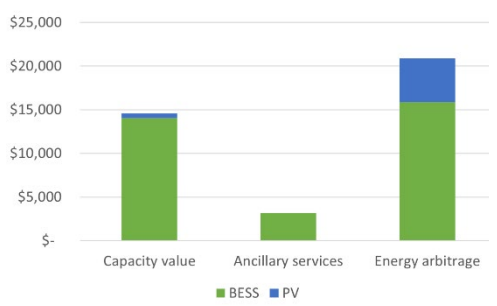
- Energy Northwest: Horn Rapids Solar, Storage and Training Center
- ESS sized at 1 MW / 4 MWh and PV (4 MW)
- Facility located on land owned by electrician union IBEW and leased by the Regional Education & Training Center – a training ground for utility-scale solar and battery techs
- Utility objectives include
  - Demand charge reduction
  - Solar integration
- PNNL focus in FY22 – testing
  - BESS troubleshooting and repair
  - Baseline testing / use case testing
  - Revision of techno-economic analysis
- Lessons learned – battery performance evaluation is critical to confirming real-world value

Technical Team: Di Wu, Alasdair Crawford, Xu Ma, Arthur Santos, Vish Viswanathan

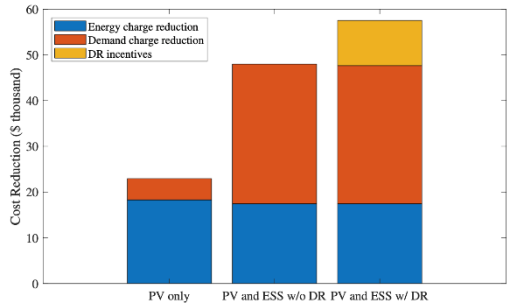
DER Assets Shared by the Utility and the Customer

- Avista Shared Energy Economy Model Pilot
- WSU Spokane Campus BESS/PV and building energy controls
- ESS sized at 0.7 MW / 1.8 MWh + 2 PV systems (200 kW)
- Utility objectives include
  - Maximize local use of solar energy
  - Load shaping between buildings
  - Enhanced outage mitigation with building controls
- PNNL focus in FY22 – revised economic model
  - Utility value
  - Customer value
  - Building modeling and transactive control
- Lessons learned – Coordination strategies utility-to-customer are key to maximize benefits





Utility Value

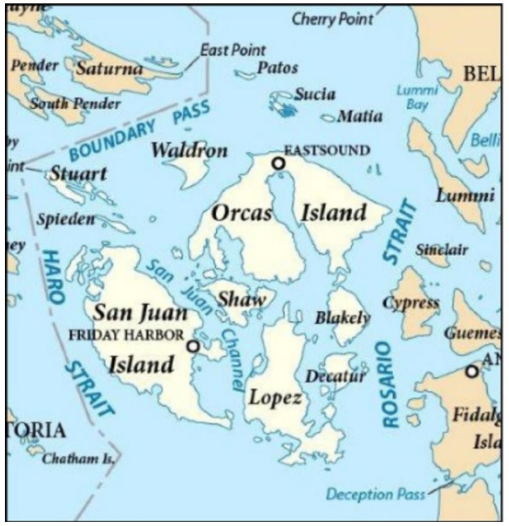


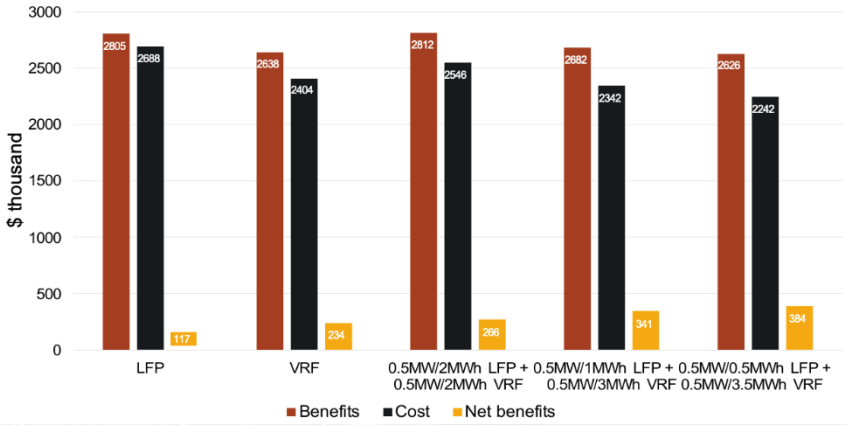
Customer Value

Technical Team: Di Wu, Tom McDermott, Rongxing Hu, Xu Ma, Sen Huang, Bowen Huang, Alasdair Crawford, Konstantinos Oikonomou, and Charlie Vartanian

Small Island Co-op Utility – Hooked on Energy Storage?

- OPALCO Hybrid ESS at San Juan Island
- Li-ion + long-duration ESS paired in one facility
- Li-ion and Flow Battery combined at 1 MW / 4 MWh
- Utility objectives include
  - Demand charge reduction
  - Load shaping
  - Submarine cable upgrade deferral
  - Resilience improvement
- PNNL focus in FY22 – techno-economic assessment
  - Optimal sizing and configuration of HESS – 5 options evaluated
  - Explore high-level controls approaches
- Lessons learned – "small" systems may struggle to attract vendors



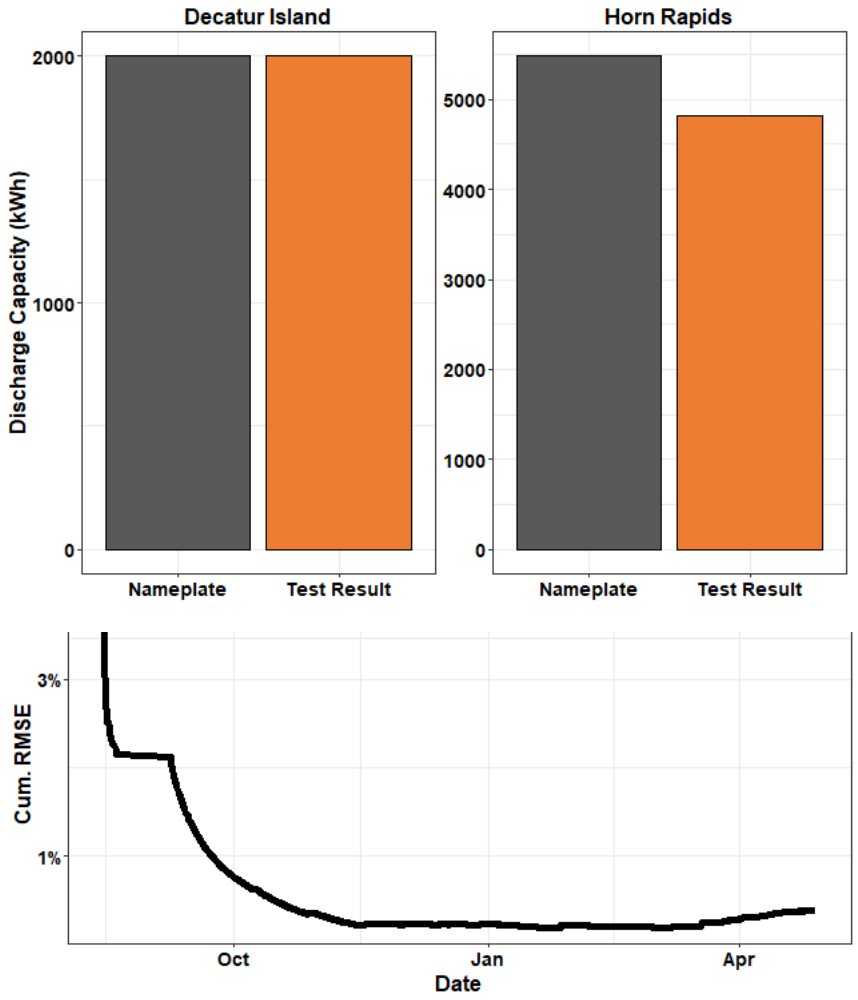


Technical Team: Diane Baldwin, Di Wu, Avijit Das, Sarmad Hanif, Alasdair Crawford, Vish Viswanathan

Battery Performance Evaluation – Two Case Studies

OPALCO Decatur Island BESS testing highlights

- Efficiency is highest in the 40-90% SOC range
- Efficiency measurements 94% avg up to 99.9%
  - unrealistically high - small errors in the meters probably contributed
- Discharge Energy of the system (2000 kWh) met expectations
- Data availability less than optimal – had to extract from vendor dashboard
- Time resolution of data was 60 sec -- made testing for rapidly changing signals difficult
  - System designed for energy applications (luckily)
- Data rounding for SOC to nearest 1% casts some doubt on other values like efficiency

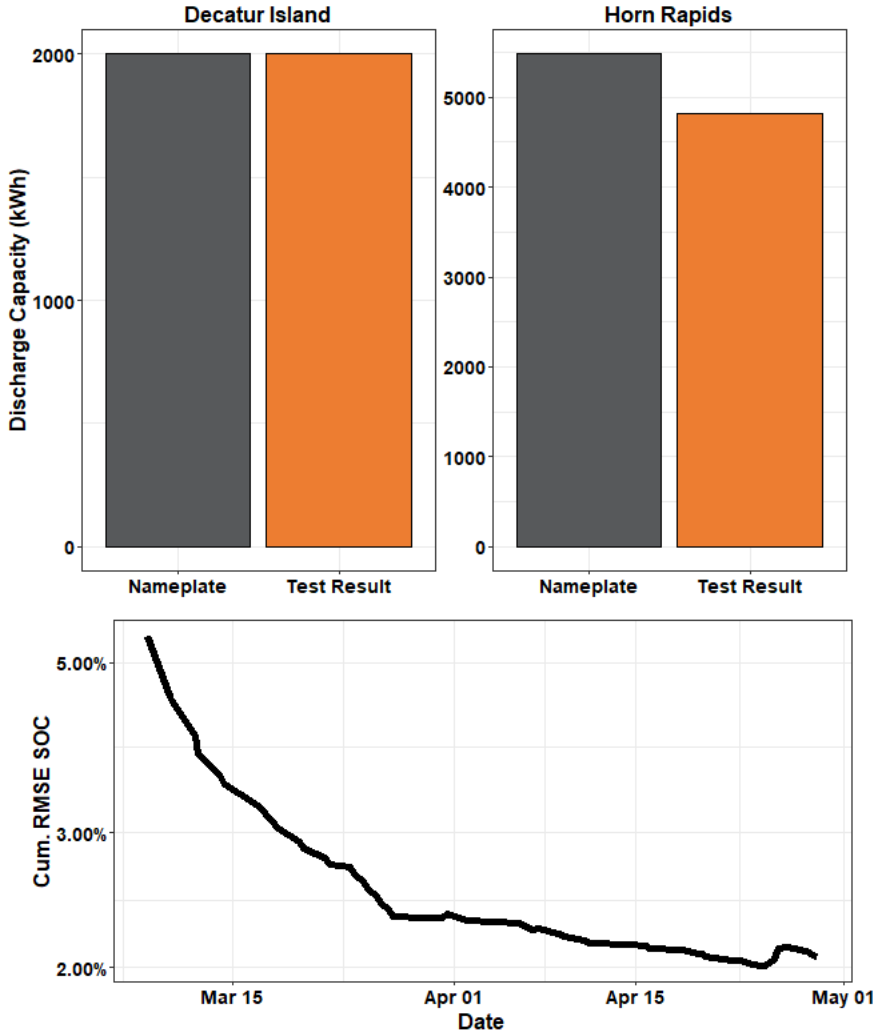


Decatur: Increasing confidence in battery model over test period

Battery Performance Evaluation – Two Case Studies

Energy NW Horn Rapids BESS testing highlights

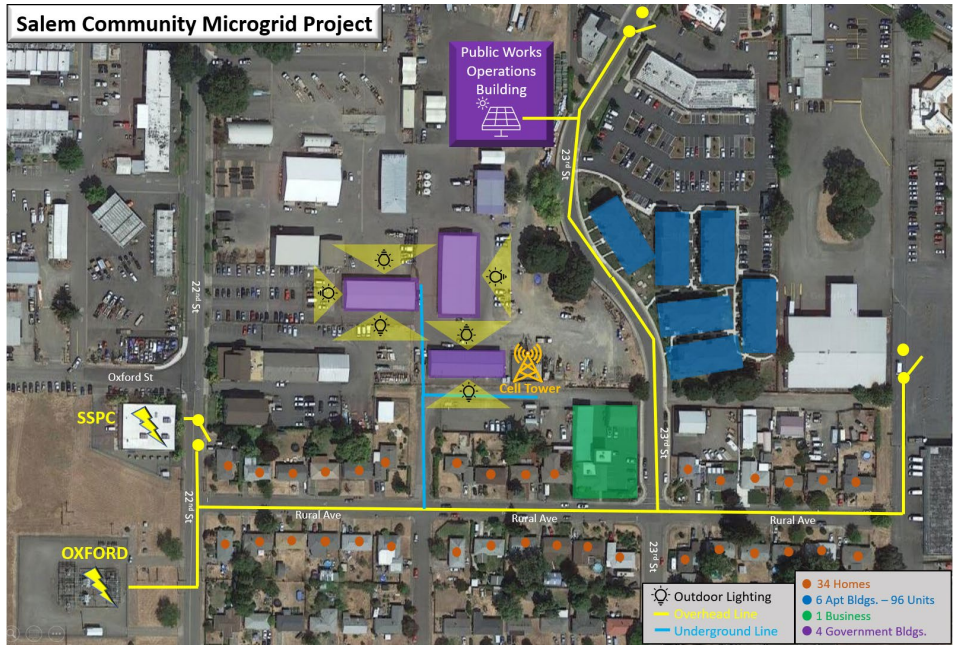
- Discharge Energy of the system less than assumed
  - 5400 kWh ONLY if you extrapolate to 100% SOC
  - SOC is kept to 5-95%, so in practice discharge energy is limited to 4800 kWh
- Vendor warranty guarantees energy availability per day – that translates to a discharge limit
  - 4000 kWh limit, testing had to straddle midnight hour
- System does not allow a rapidly changing signal
  - Manual entry was necessary for testing
- Vendor provided an API for obtaining data
- Out of the 18 strings, 2 were down during testing. Vendor was not able to resolve.
- Significant findings in battery performance evaluation led to revised economic assessment



Energy NW: Increasing confidence in battery model - longer test period needed

Energy Storage and Energy Equity
Salem Community Microgrid
Community Renewable Energy Grant Application

PNNL provided technical and grant writing assistance with a focus on community benefits and equity impacts. Upon grant acceptance, PNNL will continue to provide additional technical assistance in microgrid design, controls, and communication.



Arial view and schematic of proposed community microgrid

Project Highlights:

- Oregon's first community microgrid
- Critical hub for Citywide emergency response operations
- Provides resiliency to disadvantaged, socially vulnerable census tract
- Powered by 124 kW solar array on new Public Works building, repowered ESS at Salem Smart Power Center (up to 25MW), and PGE Oxford Substation
- Coupled with new electric vehicle charging stations

Acknowledgements

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Questions and Comments

Diane Baldwin, diane.baldwin@pnnl.gov