Pacific Northwest
NATIONAL LABORATORY

# Energy Storage Modeling and Valuation Tools

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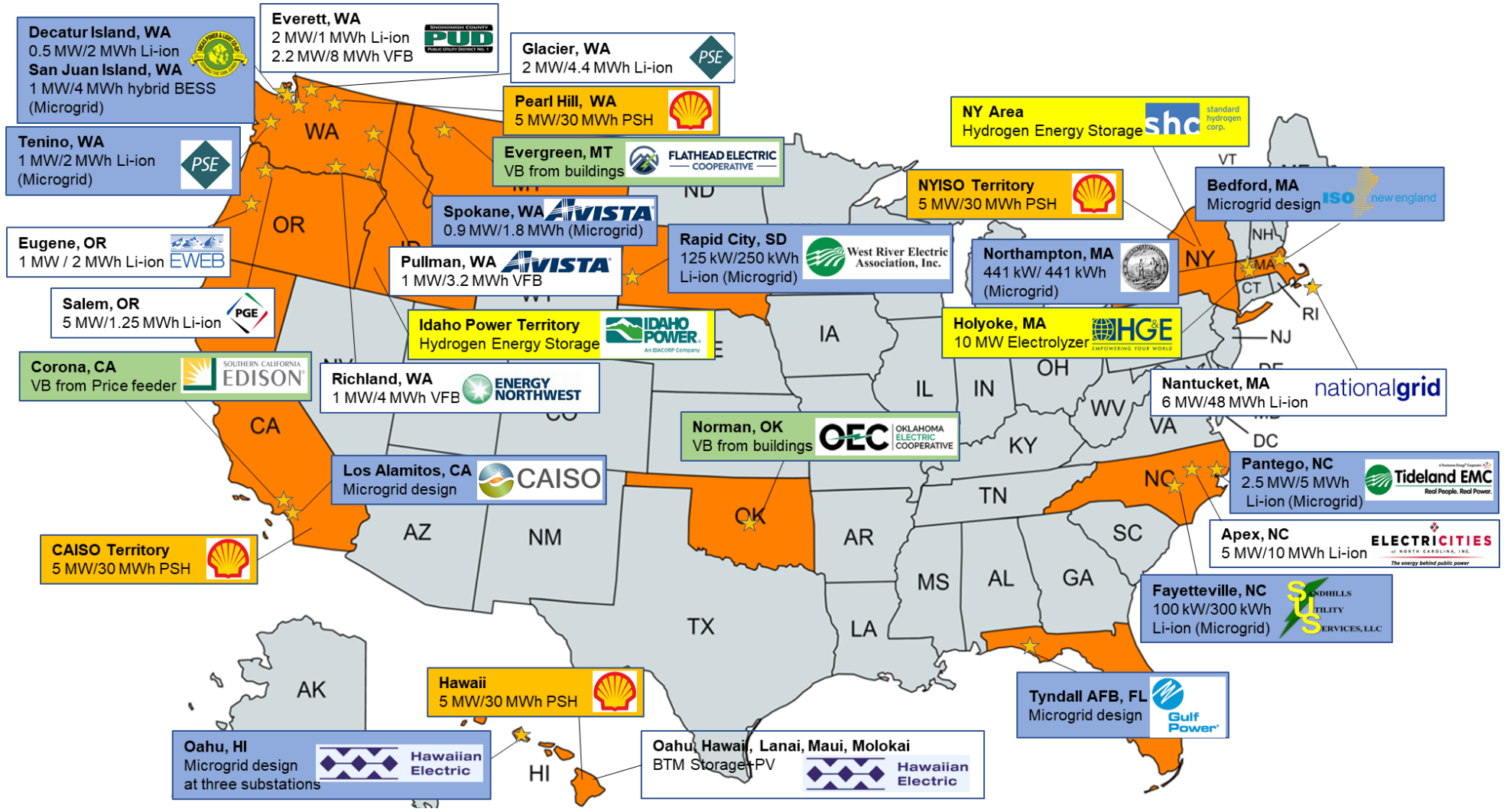
U.S. DEPARTMENT OF ENERGY BATTELLE

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

# PNNL Has Assessed Energy Storage and Microgrid Systems at More Than 30 Sites




Battery Energy Storage | Microgrids | Hydrogen | Buildings as Storage | Pumped Storage Hydro

# Clean Energy Fund Grid Demonstration Projects

**Decatur Island, WA**
0.5 MW/2 MWh Li-ion+0.5 MW PV

**San Juan Island, WA (Microgrid)**
1 MW/4 MWh hybrid BESS+3.2 MW PV

**Glacier, WA**
2 MW/4.4 MWh Li-ion

**Everett, WA**
2 MW/1 MWh Li-ion
2.2 MW/8 MWh VFB

**Richland, WA**
1 MW/4 MWh Li-ion+4 MW PV

**Spokane, WA (Microgrid)**
0.7 MW/1.8 MWh Li-ion+200 kW PV

**Tenino, WA (Microgrid)**
1 MW/2 MWh Li-ion+214 kW PV

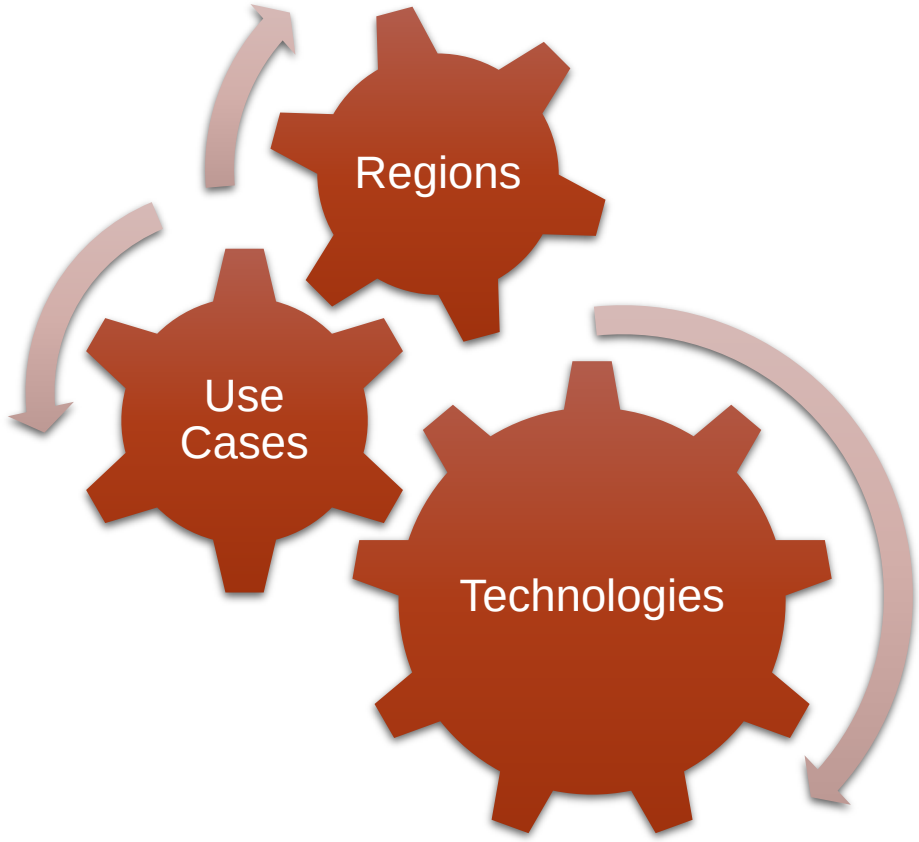
**Pullman, WA**
1 MW/3.2 MWh VFB

CEF I | CEF II | CEF III

# Needs of Energy Storage Analytics

## Numerous Factors Affect Storage Valuation

- ESS physical capability
  - Energy storage technology, design, and characteristics
- Use cases
  - Vertically integrated utilities, electricity markets, distribution utilities, and large C&I customers
  - Bulk energy, ancillary service, transmission-level, distribution-level, and end-user services
- Regions and systems
  - Different generation mix, grid infrastructure, market structures/rules, distribution system capacity, and load growth rate



# ESET™ Overview

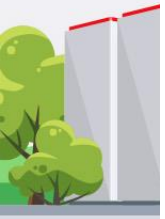
**A suite of applications that enable utilities, regulators, vendors, and researchers to model, optimize, and evaluate various energy storage systems for stacked value streams**

- Battery Storage Evaluation Tool (BSET)
- Microgrid Asset Sizing considering Cost and Resilience (MASCORE)
- Virtual Battery Assessment Tool (VBAT)
- Pumped-Storage Hydropower Evaluation Tool (PSHET)
- Hydrogen Energy Storage Evaluation Tool (HESET)


Web-based ESET: https://eset.pnnl.gov

# ESET Features

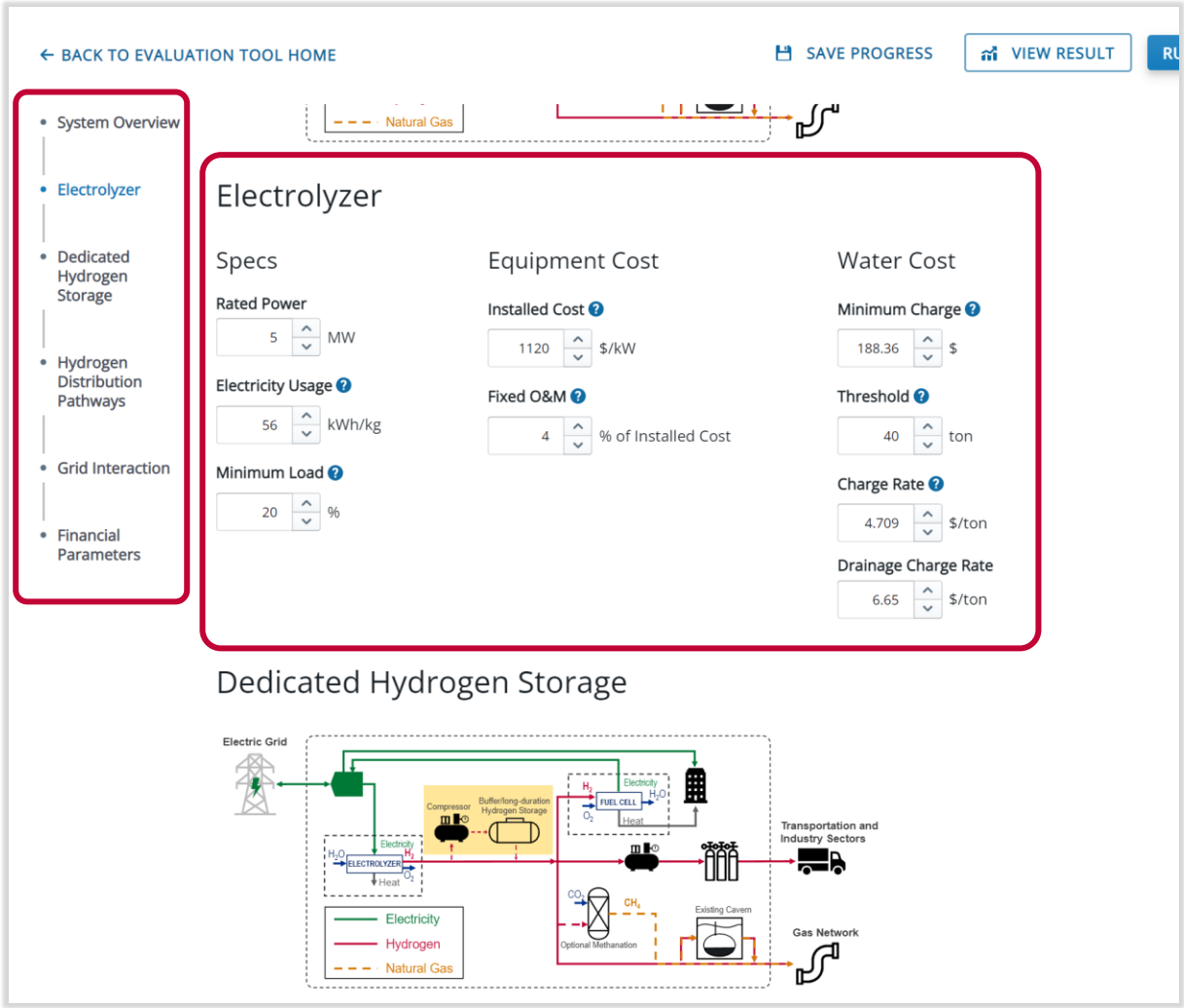
- **Various ESS models**
  - Different energy storage, hybrid, or microgrid systems
  - Appropriate levels of complexity and fidelity
  - Technical characteristics and physical capabilities
- **Advanced optimization and control methods**
  - Technically achievable benefits considering multi-dimensional couplings
  - Economic, environmental, and resilience
- **Built-in databases**
  - Electricity market prices
  - Utility rates
  - Renewables and building loads, and
  - Energy storage cost
- **Improved user experience design**



# User Experience Enhancements

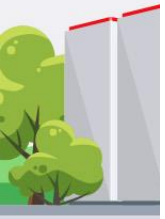
- Heuristic evaluation against web application usability principles
  - Home page
  - Navigation
  - Account management
  - Modules

- Improvements
  - Better visibility of system status
  - Better organization of information with visual hierarchy
  - More informative and useful feedback
  - More consistent visual cues across ESET
  - Improved aesthetics and minimalistic design
  - New features that support more flexible inputs and better presentation of results



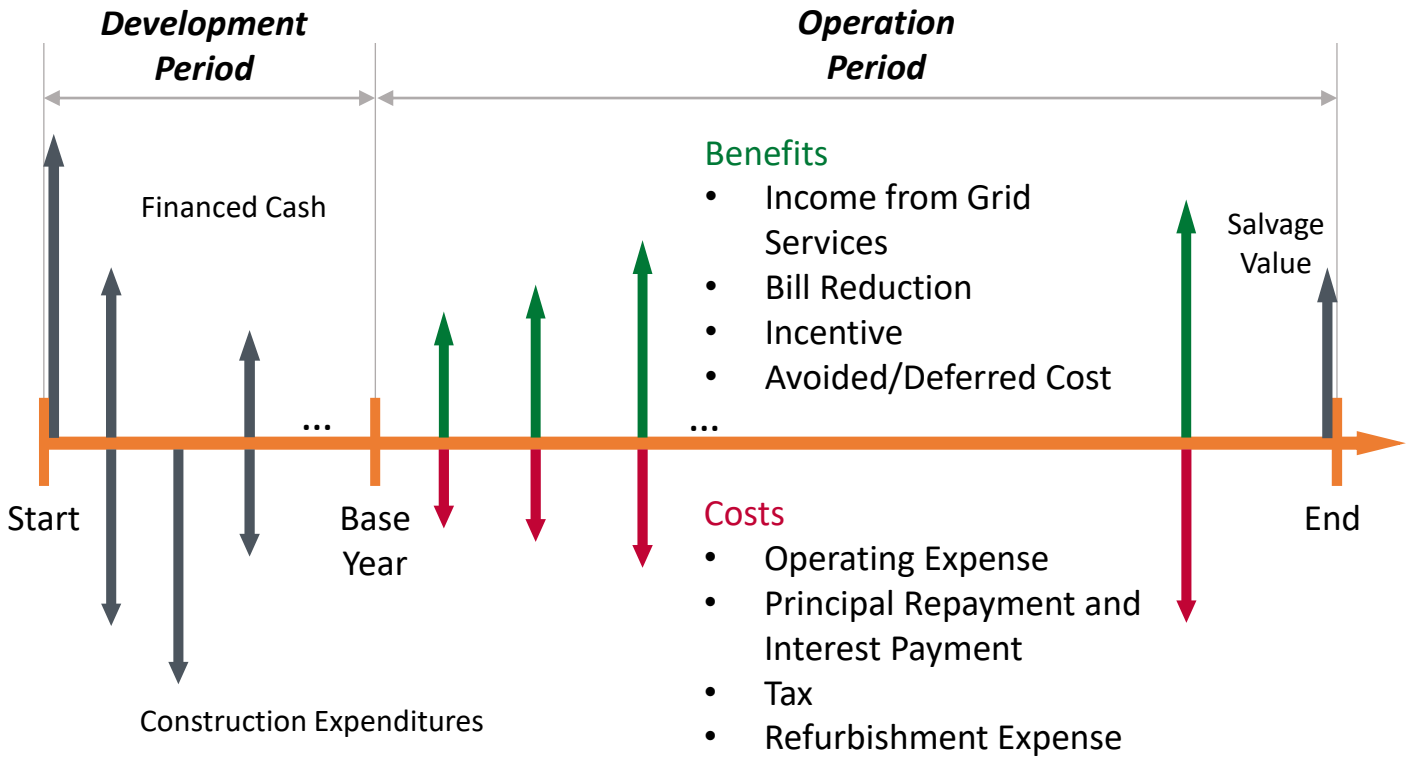
# Integrated Databases

- ISO market prices, including NYISO, ERCOT, SPP, ISO-NE, and CAISO (in progress)
  - Energy – LMP
  - Ancillary services: regulation (up, down, and mileage), spin/non-spin reserve
- Utility rate structures
  - *The Utility Rate Database* (URDB) – 3,833 EIA-recognized utility companies
  - Energy and demand charges: flat, time-of-use, tiered
- Typical building load profiles
  - *Commercial and Residential Hourly Load Profiles for all TMY3 Locations in the United States* developed by NREL
- Detailed energy storage cost
  - *Energy Storage Cost and Performance Database* developed by PNNL



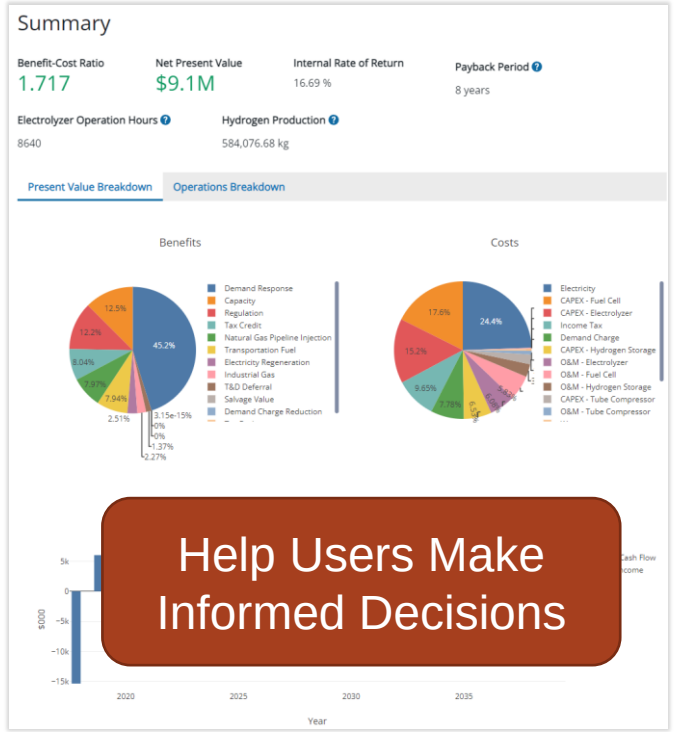
# Comprehensive Cost-Benefit Analysis Engine

- Typical Cash Flow for ESS Projects



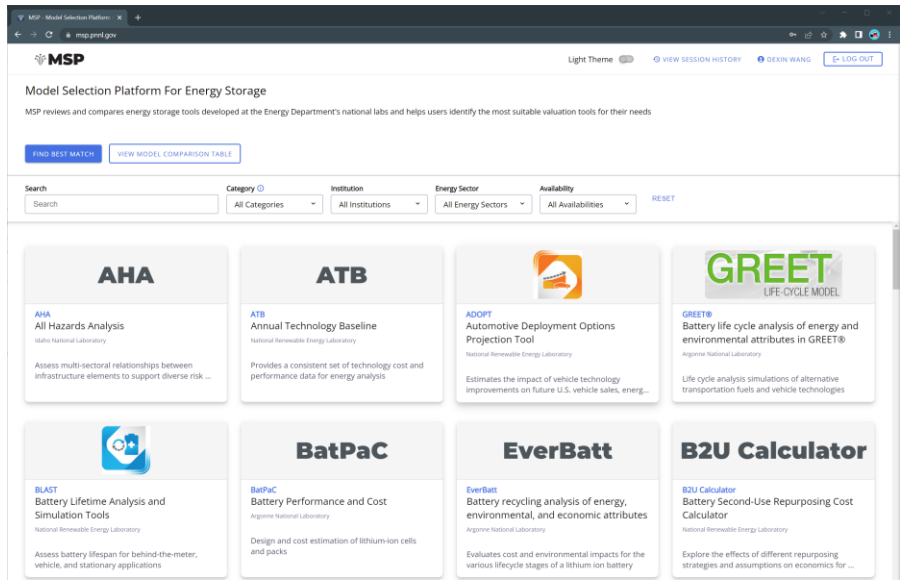

Results

- BCR, NPV, IRR
- Itemized PV Benefits and Costs
- Net income over time
- Free cash flow over time



# Model Selection Platform for Energy Storage

- Not easy to tell
  - How are they different in terms of functionalities and capabilities?
  - Which one should I choose?
- MSP reviews and compares a list of tools and suggests the best-suited tools based on users' needs and requirements
- The core of MSP selection wizard is based on:
  - Specification discovery procedure
  - Scoring engine
- Progress in the last year
  - Includes 64 tools (up from 5 in previous release)
  - Production cost modeling (PCM) tools in selection wizard and comparison table

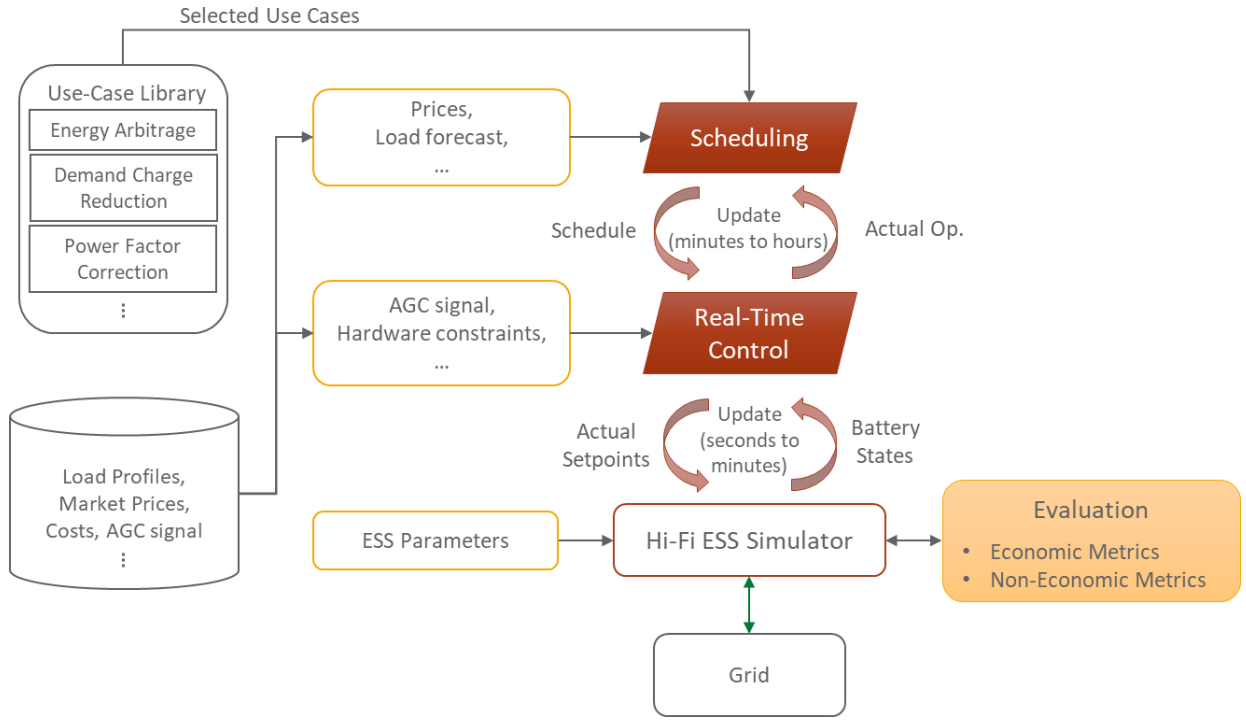



https://msp.pnnl.gov

# ES-Control

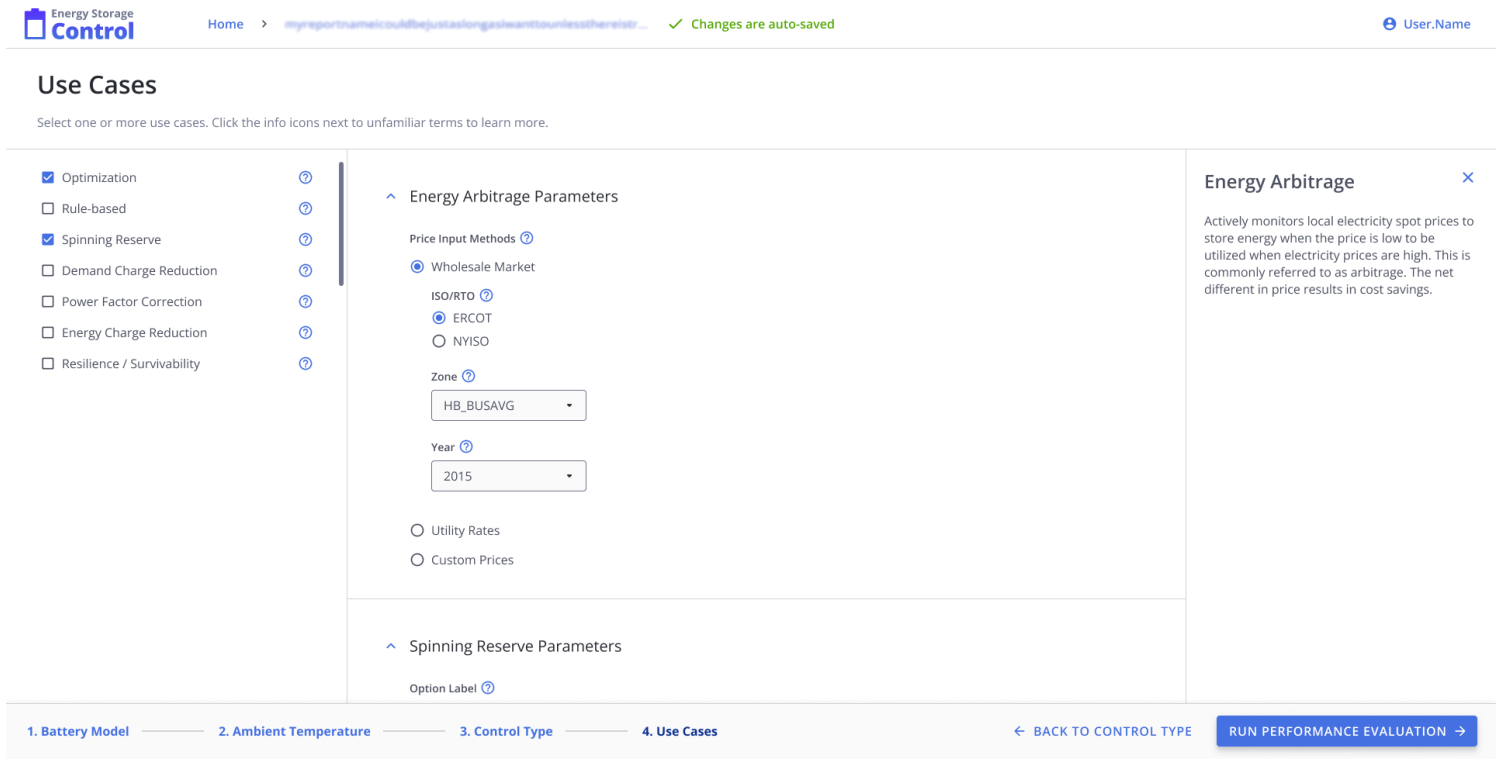
*ES-Control* is a platform for evaluation and testing of energy storage control strategies and algorithms with diversified time scales in a realistic setting, considering deployment options, use cases, and applications.

- Sandbox environment for modeling, control, simulation, and evaluation
- Representative built-in control strategies with adjustable parameters
- Open API for customized control
- Diversified energy storage models with different levels of complexity and fidelity
- Built-in database of energy storage costs, market prices, utility tariffs, etc.



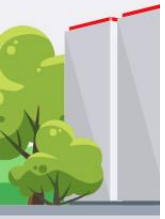
# ES-Control (cont.)

- A web-based application
- Microservices architecture for rapid iteration and scalability
- Off-the-shelf AWS services for fast development and industry standard security



# Conclusions and Future Work

- System design and project development require appropriate energy storage models with a good balance between fidelity and complexity
- Advanced modeling and analytical methods and tools are required to define technically achievable benefits
  - Integrated forecasting and stochastic dispatch for modeling and addressing uncertainties
  - Ensemble machine learning for enhanced long-duration energy storage scheduling
  - Risk-aware scheduling to better balance economic and resilience benefits
- Additional research is needed to properly select, size, and value storage with different durations for future decarbonized grid
  - Electrification of transportation, building, and industry
  - Extreme weather conditions
  - Policy design and incentive mechanisms



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*Mission – to ensure a resilient, reliable, and flexible electricity system through research, partnerships, facilitation, modeling and analytics, and emergency preparedness.*

https://www.energy.gov/oe/activities/technology-development/energy-storage

# Thank You

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