Pacific Northwest
NATIONAL LABORATORY

Energy Storage Modeling and Valuation Tools

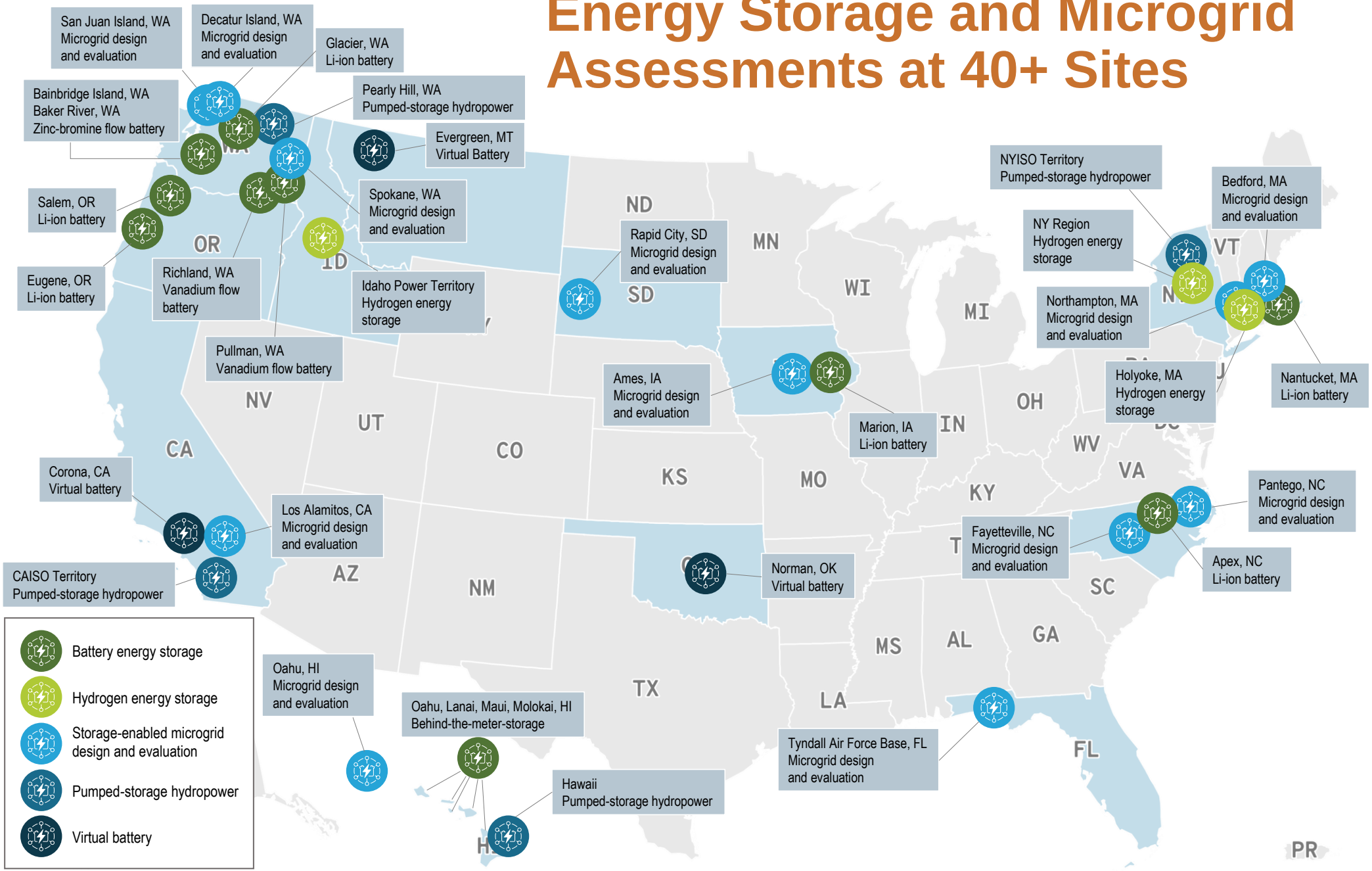
Dexin Wang, Senior Research Engineer
Pacific Northwest National Laboratory

DOE Energy Storage Financing Summit
October 8th, 2024

U.S. DEPARTMENT OF ENERGY BATTELLE

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

Energy Storage and Microgrid Assessments at 40+ Sites

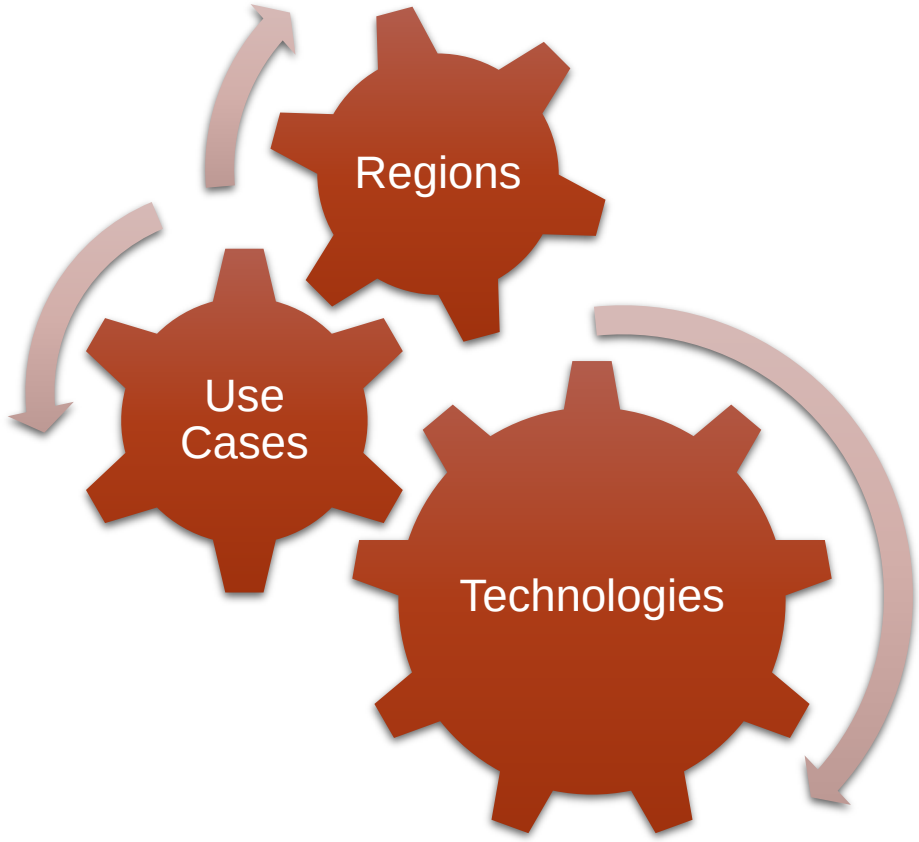


Pacific Northwest NATIONAL LABORATORY

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

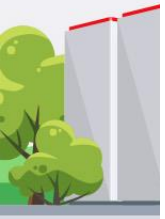


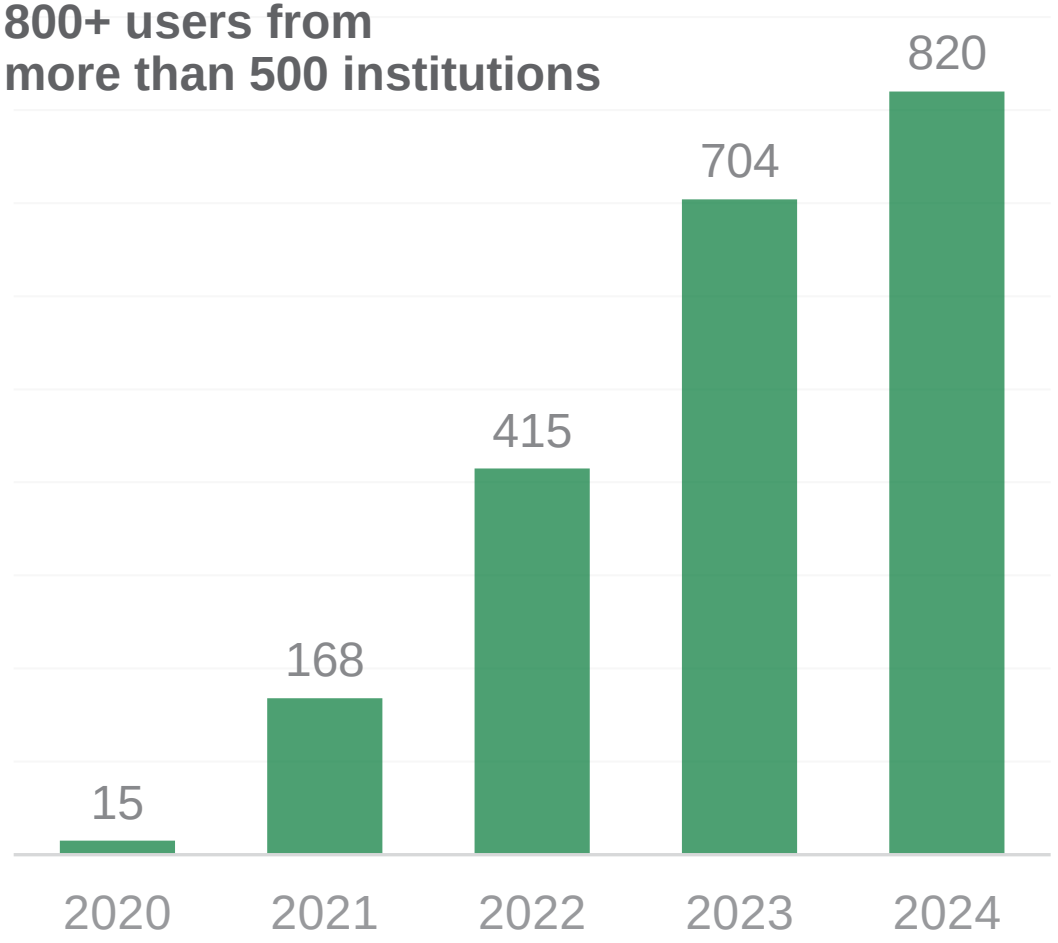
Energy Storage Evaluation Tool™

https://eset.pnnl.gov

A suite of applications that enable various stakeholders 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)
- Pumped-Storage Hydropower Evaluation Tool (PSHET)
- Hydrogen Energy Storage Evaluation Tool (HESET)
- Virtual Battery Assessment Tool (VBAT)





ESET Features

https://eset.pnnl.gov

Comprehensive Models

Properly represent diversified technical and economic characteristics of different energy storage technologies and their hybridization

Advanced Optimization

Maximize benefits and determine optimal sizing/siting, considering multi-dimensional couplings and practical constraints

Consistent Modeling

Various use cases and assumptions across different technologies and deployments, allowing for fair comparisons

Built-in Databases

Utility rates, electricity market prices, renewable and load profiles, and energy storage cost for easy and rapid input preparation

Integrated Uncertainties and Control

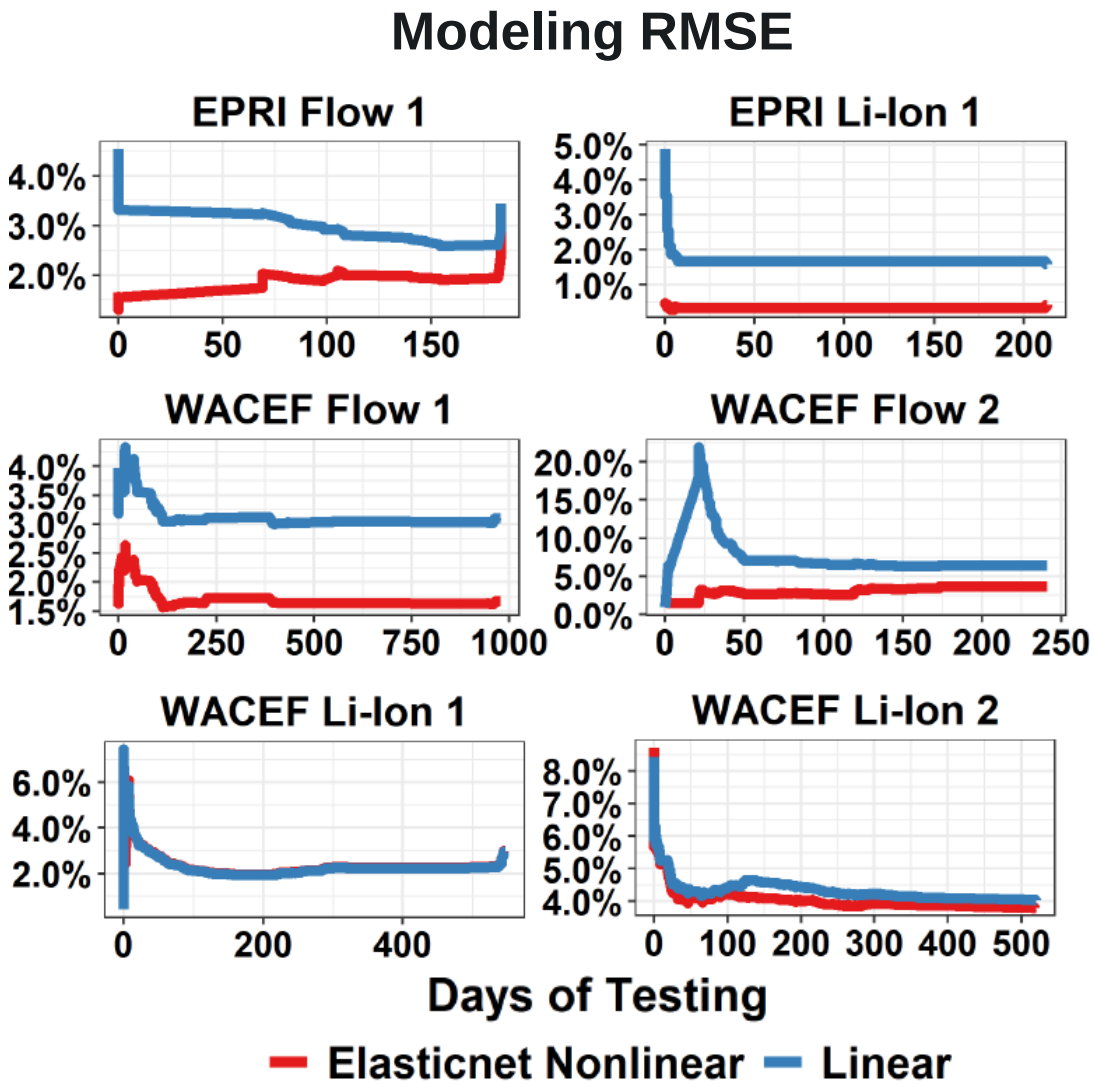
Ensure the estimated benefits align with the actual benefits of the deployed systems

Economic/Financial Analysis Engine

Articulates benefits vs costs, calculates key metrics (BCR, NPV, IRR), and reports net income and cash flow

BESS Testing and Model Validation

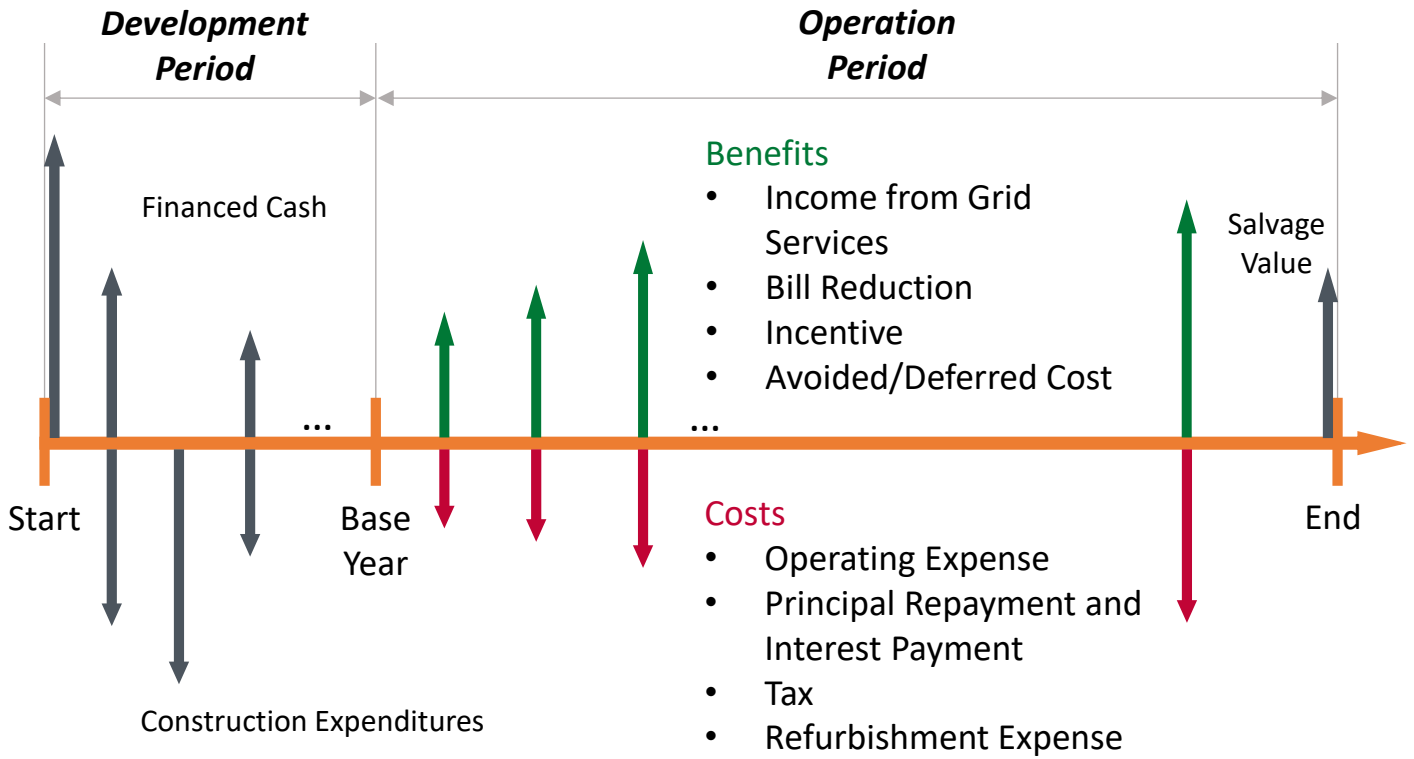
Alias	Chemistry	Rated Power (kW)	Rated Energy (kWh)	E/P Ratio (h)
EPRI Flow 1	VFB	90	270	3
EPRI Li-ion 1	NMC	1000	2000	2
EPRI Li-ion 2	NMC	1000	1000	1
CEF Flow 1	VFB	1000	3200	3.2
CEF Flow 2	VFB	2200	8000	3.6
CEF Li-ion 1	LMO/NMC	2000	1000	0.5
CEF Li-ion 2	LFP	2000	4400	2.2
CEF Li-ion 3	LFP	1000	2000	2
CEF Li-ion 3	LFP	1000	5500	5.5



- All datasets contain 1-2 years of real operational data

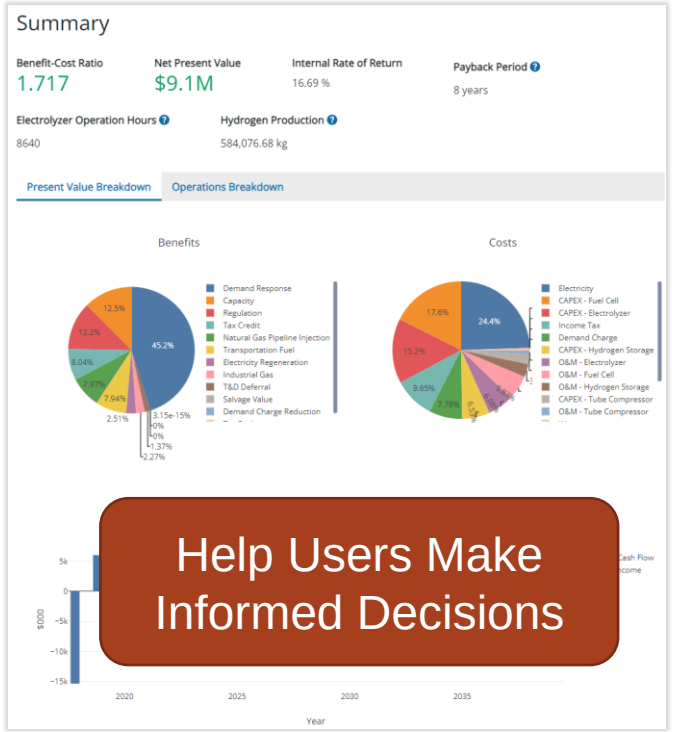
Comprehensive Cost-Benefit Analysis Engine

- Typical Cash Flow for ESS Projects



Results

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



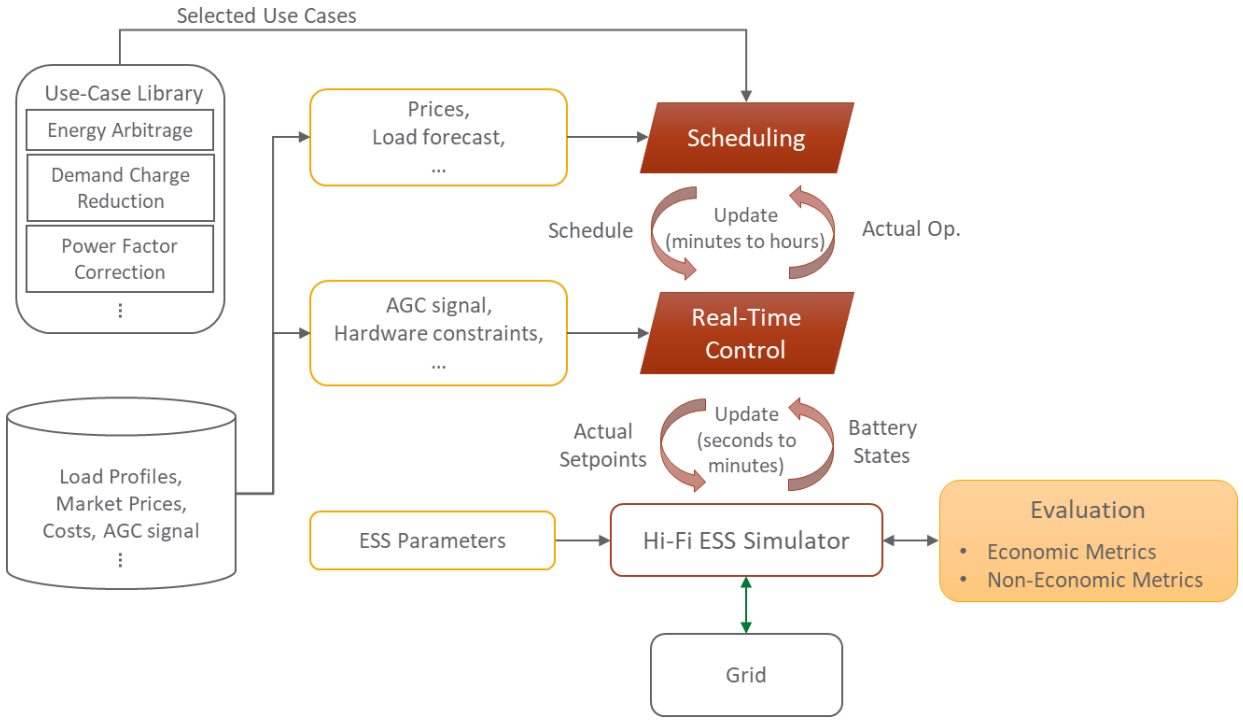
ES-Control

Energy Storage Control

https://es-control.pnnl.gov

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.

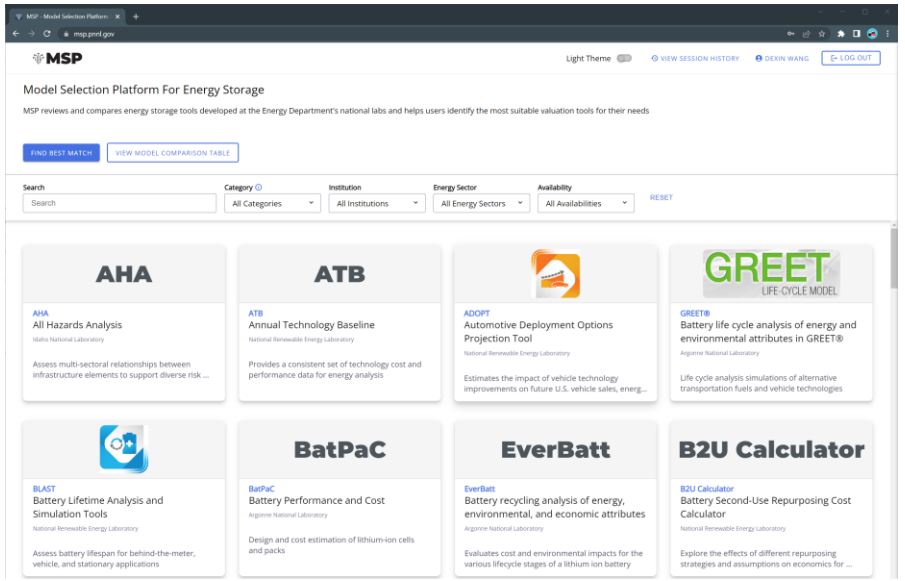


Model Selection Platform for Energy Storage

- 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

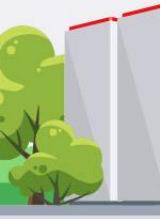
MSP

https://msp.pnnl.gov



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
  - Innovative technologies and hybrid solutions
  - Advanced control and valuation in evolving market and policy environments



Acknowledgments

This material is based upon work supported by the U.S. Department of Energy, Office of Electricity (OE), Energy Storage Division.

U.S. DEPARTMENT OF ENERGY

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

Dexin Wang
dexin.wang@pnnl.gov
(509) 372-6231

https://www.pnnl.gov/energy-storage
https://eset.pnnl.gov/
https://msp.pnnl.gov/