



Energy Storage Evaluation Tool (ESET™)

Dexin Wang, Staff Research Engineer
Pacific Northwest National Laboratory
DOE OE Energy Storage Peer Review
October 13, 2022
Presentation ID: 905

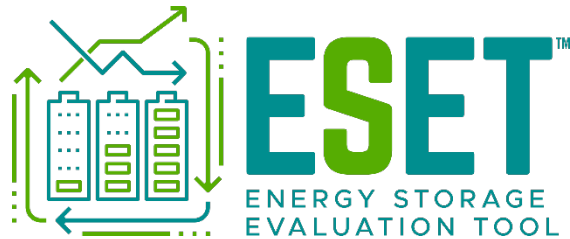
Support from DOE Office of Electricity
ENERGY STORAGE PROGRAM



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



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

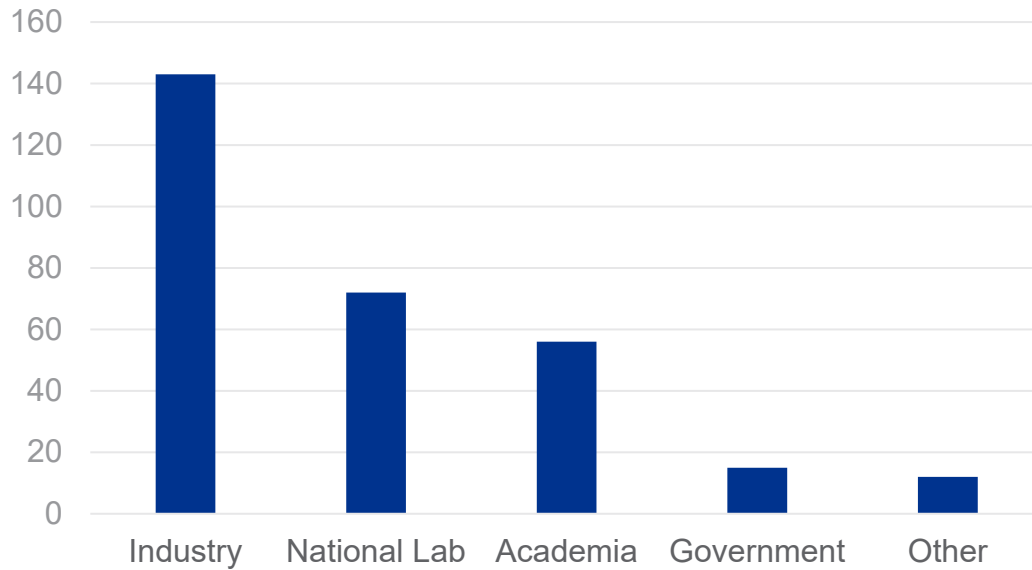
- Battery Storage Evaluation Tool (BSET)
- Microgrid Asset Sizing considering Cost and Resilience (MASCORE)
- Virtual Battery Assessment Tool (VBAT)
- Pumped-Storage Hydropower Evaluation Tool (PSHET)
- Hydrogen Energy Storage Evaluation Tool (HESET)



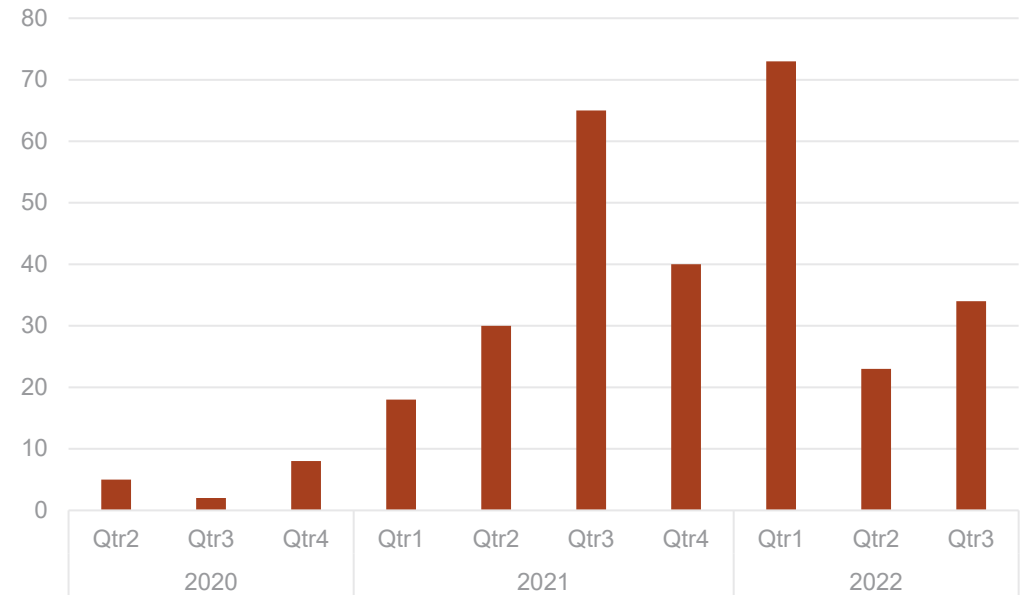
ESET User Statistics

- 300+ users from more than 200 institutions
- Steady user growth over time

User Count by Institution Category



Number of New Users



Project Team

- Dr. **Dexin Wang** – Principal Investigator (PI)
- Dr. Di Wu – Former PI, 2017–2021

Modeling & Optimization

- Dr. Xu Ma
- Dr. Bowen Huang
- Alasdair Crawford
- Dr. Vish Viswanathan
- Dr. Avijit Das
- Dr. Thia Ramachandran
- Dr. Xiaoyuan Fan

Data Analytics & Financial Analysis

- Dr. Tao Fu
- April Sun
- Dr. Mark R Weimar
- Dr. Jason Hou

UX Design

- Kaitlyn He
- Paul Tran
- Justin Wells-Driscoll
- Zimo Wang

Software Development

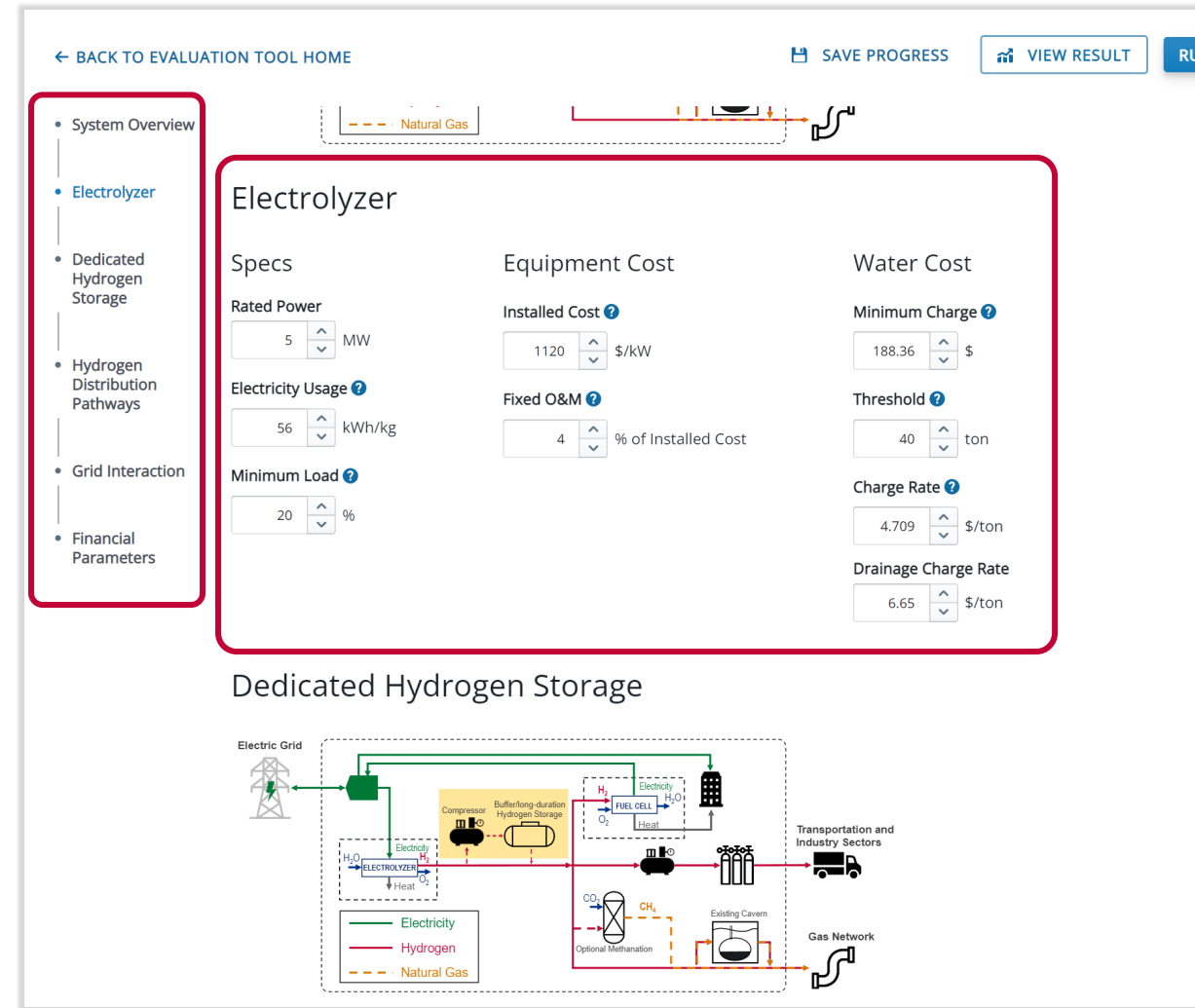
- Amelia Bleeker
- Yanyan Zhu
- Avinash Joshi
- Eric J Engel

FY22 Research Activities

- UX and UI improvements of web-based ESET
- Integration of external data sources
- Consistent modeling of grid and end-user services
- Computational resource management and task scheduling
- Dedicated cost-benefit analysis engine with enhanced capabilities
- Maintenance and technical support

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



The screenshot displays the 'Electrolyzer' configuration page within the ESET tool. The interface includes a navigation sidebar on the left with options: System Overview, Electrolyzer (selected), Dedicated Hydrogen Storage, Hydrogen Distribution Pathways, Grid Interaction, and Financial Parameters. The main content area is titled 'Electrolyzer' and is organized into three columns of adjustable parameters:

- Specs:**
 - Rated Power: 5 MW
 - Electricity Usage: 56 kWh/kg
 - Minimum Load: 20 %
- Equipment Cost:**
 - Installed Cost: 1120 \$/kW
 - Fixed O&M: 4 % of Installed Cost
- Water Cost:**
 - Minimum Charge: 188.36 \$
 - Threshold: 40 ton
 - Charge Rate: 4.709 \$/ton
 - Drainage Charge Rate: 6.65 \$/ton

Below the configuration panel is a schematic diagram titled 'Dedicated Hydrogen Storage'. The diagram illustrates the flow of energy and materials:

- Electric Grid:** Provides electricity to the Electrolyzer and Fuel Cell.
- Electrolyzer:** Converts water (H₂O) into hydrogen (H₂) and oxygen (O₂).
- Compressor:** Compresses the hydrogen.
- Buffer/long-duration Hydrogen Storage:** Stores the compressed hydrogen.
- Fuel Cell:** Converts stored hydrogen back into electricity and water.
- Optional Methanation:** A process where CO₂ and H₂ are used to produce CH₄.
- Existing Cavern:** A storage facility for natural gas or methane.
- Gas Network:** Distributes natural gas or methane.
- Transportation and Industry Sectors:** End users of the hydrogen.

 A legend at the bottom of the diagram identifies the flow lines: green for Electricity, red for Hydrogen, and orange for Natural Gas.

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

Consistent Modeling of Services

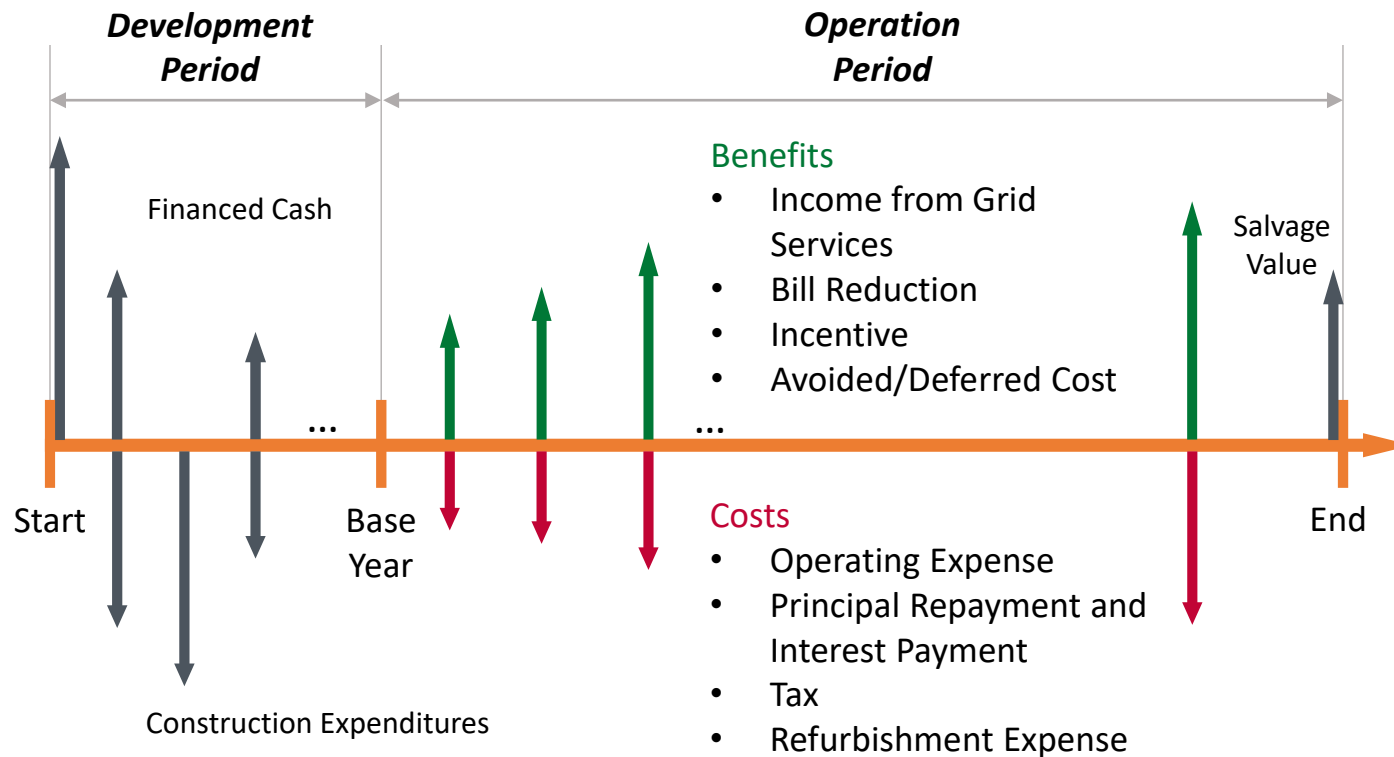
- Modeling of grid and end-user services
 - Crucial for accurate valuation of ESSs
 - Included in multiple applications in ESET
- Modular refactor of the code base related to modeling of services
 - Extract existing code segments from different applications
 - Modify and merge into generic functions
- Ensures consistent modeling and valuation across different applications
- Makes the code more reusable and easier to maintain and expand

Computational resource management

- Increased workload because of growing user base
 - Usage spikes were particularly problematic
- Limited computational resource
- Random and heterogenous computing jobs
- First in first out (FIFO) job queuing
 - Concurrent jobs
 - Waiting list
 - Useful feedback to users
- Evolving issue as users/activities continue to increase

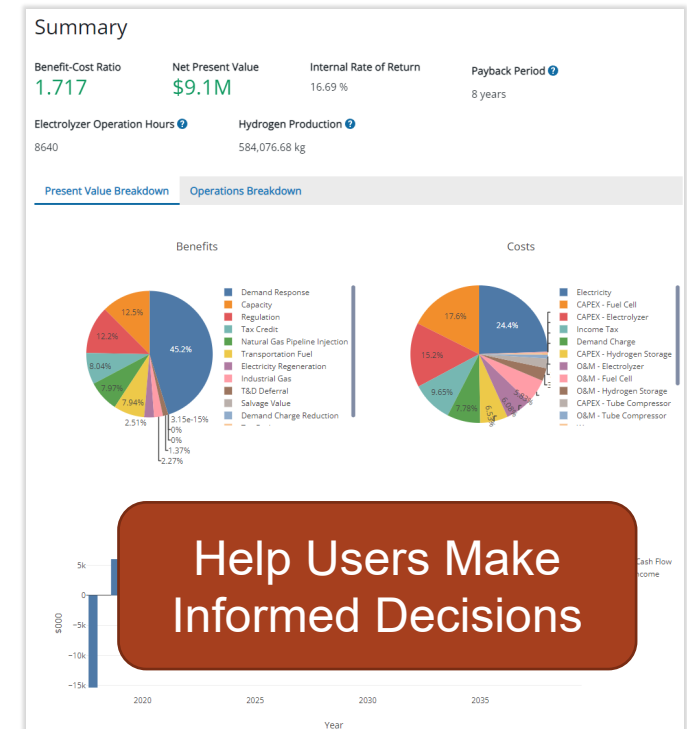
Comprehensive Cost-Benefit Analysis Engine

• Typical Cash Flow for ESS Projects



Results

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



Looking Forward

- Maintain and enhance the web-based ESET based on users' feedback
- Continue integrating new modeling and analytical capabilities developed into ESET
- Enhance ESET to enable batch run and sensitivity analysis in an automated manner
- Develop user guide for updated version of ESET
- Wrap up and release API to the public
- Continue to use ESET to support energy storage assessment projects

Acknowledgment

Dr. Imre Gyuk, DOE – Office of Electricity



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/>

