INTRODUCTION TO SESSION 9: ANALYTICS AND TOOLS

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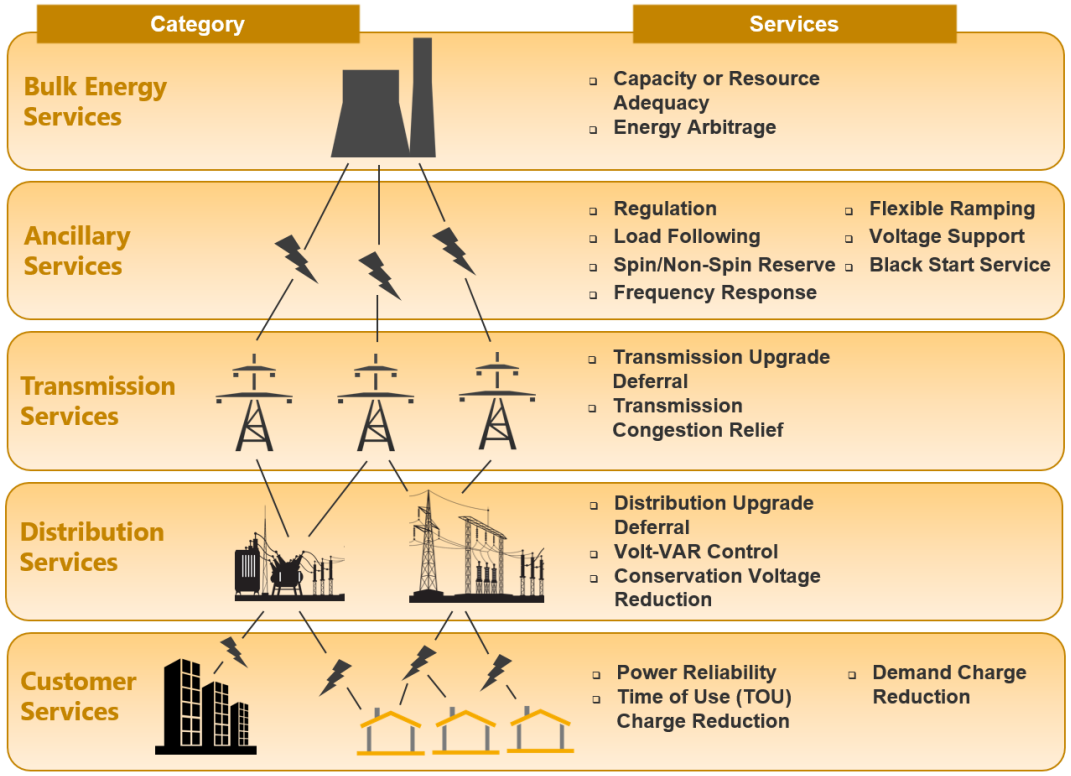
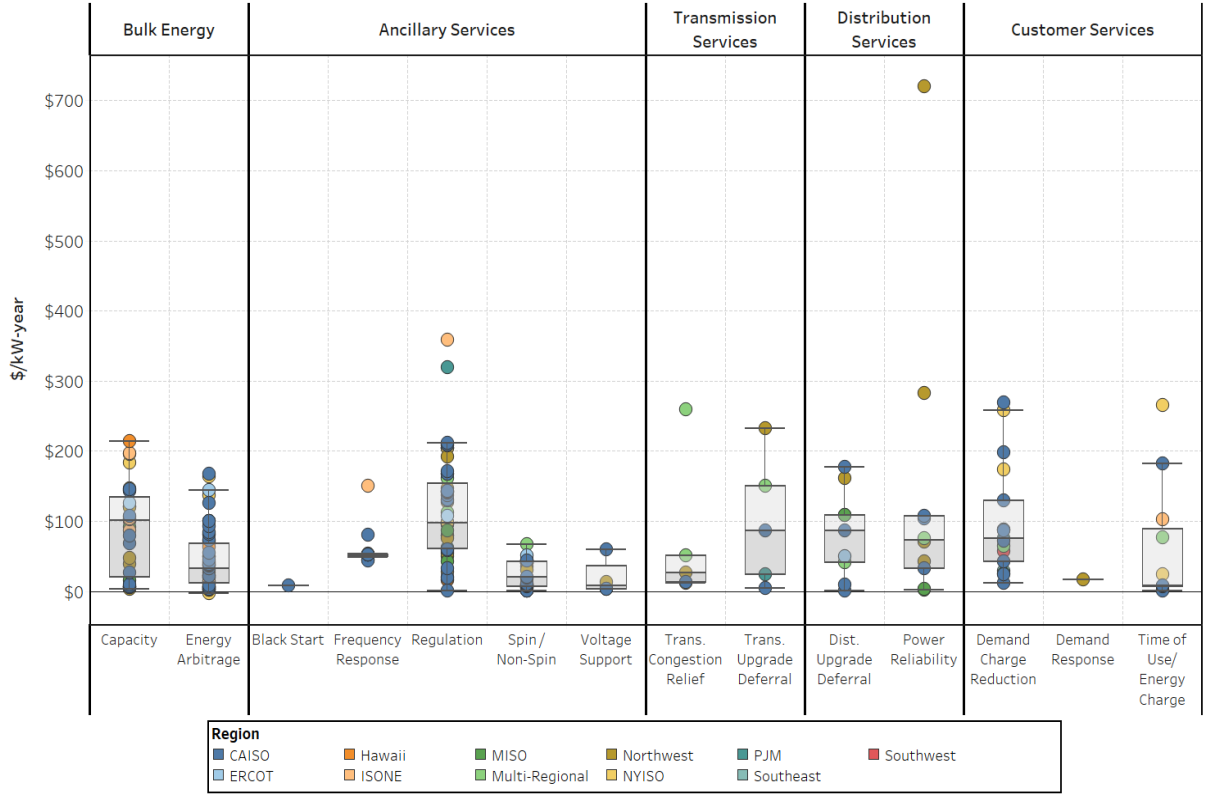
OCTOBER 13, 2022

VALUATION TAXONOMY AND META-ANALYSIS RESULTS

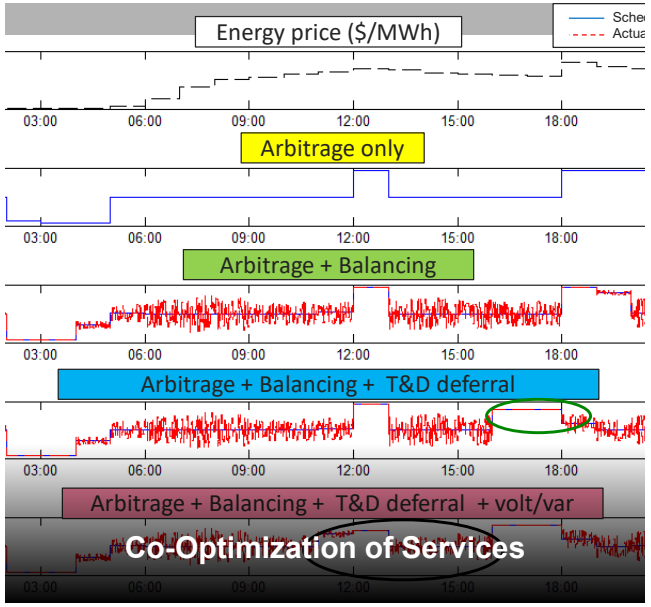




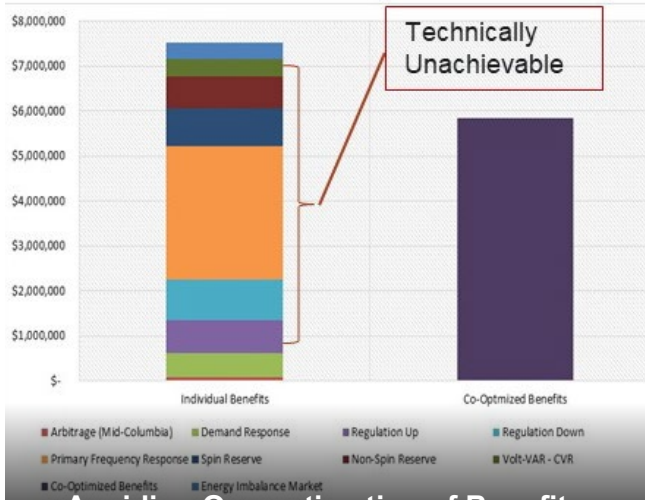
Source: Balducci, Patrick, Mongird, Kendall, and Weimar, Mark. Understanding the Value of Energy Storage for Power System Reliability and Resilience Applications. Germany: N. p., 2021. Web. https://doi.org/10.1007/s40518-021-00183-7.

CHALLENGES TO ACCURATELY ESTIMATING ECONOMIC BENEFITS

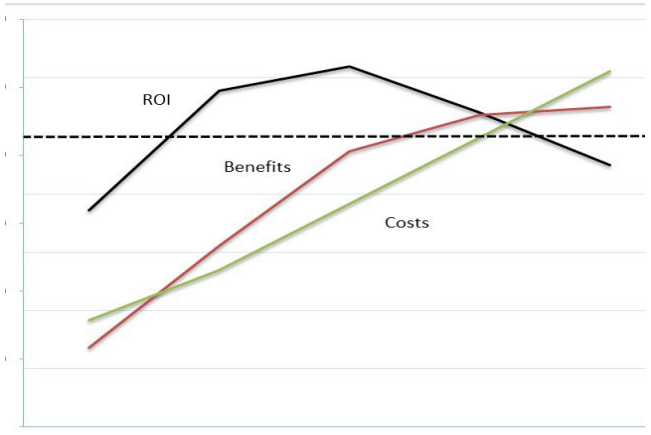
- Multidimensional competition for energy – not all services can be provided simultaneously and there exists intertemporal competition for energy
- Economic results are sensitive to sizing of energy storage system in terms of power and energy capacities
- Markets are complex and common practices of assuming perfect foresight into prices, price-taker position, and consistent performance lead to overestimation
- Battery performance is dynamic and there are challenges in capturing real-time value
- Battery degradation is an important consideration
- Advanced storage valuation tools are required



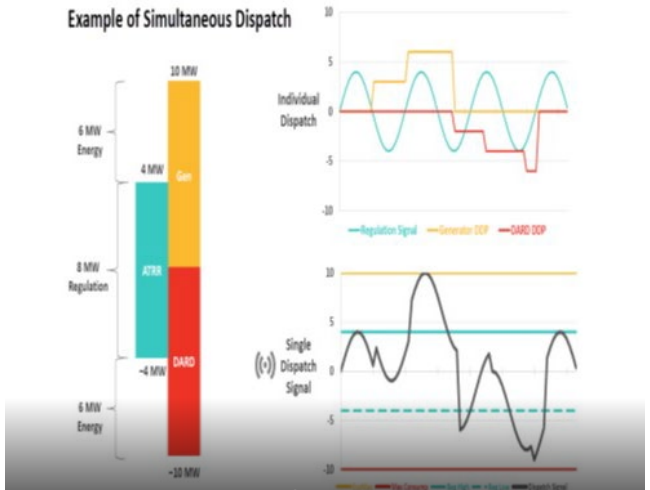
Co-Optimization of Services



Avoiding Overestimation of Benefits



Optimizing Storage System Scale



Market Complexities

ENERGY STORAGE VALUATION TOOLS

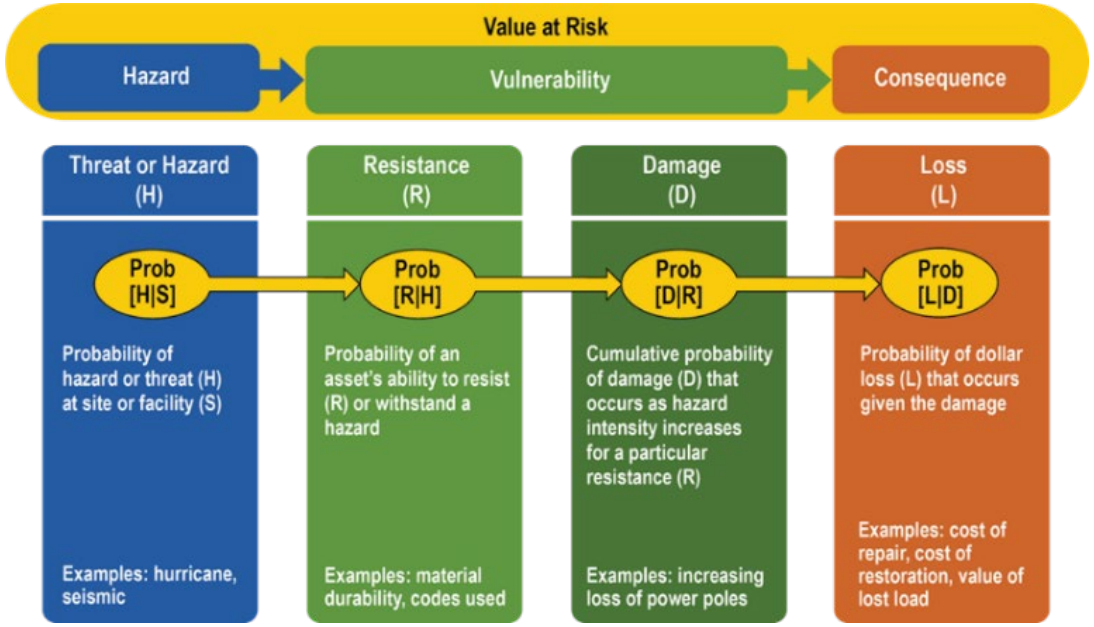
Name of Tool	Developer	Summary	Online Access
Energy Storage Evaluation Tool (ESET)	Pacific Northwest National Laboratory	ESET relies on user input time-series values and energy signals by use case to determine the optimal schedule and value of storage. It can be used for utility-owned and behind-the-meter (BTM) storage and can optimally scale the BESS.	https://availabletechnologies.pnnl.gov/technology.asp?id=413
DER-VET	Electric Power Research Institute	DER-VET facilitates the understanding of where to place and install energy storage, the optimum size as well as controls options. DER-VET implements dispatch optimization with sensitivity analysis to assist in planning energy storage project development by enabling rapid analysis of scenarios with different storage sizes, costs, and value streams.	https://www.storagevet.com/
QuESt	Sandia National Laboratories	QuESt is an open source, Python-based application suite for energy storage simulation and analysis. It includes market-focused and BTM tools that include detailed market prices and retail tariff rates from across the US.	https://energy.sandia.gov/tag/quest/
REopt Lite	National Renewable Energy Laboratory	REopt Lite is a design and analysis tool that can be used to evaluate the economic viability of grid-connected photovoltaics (PV), wind, and energy storage for BTM installations. It identifies the system sizes and battery dispatch strategy to minimize energy costs. It also estimates how long a system can sustain critical load during a grid outage.	https://reopt.nrel.gov/

ENERGY STORAGE VALUATION TOOLS – KEY CHARACTERISTICS

Category	Use Case	ESET	DER-VET	QuESt	REOpt Lite
Use Cases					
Bulk Energy	Energy Arbitrage	✓	✓	✓	✓
	Capacity	✓	✓		
Ancillary Services	Frequency Regulation	✓	✓	✓	✓
	Spin / Non-Spin	✓	✓	✓	✓
Transmission	Upgrade Deferral	✓	✓		
	Congestion Relief		✓		
Distribution	Upgrade Deferral	✓	✓		
	Volt-VAR	✓	✓		
Customer Energy Management	Power Reliability	✓	✓		✓
	TOU Charge Management	✓	✓	✓	✓
	Demand Charge Management	✓	✓	✓	✓
Energy Storage Scheduling Techniques					
Optimization Across All Services		✓	✓	✓	✓
Price Impacts		Price-taker	Price-taker	Price-taker	Price-taker
Imperfect Foresight		✓	✓		
Optimization Horizon		Rolling 24 hour Over 1 Year	Flexible; Can Cover Economic Life of Storage	One Year	One Year
Optimizes Customer and Utility Use Cases Concurrently		✓	✓		✓

VALUING RESILIENCE

- Energy storage has demonstrated the capacity to enhance grid resilience
- Resilience benefits are poorly defined and generally ignored in energy storage valuation studies
- Resilience benefits are typically evaluated using customer damage functions and interruption cost studies, sometimes evaluated using willingness to pay studies (e.g., contingent valuation method) and input-output analysis
- Resilience value can be embedded in other value streams, including transmission deferral, voltage sag compensation, and outage mitigation



Pictorial Approach to Value Risk Assessment and Resilience Valuation

- Multi-hazard risk analysis that relies on expected value calculations based on probabilistic analysis, while addressing a broad range of hazards and values tied to lost economic productivity, infrastructure damage, and injuries/fatalities is required – annual risk premium approach
- More research is needed to properly value resilience

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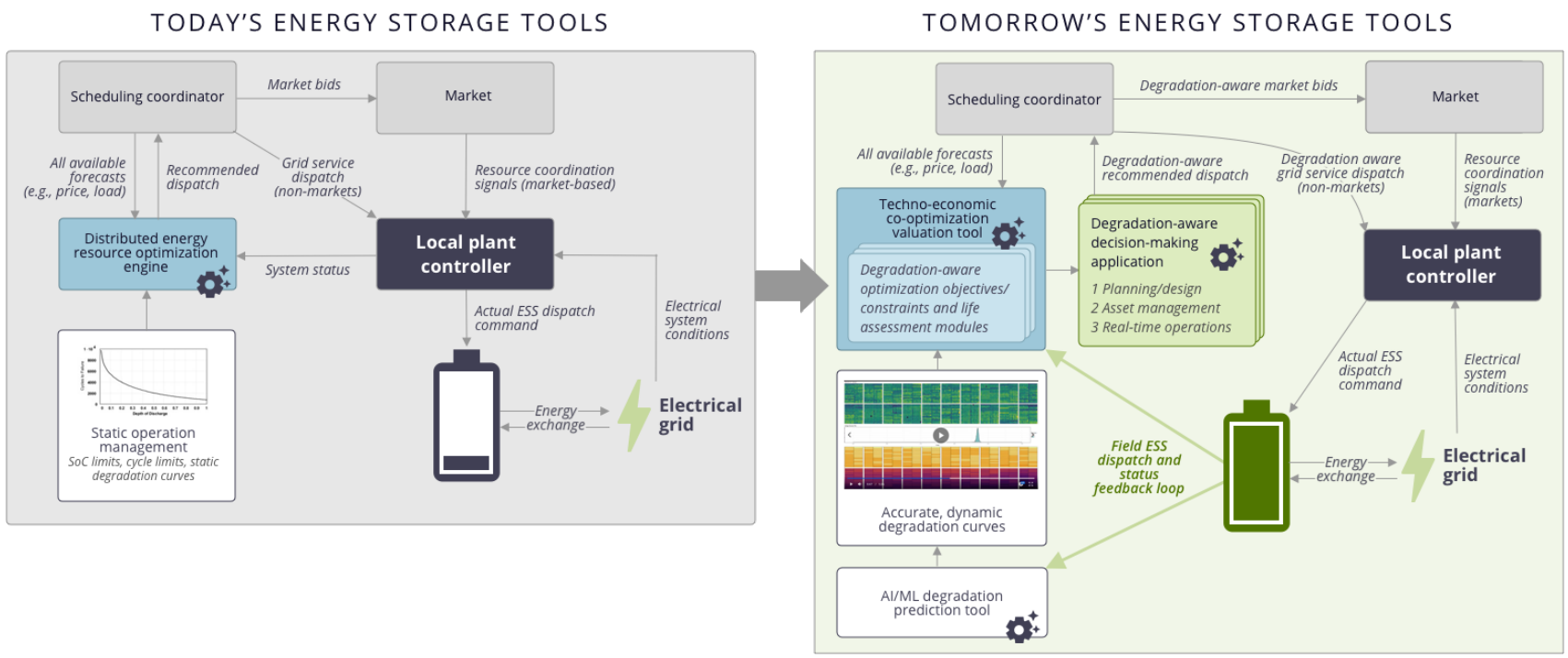
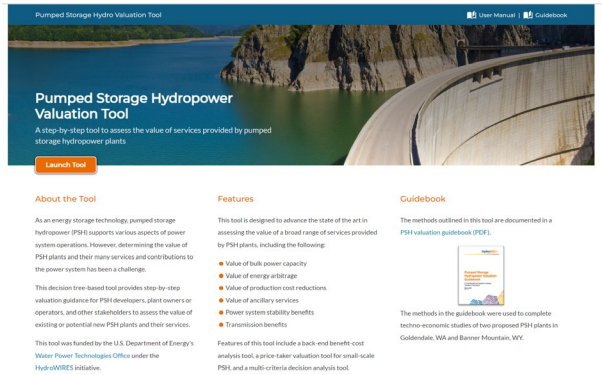
CO-OPTIMIZING WITH PRECISE BATTERY DEGRADATION PREDICTIONS IS TRANSFORMATIONAL



- ES operating life can appear in terms of a series of budgets for various cycles characterized by depth of discharge, temperature, power output, and other factors.
- Degradation-aware design/planning, asset management tools, and control systems required to allocate cycles more efficiently and expand number of cycles.
- AI degradation prediction communicates battery health estimation/prediction through degradation curves/penalties to enhance operational efficiency.

ARGONNE STORAGE VALUATION TOOLS

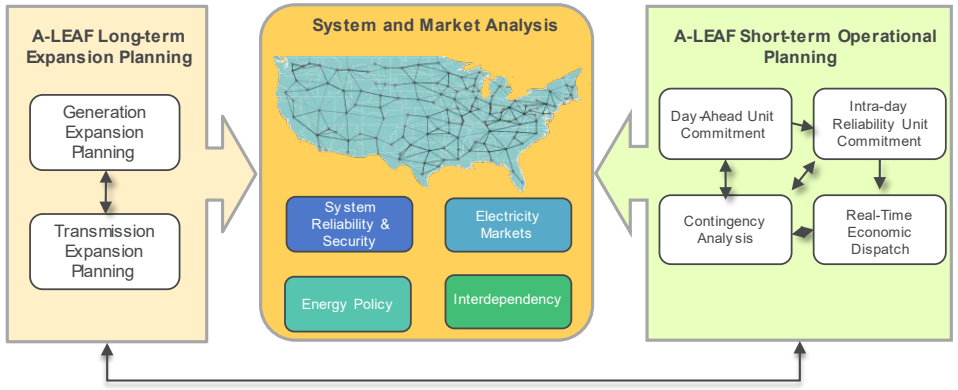
PSH Valuation Tool (PSHVT)



PSHVT Home Page

- PSHVT enables valuation from a system, plant operator, or societal perspective
- Use case coverage includes bulk energy, ancillary, transmission, behind-the-meter, and reliability services
- PSHVT has several advanced features: a) embedded price-taker model, b) multi-criteria decision analysis tool, c) embedded financial worksheets and benefit-cost analysis model, and d) A-LEAF system model
- Access tool at https://pshvt.egs.anl.gov

LDES Analysis Using A-LEAF

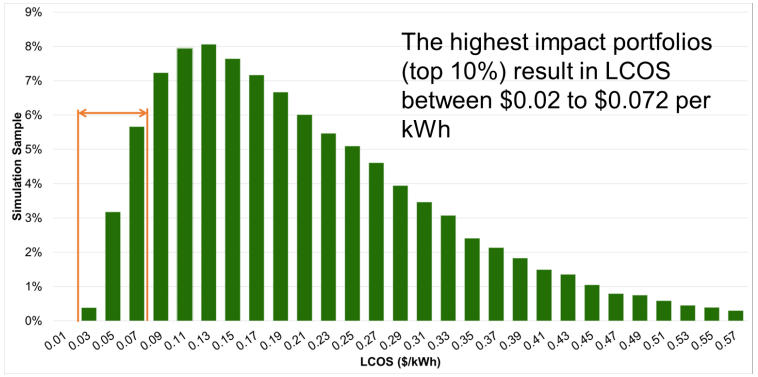


Argonne Least-Cost Electricity Framework

- Integrated national-scale power system simulation framework developed at Argonne, used to analyze issues related to the evolution of the nation's power system
- Suite of least-cost generation & transmission expansion, unit commitment, and economic dispatch models
- Determine optimal generation portfolio and hourly or sub-hourly unit dispatch under a range of user-defined input assumptions for technology characteristics and system/market requirements

ARGONNE ENERGY STORAGE EVALUATIONS IN OE

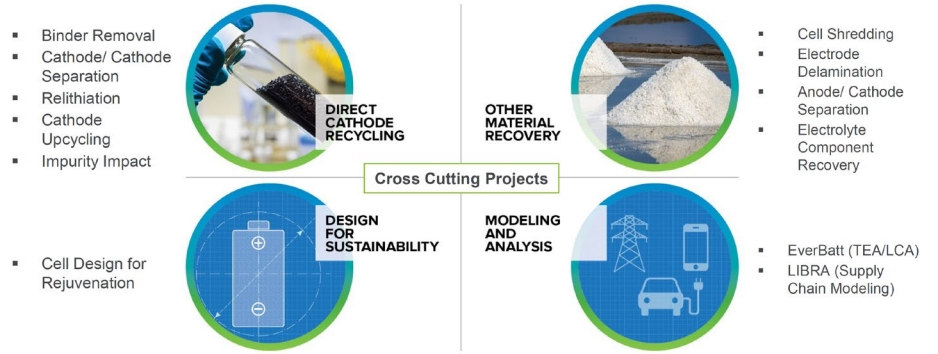
Energy Storage 2030



Innovation Portfolios for Lead Batteries

- Established 8-step framework for defining R&D pathways towards portfolios of high-impact innovations by 2030
- Evaluating 10 technologies to support Report to Congress: lead-acid, Li-ion, supercapacitors, flow batteries, PSH, CAES, flywheels, sodium-ion, thermal, hydrogen
- Define portfolios with best opportunity for achieving low levelized cost of storage (LCOS), with a goal of achieving a 5 cents/kWh LCOS and a high degree of suitability with use cases defined in ESGC Roadmap

End-of-Life Management



RECELL Center's Focus Areas

- EverBatt breaks down and evaluates each stage of the battery's lifecycle providing the opportunity to compare each stage's cost and environmental impact
- Investigate lifecycle cost and environmental impact of ESSs
- Providing information to promote better decision making

KEY ANALYTICAL NEEDS

Advanced Storage Valuation Tools	Models that consider a broad set of use cases, capture regional differences in benefits, and add realism to valuation process
Risk and Uncertainty	Important to capture key risk and uncertainty associated with imperfect foreknowledge of prices, price influencing behavior, climate uncertainty; need for stochastic optimization
Battery Characteristics	Accurately characterize battery performance, including round trip efficiency rates across varying SOCs and battery degradation caused by cycling; end-of-life management
Reliability	There are numerous reliability services (e.g., voltage support, primary frequency response, transient stability, small-signal stability) that are challenging to quantify and are rarely monetized
Cross-sectoral Modeling	With the goal of deep decarbonization top-of-mind, system of system models that consider multiple sectors and energy transport systems are required

ACKNOWLEDGMENTS

Dr. Imre Gyuk, DOE – Office of Electricity

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/energy-storage

CONTACT INFORMATION

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