Pacific Northwest
NATIONAL LABORATORY

Regulatory Research and Technical Assistance

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OE Energy Storage Program Peer Review

U.S. DEPARTMENT OF ENERGY BATTELLE

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Agenda

- **Equitable Regulatory Environment: Thrust Area Overview**
- **2022 Highlights**
  - Journal Article: “Emerging Best Practices for Modeling Energy Storage in Integrated Resource Plans”
  - Journal Article: “Defining Long-Duration Energy Storage”
  - Journal Article: “Do Mandates Deliver Cost Reductions for Energy Storage?”
  - Technical Report: “Energy Storage in Local Zoning Ordinances”
  - Conference Paper: “Economic Analysis of Vehicle-to-Grid Technology for Fleets”
  - Conference Paper: “Optimal Sizing and Operation of a Hybrid Clean Energy Center”
  - Conference Paper: “Equitable Design of Behind-the-Meter Energy Storage Programs”
- **State and Industry Engagements**
- **Looking Ahead**

Equitable Regulatory Environment Mission

Mission Statement

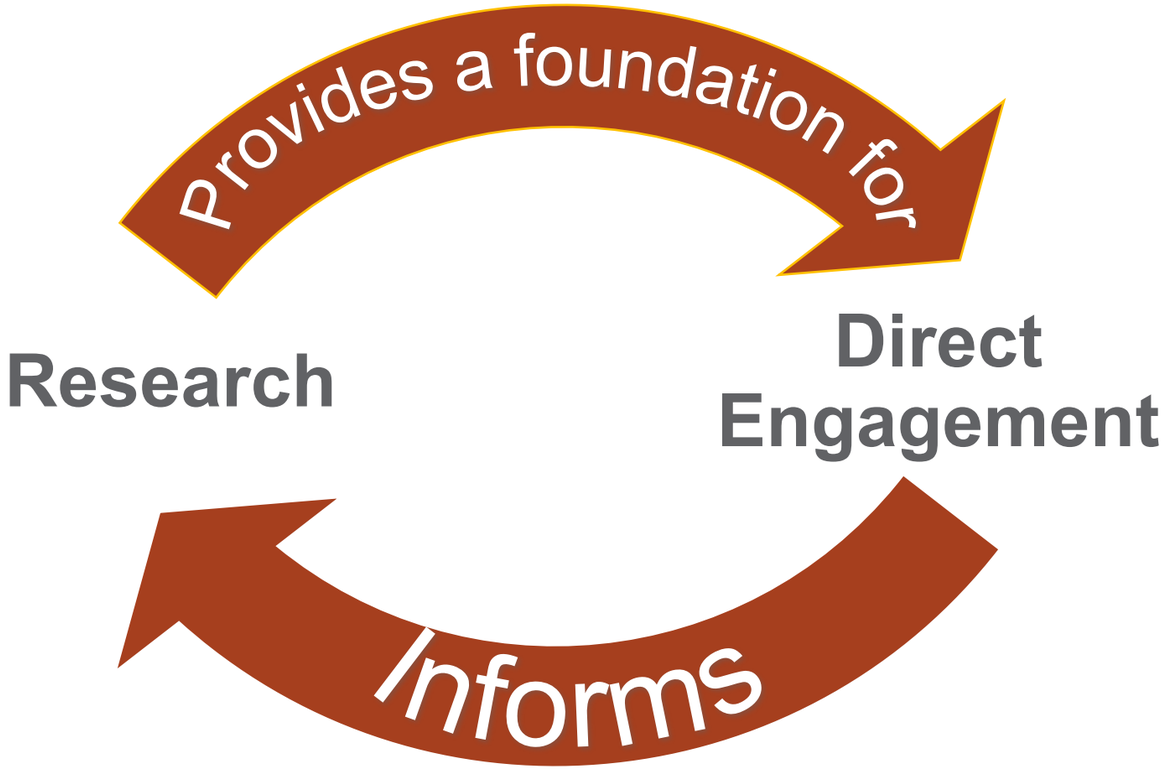
“Value propositions for grid storage depend on reducing institutional and regulatory hurdles to levels comparable with those of other grid resources.”

Program Tasks:

- **Document** federal, state and local policies affecting storage deployment
- **Review** integrated resource plans (IRPs) and similar analytic processes affecting storage development and deployment
- **Explore** alternative policies that may affect technology attributes and deployment
- **Maintain** publicly available information on storage technology and attributes affecting its deployment
- **Disseminate** comprehensive information on storage technology status, experience, and realizable contributions to grid resilience, emergency response, renewable deployment, and asset utilization
- **Provide** best practices for installation and use of energy storage to regulators, policy makers and industry

Program Model

- Policy options and impacts
- Planning obstacles and best practices
- Emerging use cases (i.e. resilience, transmission, energy system equity)
- Discrete issues (ownership, etc.)
- Energy Storage Policy Database



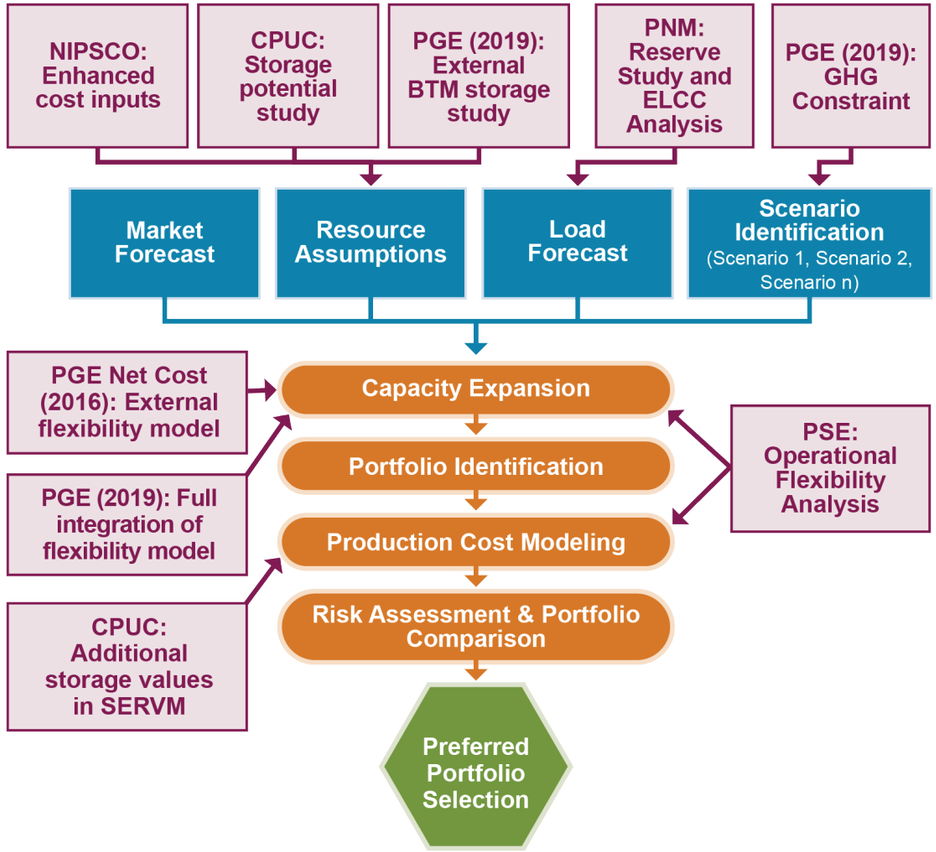
- Technical Workshops
- Conference Presentations
- Regulatory filing review
- Valuation
- Interconnection standards
- Codes and safety tutorials

Journal Article:
Emerging Best Practices for Modeling Energy Storage in IRPs

Traditional modeling tools used in integrated resources plans (IRPs) are not designed to capture the flexible and locational benefits of energy storage. In this publication, we review how leading utilities are evolving their processes to overcome those barriers.

Key findings:

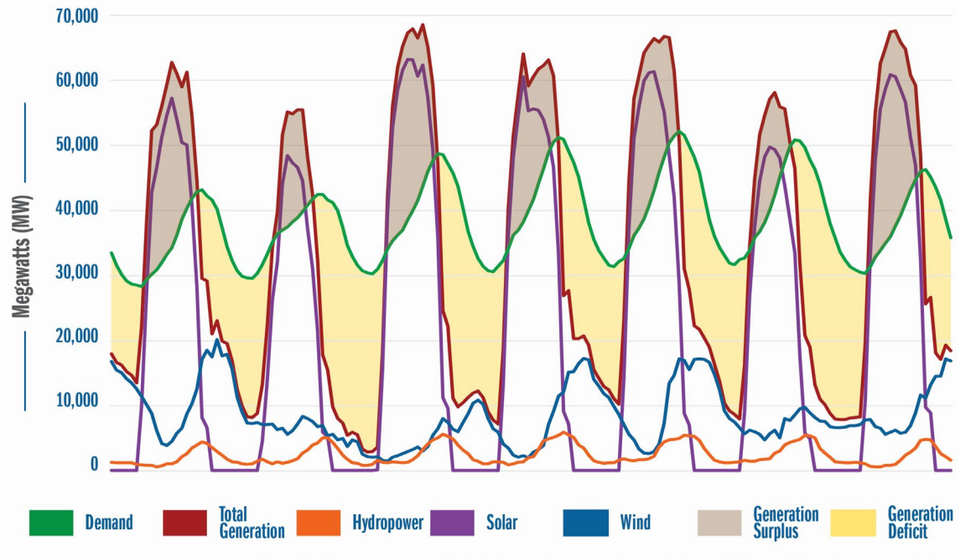
- The complex IRP process creates multiple points of entry for improving storage modeling
- Some practices relate to model inputs (cost & performance assumptions, need forecast, scenario identification)
- Others relate to the modeling process (in-house model development, commercial model licensing, flexibility valuation at various points in the process)
- IRP transparency is crucial to regulatory proceedings, but utilities differ widely in how transparently they describe their assumptions and modeling approaches



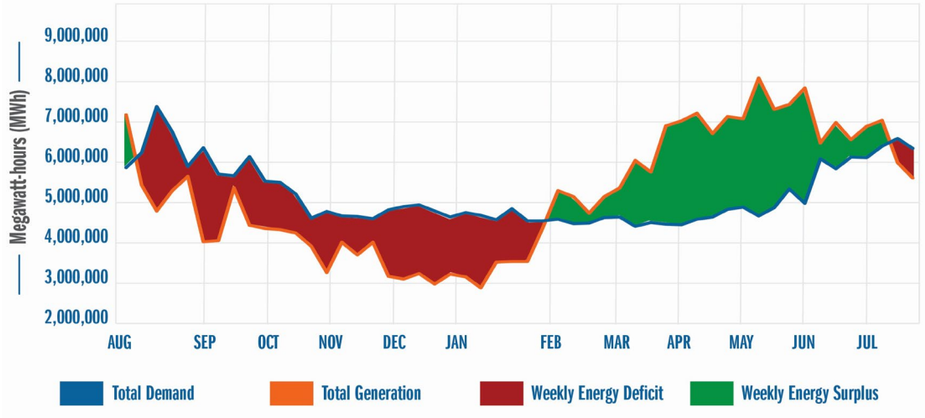
Status: Published in *IEEE Electrification Magazine*, December 2021

Journal Article:
Defining Long-Duration Energy Storage

LDES will be a necessary component in a reliable, decarbonized power grid.



Weekly Resolution



Annual Resolution

Key findings:

- There is an emerging industry consensus that “long” means 10+ hours
- Given the depth and breadth of mismatches that occur in a decarbonized power grid, LDES will be necessary
- Two classes of LDES emerge:
  - Daily (up to 20 hours)
  - Seasonal: weeks to months
- Current planning and procurement processes do not send the investment signals necessary to support LDES industry development

Status: Accepted by the *Journal of Energy Storage*

Journal Article:
Do Mandates Deliver Cost Reductions for Energy Storage?

In 2013, California implemented a mandate directing the state's investor-owned utilities to procure 1,325 MW of energy storage. This paper evaluates this policy's impact of both battery deployment and cost.

TABLE 1: DIFFERENCE-IN-DIFFERENCES MODEL FOR BATTERY SYSTEM DEPLOYMENT

	(1) Baseline DiD	(2) Wooldridge/Mundlak
Storage Mandate	0.312***	0.312***
	(0.0216)	(0.0215)
Constant	0.000	-0.0205*
	(0.0115)	(0.0116)
Observations	598	598
R-squared	0.256	0.256

Lead author Daniel Boff is presenting this paper in the poster session.

TABLE 7: POTENTIAL LEARNING ATTRIBUTABLE TO MANDATE (STORAGE BLOCK)

Learning rate	10%	12.5%	15%
Total cost reduction ($/kWh)	$68	$86	$103
Cost reduction attributable to mandate ($/kWh)	$0.79	$0.99	$1.19

Key findings:

- California's mandate had a significant impact on storage deployment in the state (31 percent increase)
- The mandate had a negligible impact on storage system prices (~$1/kWh), as the stationary storage industry is significantly smaller than the EV and personal electronics industries

Status: Submitted to *Energy Policy*

Technical Report:
Energy Storage in Local Zoning Ordinances

Local planning and zoning officials are frequently tasked with deciding where storage systems may be sited to minimize community impacts, but they may lack the familiarity with the technologies required to make appropriate zoning decisions. Uncertainty at the local zoning level has led developers to withdraw projects in some areas and has spurred moratoriums or bans on energy storage in others.

The treatment of energy storage in local zoning ordinances can be divided into four categories:

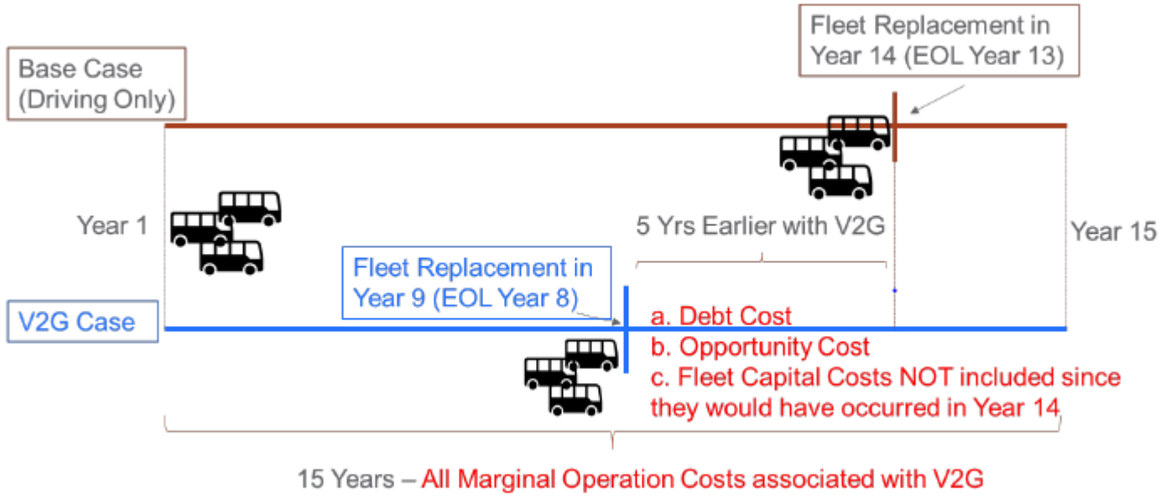
- Ordinances originally written to regulate solar installations that have been extended to energy storage
- Local adoption of fire or building codes that include standards for energy storage systems
- Ordinances specifically designed to regulate energy storage
- Ordinances that incent or encourage energy storage

Lead author Devyn Powell is presenting this paper in the poster session.

Status: Finalizing publication, may target for publication in a planning journal

Conference Paper:
Economic Analysis of Vehicle-to-Grid Technology for Fleets

This paper presents the benefits and life-cycle costs of four grid services provided by V2G for three different electric fleets: school buses, delivery vans, and maintenance trucks. We find the impact that V2G grid services has on battery cycling and degradation has the biggest influence on overall economics and the optimal choice of service.



Key findings:

- Concern about the impact of V2G on battery life has prompted most EV manufacturers to prohibit V2G as a warranty condition
- Heavy cycling applications like peak shaving and demand charge reduction offer higher revenues, but increase owner costs overall due to early battery replacement costs
- Frequency regulation has a much lower impact on battery life and therefore offers net positive revenues for EV owners
- At scale, V2G programs may be a cost-effective source of grid services while disseminating impacts

Lead author Christine Holland is presenting this paper in the poster session.

Status: Accepted by the United States Association for Energy Economics Conference (October 2022)

Conference Paper:
Optimal Sizing of a Hybrid Clean Energy Center

This paper studies the addition of energy storage to a utility-scale PV facility for two purposes: i) reducing the volatility of PV output and ii) shifting energy to meet an export limit. It presents a linear dynamical model to characterize the output of the hybrid facility and express the volatility and export power as functions of the battery's dispatch operations.

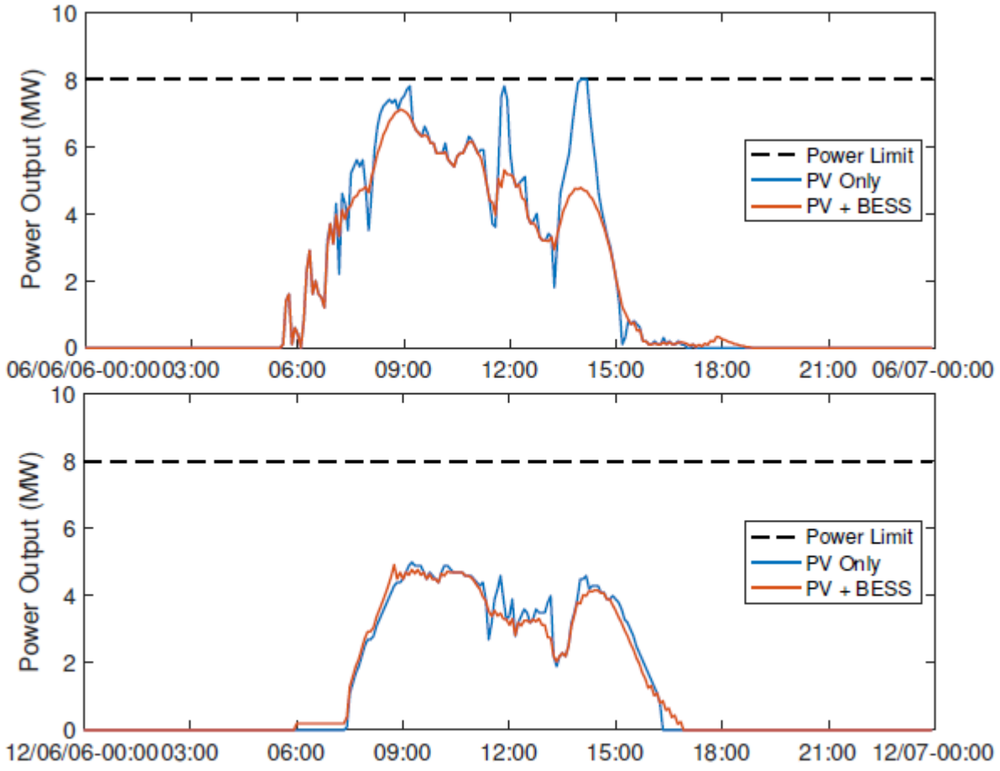


Fig. 1. Power output on two typical days in summer and winter.

Motivation:

- Duke Energy Carolinas adopted a PURPA tariff providing strong incentives for solar developers to smooth their output
- We were approached by North Carolina Utilities Commission staff to study how storage could be used to maximize compensation under the new tariff

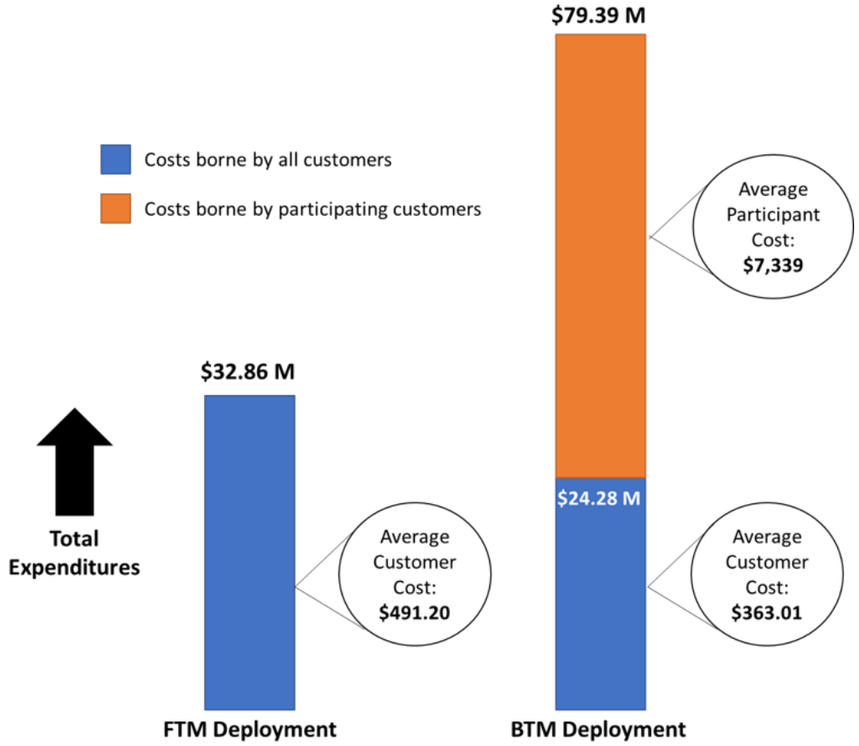
Key finding:

- Adding 1.12 MW/1.23 MWh of storage to a 10 MW PV facility would cost-effectively meet the tariff's conditions

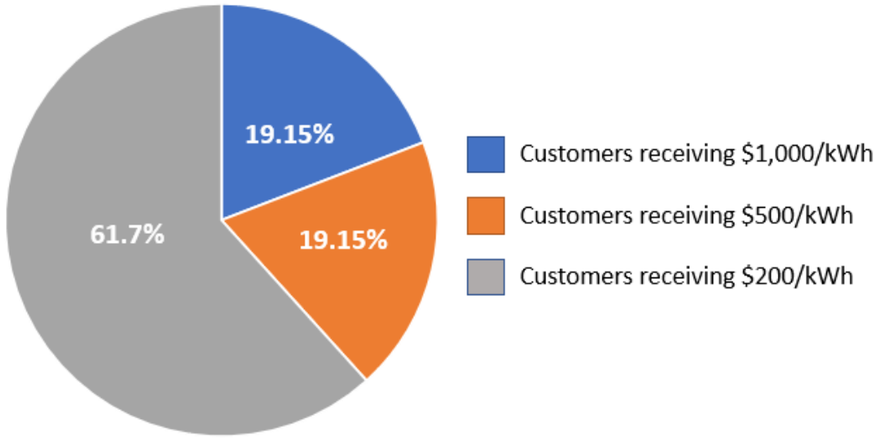
Status: Accepted by the Electrical Energy Storage Applications and Technology (EESAT) Conference (November 2022)

Conference Paper:
Equitable Design of Behind-the-Meter Energy Storage Programs

This paper evaluates different approaches to energy storage procurement from the customer's perspective and evaluates how behind-the-meter programs can be equitably structured while keeping customers financially indifferent between front-of-meter (FTM) and behind-the-meter (BTM) energy storage procurements.



BTM programs increase overall costs, but decrease costs borne by utility customers.



Tiered incentives can enable low- and moderate-income participation while keeping customers financially indifferent between FTM and BTM storage.

Status: Accepted by the Electrical Energy Storage Applications and Technology (EESAT) Conference (November 2022)

State and Industry Engagements

Illinois (with Sandia National Laboratories)

- Presented at two workshops, covering state policy options and storage as transmission

Pennsylvania

- Presented at a joint workshop of the Public Utilities Commission and Department of Environmental Protection on energy storage policy options and emerging use cases
- Assisted DEP personnel in reviewing RFP responses to a state-funded solar+storage project

Michigan (with Argonne National Laboratory)

- Presented on energy storage incentive programs at a Michigan PSC workshop

Utah

- Presented on energy storage policy options before the Public Utilities and Energy Technology Interim Committee

Indiana

- Presented on energy storage policy options and emerging uses at the Electrify Indiana conference

State and Industry Engagements

Legislative Energy Horizons Institute

- Presented on energy storage policy options and safety codes to a group of state legislators and state legislative staff

FERC

- Presented the OE Energy Storage technical assistance model at a workshop for the FERC Office of Public Participation

Detroit Edison (with Argonne National Laboratory)

- Presented on incorporating energy storage into integrated resource plans at a workshop for Detroit Edison's IRP team

National Council on Energy Policy (with Lawrence Berkeley National Laboratory)

- Webinar presentation: Energy storage in IRPs

NASEO

- Webinar presentation: Energy storage, equity, and resilience planning
- Webinar presentation: Federal and state energy storage programs

State and Industry Engagements

Energy Storage Grand Challenge – Community of Practice

- Webinar presentation: Energy storage safety and siting
- Webinar presentation: Storage as a transmission and dual-use asset

Smart Energy Industry Association (SEIA)

- Webinar presentation: Embedded energy storage

Energy Storage for Manufacturing and Industrial Decarbonization (DOE Workshop)

- Presented on the role of energy storage in decarbonizing industrial loads

Energy Storage@PNNL Webinar Series

- Webinar presentation: Trends in state energy storage policies

Northwest Energy Systems Symposium

- Conference presentation: Energy storage in IRPs

Transmission and Interconnection Summit

- Conference presentation: Storage as a transmission asset

Looking Ahead: Ongoing and Planned Projects

- Quantifying the potential for energy storage as a transmission asset
- Developing state-level guidance for energy storage projects (partnering with Washington state)
- Addressing LDES barriers in planning and procurement practices
- BTM incentive design: avoided cost basis
- Community benefits agreements for energy storage projects
- Codes and standards primer for non-engineers
- Study of state code adoption processes
- Best practices in interconnection queue reform
- Deploying energy storage in a co-op setting

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Thank you

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