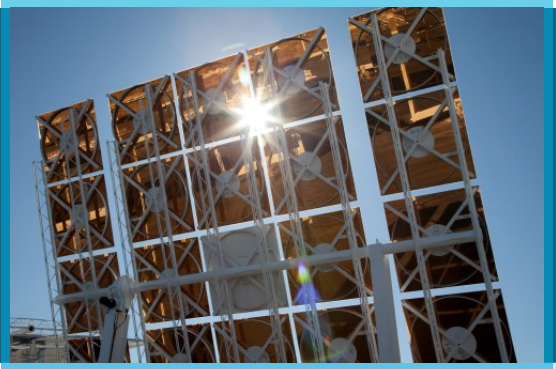
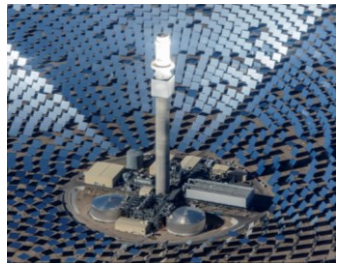
Long-Duration Energy Storage:

Policy Gaps, Regulatory Changes & Business Opportunities





PRESENTED BY

Will McNamara

Sandia National Laboratories, Albuquerque, NM

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Topics I will be covering today.

1. How does LDES "fit" into a broader market landscape?
2. What are the policy gaps that create barriers for LDES?
3. What are the regulatory changes that need to be made?
4. Sandia's work with state regulatory commissions.

Setting the stage for LDES' (future) prominent role.

- Costs for fossil fuels remain volatile and costs for renewable energy technologies are falling.
- 14 states have now adopted 100% clean / renewable energy goals, with aggressive timelines. **Decarbonization** by definition includes a comprehensive move away from fossil fuels and toward renewables and clean energy.
- The **intermittency / non-dispatchability** of renewables drives a need for long-duration energy storage (LDES).
- **Resilience and reliability** concerns are also driving a need for localized power supply, which will depend on energy storage /LDES.
- **Electrification** will increasingly become a driver for LDES. The EIA projects that electric vehicles will 31% of the global fleet by 2050. If these projections are correct, LDES will be needed to support this large increase in electrification.

The following states have adopted decarbonization / clean energy / renewable goals.

These are state-level initiatives. Utility specific initiatives are not included here

STATE	DEADLINE	GOAL	CLEAR ROLE FOR ES?
AZ	2070	100% carbon-free electricity	NO
CA	2045	100% carbon-free electricity	Somewhat
CO	2050	100% carbon free electricity	Somewhat
CT	2040	100% carbon-free electricity by	NO
HI	2045	100% renewable energy	Somewhat
IL	2050	100% carbon-free electricity	Emerging; policy being shaped by leg requirements
LA	2050	Net zero greenhouse gas emissions	NO
ME	2050	100% clean energy	NO
MA	2050	Net-zero greenhouse gas emissions	NO
MI	2050	Economy-wide carbon neutrality	NO

The following states have adopted decarbonization / clean energy / renewable goals.

These are state-level initiatives. Utility specific initiatives are not included here

STATE	DEADLINE	GOAL	CLEAR ROLE FOR ES?
NV	2050	100% carbon-free electricity	Somewhat
NJ	2050	100% carbon-free electricity	NO
NM	2045	100% carbon-free electricity	NO
NY	2040	100% carbon-free electricity	Somewhat
OR	2040	Greenhouse gas emissions reduced 100 percent below baseline emissions	Somewhat
RI	2030	100% renewable energy	NO
VA	2045	100% carbon-free electricity	NO
WA	2045	100% zero-emissions electricity	Somewhat
WI	2050	100% carbon-free electricity	NO

Decarbonization goals set the stage for LDES policymaking.

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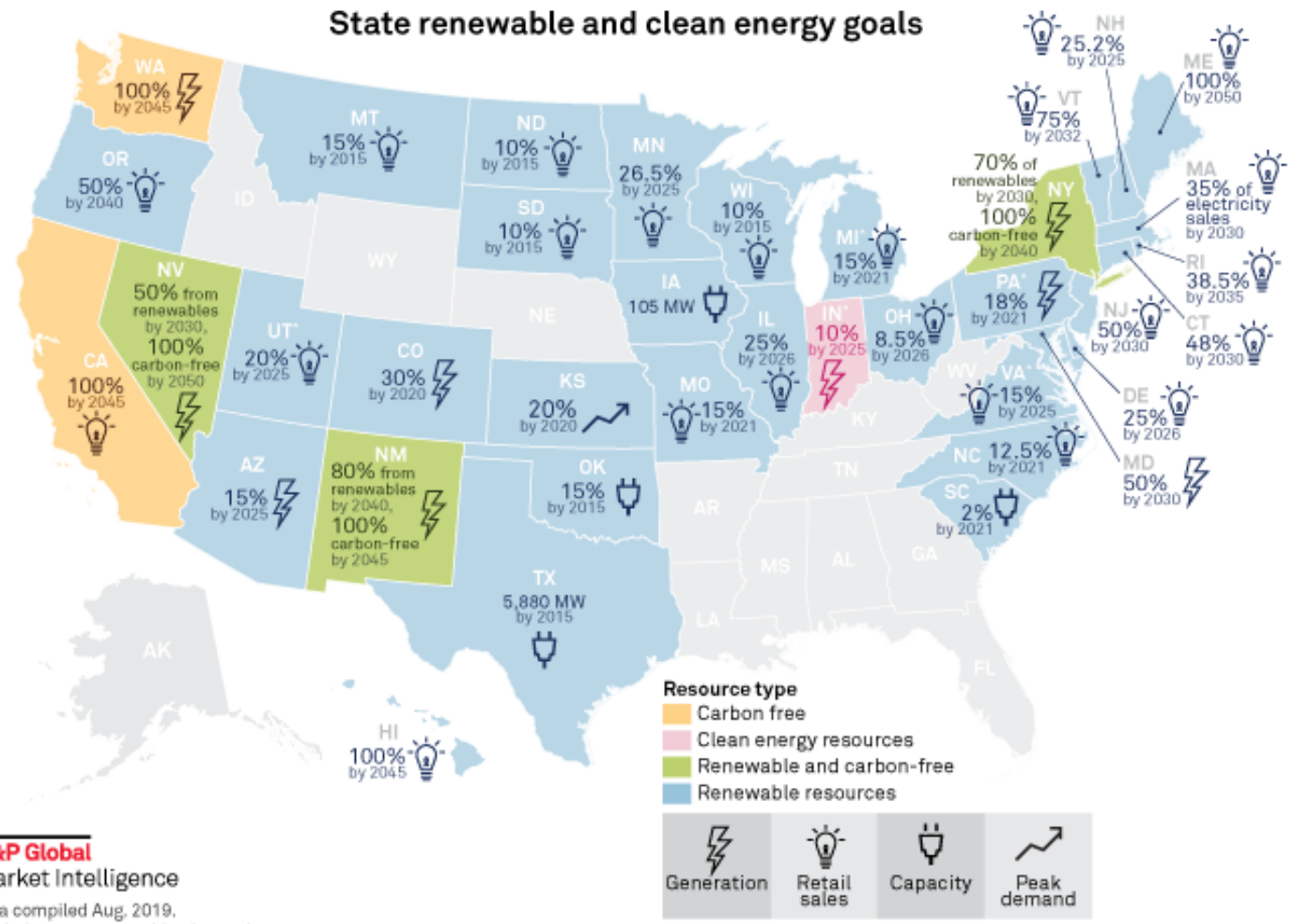
How LDES is defined varies by jurisdiction. 4+ hours, 10+ hours, seasonal?

The lack of consistency in defining LDES creates policymaking challenges.

Nevertheless, the future need for LDES is clear.

New large-capacity, long-duration energy storage solutions are needed to ensure grid performance* with increasing intermittent renewables and threats that current ES technologies (e.g., pumped hydro, batteries) alone cannot economically address.

*Stability, reliability, and resilience



S&P Global Market Intelligence

Data compiled Aug. 2019.
ˆ Includes non-renewable alternative resources.
Indiana, Kansas, North Dakota, Oklahoma, South Carolina, South Dakota, Utah and Virginia have renewable portfolio goals instead of standards.
Virginia's RPS goal is based on the volume of electricity sold in 2007.
Map credit: Ciaralou Agpalo Palicpic
Sources: S&P Global Market Intelligence; Sierra Club; Union of Concerned Scientists; Database of State Incentives for Renewables & Efficiency; and state public utility commission websites

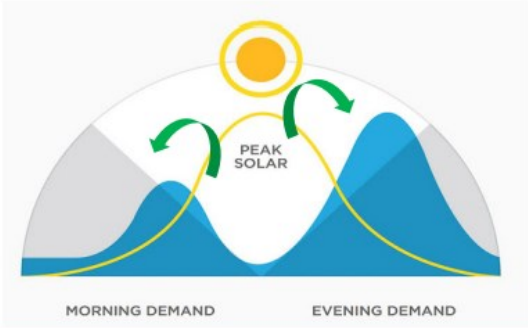
https://www.spglobal.com/marketintelligence/en/news-insights/latest-news-headlines/us-states-face-uneven-paths-in-movement-for-100-clean-energy-53419260

LDES can be supported by various technologies.

Lab experiments, commercial developments and new market needs support the development of a portfolio of LDES solutions necessary to meet decarb goals.

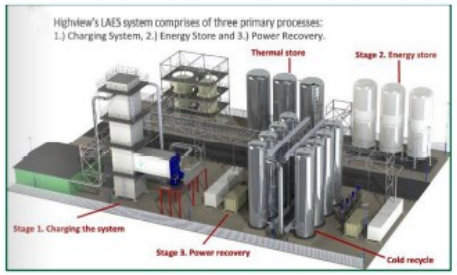
Today, lithium batteries represent the state of art for current needs of energy storage: they're fast, flexible, modular, and getting cheaper and cheaper (cost in 10 years is almost reduced by a 10x factor!)

As non-programmable renewables increase, the need for long duration (>4-6 hours) is becoming a critical topic for the balancing of electric systems



Need for competitive solutions that are safe for people and environmental friendly

…Liquid Air..



…Flow Batteries…

…Thermal Storage…

…Gravitational…

…Liquid CO_2…

…& more!

But LDES continues to face policy challenges.

- *Challenge #1:* Lack of policy consistency
  - Most states have not developed an LDES policy (CA is an exception)
  - Little agreement about where, how and why LDES will be deployed.
- *Challenge #2:* It's unclear what LDES should do, and where.
  - Most regions have only adopted a 4 hour-or-less energy storage requirement
  - Currently little need or value beyond 4 hours
- *Challenge #3:* Little consensus on how LDES should be valued or compensated.
  - In restructured markets, LDES needs to make money.
  - Efforts to define ISO/RTO, utility and customer services remain incomplete.

How LDES is defined varies by jurisdiction. 4+ hours, 10+ hours, seasonal?

The lack of consistency in defining LDES creates policymaking challenges.

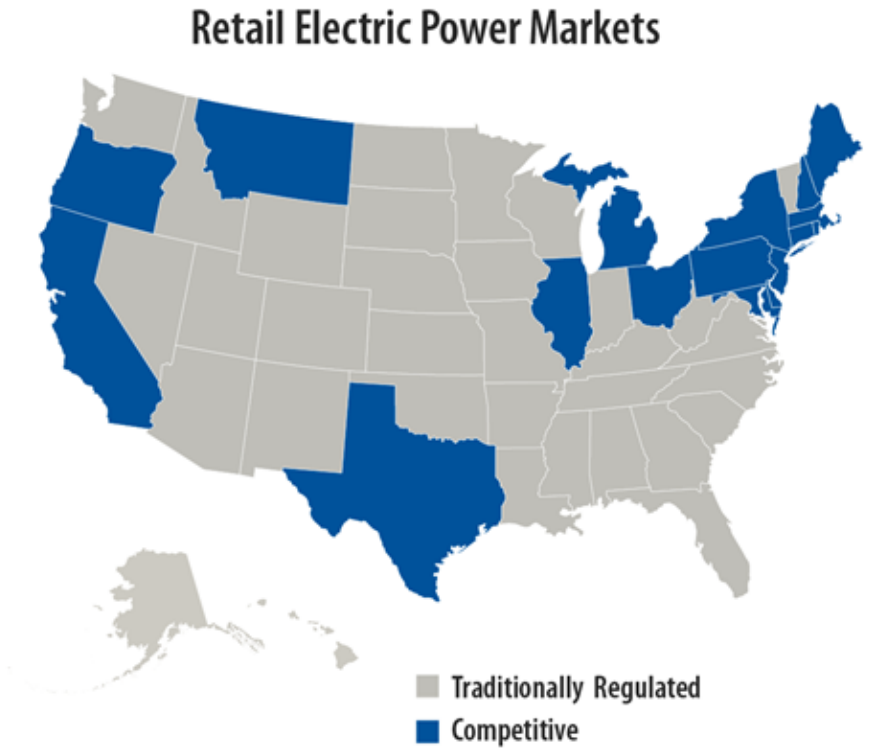
Policy Gap #1: The U.S. market is not homogenous.

Regulated Markets

"Vertically integrated" utility **owns or controls** generation, transmission, and distribution

Regulated by states (public utility commissions)
Cost recovery via rates charged to customers

LDES needs to solve grid problem and be reliable, low-risk



https://www.epa.gov/repowertoolbox/understanding-electricity-market-frameworks-policies

Restructured Markets

Market is **competitive**

Utilities usually prohibited from owning G&T assets.

RTOS/ISOs responsible for inter-/intra-state T, D and O&M with oversight from FERC

LDES needs to make money

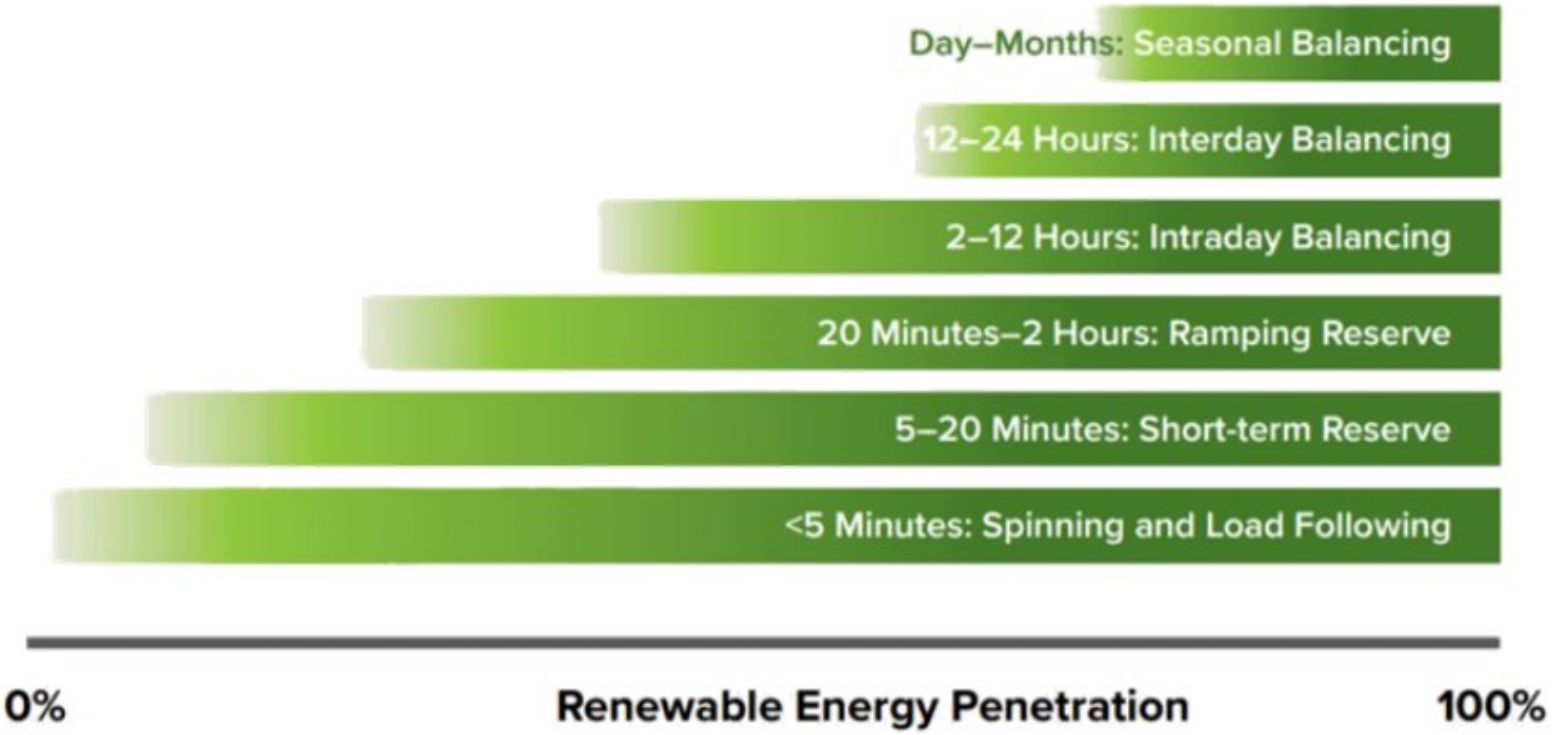
- Most states have not developed an LDES policy (CA is an exception)
- Little agreement about where, how and why LDES will be deployed.

Policy Gap #2: It's unclear what LDES should do, and where.

How to use LDES is a question for both retail and wholesale markets.

- **FERC Order 841** requires RTOs/ISOs to establish market rules, including **energy storage durations** to receive full capacity or resource adequacy credit in wholesale electricity markets
  - Nearly all regions adopted 4 hour-or-less energy storage requirement
  - **Currently little need or value beyond 4 hours**

Grid economics for LDES require solutions that can deal with multi-day, multi-week and multi-month balancing



Source: Rocky Mountain Inst.

Policy Gap #3: There is a lack of agreement on how LDES should be paid.

➢ "LDES Needs to Make Money"

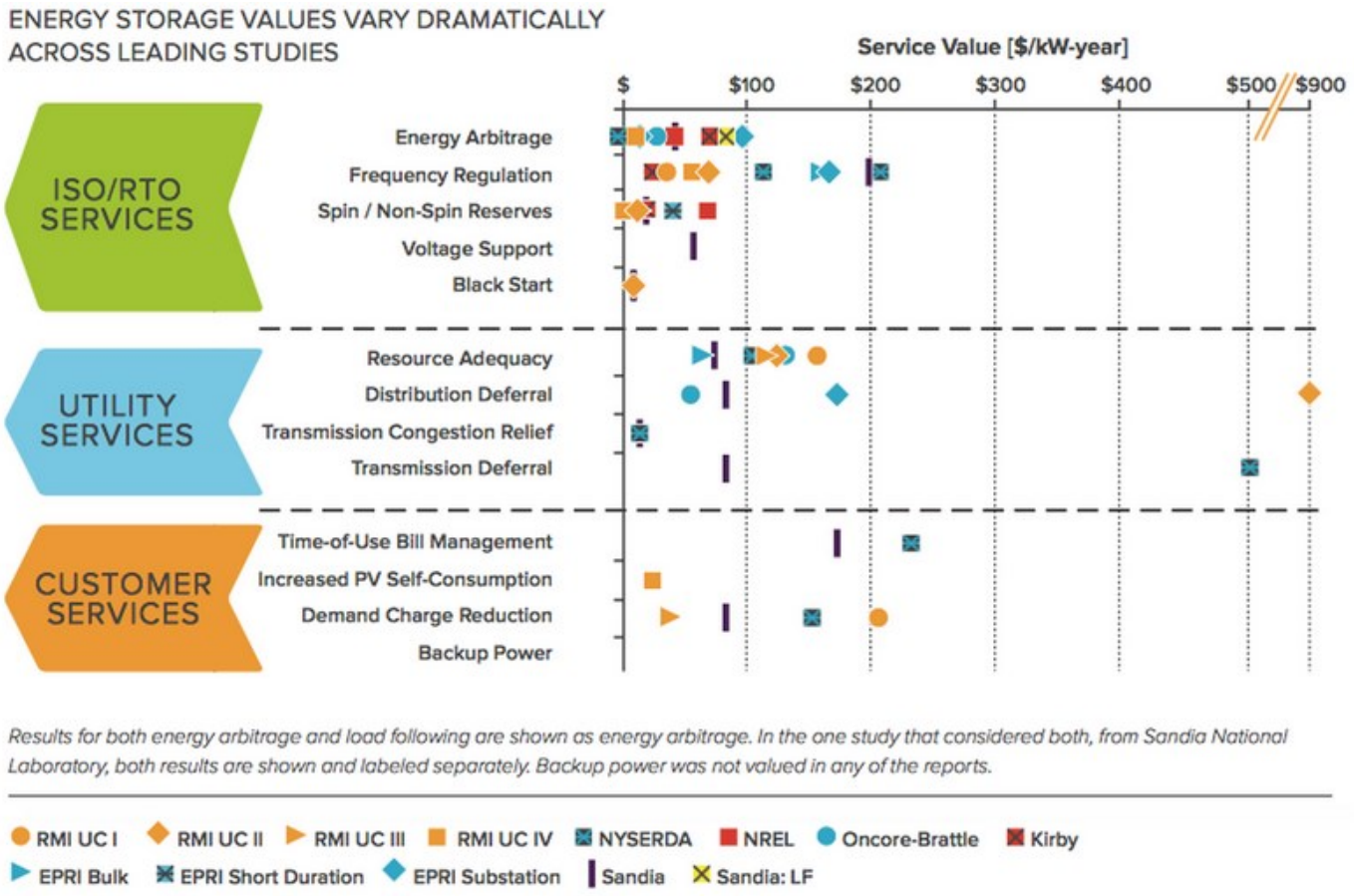


IMAGE SOURCE: ROCKY MOUNTAIN INSTITUTE'S THE ECONOMICS OF BATTERY ENERGY STORAGE.

Define & Enable Value Stacking Policies

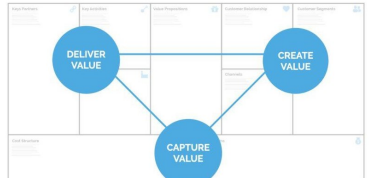
- ISO/RTO services
- Utility services
- Customer services

Create consistency between distribution/retail and transmission/wholesale value streams.

A number of regulatory changes need to be made to accommodate LDES.

- LDES is not currently valued (or needed) in existing energy markets. Aside from California, most states have given little attention to LDES. Thus, policy gaps persist across the U.S.

- Issues on which policy needs to be created can be organized into the following categories:
  - Defining Policies
  - Business Model Policies
  - Monetization / Valuation Policies
  - Risk Mitigation Policies



Market Defining Policies

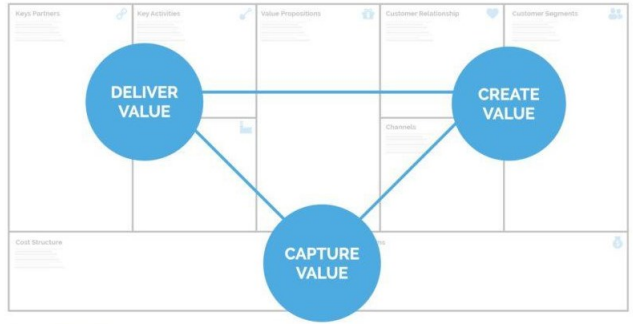
Defining an LDES market frequently starts with shaping perceptions:

- Determining how LDES will be defined in terms of duration, technologies, applications, etc.
- Including / eliminating key technologies such as include pumped hydro, electrochemical, hydrogen, and thermal storage
- Defining the fundamental market components (e.g., cost, market participation rules, degradation/losses, reliability/materials

Business Model Policies

Creating a commodity market for LDES :

- Define value drivers for LDES
- Adopt relevant components from other commodity markets (e.g., gas, water, agriculture)
- Define ownership models to ensure a level playing field
- Prevent market manipulation
- Create financing opportunities (federal and state)



Monetization / Valuation Policies

- **Defining multiple use applications (MUAs)**
  - Allowing for both distribution reliability services and market opportunities
  - Consistency between state rules and RTO/ISO rules
  - How should MUAs be prioritized?

- **Setting a price value for the following services:**
  - Energy market (time shifting, MWh)
  - Capacity market (meeting loads, MW)
  - Transmission asset (prevent thermal overloads)
  - Resilience/insurance (recovering from natural disasters)
  - Elimination of double taxation (consumption and generation)
  - Carbon tax (cost avoidance)

Risk Mitigation Policies

Investment risk in LDES can be addressed through:

- Technology demonstrations
- Pilot programs
- Federal assistance for technology development (e.g., DOE Storage Shot, CSP program, ARPA-E Days)
- State mandates for storage deployment (e.g., California) that include utility cost-recovery provisions

Summary of Policy Issues

- There is an absence of LDES policies in every state / region in the U.S. (California is the exception).
- While there is optimism surrounding LDES' future, there is still little consensus about where and how it can be used, and its value to the grid.
- Policymakers can fill this gap by:
  - Defining fundamental LDES market components;
  - Creating a commodity market for LDES;
  - Creating valuation policies by defining MUAs & setting price values for specific LDES services; and
  - Setting policies that reduce risk for LDES developers

The national labs have an opportunity to help states identify and address these gaps and barriers.

- The momentum has begun and is continuing, as state legislatures and governors have shown an increased interest in pursuing legislation designed to bolster the role of ES in achieving clean energy goals.
- High level goals are frequently handed down to regulatory commissions to implement, but the knowledge gap is steep at many commissions.
- While FERC is driving federal policy at the RTO level (e.g., Orders 841 and 2222) putting "steel in the ground" is often more directly impacted by what is happening at the state level.
- Disconnects between state and federal policy create confusion and will keep barriers in place.
- Lack of uniformity across states can create a "patchwork" marketplace for storage and prevent market developments.

Overview of SNL Policy & Outreach activities.

Format

- Custom tailored sessions based on state's needs
- 5 to 7 Sessions
- 2 hours per session
- Q&A

Speakers

- National Labs
- Industry Experts
- Local Experts
- Other PUC Staff

Topics

- Introduction to Energy Storage Systems, Economics, and Policy
- Energy Storage Economics, Valuation, and Cost Benefit Analysis
- Policy Issues
- Energy Equity
- Interconnection, Codes, and Standards
- Federal and Regional Issues (e.g., FERC Orders 840, 2222)
- Decarbonization and Energy Storage (a growing number of states are adopting 100% decarb/clean energy goals).

Activities & Engagements

Past Webinars

- **Public Utilities Commission of Nevada** - January 2020
- **Maryland Public Service Commission** - March – April 2020
- **Utah Governor's Office of Energy Development** - July – August 2020
- **Illinois Commerce Commission—November 2021 / January 2022**
- **ISU/Organization of MISO States** - August – November 2020
- **New Mexico Public Regulation Commission** - November 2020 – February 2021
- **New Jersey Board of Public Utilities** - January – March 2021
- **New England Conference of Public Utilities Commissioners** - March – June 2021
- **Wisconsin Public Service Commission** - April – July 2021
- **Microgrids & Energy Storage for Emergency Grid Resilience (FEMA Regions 7: IA, MO, KS, NE and 5: IL, IN, MI, MN, OH, WI)** – November – December 2021

"In the Works"

- Southeastern States
- Iowa Utilities Board

Publications

- Energy Equity
- LDES policy
- Rate reform

The energy storage policy landscape continues to evolve.

Sandia National Labs monitors and analyzes activity at the federal and state levels and publishes information in the Global Energy Storage Database, available at this link:

https://www.sandia.gov/ess-ssl/global-energy-storage-database/

Q&A Session

Thank you!

Contact Information:

Will McNamara

Email:
jwmcnam@sandia.gov

Cell Phone:
505-206-7156

Thank you!