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# Policy & Regulatory Issues: Federal Considerations for LDES

*Prepared for the  
California Energy Commission*

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# What I will be covering today.

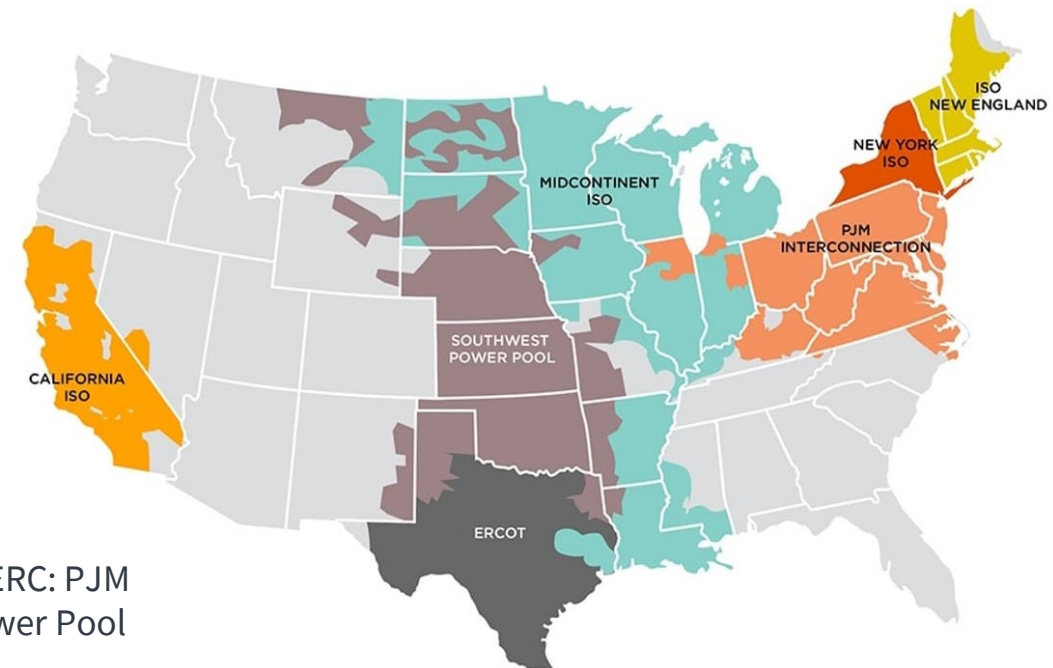
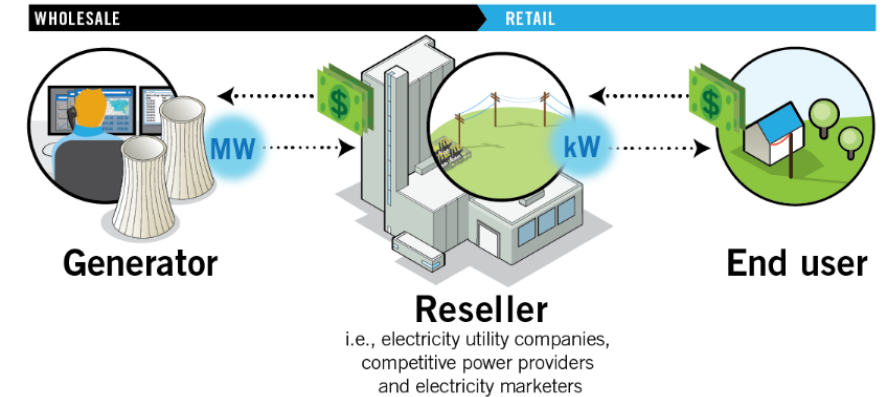


1. Focus of this presentation: Wholesale Markets Policy
2. The LDES National Consortium
3. Federal / Wholesale Market challenges we are addressing
4. Review of federal policies (e.g., FERC orders) that impact LDES
5. Current policy reforms underway in California
6. Correlation with LDES National Consortium Industry Recommendations

# Scope of this discussion: Wholesale Markets.



- Wholesale markets cover the buying and selling of electricity between energy suppliers and generators.
- The industry is presently building the policy frameworks that will enable LDES to play a significant role in wholesale electricity markets.
- It is anticipated that LDES will play a significant role by providing a stable source of power during periods of high demand or low renewable generation.
- How?
  - ✓ Energy arbitrage, including seasonal arbitrage
  - ✓ Managing renewable variability
  - ✓ Capacity market participation / resource adequacy
  - ✓ Ancillary services (frequency regulation, voltage control)



Six wholesale markets in the US are managed by ISOs/RTOs, which are regulated by FERC: PJM Interconnection (PJM), Midcontinent ISO (MISO), California ISO (CAISO), Southwest Power Pool (SPP), New York ISO (NYISO) and the ISO-New England (ISO-NE).

# Scope of this discussion: Wholesale Markets.



- **Service territory:** 132,000 square miles
- **Generating units:** 1,019
- **Miles of transmission:** 26,000
- **Peak demand (2019):** 44,301 MW

CAISO's largest transmission owners include:

- Pacific Gas and Electric Company
- Southern California Edison Company
- San Diego Gas and Electric Company
- Western Area Power Administration, Sierra Nevada Region

- CAISO manages the operation of California's bulk electric power system, transmission lines, and electricity market.
- CAISO does not sell electricity to end users, nor does it own generators, power lines, or other equipment. Rather, it's responsible for the safety, reliability, and security of the bulk power transmission system in its footprint.
- Grid-scale storage resources are being rapidly implemented on the California ISO grid to offer replacement capacity for retiring resources and integrate more renewable resources.



# How LDES Participates in CAISO.



- All of CAISO's market rules are subject to regulation by and approval from the Federal Energy Regulatory Commission (FERC).
- Energy storage resources, including LDES, participate in CAISO as Non-Generation Resources (NGRs).
  - ✓ NGRs are resources that operate as either generation or load (demand).
  - ✓ NGRs bid into the market using a single supply curve with prices for negative capacity (charging) and positive capacity (discharging).
  - ✓ NGRs can be dispatched to any operational level within their entire capacity range.



# How LDES Participates in CAISO.



- There are 2 markets within CAISO:
  - ✓ Day-ahead market: Conducted the day prior to when the energy will be consumed — typically in the morning. Buyers agree to purchase a set amount of electricity from sellers at the market price and both parties are committed — the buyer must buy, and the seller must sell.
  - ✓ Real-time energy market (“spot market”): Allows buyers to purchase electricity for immediate use, balancing actual demand and system constraints with the purchase commitments made the previous day. The real-time market typically runs once per hour and once every five minutes to manage real-time load changes and real-time pricing.

## Western Energy Imbalance Market (WEIM)

- Established in 2014.
- Platform for real-time energy trading across multiple western states beyond just California's borders; essentially, the WEIM is a larger, regional version of California's real-time market.
- This is a regional market where multiple western states can buy and sell electricity in real-time to balance supply and demand across a wider geographic area, managed by the California ISO.
- 22 participating entities representing 79% of the load in the Western Interconnection.

# Resource Adequacy & Ancillary Services



- CAISO does not have a capacity market.
- Resource adequacy is regulated by the CPUC by requiring load-serving entities (IOUs, community choice aggregators, and energy service providers) to maintain a Planning Reserve Margin (PRM), resources above the peak load.
- The PRM exists to cover the differences between forecasted and actual demand. For 2024 and 2025 it is 17%.
- LSE's must demonstrate they have enough capacity to meet demand on the ISO's "worst day" of each month (i.e., the "Slice of Day" policy that is regulated by the CPUC).

## Ancillary Services

- ✓ Regulation up: Units that can move above their scheduled operating point to maintain the frequency on the system by balancing generation and demand.
- ✓ Regulation down: Units that can move quickly below their scheduled operating point.
- ✓ Spinning reserve: Units that are already synchronized with the grid and can respond within 10 minutes of a CAISO dispatch signal.
- ✓ Non-spinning reserve: Resources that are capable of synchronizing with the grid and responding within 10 minutes of a CAISO dispatch signal.

# CAISO Continues to Evolve, Under FERC Reg.



- The CAISO energy storage market model is evolving.
  - ✓ Real-time market has a shorter optimization horizon (a single hour).
  - ✓ This can make it more difficult to capture periods when it is critical that the storage resources have state of charge for several hours to meet system needs.
  - ✓ Suggested reforms would have the real-time market horizon include multi-hour or a range to maximize market optimization to acknowledge the LDES charge and discharge potential over longer periods of time.



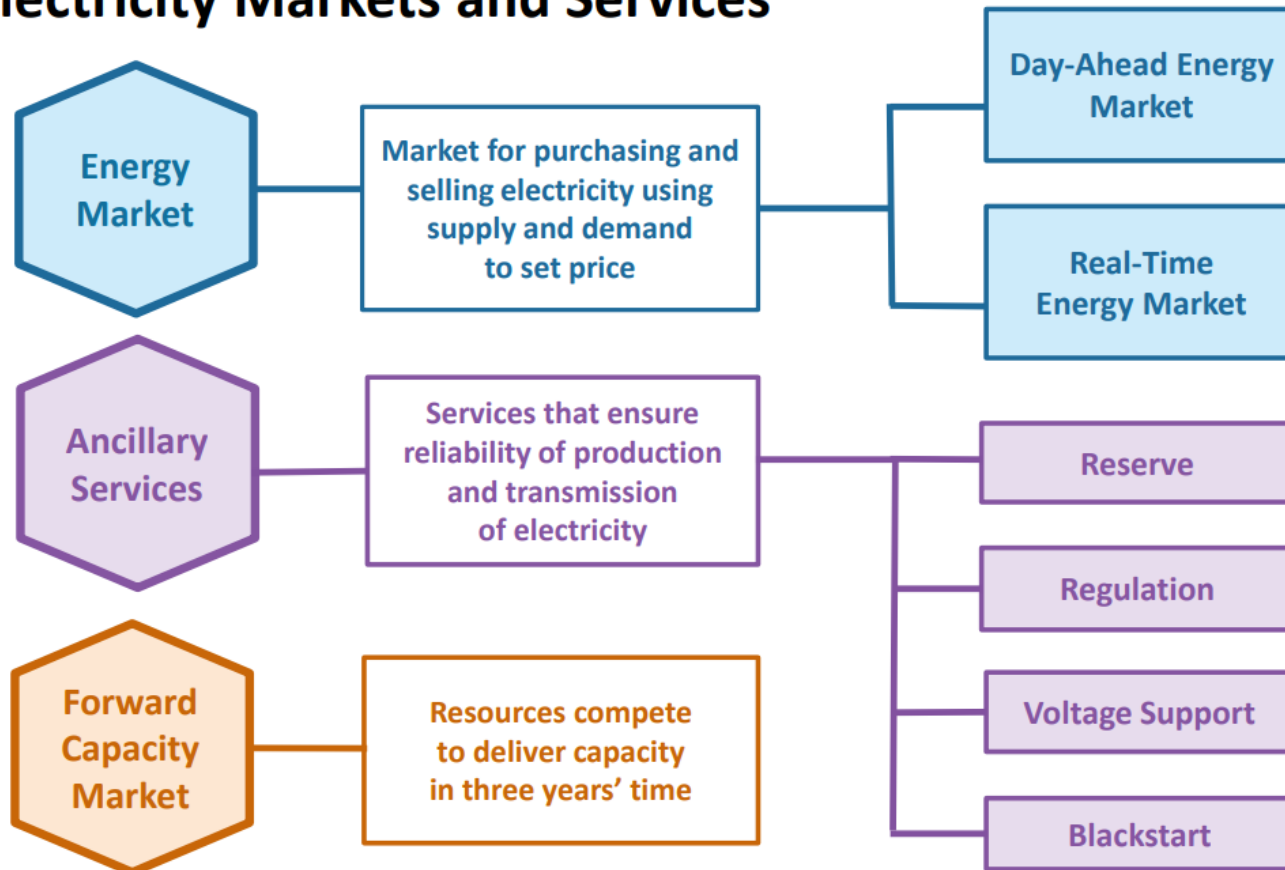


# Relevant FERC Orders

FERC's Orders are intended to create a "level playing field" for ES assets to participate in wholesale markets.



## Storage Can Participate in All of the Region's Wholesale Electricity Markets and Services



- Energy markets (standard electric energy products;
- Ancillary services (target products to maintain system functionality; and
- Capacity markets (capability or availability to produce power at a specific point in time).

CAISO does not have a capacity market.

# Major FERC Orders Affecting Energy Storage (1)



## ORDER 841—August 2018

Required RTOs/ISOs to establish a participation model consisting of market rules that ensure:

- Energy storage resources are eligible to provide all capacity, energy, and ancillary services they are technically capable of providing.
- RTO/ISO tariffs account for physical and operational characteristics of energy storage.
- Energy storage resources are able to be dispatched and set the wholesale market clearing price as both a wholesale seller and a wholesale buyer.
- RTO/ISO tariffs establish a minimum size requirement for energy storage resources not to exceed 100 kW.

FERC has found CAISO to be in compliance with Order No. 841.

# Major FERC Orders Affecting Energy Storage (2)



## ORDER 2222—September 2020

- Focuses on aggregations of small resources. Defines a distributed energy resource (DER) as “any resource located on the distribution system, any subsystem thereof or behind a customer meter.” This definition may include storage resources.
- Finds existing RTO/ISO market rules are unjust and unreasonable in light of barriers to the participation of DER aggregations in the RTO/ISO markets.
- DERs tend to be too small to meet the minimum size requirements to participate in the RTO/ISO markets on a stand-alone basis and may be unable to meet certain qualification and performance requirements.
- Existing participation models for aggregated resources, including DERs, often require those resources to participate in the RTO/ISO markets as demand response, which limits their operations and the services that they are eligible to provide.
- RTOs/ISOS must amend their tariffs to allow DER aggregators to participate in their markets

After making requested revisions (e.g., reducing the minimum required capacity for DERs), CAISO is now considered compliant with Order 2222.

# Many state-level policy questions result from Order 2222.



- How much control should utilities have over how DERs serving wholesale market needs are allowed to connect to the grid in the first place?
- How much control should utilities have over how often and at what scale DERs are dispatched to serve the bulk power grid, particularly when those actions could disrupt the lower-voltage grids utilities are responsible for?
- What hard boundaries should be established between payments for wholesale energy market activities and payments for retail-level (i.e., state-regulated and utility-administered) programs?
- When these jurisdictional or economic boundaries are in question, who gets to decide how to resolve them?
- Tensions may intensify between DERs developers who will resist limits placed on how DERs can participate in wholesale energy markets, and utilities + state regulators who are concerned with how allowing DERs participate in wholesale markets may wreak havoc on distribution grids and state-level policy.



# Major FERC Orders Affecting Energy Storage (3)



## ORDER 2023

- Reforms to implement a first-ready, first-served cluster study process
  - ✓ Public Interconnection Information
  - ✓ Cluster Study Process
  - ✓ Allocation of Network Upgrade Costs for Interconnection Customers in Clusters
  - ✓ Financial Commitments and Readiness Requirements
  - ✓ Transition Process
- Reforms to increase the Speed of Queue Processing
  - ✓ Affected System Study Process
  - ✓ Study Delay Penalties
- Reforms to incorporate technological advancements
  - ✓ Increasing flexibility in the generator interconnection process
  - ✓ Evaluating alternative transmission technologies in the Generator Interconnection Process
  - ✓ Modeling and performance requirements for non-synchronous generating facilities.

CAISO submitted its compliance filing for FERC Order No. 2023 on May 16, 2024, in Docket No. ER24-2042. The filing is pending before FERC.

# Energy Storage Policy in California

# Current Status—Energy Storage Policy in California

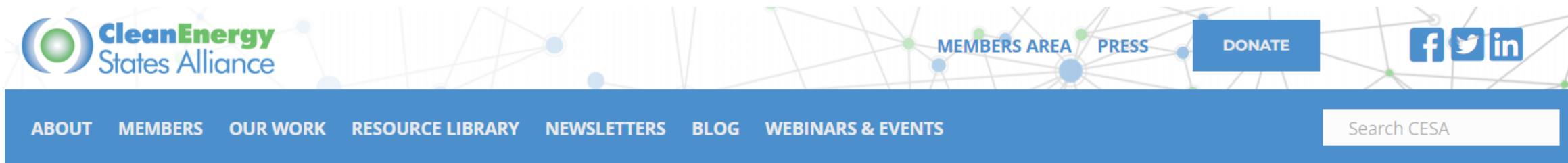


- Decarbonization: Pledge to slash planet-warming emissions by 40% of 1990 levels by 2030 and achieve 100% carbon—free electricity by 2045 (Sources: SB 32 in 2016 and the 100 Percent Clean Energy Act of 2018, applicable to electricity retail sales and electricity procured to serve state agencies).
  
- Will California achieve this target? 2024 report entitled California Green Innovation Index (from Next 10 and Beacon Economics) says “No” although target can be met by 2047.
  - ✓ The researchers calculated that the state had reduced emissions an average of 1.5% annually between 2010 and 2021. Emissions have fallen just 11.5% below those of 1990.
  - ✓ To reach the 2030 goal it would now have to reduce emissions by 4.6% a year. Although pollution plummeted during the pandemic in 2020, carbon emissions increased by 3.4% the following year, according to the analysis.
  - ✓ California Air Resources Board — contests these findings and claims the state is on track to meet its goals.

# Current Status—Energy Storage Policy in California



## ➤ Energy Storage Procurement:



State	Energy Storage Procurement Targets	Current status	Percent of final target met	Comments	Originating Source	Mandate/Goal/Target
California	1,825 MW procured by 2020 and installed by 2024. Carve-out of 500 MW for BTM. Additional 2 GW (1 GW of 12-hr storage and 1 GW multi-day) of LDES to be deployed between 2031 and 2037.	10,383 MW total (8,736 MW utility, 571 MW commercial, 1,076 residential) (4999 pending 1,193 MW BTM)	569%	In 2010, the California Legislature authorized the California Public Utilities Commission (CPUC) to consider establishing <a href="#">energy storage targets</a> . The CPUC established their storage procurement targets in 2013, authorized by AB 2514. The procurement targets apply to the state's three largest Investor Owned Utilities. This goal has been achieved. LDES targets were set in August 2024 as part of AB 1373, which sets larger clean energy targets. Statewide energy storage installation data is tracked <a href="#">here</a> .	Legislation and regulation	Mandate

California’s original procurement policy for energy storage did not specify duration requirements (i.e., it was not specific to LDES).

# LDES Policy.



- AB 1373 directed CPUC to assess the need for DWR to procure long lead-time energy resources, including LDES.
- A result of this legislative policy is that California will solicit up to 2 GW of LDES resources as part of a 10.6-GW centralized procurement for emerging clean energy technologies to be deployed between 2031 and 2037.
- Set to begin in 2026, the planned energy storage solicitations will request bids for up to 1 GW of resources with durations of at least 12 hours and 1 GW of multi-day storage resources.
- The California Department of Water Resources will lead the procurement through its Statewide Energy Office, which focuses on “emerging and existing technologies that need scaling to lower costs.

Resource Type	Maximum Quantity	Solicitations Beginning In	Online by
Long Duration Energy Storage: 12 hour+ duration	1 GW	2026	2031-2037
Long Duration Energy Storage: multiple day duration	1 GW	2026	2031-2037
Geothermal	1 GW	2027	2031-2037
Offshore Wind	7.6 GW	2027	2035-2037

LDES developers (e.g., Hydrostor) have argued in favor of reducing the shorter LDES category’s duration threshold from 12 hours to eight hours “to comport with current definitions elsewhere, including in resource adequacy.



# Current Status—LDES Deployment.



- As of late 2022, California load-serving entities had committed to build only about 510 MW of LDES resources through 2035, significantly less than the 2 GW envisioned in the procurement strategy (CPUC analysis).
- A December 2023 analysis by the Brattle Group found the CAISO footprint may need 5 GW of LDES resources by 2045, if it retains its gas generation or up to 37 GW of LDES resources if it fully retires gas generation.
- Strategen Consulting study concluded that California will need between 45 and 55 GW of LDES by 2045 to achieve its decarbonization goals while retaining reliability.
- Battery storage capacity grew from about 500 MW in 2020 to 11,200 MW in June 2024 in the CAISO balancing area.
- Over half of this capacity is physically paired with solar or wind generation, either sharing a point of interconnection under the co-located model or as a single hybrid resource.
- The Western Energy Imbalance Market (WEIM) includes about 3,500 MW of participating battery capacity as of June 2024. This is a nearly three-fold increase in battery capacity in the WEIM since June 2023.

*What additional policy changes will be needed to enable California to meet its decarbonization and LDES goals?*

# LDES Projects



- CEC awarded \$26.7 million to three LDES projects that will serve low-income and tribal communities.
  - One project that has received funding under the CEC program is in fact the largest LDES project to date in the state. The CEC awarded a \$30 million grant to Form Energy to build a 5 MW / 500 MWh iron-air battery storage project at a Pacific Gas & Electric substation in Mendocino, California.
  - 1.5-MW/6.6-MWh zinc bromine flow battery system connected to a microgrid serving the Barona Group of Capitan Grande Band of Mission Indians;
  - A 3-MWh thermochemical energy storage system serving the University of California at San Diego's medical campus; and
  - a 100-kW/10-MWh reversible carbon dioxide-to-carbon storage system that will pair with an existing 7-MW solar photovoltaic facility to provide up to 100 hours of capacity. The Barona Group and UC-San Diego batteries will be capable of discharging continuously for at least 24 hours.
- California has drawn proposals for larger LDES developments as well. Hydrostor is developing a 500 MW/4,000 MWh facility in Kern County, California, that will be capable of continuous discharge for at least eight hours, the company says.

# What Policy Reforms are Still Needed?

# LDES in Wholesale Markets.



- Across all RTOs/ISOs, to enable long-duration energy storage (LDES) in wholesale markets, significant changes are needed:

Market Design Modifications	Regulatory Reforms	Technological Advancements:
<ul style="list-style-type: none"><li>○ Assign appropriate capacity credits to LDES based on long discharge duration, not just power rating, to accurately reflect value in grid reliability.</li><li>○ Implement pricing structures that incentivize charging during low-demand periods and discharging during peak demand, allowing LDES to capitalize on price arbitrage opportunities.</li><li>○ Develop new market products specifically for LDES, such as "energy capacity" markets that allow LDES to sell their ability to provide sustained power over extended periods.</li></ul>	<ul style="list-style-type: none"><li>○ Define LDES as a distinct asset class within the market, allowing for tailored regulations and market rules to optimize its participation.</li><li>○ Enable flexible dispatch of LDES to respond to grid needs, including the ability to charge and discharge at different times depending on market conditions.</li><li>○ Ensure LDES can fully participate in ancillary services markets, such as frequency regulation and voltage control, to maximize revenue streams.</li></ul>	<ul style="list-style-type: none"><li>○ Continued R&amp;D efforts are crucial to reduce the cost of LDES technologies, making them more competitive in the market.</li><li>○ Enhance the round-trip efficiency of LDES systems to maximize energy storage capacity and profitability.</li></ul>



LDES NATIONAL  
CONSORTIUM

# The National Consortium for the Advancement of LDES Technologies

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**OCED**  
Office of Clean Energy Demonstrations



**OTT**  
Office of Technology Transitions

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# The National Consortium for the Advancement of LDES Technologies



The LDES National Consortium provides a forum through which stakeholders across the LDES ecosystem can convene to **identify barriers, determine potential synergies, and collaboratively develop and implement strategies necessary to achieve LDES technology commercialization** within the next decade.

## MAJOR DELIVERABLES OVER NEXT THREE YEARS:

- LDES Demonstrations & Deployments Tracking System
- LDES Technology Maturity Evaluation Framework
- Assessment of Utility Needs for LDES
- Geographical Readiness Assessments
- Evaluation of US Wholesale Markets
- Evaluation of US Retail Markets
- Full Set of Commercial Pathways Recommendations
- Networking and Community Outreach



### Lab Leadership

Lead by Sandia Labs partnering with ANL, INL, NREL, ORNL, & PNNL



### 180+ Teaming Partners

LDES National Consortium will be comprised of U.S. industry and community stakeholders, known as "Teaming Partners."

**3 Years  
\$7M Federal  
Funds + Cost  
Share**

**16 Tiger  
Teams**  
Topical working groups to evaluate challenges.



### Website

Community of Knowledge and Best Practices ensuring findings are easily accessible

**National Launch: January 2024**

# Organizational Structure



## TIGER TEAMS

- Customer Adoption
- Demonstrations & Deployments
- Economics & Valuation
- Equity
- Grid Infrastructure
- Interconnection, Standards & Permitting
- Investor Confidence / Finance
- Market Planning
- Policy & Regulations
- Reliability & Resilience
- Safety & Grid Security
- Supply Chain & Manufacturing Efficiencies
- Technology Development, Evaluation & Testing
- Use Case Development
- Utility Resource Planning
- Workforce Development

Tiger Teams will develop what ultimately will become the public stakeholder recommendations for these specific focus areas.

- ❖ The recommendations address the commercialization challenges referenced by the DOE's 2023 Lift-off Report.
- ❖ The 11 challenges were assigned to the 16 Tiger Teams; most of the challenges now have 5-10 recommendations associated with them.
- ❖ Along with making the recommendations, we will be developing an implementation tracking system to track results. (Findings will be included in forthcoming assessment reports).

**DOE funded, Lab facilitated, and Industry driven!**

**As of September 2024, we now have 190 Teaming Partners!**



# 11 Challenges—Pulled directly from the DOE's Lift-Off Report.



1. Cost of an LDES system needs to come down by 2030
2. LDES technologies must achieve 7-15% improvement in roundtrip efficiency to compete with Li-ion storage and hydrogen.
3. The specific needs related to LDES workforce training (i.e., skills and training) are presently not well defined.
4. A uniform approach toward developing resource adequacy compensation for LDES technologies does not exist, in either regulated markets (PUC evaluation) or competitive markets (ISO/RTO).
5. A comprehensive assessment of necessary supply chain improvements specific to LDES technologies does not presently exist.
6. There is presently a lack of resources regarding how to evaluate grid upgrades or expansions that will be necessary to accommodate both new variable renewable generation sites and LDES systems
7. Presently, there is no publicly available evaluation of LDES technologies against primary competitive factors.
8. LDES is not included in most utility grid firming plans.
9. LDES use cases require market changes at the wholesale level.
10. ISO and RTO markets will need to develop support mechanisms.
11. State-level policymaking specific to LDES has been very limited.

# LDES Consortium Industry Recommendations



A uniform approach toward developing resource adequacy compensation for LDES technologies does not exist, in either regulated markets (PUC evaluation) or competitive markets (ISO/RTO).

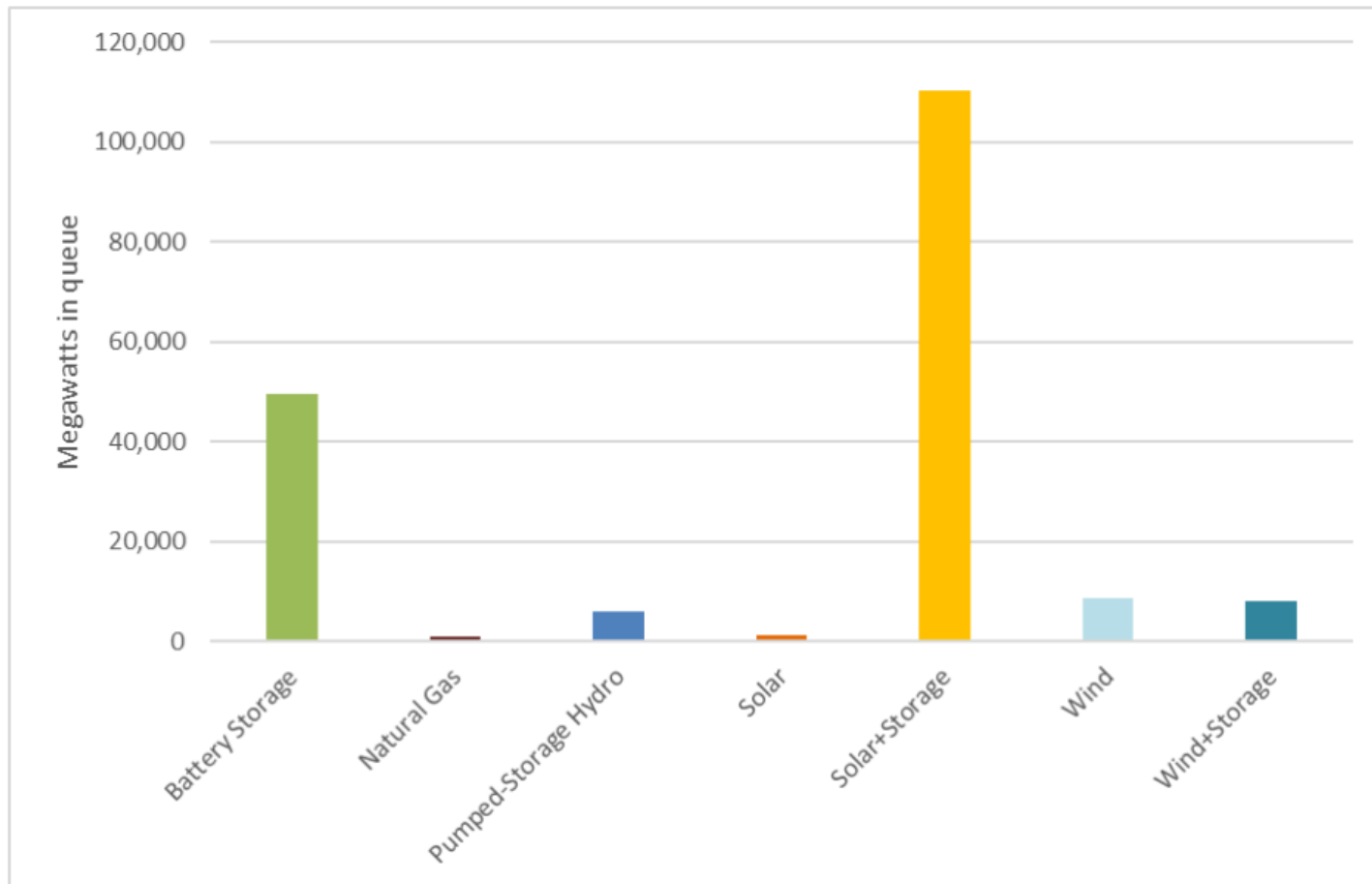
- Recognizing that CAISO does not have a capacity market and RA is managed by the CPUC.
- However, analysis has shown that significant portion of battery capacity used to meet RA requirements is unavailable to the Real-time market in some hours during tight system conditions.
- This is due to how batteries are bid into the real-time market, state-of-charge constraints set by battery operators, which prevent batteries from being fully charged and then discharging up to their nameplate capacity during some peak net load hours.
- Evaluate alternatives to the ELCC metric as a means of evaluating the contributions that LDES can made toward resource adequacy requirements.
  - ✓ California has used ELCC since 2018, but in 2025 will migrate to a “slice of day” RA framework, in which LSEs must show they have enough capacity to meet demand for every hour of the day on the month's "worst day.”
  - ✓ However, the simplicity offered by the slice-of-day approach means sacrificing some detail about resource availability included in ELCC modeling, such as correlated resource availability over the course of multiple days.

# Interconnection Queue Reform.



## INTERCONNECTION QUEUE

There are 185 GW of proposed new generation in the CAISO queue (October 2023). The CAISO interconnection queue is a snapshot of what our overall resource mix will look like under decarbonization pathways: hybrid and standalone storage resources make up 90% of proposed megawatts, with little power coming from natural gas.



## Interconnection Queue Reform

- CAISO has increased the requirements for project readiness to advance to the interconnection study process.
- Designation of priority zones.
- Cluster approvals.



# LDES Consortium Industry Recommendations



There is presently a lack of resources regarding how to evaluate grid upgrades or expansions that will be necessary to accommodate both new variable renewable generation sites and LDES systems.

- Most of the recommendations addressing this challenge relate to interconnection queue reform.
- CAISO is pursuing widespread interconnection reform measures.
- Still pending FERC approval, CAISO has proposed “transformational reforms” under which it will assess three criteria when determining whether a project should move into the interconnection study phase: commercial interest (30%); project viability (35%); and system need 35%)
- The highest-ranking projects will advance to the study phase in descending order of project score, until the available and planned transmission capacity for each constraint is filled to 150% of that capacity.

LDES use cases require market changes at the wholesale level.

- Implement new market products that capture storage costs and generate more efficient market prices
- Extend electricity market dispatch optimization horizons.
- Remove the obstacles preventing full market participation by large dispatchable loads in wholesale markets, with a focus on the tariff changes and modernization needs to enable those resources to contribute their range of services into the market.
- Pursue granular tariffs that accurately capture the marginal cost and benefits of loads based on time of use on transmission, distribution, energy and fuel adjustment charges.

ISO and RTO markets will need to develop support mechanisms.

- Conduct a comprehensive study of which support mechanisms already exist and which need to be developed in ISO/RTO markets for LDES, including LDES technologies under development.
- Conduct an examination of why “storage as transmission” tariffs have not been more successful in the RTOs in which they have been developed, to identify what storage can do and cannot do in respect to transmission applications.
- Conduct further analysis to determine how to capture the value of emissions and translate value into a compensation metric in wholesale markets, based on a presumption that carbon pricing as a fixed value may not send the right market signals or achieve intended impacts toward achieving LDES commercialization.
- Establish compensation mechanisms for LDES that are distinct from energy and capacity revenues.

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/>

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