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Energy Storage Policy: State & Federal Considerations

Prepared for the

Colorado Public Utilities Commission

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Sandia National Laboratories is a multimission laboratory managed and operated by National Technology & Engineering Solutions of Sandia, LLC, a wholly owned subsidiary of Honeywell International Inc., for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-NA0003525.

What I will be covering today.

1. Key differences across states in how energy storage is regulated.
2. Policy issues shaping the future for Decarbonization and Long-Duration Energy Storage.
3. State policy levers for energy storage.
4. Review of Colorado’s relevant policies.
5. Emerging role for LDES (what is it, what applications will it serve, and how will it create market revenue).
6. Introducing the LDES National Consortium.

The U.S. electricity market is not homogenous.

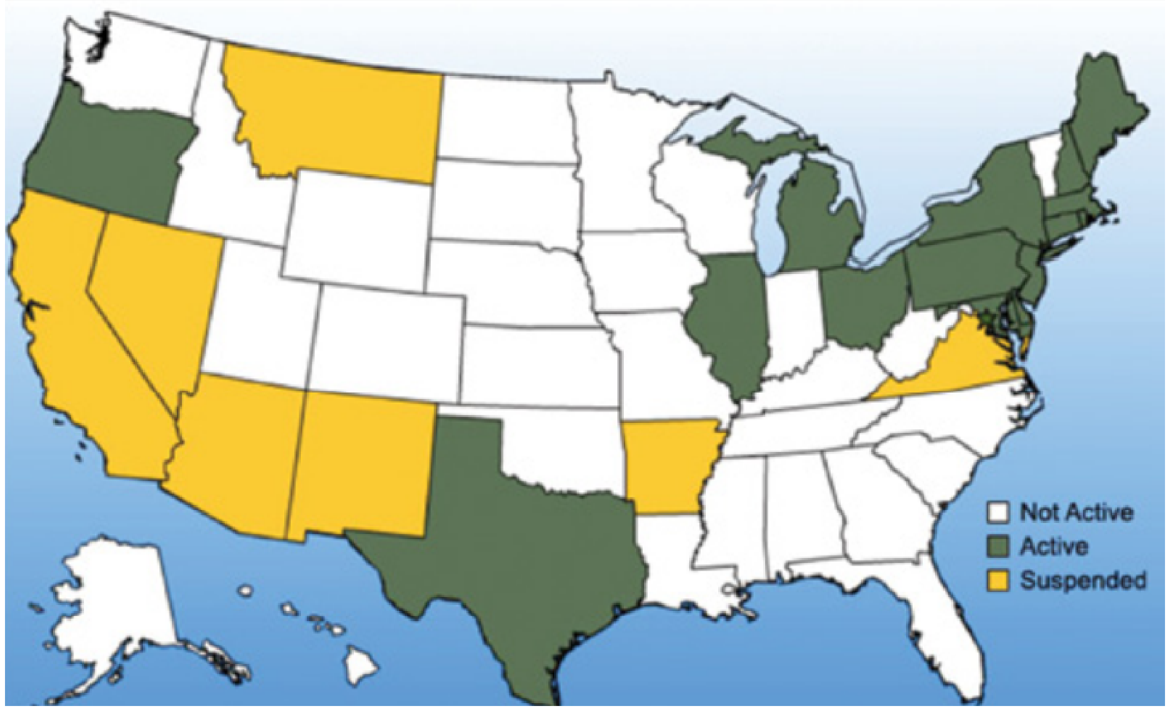
Regulated Markets

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

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

PUC can direct utility action & investments

Status of Electric Restructuring by State



Colorado is a vertically integrated state and is not part of an RTO, although Colorado utilities do participate in the Western Energy Imbalance Market run by the California ISO.

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

Role of PUC varies state to state

Federal vs. State Responsibilities

FEDERAL

FERC, Congress, DOE

- Rules governing wholesale markets / ISOs/RTOs (FERC)*
- Rules governing transmission lines (FERC)
- Tax credit for solar + storage (Congress)
- R&D funding, deployment grants, resilience programs (DOE)

STATES

PUCs, state legislatures, executive directives from governors

- Retail markets
- Operations of distribution networks
- Utility rates
- Other enabling policies

**Colorado is not part of an established ISO/RTO and thus the FERC rules are generally not applicable. However SB 72, passed in 2021, requires Colorado transmission utilities to join an RTO by 2030.*

Energy storage policy development pathways vary across states.

Regulated states may instinctively emphasize distribution system applications:

"ES needs to solve a problem."

Restructured states may place greater emphasis on developing a market:

"ES needs to make money."

States with Vertically Integrated IOUs	States with Restructured IOUs
• Consider expanding policies that encourage value stacking of BTM services (third-party asset ownership of BES assets is particularly effective) • Consider developing policies that encourage a wider range of BES services at the grid scale • Evaluate integrated resource planning (IRP) requirements for opportunities to encourage BES consideration • Consider adopting BES targets or mandates, and/or expanding renewable energy targets	• Consider developing policies that encourage value stacking of BES services at the grid scale • Consider adopting BES targets or mandates • Work with wholesale market organization to enable competition for grid services that BES can qualify to provide

Energy Storage Policy—Current Status

- 19 states (plus the District of Columbia) have adopted decarbonization goals, however, not all have set policy for energy storage deployment.
- About 15 states have adopted some form of energy storage policy, which in all cases exists along with a renewables policy.
- Energy storage activity still driven mostly in states that have the following policies:
  - Utility **procurement mandates, targets or goals** (10 states);
  - Financial **incentives / subsidies** (CA, MD, NJ, NY);
  - State-funded **demonstration projects** (MA, MD, NY, UT, WA)
- Requiring storage in **utility IRPs** is also becoming more common. (NV, NM)

***Deployment*:**

- Installation has been mostly concentrated in CA-ISO and PJM regions, and in states that have developed enabling policy frameworks. Texas is an exception, where business incentives & wholesale opportunities have driven ES development.
- 8 GW of utility-scale battery storage as of 2022 expected to increase by a further 20.8 GW by 2025 (ERCOT, NYISO, and ISO-NE)

State-level Regulatory Roadmaps

- ***Considerations:***
  - ✓ How can energy storage support broader clean energy goals adopted by the state?
  - ✓ Do the current regulatory structures allow energy storage to compete on a level playing field?
  - ✓ Are the right state agencies and stakeholders working together to address existing barriers for energy storage?

- ***Actions:***
  - ✓ Develop an ES Roadmap that identifies policy, technology and process changes to address challenges faced by the storage sector.
  - ✓ Determine what specific policies make the most sense in a specific state.
  - ✓ Ensure collaboration with all stakeholders.

Nationally, policy levers for ES are emerging.

1. Procurement mandates, targets, or goals
2. Ownership models for ES assets
3. Inclusion of ES in utility IRPs
4. Incentives, tax credits, or other subsidies
5. Prioritization of specific use applications for ES technologies
6. State-sanctioned benefit-cost analysis
7. Distribution system modeling for location-specific siting of ES technologies
8. Changes to existing net metering programs to accommodate BTM energy storage
9. Changes to legacy interconnection standards to enable deployment of BTM ES
10. Changes to existing RPS programs to include or specifically carve out ES requirements
11. Use of time-variant electric rates to spur the development of BTM storage technologies
12. Retail rate re-design
13. Equity policies specific to ES technologies

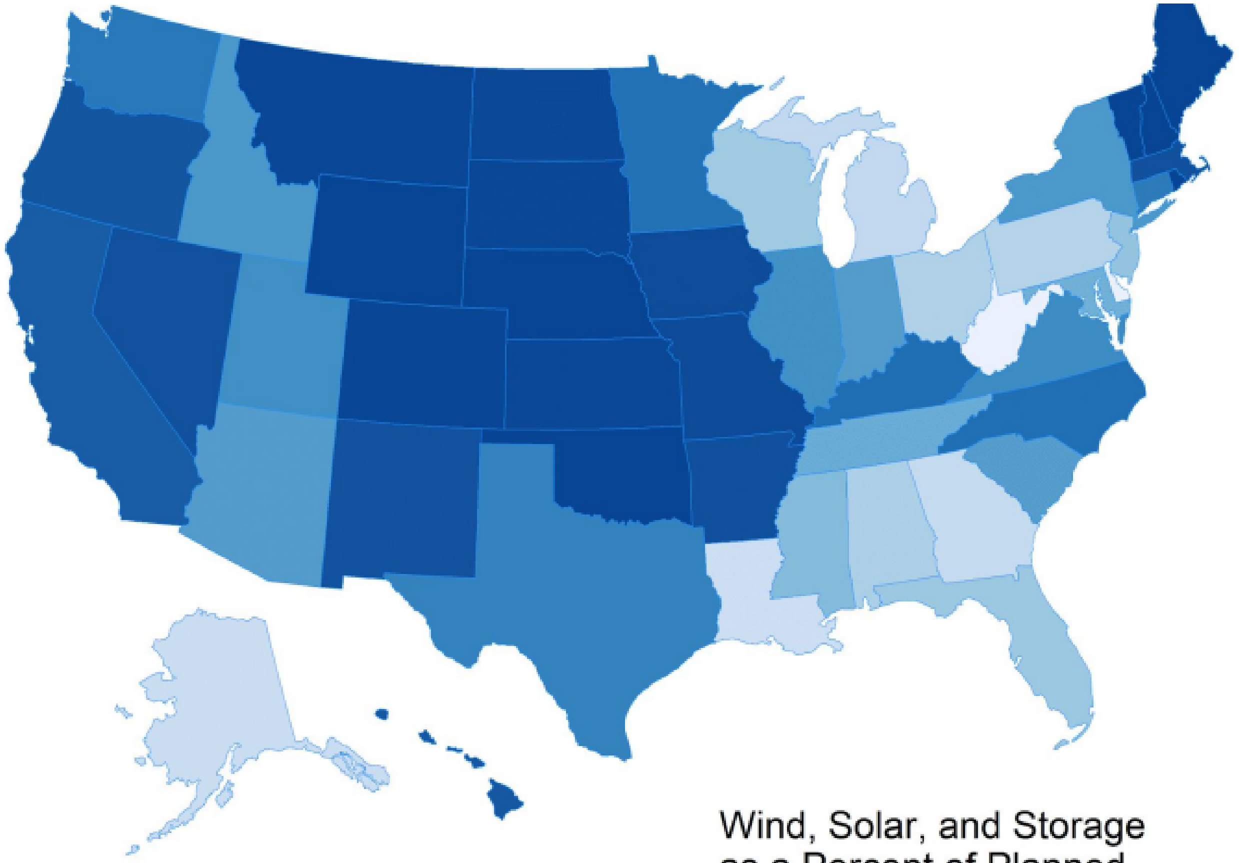
Sandia's analysis seeks to continually assess:

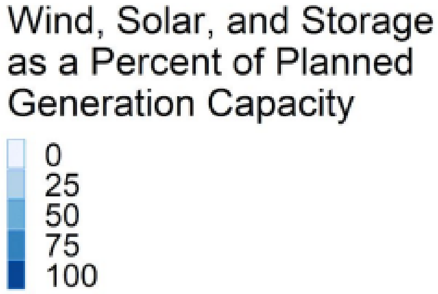
- *The extent to which these policy issues are being prioritized in the leading decarbonization states;*
- *How they are being applied to help advance decarbonization efforts, and*
- *The extent to which key, preliminary outcomes from state activities can be measured.*

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

	STATE	DEADLINE	GOAL	CLEAR ROLE FOR ES/LDES
1	AZ	2070	100% carbon-free electricity	NO
2	CA	2045	100% carbon-free electricity	YES
3	CO	2050	100% carbon free electricity	Somewhat
4	CT	2040	100% carbon-free electricity	Somewhat
5	HI	2045	100% renewable energy	Somewhat
6	IL	2050	100% carbon-free electricity	Emerging
7	LA	2050	Net zero greenhouse gas emissions	NO
8	ME	2050	100% clean energy	NO
9	MA	2050	Net-zero greenhouse gas emissions	Somewhat
10	MI	2050	Economy-wide carbon neutrality	NO
11	NJ	2050	100% carbon-free electricity	Somewhat
12	NM	2045	100% carbon-free electricity	NO
13	NV	2050	100% carbon-free electricity	Somewhat
14	NY	2040	100% carbon-free electricity	Somewhat
15	OR	2040	Greenhouse gas emissions reduced 100 percent below baseline emissions	Somewhat
16	RI	2030	100% renewable energy	NO
17	VA	2045	100% carbon-free electricity	NO
18	WA	2045	100% zero-emissions electricity	Somewhat
19	WI	2050	100% carbon-free electricity	NO

A continued strong build-out of renewables is expected through this decade and beyond.

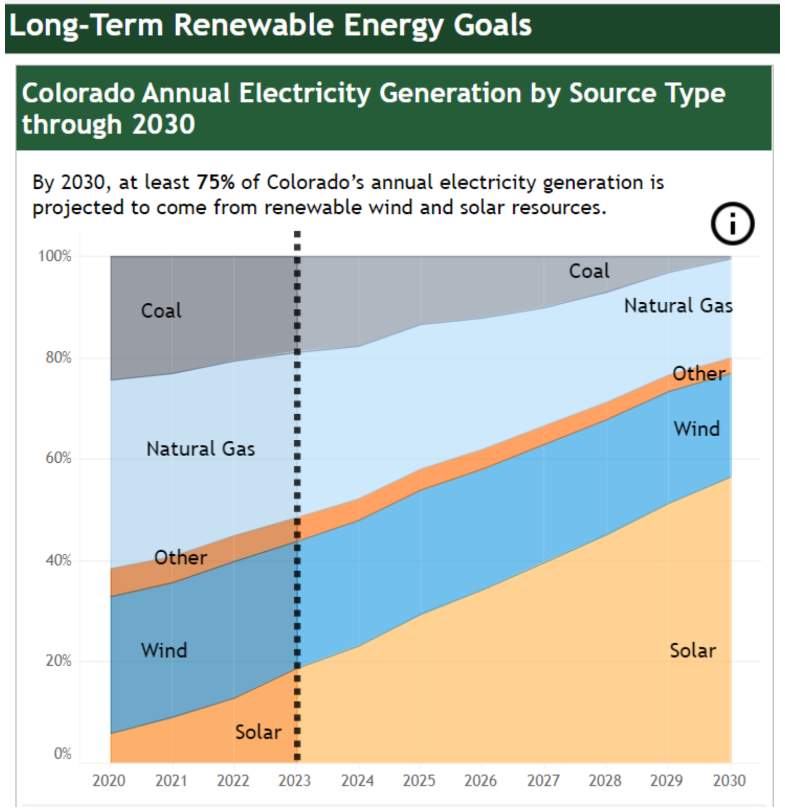




- Source: S&P Global Market Intelligence

In 2023, renewable sources of energy accounted for 39% of Colorado's total in-state electricity net generation.

- 70% of this renewable generation came from wind power. (EIA data)



Source: Office of Governor Jared Polis

Colorado—Energy Storage Policy Summary

- Transition to 100% clean electricity generation by 2040.
- Colorado does not have a statewide energy storage procurement goal, target or mandate.
- As of July 2023, Colorado's energy storage capacity was 237 MW.

SB 18-009	HB 18-1270	SB 19-236	HB 23-1039
Established a customer right to install energy storage.	Directed the PUC to adopt rules establishing mechanisms for the procurement of energy storage systems by electric IOUs. • C/B analyses must include such factors as grid reliability and reduced need for additional peak generating capacity. ➢ At the end of 2018, the PUC issued rules incorporating storage into utility planning processes.	Established a requirement, directed through the PUC, for utilities to file distribution system plans that include the evaluation of non-wires alternatives. Plans must be submitted every two years.	Established the requirement for an annual resource adequacy report provided to regulatory oversight entity (CORE's Board) that covers current and forward 5-year period.

Resource Adequacy

- ➢ Whether a state is vertically integrated or restructured impacts the approach to RA.
  - ✓ Can be addressed through centralized procurement by a state or vertically integrated utility.
  - ✓ Organized capacity markets in RTOs/ISOs include auctions for forward buying and selling of capacity resources. There are exceptions (CA-ISO and ERCOT do not have capacity markets).
- ➢ In Colorado, RA is defined as "the ability to meet firm native load with available resources, throughout year" and is regulated by the Colorado Energy Office and the PUC.
- ✓ The standard for resource adequacy planning in the United States is the 1-day-in-10-years standard (i.e., Loss of Load Expectation), which means that the probability of an outage due to insufficient capacity is less than one day in 10 years
- ➢ Storage resources add complexities to capacity expansion models since their RA value is highly dependent on the resource mix, especially their interaction with other storage and renewable resources.

Storage Inclusion in Resource Adequacy

- Energy storage plays a critical role in meeting resource adequacy requirements by providing a flexible way to balance electricity supply and demand.

Storage's Role in RA

- ✓ Peak load management
- ✓ Renewable energy integration
- ✓ Grid stability
- ✓ Demand response

- However, storage resources add complexities to capacity expansion models.
- The RA value of storage resources is highly dependent on the resource mix, especially their interaction with other storage and renewable resources.

Key Considerations

- ✓ Storage duration
- ✓ Charging and discharging capabilities
- ✓ Location and grid integration

Accredited Capacity

- ***Colorado definition:*** The capacity value given to a particular resource based on nameplate capacity and the ELCC that is applicable to the resource, as identified and explained by the LSE in its RA annual report.
- ELCC is calculated using probabilistic grid modeling, which involves running many simulations where important variables like electricity load and renewable generation vary randomly.
- *Example:* If a 100 MW solar facility can replace 40 MW of a perfectly-available resource while maintaining the same reliability, the solar facility's ELCC is 40%
- Utilities typically use ELCC as a method to determine the capacity credit for non-dispatchable renewable and dispatchable storage resources.
  - ✓ **Average ELCC**: Calculates the expected reliable capacity of a group of resources; this produces a total ELCC for the portfolio, which is then allocated to individual resources.
  - ✓ **Marginal ELCC**: Measures the capacity accreditation of individual intermittent resources relative to all other intermittent resources that were added before it.

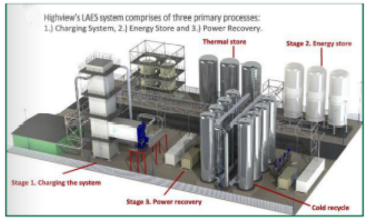
How does storage ELCC interact with wind and solar ELCC in the context of resource adequacy in resource planning?

- ✓ ELCC interacts with wind and solar ELCC by essentially "smoothing out" their intermittent nature, thereby increasing the effective capacity contribution of the combined renewable energy portfolio.
- ✓ However, as more storage is added to the grid, its individual ELCC can decline due to saturation effects, highlighting the need for careful integration and optimization of all resources to maximize reliability.
- ✓ The effectiveness of storage in enhancing ELCC depends on its storage duration.

The intermittency of renewables drives the need for LDES.

- ➢ As renewables penetration exceeds 60%, this creates critical operational needs and market opportunities for LDES (e.g., grid stress events, extreme weather).
- ➢ Depending solely on lithium-ion batteries is not an option.
- ➢ For true LDES (10 hours +) we will have to turn to Thermal, Gravity, or Chemical Storage.

…Liquid Air..



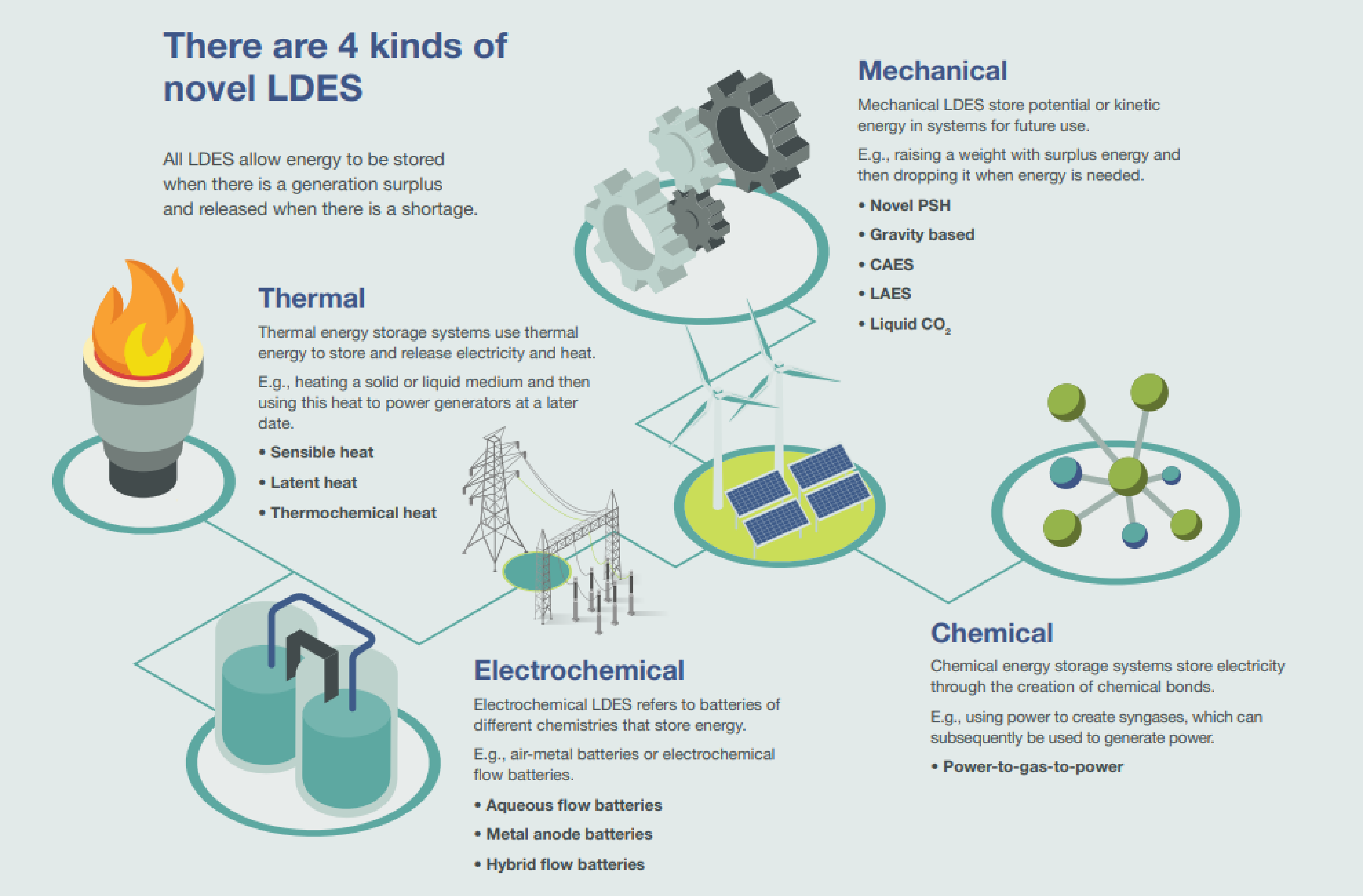
…Flow Batteries…

…Thermal Storage…

…Gravitational…

…Liquid CO_2…

- ❖ The good news: LDES comprises a wide family of technologies with differing technological maturities and market readiness…any technology that can be deployed competitively to storage energy for prolonged periods (hours, days, weeks).
- ❖ Lab experiments, commercial developments and new market needs support the development of a portfolio of LDES solutions necessary to meet decarb goals.



Source: Pathways to Commercial Liftoff: Long Duration Energy Storage, DOE

Key LDES storage types and parameters

Energy storage form	Technology	Market readiness	Max deployment size, MW	Max nominal duration, Hours	Average RTE[1] %
Mechanical	Novel pumped hydro (PSH)	Commercial	10–100	0–15	50–80
	Gravity-based	Pilot	20–1,000	0–15	70–90
	Compressed air (CAES)	Commercial	200–500	6–24	40–70
	Liquid air (LAES)	Pilot (commercial announced)	50–100	10–25	40–70
	Liquid CO_2	Pilot	10–500	4–24	70–80
Thermal	Sensible heat (eg, molten salts, rock material, concrete)	R&D/pilot	10–500	200	55–90
	Latent heat (eg, aluminum alloy)	Commercial	10–100	25–100	20–50
	Thermochemical heat (eg, zeolites, silica gel)	R&D	na	na	na
Chemical	Power-to-gas-(incl. hydrogen, syngas)-to-power	Pilot (commercial announced)	10–100	500–1,000	40–70
Electrochemical	Aqueous electrolyte flow batteries	Pilot/commercial	10–100	25–100	50–80
	Metal anode batteries	R&D/pilot	10–100	50–200	40–70
	Hybrid flow battery, with liquid electrolyte and metal anode	Commercial	>100	25–50	55–75

1. Power-to-power only. RTEs of systems discharging other forms of energies such as heat can be significantly higher.

Source: Pathways to Commercial Liftoff: Long Duration Energy Storage, DOE

Use case and application opportunities will likely have different timelines.

Low | Medium | High

Likely timing of commercialization	Use case	Application	Key stakeholders (not exhaustive)	Direct Competition with Lithiumion[1]
2023	**Load management services**	Large energy consumers (e.g., distribution centers, industrials) could use LDES to manage seasonal or week to weekend demand changes (e.g., freight charging purposes during peak season)	• Large peaking power consumers • Energy services players	High
	Firming for PPAs	Renewable PPAs can use LDES to ensure that businesses can procure 24/7 (and additional) renewable electricity	• Leading ESG customers	High
	Microgrid resiliency	LDES can ensure reliable power in isolated areas or the grid has shown to be unreliable / insufficient for a specific set of needs	• Local power authorities • Microgrid developers or integrators	High
	Utility resource planning	Utilities or CCAs can include LDES as an energy resource in integrated long-term energy planning to meet VRE balancing needs	• Vertically integrated & T&D utilities	High
	Transmission and Distribution Deferral	LDES can offset the need for new transmission and distribution capacity by installing storage in constrained areas to avoid costly, long-term asset upgrades	• Utilities • T&D developers • Equity infra investors	Medium
2030+	**Energy market participation**	LDES can play a role in shifting electricity from times of high supply to times of high demand, meet demand during system peak, and provide power system stability (e.g., inertia, frequency regulation)	• RES / T&D developers • Asset owners (IPPs) • Debt investors	Low

Source: Pathways to Commercial Liftoff: Long Duration Energy Storage, DOE

Future role for LDES

- ➢ **How do developers anticipate LDES to be used in future markets?**
- ➢ **Could LDES technologies potentially earn significant revenues in the ancillary service markets?**

- ✓ Important to realize that LDES does not refer to just one technology.
- ✓ The future will likely be comprised of a diversity of LDES technologies serving different applications in different markets for different customers.
- ✓ With that said, as of now LDES can already be used in load management services (frequency regulation, voltage control) and for microgrid resiliency.
- ✓ Current thinking is that beyond 2030, LDES will play an increasing important role in utility resource planning, and through providing ancillary services in energy markets.
- ✓ Much of this will depend on the regulatory structures put into place that either enable or impede the services that LDES technologies can provide.

Challenges—High-level perspectives.

- ***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.

ES policy opportunities, gaps & barriers.

- As noted, only 15 U.S. states have developed what can be considered a substantive policy framework for **energy storage,** and only California has taken steps to frame out policies for LDES specifically.

- When considering LDES, there is little industry consensus on how the term should be defined.

  - Different duration requirements (e.g., PJM's initial attempt to require 10 hours)

  - Lack of agreement on what LDES technologies would, could, or should be required to do.

- Even those states that have adopted 100% clean energy / renewable goals have not defined a role for LDES.

- While there is great optimism about the future prospects for LDES, there is no unanimous agreement across U.S. markets about where, how and why LDES will be deployed.

All of this led to the DOE's Lab-only Proposal Call.

- Released in the summer of 2023.
- U.S. DOE Office of Technology Transitions and Office of Clean Energy Demonstrations
- Funding provided by Bipartisan Infrastructure Law Technology Commercialization Fund
- Intended to address commercialization challenges that arise when many entities working in similar areas work in isolation.
- 50% cost-sharing requirement due to the opportunity being defined as a demonstration project.
- Sandia applied as lead lab with five lab partners.


Technology Commercialization Fund | ENERGY | OFFICE OF Technology Transitions | OCED

U.S. Department of Energy
Office of Technology Transitions
and
Office of Clean Energy Demonstrations
Bipartisan Infrastructure Law
Technology Commercialization Fund
National Laboratory Call for Proposals
Collaborative Alignment for Critical Technology Industries
DE-LC-000L002
Fiscal Year 2023

This lab call is being issued as part of the Bipartisan Infrastructure Law (BIL) Technology Commercialization Fund (TCF) by the U.S. Department of Energy's (DOE's) Office of Technology Transitions (OTT) in partnership with the Office of Clean Energy Demonstrations (OCED). This call solicits proposals from across the DOE national laboratory complex to bring together stakeholders across industries to address challenges that result when people work on similar issues in isolation and develop actionable recommendations, strategies, and best practices to facilitate scale-up and replication. This lab call is focused on industry alignment for clean hydrogen and long duration energy storage technologies.

LDES NATIONAL CONSORTIUM

The National Consortium for the Advancement of LDES Technologies

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U.S. DEPARTMENT OF ENERGY NNSA

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OCED OTT Office of Technology Transitions

This project is funded by the Infrastructure Investment and Jobs Act, also known as the Bipartisan Infrastructure Law (BIL), as part of the DOE Technology Commercialization Fund (TCF), administered by the Office of Technology Transitions in collaboration with the Office of Clean Energy Demonstrations.

Sandia National Laboratories | Argonne National Laboratory | INL Idaho National Laboratory | NREL National Renewable Energy Laboratory | Oak Ridge National Laboratory | Pacific Northwest National Laboratory

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

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.

We have released our first set of Industry Recommendations

- 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).
- The Industry Recommendations are publicly available at https://ldesconsortium.sandia.gov/industry-recommendations/

#11—State level policymaking.

- States that have adopted an energy storage procurement target, goal or mandate should be encouraged to take a further step and specifically identify the amount of LDES that is to be procured at where renewable energy mix is high and the storage gap is large.
- Compile/develop LDES policy recommendations for states.
- Develop an LDES benefit/cost model, to use in utility regulatory dockets.
- Develop IRP guidance materials advising LSEs on how to include LDES in long-term resource plans.
- States should be encouraged to conduct analysis examining the potential for an increase of “winter peaking” scenarios, which would require a significant need for LDES resources. and/or additional generations to meet customer needs.

Website Information

The Community of Knowledge & Best Practices Website is the official name for the LDES National Consortium's public facing Website.

- **The Website will be the primary repository for the output of the LDES National Consortium, along with knowledge-sharing information that seeks to enhance the public's understanding of LDES and the role it will play in the energy future of the US.**
- **It is anticipated that the Website will include, but is not limited to:**
  - A list of participating Teaming Partners that includes organization name, URL, primary point of contact name and title, and contact information (after approval from the Teaming Partner organization).
  - Commercialization recommendations developed by Tiger Teams.
  - A glossary of "LDES common terminology" with suggestions on how key terms should be defined.
  - A library of previously published LDES materials developed by our national Lab Partners and DOE offices.

ldesconsortium.sandia.gov

The LDES market is still quite nascent.

We are in the midst of a full convergence of industry forces… technology, manufacturing, supplies, investors, policymakers and customers are all coming together to move the energy sector forward!

- From now through 2030, we will likely remain in a phase of **demonstrations and solution development**, spurred largely by federal subsidies.
- Literally billions of dollars being injected into this space driving what is nothing less than an industry transformation!
- Now is the time to define end-use applications and how LDES technologies can be used!
- Ultimately, a diverse set of LDES technologies will be needed for different applications in different locations.

Acknowledgements

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THANK YOU!

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