Planning Implications with Storage and IBRs

Long Duration Energy Storage

Babu Chalamala, Ph.D.

Sandia National Laboratories

2023 ESIG Spring Technical Workshop, March 30, 2023

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.
SAND2021-XXXXX

Longer Duration Energy Storage

- LDES technologies are generally defined at 10+ hours of duration (Department of Energy)
  - Majority of currently deployed BESS is for applications that require ~4 hours at rated power
  - For 10+ hour or longer duration, no mature commercial products available nor clear market needs
- What are the driving forces for LDES?
  - Increasing role of renewables, drive towards a grid with fossil free generation
  - Operational reliability and grid resiliency
  - Societal desire for deeper decarbonization
  - Electrification of transportation, and industry (in the near and distant future)

What is Long Duration Energy Storage?

Department of Energy: LDES defined at 10 + hours of duration

LDES Council: Duration by segments, Intraday (8-12 hours), multi-day/week (24-80 hours), and seasonal storage (100+ hours)

Available technologies are not limited to batteries

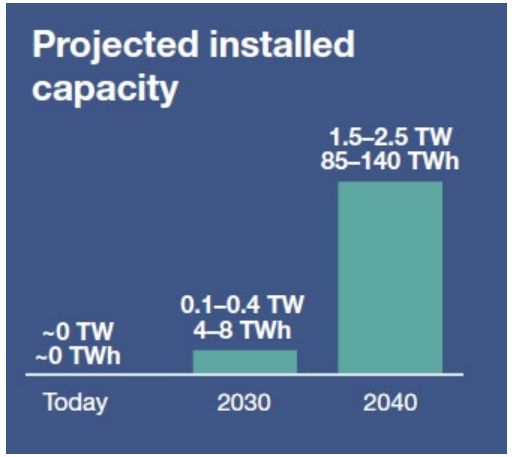
- Electrochemical: Range of battery technology from Li-ion, Flow batteries, metal-air…
- Mechanical: PSH, Gravity, and other novel approaches
- Thermal: variety of approaches to molten salts to bulk materials
- Chemical carriers: liquid fuels, hydrogen, etc..

Longer duration, days to seasonal, is a major gap

- Market is not yet ready, economic valuation metrics are beginning to be analyzed
- Technologies are not ready and mature, all options incl. batteries, hydrogen, thermal, liquid fuels

LDES Council projections for 2040 capacity show large market opportunity

- Market predicated on significant cost reductions. Where technical breakthroughs and innovations come from is not obvious



LDES Council, 2021 Report:
Net Zero Power: LDES for a Renewable Grid
McKinsey, 2021"

Bath County, VA Pumped Storage: 3,003 MW, 24,000 MWh (8 hour)
Moss Landing BESS: 400MW/1,600MWh (4 hour)

What are the drivers for LDES?

Federal Funding and policy changes

State led initiatives

Increasing role of renewables

IIJA - LDES Demonstration Projects

Infrastructure Investment and Jobs Act (IIJA)

DOE's Office of Clean Energy Demonstrations has grouped IIJA sections 40101(a) and 40101(b) under one FOA directed to "Long Duration Energy Storage Demonstrations," or "LDES" Demonstrations.

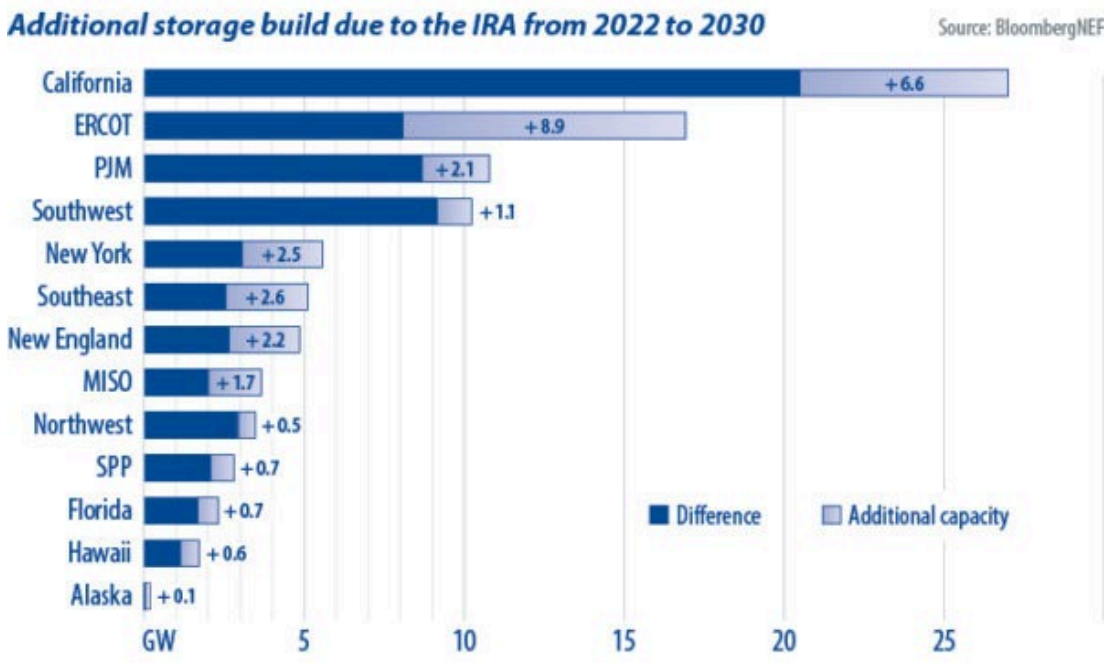
- $350 million in funding for LDES projects offering between 10 and 24-hours duration. 11 projects will be funded.
- 50 percent of projects costs will be subsidized.

IIJA Programs	IIJA Funding
Resilience - Utilities section 40101	$5B
Resilience - States & Tribes section 40103(b)	$5B
Resilience - Remote Areas section 40103(c)	$1B
Grid Modernization section 40107	$3B
Advanced Manufacturing section 40209	$750M
Clean Energy Projects on Mine Lands section 40342	$500M
Storage Demonstrations section 41001(a)	$355M
Long-Duration Storage Demonstrations section 41001(b)	$150M
TOTAL	**$15.755B**

Inflation Reduction Act (IRA) – ITC for Storage

Inflation Reduction Act (IRA)

- ITC for stand-alone storage
- The 10-year duration of the tax credit will help developers fund the long development cycle of technologies, from design through to construction.
- Bonus credits available for siting of clean energy facilities at former coal mines and in disadvantaged communities.



OCED Lab Call: LDES for Resiliency

DOE OCED will fund two $10M projects at national lab sites to test and validate 500kW/24 hour nearly mature LDES energy storage technology to support energy resiliency at a lab site. Nearly mature technology guidelines:

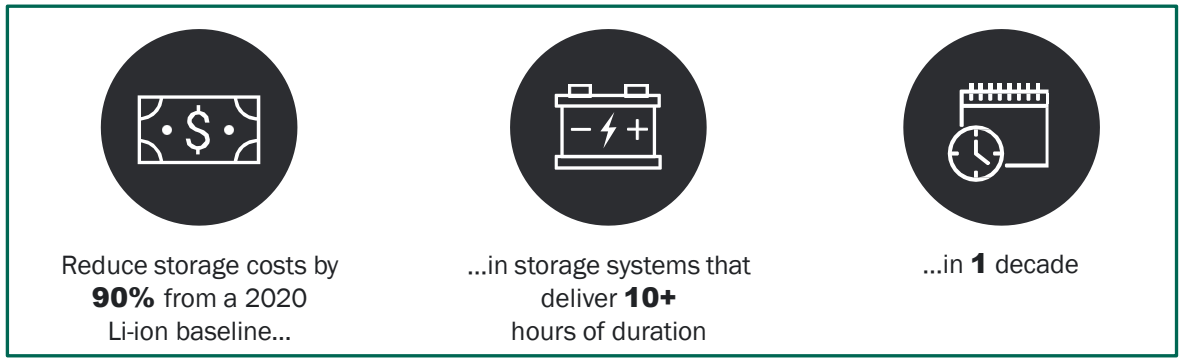
- A technology that was previously demonstrated at the early-moderately mature stage but is still considered precommercial for an intended, at scale end-use (the expected commercialization timeframe is 2-5 years)
- A technology that could leverage this demonstration opportunity to go through comprehensive validation that will de-risk its use and encourage further investment and deployment from industry.

Labs must clearly state how this project supports energy resiliency objectives. Labs have the flexibility to identify unique or locally relevant resiliency requirements or metrics so long as they are properly justified as being broadly applicable. Examples of resilience metrics include:

- DOD: Critical mission continuity of operations for a minimum of 14 days
- FEMA: Defines a "long-term" outage as 72+ hours
- NFPA: Secondary power supplies for alarm systems are designed to provide enough capacity to power the entire system for 24 hours on standby and facilities such as hospitals should have a minimum of 96 hours of fuel supply stored for emergency standby

DOE Earth Shot Programs: LDES and Hydrogen

ENERGY earthshots
U.S. DEPARTMENT OF ENERGY



LONG DURATION STORAGE SHOT

HYDROGEN SHOT

Energy Storage Demonstration and Validation (ROVI)
Storage Innovations (SI) 2030
Energy Innovation Hub Program

Regional Clean Hydrogen Hubs ($8B)
Clean Hydrogen Electrolysis Program
Clean Hydrogen Manufacturing and Recycling RDD&D

CEC and NYSERDA Funding

California Energy Commission: $380M LDES funding. Carve out for LDES in within ES targets.

2020 EPIC Solicitation: $100M+, supporting new and emerging non-lithium-ion technologies

- 11 field demonstrations of non-lithium ion LDES
- 20+ hours of duration for two demos

8 applied research grants

- 3 projects: 20 to 100+ hours of duration
- 3 grants on Green hydrogen storage applications

2023: $380M new LDES funding

NYSERDA: Supporting early stage demonstrations of LDES including modular hydro, and hydrogen.

- 2021: $13M for 13 projects
- 2022: $17 in funded projects

Outside of CA and NY, there is an absence of LDES policies and funding support in most other states.

What needs to happen to create an LDES market?

Long-term System Planning

How to best incorporate LDES into energy markets and operations

- Understand LDES economics under different market models and use cases
- Understand LDES impact on energy markets under very high renewables and 100% carbon free resources

Early compensation mechanisms that reduce uncertainty for investors while the market is still growing

Understand LDES – Resource tradeoffs considering renewable variability

- Determine LDES costs – benefits relationships for different LDES economics and penetrations

Supportive policies, regulations, and market designs (e.g., capacity mechanisms and policies that capture the full value of LDES)

Apply lessons from other commodities markets with resource variability and long term storage, linking physical spot markets and financial futures markets

Summary

Do we have LDES technology solutions to support a 100 renewable electric grid?

Has anything really changed in the technologies to make the cheaper, more suitable?

There are gaps with energy storage in the short term, applications that need longer duration are open to LDES. However, issues exist that keep LDES from being a ready solution.

- Emerging battery technologies are burdened by lower efficiencies (compared to Lithium), large footprints, and no ready monetizable market segment to deploy projects
- Technologies such as redox flow batteries and NaS batteries can do 12 hours, but challenge remains finding near term opportunities

With greater focus on decarbonization and increasing commitment to reach 100% renewables goals, market opportunities and needs beginning to emerge for LDES

- Will it take 5 years or 10 years for a sizable market to emerge?