



Enabling Long Duration Energy Storage (LDES) in PJM

LDES Council White Paper Re: PJM's *Powering Reliability through Market Design*

Anna J. Siefken, Director for Policy & Markets, North America
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Long Duration Energy Storage (LDES) Council

Scaling Reliability, Affordability, and Security for the World's Energy Systems



The LDES Council forges **powerful partnerships** with stakeholders, amplifying awareness of the critical need for LDES to ensure flexibility, resilience, reliability, security, and affordability across all industrial sectors.

8+ Hours

What is long duration energy storage (LDES)?

Any long duration technology storing energy in various forms – chemical, thermal, mechanical, or electrochemical – and able to dispatch energy or heat for **8+ hours** to days, weeks, or seasons.



OUR VISION FOR 2040

8 TW
of LDES Deployed

Total potential LDES capacity including power (3 TW) and heat (5 TW)

\$4 Trillion
invested

Total capex required to deploy LDES by 2040, in USD

\$540 billion
annual savings

Realized across the entire energy system, in USD



ldescouncil.com

LDES Council Membership



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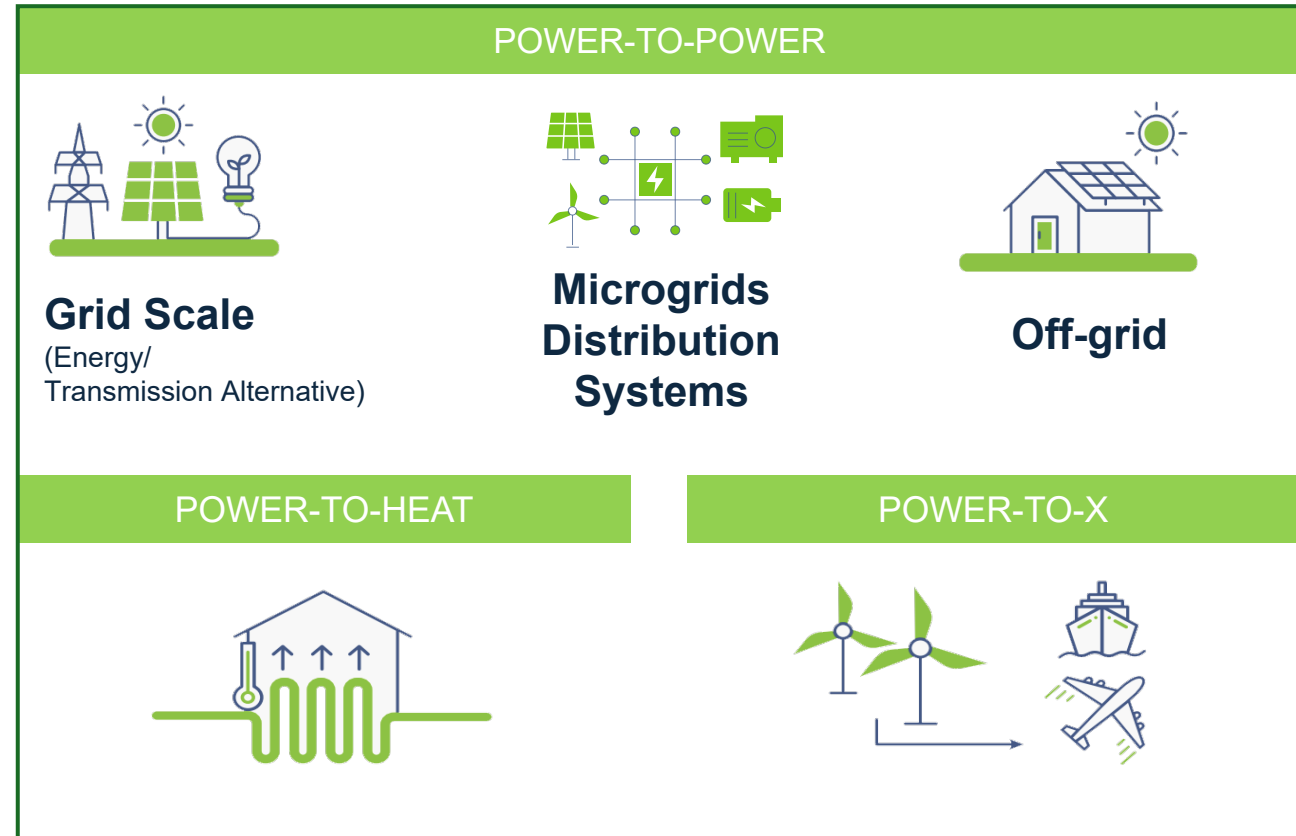


LDES offers a diverse suite of solutions that are “fit for purpose”



LDES can:

- Shift clean energy across hours, days, and seasons
- Extend grid services that traditional resources provide
- Provide 24x7 heat for chemical, food and beverage manufacturing, and heavy industrial needs
- Meet off-grid and microgrid electrical needs during peak demand
- Keep the energy system supplied during long gaps in generation
- Remove excess generation avoiding curtailment costs



Thermal / TES

Stores heat or cold in materials like **molten salt, sand, bricks or rocks**, and releases it later as heat, cooling, or electricity.

Electrochemical

Stores energy in batteries using chemistries such as **flow, metal-air, zinc, sodium or lithium**, and discharges it later as electricity.

Mechanical

Stores energy using systems like **pumped hydro, gravity, flywheels, compressed air (CAES) or liquid air (LAES)**, and releases it later as mechanical power or electricity.

Chemical

Stores energy in **chemical fuels such as hydrogen or ammonia**, which can be held long-term and used later for power, heat, or industrial processes.

Modernizing PJM's market for emerging resources like LDES



Longer duration storage is required to meet increasing resource adequacy needs.

1

Firm capacity

Sustain dispatch through prolonged peaks, outages and energy shortfalls after shorter-duration resources are depleted.

2

Lower shortfall and tail risk

Reduce both the likelihood and magnitude of LOLE and unserved energy (EUE) during system stress events.

3

Flexibility as load grows

Balance supply and demand over longer time horizons as electricity demand and variable generation increase.

4

Resilience + Cost control

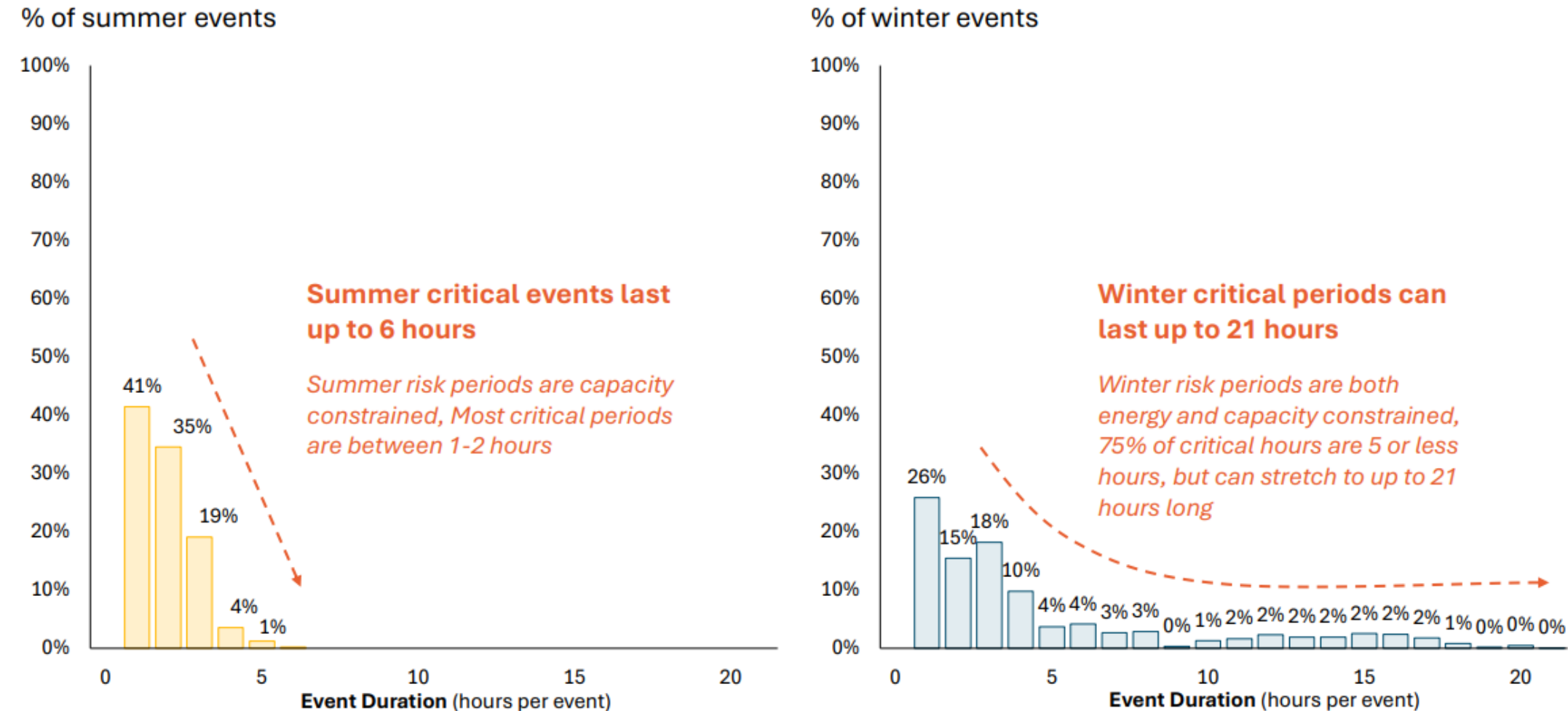
Shift energy across multi-day events, complement other resources, and reduce the need for excess capacity investments.

16–23 GW of storage may be needed in PJM over the next 7–15 years. Brattle Group (2025)

Modernizing PJM's market for emerging resources like LDES



Figure 28: Duration of Critical Hour Periods

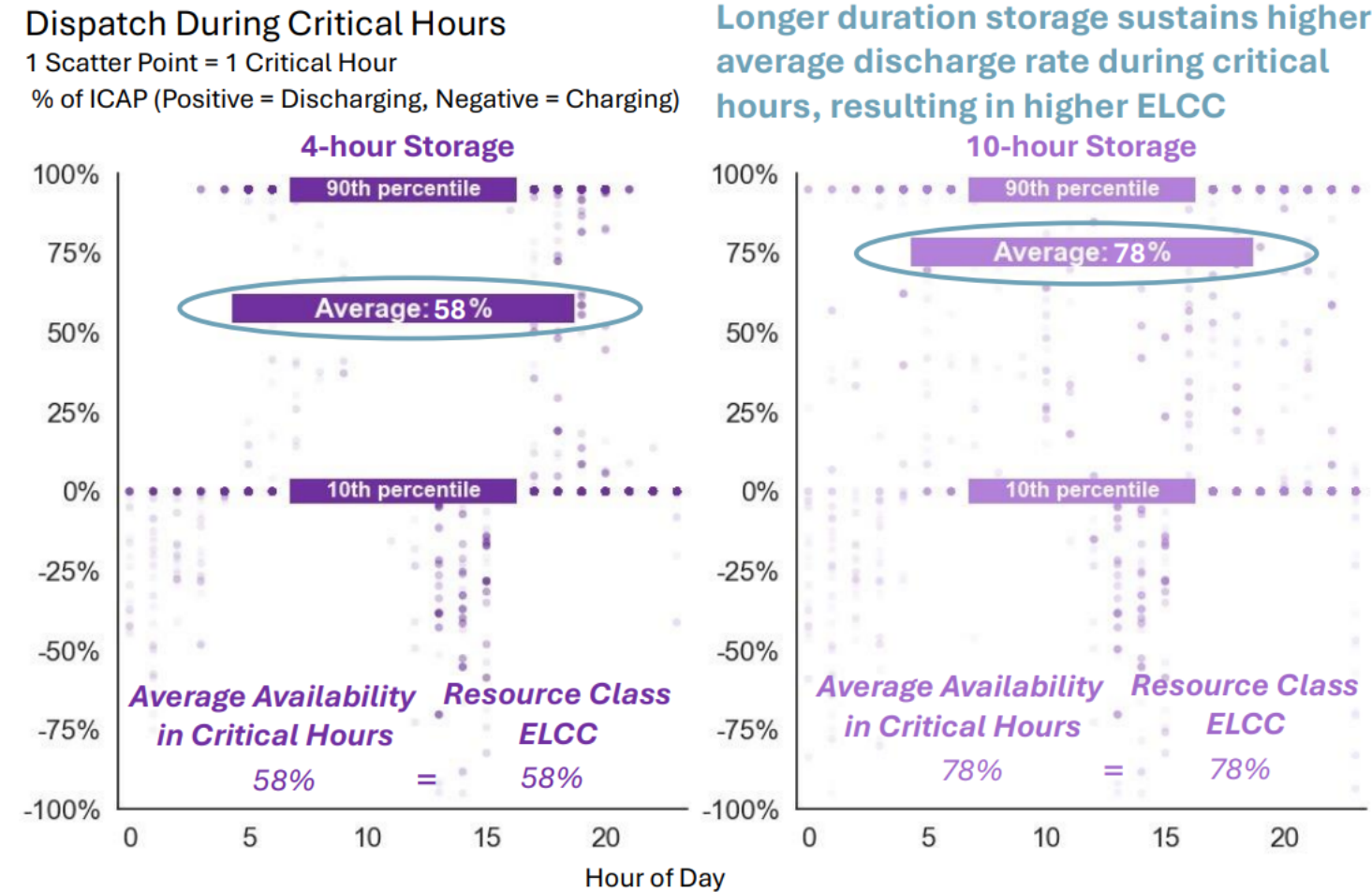


Source: PJM ELCC / RRS Model Evaluation (Dec 2025)

Modernizing PJM's market for emerging resources like LDES



Figure 29: Storage Dispatch in Critical Hours



Source: PJM ELCC / RRS Model Evaluation (Dec 2025)

What's Holding LDES Back Today?



LDES represents a **\$4 trillion investment** opportunity by 2040, with the potential to deliver up to **\$540 billion** in annual system cost **savings**.



**Yet large-scale deployment is still slowed
by a few critical gaps.**



Policy frameworks
don't yet fully value
what LDES delivers



System planning
hasn't caught up with
long duration needs



Investment lacks
stable, long-term
signals

A durable solution combines Path A with targeted Path B reforms



PATH A | Long-term contracting

Near-term priority

- Expand long-term hedging and forward commitments
- Improve revenue certainty, predictability, and project bankability
- Preserves signals for reliability

PATH B | Flexible loads

Targeted elements

- Enable flexible interconnection arrangements
- Recognize BTM reliability contribution
- Reward large loads that reduce grid demand during scarcity

PATH C | Merchant revenues

Apply a financeability test

- E&AS revenues can complement investment
- Do not rely on episodic scarcity revenues alone
- Preserve durable, investment-grade revenue certainty

All three pathways still depend on interconnection and accreditation reform.

1. Revenue certainty: make reliability investments financeable



“Long-term revenue certainty is a structural requirement, not a preference.” — PJM (p. 31)

Current barrier

Annual capacity auctions + volatile merchant revenues

- Long development horizons, high upfront capital needs, and long operating lives.
- Uncertain future revenues can prevent otherwise valuable projects from reaching financing.



Market design response

Create durable revenue visibility

- Long-term contracts / utility procurement
- Capacity payments and forward commitments
- CfDs or other hedging structures
- Financial guarantees where appropriate

Goal: Reduce investment risk while reducing exposure to price volatility for customers.

2. Interconnection: Allowing LDES to meet demand



Queue reform is improving, but LDES still faces timing and eligibility barriers.

Barrier

Long study timelines, uncertain upgrade costs, and queue rules can delay new LDES for years.



Opportunity

66.5+ GW of storage applied in the first cycle of PJM's reformed process = evidence of a deep storage pipeline.



LDES-specific reforms

- Enable procurement pathways for projects not yet queued
- Reduce minimum project sizes where appropriate
- Recognize longer development timelines.

Interconnecting LDES can also maximize existing grid assets by relieving constraints, absorbing excess energy, and deferring upgrades.

3. Capacity accreditation: Recognize the value of duration

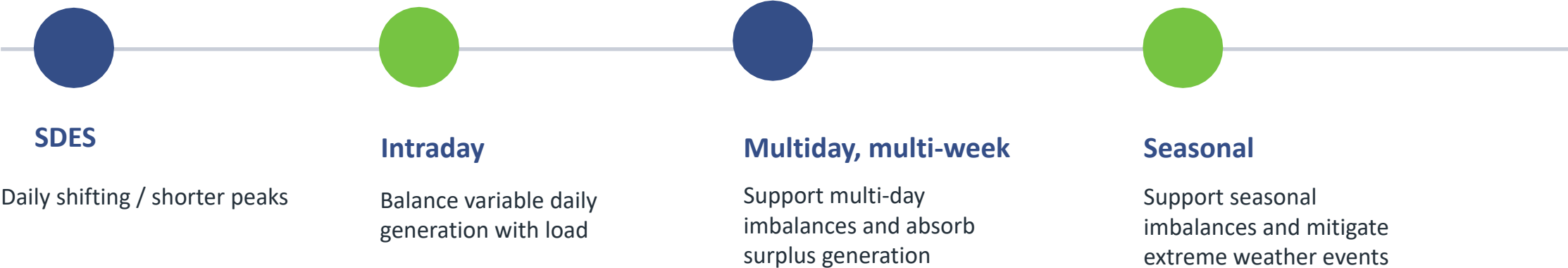


Duration must be visible in the methodology.

Why it matters

If extended-duration reliability value is understated, LDES receives lower capacity revenues and weaker investment signals than its system contribution warrants.

Recommended duration categories (Beyond 10 hours)



Refine ELCC so that duration, operational flexibility, and sustained energy delivery are reflected in accreditation and compensation.

No single pathway is sufficient without the enabling reforms that make reliable resources investable.



1

Provide durable revenue certainty

Use Path A to expand long-term contracting and forward commitments.

2

Unlock flexible load participation

Use targeted Path B reforms to recognize BTM LDES and reward demand flexibility.

3

Protect financeability

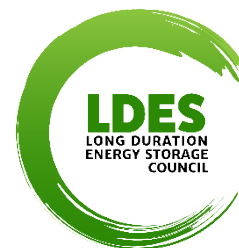
Evaluate Path C against whether capital-intensive reliability resources can secure investment-grade revenues.

4

Fix the enabling rules

Accelerate interconnection and refine ELCC to recognize extended-duration reliability value.

Modernize the market to recognize, compensate and integrate resources that can sustain reliability for longer periods.



Anna J. Siefken

Director for Policy & Markets, North America
Long Duration Energy Storage (LDES) Council

asiefken@ldescouncil.com

+1 703.472.2749

[linkedin.com/in/annajsiefken](https://www.linkedin.com/in/annajsiefken)

