Long-Duration Energy Storage: The Economics, the Hype, and the Hard Truths

> Long-duration energy storage (LDES) is one of the most discussed — and most misunderstood — topics in the energy transition. At TechConnect 2026's Energy Storage track in Raleigh, NC, a striking absence spoke volumes: not a single presentation covered lithium-ion. Instead, the stage belonged to challengers — zinc, sodium, flow batteries, and thermal systems. Here is what was learned.

THE ECONOMICS

Why Idle Time Is the Killer of Long-Duration Storage

The most fundamental challenge facing LDES technologies is not chemistry — it is how rarely they are asked to work. The economics of any storage technology hinge on cost per delivered kWh, which means cycle count matters enormously.

A lithium-ion battery priced at $250/kWh with $12/kWh operating costs, cycled once per day for 20 years, delivers energy at roughly 3.5 cents per kWh. That is a compelling number. But a 100-hour LDES battery — even at a headline cost target of just $40/kWh — tells a very different story. Its low round-trip efficiency (RTE) and slow recharge rate may limit it to only 20 cycles per year. Factor in operating costs driven by larger physical plant and higher service requirements, and the delivered cost climbs to around 16 cents per kWh. Nearly five times more expensive than the "costlier" lithium-ion alternative.

> *"The trick is, lithium-ion needs to be kept busy to keep its cost per kWh low — and that busyness is precisely its competitive advantage."*

Lithium-ion's versatility allows it to earn its keep daily: peak-shaving, grid stabilisation, demand charge reduction, and energy arbitrage. For example, a well-utilised 10-hour battery providing grid services for an average of two hours per day, while occasionally fulfilling long-duration roles twenty times per year, can deliver energy at around 14 cents per kWh — competitive territory, with a broader value stack to boot.

KEY ECONOMICS TAKEAWAYS
→ LDES cost comparisons often ignore cycle frequency — a critical oversight
→ Low round-trip efficiency compounds costs with every kWh charged
→ Installation costs are not constant across technologies — energy density matters
→ Lithium-ion's versatility lets it reduce its effective cost through daily use

HIDDEN COSTS

Efficiency Losses and Installation: The Costs No One Talks About

The Cost of Inefficiency

Round-trip efficiency (RTE) is not a footnote — it is a direct operating cost. For every unit of energy dispatched, you must pay to charge it, and the charge cost scales inversely with RTE. At a US bulk energy rate of $0.05/kWh, a 50% RTE system adds ten cents per kWh to its operating cost. A 90% RTE BESS, by comparison, adds only 5.5 cents. That six-cent gap, accumulated over thousands of cycles, is enormous.

The Cost of Installation

Perhaps the most under-appreciated variable in LDES economics is installation cost. Every 20-foot storage container deployed on a site incurs a broadly similar set of physical costs — concrete foundations, trenching, wiring, commissioning — regardless of how much energy sits inside it.

A technology with half the energy density therefore doubles its installation cost on a per-kWh basis. EPRI's recent bottom-up analysis confirmed this starkly: EPC costs for some flow battery technologies reached over $60/kWh, while leading lithium-ion products including TeraStor, achieved below $20/kWh. Longer-duration technologies often require additional infrastructure — water processing, gas venting, electrolyte piping — which compounds the installation premium further.

Technology	EPC Cost	System RTE	Notable Issues
Leading Li-ion (including TeraStor)	**< $20 / kWh**	**~90%**	Fire safety concerns
Flow Batteries (various)	>$60 / kWh	55–80%	Energy density, complexity
Zinc Batteries	~$32 / kWh	~70%	Scale, commercial maturity
Sodium Ion	~$30 / kWh	~85%	Energy density, Wide voltage range

POLICY & INDUSTRY

The DOE's 10/10/10 Challenge and What It Reveals

In 2020, the Department of Energy set an ambitious target: LDES (10+ hours) reaching $0.05/kWh or less — one-tenth of its then-current cost — within 10 years. A 2023 progress report tracked candidate technologies against this goal, finding that at the time, only three were close to the target with significant investment. (Lithium-ion, in the author's view, has already cleared the bar).

Erik Hsieh, Deputy Director of the DOE's Office of Electricity, offered three forward-looking propositions for how energy storage will succeed in the coming decades:

1. Second-order functions matter more: Energy storage's greatest value may come from enabling other assets — as in Chile, where storage allows power plants to deliver more to the grid by offloading balancing duties.
2. Energy hedging for large loads: Industrial consumers can buy cheap off-peak energy ahead of time and use storage to shield against intra-period price spikes.
3. Deeper integration with loads and generation: Future storage will be tightly coupled with the assets it serves, rather than acting as a standalone buffer.

One critical methodological question was raised at the DOE presentation: their LCOS comparisons assumed once-per-day cycling across all technologies — a metric that may not be accurate for LDES, which by design, cycles far less frequently. The DOE acknowledged this but cited the need for a common benchmark. The absence of NPV discounting of energy usage in the denominator was also flagged as a departure from how power plant LCOE are typically calculated.

CONFERENCE HIGHLIGHTS

Technologies on Show: A Candid Assessment

The conference presentations spanned three broad categories — zinc/sodium/lead chemistries, flow batteries, and thermal energy storage. Here is a summary of the most noteworthy.

Zinc, Sodium & Lead Chemistries

Zinc featured prominently, with researchers from Stony Brook University, Northeastern, West Virginia University, and commercial player Urban Electric Power all presenting. Zinc's appeal lies in its high volumetric energy density enabled by the ability to offer two or more electrons per atom — but its Achilles heel is dendrite formation, which limits cycle life and complicates cell design.

Urban Electric Power (ZnMnO) presented a compelling niche application: by limiting depth of discharge, alkaline ZnMnO cells can achieve thousands of cycles — even though the same cell would last only a handful at full depth of discharge. This aligns well with applications combining frequent, shallow peak-shaving with occasional deep discharges during outages, such as backup power.

West Virginia University shared a promising additive for aqueous zinc batteries: lanthanum nitrate. Added to the electrolyte, it compresses the electric double layer, reduces repulsion, and promotes dense, stable zinc deposition — yielding nearly 1,000 cycles in tests. If transferable to flow battery anodes, this could significantly reduce the need for complete discharges to reset the anode plates.

On sodium-ion, the enthusiasm from NREL and DOE was difficult to reconcile with the technical reality presented. The charge/discharge curve shown spanned roughly 1V to 4V, with nearly a third of the SOC sitting below 2V. To harvest energy from that low-voltage range, a bidirectional DC/DC converter is required — rated for full power at minimum cell voltage. In total, the power conversion portion of a sodium ESS could run approximately 2.5× that of an equivalent lithium-ion installation.

Lead-acid made a surprise appearance via the Battery Council International. New developments have reportedly achieved 5,000 cycles — albeit at only 20% depth of discharge. Weight, volume, and partial-state-of-charge limitations remain unresolved.

Flow Batteries

The BESSt Company
ZINC-POLYIODIDE FLOW
Claims 20× higher energy density than vanadium redox and infinite cycle life. RTE of 75–80% is strong for a flow technology. Uneven zinc plating remains an active challenge. US manufacturing and on-site electrolyte production planned.
HIGH RTE PLATING CHALLENGE

CMBlu
ORGANIC SOLID FLOW
Pumps solid organic particles in suspension. Claims DC RTE >80%, 20,000+ cycle life, and rejuvenation capability. Modular and aqueous-based. Targets cost competitiveness with lithium-ion at 8+ hour durations.
80%+ RTE 20K+ CYCLES

Quino Energy
ORGANIC QUINONE FLOW
Spun out of Harvard University. Drop-in replacement for vanadium electrolyte. Targeting $188/kWh installed cost. Energy density is low — 500 kWh per 30' container — which will create installation cost headwinds.
LOW DENSITY $188/KWH TARGET

Thermal Energy Storage

Thermal storage is getting more attention lately Several companies presented approaches ranging from heated rock to geothermal cooling loops. It's undeniable advantages are service longevity and site safety.

Rock Energy Storage
RESISTIVE HEAT → STEAM
Electricity in, heat out — and in the future, heat in, heat out to and from industrial heat processes. Claims 97% RTE for the thermal portion only; no electricity conversion is included in that figure. Electric resistance heaters have a 5-year lifespan.
NO ELEC. RTE STATED

Echogen
CO_2 THERMAL / HEAT PUMP
Uses CO_2 to move heat between hot, cool, and cold reservoirs. Claims 60-year lifespan. Partnering with Westinghouse on a €330M European project: 50 MW × 24 hours = 1.2 GWh at ~$220/kWh all-in. Efficiency undisclosed.
EFFICIENCY UNDISCLOSED 60-YEAR LIFE

Teverra
GEOTHERMAL DATA CENTRE COOLING
Addresses 600kW–1MW data centre rack densities. Geothermal storage accepts daytime heat and delivers to thermal consumers overnight, improving COP from 3–4 to 15–40. Reduces cooling power per rack from 250–330 kW to 25–70 kW.
COP 15–40

CO_2 Energy Dome (EPRI)
COMPRESSED CO_2
Alternates between liquid and gaseous CO_2, capturing heat of compression. ~75% RTE — strong for a thermal system. About 60% of energy stored as heat, 40% as liquid CO_2. Partnership with Google for a pilot project.
~75% RTE GOOGLE-BACKED

SUMMARY

The Bottom Line

Long-duration energy storage remains a genuinely important problem to solve — the grid will need multi-day storage capacity as variable renewable penetration grows. But the field is hampered by a persistent tendency to compare technologies on metrics that obscure rather than illuminate real-world economics.

Three issues are particularly common in LDES marketing and research:

1. Misstated or misapplied costs. LCOS figures that assume daily cycling unfairly promote LDES costs since they rarely operate so often. LDES advocates often ignore the real installation cost premiums and neglect the effects of RTE penalties on life-time operating costs.

2. Cherry-picked safety comparisons. Many LDES proponents cite thermal runaway as lithium-ion's fatal flaw, while minimising hydrogen evolution, chemical hazards, and other safety concerns present in their own systems.

3. Density blindness. The physical size of a system has a direct and substantial impact on installed cost, land use, and grid siting. Technologies that require twice the footprint incur twice the site cost per kWh — a multiplier that must be carried through every economic comparison.

The most promising technologies observed — CMBlu's solid flow system, The BESSt Company's zinc-polyiodide, and the CO_2 Energy Dome — combine high RTE with credible cost roadmaps and genuine technical differentiation. West Virginia University's lanthanum nitrate work on zinc dendrites could prove broadly enabling if it translates to commercial cells.

The LDES National Consortium and PNNL's testing centre represent important public infrastructure for separating genuine performance from promotional claims. Their rigorous evaluation frameworks will be essential as more technologies move toward commercial deployment.