EXECUTIVE BRIEF

# The missing market for time

*Why long-duration energy storage is waiting on markets, not invention*

Based on a structured review of 50 interviews from the Climate Confident and associated podcast archives

# Contents

## Introduction

Power systems are acquiring renewable generation faster than they are acquiring the ability to move that electricity across time. Solar output peaks when demand may not. Wind can disappear for hours or days. Curtailment is rising in constrained regions even as fossil generation remains available for periods when renewable production falls. Long-duration energy storage (LDES) is intended to close part of that gap by shifting electricity, heat or another energy carrier across many hours, days or, in some cases, seasons.

The technology category is broad. It includes flow batteries, compressed-air systems, thermal storage, pumped hydro and chemical routes such as hydrogen, alongside other mechanical and electrochemical designs. These technologies do not have identical economics, operating characteristics or levels of maturity. Treating LDES as one product obscures the central management question: what duration, response profile and reliability does a particular power system actually require, and how will that service be paid for?

This brief examines interviews across the *Climate Confident* archive, with relevant contextual evidence from the wider podcast corpus, to understand why deployment remains below the scale increasingly required by renewable power systems. The evidence points to a commercial and institutional bottleneck more than a single technological one. Many storage and flexibility technologies are already deployable. What is missing is a sufficiently dependable route from system need to contracted revenue, finance, construction and operation.

That distinction matters for executives, utilities, investors and policy-makers. A technically credible asset cannot attract capital if markets do not value the hours it covers. A procurement target cannot produce capacity if contracts do not support financing. A bankable project cannot connect if the grid, permitting system or supply chain cannot deliver it. Scaling LDES therefore requires a sequence of decisions, not a technology beauty contest.

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## Executive brief

Long-duration energy storage is not waiting for one decisive technical breakthrough. It is waiting for power systems to define the service they need, procure it over an investable horizon and allow projects to earn revenue from the multiple forms of value they provide.

The strongest evidence identifies four mutually reinforcing barriers. First, electricity markets are generally better at pricing units of energy and short-term balancing than availability across long periods. Secondly, procurement often favours familiar short-duration products or the lowest upfront capital cost rather than lifecycle system value. Thirdly, uncertain revenues, limited operating histories and long development cycles make otherwise credible projects difficult to finance. Finally, grid connections, permitting, manufacturing capacity and standards slow projects after the investment case has been made.

Technology still matters. Some storage pathways lose too much energy in conversion; some depend on local geology; some trade energy density for cycle life; and novel systems must prove utility-grade reliability. But the archive does not support "the technology is not ready" as a sufficient explanation for slow deployment. Nor does it support LDES as the universal answer to renewable variability. Transmission, demand response, flexible generation, interconnection, short-duration batteries and renewable overbuild can all compete with or complement it.

The executive implication is straightforward: start with the system requirement, not the preferred technology. Define the duration and reliability gap. Translate it into a duration-aware procurement product. Contract enough revenue certainty to make the project financeable. Then evaluate the full delivery chain, including interconnection, permitting, manufacturing, verification and long-term operating responsibility.

| Leadership decision | The question that must be answered |
|---|---|
| Define the need | Which hours, days or seasonal conditions cannot be covered economically by existing flexibility? |
| Value time | What is dependable energy availability during those periods worth to the system? |
| Make it investable | Which contract, market access or revenue stack will support financing over the asset's useful life? |
| Prove deliverability | Can the project connect, secure permits, source components and meet utility reliability requirements on schedule? |
| Govern the portfolio | Which combination of storage, networks, demand flexibility and firm generation produces the lowest credible system cost? |

## The issue is not storage capacity. It is useful duration

Installed megawatts and megawatt-hours do not by themselves describe the service a system needs. A battery designed to smooth short fluctuations, a resource that shifts solar generation into the evening peak and an asset intended to cover a multi-day wind drought solve different problems. LDES becomes commercially meaningful only when planners model those periods explicitly.

Oonagh O'Grady, Vice President at compressed-air storage developer Hydrostor, argues that systems need duration-aware modelling to identify their specific multi-hour or multi-day gaps. Without it, targets risk becoming generic storage aspirations rather than a description of the capacity, discharge duration and operating duty required. She also makes the timing problem explicit: assets with long development and construction lead times must enter procurement well before the 2030s need becomes visible in real-time operations. [1]

The distinction was already visible in an earlier conversation with Michael Terrell, then Director of Energy at Google. Annual renewable-energy matching did not guarantee carbon-free electricity in every location and every hour. Moving towards continuous carbon-free operation exposed periods that could not be covered cost-effectively by the existing mix and therefore required storage, firm clean resources, demand management or wider market coordination. [2]

This is why storage planning should begin with the residual system gap after other options have been considered. Anders Lindberg, President of Wärtsilä Energy, describes flexibility technologies as commercially available today, but cautions that relying solely on batteries can require substantial overbuilding of renewable generation and storage. Anja Frada, Chief Operating Officer of Wärtsilä's Energy business at the time of her interview, similarly argues for a portfolio combining renewables, storage and flexible generation rather than treating storage as an isolated route to a fully renewable grid. [3] [4]

The relevant unit of analysis is therefore not the storage project. It is the system condition the project must cover. That discipline prevents buyers from procuring a familiar duration because it is easy to specify while leaving the more consequential reliability gap unresolved.

> **Executive decision:** Require system planners and procurement teams to define uncovered hours, discharge duration, response requirements and reliability standards before selecting a technology or announcing a storage target.

 

## Markets do not yet know how to price time

Power markets typically expose storage to several possible revenue streams: energy arbitrage, capacity, balancing, congestion relief and ancillary services. In principle, an LDES asset can provide several of them. In practice, market access, product definitions and settlement rules may not allow the project to capture enough of that combined value over a financeable period.

Julia Souder, CEO of the Long Duration Energy Storage Council, identifies the central failure directly: markets do not know how to price time. Systems can reward power delivered now, or reserve held for short balancing intervals, without placing an adequate value on the ability to discharge through a prolonged period of scarcity. Her evidence also shows why revenue stacking is not a simple solution. An asset may create value for generation owners, network operators and consumers, yet lack the market products or contractual access required to be paid by each beneficiary. [5]

That problem has remained visible over time. In Souder's earlier appearance on *Climate Confident*, she stressed that explicit targets and market signals were needed to create investment. The more recent interview shifts the emphasis from awareness towards implementation: projects are becoming larger and operating data is improving, but payment structures and procurement design remain behind the technology. [6]

Existing capacity arrangements can also preserve the incumbent alternative. John Sturman, Managing Director of NatPower UK, notes that capacity markets may pay gas peaking plants to remain available. That is not automatically irrational: systems need dependable capacity. But unless low-carbon resources can compete for an equivalent reliability service on terms that reflect duration, the market can continue buying the familiar solution even where storage might produce a lower-emission portfolio. [7]

Market reform should not mean guaranteeing every storage technology a return. It means defining products that correspond to system needs, allowing qualified resources to compete and preventing short settlement periods from making long-duration capability financially invisible. Where markets cannot yet provide sufficient certainty, competitive long-term contracts can bridge the gap while performance evidence accumulates.

> **Executive decision:** Create duration-specific, technology-neutral products that pay for dependable availability during defined system stress periods and permit storage to earn from the services it can verifiably deliver.

## Procurement determines whether a project can be financed

Targets create direction; contracts create assets. The archive repeatedly shows a gap between announcing the need for LDES and procuring it in a form lenders and investors can underwrite.

O'Grady's evidence connects the stages clearly. If modelling identifies a long-duration requirement, an explicit target can signal intent, but the target must move quickly into a procurement process and a revenue-certainty contract. Souder makes the same point from the industry-wide perspective: procurement designed around shorter durations can exclude longer-duration systems before their lifecycle value is compared. The bottleneck is therefore not merely "more policy". It is the design of an investable transaction. [1] [5]

Upfront-cost comparisons can distort that transaction. Raj DasGupta, CEO of Electrovaya, describes procurement processes that favour lower initial capital cost even where a different battery architecture offers substantially longer cycle life. Matt Harper, Chief Commercial Officer and co-founder of Invinity Energy Systems, explains that flow-battery economics depend on high utilisation and long asset life; whether those characteristics are rewarded varies materially by jurisdiction and market mandate. The general lesson is not that one chemistry is superior, but that procurement must compare the cost of delivering the required service across the asset's operating life. [8] [9]

Bankability then becomes a consequence of structure. Investors must assess construction risk, technology performance, degradation, operating revenues and counterparty quality over assets expected to run for many years. Limited fleet data increases uncertainty for novel designs, while purely merchant revenues can be difficult to forecast. Souder reports that larger projects and accumulating operating evidence are improving confidence, but financing remains a primary constraint. Contracts that establish credible floors or availability payments can turn technical capability into an underwritable cash flow without removing performance risk from the developer.

The wrong response is to make public support permanent or indiscriminate. Early contracts should discover prices, require measurable performance and reduce support as technologies and markets mature. The objective is a repeatable asset class, not a protected demonstration programme.

> **Executive decision:** Evaluate storage bids on the lifecycle cost of the specified service, and use competitive contracts with explicit performance, availability and revenue provisions where merchant markets cannot yet support financing.

## Delivery constraints begin after the contract is signed

An investable project can still fail to reach operation. Transmission and distribution capacity, interconnection queues, local permitting, equipment availability and inexperienced supply chains can each become the critical path.

Sturman argues that insufficient investment in electricity networks has left grids unprepared for large additions of renewables and storage. He also warns that zonal technology limits and connection caps can prevent projects from entering the system even where their capabilities are valuable. O'Grady adds the commercial consequence: curtailment and network congestion weaken the renewable business case and therefore affect the value storage is intended to recover. [7] [1]

Manufacturing presents a different scaling problem. Min Tang, Director of the International Business Unit at Rongke Power, describes an early flow-battery supply chain in which missing suppliers forced manufacturers to produce components themselves. Scaling requires a broader supplier base, standardised stacks and containerised designs, and factory-acceptance testing that reduces project-level uncertainty. [10]

Brad Hartwig, founder and CEO of Arbor Energy, brings the reliability requirement into view. Technologies intended to provide long-duration firming must withstand continuous operating conditions and meet the exacting availability expectations of utilities. Until manufacturing volumes rise, their unit costs may also remain above alternative firming options. That combination—high reliability expectations before large-scale learning has occurred—is a genuine commercialisation challenge, not simply institutional conservatism. [11]

These constraints argue for programme-level delivery governance. Interconnection, permitting, standardisation, warranties, factory capacity, skilled labour and long-term service should be assessed alongside technology performance and price. Otherwise, procurement can select an attractive asset that the delivery system cannot build on time.

**Executive decision:** Make grid access, permitting, factory capacity, testing standards, warranties and long-term serviceability part of the investment gate—not post-award implementation details.

## Technology is ready in the plural, not in the abstract

The evidence supports neither of the slogans often applied to LDES: “the technology is ready” and “the technology is not ready”. Readiness depends on the pathway, duty cycle, location and reliability requirement.

Emily Pontecorvo, then a staff writer at climate publication *Grist*, highlights the substantial round-trip losses involved in converting electricity to hydrogen and back. Auke Hoekstra, a researcher at Eindhoven University of Technology, similarly distinguishes relatively efficient daily storage from the harder problem of seasonal storage through chemical carriers. Hydrogen may still have value where molecules, very long duration or existing infrastructure matter, but efficiency changes how much renewable generation must be built to support it. [12] [13]

Other technologies face different constraints. DasGupta describes the trade-off between very long cycle life and energy density in some battery designs. Jarand Rystad, founder of Rystad Energy, notes that seasonal thermal storage can depend on suitable geology, making opportunity and cost location-specific. John O’Donnell, CEO of Rondo Energy, presents electric thermal storage as a route to decarbonising industrial heat, but also identifies the need to scale the product, manufacturing base and commercial organisation. [8] [14] [15]

The portfolio implication is important. Storage technologies should be qualified against use cases, not ranked on a single league table. Round-trip efficiency, discharge duration, cycle life, response speed, siting constraints, materials, safety, build time and service capability all matter. The best resource for a four-hour evening peak may be a poor choice for a multi-day shortfall or continuous industrial heat.

**Executive decision:** Maintain a technology-neutral qualification framework tied to defined use cases. Treat efficiency, duration, reliability, siting and lifecycle performance as interacting requirements rather than universal rankings.

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## What leaders should do now

1. **Model the residual flexibility gap.** Identify the periods that remain after transmission, interconnection, demand response, short-duration storage, renewable diversity and firm clean generation are considered.
2. **Specify the service in time.** Define discharge duration, response time, availability, cycling profile, location and recovery requirements in operational terms.
3. **Create an investable procurement route.** Move from targets to competitive tenders and contracts that provide sufficient revenue certainty while retaining construction and performance accountability.
4. **Compare lifecycle system cost.** Include renewable overbuild, conversion losses, degradation, networks, curtailment, fuel exposure, useful life and end-of-life obligations—not only initial capital expenditure.
5. **Secure deliverability early.** Treat interconnection, permitting, supply capacity, factory testing, warranties, service and operating skills as gating conditions.
6. **Build evidence into the market.** Publish standardised performance data where commercially possible, verify availability and degradation, and use successive procurements to reduce risk premiums.
7. **Govern storage as a portfolio.** Review storage alongside demand flexibility, transmission and firm generation so that one favoured technology does not become the default answer to every duration problem.

## Where the evidence is less conclusive

The interviews do not establish a universally optimal storage duration, technology mix or market mechanism. Power systems differ in renewable resources, network capacity, demand shape, existing generation, geology, regulation and interconnection. A design that is economic in one jurisdiction may not transfer to another.

The archive also contains more technology vendors, solution providers and advocates than independent asset owners reporting audited lifetime performance. Vendor evidence is valuable for identifying mechanisms and delivery constraints, but it cannot independently establish fleet-wide cost, degradation or reliability. Quantitative claims therefore require project-level verification before being used in investment decisions.

There is a genuine disagreement of emphasis. Industry advocates describe finance and market design as the principal near-term bottlenecks, while other guests stress conversion losses, manufacturing maturity, utility reliability expectations and the cost of relying too heavily on storage. These positions are not mutually exclusive. They indicate that some technologies are ready for defined commercial applications while the category as a whole remains heterogeneous.

Finally, retrieval frequency is not evidence of prevalence. The archive is a purposively selected collection of expert interviews, not a representative survey of power systems, investors or storage projects. The conclusions identify recurring mechanisms supported across the interviews examined; they do not estimate how often each barrier occurs in the wider market.

## About this research

This brief draws on a structured review of 50 interviews selected from the *Climate Confident*, *Resilient Supply Chain*, *Sustainable Supply Chain* and *Digital Supply Chain* archives in response to a preregistered research question about the barriers to scaling long-duration energy storage. The selected evidence spans interviews published from January 2021 to September 2026.

The research process retrieved 100 evidence passages, extracted and grouped claims, tested themes across episodes, and then subjected every claim to a human directness review. Of 124 claims, 43 were classified as direct LDES evidence, 37 as broader storage evidence, 34 as relevant context and 10 as indirect analogy. Indirect analogies were excluded from LDES support counts. The final brief gives priority to direct evidence and uses contextual material only to explain mechanisms.

The archive is not a random or representative sample. Guests were selected editorially, coverage is uneven across technologies and regions, and transcript quality varies. The research therefore supports qualitative conclusions about recurring barriers and competing explanations, not market-share estimates or claims about what "the industry" universally believes.

## Source interviews

The interviews below are the sources actually cited in this brief. Titles and affiliations reflect the interview record.

1. *Oonagh O'Grady, Vice President, Hydrostor — Long-Duration Storage Tackles Clean Energy's Reliability Gap*
2. *Michael Terrell, Director of Energy, Google — Reducing Google's Carbon Footprint*
3. *Anders Lindberg, President, Wärtsilä Energy — Why Flexibility, Not Generation, Is the Real Energy Bottleneck*
4. *Anja Frada, Chief Operating Officer, Energy, Wärtsilä — Path to a Net-Zero Future*
5. *Julia Souder, CEO, Long Duration Energy Storage Council — Long-Duration Energy Storage Is Ready. The Energy Markets Aren't*
6. *Julia Souder, CEO, Long Duration Energy Storage Council — The Next Big Leap in Renewable Energy*
7. *John Sturman, Managing Director, NatPower UK — Grid Decarbonisation at Scale*
8. *Raj DasGupta, Chief Executive Officer, Electrovaya — Electrifying Heavy-Duty*
9. *Matt Harper, Chief Commercial Officer and co-founder, Invinity Energy Systems — Beyond Lithium*
10. *Min Tang, Director of the International Business Unit, Rongke Power — No One Wants to Ship Water*
11. *Brad Hartwig, founder and CEO, Arbor Energy — Why Turbine Shortages Could Slow AI, Data Centres, and Decarbonisation*
12. *Emily Pontecorvo, staff writer, Grist — Green Hydrogen: Separating Fact from Fiction*
13. *Auke Hoekstra, researcher, Eindhoven University of Technology — Renewable Energy, Storage, and Electric Transportation*
14. *Jarand Rystad, founder, Rystad Energy — What the Energy Transition Is Still Getting Wrong*
15. *John O'Donnell, Chief Executive Officer, Rondo Energy — Reducing Climate Emissions with Zero-Emission Industrial Heat and Power*

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## About Tom Raftery

Tom Raftery is a sustainability and technology executive, analyst and broadcaster whose work focuses on climate, energy, digital transformation and resilient supply chains. He hosts the **Resilient Supply Chain** and **Climate Confident** podcasts, where he interviews business leaders, policymakers and innovators about the practical changes required to decarbonise industry and build more adaptable operating systems.

Previously a Global Vice President at SAP, Tom worked on strategy at the intersection of sustainability, energy and emerging technology. He has also spent more than a decade as an independent industry analyst and futurist, including seven years leading sustainability research at RedMonk and work with Gerd Leonhard's Futures Agency.

Earlier in his career, Tom co-founded an Irish software-development company, a social-media consultancy and Cork Internet eXchange, an energy-efficient data centre. That combination of technical, entrepreneurial and advisory experience shapes his approach: he connects new technology to the commercial, organisational and environmental realities that determine whether it creates value.

Tom is an international keynote speaker, a guest lecturer at Instituto Internacional San Telmo and an advisor to startups working in climate and supply-chain technology. Through Podcast Archive AI, he is also developing an evidence-led publishing practice that turns years of expert interviews into traceable, decision-focused research for senior business leaders.