



Cheap today, costly for a **century**



**Mike
Westerman**

Global Hydropower
Lead, GHD

Batteries win on the sticker price, pumped hydro wins once you count the full cost of a lifetime. For roughly 48 hours in June 2026, the wind almost disappeared across South Australia. With little sun to help and no long-duration storage to fall back on, the state leaned on diesel and gas.

The average wholesale price over that window sat above AUD 800 per megawatt hour, with peaks slamming into the market cap of AUD 20,300. A 12 to 16 hour pumped hydro scheme would have carried the state through those peaks for days. Wind supplied barely one percent of the state's power across those four days and batteries drained by evening¹.

These events, wind and solar droughts hitting grids moving off coal, are rare. But they are becoming frequent enough to earn a name: power system planners call them dunkelflaute. In German, dunkel means dark and flaute means lull². It describes the moments when the lights go out through lack of power.

When renewables go quiet, every grid faces the same test

The challenge Australia faces is playing out as coal and gas give way to wind and solar.

Iberia provided a live demonstration of the challenge. On 28 April 2025, the Spanish and Portuguese grids collapsed in under 90 seconds, cutting power to more than 50 million people. Investigators pointed not to a shortage of energy, but to a shortage of the services that damp out instability, traditionally supplied by thermal generation and pumped hydro, largely absent from the solar and wind resources running at high penetration⁴.

Batteries move the afternoon. Nothing yet moves the night.

The evening peak is a shifting problem. The overnight block, repeated night after night through cloudy winter stretches with little chance to recharge, is a different order of task.

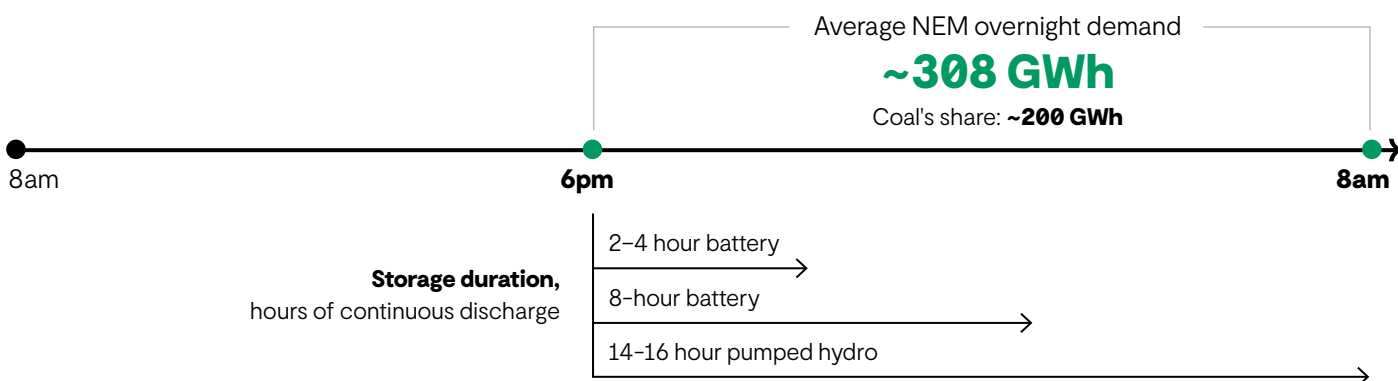
Britain has moved first on the policy response, ending a four-decade investment drought through a technology-neutral cap-and-floor mechanism designed to underwrite long-duration electricity storage projects.⁵

Different markets, same lesson: replacing coal's megawatt-hours is the easy part. Replacing what keeps the grid standing is the real test. The question is not whether long-duration storage is needed. It is which technologies can keep the lights on when renewables go quiet and do so at the lowest cost over an asset's full life.

The problem is not the afternoon. It is the 14 hours after dark

According to Australian Energy Market Operator's (AEMO) 2024 Integrated System Plan, around 90 percent of Australia's coal fleet is expected to retire before 2035⁶. The instinctive fix is to shift cheap midday solar into the evening peak. Batteries do that well.

That is the easy part. Across Australia's National Electricity Market (NEM), demand between 6pm and 8am averages about 308 GWh a night and coal still supplies roughly two-thirds of it, close to 200 GWh. Replacing that overnight block, night after night, including through cloudy winter stretches with little chance to recharge, is a different order of task.



Source: AEMO Integrated System Plan 2024; GHD analysis.

Batteries solved the easy part

Battery energy storage has been one of the NEM's success stories. It responds in milliseconds, deploys in modules, competes hard in arbitrage and frequency markets, and has helped take the edge off peak prices.

The economics work best in short-duration, high-cycling roles. Stretch a battery to cover 14 or 16 hours and the maths shifts. More of the asset must sit in reserve rather than earn and there is no commercial 14-hour battery system operating anywhere today.

There is a subtler catch too. Battery prices have fallen because cell prices have fallen. But the rest of the system, the power electronics, civil works, grid connection and construction, does not follow the same curve. In Australia, those costs set a floor that cell savings cannot push through.

What a coal plant actually leaves behind

When a synchronous coal generator shuts down, the grid loses dispatchable energy. It also loses inertia, system strength, fault current and black-start capability, the invisible services that keep voltage and frequency inside safe limits.

Pumped hydro replaces both because it spins synchronous machines, so it delivers those stability services the way coal did, while also shifting energy across many hours. Batteries provide fast frequency response and their grid-forming abilities are improving, but AEMO has not yet rated them as suitable for many of the services pumped hydro provides today. On present evidence, only pumped hydro can do all of it at once.

The number that matters is not the sticker price

Compare the two on day-one capital cost and they look close. On a like-for-like basis, GHD's modelling puts 16-hour pumped hydro at about AUD 283 per kilowatt hour against about AUD 304 for an equivalent battery.

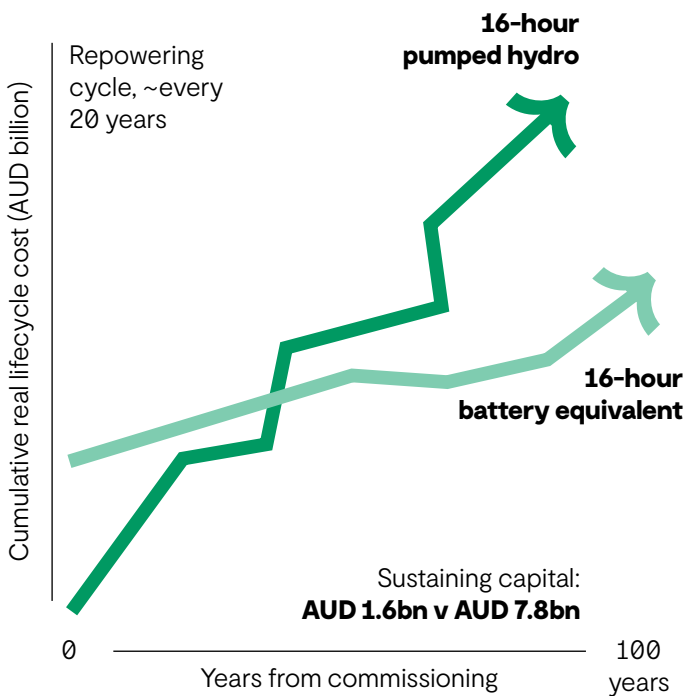
The gap opens over time. A pumped hydro scheme's civil works, its reservoirs, tunnels and waterways are built to last 80 to 100 years, with periodic refurbishment of the electro-mechanical gear. A battery has to be repowered roughly every 20 years as its cells degrade.

Run that out over a 100-year horizon and the picture is stark. Sustaining capital lands at about AUD 1.6 billion for pumped hydro turbine overhauls versus about AUD 7.8 billion of battery repowering. Total real lifecycle cost comes to roughly AUD 15.3 billion for pumped hydro against AUD 19.3 billion for an equivalent 16-hour battery. Pumped hydro also lands a lower levelised cost of storage, about AUD 56 per megawatt hour today versus AUD 71 for batteries.



Close on day one. AUD 4 billion apart by year 100.

Battery cells degrade and must be replaced roughly five times across the life of a single pumped hydro civil structure. Levelised cost of storage: AUD 56/MWh v AUD 71/MWh.



Source: GHD modelling, 2026.

Where the money gets spent

There is a strategic dimension the balance sheet does not always capture. Pumped hydro is construction-led. Around 70 percent of its cost is civil works, tunnelling, earthworks and transmission, most of it spent in Australian regional communities.

Batteries are the reverse. More than 75 percent of the cost is manufactured equipment, and the International Energy Agency finds China holds close to 85 per cent of global battery cell production capacity, alongside dominant shares of cathode and anode material⁷. As storage becomes structural to the grid and as batteries need replacing again and again, that offshore exposure becomes a question of sovereign resilience, not just price.

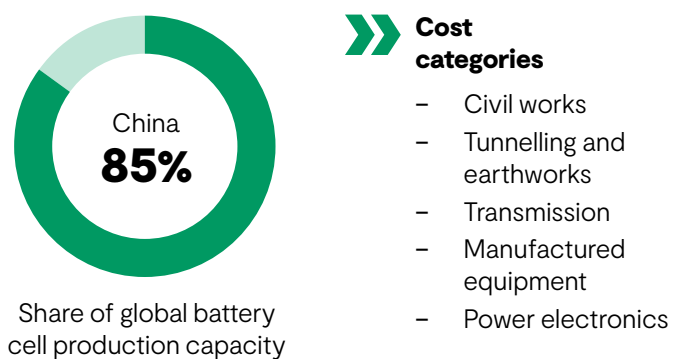
This is not a contest

None of this makes pumped hydro the rival of batteries. They do different jobs. Batteries own rapid response and short-duration balancing. Pumped hydro owns long-duration firming, synchronous support and the insurance value that shows up in weeks like that South Australian wind drought. Peer-reviewed modelling in Nature Communications finds long-duration storage is most valuable in wind-heavy grids and that enabling long storage cycles can cut prices during peak demand by more than 70 percent⁸.

Delivery risk is real and worth naming plainly. The lessons from Snowy 2.0 and Pioneer-Burdekin are about contracting, ground risk and community engagement, not about the maturity of the technology itself. Snowy 2.0 makes the point: its budget has blown out from an initial AUD 2 billion to well beyond the AUD 12 billion reset, driven by geology and delivery rather than any flaw in pumped hydro as a technology⁹. In pumped hydro, location is the dominant variable.

One spends in the regions. One spends offshore.

As storage becomes structural to the grid, and as batteries need replacing again and again, cost composition becomes a question of sovereign resilience, not just price.



Source: International Energy Agency, Batteries and Secure Energy Transitions, 2024.

What the next decade asks of us

Australia is not just replacing coal's energy. It is replacing coal's reliability and the system services that hold the grid together. The investment decisions made in the next few years will lock in the shape of the grid for generations, so they need to be judged on the full life of the asset, not the lowest upfront invoice.

That means costing storage against the days the wind drops, the recharge that never comes and valuing the difference between capacity and capability. The portfolios that hold up will not be the ones that chase the cheapest megawatt hour today. They will be the ones built to keep delivering firm power and system security when the next wind drought arrives.

Australia is not confronting this challenge alone. Across Europe, grid operators are planning for increasingly severe renewable energy droughts with research suggesting hundreds of terawatt-hours of long-duration storage may ultimately be required to maintain reliability during extended dunkelflaute events². Britain has responded by introducing a dedicated investment framework for long-duration energy storage, while Spain's 2025 blackout reinforced the importance of maintaining system strength alongside high levels of renewable generation^{4,5}.

The lesson emerging across these markets is remarkably consistent. Building renewable generation is only the first stage of the transition. The harder task is ensuring the system can continue to provide affordable, reliable electricity when the wind is not blowing and the sun is not shining. That is rapidly turning long-duration storage from an energy investment into critical national infrastructure.

The choice was never batteries or pumped hydro. Batteries are likely to dominate short-duration balancing and fast-response services. Pumped hydro is likely to remain critical for long-duration firming, synchronous support and resilience during extended renewable droughts.

The real question facing Australia's National Electricity Market is not whether we need long-duration storage. It is whether we build enough of it, soon enough, while coal remains available to support the transition. Markets around the world are discovering that replacing coal's megawatt-hours is relatively straightforward. Replacing the reliability, stability and security it provides is the real challenge. The systems that emerge strongest from the energy transition will not be those that generate the most renewable power. They will be those that can depend on it when conditions are at their worst. /

References

1. ABC News, June 2026
[Electricity price spikes and batteries drain as wind drought tests green flag-bearer](#)
2. Kittel, M. & Schill, W-P., 2026 [Quantifying the Dunkelflaute: An analysis of variable renewable energy droughts in Europe](#), Communications Earth & Environment
3. ENTSO-E, 2025
[Update on the Iberian Peninsula System Separation Event of 28 April 2025](#)
4. UK Department for Energy Security and Net Zero, 2024
[Long Duration Electricity Storage Cap and Floor Scheme](#)
5. Australian Energy Market Operator (AEMO), 2024 [Integrated System Plan 2024](#)
6. International Energy Agency (IEA), 2024 [Batteries and Secure Energy Transitions](#)
<https://www.iea.org/reports/batteries-and-secure-energy-transitions>
7. Nature Communications, Ziegler, M. et al., 2024 [The value of long-duration energy storage under various grid conditions in a zero-emissions future](#)
8. ABC News, October 2025
[Snowy 2.0 faces cost blowouts beyond previous \\$12 billion target](#)

