GRID-SCALE ENERGY STORAGE:

Essential Infrastructure and Emerging Solutions

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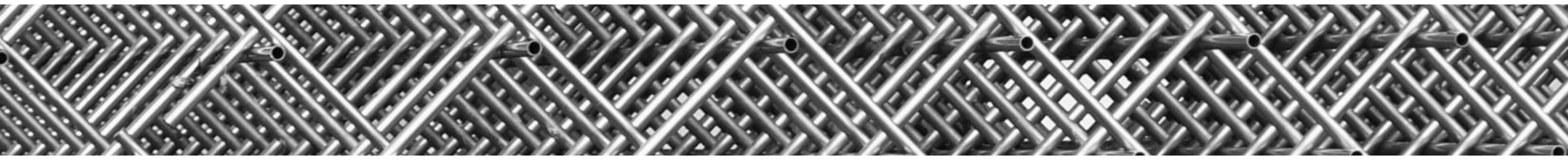
Grid-scale energy storage is the less glamorous but essential complement to renewable energy in the global decarbonisation pursuit, offering necessary stability to renewables' temperamental supply. Forms of storage at varying degrees of development and deployment have emerged as solutions. Each carries its own benefits and drawbacks, and not all are likely to gain traction over time.



In the drive for the decarbonisation of the energy sector, the increasing prominence of renewable energy and its intermittency – the inability of solar and wind power to provide steady, constant energy around the clock and regardless of weather – is undoubtedly one of the key challenges. Rising geopolitical tensions – be it Sino-American or the tragic outbreaks of war in Ukraine and in the Middle East – have heightened concerns about the security of energy supply, and the impetus for countries and regional blocks to insulate themselves from risks that a trading partner turned rogue may suddenly turn off the gas taps, cut oil supply, or consolidate control of cobalt mining. It is against this backdrop that the drive for grid-scale energy storage has gathered considerable momentum.

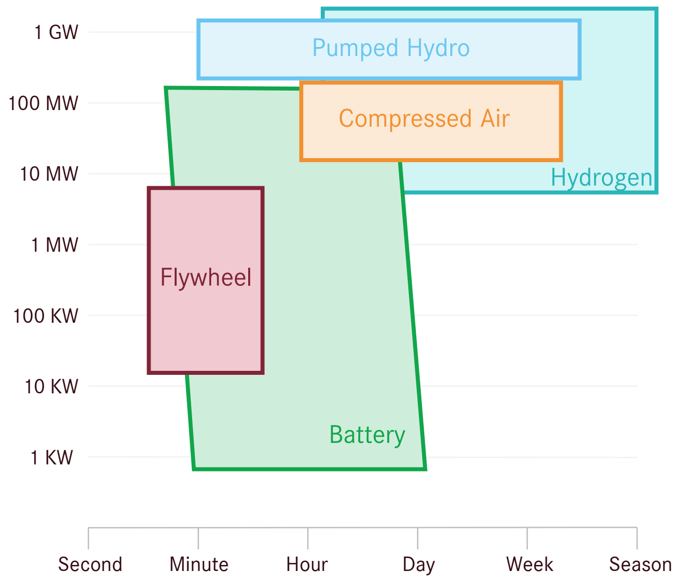
Grid-scale energy storage is a longstanding component of power networks and represents any form of technology connected to the power grid capable of storing energy and resupplying it back to the grid at a favourable time. Mitigating the risks of intermittency of renewables and geopolitics are certainly key drivers underpinning energy storage demand, but energy storage's impact is much broader than that. Depending on a range of factors, including response time and storage capacity, energy storage can fulfil a number of more technical roles, including optimising electricity networks (potentially lowering electricity prices and infrastructure costs) and ensuring grid stability (reducing the risks of blackouts and brownouts).

Duration, or how long energy can be stored before being discharged, is a key differentiator in the roles of energy storage. Short duration storage is suited to rapid charging or discharging.[1] Being able to store and discharge energy at appropriate windows helps stabilise pricing for users and reduces the need for importing power at expensive peak rates. Frequency mismatches – which occur when there is a disconnect between supply and demand – can also be better managed with energy storage infrastructure that can respond in microseconds. Medium duration storage can help manage intra-day renewable energy intermittency (for example, storing solar power for four to 12 hours), or over days, even beyond a week, which is useful for changes in wind patterns.

Finally, long duration energy storage (LDES) – ranging from a week to potentially years, can play a role in seasonal changes in energy demand, interconnector failures, energy security and, of course, the dreaded dunkelflaute (the German word to describe periods of time over which there is limited sun and wind, and accordingly, when little energy can be generated from solar or wind power).

Grid-scale energy storage has long been dominated by pumped hydropower storage. However, other forms of storage at varying degrees of implementation – some purely conceptual, others decades (even centuries) old but under-utililised or unproven at scale – have emerged as solutions. Lithium-ion batteries are currently the most scalable type of grid-scale storage; hydrogen, meanwhile, is an emerging technology that has the potential for seasonal storage of renewable energy. The optimal grid-scale energy storage solution for a given purpose will depend on a range of factors, including duration, storage capacity and rate of discharge.

FIGURE 1: ENERGY STORAGE, POWER AND DURATION



Source: PATRIZIA, US Energy Information Administration

[1] While there is currently no universally accepted definition for short, medium or long duration storage, one recent guide issued by UK Parliament segments them into discharging energy in under four hours, four to 200 hours, and over 200 hours respectively (*POSTnote 688, 20 Dec 2022, Joshua Lait and Alan Walker*).

Lithium-ion batteries can discharge power to the grid in under one second, however rarely store more than two hours' worth of energy. They also degrade over time. Pumped hydropower can store and discharge a comparatively gargantuan amount of power to the grid but tend to ramp up to full production in a couple of minutes, which can be too slow for certain grid support services. Pumped hydro can degrade too, but over centuries and assuming no regular maintenance. Flywheel response times are even faster than batteries, but they cannot store energy for more than a short maximum duration, typically measured in minutes. They are also a nascent technology for grid-scale storage.

Trade-offs must also be made around efficacy – that is, how much energy is lost in the process of charging, storing and discharging. This measure – referred to as 'round-trip efficiency' (RTE), has a material impact in weighing up energy storage options; lithium-ion batteries have an RTE of around 90% and pumped hydropower around 75%. Other nascent options tend to average between 40% to 75%.

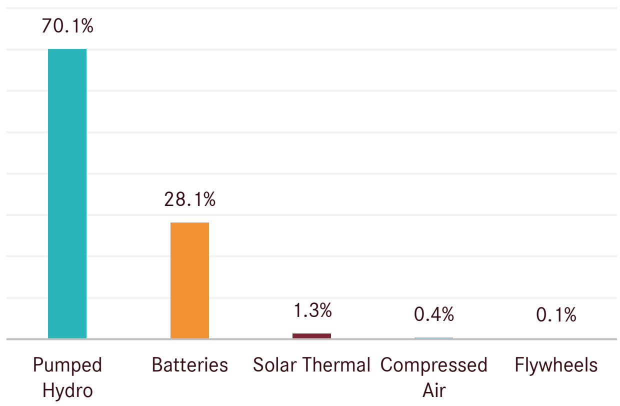
Despite the broad range of potential energy storage solutions commercially available or being trialed, there is a significant skew among current capacity to pumped hydro storage, which represents 94% of global storage. In the US, it accounts for around 70% of total storage currently, with lithium-ion batteries making up most of the balance. Indeed, so small is the storage currently provided by compressed air and flywheels in the US that the first commercial hydrogen storage project targeting energy storage – due for completion in 2025 – will represent more storage than all flywheels and compressed air facilities currently in the US combined.

This drives home an important point about energy storage options – for grid-scale solutions, pumped hydro and batteries are the only ones with a proven track record; the remainders are yet to offer viable round-trip efficiency, and their economic viability without generous government support remains uncertain.

While investment and deployment of grid-scale energy storage has been increasing, Chart 2 illustrates just how much investment will be required to achieve the Net Zero Emissions by 2050 scenario (NZE). Several challenges need to be overcome, including the initial high capital costs for grid-scale energy storage systems, and regulatory frameworks that are constantly evolving and may not always incentivise deployment. Furthermore, some storage technologies rely on specific materials or geological features, limiting their scalability or availability in certain regions. For example, the production of lithium-ion batteries requires the extraction and processing of lithium, cobalt and nickel, which can have significant environmental impacts and has raised concerns about potential resource depletion.

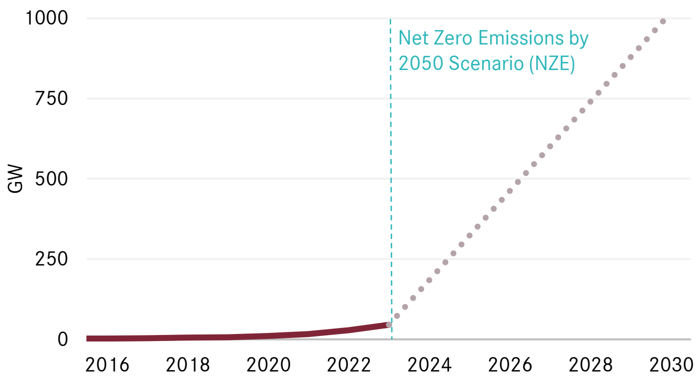
Large scale energy storage infrastructure will undoubtedly play a critical role in decarbonising electricity grids around the world. When and how infrastructure investors should allocate capital to this emerging asset type is less clear. Despite this, global energy storage capacity is forecast to grow quickly, and so is the interest of international infrastructure investors in this asset type. *Given the growing prominence of the sector, we will cover the varying types of energy storage in more depth in a series of research briefs over the course of 2024.*

CHART 1: SHARE OF ENERGY STORAGE SYSTEMS FOR ELECTRICITY GENERATION IN THE US, 2022



Source: PATRIZIA, US Energy Information Administration

CHART 2: GLOBAL INSTALLED GRID-SCALE BATTERY STORAGE CAPACITY IN NZE, 2016 - 2030



Source: PATRIZIA, International Energy Agency

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