'Longer-duration storage' and its role in the future of energy

Long duration | What are the best ways to match up long-duration energy storage technologies to applications and revenues? And what is 'longer-duration' storage and when will we need it? Florian Mayr and Dr Fabio Oldenburg at Apricum - The Cleantech Advisory offer some perspectives.

Between five and more than 1,000 hours of energy discharge – that's what the term "long-duration energy storage" encompasses in the industry today. It's a very broad definition that covers a wide array of storage technologies and use cases.

An increasing number of projects within this diverse space has been announced over the last few months. UK transmission system operator National Grid ordered a 50MW overground liquid air energy storage system with a five-hour discharge duration from Highview Power that will be connected to the grid in 2022. Lockheed Martin commissioned its first 500kW flow battery with a discharge duration of five hours and utility Dominion Energy just announced plans for an 800MW pumped hydro storage project in the USA with a 10-hour discharge time.

There seems to be one common attribute for most current long-duration projects: they focus on the lower end of the discharge duration range mentioned above, delivering energy at full power capacity for five to 10 hours.

The longer the desired discharge duration, the more challenging it is to apply storage. Why is that? Let's have a look at demand, cost and regulatory support of systems aiming for a discharge from multiple days up to months, at the mid- to upper end of the long-duration discharge range. To distinguish those from today's more common intraday applications (five to 10 hours discharge), they are referred to as "longer-duration" storage in the following.

Demand for longer-duration storage

The primary use case for a longer-duration storage system is always a form of "energy supply shift", shifting renewable energy from its time of generation to meet energy demand at a different time.

The motivation can be to sell more renewable energy by avoiding grid congestion at times of abundant renewable resources and being able to also serve demand when the sun is not shining brightly or the wind is not blowing. Another common intention, also in combination with the previous, is to charge when energy is cheap and discharge when it's more costly, either to save money or to make profits.

Highview Power's liquid air energy storage (LAES) is being deployed at a 50MW / 250MWh site with a portion of the costs supported by the UK government.

Last but not least, security of supply can be a reason. For example, Californians are increasingly exposed to Public Safety Power Shutoffs (PSPS) when utilities stop transmitting power to areas at risk of wildfires, as faulty lines have caused major fire disasters. Shutoffs can last for days, weeks or even months.

Energy supply shift can be stacked with other services such as peak shaving or balancing services, but the primary use case always needs to be applicable. In other words, you always need longer periods of no wind or sun, high-power prices and/or supply disruptions to benefit from longer discharge durations.

Living in Germany, we can confirm that there are elevated periods of very limited sunshine in the winter. If at the same time there is low wind, variable renewable energy is not available to satisfy demand. There is even a term for this: "dunkelflaute" or "dark lull", which can last for days and usually results in higher wholesale power prices.

In other geographies, there are seasonal power prices, such as Saudi Arabia where consumers often pay increased prices in summer when an even higher than usual need for air conditioning makes power demand surge. In theory, electricity generated in winter could be sold at a higher price in summer.

A certain revenue potential for longer-duration storage therefore exists, but the value today is often still limited. A recent study published by the US Electric Power Research Institute (EPRI) visualised this by comparing the time-shift value for different charge/discharge durations in California. Given the California ISO's day-ahead aggregated energy prices in 2019, a battery system with a four-hour discharge duration would have captured 76% of the value of a 20-hour battery.

Cost of longer-duration storage

This intrinsic challenge of longer-duration storage is often overlooked: the economics of an energy storage system in general depend a lot on the number of full charging/discharging cycles over the lifetime of that system — its utilisation. You usually get remunerated for each kWh of electricity stored and discharged. The higher the total number of full cycles at a given capacity, the higher the usable energy over the lifetime and the higher the return on investment.

Energy storage systems that target longer discharge durations such as weeks or months have limited annual cycles per definition. Take seasonal storage: if you transfer electricity generated by PV in winter to satisfy higher demand in the hot summer and only cycle once per year, the battery discharges during the summer months and will only recharge when it's winter again. The same logic applies to that "dark lull" in Germany. It typically occurs only twice a year at most.

An energy storage system capable of serving longer-duration use cases could be used for long- or even short-duration applications as well. The number of full cycles could potentially increase, but you would need to compete with storage systems with a smaller energy capacity, which would require substantial cost advantages for each kWh of energy capacity added.

We can derive the following success factors for longer-duration storage: low marginal cost of capacity (entailing the use of a highly abundant and cheap energy storage medium), independent scaling of power and capacity to avoid extra cost for un-utilised power, low self-discharge rates and high flexibility to switch between different levels of utilisation.

Overcoming technical hurdles alone does not secure commercial viability. Innovative long-duration storage technologies may suffer punitive debt financing costs and structures. The challenge is to convince conservative creditors that an emerging technology's commercial and operating structures underpin bankable long-term revenues, and that its application is still robust across decades of potential operation - credit availability can depend on a 90% probability revenue scenario.

Comprehensive risk mitigation across all dimensions of construction and operation is required to achieve maximal project financing. Creditors seek reliable obligations and remedies for all counterparties to maintain stable operations. The performance and reliability of the energy storage asset must be proven, ideally by third-party audits, certificates, warranties and long-term demonstration in the megawatt scale. Such comprehensive assurances can be a stretch when applying innovative technologies in project development: underwriting from commercial sponsors eager to facilitate technological deployment can fill that breach.

Here we see the value of emerging technologies participating in government-backed demonstration projects, as with Highview Power's 50MW cryogenic battery in the UK, which has found both corporate and public sponsorship for the first commercial deployment.

The regulatory view

To achieve the CO2-reduction targets that leading economies have committed to, policies and market regulations need to be adapted to further push the share of renewable energy sources. The proliferation of variable renewable energy automatically increases the value and demand for long- and longer-duration energy storage. At the same time, the attractiveness of their biggest competitor, the gas-fired power plant, would need to be reduced for maximum emission reductions. Strategic decisions that restrict the expansion of further gas-infrastructure in combination with an adequate taxation of CO2-emissions can open doors for long-duration storage.

Credit: BASF NB

This wind farm in South Korea uses NGK sodium-sulfur batteries as a buffer to ensure stable hydrogen production is possible.

Recently, legislation has also started to directly ask for long-duration energy storage. Last year, policymakers in Australia's New South Wales debated a bill to strengthen the state's electricity infrastructure by investing in 2GW energy storage capacity that can be dispatched for at least eight hours.

In California, a group of 11 community choice aggregators (CCA) recently highlighted their need for 1GW long-duration storage by 2026 and launched the first tender for 500MW storage capacity with eight hours as a minimum discharge duration. Responses included li-ion, flow batteries, CAES, pumped hydro, thermal and gravity storage.

When it comes to longer-duration storage, policies tend mostly to focus on promoting R&D and funding demonstration projects because of the current lack of demand for discharge durations over days, weeks or months as well as the commercial immaturity of suitable technologies. A prominent example is Minnesota electric utility Great River Energy's pilot for a 1MW/150MWh battery from startup Form Energy. Previously, the company received funding from the USA's Advanced Research Projects Agency-Energy (ARPA-E) as part of support for storage technologies with up to 100 hours of discharge duration.

Another example is the Advanced Clean Energy Storage Project in Delta, Utah (USA). Among other targets, by 2025 it aims to generate green hydrogen and store it in a salt cavern for later electricity generation – basically constituting longer-duration energy storage for 150,000MWh of renewable energy.

How long and when do you need it?

Is long- (or longer-) duration the "holy grail of energy storage" as is often claimed by the media? Well, that depends on your definition of "long". Are we speaking about hours, days, weeks or months of discharge duration? Are we looking at today's applications or use cases in five or 10 years from now?

In this upcoming "decade of energy storage", we see the biggest opportunity for long-duration storage that can shift PV and wind power within the course of a day to offer a dispatchable clean energy asset competitive to fossil fuel-based alternatives.

Increasing shares of renewables in the generation mix will create sufficient price spreads due to cannibalisation of prices at times of plentiful sun and wind. Depending on the demand profile when it's dark, five to 10 hours of discharge (at full power capacity) will usually do the trick. Liquid air energy storage, redox flow and sodium sulfur batteries all utilise a low-cost abundant storage medium where power and capacity can be scaled independently; this makes them promising candidates for long-duration storage that can be competitively applied in an increasing number of settings.

When all the lower hanging fruit for decarbonisation has been harvested, the urgency for longer discharge duration storage will increase. To approach a 100% renewable power system seasonal storage will be required.

Costs for suitable solutions that can easily scale up energy capacity to discharge for weeks and months, such as green hydrogen, will come down substantially due to technological advances and economies of scale. Until then, joint efforts across the entire value chain of energy storage and the strong support of policymakers are needed to pave the way to a decarbonised economy.

Authors

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