VOLTILITY

Long-Duration Energy Storage: Competitive Options for the Eight-Hour Plus Market

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Flow batteries, compressed air, and pumped storage can all compete in the long-duration market and as the technology improves, costs are dropping while the price of lithium rises.

As it becomes ever more evident that – for both technical and commercial reasons – lithium-ion batteries alone will not deliver the envisaged carbon-free electricity grids of the future, alternative technologies that can provide power for longer periods are claiming more attention.

The decisions within the past six months by California Community Power (CC Power), the group of community choice aggregators (CCAs) in California, to award its first two eight-hour energy storage contracts to lithium-ion projects might seem to undermine this claim, but two significant developments have taken place since CC Power issued its Joint RFO for long-duration storage in 2020.

One has been the exponential surge in lithium-ion costs over the course of 2021 – with the price of raw lithium itself rising by more than 450% over the year – while the other has been an advance of some alternative energy storage technologies to the cusp of commercial deployment.

Two technologies that have attracted significant investment over the past year are iron flow batteries and compressed air energy storage, which sit at opposite ends of the spectrum in terms of the size of energy storage facility they will naturally provide.

Iron Flow Battery Storage
ESS, Inc. is a leader in iron flow battery technology. It has patented a system that runs a solution of iron, salt, and water (electrolyte) through an electrode to provide between four and 12 hours of deliverable power.

With nearly USD240m of financial resources available at the year-end from its merger – and a second-generation 400kWh containerized unit that it has developed for both front-of-the-meter and behind-the-meter applications – the company is looking to make significant inroads into the market this year.

Its confidence arises from the increasingly pressing need for utilities and other grid operators to incorporate storage solutions that can discharge over longer periods than the four-hour norm for lithium-ion batteries (which remains the technology's optimal discharge time).

This is because four-hour storage alone will not be enough to support grids that rely entirely on carbon-free generation, with a preponderance of intermittent wind and solar.

"If you want to get to zero-carbon grids, you soon find out that four-hour storage alone won't cut it," said Hugh McDermott, Senior Vice President for Business Development & Sales at ESS, Inc.

Rapid Growth Opportunity
ESS, Inc. is consequently positioning its business for a rapid rate of growth in the coming years, despite the company reporting an operational loss of USD60.9m for 2021. It forecasts that its revenues will reach USD37m this year, with significant future growth as it expands its operations in Australia, Europe, and the US.

The company certainly has serious backers to support it in these endeavours, with Breakthrough Energy Ventures, SB Energy, Fidelity Management, and BASF Venture Capital among its equity investors.

Compressed Air Storage
Canadian-based Hydrostor, meanwhile, has been a lead developer of the technology that stores compressed air underground to run it up through a turbine – or turbines – to produce electricity on demand. The air is compressed by water in a flooded underground cavern and can be discharged at varying rates to generate electricity over periods ranging from eight to 24 hours.

Capital-Intensive Projects
In marked contrast to the iron flow batteries, whose small unit size will probably limit them to projects of under 50MW in scale, compressed air technology is capital intensive and requires a minimum project size of 300MW-400MW to be commercially viable (although Hydrostor is developing a 200MW scheme in Australia where site-specific conditions have reduced the necessary capital outlay).

While Hydrostor carried out its initial testing in existing salt caverns, it has now developed a method to excavate the necessary repositories in suitable rock – a change that has reduced the required size of the underground facility by a factor of 20. "We can now build anywhere there's bedrock," confirmed Hydrostor CEO Curtis VanWalleghem.

Long Operational Life
Compressed air storage facilities are expensive to construct, with a capital cost of around USD2,000/kW of capacity (USD1bn for a 500MW facility). To offset the high initial outlay, however, they offer a long operational life of between 50 and 100 years, with little or no maintenance expenditure needed on their core elements (the turbines would, of course, be subject to the usual wear and tear, maintenance, and renewal requirements).

Hydrostor has also embarked on a transition into a commercial operation. The company received a USD250m equity injection from Goldman Sachs in January 2022 and currently has three projects at an advanced stage of development – two schemes in California with capacities of 500MW/4,000MWh (Gem Energy Storage Center) and 400MW/3,200MWh (Pecho Energy Storage Center), and the smaller one of 200MW in Australia.

VanWalleghem said he expected to achieve financial close on two of them (one being the Australian project) early next year.

20-Hour Dispatch
Hydrostor is also currently looking at a 2,000MW project in an undisclosed location, which would have a 20-hour discharge capability, and VanWalleghem is confident of reducing the technology's capital costs by 15%-25% through smarter and more innovative engineering.

He explained that the company had been obliged to adopt a conservative approach to the components used in its system while it was trying to secure financial backing. "We kept it boring to be bankable," he said.

While there will obviously be geographical constraints as to where compressed air storage can be deployed – it would not be a feasible option in condensed urban areas – VanWalleghem said interest in the technology had grown hugely around the world over the past five years.

New Markets
Whereas in 2017 his team had only been able to find two potential markets for the technology – in California and Australia – there was now genuine interest in several other countries, including the UK, Ireland, and India. "What we're seeing now is that a lot more markets are opening up for this," he said.

While ESS, Inc. and Hydrostor are intending to take iron flow batteries and compressed air storage into utility-scale commercial operation, these two technologies will not provide the only answer for long-duration energy storage.

The Tennessee Valley Authority (TVA), the federally owned electric utility corporation that covers all of Tennessee and provides electricity to parts of six other US states, is currently focusing on other options as it plans to deploy 2.4GW of storage by 2028 and 5.3GW by 2038.

Pumped Storage
Dr. Joe Hoagland, TVA's Vice President of Enterprise Relations & Innovation, said the authority was currently focusing on the more traditional option of pumped storage.

The TVA owns and operates the 1,616MW Raccoon Mountain Pumped Storage facility in Tennessee's Marion County, which can generate electricity for 22 hours. Hoagland said recent improvements in turbine technology had the potential to extend the technology's generation time to 80 hours. "For long-duration facilities, pumped storage is one of the best options out there," he maintained.

Developing new pumped storage facilities will be a capital intensive undertaking, however, that depends on access to the right geology (which Tennessee possesses) and the ability to overcome environmental objections to flooding large areas of high ground.

They are consequently long-term projects, and TVA is also looking at options it can develop in the short-term. One of these ideas is to assemble a fleet of lithium-ion batteries that – in combination – would be able to deliver around one-fifth of the total combined capacity for a period of 20 hours.

Mix of Sources
It seems clear even at this nascent stage in the deployment of long-duration storage that no one

technology is likely to dominate the market, and the provision of what will be a vital capability for power grids of the future will come from a substantial mix of different sources.