ARTICLE

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ENERGY INSIGHTS

Long-duration Energy Storage: Useful Considerations for Procuring Entities

In recent years, the integration of an ever-increasing amount of intermittent renewables coupled with severe weather has challenged the operation of energy markets across the United States. Most notably, the recent storm-induced power crisis in Texas due to Winter Storm Uri in February resulted in ERCOT implementing rotating power outages. High temperatures in California resulted in the CAISO issuing flex alerts for power conservation and ultimately implementing rolling power outages as well. Policymakers across both regional transmission organizations (RTOs) have responded by elevating the importance of reliability, but there remains a lack of clear direction regarding the most efficient and cost-effective alternatives.

Many energy industry leaders see long duration energy storage (LDES) as a leading solution. To be successful in rolling out LDES, utilities and procuring entities must, at a minimum:

— Engage early on with developers to determine the universe of options.

— Establish an ongoing dialogue with policy and regulatory stakeholders.

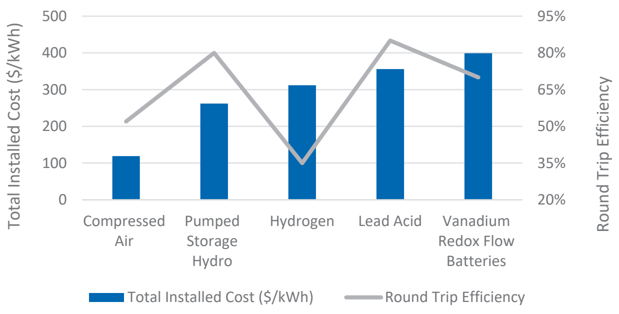
— Structure offtake agreements that maximize benefits to the utility while mitigating risk over the contract’s duration.

LDES Technology Landscape and Current Challenges

Despite the current popularity of LDES, the concept is well-established. Any energy storage that discharges more than 10 hours of rated energy qualifies as LDES.[1] Pumped-storage hydropower, which has been around for decades, is the most common form of long-duration storage in the United States. According to the U.S. Department of Energy, 43 pumped-storage hydropower facilities were built in the latter half of last century, providing nearly 100 GW of storage.[2] Although pumped hydro is reliable and well-proven, it has not been widely adopted, as lengthy permitting processes, geographical and topographical challenges, and varied project economics have prevented this technology from scaling more rapidly.

If total installed costs for LDES can decrease at a pace similar to solar PV or lithium-ion batteries, it could have a huge impact on electricity costs, grid reliability and GHG emissions in the next few decades. A recently published study by Nature Energy[3] concluded that systems with the greatest impact on electricity cost and firm generation have storage durations exceeding 100 hours and could reduce electricity costs by 10% if the total installed cost of the asset is less than $20/kWh. **Exhibit 1** compares the total installed cost for five promising long duration storage technologies and illustrates that current costs are far greater than the $20/kWh benchmark. Similar to renewable technologies, LDES will only reach scale with significant improvement in economics. This can come organically from cost per unit decreases based upon cost efficiencies, but also could be an opportunity to introduce incentives similar to those that helped solar and wind markets mature.

Exhibit 1: Total Installed Cost and Roundtrip Efficiency of Five Promising Long-duration Storage Technologies



Source: From Nature Energy www.nature.com/natureenergy[4]

Round-trip efficiency is defined as the ratio of energy put in (in MWh) to energy retrieved from storage (in MWh)[5]

Different LDES technologies present varying opportunities and constraints regarding energy storage capacity (duration), charge and discharge power capacity (i.e., ability to charge and dispense large amounts of energy at once) and charge and discharge efficiency. Flow batteries, for example, which are made of either vanadium redox or zinc bromine, are unlike their lithium-ion counterparts in that they are unable to charge or dispense charge rapidly. However, when considering only LDES technologies, the power capacity compares favorably, and unlike lithium-ion batteries, can store energy for longer durations (10-24 hours). This is an appealing option, as can be seen in **Exhibit 1**, but it is relatively expensive to build flow batteries with large storage capacities. Hydrogen, on the other hand, is relatively cheap in terms of storage capacity costs, but requires a great deal of infrastructure to create, store and burn, resulting in high power capacity costs and low efficiency. Compressed air, while much more cost-efficient than the previously mentioned sources, is geographically limited in its usage, as it requires large saline aquifers or salt caverns to achieve such low costs.

There are many other technologies in the works that show promise as potential long duration solutions, but are still in their early stages of development, such as thermal batteries and flywheels. Recognizing the challenges that currently face LDES, namely high development costs and underdeveloped technology, policy makers and regulators are working to shift policy to encourage the continued implementation of long duration storage.

Exhibit 2: Capacity, Duration, Lifecycle and Current Deployment Stage of Eight Selected LDES

LDES Source	Average Capacity (MW)	Average Duration (hours.)	Average Lifecycle (years)	Deployment Stage
Thermal Battery	0.2+	6 – 20	30	Not ready
Gravity	0.04 – 8	5 – 24	30	Pilot
Zinc Battery	1 – 10	10	30	Pilot
Flow Battery	1 – 20	10 – 24	25	Deployed in market
Flywheel	5 – 25	10 – 24	35	Shorter-term usage deployed in market
Liquid Air	25 – 150	8 – 24	50	Commercial
Concentrating Solar Thermal	50 – 250	10 – 24	75	Commercial
Pumped Storage	10 – 2400	8 – 36	100	Commercial

Source: Infographic from the LDES Association of California[6]

Positive Policy Shifts and Demonstrations of LDES

The Energy Act of 2020[7] directed the Department of Energy, in partnership with the Department of Defense to create a Long Duration Demonstration Initiative and Joint Program to aid promising long duration energy storage technologies and help new LDES technologies become economically viable. Building on this further, the Department of Energy announced in July 2021 a goal of reducing the cost of LDES by 90% by 2030.[8]

Similarly, state policies are rapidly shifting to support or require implementation of LDES. In June 2021, the California Public Utilities Commission mandated that load-serving entities in the state procure 11.5 GW of capacity (Net Qualifying Capacity) from clean resources by 2023-2026.[9] By 2026, one GW of this capacity is mandated to come from long lead time resources, specifically long duration storage. While the scale of procurement required is historic, California is not the only state with near-term plans for the implementation of long duration storage as evidenced by innovation challenges and pilot projects in several other states. Examples include:

- The New York Power Authority announced in April the signing of an agreement with Zinc8 Energy Solutions for deployment of a 100 kW/1 MWh zinc air energy storage project, the state's first demonstration of long duration storage.[10] The zinc solution was chosen over lithium-ion not only because of its longer duration but also because, unlike lithium-ion, zinc is not toxic to dispose.
- Minnesota-based utility Great River Energy has partnered with Form Energy to deploy a 1 MW aqueous air battery by 2023, which is estimated to deliver over 150 hours of energy continuously.[11]

Policymakers and modern grid operators are both attuned to the need to implement LDES. While pilots are helpful in demonstrating technology, how do utilities (and other load-serving entities) move past the pilot stage? How do they balance decarbonization goals and compliance mandates with customer affordability, technology risk and general market integration? While each utility or load-serving entity will have its own resource mix and needs, the following three principles should be top of mind for executives planning their procurement of LDES.

1. Engage early with developers

Procuring entities should broadly engage with developers early to understand which technologies and developers are active in their markets, as well as the considerations and challenges that will need to be addressed. As an example, a group of 11 community choice aggregators (CCAs) in California issued a request for information in 2020 to identify storage technologies with a duration of eight-plus hours, creating an opportunity to review and assess options prior to receiving the mandate to procure long duration storage from the California Public Utilities Commission in 2021. Having a head start in understanding technologies, costs and operational benefits allowed the CCAs to discuss options with developers and understand available alternatives, informing their contract development and IRP implications, and ultimately reducing time during future negotiations. The RFO generated 314 offers from 51 entities, covering 18 different LDES technologies.[12]

2. Establish an ongoing dialogue with policy and regulatory stakeholders

Varying factors complicate the integration of LDES, including the differing ownership models of long duration storage, namely utility ownership and third-party ownership. The two models each have their own opportunities and constraints. Utility ownership allows for a greater ability to centrally plan LDES utilization for maximum value, allowing for greater grid flexibility and efficiency. Furthermore, utility ownership would benefit from economies of scale, allowing for more LDES capacity at the cheapest cost. Third-party ownership, on the other hand, creates opportunities for utilities to shift development risk, but could result in less organized central planning and economies of scale depending on the types of technologies selected.

Because of this complication and others that exist in the undeveloped LDES market, successful integration of long duration storage at scale requires consistent communication between the procuring entity, the system operator (if applicable) and the regulator to mitigate risks such as compliance penalties, market design issues (i.e., difficulty bidding asset into the market), interconnection delays and regulatory approval delays.

The 2010 founding of the New York Battery and Energy Storage Technology Consortium (NY-BEST) displays a way in which a mutually beneficial dialogue between LDES stakeholders and policymakers can be established and maintained. NY-BEST is a non-profit that provides its members with policy updates and advisory services to help them navigate the complex and evolving storage industry. Members of the consortium are given a voice to influence policies, laws, and regulations, as the consortium participates in both New York State government and NYISO activities that impact energy policy.[13] Recently, NY-BEST played a key role in advocating for legislation that led to Governor Cuomo establishing a 1500 MW goal by 2025 for energy storage deployment. The Consortium currently has 185 members, including utilities such as Con Edison and Central Hudson Gas & Electric,[14] and is poised to continue advancing New York's role as a leading market for LDES.

LONG DURATION STORAGE LIFESPAN

Compressed Air
Lifespan: 30 years

Pumped Storage Hydro
Lifespan: 40 years

Hydrogen
Lifespan: 30 years

Lead Acid
Lifespan: ~2 years

Vanadium Redox Flow Battery
Lifespan: 15 years

3. Design offtake agreement to mitigate risk over contract duration

While the design of the offtake agreement will vary depending on the type of market and procuring entity (vertically-integrated market vs. ISO/RTO), the best practices should be considered.

The offtake agreement should be designed to ensure that the procuring entity can maximize the value of the asset over the duration of the agreement, while also providing enough revenue certainty to the asset owner to allow for financing. To the extent possible, the agreement should provide flexibility for changes in law to ensure that the procuring entity can realize the value of all of the project attributes (may include energy and other attributes such as resource adequacy and renewable energy credits, depending on the type of asset and whether co-located with another renewable source) over the life of the asset. Performance guarantees (primarily availability) and force majeure provisions will be of particular importance, given the scale and impacts to the system if this asset is unable to perform.

Endnotes

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