Long-duration energy storage: The time is now

May 25 2023, by Courtney Stenson

Long-duration energy storage is a likely candidate to help states meet aggressive decarbonization goals. Credit: Stephanie King / Pacific Northwest National Laboratory

How can U.S. states with aggressive decarbonization goals coupled with federal decarbonization goals have energy when they need it? Long-duration energy storage (LDES) is a likely candidate. LDES systems are large energy storage installations that can store renewable energy until needed and can provide a much-needed solution for a reliable and decarbonized grid. But planning needs to start now, according to new research from Pacific Northwest National Laboratory (PNNL).

"Defining Long Duration Energy Storage," a report by Senior Energy Analyst Jeremy Twitchell and Waterpower Advisor Kyle DeSomber from PNNL, explores how the growth of renewable energy generation will require LDES to fill the gap between variable energy generation and customer demands. The report also describes the barriers in current energy planning and procurement processes that prevent planners from recognizing those needs.

"This isn't something we are going to be able to flex out of like we have in the past," said Twitchell.

"Things like energy efficiency, demand response, and overbuilding generation capacity will all be part of the solution. But when you look at the sheer size of these mismatches between when energy is produced in a decarbonized grid and when it is consumed, we simply can't deploy those things at the required scale," Twitchell added.

The report, published in the *Journal of Energy Storage*, looks at how the amount of variable energy—such as wind and solar—available for the grid is changing, outlines new definitions for long-term energy storage, and uses an illustrative example of California's power needs to demonstrate future shortfalls.

Why does this matter now?

In addition to the non-binding federal goal that all electric generation will be provided from clean energy sources by 2035, many more states have adopted binding or non-binding decarbonization policies—which means a fundamental change in how energy is produced.

For example, 16 states and territories have binding requirements for 100% clean or net-zero energy (12 states at 100% clean energy, four states at net zero), and six states have non-binding goals for 100% clean or net-zero energy (three states at 100% clean energy, and three states at net zero).

Why do variable energy sources and planners need long-duration energy storage?

Variable energy resources are increasingly included as a central component of how grid planners meet customer demand. But variable energy is exactly that—variable. For it to produce energy, the wind needs to blow, or the sun needs to shine. This poses a huge challenge for grid operators that must meet customer demands in real time.

LDES gives electricity a shelf life so grid operators can use it more effectively and for longer terms when taking into consideration changing customer demands, climate, extreme weather events, and seasonal dependencies.

Think of energy storage systems like the battery in your cell phone, which only stays charged for so long despite there being small things that can extend the battery's life. If your phone is not recharged, it will die. The same is true with long-duration energy storage.

Currently, LDES is loosely defined anywhere between 10 to 100 hours. Twitchell and DeSomber propose that industry adopt two classes of LDES: one class, diurnal, lasts up to 20 hours to reconcile daily cycles of

surplus and deficits in generation. The second class, seasonal, reconciles seasonal periods of surplus power generation with seasonal periods of insufficient generation. By thinking of long-duration energy in two different ways, utility and grid planners can look at historical load data and better pinpoint the length of "stop gap" energy that will be needed.

California, we have a mismatch

Using load and generation data from the California Independent System Operator, Twitchell and DeSomber created a model to show energy shortfalls. "Looking at our data in our illustrative example of California, the deficit is 30 gigawatts of capacity in one day—approximately half of California's total generation in one day," said Twitchell. To make up that deficit, the state would need 15 Hoover Dams producing energy over that same period.

As expected, energy consumption is highest during the morning between 5 and 8 a.m. and in the evening after 5 p.m. Throughout the day, solar resources begin producing energy, which helps offset what customers need. Demand is at its highest at 6 p.m., but solar-produced energy begins to dramatically fall from 5 to 8 p.m., which creates a shortfall.

Long-duration energy storage for the future

Binding clean energy targets set in 28 states and Washington, D.C. will require about 34% of electricity consumed in the United States to be from non-emitting resources by 2050, based on those states' share of electricity consumption in 2020. This means that by the year 2050, the amount of non-emitting generation on the grid will need to increase by almost 50%.

Incorporating all that variable generation while keeping the lights on will be a significant undertaking.

"Much of the research that has been done in this space concludes that long-duration energy storage can reduce the costs of operating a fully decarbonized power grid," said Twitchell. "These findings are important, but our paper takes the additional step to explain that long-duration energy storage is not a luxury, but a necessity. This is not an economic paradigm, it's a reliability paradigm."

Others in industry and research are collectively tackling this challenge as well. One of them is Julia Souder, the CEO for the Long Duration Energy Storage Council, a global non-profit that works to accelerate the decarbonization of the world through the acceleration of long-duration energy storage.

"LDES is a necessity to effectively de-risk our clean energy future and PNNL reiterates the critical fact that the clean energy transition is not possible without it," Souder said. "As the market matures, grid planners and operators will benefit from the research here that displays how LDES provides a flexible, resilient, secure, and affordable solution to meet tomorrow's energy grid needs. And, as we look to multi-hour, multi-day, and seasonal energy storage solutions to achieve 24/7 clean energy, the planning and procurement process needs to be much more inclusive to allow LDES to fully participate in the market."

Now is the time to act

Twitchell, DeSomber, and Souder all agree: The time to act is now.

"The motivation for this paper and research was to make the case that LDES will be an absolute necessity in a decarbonized grid," Twitchell said. "If we want it to be available when we need it, then we need to start sending clear market signals that will support research and development of LDES technologies now. These technologies take years to develop, but our energy planning and procurement processes work on short (less

than three-year) cycles. By the time our processes identify LDES needs, there won't be time to develop and deploy them."

More information: Jeremy Twitchell et al, Defining long duration energy storage, *Journal of Energy Storage* (2023). DOI: 10.1016/j.est.2022.105787

Provided by Pacific Northwest National Laboratory