



# Solar energy storage solutions

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Solar panels have one job: They collect sunlight and transform it into electricity. But they can make that energy only when the sun is shining. That's why the ability to store solar energy for later use is important: It helps to keep the balance between electricity generation and demand. Lithium-ion batteries are one way to store this energy--the same batteries that power your phone.

There are many ways to store energy: pumped hydroelectric storage, which stores water and later uses it to generate power; batteries that contain zinc or nickel; and molten-salt thermal storage, which generates heat, to name a few. Some of these systems can store large amounts of energy.

Lithium is a lightweight metal that an electric current can easily pass through. Lithium ions make a battery rechargeable because their chemical reactions are reversible, allowing them to absorb power and discharge it later. Lithium-ion batteries can store a lot of energy, and they hold a charge for longer than other kinds of batteries. The cost of lithium-ion batteries is dropping because more people are buying electric vehicles that depend on them.

Many solar-energy system owners are looking at ways to connect their system to a battery so they can use that energy at night or in the event of a power outage. Simply put, a solar-plus-storage system is a battery system that is charged by a connected solar system, such as a photovoltaic (PV) one.

In an effort to track this trend, researchers at the National Renewable Energy Laboratory (NREL) created a first-of-its-kind benchmark of U.S. utility-scale solar-plus-storage systems. To determine the cost of a solar-plus-storage system for this study, the researchers used a 100 megawatt (MW) PV system combined with a 60 MW lithium-ion battery that had 4 hours of storage (240 megawatt-hours). A 100 MW PV system is large, or utility-scale, and would be mounted on the ground instead of on a rooftop.

A megawatt-hour (MWh) is the unit used to describe the amount of energy a battery can store. Take, for instance, a 240 MWh lithium-ion battery with a maximum capacity of 60 MW. Now imagine the battery is a lake storing water that can be released to create electricity. A 60 MW system with 4 hours of storage could work in a number of ways:

So you can get a lot of power in a short time or less power over a longer time. A 240 MWh battery could power 30 MW over 8 hours, but depending on its MW capacity, it may not be able to get 60 MW of power instantly. That is why a storage system is referred to by both the capacity and the storage time (e.g., a 60 MW battery with 4 hours of storage) or--less ideal--by the MWh size (e.g., 240 MWh).

A standalone 60 MW storage system will decrease in cost per megawatt-hour (MWh) as duration increases. Meaning, the longer your storage lasts, the lower the cost per MWh. That's because the cost of inverters and

other hardware account for more of the system's costs over a shorter period.

Putting a PV system and a storage system in the same place, known as co-location, enables the two systems to share some hardware components, which can lower costs. Co-location can also reduce costs related to site preparation, land acquisition, labor for installation, permitting, interconnection, and developer overhead and profit.

When PV and battery storage are co-located, they can be connected by either a DC-coupled or an AC-coupled configuration. DC, or direct current, is what batteries use to store energy and how PV panels generate electricity. AC, or alternating current, is what the grid and appliances use. A DC-coupled system needs a bidirectional inverter to connect battery storage directly to the PV array, while an AC-coupled system needs a bidirectional inverter and a PV inverter. Various factors figure into the choice of system, and it's up to the owner to decide which would work best.

When choosing between DC and AC, the technical factors that affect the system's performance must be considered, as well as costs. The cost of the co-located, DC-coupled system is 8% lower than the cost of the system with PV and storage sited separately, and the cost of the co-located, AC-coupled system is 7% lower. NREL's new cost model can be used to assess the costs of utility-scale solar-plus-storage systems and help guide future research and development to reduce costs.

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