



Best way to store solar energy

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Renewable-energy storage is important to help humanity reduce its dependence on fossil fuels such as oil and coal, which produce carbon dioxide and other greenhouse gases that cause climate change.

Harnessing the power of the sun with solar panels and utilizing wind power with wind turbines are two common ways to generate renewable energy. But the sun isn't always shining and the wind isn't always blowing when we want electricity, and sometimes they produce surplus energy when demand is low.

To reduce the impact of inconsistent energy generation from renewable sources, scientists and engineers are developing ways to store excess energy for use when it's needed. There are many different ways energy can be stored, and new storage techniques are being developed and refined all the time. Here are some of the best and most promising methods for storing renewable energy.

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Batteries are probably the most familiar method of storing energy. Humans use batteries in all sorts of electrical devices, from smartphones to cars. The most popular batteries are lithium-ion batteries, which are used in small devices and also make up more than 90% of battery storage on the global electricity grid, according to the Environmental and Energy Study Institute in Washington, D.C., a non-profit organization that promotes sustainable energy.

The negative end of a battery is connected to an electrode called the anode and the positive end is connected to another electrode called the cathode. Electrolyte, a liquid substance of electrically charged ions inside the battery, combines with the material of the electrodes to produce a chemical reaction that generates an electrical current. In lithium-ion batteries, the anode and cathode store lithium, according to the U.S. Department of Energy. The electrolyte carries positively charged lithium-ions from the anode to the cathode to power something and vice versa when the battery is charged, which can be done using renewable energy.

Lithium-ion batteries have some disadvantages. For example, they become less efficient and more likely to fail over time, according to the Clean Energy Institute at the University of Washington. They are also expensive to produce on a large scale, and extracting the raw materials needed to make them has a negative environmental impact. Like most other energy-storage methods, batteries don't retain all the energy that is put in them; they have an efficiency of 85% to 95%, according to a 2020 report by the World Energy Council, a network of energy leaders promoting sustainable energy.

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Pumped hydro energy storage, or pumped storage hydropower, uses two water reservoirs to store electricity.

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Excess energy is used to pump water from a lower reservoir to a higher reservoir. Then, when the electricity is needed, water in the higher reservoir is released to flow back down to the lower reservoir through turbines that generate electricity, according to a 2021 review of pumped hydro energy storage published in the journal *Progress in Energy*. Not all of the energy used to pump the water up is regained when it is released; hydro energy storage has an efficiency of about 75% to 85%, according to the 2020 World Energy Council report.

The largest pumped hydroelectric storage facility in the world is in Virginia and serves power to about 750,000 homes, according to the Environmental and Energy Study Institute. Pumped hydro energy storage systems are typically built into, or near, rivers alongside the production of hydroelectric energy. However, they can also be used using seawater from oceans. A pumped hydro energy storage system on Okinawa Island, Japan, pulls seawater out of the ocean and up a hill through a pipeline. The system then releases the water back down through the pipe to power turbines and generate electricity, according to the University of Strathclyde in Scotland.

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Pumped thermal electricity storage involves using electricity generated from renewable sources to heat gravel or another heat-retaining material inside an insulated tank. This heat can then be used to generate electricity when needed, according to a 2020 article in *The Conversation* by Antoine Koen, a doctoral candidate in pumped thermal energy storage, and Pau Farres Antunez, a researcher in energy storage, both at the University of Cambridge in England.

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