BLOG

Charging up – An intro to energy storage

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Saturday evening on the edge of a great night, your energy can seem limitless. But come Monday morning, you're exhausted, and not even coffee will do the trick. If only you could save a some of that Friday night energy and store it for Monday morning.

I can't save personal energy and use it later when I need a jolt, but energy storage is real. It's especially compelling right now because it can play a big role in making cities and towns more resilient to weather-related events, and resiliency is getting a lot of attention, and funding. Energy storage placed near buildings can provide backup power during an outage. Energy storage by a utility can provide a bump of energy to the grid during peak use times. The Department of Energy emphasized the importance of energy storage for the "future grid" in a 2013 report on grid energy storage, also highlighting the heightened security these technologies could provide against cyber and physical vulnerabilities.

A Google search turns up a wide array of innovation around energy storage. But it helps to understand the basic mechanisms of energy storage first. Here is a quick primer on some of the most common forms of energy storage with some links at the end for more information.

What energy storage looks like

There are a number of ways to think about energy storage. The Energy Storage Association offers a simple way of breaking the field down. They identify four primary energy storage mechanisms: electrical, mechanical, thermal, and chemical storage.

Electrical energy storage

With electrical storage, energy is stored electrostatically, as in a capacitor. Like a battery, a capacitor stores an electrical charge, but while a battery's energy is released slowly, a capacitor releases its charge very quickly (think of a flash on a camera). Supercapacitors or ultracapacitors have capacitance values that are exponentially higher than a regular capacitor. All these capacitors have a long life, and they can be charged and discharged many times. They can also be produced in a range of sizes. Smaller capacitors are used in handheld electronic devices, while supercapacitors are ideal for city buses and electric cars.

Supercapacitors are attracting a fair amount of attention these days. Creative research into supercapacitor development has pushed stories about using cigarette butts and hemp for capacitors into the news. Tesla CEO Elon Musk has commented on their potential. But supercapacitors are more than a flash in the pan. They offer real potential for infrastructure use. For example, the Long Island Rail Road in New York and the Southeastern Pennsylvania Transit Authority are actively testing their ability to store energy produced by the trains, such as when they brake, in supercapacitors to increase train efficiency and provide back up when their electric load is high. The supercapacitors can also ramp up to full power much faster than a power plant can, and in Pennsylvania, they are generating revenue for the City of Philadelphia.

Mechanical energy storage

Mechanical energy storage uses the position of something to store energy. Pumped hydropower is a great example, used in the US and abroad for the greater part of the last century. Pumped hydropower involves pumping water to an upper reservoir during off-peak times and storing it at an elevated location, like behind a dam. During peak times of electricity demand, this stored water is released downhill through turbines to generate energy. The position of the water – elevated – is what makes energy storage possible. When the water is released, gravity pulls it downhill, allowing energy generation. Other examples of mechanical energy storage include compressed air and flywheels.

Pumped hydropower has been an especially controversial energy resource for many years, in part because of its potential to disrupt not only the environment in which it is implemented, but also environments downstream as well (think of the controversy about big dams). But given hydropower's affordability and reliability, many are working to make it a more sustainable option. For example, a recent hydropower project in Ontario involved aboriginal communities, a municipality, and a private developer and provides a new model for realizing this kind of energy storage. The project both recognizes the importance of ecological sustainability and treats all stakeholders as equal partners. Another example is New York. The fourth-largest hydropower producer in the U.S., the state just announced plans to build a new 14 MW hydroelectric facility at the city's Cannonsville Reservoir with in-stream hydrokinetic systems that use turbines to capture the energy of the water as it's released from the reservoir.

Thermal energy storage

Thermal energy storage is the temporary storage of heat or cold for later use. This energy can be used to supply electricity during peak demand, or as an independent cooling system or a supplement to such a system, to help reduce electricity demand when it's particularly hot. Two thermal energy storage technologies, molten salt and ice-based storage systems, are gaining visibility as viable options for storing energy for the grid.

Solar power plants produce energy throughout the day when the sun is shining. Any leftover energy produced can be stored in other materials, like molten salts. Molten salts are a solid that can reach a liquid state at a higher temperature. Excess energy can be stored in these molten salts, an effective heat retainer, and used later for electricity. A solar power plant in Arizona uses this application: at night, after the molten salts are turned into liquid (from the sun's warmth throughout the day) they're pumped out as steam through a generator. This steam can then power a turbine and produce electricity when it's needed.

Ice-based cooling is another common application of thermal energy storage. With ice-based cooling, a large-quantity of ice is made overnight during off-peak hours when energy is less expensive. Then during the day, when cooling is needed, the ice is allowed to melt and the cold air around it is distributed with a fan or pumping system. Ice-based storage can be a cost effective cooling strategy; a school district in Florida can attest to that. They were able to save about $5 million dollars by installing ice storage tanks in 15 of their schools.

Chemical energy storage

Chemical energy storage stores energy in the bonds of chemical compounds. Energy is released when those bonds are broken. Batteries are the most common example of chemical energy storage, but they have come a long way from the AA battery you put in your flashlight. With batteries integrated into high-profile microgrids like the one at Alcatraz, they have gained significant traction as an important tool for resiliency planning – and they're gaining momentum in the solar PV market as well. Another notable integration of battery storage for the grid is via electric vehicles. The Pecan Street Project in Austin, Texas, is a large-scale EV/solar/smart grid integration project that connects electric vehicles to the grid.

But batteries still have a ways to go. Batteries come in a range of sizes and can be pretty large, but even the grid-based batteries aren't as large as you might expect. Earlier this year, Forbes profiled large batteries and called out the world's largest battery in the city of Sendai in Japan. That battery is designed to provide 40 MW of electricity for about half an hour. Put another way, it could power 32,000 homes, but for about 30 minutes. But with interest by companies like Tesla to develop commercial battery storage options for businesses and homeowners, battery prospects should continue to improve.

Learn more

Given all of the various developments around energy storage these days, there is no shortage of reading material. If you're interested, we invite you to visit this sample of sites to read more about energy storage technologies and projects.

Energy Storage Association – an industry organization and resource

Department of Energy's Global Energy Storage Database – the DOE's database on grid-connected energy storage projects

Smart Grid News: Storage – news on emerging technologies

Energy Storage Technologies Primer – from *Power* magazine

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