

Cleaner Energy and a Box To Store It In

While it's been known for a long time that the need to store the energy generated by renewable power – for times when the sun doesn't shine and the wind doesn't blow – is at least as urgent as the need to generate clean energy, it takes a perfect storm (pardon the pun) of events to bring the storage issue to the forefront of the media and public consciousness.

The first event is two catastrophic losses of electric utilities across a wide swathe of the country for the second time in two months. During the days that followed this summer's Hurricane Irene, which swept inland over much of the northeast from the Atlantic Ocean in late August, about four million American homes and businesses were without electricity, many for the better part of a week. Not quite two months later, a freak late-October nor'easter snowstorm left nearly three million Americans from Maryland to Maine without power for days, with some areas experiencing outages over a week in duration. As frustrations mounted and utilities failed to meet expectations for the second time in two months, the topic of personal, renewable energy – and the ability to store it – crept into more peoples' dinner table talk.

The second event is the bankruptcy reorganization of Tyngsboro, Massachusetts-based [Beacon Power](#), which provides utility frequency regulation – the flow management and storage of electricity. The company generated buzz when it filed for Chapter 11 bankruptcy on October 30 after having received a \$43 million loan guarantee from the federal government (from the same fund as failing California solar company Solyndra) as well as funds from the State of Massachusetts. Critics of renewable energy put it onto the political parade float along with Solyndra, which collapsed recently after an infusion of millions in federal loan guarantees.

What many people are missing here is that Beacon Power, with its first grid-scale plant that began operation in January of 2011, isn't necessarily only about renewable energy, and waving the "Renewable Energy is For Crunchy Hippies With No Jobs" flag overshoots the point by miles. Its technologies were developed to solve an important problem in modern power grids and a major goal of a nationwide "smart grid."

Storage solutions aren't only about renewable energy. Storage technologies are required even on a power grid that runs on traditional (read: fossil fuel-generated) energy. Storage and frequency regulation providers help stabilize the flow of energy through the electric grid, which helps keep prices down for energy consumers. According to the [Electricity Storage Association](#) (ESA), "Energy storage provides a resource-neutral ability to use energy when we need it at the price we want it. As we add electric vehicles, renewable energy, and other systems that affect the dynamics of our electric grid, we will need the flexibility, reliability, efficiency and security that energy storage solutions provide."

"Energy when we need it" is the key here. Even in a large utility that runs on coal, for example, spikes in electricity requirements are hard to meet quickly (some have likened the problem to trying to turn the Titanic in time to avoid the iceberg). These high peak load demands are typically met by bringing dirty, low-efficiency plants online, which costs more and skyrockets utility emissions. Better technology for storing excess energy would not only benefit the renewable energy industry, increasing its efficiency, reliability and practicality, but would also help traditional energy generators meet their peak load needs with cleaner solutions that would provide necessary surges faster than with traditional methods.

One big roadblock to the development of energy regulation and storage technologies has been the lack of standards regarding how to properly compensate the companies that have developed and are now operating these advanced storage and regulation technologies: many industry insiders blame the bankruptcy of Beacon Power to instabilities in the way the company has been compensated for its services. In early November, shortly after Beacon Power filed for Chapter 11, the [Federal Energy Regulatory Commission](#) (FERC) approved a new rule that will provide incentive payments to companies like Beacon that manage the energy moving through the grid. The new legislation will effectively change the way utilities who operate the power grid pay companies like Beacon that provide frequency regulation to help make sure electricity flows through the grid efficiently at a constant frequency of 60 hertz.

While the FERC ruling wasn't specifically crafted to rescue Beacon – the ruling was first proposed back in February – it may result in doing just that once it goes into full effect, since it ultimately may double Beacon's revenue, boost its share price and inviting new sources of capital to come forward.

FERC spokesman Craig Cano told [Bloomberg](#), "It's an industry-wide final rule addressing compensation for any provider."

The FERC ruling will benefit more than just Beacon, however. It will benefit a host of companies using technologies both old-fashioned and cutting-edge that regulate and store energy. And as these technologies are developed and refined, they will also benefit the renewable energy industry, allowing nationwide energy providers, municipal organizations and even individuals to make better use of clean energy sources. Some of the most prominent energy regulation and storage technologies include the following:

Flywheels

A flywheel is a rather old-fashioned mechanical device that can be used to store rotational energy (it's the primary means by which Beacon Power

regulates grid energy). In the simplest terms, it's a device that uses excess energy to wind up, and remains locked in place until the energy it contains is needed, at which time it's allowed to (or induced to) unwind, releasing the power it has been storing in the form of kinetic energy. As the flywheel unwinds, it can be used to generate electricity.

It's hardly a new concept: the basics of the flywheel can be traced back to the dim origins of human history in form of pottery wheels or spindles for spinning raw textile fabric into thread and yarn.

Modern flywheels are used in many manufacturing processes when a machine requires more energy for short bursts than the standard electrical supply can provide: the flywheels collect energy over a period of lower power demand, and when the machine needs a surge in power, the energy released from the flywheel provides that extra energy "punch" the machine's engine cannot quite meet alone.



Some of Beacon Power's flywheels.

A modern flywheel energy storage (FES) system is made up of a rotor suspended by bearings (often magnetic) inside a vacuum chamber – this helps reduce friction, allowing for faster rotation – and ultimately connected to an electrical system that includes both a motor (to wind up the flywheel when excess power is available) and an electrical generator (to turn the rotational energy back in electricity when more power is needed).

Thermal energy storage

Thermal energy, of course, is heat and cold, and thermal energy storage is hardly new. If you'd been alive two hundred years ago, you might have found yourself heating up bricks in your fireplace at night, then wrapping them in flannel and depositing them at the bottom of your bed so the bricks would slowly release their stored heat overnight, keeping you toasty at least partway through the night.

The same principles apply today, albeit via more high-tech methods. Thermal heat storage is an important technique for stockpiling excess energy generated by solar panels. In some cases, solar energy is used to heat water to the boiling point in highly insulated containers in a building, and the hot water is later circulated through the building to produce heat when needed. Some solar systems can be adapted so the heat collected is pumped into the soil adjoining a building, warming it and keeping it warm so that when extra heat is needed, it can be drawn back into the building.

Another technique involves using solar energy to heat a salt solution of sodium nitrate and potassium nitrate (salt peter) to very high temperatures (the salt can be pumped through solar panels to collect the heat), after which it's stored in a highly insulated tank, reaching temperatures of 550 degrees Fahrenheit and staying hot for up to a week. When excess energy is required, the super-hot salt solution can be sent to a traditional steam generator that can drive a turbine to produce electricity.

Excess heat can also be stored in solar ponds. The sun's heat (without the help of solar panels) warms a pond full of water containing three different layers of salinity (the salt content increases with the water's depth). This traps the sun's heat at the bottom of the pond, since the hotter, saltier water at the bottom can't rise and convect since it's heavier than the water in the layers above it. An industrial site with a gradient solar pond like this could store and then tap this hot water as energy by pumping it from the bottom of the pond into a heat exchanger or an evaporator, removing the heat and turning it into power.

On the flip side, renewable energy, when it's plentiful (or traditional energy produced during cheaper, cleaner nighttime generation hours) can also be used to make ice that can be stored in the house for natural, clean cooling during summer air conditioning season, at peak daylight hours or in hot climates.

Compressed air energy storage

During times of plentiful energy, air can be compressed and stored in large underground reservoirs. When peak energy is required (or the sun stops shining and the wind stops blowing), the air can be released from the underground reservoirs and heated, then converted to energy with the help of turbines.

Pumped hydroelectric energy

One of the simplest methods of storing energy involves water: the water is pumped to a high reservoir when power is available or cheap and clean, and it is stored there until power is needed, at which time it's released and, thanks to gravity, it moves to a lower reservoir while at the same time driving a turbine and creating electricity.

Batteries

While renewable energy fights for its reputation, investment funds and public acceptance, companies that specialize in advancing battery storage technologies seem to move quietly onward, getting ready for their close-up. The mantra behind these developing battery technologies is more power and storage capacity in smaller-sized batteries: some companies have attained the kind of storage capacity as the battery in an electric car or a golf cart set inside batteries closer to the size of those that power portable electronic devices. Another need driving the battery industry is for cleaner batteries: the irony of generating clean, zero emissions power from solar panels or wind turbines and then putting into dirty, toxic, lead-acid batteries is lost on no one.

While companies perfecting battery technology to store renewable energy or cheaper, cleaner off-peak energy have moved toward ion-lithium batteries, which are cleaner, smaller and more efficient, battery technology has also pushed in other directions.

Researchers are also toying with newer batteries based on something called redox flow technology. These flow batteries operate in a way similar to fuel cells, though they differ in that they store their fuel within the battery system instead of taking it from an external source, as a fuel cell does. In a flow battery, an electrolyte flows through an electrochemical cell, converting chemical energy into electricity – like a fuel cell. The electrolyte is stored in external tanks and either pumped mechanically or allowed to flow naturally thanks to gravity into the batteries' cells or reactor to produce power. The system then recovers and recharges the spent electrolyte so it can be used again.

Hydrogen storage

While hydrogen fuel cells are clean, they suffer from one enormous drawback: the production of hydrogen is still an energy-intensive process and often requires energy from "dirty" sources to hydrolyze water and create the hydrogen. In green energy terms, hydrogen can be produced during times of excess capacity from renewable energy sources such as wind and solar. When the excess capacity ceases and the energy is required, the hydrogen can then be used to power hydrogen fuel cells.

Another advancement in hydrogen-related storage includes the use of metal hydride storage technologies, which involves using an alkaline fuel cell that is able to chemically bond with hydrogen, storing it within the cell until its energy is needed. While this method is still in the laboratory – researchers have yet to make it affordable and efficient enough to operate on a large scale – it has advantages over traditional hydrogen fuel cells, including a longer shelf life, a faster start-up and operation for longer periods without the need to swap out external hydrogen fuel sources.

So while the nation tries to march toward an ever "smarter" power grid, the important job of regulating and moderating the flow of electricity through the grid has fallen onto the shoulders of companies like Beacon Power – who are begrudged their government and state investment cash by many. If we could put electricity into a box and keep it for later, we'd have few problems. But as our energy needs rise alongside our need to keep power generation cleaner and more efficient, the furthering of these technologies is in everyone's best interest. In the end, they may just solve many of the nation's energy problems.