Batteries, Cryogenics, and Renewable Energy: An Overview of the Lenfest Center for Sustainable Energy's 2012 Energy Storage Symposium

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How does that Energizer Bunny do it? He's been cruising along and beating his drum for years of Energizer television commercials, powered by what appears to be the same battery. Of course, the answer is he doesn't do it, it's a commercial, and (spoiler alert) the Energizer Bunny isn't real. But he does represent the ultimate goal of energy storage: energy efficiently stored in a compact system that allows for long-term use. If and when the loftiest goals of energy storage are reached, an electric car will be able to drive 5,000 miles without a recharge and every watt of electricity that is generated by power plants and not immediately used will be stashed away until it is needed.

It was the pursuit of those goals that brought together presenters and attendees at the Lenfest Center for Sustainable Energy's 2012 Energy Storage Symposium on May 2 and 3. Sponsored by Columbia's Earth Institute and co-organized by the Lenfest Center and the Technical University of Denmark's (DTU) Department of Energy Conversion and Storage, the symposium brought together experts on energy storage from the scientific and engineering sector as well as from the energy market and public utility sectors. The presentations and discussions at the conference focused on specific storage technologies but also covered the current market and regulatory trends affecting the storage industry.

Why would the Lenfest Center devote two days to sharing ideas on energy storage? Put simply, renewable energy needs energy storage. Take the two most promising and widely used sources of renewable energy: wind and solar power. These energy sources are unpredictable—no one knows for sure when it will be windy or sunny, which means if you depend on solar power and want to run the washing machine after dark, you're out of luck. That's where energy storage comes in; with it, all the electricity generated by solar power in the afternoon that is not immediately consumed can be set aside to run the washing machine in the evening. There are a number of technologies that can currently store energy from renewable sources, but they will need to be expanded, improved upon, and supplemented with new technologies before the world can make a large-scale shift toward renewable energy.

<u>A Sampling of Storage Technologies</u>

The simplest and currently most effective method of energy storage is pumped hydro storage (PHS), used at many of the world's hydroelectric plants. In PHS systems, surplus power is used to pump water against gravity and deposit it in the hydro plant's upper reservoir, and when demand for electricity increases, flood gates are opened to allow that pumped water to increase the downward flow rate and increase generation. Anyone interested in seeing PHS in action should visit the Niagra Falls hydro facility and visitors' center, offered Guy Sliker of the New York Power Authority. PHS can also be used in combination other types of power plants, including wind and nuclear facilities. As explained at the symposium by Dr. Mogens Mogensen of DTU, such combinations are common in Europe, and PHS offers a relatively high efficiency of 65 to 80 percent. However, movement to renewable energy on a global scale requires other storage technologies that can be used at facilities without hydroelectric resources.

Batteries, the most prolific sources of stored energy, offer promising storage applications as well (besides powering drum-beating bunnies). Several presenters at the symposium

shared their work on battery technologies with an eye on storing power from the electrical grid or other stationary sources. Dr. Jay Whitacre of Carnegie-Mellon University described the progress in his battery research, which is supported by the University-founded Aquion Energy. Dr. Whitacre plans to scale up the technologies that have proven effective in preliminary tests to sizes compatible with electrical grids by 2013 or 2014. Dr. Sanjoy Banerjee, Director of the City University of New York's Energy Institute, presented work from his pursuit of "the immortal battery." Dr. Banerjee has refined methods for breaking up the snowflake-shaped dendrites that form inside batteries and cause their expiration. Pursuing similar goals through different methods, both presenters emphasized that the technologies that they have designed and tested utilize environmentally benign materials whenever possible.

Tim Fox, IMechE

A third energy storage option that is compelling in its simplicity is compressed air storage. In this model, surplus electricity is used to compress air and force it into storage in underground caverns. When electricity demand spikes, the air is released in a controlled manner that spins a turbine, generating supplemental electricity to meet demand. Dr. Mogensen noted that compressed air storage has been used at a large scale and offers 70 percent efficiency. Presenter Tim Fox of the U.K.'s Institution of Mechanical Engineers shared an interesting offshoot of compressed air storage: cryogenic electricity storage. In a process adapted from the air separation industry, ambient air is compressed through a series of temperature and pressure changes and then stored as liquid nitrogen at extremely low temperature (cryogenics is the study of elements at temperatures below -150 degrees Celsius or -238 degrees Fahrenheit). When power demand climbs, the liquid is heated and rotates turbines as it expands into a gas, generating electricity. Mr. Fox highlighted cryogenic storage's reliability, geographic flexibility, high storage capacity (second only to that of PHS), and ability to pair with factories and other industrial facilities that produce waste heat. Cryogenic storage pilot facilities been proven viable in small and medium-scale tests, and hold promise for wide use across the U.K., Mr. Fox said.

The Future of Energy Storage and Renewable Energy

As the numerous presentations of promising energy storage systems made clear, storage technologies are evolving with unprecedented speed and a diverse combination of technologies will undoubtedly be a key component in a low-carbon future. But what needs to happen to bring those technologies to the mainstream and fit them into existing electrical generation and distribution networks?


From left: Mark Torpey, NYSERDA; Guy Sliker, NYPA; John Bøgild Hansen, Haldor Topsøe A/S; Aubrey Braz, ConEdison

In the U.S., the environmental externalities of electrical generation from fossil fuels must be built into energy prices, said Mark Torpey, Director of Research and Development at the New York State Energy Research and Development Authority. The logical extension of Mr. Torpey's argument being that the costs of nonrenewable energy generation (the negative health effects of coal power plant emissions,

for example) must be integrated into electricity prices to make renewable energy more cost-competitive. Mr. Sliker added that, because storage is essential to the large-scale success of renewables, government support for the research and development of renewable technology should extend to storage technology as well.

A view shared by many of the symposium's participants is that we have only scratched the surface in terms of understanding the potential of energy storage technologies. In addition to the crucial support they provide to renewable energy sources, they offer many, some currently unknown, ancillary benefits. One such benefit is storage technologies' potential to reduce the need for more electrical generating facilities. By combining storage with existing facilities and grid systems, Mr. Fox observed, plant operators can improve their return on investment by "sweating" more electricity out of existing plants, and the resulting boost in electricity supply could preempt the construction of new carbon-emitting sources. In the same way, improved efficiency through storage could render complex and expensive electrical grid upgrades unnecessary.

In his closing remarks, Klaus Lackner, Director of the Lenfest Center and host of the event, stated plainly the future of energy storage is "as clear as mud." Despite uncertainty, Dr. Lackner was optimistic about what the future held for storage and its application to renewable energy "We're moving in the right direction," he said, pointing to recent major advancements in battery life and lower battery costs as examples. In contrast, Lackner is more fatalistic about the future of policy changes that might enable the application of these technologies. "Eventually, climate change will hurt," he said, "then we'll do something about it." Offering an outsider's perspective on the issue, John Hansen of Haldor Topsøe paraphrased a quote from Winston Churchill: "You can always count on America to do the right thing...after they've tried everything else."

Whenever the U.S. finally chooses to "do the right thing" and fully embrace renewable energy sources, energy storage will play a vital role in the historic shift. It's a good bet that the people and ideas present at the Energy Storage Symposium will have a hand in America's renewable energy transformation.

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For details on the symposium or the Lenfest Center, visit www.energy.columbia.edu.