July 26, 2013

Clean Energy Breakthroughs: Grid-Scale Energy Storage

Bicameral Task Force on Climate Change

Co-Chairs Rep. Henry A. Waxman, Sen. Sheldon Whitehouse, Rep. Bobby L. Rush, Sen. Edward J. Markey, Rep. Earl Blumenauer, and Sen. Ben Cardin

About the Series

The Bicameral Task Force on Climate Change is issuing a series of fact sheets examining emerging energy technologies that could play a significant role in the clean energy economy of the future. The transition to a clean energy economy presents technical challenges for which scientists and researchers across the country and around the world are developing solutions. Each fact sheet in the Clean Energy Breakthroughs series will examine a technical challenge, describe the opportunities it presents, and highlight new technologies that are being developed to address the challenge. Some of the profiled technologies will ultimately succeed in the commercial market while others may not.

This Clean Energy Breakthrough is the second to examine the progress being made on grid-scale energy storage.

The Challenge

As described in the first fact sheet on grid-scale storage, today's electric grid has a limited ability to store energy. Flexible, affordable, large-scale energy storage would allow excess energy from variable resources to be stored until that energy is needed. This would further enable the widespread deployment of wind and solar generation, substantially reducing carbon emissions from the electric sector while boosting clean energy manufacturing and jobs in the United States.

The Technologies

General Compression's Compressed-Air Energy Storage

A company called General Compression has developed a system that stores excess electricity in compressed air in salt caverns or pressurized storage tanks. When electricity is needed, the process is reversed and electricity is produced by expanding the compressed air. Salt caverns, which also are used to store natural gas, are well-suited for storing the pressurized air.

With conventional air compression technologies, the air heats up during compression and cools down during expansion. This means that some of the energy is lost as waste heat during compression and equipment can freeze during expansion. Typically, natural gas is burned to warm the cold air during expansion, which reduces the efficiency of the process and releases carbon pollution. Unlike traditional air compression technologies, General Compression's technology does not burn natural gas to convert the stored high-pressure air back into electricity. To avoid heating the air during compression, the General Compression technology channels that heat into warming water, where the heat is stored until it is used to warm the compressed air during expansion. The General Compression technology has 70% round-trip efficiency, meaning that 70% of the stored electricity can later be released as usable electricity. Conventional air compression storage technologies can experience efficiency losses of up to 50%.

General Compression has successfully demonstrated the technology, which has several potential applications. In early 2011, a 100 kilowatt unit was commissioned in Watertown, Massachusetts.

In December 2012, the company partnered with ConocoPhillips to deploy a two-megawatt demonstration project in Gaines, Texas. The system can firm the intermittent generation from an attached two-megawatt wind turbine by storing excess renewable electricity during periods of low demand and releasing the energy to the electric grid during periods of high demand. The system is capable of storing 250 hours of the full output of the two-megawatt turbine.

General Commission plans to offer modular, five to six megawatt commercial systems with the first such system coming online in two and a half years. The company has raised $100 million in capital since 2006. One investor is Duke Energy, which is interested in how the energy storage system could open new markets for its wind projects and allow non-intermittent, nuclear generation to store energy at night when demand is low and sell it during times of peak demand. Similarly, the system could effectively raise the capacity factor of transmission lines by storing power delivered during the night rather than adding to transmission congestion during the day. Energy from the storage system also can be dispatched quickly; the system can switch from full compression to full expansion in seconds.

CUNY Energy Institute/Urban Electric Power Rechargeable Zinc Battery

The City University of New York (CUNY) Energy Institute is developing low-cost, rechargeable zinc batteries. The Institute and a spin-off company called Urban Electric Power are pursuing two technologies: a zinc-nickel oxide battery, which will be available in a commercial prototype this summer, and a zinc-manganese dioxide battery, which has the potential to be much cheaper. Like traditional zinc alkaline consumer batteries, these batteries are made from abundant, low-cost materials. Unlike traditional consumer batteries, they are long-lasting and rechargeable.

The main obstacle to rechargeable zinc batteries has been degradation of battery performance due to the formation of dendrites. When a zinc battery is charged, zinc metal is formed. When it is discharged, a zinc oxide powder is formed. After cycles of charging and discharging, the zinc electrode is not uniformly reconstituted and hard metal fingers called dendrites form. These dendrites reduce battery performance and eventually short out the battery. The CUNY Energy Institute technology controls dendrite formation over thousands of cycles by (1) circulating the electrolyte within the battery in order to make zinc concentrations uniform and/or (2) tailoring the charging protocol. The zinc-manganese battery has been successfully tested through more than 2,000 recharge cycles. The goal is for the battery to last for 5,000 recharge cycles so that it could operate for about 15 years. The developers expect the zinc-manganese version of the battery to cost less than $100 per kilowatt hour, which would be cost competitive with traditional pumped hydro storage, while being much more flexible.

Urban Electric Power will be demonstrating a 200 kilowatt hour, flow-assisted zinc-nickel commercial prototype this summer. With support from Con Edison and the New York State Energy Research and Development Authority, the prototype battery will be used in a peak shaving project that will reduce a CUNY building's peak demand by 20% with a payback period of four to five years. These 200 kilowatt hour modules also can be stacked together at substations to defer construction of new transmission lines. The company is developing 50 kilowatt hour modules of the less expensive zinc-manganese dioxide batteries, which can be used to firm the power supplied from intermittent solar and wind energy sources. Urban Electric Power expects to offer the rechargeable zinc-manganese battery to customers in 2014.

The Potential

Energy storage technologies like General Compression's compressed-air energy storage and the CUNY/Urban Electric Power flow-assisted rechargeable zinc batteries have multiple potential applications. In addition to supporting intermittent renewable energy, assisting during peak demand, and easing the need for new transmission lines, energy storage technologies can increase the reliability of the electric grid and reduce the frequency of power interruptions, which cost consumers approximately $80 billion a year.[1]

The market potential for cost-effective energy storage technologies is huge. Sandia National Laboratories has calculated the potential U.S. market demand for energy storage for just one application – storing excess renewable energy - to be more than 36,000 megawatts over ten years.[2] The worldwide market for grid-scale energy storage is expected to exceed $30 billion per year by 2022.[3]

---

[1] U.S. Department of Energy, *Electric Power Industry Needs for Grid-Scale Storage Applications* (Dec. 2010).

[2] Sandia National Laboratories, *Energy Storage for the Electricity Grid: Benefits and Market Potential Assessment Guide* (Feb. 2010).

[3] *Energy Storage on the Grid Will Surpass $30 Billion in Annual Market Value by 2022, Forecasts Pike Research,* Business Wire (Oct. 24, 2012).