Researchers building flow battery prototype to augment grid

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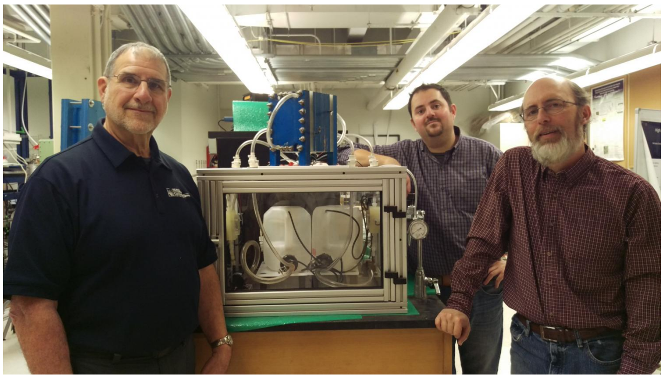

From left-to-right, researchers Bob Savinell, Nick Sinclair and Jesse Wainright, with a 100-watt version of their iron-flow battery. The engineers are scaling up the technology and plan to begin testing a 1-kilowatt prototype within a year. Credit: Bob Savinell

Researchers at Case Western Reserve University are scaling up a prototype iron-flow battery to provide cleaner and cheaper power when renewable energy sources are ebbing or demand is peaking. The battery would also efficiently store excess electricity when use is low.

The engineers received $1.17 million in federal funding and have begun building a 1-kilowatt prototype to provide enough power to run a small window air conditioner, big screen LCD TV, Xbox 360 gaming system and a lamp with a 100-watt incandescent bulb for six hours.

The grant brings the total U.S. Department of Energy's Advanced Research Projects Agency-Energy, or ARPA-E, funding to nearly $3.25 million for this project over the last five years.

"Intermittent energy sources, such as solar and wind, combined with traditional sources of coal and nuclear power, are powering the grid. To meet peak demand, we often use less-efficient coal or gas-powered turbines," said Bob Savinell, distinguished university professor and professor of chemical engineering at Case Western Reserve and co-leader of the flow battery project.

"But if we can store excess energy and make it available at peak use," he said, "we can increase the overall efficiency and decrease the amount of carbon dioxide emitted and lower the cost of electricity."

The biggest challenge to using a battery or other electrochemical device is cost, so Savinell and Jesse Wainright, research professor of chemical engineering, have been developing batteries based on iron, water and other inexpensive materials.

The flow batteries are also safer to operate than lithium ion batteries or others made with exotic, costly and toxic ingredients.

How flow batteries work

In standard batteries, power and energy densities are limited by wrapping all the materials used to convert chemical energy to electrical energy inside a single cell. The batteries wear out as the electrodes, which are part of the fuel, are consumed over time.

In flow batteries, chemical reactants used to produce electrical energy are stored in two tanks, and the electrodes—which are not used as fuel—are housed in a separate chamber. Reactants are pumped through the cell stack, delivering electrons in one direction to charge the battery and to discharge the system in the other.

Flow batteries can be built to produce or store a range of power, by increasing or decreasing the cells in the stack and size of reactant tanks.

The batteries can also be placed in neighborhoods, hospitals or most anywhere. Other energy storage methods are limited by geography. For example, pumped hydroelectric requires elevation changes, and compressed air storage needs caverns.

The prototype

The prototype includes a stack of 10 cells in a battery and is expected to be about the size of a desktop printer tied to two tanks containing a total of 45 gallons of mild electrolyte.

Savinell and Wainright have replaced the conventional solid electrode in the negative half of the battery cell with a slurry of flowing electrically conducting carbon particles that can be used to help convert chemical energy to electrical, and vice-versa. As much slurry as needed can be pumped through the negative chamber and stored in a separate tank. The volume stored determines energy storage capacity, independent of the power density.

"This technology has the potential to be very low-cost, very robust and environmentally benign," Savinell said. Unlike the acid in a typical car battery, the electrolyte in the flow battery is only moderately acidic. "If the tanks leak, it's not a catastrophe, and if you fall in a tank, you won't get hurt," he said.

Nick Sinclair, a research engineer and part-time PhD student at Case Western Reserve, began working on the battery as part of his senior design project in 2011. He came on board as a project engineer after graduating that spring and is now an integral member of the research side of the work.

"We're very interested in knowing some of the most fundamental aspects, starting with how the size, shape, surface chemistry and other characteristics of carbon particles used to make the slurry electrode contribute to making the electrode conductive," Sinclair said.

"Understanding the principles and details on which the battery operates will provide the basis for more broadly using the technology", he said.

Savinell's lab hopes to begin testing the prototype within a year. The flow battery can be used not only to augment power to the grid when solar power wanes, but also as a back-up power source for data centers and hospitals and more.

Since beginning research and development of the iron flow battery, Savinell and his colleagues have submitted several patent applications in the U.S. and internationally and published 12 academic papers on the research, with more in the works.

Provided by Case Western Reserve University

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