New energy storage methods may overcome solar energy's flaws

Umair Irfan, Environment & Energy Publishing, 10-6-11

The sun is the most abundant power source on Earth, but new designs soon hitting the market could keep its energy flowing even after sunset.

Researchers are exploring various strategies to put sunshine on tap, converting the sun's energy into fuels that can be stored, transported and used as needed. Setting excess power aside can help solar plants produce consistent electricity throughout the day, diminishing one of solar energy's biggest drawbacks. Sun-derived fuels can also be used to power fuel cells that drive cars or provide heat to warm homes.

One storage method is hydrogen from a thin, flat solar leaf.

"The way this works it the leaf sample is illuminated. The sample absorbs that light and generates electrons," said Tom Jarvi, chief technology officer at Sun Catalytix, the company bringing the technology to the market. He said the free electrons on the leaf's surface then interact with water, catalyzing its split into oxygen on the leaf's light side and hydrogen on the dark side. The mechanism mimics how plants convert sunlight into energy, hence "leaf."

Jarvi, along with lead researcher Daniel Nocera, a professor of energy and chemistry at the Massachusetts Institute of Technology, co-authored a paper demonstrating this device last week in the journal *Science*.

"This particular result is a combination of several things that have not been pulled together in the past," said Jarvi. In the paper, the leaf was wireless, with no external inputs or electrodes, and was made with low-cost materials like silicon and cobalt. In addition, the device yielded 2.5 percent efficiency in converting light to hydrogen.

The goal now is to reduce costs even further while increasing the system's efficiency.

"Our real, sincere focus at this point is springboarding off this leaf result and working on the nanoscale," said Jarvi. Mike Decelle, president and CEO of Sun Catalytix, said the current strategy is to create nanoparticles that can produce hydrogen from water. "The way to visualize this is that instead of a large-scale solar cell, you have billions of solar cells," said Decelle. "That will deliver the lowest-cost hydrogen we're striving for."

Trapping heat as well as energy

Solar energy can also be used to produce conventional carbon-based fuels, like gasoline. The advantage of this system is that the infrastructure to make and use the fuel is already in place.

At the University of Illinois, Urbana-Champaign, researchers have developed a way to efficiently convert carbon dioxide to carbon monoxide, a component of synthetic gas, or "syngas."

"Oil companies have processes to turn this [syngas] into gasoline, diesel fuel and jet fuel," said Rich Masel, CEO of Dioxide Materials and a retired professor, pointing out how companies like BP PLC have operated synthetic fuel facilities for 20 years, albeit using natural gas instead of recycled carbon as a feedstock.

Working with Brian Rosen, a chemical engineering graduate student; Wei Zhu, a recent chemical engineering Ph.D.; Amin Salehi-Khojin, a postdoctoral researcher; and other scientists at Illinois, Masel used ionic liquids to stabilize intermediates in the dioxide-monoxide conversion. The ionic liquids are solutions of charged molecules that bind to the carbon compounds, drastically lowering the energy required for the reaction. Masel envisions this system being driven by solar energy, producing fuel to power cars, planes and power generators to fill gaps in solar electricity production.

"It's a really great project because you can reduce carbon dioxide and you can store solar energy and wind energy in a more efficient form," said Zhu. The team also published its findings in *Science*.

However researchers aren't just looking at converting the sun's light into electricity; some are also looking at ways to trap its heat. Jeffrey Grossman, an associate professor in MIT's Department of Materials Science and Engineering, recently received a grant from the Advanced Research Projects Agency-Energy (ARPA-E) to capture the sun's warmth and release it on demand.

"We're all very familiar with the concept of stored electrical energy. That's the battery, as well as other things like supercapacitors," said Grossman. "That doesn't exist for heat, at least not in a way that's rechargeable."

Charging 'heat batteries' in the sun

Using a compound called azobenzene along with carbon nanotubes -- tiny cylinders made from carbon -- Grossman created a way to capture the sun's energy and store it in a single step. The same material can then be triggered to produce heat upward of 350 degrees Celsius as needed.

"The [energy] density here is considerably less than gasoline, but just as good as or better than a lithium-ion battery," said Grossman. "What we need are rechargeable [heat] batteries that we can recharge 10,000 times, and the charging station is the sun."

Storing heat is important because ultimately, 90 percent of energy ends up as heat, according to Grossman. He said this technology can be used to generate power or heat at scales from portable devices to grid-level solar concentrators. In addition, the thermal storage compound can be pumped through pipes and distributed to homes to warm air or heat water.

Grossman is now seeking to improve the thermal compound's energy density to make it comparable to or better than fossil fuels.