Perovskite solar technology shows quick energy returns

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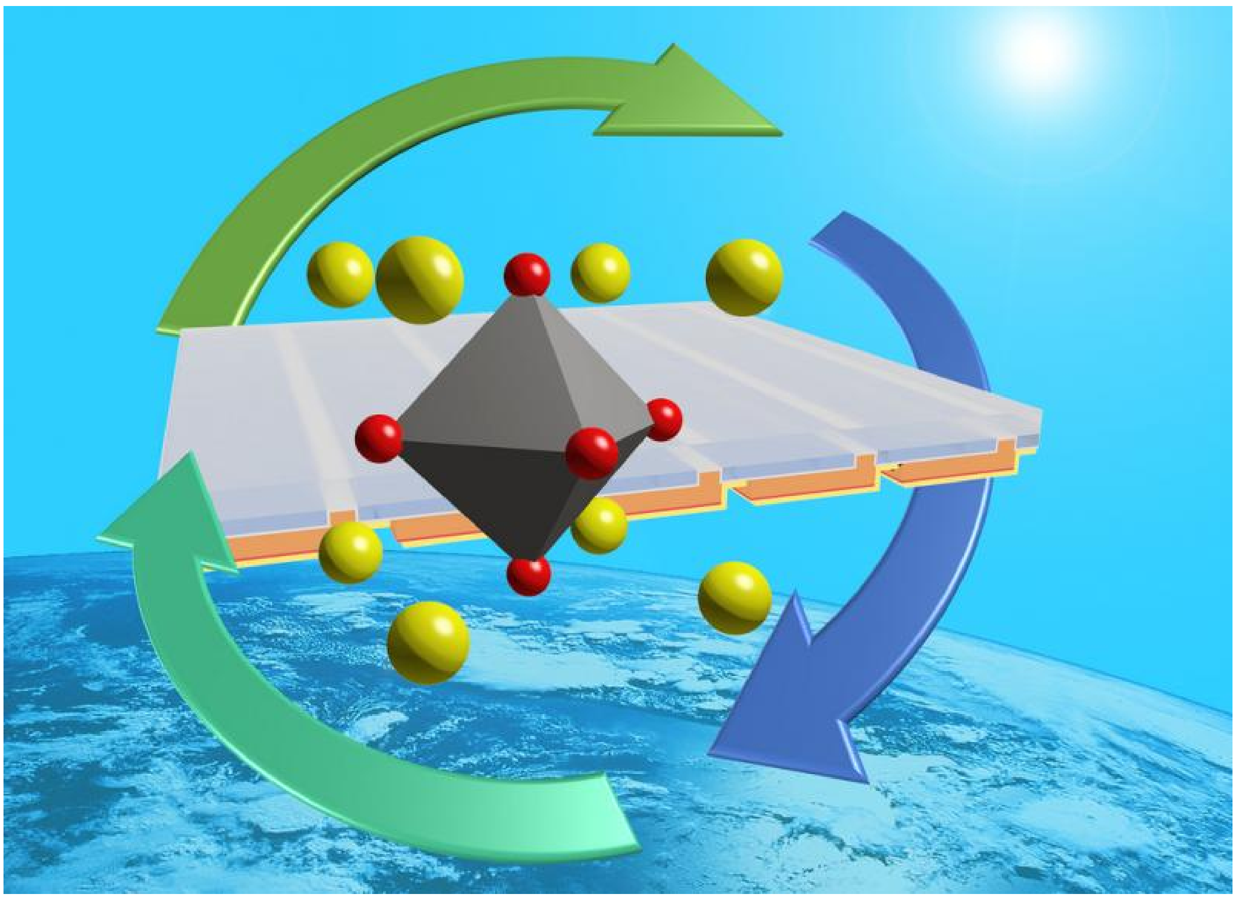

This graphic shows the semi-cubic structure of perovskite materials, and how they would fit into a solar power device. An Argonne-Northwestern study found that perovskite-based solar technology has the quickest energy payback time of all current solar technologies. Credit: Seth Darling

Solar panels are an investment—not only in terms of money, but also energy. It takes energy to mine, process and purify raw materials, and then to manufacture and install the final product.

Silicon-based panels, which dominate the market for solar power, usually need about two years to return this energy investment. But for technology made with perovskites—a class of materials causing quite a buzz in the solar research community—the energy payback time could be as quick as two to three months.

By this metric, perovskite modules are better than any solar technology that is commercially available today.

These are the findings of a study by scientists at Northwestern University and the U.S. Department of Energy's Argonne National Laboratory. The study took a broad perspective in evaluating solar technology: In what's called a cradle-to-grave life cycle assessment, scientists traced a product from the mining of its raw materials until its retirement in a landfill. They determined the ecological impacts of making a solar panel and calculated how long it would take to recover the energy invested.

Perovskite technology has yet to be commercialized, but researchers everywhere are excited about the materials. Most projects, however, have been narrowly focused on conversion efficiency—how effectively the technology transforms sunlight into useable energy.

"People see 11 percent efficiency and assume it's a better product than something that's 9 percent efficient," said Fengqi You, corresponding author on the paper and assistant professor of chemical and biological engineering at Northwestern. "But that's not necessarily true."

A more comprehensive way to compare solar technology is the energy payback time, which also considers the energy that went into creating the product.

This study looked at the energy inputs and outputs of two perovskite modules. A solar panel consists of many parts, and the module is the piece directly involved in converting energy from one form into another—sunlight into electricity.

Perovskites lag behind silicon in conversion efficiency, but they require much less energy to be made into a solar module. So perovskite modules pull ahead with a substantially shorter energy payback time—the shortest, in fact, among existing options for solar power.

"Appreciating energy payback times is important if we want to move perovskites from the world of scientific curiosity to the world of relevant commercial technology," said Seth Darling, an Argonne scientist and co-author on the paper.

To get a complete picture of the environmental impacts a perovskite panel could have, the researchers also analyzed metals used for electrodes and other parts of the device.

One of the modules tested includes lead and gold, among other metals. Many perovskite models have lead in their active layer, which absorbs sunlight and plays a leading role in conversion efficiency. People in the research community have expressed concern because everyone knows lead can be toxic, Darling said.

Surprisingly, the team's assessment showed that gold was much more problematic.

Gold isn't typically perceived as hazardous, but the process of mining the precious metal is extremely damaging to the environment. The module in this study uses gold in its positive electrode, where charges are collected in the process of generating electricity.

The harmful effects of gold mining, an indirect impact of this particular perovskite technology, is something that could only be uncovered by a cradle-to-grave investigation, said Jian Gong, the study's first author and a PhD student in You's research group at Northwestern.

The team hopes that future projects use this same zoomed-out approach to identify the best materials and manufacturing processes for the next generation of solar technology—products that will have to be environmentally sustainable and commercially viable.

"Soon, we're going to need to produce an extremely high number of solar panels," You said. "We don't have time for trial-and-error in finding the ideal design. We need a more rigorous approach, a method that systematically considers all variables."

While this paper featured a thorough environmental assessment of different solar power options, further studies are needed to factor in economic costs. Before putting a perovskite panel on the market, scientists will likely have to replace gold and other unsustainable materials, for both environmental and economic reasons, Darling said.

In addition, extending the lifetime of perovskite modules will be important in order to make sure they are stable enough for long-term commercial use, You said. Despite a few necessary improvements, he said perovskite technology could be commercialized within two years if researchers use comprehensive analysis to optimize the selection of raw materials and manufacturing.

One of the motivations for this study, according to the authors, was the need to improve technology so that solar energy can be scaled up in a big way.

Global energy demand is expected to nearly double by 2050, and Darling said there's no question that solar power must contribute a significant fraction.

The real question, Darling said, is "How quickly do we have to get a technology to market to save the planet? And how can we make that happen?"

More information: "Perovskite photovoltaics: life-cycle assessment of energy and environmental impacts." *Energy Environ*. Sci., 2015,8, 1953-1968 DOI: 10.1039/C5EE00615E

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