SUSTAINABILITY

How does solar power work?

Chemist Paul Alivisatos explains how to generate electricity from sunlight

By Susannah Locke on October 20, 2008

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The sun—that power plant in the sky—bathes Earth in ample energy to fulfill all the world's power needs many times over. It doesn't give off carbon dioxide emissions. It won't run out. And it's free.

So how on Earth can people turn this bounty of sunbeams into useful electricity?

The sun's light (and all light) contains energy. Usually, when light hits an object the energy turns into heat, like the warmth you feel while sitting in the sun. But when light hits certain materials the energy turns into an electrical current instead, which we can then harness for power.

Old-school solar technology uses large crystals made out of silicon, which produces an electrical current when struck by light. Silicon can do this because the electrons in the crystal get up and move when exposed to light instead of just jiggling in place to make heat. The silicon turns a good portion of light energy into electricity, but it is expensive because big crystals are hard to grow.

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Newer materials use smaller, cheaper crystals, such as copper-indium-gallium-selenide, that can be shaped into flexible films. This "thin-film" solar technology, however, is not as good as silicon at turning light into electricity.

Right now, solar energy only accounts for a tiny portion of the U.S.'s total electricity generation, because it is more expensive than alternatives like cheap but highly polluting coal. Solar power is about five times as expensive as what people pay for the current that comes out of the outlets.

In order to have a hope of replacing fossil fuels, scientists need to develop materials that can be easily mass-produced and convert enough sunlight to electricity to be worth the investment.

We asked Paul Alivisatos, deputy laboratory director at Lawrence Berkeley National Laboratory in California and a leader of their Helios solar energy research project, to explain how people capture energy from sunlight and how we can do it better.

[*An edited transcript of the interview follows.*]

What is a solar cell?
A solar cell is a device people can make that takes the energy of sunlight and converts it into electricity.

How does a solar cell turn sunlight into electricity?
In a crystal, the bonds [between silicon atoms] are made of electrons that are shared between all of the atoms of the crystal. The light gets absorbed, and one of the electrons that's in one of the bonds gets excited up to a higher energy level and can move around

more freely than when it was bound. That electron can then move around the crystal freely, and we can get a current.

Imagine that you have a ledge, like a shelf on the wall, and you take a ball and you throw it up on that ledge. That's like promoting an electron to a higher energy level, and it can't fall down. A photon [packet of light energy] comes in, and it bumps up the electron onto the ledge [representing the higher energy level] and it stays there until we can come and collect the energy [by using the electricity].

What's the biggest difference between how a plant captures light energy and how we do it with solar cells?
We wish we could do what plants do because plants absorb the light, and [they use] that electron to change a chemical bond inside the plant to actually make fuel.

Could you do artificial photosynthesis and emulate a plant?
We would love to be able to make a solar cell that instead of making electricity makes fuel. That would be a very big advance. It's a very active topic right now among researchers, but it's hard to predict when we will be able to use it.

One of the reasons we like to plant trees is because they take the CO_2 out of the air. If we could do that [with a solar cell], then we could actually deal with global warming problems even more directly because we'd be pulling the CO_2 out of the air to make our fuel.

How good are current solar cells at capturing light energy?
So we can talk about the power efficiency. The power efficiency of a typical crystalline silicon cell is in the 22 to 23 percent [range, meaning they convert as much as 23 percent of the light striking them into electricity]. The ones that you typically might be able to afford to put on your rooftop are lower than that, somewhere between 15 and 18 percent. The most efficient, like the ones that go on satellites, might have power efficiencies approaching 50 percent.

The power efficiency is one measure, but the other thing that we're very concerned about is the cost of making them and the scale of production.

In my opinion, the silicon technology doesn't scale [up] too well [because it's expensive to make]. We need to invent some new technology, [which] may not be as efficient, but you need to be able to make millions of acres of stuff if you want to get a lot of energy. People are trying to use new materials like plastics and nanoparticles.

The total solar production in 2004 was around one thousandth of the total power consumption of the U.S. It's just not enough. Something's gotta change. We're not there yet. There's a lot of discoveries still to be made.

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