Product Development

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Sunny Side Up

Christine Bordonaro

Photo taken by Benjamin T. Erwin

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Some researchers estimate that in just three days the sun transfers more energy to Earth than the energy in all the fossil fuels on the planet. That's a lot of energy! By harnessing even a small percentage of it, we could start to solve some of the health and environmental problems associated with using fossil fuels as our primary source of energy.

Finding ways to capture that energy cost effectively is the major goal of my work. I'm Christine Bordonaro, and my company, Evergreen Solar, makes solar panels to generate electric power using the energy from sunlight. The solar panels we use today provide enough electricity to power calculators, schools, cars, and even satellites in space. We're working to make them more useful by increasing their efficiency and decreasing their cost.

Renewable energy sources are energy sources that regenerate themselves.

Courtesy of Pacific Northwest National Laboratory

Wind and hydroelectric power are two renewable energy sources. A hydroelectric dam harnesses the energy in falling water to turn a turbine and generate electricity.

I'm excited to share my experiences as an engineer because, when I was growing up, I had no way of finding out what engineers did. As a high school student in Rochester, New York, I was good at math and science. My teachers encouraged me to study engineering in college. But I didn't really know what engineering was or what engineers did until I was well on my way to becoming one.

In college, I studied mechanical engineering. The courses I took covered a wide range of topics including design, construction, and product development. In graduate school, I got interested in materials science, which studies the characteristics and uses of the various materials. I was fascinated how two materials made up of the same basic substances can have totally different properties. I studied polymers—or plastics—and eventually got a Masters Degree and a Ph.D. from Rensselaer Polytechnic Institute.

When I learned about a job opening at Evergreen Solar I became excited. This job would let me develop solar technologies that could help solve some very serious environmental and public health problems. As a renewable energy source, the sun can give us as much solar energy as we want. Unlike coal or oil, there is a constant self-replenishing source: the sun!

Solar energy offers other benefits too. For one, using solar energy allows ***decentralized electrical generation.*** That means that anyone anywhere can put a solar panel in a sunny spot, plug it in, and get power. Solar panels generate electricity on the spot. No power grid required!

In a ***centralized electrical generation*** system, large volumes of fossil fuels are mined, stored, and transported to power stations that generate electricity, which is distributed across the power grid. Solar power, on the other hand, does not require storing, transporting, and burning fossil fuels for electrical power. And very little solar power gets "lost" through miles and miles of wire on the grid.

With ***decentralized electrical generation,*** anyone anywhere can put a solar panel in a sunny spot, hook it up to an electronic device, and get power.

With ***centralized electrical generation,*** large volumes of fossil fuels are mined, stored, and transported to power stations that generate and distribute electricity through an extensive network of wires.

What Is Solar Energy?

The energy in sunlight originates at the sun's center. The sun, made mostly of hydrogen, has a very strong gravitational field, strong enough to hold the planets of our solar system in orbit. At the sun's core, the pressure is so huge that the temperature reaches about 14 million degrees Celsius, which results in a nuclear reaction called fusion. Unlike a nuclear reactor that generates heat by splitting atoms in a process called fission, a star, like the sun, uses the generated heat to fuse the atoms of hydrogen into helium. This process releases a tremendous amount of energy that radiates from the sun in all directions.

Radiation is the energy transmitted in all directions from a source in the form of waves and rays. Whether it's the sound waves from your headphones, heat from a stove, or the light from the sun, you live with radiation every day. When the radiation from the sun reaches the Earth, much of the energy warms the atmosphere, raising the Earth's temperature.

In ***active solar technologies,*** sunlight is used to warm a fluid, such as water, which is pumped to a storage tank, called a solar collector. The stored hot fluid can then be used for space heating or as a hot water supply. Because these systems require pumps to move the fluid around, they are referred to as active solar technologies.

Passive solar technologies are designed to use the remaining energy mostly for heat or light. Buildings designed with passive technologies often have large south-facing windows, allowing plenty of sunlight to pour in. Some buildings are made from materials that readily absorb energy from the sun. The floors and walls made from concrete, brick, and other materials absorb the sun's energy by heating up during the day. At night, the stored energy radiates to its surroundings.

Radiation 
is the energy transmitted in all directions from a source in the form of waves and rays.

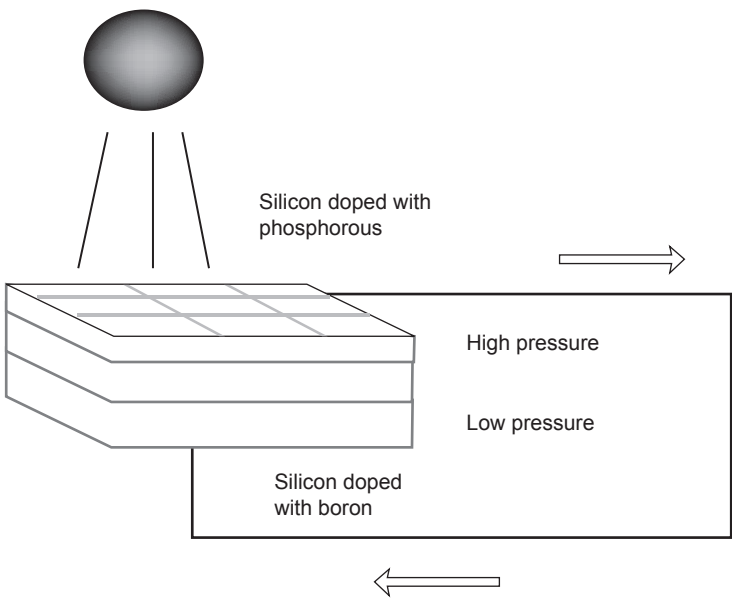
Courtesy of Stefano Paltera/Solar Decathlon

Here at Evergreen Solar, we harness the energy in sunlight in a different way altogether. We make ***photovoltaic,*** or PV, cells. PV cells transfer the energy in light (photo) into electricity (voltaic).

Many PV cells are made with silicon, which is found in sand. And sand is one of the most abundant elements on Earth. Pure silicon itself is not a very good conductor, so it is mixed with some other materials that increase its conductivity. In a manufacturing process called "doping," we add phosphorus to one side of the PV cell, while the other side is doped with boron. When the cell is exposed to light, a greater charge builds up on the side of the cell that is doped with phosphorus. The two sides of the cell can then be connected into a circuit.

When sunlight strikes the cell, the difference in charge on the two sides creates an electric pressure difference or voltage. Charge flows in a current from the phosphorus-doped side of the cell through the circuit to the boron-doped side of the cell. While each cell can produce only a small current, by connecting PV cells together, we can construct solar panels that can produce usable power.

A Photovoltaic Cell



In the Dark

Whenever I describe to my friends how solar cells work, they always ask the same question: "What happens at night when there is not enough light to create a current?" It's a good question. You would never want to install solar panels in your home if you thought you couldn't turn on lights or take a warm shower at night, would you? But there's no getting around the fact that PV cells need light to generate electricity. Some people purchase expensive batteries that store extra electrical power generated by the panels during the day, which powers their homes at night.

More often, people keep their homes connected to the distribution grid, so they can buy electricity from the grid at night. During the day, their solar panels often generate more electricity than they need and the excess electricity is fed back into the grid. Most power companies will even buy the electricity that a homeowner supplies to the grid. In a sense, these homes act like small power plants in daylight hours.

Why Not Go Solar?

Given that solar panels can help the environment and bring in a little extra income, why doesn't everyone have them? Well, there are a few problems associated with PV technology that engineers have yet to truly solve, but we're getting closer. To start with, solar cells need to be more efficient. A solar cell only transfers about 15 percent of the radiation that hits it into electricity. Each solar panel that has two strings of 36 solar cells generates about 100 Watts of electricity—enough electrical energy to power one bright light bulb. To supply electricity to an entire house, you need many solar panels connected together. For this reason, it's critical for PV cells to be as efficient as possible.

One type of technology that improves efficiency allows the solar cells to track the sun moving across the sky much the way a sunflower does. This maximizes the amount of light that hits a cell and the amount of electricity that each panel can produce. Evergreen is also working to create anti-reflective coatings for solar panels that will allow more sunlight to pass into the cell instead of being reflected from the panel's surface.

Many people find the costs of buying and installing solar panels too high. While the initial installation costs are high, over the life of the PV panels, homeowners can save enough on electrical bills to make up most or all of the costs. States such as California, New Jersey, and Maryland now offer to pay up to 70% of the installation fees as an incentive for residents to switch to solar power. Some European countries offer even larger financial incentives to go solar. This may explain why Germany produces twice as much electric power using solar energy than the United States, while its population is just over a quarter of the size. It also may explain why Evergreen sells a lot of solar panels to Germany.

At Evergreen Solar, we're optimizing our manufacturing systems to bring the costs of solar panels down so that more people—in the United States and abroad—find them affordable. The way we make our silicon cells, for instance, reduces costs. Most companies take a block of silicon and cut it. If you have ever used a saw to cut anything, you know that a small strip of the material as wide as the thickness of the saw turns into sawdust. The same is true for cutting silicon. Cutting a thin slice of silicon from a block results in silicon dust on the floor. We warm our silicon until it melts, then pull it upward between two strings. This process saves us money because we don't waste very much silicon.

I believe that using solar energy will be commonplace in the United States one day. But before that can happen, we have to keep working on ways to improve PV cells. I'm proud to be a part of that effort!

What's the Story?

1. Why is it beneficial to use renewable energy sources?

2. Why does Christine say that solar technologies represent decentralized power generation? What are the advantages of this type of power generation?

3. How do homes powered by PV panels get power at night?

Designing with Math and Science

4. Christine says that solar panels are only about 15 percent efficient. What are the inputs and outputs of the solar panel system that Christine is using to determine efficiency?

5. What is radiation?

Connecting the Dots

6 What are some differences between how solar panels generate electricity and how a generator in a coal-fired power plant generates electricity?

What Do You Think?

7. Imagine that you've just been hired by the marketing department of Evergreen Solar. Your job is to create an advertisement for a national magazine that will get more people interested in solar panels despite the costs of installing them. Your ad must describe how the benefits of solar outweigh the installation costs. Use drawings and text to describe what your ad would be like.