Solar Electricity

Re-Energy
Backgrounder

Solar Energy

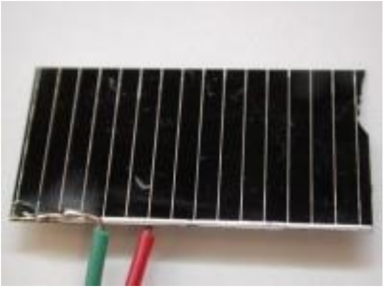
On planet Earth, sunlight is an incredibly important form of energy. Every day, the sun pours unimaginable amounts of energy into space. Some of it is in the form of infrared and ultraviolet light, but most of it is in the form of visible light. Some of this energy falls on the Earth, where it warms our planet's surface, drives ocean currents, rivers, and winds, and is used by plants to make food. Life on Earth depends totally on the sun.

The sun emits unimaginable amounts of energy into space every day, mostly in the form of visible light.
Photo courtesy of NASA

Photovoltaic Cells

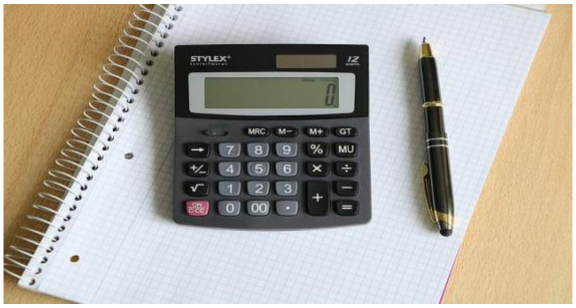
Visible light can be converted directly to electricity by a space-age technology called a photovoltaic cell, also called a solar cell. Most photovoltaic cells are made from a crystalline substance called silicon, one of the Earth's most common materials. Solar cells are typically made by slicing a large crystal of silicon into thin wafers and putting two separate wafers with different electrical properties together, along with wires to enable electrons to travel between layers.

When sunlight strikes the solar cell, electrons naturally travel from one layer to the other through the wire because of the different properties of the two silicon wafers.



A photovoltaic cell consists of a thin piece of specially coated silicon, with wires attached to capture the flow of electricity

A single cell can produce only very tiny amounts of electricity-barely enough to light up a small light bulb or power a calculator. Nonetheless, single photovoltaic cells are used in many small electronic appliances such as watches and calculators.



This calculator is powered by a single photovoltaic cell.
Photo courtesy of Pixabay

Photovoltaic Arrays

To capture and convert more energy from the sun, photovoltaic cells are linked to form photovoltaic arrays. An array is simply a large number of single cells connected by wires. Linked together in an array, solar cells can produce enough electricity to do some serious work! Many buildings generate most of their electrical needs from solar photovoltaic arrays, including the Toronto Healthy House, which gets 80% of its power from the sun.

Photovoltaic arrays are becoming a familiar sight along roadsides, on farms, and in the city, wherever portable electricity is needed. They are commonly used to provide power for portable construction signs, emergency telephones, and remote industrial facilities. They are also becoming popular as a way of supplying electricity for remote power applications such as homes and cabins that are located away from power lines, for sailboats, recreational vehicles, telecommunications facilities, oil and gas operations, and sometimes entire villages in tropical countries, for example.

Many single photovoltaic cells are connected by wires and mounted on a flat panel to form a photo-voltaic array - *Photo courtesy of Solar Futures International*

Storing Electricity

Solar panels make electricity in all kinds of conditions, from cloudy skies to full sunlight, in all seasons of the year. But they don't work at all during the nighttime! To make electricity available after sundown, the energy must be stored during the day for later use. The usual storage device is a rechargeable battery.

The batteries used with solar arrays must be able to discharge and recharge again many times. They contain special parts and chemicals not found in disposable batteries. They are also usually larger and more expensive than their disposal cousins.

Besides solar panels and rechargeable batteries, modern photovoltaic systems are usually equipped with some kind of electronic charge controller. The main job of the charger controller is to feed electricity from the solar panel to the battery in the most efficient manner and to prevent the solar panel from overcharging the battery. The charge controller also protects the solar panels from electrical damage.

In many cases, people need the electricity stored in the rechargeable batteries for use with normal household appliances. The problem is that most of the appliances require 110 volts of alternating current (110V AC), whereas the battery puts out only direct current (DC), usually at a much lower voltage. A device called a power inverter solves this problem by converting the battery's low voltage direct current to 110 volts of alternating current. Modern charge controlled often come equipped with their own built-in power inverters.

Solar Electricity in Everyday Use

Photovoltaic panels, like computers and other technologies, are getting cheaper and easier to buy. In fact, many people consider them a great alternative to gas-powered generators or connections to the regular electricity supply. Some countries, such as Japan, have encouraged businesses and communities to install solar panels on the roofs of new buildings to reduce the need for electricity from other sources.

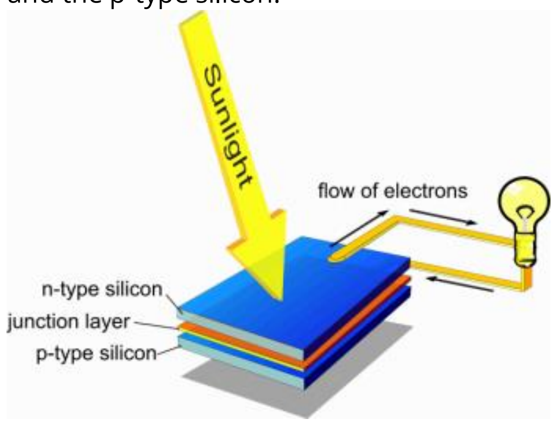
Many homes and business have both a connection to the commercial electrical supply system, often called the “electricity grid”. The solar panels can provide all or most of the building’s electrical supply during the day, and the grid supplies whatever other electricity may be needed during the night. In some cases, the panels make more electricity than is needed in the building, and the excess electricity is sold to the power company. This results in the power company sending the building owner a cheque instead of a bill for selling them the electricity!

Questions

1. List all the appliances in your home, school or neighborhood that have a photovoltaic cell or array on them.
2. What are the advantages of solar electricity over electricity made from fossil fuels, nuclear fuels, or hydroelectricity?
3. What are the problems or disadvantages of solar electricity?

How Photovoltaic Cells Work

Photovoltaic cells are marvels of sub-atomic physics. They are constructed by layering special materials called semiconductors into thin, flat sandwiches, called solar cells. There are three layers: the uppermost layer consists of “n-type silicon”, which can release negatively charged particles called electrons when stimulated by light. The lower layer is composed of “p-type silicon” and develops a positive charge when stimulated by light. The middle layer is called the “junction layer” and acts as an insulator between the n-type silicon and the p-type silicon.



A ray of light consists of a stream of photons, which are tiny packets of light energy moving along around 300,000 kilometers per second. When these energy packets strike the upper layer of a solar cell, they jar loose electrons, which builds a negative charge in the silicon layer. (HINT: which is why it is called the n-type silicon!) These electrons are attracted to the p-type silicon in the layer below, but are forced to travel through an electric circuit made of thin connecting wires. Electrons generated on the upper layers of several cells are gathered together to form an electric current, and are sent down a wire to a motor or some other appliance. Once they have done their work, the electrons are allowed to return to the lower layer of the solar cell, completing the circuit. The amount of electricity the panel can produce depends on the intensity of the light, the number of cells arranges on the panel, and how they are connected to each other.

Solar Heat

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Backgrounder

The Sun: Permanent Power

The Sun is the ultimate renewable energy source. Every day for billions of years the sun has been pouring out unimaginable amount of energy. The Earth orbiting at a distance of 150 million kilometres from the sun, intercepts a tiny fraction of this solar output.

Light from the sun provides heat that drives atmospheric winds and ocean currents on Earth surface.

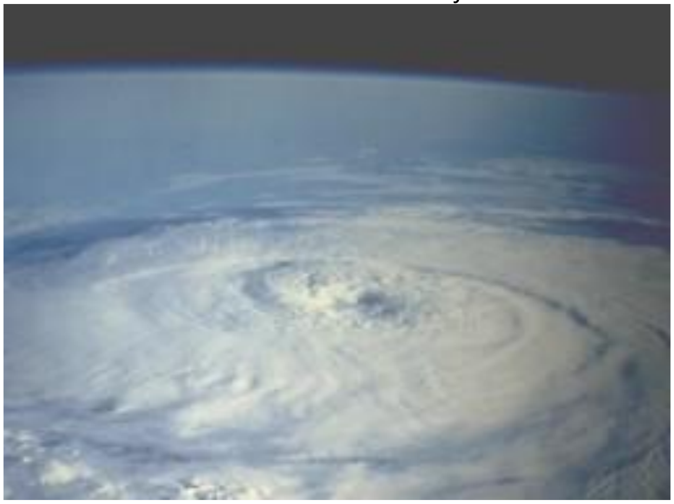


Photo courtesy of NASA

At the Earth's surface, incoming energy from the sun is absorbed by the land, water and atmosphere, and concentrated into measurable heat. This heat acts like a giant engine, creating winds and currents in our atmosphere, oceans, and rivers. The sun's energy also keeps the Earth hospitable warm, a balmy plus 15 degrees Celsius.

Most of the sun's energy is emitted as visible light. The trick to using it as an energy source is being able to convert it from visible light into heat, electricity, or some other useful form. Most systems that capture solar energy convert it to heat or electricity, the two forms of energy we use the most.

As an energy source, the sun has a few limitations. Obviously, sunlight is available only during the day-time. And when it is available, sunlight may be hindered by clouds, dust, or pollution in the atmosphere, or by trees, buildings or other physical obstructions. Nonetheless, sunlight is a highly practical and clean source of energy in many places around the world.

Getting Heat from Sunlight

If you want to capture heat from sunlight, you will need three things: bright light, a surface or fluid that can absorb the light and change it into heat, and a way to store and use the heat once it has been produced. Most solar heating systems depend on at least two of these factors working together.

A good example is a greenhouse. Greenhouses are designed to allow sunlight in, and then trap heat so that young plants can get a head start in the growing season. The glass of the greenhouse lets in lots of sunlight, which is absorbed by plants, floor, soil, and other dark surfaces inside. As these surfaces absorb sunlight, they warm up, causing the air above them to get hotter. Because the greenhouse is an enclosed space, the heat accumulates inside the building.

Most greenhouses can get so hot in the summer that, without ventilation, the heat would eventually kill all the plants.

Concentrating Sunlight

To get the high temperatures needed to heat water or cook food, it is sometimes necessary to concentrate large amounts of sunlight on a small light-absorbing area. The most common approach is to use some kind of curbed reflective panel. A reflector with a parabolic curve can easily concentrate enough sunlight on a very small spot to start a fire.

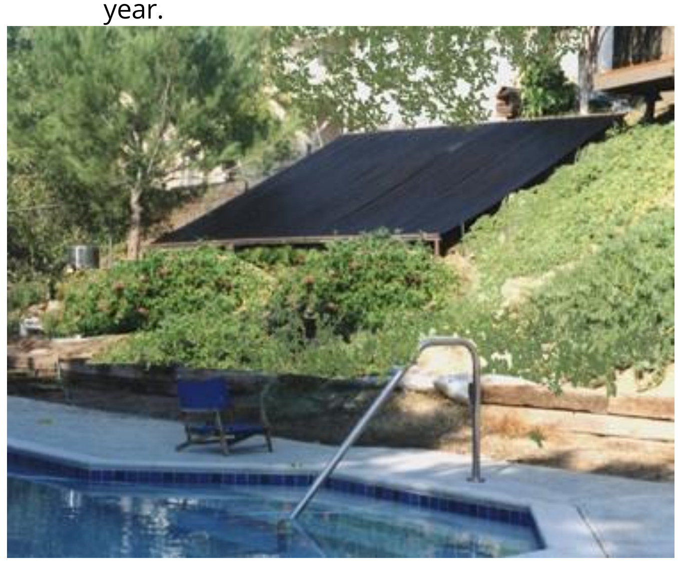
A parabolic reflector can produce extremely high temperatures when aimed at the sun.

Photo courtesy of Solar Futures International

Practical Uses for Solar Heat

Solar heat is one of the cheapest and most practical forms of renewable energy. Here are a few of the most common applications:

1. **Solar heat water heaters:** The sun's light is an excellent source of hot water for home or commercial use, such as swimming pools, car washes and laundromats.
2. **Cooking:** Simple solar ovens and cookers are used around the world in both commercial kitchen's and in people's homes. Solar cookers can be made with everyday materials such as cardboard and tinfoil.
3. **Home heating:** Many homes are designed to take advantage of the sun to provide at least part of the heat required over the course of a year.



The black panels near the pool side are metallic heat exchangers that absorb solar energy efficiently, and this cost-saving energy to heat the pool.
Photo courtesy of Sun Ray Solar

Solar Hot Water Heating

Each of our homes uses quite a lot of hot water, usually supplied by a gas or electric hot water heater. These appliances can be expensive to run and they cause environmental impacts. A great way to make lots of hot water for the home is with a solar-powered hot water heater. A solar hot water heater consists of a large, flat metal box mounted on the roof of a building. It contains a network of water pipes connected to the home's plumbing system. The metal lining and the pipes generate heat when sunshine falls on the box. The heat is carried away by water that flows through the pipes and then is stored in an insulated tank for later use. The hot water can be used for laundry or showers, or it can be send through pipes under the floor to heat a room or building. This system can supply some or all of the hot water needed by the home, which can make a big difference in monthly energy costs!

A solar cooker uses an insulated box and reflective panels to generate the temperatures needed to cook food. Photo courtesy of The Solar Cooking Archive

Solar Cookers

If you have ever stepped into a car that was parked outside a hot sunny day, you already know something about solar cookers! A solar oven works much like a mini-greenhouse, but with a few differences. The light-absorbing surface is enclosed in a tightly sealed, well-insulated box. Sunlight comes in through a pane of glass and is then absorbed and changed into heat by the black surfaces inside the box. Insulation around the box keeps the heat in. Reflective panels increase the amount of sunlight entering the box. When pointed at the sun, the temperature in a solar cooker can easily rise high enough to bake bread.

Home Heating

Many homes are designed so that they can meet at least some of their heating requirements form the sun's energy. Such homes have large south-facing windows (or north-facing if located in the southern hemisphere) that allow sunlight to heat up a room. The houses insulation helps keep the heat in. This is called **passive solar heating,** because no pumps, fans, or other types of equipment are used. For example, the Toronto Healthy House derives 75% of its space heating needs from the sun.

Photo courtesy of the Canadian Mortgage and Housing Corporation.