Photons

Packets of Energy from the Sun

Ian Woofenden

Derivation: From Greek photo-, *"light," and* on, *"unit." The word "photon" was proposed by chemist Gilbert N. Lewis in a letter to* Nature *magazine in 1926.*

One of the long-standing debates in science is whether light is a particle or a wave. Isaac Newton theorized that light traveling from the sun is particles. Dutch astronomer Christiaan Huygens believed that light is made up of waves.

Albert Einstein and other scientists' conclusions combined Newton's and Huygens' theories, proposing that light comes in small packets of energy that share characteristics of both particles and waves. He showed that each of these characteristics may be observed depending on the context. While energy appears to be transmitted from the sun via electromagnetic waves, when it comes to phenomena like light, those waves seem to be made of particles.

Trying to visualize this is the same as trying to visualize any physical process—our mental models may help or hinder us. *Home Power* publisher and renewable energy guru Richard Perez says, "In reality, neither explanation represents 'truth.' Both are merely descriptions based on our limited point of view. All particles—protons, electrons, photons, gravitons, mesons, bosons, magetrons, and the remaining huge list—are fictional entities that we use to describe disturbances or anomalies in space and time. While we can manipulate energy, we really don't have a clue as to what it really is."

Fortunately, the sun works, whether we understand the physics behind it or not. On Earth, the energy we use on a daily basis comes from the sun, and photons, these mysterious light particle–wave entities, are the delivery vehicle. How they are received on Earth affects us and how we use the energy.

Even fossil fuels are the result of photon energy from the sun. The process of photosynthesis (from the Greek words for "light" and "bringing together") uses the sun's energy to combine carbon dioxide from the air, and water from the soil into food to grow plants. Ancient plants received solar energy, just as today's plants do. As these plants decayed and were trapped under layers of sediment, the pressure and heat of overlying layers of earth transformed them into fossil fuels. When we use these fuels, we're tapping this stored solar energy. But these resources are limited because they take eons to form, and using them results in air, soil, and water pollution.

Using renewable energy technologies is a much cleaner way to use the sun. With photovoltaic (PV) panels, photons bump electrons in a solar cell into an electrical circuit, satisfying our need for electricity. With solar hot water panels, the sun's energy is absorbed by dark materials, increasing the vibration of the molecules, which we experience as heat. This same process can heat our homes directly through passive solar design or through solar air collectors. Solar heat energy in the earth is also used by ground-source heat pumps—a very efficient home heating system.

The same reception of photons and conversion to heat drives a couple of other energy forms here on Earth—wind and hydropower. The sun's energy heats the land, which in turn heats the atmosphere. This heating is uneven, due in part to the unevenness of the Earth's surface. So some places are hotter than others, and this creates differences in air density. In the end, this causes wind, which can be tapped for electrical and mechanical energy.

The sun also drives the hydrological cycle, evaporating water from oceans and lakes, where it rises into the sky and condenses to form clouds. Clouds then drop the water as rain or snow, creating streams and rivers, which eventually return to the ocean to be evaporated again. This falling water is a particularly potent and reliable source of energy, and renews itself continually.

The sun's energy travels 92.9 million miles in about 8.3 minutes (186,282 miles per second). About half the energy aimed at the Earth reaches its surface, with the rest being reflected, blocked, or absorbed by the atmosphere. According to a July 1999 article in *Science* magazine, a square of PVs about 100 miles (161 km) on a side could have satisfied the electrical energy needs of United States that year.

Although this is a large area (roughly the size of Massachusetts), it is less than one-quarter of the land that is covered by impervious surfaces like roads and parking lots. If wind energy is part of the mix, the needed space for PV shrinks. If geothermal energy is also tapped, the space needed for PV shrinks again, and shrinks even further if hydroelectric energy becomes part of the equation. The point is clear—we can gather more than enough renewable energy to power our society. The sun is doing the hard work, and we just need to be clever about collecting a few packets of energy from it.

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