

SAVING MONEY WITH SUNSHINE

Candace Brown

After working outdoors on a cold winter day, nothing beats coming home to a nice hot shower made possible by simply turning on the tap. Humans and hot water have had a happy relationship ever since some ancient ancestor first discovered a hot springs or heated water over an open fire. The eventual development of electric, gas, or propane water heaters not only provided hot water but also storage of large quantities of it, making personal and household cleanliness much easier. The beauty of today's technologies for heating this precious resource is that they have returned to the most basic of God's life-sustaining gifts—the sun. By harvesting the power of clean, natural sunlight, in ways this

article will explain, we can enjoy hot water without polluting the environment or connecting to an electrical utility grid.

Although these systems are most efficient in areas with predominantly sunny skies, solar energy can actually work anywhere. It offers insurance against unforeseen and uncontrollable increases in the price of propane and other fuels and freedom from dependence on fuel distributors. Solar energy provides power in even the most remote, off-grid locations, and even though initial costs, pay-back time, and maintenance requirements vary, some systems can last 25 years. They are increasingly a smart and highly satisfying investment.



This "array" of 36 PV solar panels looks neat and attractive on the roof of this house. The owners can count on substantial energy savings and increased property value.

Photo courtesy: Wholesale Solar

An introduction to Off-Grid Solar Water Heating



This photo shows the evacuated tubes in a solar thermal collector. The horizontal structure running along the top of the tubes is not a storage tank, but rather an insulated line for the glycol heat transfer fluid.

Photo courtesy: Apricus® Solar Hot Water

An overview of how solar power can produce heat or electricity

At the most basic level, all solar energy systems require “collectors,” with as much unobstructed exposure to the sun as possible, in order to efficiently harvest its radiant energy. Collectors are mounted on a roof top, on the ground (like in a field), or even on a sunny wall. A solar system also requires an insulated storage tank to hold the heated water. The particular aspects of any solar energy system depend on many variables such as the amount of hot water needed, the latitude of the location (its distance from the equator), the building’s orientation to the sun, and the temperature extremes of the local climate. Every situation is different, so these factors become part of careful calculations to create a customized design.

Two very different types of collectors are used, with two very different end results. Solar **thermal** systems, which have been around for decades, **convert sunlight to heat**. They raise the temperature of water through direct exposure to the sun’s heat, or indirectly, by first heating a **heat transfer liquid** like propylene

glycol anti-freeze which, in turn, transfers its heat to the water. In addition to these differences, are the differences in how this liquid is circulated through the system using either an **active** method (which involves pumps) or a **passive** method. **Passive circulation** uses natural **convection**—the tendency for warmer liquids to rise and cooler liquids to sink.

While such “thermal” systems continue to be used, the most up-to-date method of collecting the sun’s energy involves **photovoltaics**, a branch of technology that uses sunlight **to create electricity** instead of heat. That electricity is then used for water heating, as will be explained later on in this article. Photovoltaic, or “PV” systems are continuously improving and becoming more affordable and versatile.

Solar Thermal Water Heating Systems

Thermal water heating can be accomplished with a collection method that uses “evacuated tubes” made of transparent glass

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and arranged in parallel rows running vertically on the angled roof. A typical number might be 30. Each glass tube encloses a smaller tube of copper, an excellent conductor of heat. The air in the space between the two tubes is removed, or “evacuated,” to create a vacuum, which insulates the fluid inside the internal tube. At the top, higher than the tubes, is a horizontal storage tank. It is filled by thermo-syphoning as the heated water rises. This method is simple and effective, but the storage tank could place as much as 800 pounds of extra weight on the roof. Such systems are also vulnerable to freezing, although some are designed to drain automatically when temperatures drop.

A “flat plate” type of collector consists of rows of copper pipes arranged over a heat absorbing backing, such as a large copper plate which has been darkened for extra heat absorption. These components are contained within a shallow box with a clear glass cover, creating a greenhouse effect for even more heat. The pipes contain a heat transferring liquid, usually propylene glycol. Once heated by the sun, this liquid is sent through “heat exchanger” pipes located inside or outside of a hot water storage tank, where it raises the temperature of the water inside the tank. The heated water naturally rises to the top of the tank, where it is drawn off for household use, to be replaced by cold water entering the tank at a lower level.

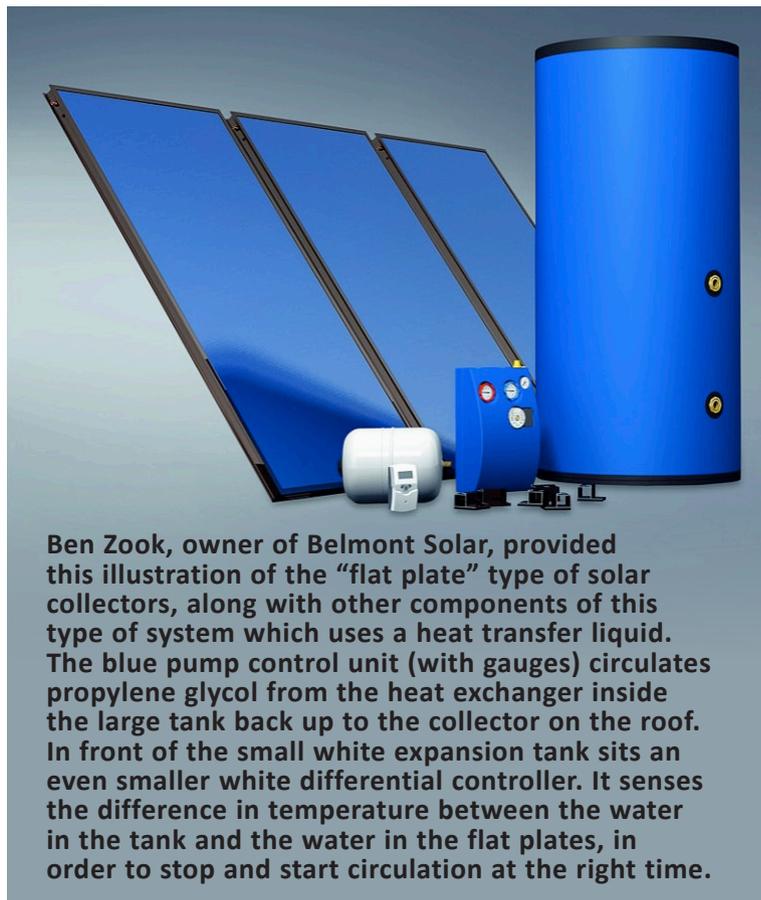
Photovoltaic Solar Power

The basic PV unit is called a cell. For some applications, a cell might be tiny, less than an inch across, but they are more often several inches across. These are arranged in rows and wired together to create a photovoltaic module (commonly called a “solar panel”) that might measure 39 inches by 65 inches. These PV modules containing certain types of natural materials called “semiconductors” because their ability to conduct electricity is neither as good as a metal like copper or as poor as an “insulator” like glass, but somewhere in between. An example is silicon. When sunlight, in the form of elementary particles called photons, strikes the molecules in a semiconductor material, the electrons orbiting around those molecules are freed but forced to flow in one direction, creating an electric current.

For some situations, a single cell or panel can supply a modest power need. For example, one 6- by 6-inch cell can run a small circulation pump in an active solar thermal water heating system, although it would more often be larger. In other cases, multiple panels are combined to create a solar “array.” A huge array of solar panels can generate enough electrical power, all from free sunlight, to serve a large building, when connected to an electrical grid. Businesses or homeowners with solar systems that are connected to the public power grid can actually sell any excess solar power produced back to the grid.

Industry perspectives

Ben Zook, owner of Belmont Solar in Gordonville, Pennsylvania, is one of two experts interviewed for this article. The potential for solar energy, especially when combined with batteries in off-grid or grid-tied applications, inspired him to pursue a career in this field. He was only 18 years old when he started Belmont Solar, nearly two decades ago, building up a successful business through outstanding customer service. Beginning as an electrician, Zook devoted himself to advanced education and training at the Thaddeus Stevens College of Technology. In 2008, after more intense study, he earned his certification as a PV installer from the North American Board of Certified Energy Practitioners. He specializes in full-service



Ben Zook, owner of Belmont Solar, provided this illustration of the “flat plate” type of solar collectors, along with other components of this type of system which uses a heat transfer liquid. The blue pump control unit (with gauges) circulates propylene glycol from the heat exchanger inside the large tank back up to the collector on the roof. In front of the small white expansion tank sits an even smaller white differential controller. It senses the difference in temperature between the water in the tank and the water in the flat plates, in order to stop and start circulation at the right time.

installations of solar energy systems and loves educating people about the great advantages of renewable energy.

“I love seeing solar systems that are designed well, installed well, and last for a long time,” Zook said. “People are *thrilled* with them even ten years later. If you want to do hot water heating off-grid, a typical hot water heater setup, has two 4- by 8-foot collectors on the roof, feeding an 80-gallon tank. During spring, summer, and fall, that tank will usually maintain the temperature it should, unless it gets cloudy for a day or two and depending on its usage.”

According to Zook, when it came to adopting solar energy, Amish communities were about eight years ahead of everyone else, even if only on a small scale. His customized systems, using PV modules to charge a battery bank, are now making the Amish leaders where this technology is concerned as well, even though many households still use propane, coal, and wood. “They are currently about eight years ahead in using batteries, compared to the rest of the population,” he said.

He still services a lot of solar thermal hot water systems and wants to keep the existing ones operational, because they last a long time. Some installed back in the 1980s still work well, even with tanks as old as 20 or 30 years.

One West Coast expert in solar technology is Wil VandeWiel, who previously lived for nine years in Lancaster County, Pennsylvania. During 2019, he became the CEO of a company

Wholesale Solar provided this photo showing a simple and very practical application on a farm, using solar power to run a pump to provide water for livestock.



called Wholesale Solar, founded in 1992. It has offices in Ashland, Oregon, and Mt. Shasta, California. In spite of its name, which will soon change under VandeWiel's leadership, Wholesale Solar is not a wholesale business. This company sells PV panels from a variety of major manufacturers, all carefully vetted, and specializes in supporting do-it-yourself solar projects, off-grid applications, and, increasingly, systems for farms.

"We are focused on support and design, and provide solar systems completely customized to the customer's needs," VandeWiel said. "We can recommend installation for off-grid and grid-tied residential and light commercial systems."

He spoke enthusiastically about heat pump type water heaters, such as those made by the A.O. Smith Corporation and Rheem Manufacturing Company. A heat pump water heater uses an evaporator containing a refrigerant that absorbs heat from the surrounding indoor air and transfers that heat to water in the tank through a condenser coil. Think of it as refrigeration in reverse.

"The heat pump is very efficient," VandeWiel said. "You only need about two kilowatts for a heat pump to do its job. Currently a mid-end to higher-end PV panel, 72 cells, is about 400 watts, so you need six of those and a 2-kilowatt inverter. A heat pump water heaters costs about \$2,000. If you want to go solar, you're talking about four panels and an inverter. That is, including installation, another \$2,000, so for \$4,000 you have a complete working system."

Zook gave an example of a system using 3-6 solar PV modules. The power comes down off the roof through a disconnect controller and into a standard electric heating element in a hot water tank. With an electric, or electric heat pump type water heater, a single tank is most often used. However, if the home already has a propane water heater, a separate electric tank is installed, to preheat the water before it enters the standard propane or on-demand hot water tank (which can also run on propane). This preheating means far less propane would be needed, thereby saving money.

The industry is always ripe for innovation. A company called Next Generation Energy LLC offers the Sun Bandit® water heater for off-grid use. Its glass-lined and heavily insulated stainless-steel tank, in capacities ranging from 30-119 gallons for electric or in the case of propane, 100 gallons with a 76,000-Btu backup burner. The Sun Bandit tank can be used as either the primary tank or preheater. CyboEnergy, Inc. offers a patented solar power Mini-Inverter called the CyboInverter H Model for customers who are completely off the grid. Midnight Solar, Inc. is becoming an industry leader by producing innovative and cost-effective AC and DC disconnect boxes, along with other products used for alternative energy systems.

The solar scene began to change in about 2012. As interest increased, the stage was set for prices of PV panels to decrease. "The manufacturers needed demand for reaching economies of scale, and the market back then seemed to be waiting on price and grid parity," Zook said.

VandeWiel stressed how PV solar panels have dropped in price while increasing efficiency. "That means cloudy skies are not so much the biggest differentiators," he said. "Since the price of these panels went down so dramatically, what people do is oversize their solar installation. So you put around about 30% more on your roof, or wherever you want them, than you actually need. It's very pragmatic because, in general, the panels aren't that expensive anymore."

"What can be done with PV solar would not have been even



Belmont Solar offers customized solutions to meet their clients' needs. Zook shared this photo of a recent installation that combined flat plate solar thermal collectors with PV solar panels.

imagined ten years ago," Zook said, noting that the technology is improving by 5% *per year*. He pointed out that these days, an investment of \$10,000-\$30,000 will buy a system of double or triple value compared to what it would buy 10 or 15 years ago. He expects this trend to continue, as battery storage and other aspects keep improving. He would like to see an increased willingness for people to invest in what is sure to benefit them greatly.

He summed up the three things his company constantly strives to provide, using the letters P.E.N.—performance, education, neatness. His systems definitely perform well and are neat, but he says education is the greatest challenge. The basis for everything Belmont Solar is, believes, and does, is the continuing fascination Zook has had with solar energy since his teens. "Solar is wonderful, *increasingly* wonderful," he said.

Resources for readers:

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Sunbandit® Solar Hybrid Energy Systems

Phone (800) 741-0247 Ask your local hot water tank retailers for information on **A.O. Smith** and **Rheem** products.

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