Youth Education & Interpretation It's in Our Nature

Energy Producing Systems: Solar Power

Energy from the Sun falls on our planet on a daily basis. The warmth of the Sun creates conditions on Earth conducive to life. The weather patterns that occur on the Earth are driven by the Sun's **radiant energy**. Step outside on a sunny day and one is instantly aware of the power of the Sun. Spend too much time out in the Sun and this energy can actually burn your skin as effectively as an open flame! The Sun drives the process of **photosynthesis** that all plants depend on. The Sun is a virtually inexhaustible supply of energy. It is a gigantic continuous **nuclear fusion reaction** that has been on going for the last 5 billion years. Humans have recently developed technology to directly tap the Sun's energy, although, in many ways we have been using the Sun's energy all along. The energy we get from our food is derived directly or indirectly from plants and most life forms on this planet owes their existence to the Sun.

Solar energy technologies have significantly improved since their introduction and have decreased in price. These systems are more efficient, reliable and less expensive. **Solar energy systems** do not produce air or water pollution during operation, can be applied in remote locations and are a renewable source of energy. Some solar energy systems convert the Sun's radiant energy to **electrical power** that can be used for heating and cooling and even have applications in our transportation systems. As our need for energy increases and our ability to use fossil fuels decreases, solar energy will provide a **renewable energy source** to meet our future energy needs.

Types of Solar energy Systems

Photovoltaic

Photovoltaic (PV) cells are designed to generate electrical power directly from sunlight. **Solar photovoltaic (PV) systems** have no moving parts, require very little maintenance, do not produce pollution or consume water during operation. Modern PV systems can covert around 15 to 20 percent of the Sun's energy to electrical power. Some experimental systems have reached as high as 46 percent! Most PV systems are made of a series of photo-cells constructed of thin layers of silicon. Sunlight is composed of **light energy** in the form of photons. When these photons strike the silicon layers of a photo-cell it bumps free electrons generating an electrical current. Photovoltaic systems can be easily expanded to generate the amount of electricity required for a given application and can be specifically tailored by adding or removing photo-cells. Small PV systems can be used to power stop lights, streetlights or small water pumps in remote locations. Solar PV arrays can be used to provide larger electrical needs such as for a school building or residential home. These systems can use batteries to store the electricity generated during the day providing power for nighttime electrical needs or when cloud cover reduces total sunlight. Solar PV systems are one of the best **distributed energy generation** resources. These systems can use a net metering approach which allows the electric meter to turn backwards when excess power is being generated. Small photovoltaic systems have been in widespread use in calculators and other small electronic devices for some time.

Solar Thermal

Solar Thermal Systems are designed to concentrate the Sun's energy and convert it to **thermal energy**. Examples can be as simple as a roof mounted hot water tank painted black to absorb sunlight or as sophisticated as an entire system of Sun-tracking parabolic mirrors generating heat to produce steam from water.

One of the most common uses of solar-thermal technology is in domestic water heating. Hot water heating is often the second leading home energy expense. In general these solar systems use a network of liquid filled tubes painted black to absorb sunlight and contain either water or an appropriate thermally conductive liquid (ethylene glycol) to carry the captured heat to its application. This approach can also be modified to meet residential space heating needs by storing the hot water generated during the day in tanks or a plumbing network located inside the home. This type of system is designed to release heat during the night. Heating of swimming pools is an excellent application for solar-thermal technology. These relatively simple systems are designed to heat the pool water during the day and use the thermal mass of the swimming pool to retain the heat during the night.

Large, high-temperature CSP systems such as this tower array can heat the central tower to over 1,800°F!

Advanced solar-thermal systems, also known as **concentrated solar power** (CSP) can be designed that utilize large grids of mirrors or lenses to concentrate the Sun's energy. There are three major CSP design types. Linear systems use lines of parabolic or flat mirrors directed at lines of carrier fluid pipes. Dish engine systems use mirror-covered, Sun-tracking dishes (think satellite dish) which direct solar energy to a collector attached to each dish. Dish engines are the most efficient solar technologies currently in existence. The final major design type is a tower array such as the one shown to the right. With all designs, captured solar energy is used either to directly heat water to steam or to heat a carrier fluid (often a molten salt or oil) that is then circulated through a boiler to generate steam. The resulting steam can then be used to drive **turbine** systems to generate electricity or to provide mechanical power using a steam engine system. The heated working fluids can also be stored until night or other times of limited solar energy. Significant academic and government investment from 2010 to 2015 decreased the price of CSP electricity by 36 percent to $0.12 per kWh with the eventual goal of $0.06 by 2020.

Passive Solar

Large windows and light deflecting fins work together on the Lewis and Clark State Office Building to provide a brightly lit environment that does not heat up during the summer.

One of the simplest ways to use the power of the Sun is in building design. Most homes can be designed or modified to take advantage of sunlight. This is known as **passive solar design**. Half the energy used by an average residential home goes toward heating and cooling needs. Solar energy can be used to heat buildings by using south facing windows designed to let the Sun's warmth in during the winter months. Thick foundations and walls are used to store the Sun's thermal energy and release the heat during the night. During the summer roof overhangs, shutters, glazes and trees can be used to deflect solar heat helping to keep a building cooler. In areas with significant numbers of cloudy days, buildings can still use sunlight for passive lighting needs. Schools, industries and commercial businesses that are occupied mainly during daylight hours can especially benefit from passive solar lighting and heating. Passive solar lighting can be a major consideration in commercial and residential buildings where 10 percent of all electricity consumption in the U.S. went to lighting in 2015. Tests conducted by the National Renewable Energy Laboratory indicate that passive solar design buildings use up to 50 percent less energy to heat than conventional buildings. In most cases passive solar homes are no more expensive to construct than traditional designs. Such homes often offer a more open and pleasing floor plan, reduced indoor air pollution and significantly reduced energy consumption. The Lewis and Clark State Office Building in Jefferson City is an example of a building which utilizes passive solar design.

Where do Solar Systems Work?

Passive solar lighting is applicable in any location in the world and can significantly reduce the energy required for daytime lighting. Worldwide more than 1.2 billion people still do not have direct access to electricity. The cost of connecting remote or rural areas to the standard electric grid system is often far more expensive than installing solar systems. A significant advantage of solar power is the ability to provide stand-alone power for local applications. The number of sunny days available can be a factor for practical application of photovoltaic and solar-thermal systems. The actual amount of sunlight required depends on each specific solar application. The brightest opportunities for solar power exist in the sunbelt states of Arizona, Nevada, New Mexico and parts of Texas and Southern California.

Solar opportunities are also available throughout the Midwest and Mountain states. In these locations passive solar building designs are especially useful and can significantly reduce energy costs associated with heating and lighting. The continually decreasing cost of solar technologies make them more feasible for residential and commercial consumers. Advances in net metering further add incentives for private residential and commercial solar installations.

Specific Characteristics of Solar Power

Seasonal variations and occasional cloudy days do affect the availability of solar energy. Independent residential photovoltaic solar systems often use a system of batteries to store electrical power generated during the day for use at night or in the event of persistent cloudy days. Large utility-level solar applications can solve the intermittent characteristics of solar power by using pumped storage systems or special working fluids like molten salts with CSP systems. Solar power can also be used to split water in order to generate hydrogen gas by breaking the bonds of water molecules releasing hydrogen, which is a fuel source that can be stored and distributed in a manner similar to existing systems for natural gas.

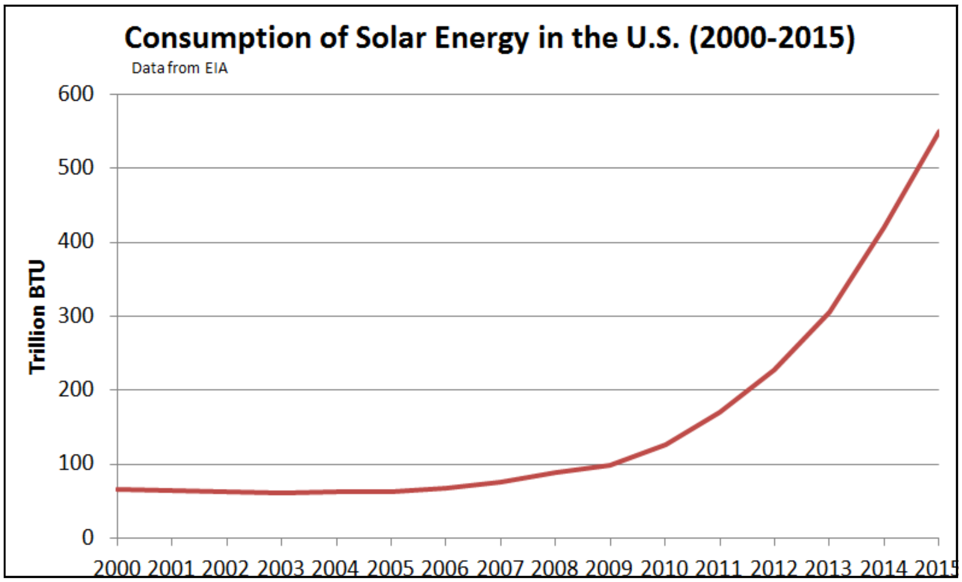
While early solar panels installed on the roofs of buildings tended to have a large visual impact, new solar panel designs have been incorporated into roof shingles. This system looks similar to the roof of a home using a conventional power system. Other solar technology developments are rapidly advancing such as solar roadway panels which can be illuminated to show lane lines, indicate hazards ahead, heat to melt snow and ice, and generate electricity.

The Future of Solar Power in Missouri

The cost of capturing solar energy has dropped dramatically in recent years. From 2010 to 2015 the cost of installing solar arrays decreased 54% for utility, 63% for commercial, and 55% for residential installations. As a result solar energy production and consumption has grown drastically across the U.S. in recent years and is projected to increase even more. Due to its intermittent nature, solar can not currently compete with coal, natural gas, and nuclear to produce baseload electricity. It is also still somewhat dependent upon government subsidies to be commercially viable. However, with continually decreasing costs and increasing efficiencies, solar will only increase in its capability to be a reliable complement to standard electricity production.

Missouri currently has 136 MW of solar capacity, 19th in the country. PV systems are currently used to pump water in remote locations, provide power for traffic lights, provide power for telecommunication towers and supplemental residential power. The state is expected to install 325 MW during the next five years, ranking 27th in the country, but the potential is much greater. It is estimated that Missouri has a greater potential for solar energy than the entire country of Germany—which currently leads the world in installed solar power capability. Missouri will have one of the earliest solar roadway pilot projects along its historic Route 66 near Conway.

Missouri currently derives about 83 percent of its electrical needs from burning coal. Through the use of passive solar home designs, photovoltaic systems and solar thermal hot water heating systems a modern Missouri home could greatly reduce its reliance on fossil fuels. The use of solar power systems and designs could not only help Missouri reduce the flow out of state of dollars spent on energy, but would reduce the pollution associated with current levels of fossil fuel use.



Glossary

Concentrated solar power: More complex utility-scale solar thermal systems which use a series of mirrors to concentrate solar energy on a fixed location to heat a carrier fluid to heat water to generate steam to power turbines and generate electrical power

Distributed energy generation: The use of small localized power production systems to generate electrical power usually for a specific on-site application and sometimes to the larger electric grid. Solar photovoltaic systems and wind power systems are common distributed energy generation methods

Electrical power: Electrical energy used to conduct work; the measure of the rate of electrical energy used by a circuit. This is usually measured using a unit called a Watt (W)

Light energy: See radiant energy

Nuclear fusion reactions: The process of combining the nuclei of atoms to release immense amounts of energy

Passive solar design: Architecture, landscaping, and other design methods which capture and utilize solar thermal and radiant energy to naturally heat and light homes

Photosynthesis: The biological process by which certain organisms (primarily plants) convert light energy (primarily from the Sun) into stored chemical energy

Radiant energy/Radiation: Transmission or emission of kinetic energy as waves through space. Light is one type of radiant energy. Electromagnetic radiation can be classified by the electromagnetic spectrum

Renewable energy source/fuel: Primary energy source that can be replenished at an equal or greater rate to its consumption; sustainable energy source

Solar energy systems: Energy generation methods which harness the radiant and thermal energy of the Sun. The two primary types of solar energy systems are solar photovoltaics and solar thermals

Solar photovoltaic systems: Solar energy system in which solar light energy in the form of photons passes through glass and hits a semiconductor which then excites and displaces electrons which are conducted into an electrical current to generate electrical power

Solar Thermal Systems: Solar energy system in which thermal energy from the Sun is utilized to heat water or other liquids. Larger scale systems are known as concentrated solar power systems

Thermal energy: Kinetic energy associated with the movement of molecules; commonly produced from combustion. Heat is the transfer of thermal energy from bodies of higher kinetic energy to lower kinetic energy

Turbine: A device which harnesses the kinetic energy of an incoming force (often steam, water, or air) to spin rotors and create mechanical power. In electrical power generation the spinning motion of turbine rotors is used to turn generators which use rotating magnets inside copper wire to create an electrical current

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