PEP

POWER EFFICIENCY PROJECT

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How Solar Energy Is Collected and Distributed

What is Solar Energy?

We know **solar energy** as a source of light and heat. Solar radiation is radiant energy emitted by the sun in the form of **electromagnetic waves**. The sun emits a vast amount of solar energy, but once that energy begins to travel through the Earth's atmosphere, the solar rays are absorbed by ozone, carbon dioxide, and other compounds and scattered by dust and water molecules. Incredibly, the amount of solar radiation hitting Earth in one hour is still enough to produce more energy than the entire world population used in 2001.[1] A variety of technologies and processes are used to collect and utilize solar energy.

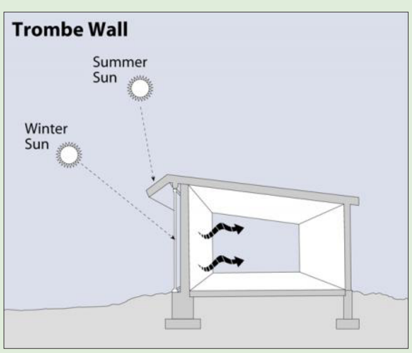

Figure 1:

A trombe wall.

Source: http://energy.gov/energysaver/passive-solar-home-design

Passive Solar Technologies

Passive solar heating optimizes the design of a building to use natural heating effects of solar energy in the winter and reject solar heat in the summer, which reduces energy costs year-round. Elements of passive solar heating include properly oriented windows and thermal mass materials that absorb heat from sunlight in the winter and absorb warm air from the house in the summer. Distribution mechanisms like **conduction**, **convection**, and **radiation** can be cleverly manipulated to distribute solar heat around the building; and control strategies like operable insulating shutter/awnings, electronic sensing devices, and differential thermostats.[2] The **trombe wall** is an architectural feature that takes advantage of the differing angles of the sun during the summer and winter months to regulate the solar heat entering the building (**Figure 1**).

Concentrating Solar Thermal Technologies

Concentrating solar thermal (CST) technologies were developed as a way to make traditional production of electricity more renewable. The CST process uses solar heat instead of fossil fuels to boil water and generate steam to drive a turbine-generator – a diagram of this process can be seen in **Figure 2**. The system consists of **concentrators**, usually mirrors, which direct the solar heat at a fluid medium to generate steam, turn a turbine, which converts the **mechanical energy** of the spinning turbine to **electrical energy**, and produce electricity.[3] There are many versions of this design which differ based on the concentrator

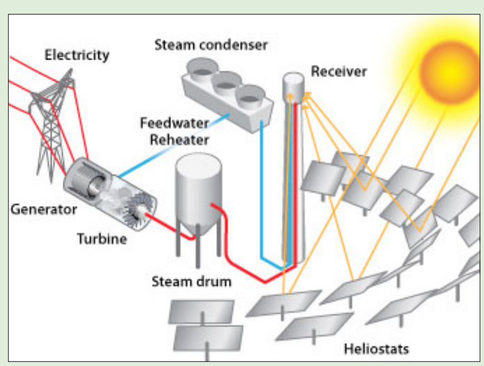

Figure 2:

Concentrating solar thermal power plant grid connection.

Source: http://www.eia.gov/todayinenergy/detail.cfm?id=530 orientations and optional tracking technology: a linear system, a dish system, and a power tower system. Solar power generated through concentrating solar thermal technology is produced in alternating current (AC) electricity so it can be connected to the grid directly.[3]

Solar Photovoltaic

A solar cell, or **solar photovoltaic** (PV) cell, is the technology most people think of when discussing solar energy. A photovoltaic system converts **light energy** to **electrical energy** using a **semi-conductive** material, usually silicon.[4] Generally, a solar PV system is comprised of a group of solar panels made up of interconnected solar cells.[5] **A solar cell** is made up of a semiconductor wafer treated with chemicals to form an electric field, with one side being positively charged and the other being negatively charged. When the wafer is placed in the sun, the **photons** of the light energy excite the **free electrons**, which travel through a conducting wire from the negative side to the positive side. When the conductors are connected to an external load (**Figure 3**), electricity flows in the circuit.[4] Solar power generated by a photovoltaic system is produced in **direct current (DC) electricity** and can be stored in batteries in an off-grid system. However, if a PV system is connected to a local utility grid, the power needs to be converted into alternating current (AC) electricity by an **inverter** before being distributed.[5]

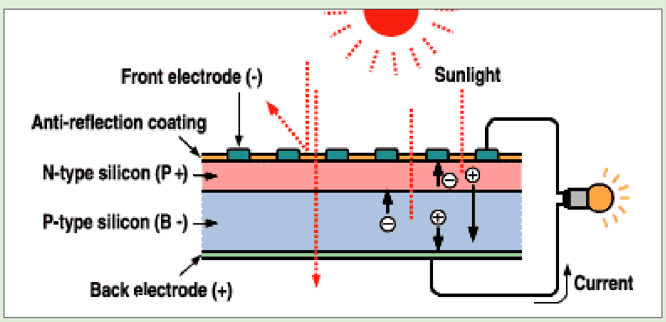

Figure 3:

Diagram of solar cell connected to an external load.
Source: http://www.bls.gov/green/solar_power/

Figure 4:

Solar PV System installed at Peeper Ranch in Lenexa, KS.
Source: http://kansasenergy.org/solar_photos.htm

Solar Energy in Kansas

The most common solar energy systems currently found in Kansas are photovoltaic panels, an example of which can be seen in **Figure 4**. From implementing solar panels onto the roofs of personal homes, schools, and community buildings to utilizing solar panels for off-grid purposes, Kansas is growing in solar energy generation.[4] In 2011, the Kansas Department of Transportation reported 93 solar PV installations used along state and U.S. highways. These installations range in capacity from 20-40 watts and are used to charge batteries which power a variety of traffic counters/signs and weather stations.[6]

Curriculum & Activity Links

Primary

- Solar Energy Fact Sheet, Grades K-2, http://www.need.org/files/curriculum/infobook/SolarP.pdf
- Solar Energy Fact Sheet, Grades 3-5, http://www.need.org/files/curriculum/infobook/SolarE.pdf
- Hands-On Activity: Build a Pizza Box Solar Oven, Grades K-4, https://energy.gov/sites/prod/files/2015/02/f20/PizzaBoxSolarOven.pdf
- The Sun and its Energy: Teacher Guide, Grades K-2, http://www.need.org/files/curriculum/guides/The%20Sun%20and%20its%20Energy.pdf

Intermediate

- Solar Energy Fact Sheet, Grades 5-8, http://www.need.org/files/curriculum/infobook/SolarI.pdf
- Hands-On Activity: Build a Pizza Box Solar Oven, Grades 5-8, https://energy.gov/sites/prod/files/2015/02/f20/PizzaBoxSolarOven.pdf
- Energy from the Sun: Teacher Guide, Grades 6-8, http://www.need.org/files/curriculum/guides/EnergyfromtheSunTeacherGuide.pdf
- Exploring Solar Energy Student Guide (7 Activities), Grades 5-8, https://www1.eere.energy.gov/education/pdfs/solar_exploringsolarenergystudent.pdf

Secondary

- Solar Energy Fact Sheet, Grades 9-12, http://www.need.org/files/curriculum/infobook/SolarS.pdf
- Hands-On Activity: Build a Pizza Box Solar Oven, Grades 9-12, https://energy.gov/sites/prod/files/2015/02/f20/PizzaBoxSolarOven.pdf
- Exploring Photovoltaics: Teacher Guide, Grades 9-12, http://www.need.org/files/curriculum/guides/Photovoltaics%20Teacher%20Guide.pdf

References

1. Tsao, Jeff, Nate Lewis, and George Crabtree. "Solar FAQs." Vital 5.3 (2006): 10. Sandia National Laboratories. Sandia National Laboratories, 20 Apr. 2006. Web. 27 Mar. 2017. http://www.sandia.gov/~jytsao/Solar%20FAQs.pdf
2. "Passive Solar Home Design." US Department of Energy. Web. 09 Sept. 2016. http://energy.gov/energysaver/passive-solar-home-design
3. "Concentrating Solar Power Technologies Offer Utility-scale Power Production." U.S. Energy Information Administration. 16 May 2011. Web. 09 Sept. 2016. http://www.eia.gov/todayinenergy/detail.cfm?id=530
4. Hamilton, James. "Growth of Solar Power in the United States." U.S. Bureau of Labor Statistics. U.S. Department of Labor. Web. 09 Sept. 2016. http://www.bls.gov/green/solar_power/
5. "Solar Photovoltaic." HK RE Net. Hong Kong Electrical and Mechanical Services Department. Web. 09 Sept. 2016. http://re.emsd.gov.hk/english/solar/solar_ph/solar_ph_to.html>
6. White, Scott W. "Solar Development in Kansas." Kansas Energy Information Network: 25 Sept. 2012. Web. 9 Sept. 2016. http://kansasenergy.org/documents/Solar%20Development%20in%20Kansas_092412.pdf

For more information on solar energy is collected and distributed, contact Kansas State University Engineering Extension at 785-532-4998 or dcarter@ksu.edu.