LESSON

Fundamentals of Solar Energy

BIG IDEA(S)

Solar energy can be captured and converted into other forms of energy in biological and man-made systems.

OBJECTIVES

Students will be able to:

- Recall and share basic information about the history of solar power
- List and explain the differing ways that solar power is captured (fossil fuels, passive shelter design, and solar panels)
- Explain how electrons are involved in solar energy transformations
- Compare the possibilities and limitations of using solar energy

BRIGHT SOLAR FUTURES

SOLAR

TOPIC OF STUDY

Energy Systems

2 HOURS

TASK LIST SUBCATEGORY

102 Describe how energy is fundamental to our everyday lives

104 Describe sources and uses of energy

107 Describe the fundamentals of solar energy

702 Recognize and use electrical concepts, terminology, relationships, and formulas

STANDARDS

PA/SDP

3.2.12.B3. Describe the relationship between the average kinetic molecular energy, temperature, and phase changes.

3.2.10.B2. Explain how the overall energy flowing through a system remains constant; Describe the work- energy theorem. Explain the relationships between work and power

3.2.C.B3. Describe the law of conservation of energy.

KEY TERMS

solar power
solar energy
sunlight (irradiance)
arrays
panels
silicon
solar radiation
pyranometer
cells
electrons
valence
AC and DC
photons
semiconductors
inverters

INSTRUCTIONAL

TEXTS/REFERENCES

Solar Photovoltaic Basics, Sean White, 2019, pp.1; 43-59

Solar Electric Handbook: Photovoltaic Fundamentals, SEI, 2013. pp 40-46

MATERIALS NEEDED

Teacher Presentation: Instructor will deliver a talk based on the resource information provided below

Content:

- Use of solar panels and inverters in the lab
- How solar panels work:
  How do solar panels work? (Physics of Solar Cells)
- Overview:

Technology: Teacher computer, projection device, student computers and telephones as needed

IMPLEMENTATION (LESSON PLAN)

ENGAGE

- In pairs, have students draw a diagram of the sun's rays, how they think they might be collected, how they are changed into electric power. Explain that they should make up any explanation and that this is a way to make strong connection to the material (prediction, recall of knowledge, synthesis) **AND/OR**
- Pictures of pieces of bread, a cell phone, and an e-bike will be shown to students. They will have to choose one to explain how that thing gets the energy that is stored inside. Choose volunteers to explain their reasoning for each and get class input to come up with the best agreed upon explanation.

SUN ENERGY: Provide background information as appropriate

- The sun is the main source of the energy that powers life on earth. It gives the energy necessary for plants and food to grow. It provides the temperature environment that makes life possible. During the past three hundred years, humans have experienced a huge improvement in the standard of living for most people. This improvement was powered by carbon based energy sources such as wood, coal, and petroleum. Even these fuels are essentially stored forms of solar energy, where the solar power used to create the plants they came from is released when they are burned. They are sometimes called fossil fuels since the plants that formed them were crushed beneath the earth and compressed for millions of years, in order to form the fuels we then mine from the earth.
- Solar energy is also utilized in well designed homes and buildings through the use of what is called passive solar design. We experience the greatest amount of heating from the sun when it is highest in the sky, during the middle of the day. At that point the sun is seen to be in the south. Buildings utilizing passive solar design are positioned so that sunlight comes in through south facing windows and the heat from it is captured by materials such as stone that can store it and radiate it back into the building's interior. Well designed passive solar buildings also are well sealed and well insulated to keep the solar heat gain from escaping the structure to the outside air.
  - Solar Power is measured in power per unit area and most often in watts per square meter
  - Solar Energy. Since power x time + energy, then solar power x time = solar energy

SOLAR HISTORY

- Over the last 130 years, however, another method of using the energy from the sun has been developed. In 1883, an American inventor named Charles Fritts developed the first solar panel. By taking a layer of the element selenium and coating it with a very thin layer of gold he was able to generate a small electrical current when the material was placed in the sun. These first solar panels were not at all efficient. They could only convert about 1% of the energy hitting them into electrical energy.
- Then in 1941, Russell Ohl used silicon for the basis of panels that were 5% efficient. Since then, many improvements have been made and now the average solar panel sold operates at about 17% efficiency and they are still improving.

EXPLORE

Show this YouTube segment on solar panels twice - once all the way through and then stopping as students have questions. Students should be cautioned that they won't necessarily understand every bit of the video but that is ok. Instructor will show the YouTube segment explaining inverters. Instructor will point out the parts of the actual solar panel and inverter. How Do Solar Panels Work? (Physics of Solar Cells)

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IMPLEMENTATION (LESSON PLAN) - CONTINUED

EXPLAIN

- Here is a more in depth description of **how solar panels work**. Light is a form of energy. The particles that carry the energy of light are called photons. In certain materials, the electrons in the outermost shell of their atoms can be made to escape from the atom if they are hit by photons. Other materials are in need of electrons in their outer shells. The difference between the two can be utilized to cause an electric current flow. We can tell which elements tend to need electrons and which tend to lose electrons by their position on the periodic table. Elements on the periodic table are organized according to the number of electrons they have in their outer shells.
- Phosphorus and boron are typical materials that have the tendencies just described. In a solar panel, thin layers of silicon, which is a poor conductor, are coated or doped on differing sides with these two types of materials. When hit with light, the silicon becomes an area where electrons traveling between the two doping elements collect and can be tapped off as current.
- These techniques are used to produce small solar cells. Solar cells are then combined to make solar panels. And finally, for most large scale uses, many panels are wired together into a solar array.
- Solar panels produce direct current. As we learned in the unit on power generation and transmission, alternating current more easily allows the voltage to be stepped up for transmission over long distances and household use. To make this change, a device called an inverter is used. It converts the DC power produced by solar panels into AC power.

EXTEND

- Extend the lesson by presenting how a power inverter works https://www.youtube.com/watch?v=ilqhAX0l7lI
- Teacher will use the solar panel and inverter project supplied by SolarStates
- There are many practical considerations involved in constructing a solar array. The panels need to be oriented at an angle that takes best advantage of the sun's rays. In addition, attention must be paid to any sources of shade that might block the sun at various points during the day. Some solar panels are mounted on supports that move to stay aligned with the sun as it changes position in the sky. In actuality it is not the sun that is moving but the fact that the earth rotates that makes the sun appear in different positions in the sky.
- Until recently solar energy couldn't compete with electricity generated by different means. Solar panels used to be much more expensive than they are now and had the disadvantage of not producing power during the night or during periods of the day when the sun was blocked by clouds. Now batteries can help store power from solar panels to bridge times when current isn't being generated. Solar panels are particularly advantageous during the daylight hours of peak electrical demand, when traditional sources of electricity are most expensive. Also, solar power does not require an expensive and potentially unreliable transmission grid to bring centrally produced power to dispersed users. But perhaps the biggest advantage of solar is that, unlike fossil fuels, it does not produce CO2, the greenhouse gas responsible for global warming.

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