104 Period 15: Solar Energy – Consequences of its Use

1. a) What is insolation? b) What affects how much insolation a given region receives? Examine the solar insolation map of the U.S. in the classroom. c) Which regions tend to have greater insolation? Why?

   a. Solar insolation is the amount of solar power passing through a given area. (Note: insolation should not be confused with insulation.) b. The latitude, the time of year, the time of day, and the amount of cloud cover all affect the solar insulation. c. The southwestern portion of U.S. receives the most solar insolation. Regions nearer the equator (south in the U.S.) receive more insolation than regions near the poles. Drier regions (such as the desert southwest) receive more insulation than wetter (cloudier) climates (such as that in the southeast).

2. a) What is the greenhouse effect? b) How does the amount of energy reaching the Earth compare with the amount of energy leaving the Earth? c) How does the type of energy reaching the Earth compare with the type of energy leaving the Earth?

   a. All objects give off electromagnetic radiation with the range of frequencies proportional to their temperature. Energy given off by the Sun is primarily in the visible light region of the electromagnetic spectrum, while energy given off by the much cooler Earth is in the infrared region. Gasses in the atmosphere allow incoming visible light to pass through but absorb outgoing infrared radiation. This is called the greenhouse effect. The greenhouse effect is a perfectly natural phenomenon that keeps the temperature of the Earth's surface comfortably warm. (Without this effect, surface temperatures would be much colder on average and would experience severe fluctuations from day to night.) Often the term "greenhouse effect" is used to refer to the "enhanced greenhouse effect" in which human activities lead to unnaturally high concentrations of greenhouse gasses such as carbon dioxide, methane, CFCs, and water vapor. It is believed that such high concentrations of these greenhouse gasses could lead to global warming.

   b. If the average temperature of the Earth is to remain constant over time, then the amount of outgoing energy must be equal to the amount of incoming radiation.

   c. The sun gives off energy centered in the visible light region (and also gives off significant amounts of infrared and ultraviolet radiation). The Earth gives off primarily infrared radiation.

3. List the advantages and disadvantages of the various energy sources discussed (fossil fuels, nuclear, tidal, hydroelectric, geothermal, wind, biomass) Which are ultimately forms of solar energy?

This could be rather complicated since the advantages and disadvantages of each are relative. Fossil fuels have the advantage of currently being cheap and rather plentiful. On the other hand, supplies are believed to be limited, mining and drilling for coal, oil and gas can be environmentally destructive, burning fossil fuels creates pollution and releases greenhouse gasses.

Nuclear power plants do not release greenhouse gasses or give off pollution. There is a safety problem with older nuclear power plants and all nuclear power plants generate radioactive waste, a problem for which there is yet no feasible solution.

Tidal, hydroelectric, geothermal, wind, and biomass energy sources do not produce pollution but can still harm the ecosystem in their implementation (damming rivers can kill off fish that spawn upstream, drilling geothermal wells may be a threat to certain ecosystems such as the rain forests in Hawaii.)

Solar energy seems to be the most environmentally friendly, but the manufacturing of solar cells can involve CFCs which destroy the ozone layer. Furthermore, it is still too expensive to be in many instances. Hopefully, solar energy will soon become much cheaper and its advantages will outweigh its disadvantages.

All of the above energy sources are ultimately forms of solar energy except nuclear, tidal, and geothermal.

5. At your tables you have parabolic solar reflectors, spotlights, and black copper cups to hold water which you can try to boil. a) What is the purpose of the reflector? b) Does it matter where you put the light or the cup of water? If so, where should you put them? If not, why not?

a. The purpose of the reflector is to concentrate the light. b. If the light is sufficiently far away so that the rays of light coming from it are essential parallel (such as the case with the Sun's light), then the position of the light does not matter. The reflector has a focal point, however, and the position of the cup does matter. A small piece of paper can be centered in front of the reflector (with the light on) and moved closer and farther until the light appears to be concentrated on it. This is where the cup should be placed.

6. Compare the solar water heater we have in class to those you see in the videos. a) Would it make economic sense to use the type we have in class in a location in Ohio? b) How should a solar heater be positioned in Ohio? c) If you could make it movable, how should it move throughout the day or throughout the year?

a. While a solar home would be most effective in a sunnier region (such as southwest U.S.), many features of the solar home would make economic sense for a home built in Ohio. The cost of any feature must be weighed against its potential savings to determine its payback time (the time required for the feature's savings to cover the initial cost).

b. Chapter 14 of the textbook (page 172) shows a diagram of how a solar collector should be positioned (at 40 degrees since Columbus is at 40 degrees latitude). Note: a 40 degree latitude marker is located with the sundial just to the north of the Main Library here on campus.) c. It should follow the sun, tracking east to west during the course of the day tilting so that the sun's rays are perpendicular to its surface. (Notice that the sun's position above the horizon is not a constant 40 degrees but varies according to the time of day and time of year.

7. Experiment with the devices that run on solar cells. a) How efficient are the solar cells? Connect a 1 watt bulb (flashlight bulb) to a solar cell. b) Can you get it to light using a 100 watt bulb as an energy source? c) using a 150 watt spotlight?

The solar cells we have in class seem to be not much more than 1% efficient. The 100 watt bulb cannot generally make a 1 watt bulb connected to a solar cell light, though only a fraction of that 100 watts is converted into light which actually shines on the solar cell. The 150 watt spotlights concentrate the light to shine in one direction and can make the small bulbs light.

8. Describe the features of a solar home. How can trees or an appropriately built roof overhang save energy? What are methods for storing energy gathered during daylight hours?

Textbook chapter 15 describes the features of a solar home on pages 189-190. Trees or a roof overhang on the south side of a house can shade windows from the direct sun in the summer (when the sun is higher above the horizon), but allow the sun to shine in through windows in the winter (when the sun is lower). A thermal mass may be used to store solar energy gathered during the day for use at night when the temperature drops.