Mapping Insolation Values In Texas

RENEWABLE ENERGY
THE INFINITE POWER OF TEXAS

FOR USE WITH FACT SHEET NO. 12: SOLAR ELECTRICITY WORKS FOR TEXAS

TEXAS ESSENTIAL KNOWLEDGE AND SKILLS

TEKS utilized include: **SCI.** (a) (2) identify components of the solar system...learn how seasons and the length of the day are caused by the tilt and rotation of the Earth as it orbits the sun; (b) 6.2(E) construct...maps...to organize, examine, and evaluate data; 6.5(A) identify and describe a system that results from the combination of two or more systems, such as in the solar system; 6.13(A) identify characteristics of objects in our solar system including the sun; **MATH** (b) 6.2(D) estimate and round to approximate reasonable results; **SOC. S** 6.3(A) create thematic maps...depicting various aspects of countries; 6.5(A) explain factors such as distribution of natural resources that influence...economic development; 6.6(B) describe...the physical processes that produce nonrenewable natural resources; 6.7(A) identify and analyze ways people have adapted to the physical environment in selected places; 6.7(B) analyze ways people have modified the physical environment; 6.7(C) describe ways in which technology influences human capacity to modify the physical environment; **L.A.** 6.13(C) use multiple sources including electronic texts...and print resources; 6.13(D) interpret...sources of information such as maps; 6.13(G) draw conclusions from information gathered from multiple sources; 6.20(D) organize ideas gained from multiple sources...such as outlines, conceptual maps.

OVERVIEW

Students will learn a variety of applications for photovoltaic power. Students will map areas of Texas for solar insolation to learn where photovoltaic power has the greatest potential. The many possibilities for using solar power is a central theme.

TIME FRAME

One 45-minute period

TEACHER GUIDE

Background Information

Fossil fuels captured solar energy millions of years ago and provide most of our energy today. Photovoltaic systems convert solar energy directly to electrical energy. The amount of solar energy reaching the earth's atmosphere is about 1.94 calories per square meter per minute! This number is known as the "solar constant." However, the amount that actually reaches the ground varies depending on weather conditions, the amount of particulate matter and water in the air, and the angle of the earth's surface in relation to the direction of the sun. Most of Texas receives enough sunlight to make using solar energy feasible.

Teaching Instructions

The teacher should read the student activity first. Students can research rainfall amounts throughout Texas to determine where there is less sunlight, in addition to creating a solar insolation map.

Direct the class to read the Student Activity together and lead discussion on each paragraph. Students will need direction on how to proceed with locating their map coordinates. Some examples on a large classroom globe/map will provide them with assistance. Students can work in groups of four, but each student should complete all parts of the activity.

ASSESSMENT ANSWERS

Short Answer Questions

1. Advantages to using photovoltaic systems include creating less environmental pollution, not relying on other countries for energy, no cost fluctuations for energy usage, flexibility, independence, reliability, no transportation or on-going generating costs for the energy, little maintenance required, no need for military protection of resource sites. Disadvantages include storage in stand-alone systems for night use of energy, high initial cost, less efficiency where there is heavy rainfall.
2. Hometown locations will vary.

3. The greatest latitude possible is 90 degrees.
4. The sun is about 93,000,000 miles from the Earth.
5. The Prime Meridian is drawn through Greenwich, England.

Mulitiple Choice Questions

1 b 2 d 3 b 4 d 5 c 6 d
7 d 8 a (best answer) 9 a 10 d

STUDENT ACTIVITY #12: MAPPING INSOLATION VALUES IN TEXAS

Key Vocabulary
define the following terms:
angle of incidence, calorie, electrical power grid, insolation, latitude, longitude, photovoltaic cells, PV module, solar constant, watt

Materials (1 per student)
- map of Texas with degrees of latitude indicated
- colored pencils, green, yellow, & blue

GLOSSARY

angle of incidence – the angle between a ray of the sun's light falling on a surface point and the normal (perpendicular) to the surface

calorie – the quantity of heat required to raise the temperature of one gram of water by one degree centigrade

electrical power grid – a network of high voltage transmission lines distributing electrical power throughout a region

insolation – exposure to the sun's rays (especially for drying)

latitude – angular distance on a meridian; locality defined by parallels of latitude

longitude – angular distance, east or west, measured as the angle between the 2 meridians

photovoltaic (PV) cells – convert sunlight into electricity; made from layers of semiconductor materials (silicon); come from "photo" meaning light and "voltaic" meaning producing electricity

PV module – dozens of PV cells interconnected and sealed to be waterproof

solar constant – the average rate per unit area at which energy is received by the earth from the sun, equal to approximately 1,388 watts per square meter

watt – unit of electrical power (current of 1 amp flowing through a potential difference of one volt); wattage is amount of electric power in an appliance; symbol is w

PERFORMING THE ACTIVITY

An enormous amount of solar energy reaches the earth each day. The sun, which is approximately 93,000,000 miles away, converts hydrogen to helium in its core. Energy from this reaction arrives at the sun's surface and is radiated into space. Enough of this energy dependably reaches the Earth so that life as we know it has been maintained. The amount of energy that reaches the atmosphere, the solar constant, has been measured to be 1.94 calories per square centimeter per minute! Millions of years ago fossil fuels captured some of this solar energy, and we are now using that energy source today. Photovoltaic (PV) systems now convert solar energy directly into electricity. The use of PV is an economical and clean method of electricity production.

Insolation is the measurement for the amount of solar energy reaching the earth. The amount of energy that reaches the earth's surface is dependent on the conditions of the atmosphere and the angle of the surface in relation to the sun. Because the earth is a sphere, the surface angle slopes away from the sun at the poles. The tilt of the earth's axis causing a change in the angle of incidence throughout a year is the reason for the change of seasons.

Finding places on the globe requires some sort of numbering system or grid. Positions are measured in degrees, minutes, and seconds. Latitude is determined by an angle at the center of the Earth measured in a north-south plane pole-ward from the Equator. There is a 90-degree arc between the Equator and the North Pole, and a 90-degree arc between the Equator and the South Pole, so the greatest latitude possible is 90 degrees North or 90 degrees South. Starting at the Equator, equidistant circles are drawn parallel to the Equator and to each other. We call these equidistant circles parallels.

Longitude is the amount of arc created by drawing a line from the center of the Earth to an intersection of the

Equator. Longitude is a measurement of location east or west of the Prime Meridian of Greenwich, England. Longitude measures 180 degrees both east and west of the Prime Meridian, drawn from Pole to Pole where they meet. There are 69.17 miles per degree of longitude at the Equator with 0 miles at the poles.

Create an insolation map and determine which areas in Texas are best suited for production of electricity through photovoltaics. (The areas receiving the greatest amount of solar energy are best suited for photovoltaic production of electricity.) The map already has the degrees of latitude printed to make your task easier.

1. On your map of Texas, plot the following points and mark them as groups "A" and "B"
- Points "A"
  N36, W102
  N34, W101
  N32, W101
  N30, W102
- Points "B"
  N33, W94
  N29, W98
  N27, W100
2. Draw a line connecting all points "A"
3. Draw a line connecting all points "B"

Definition:
Kilowatt hours per meter squared per day = kWh/m^2/day

- The area west of the line "A" receive 4-5 kWh/m^2/day, color this area yellow.
- The area between lines "A" and "B" receive 3-4 kWh/m^2/day, color this area green.
- All the area east of the line connecting points "B" receive 2-3 kWh/m^2/day. Color this area blue.

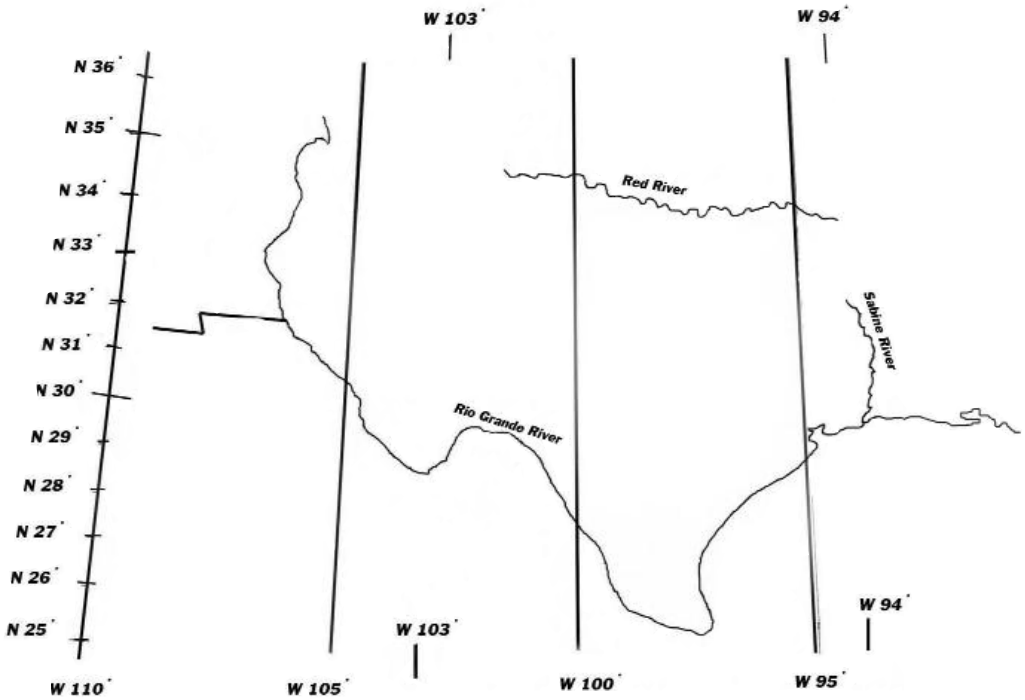
Plot the following points on your map and number them 1-9

1. N32, W106
2. N32, W103
3. N36, W103
4. N36, W100
5. N34, W100
6. N33, W94
7. N32, W94
8. N29, W93 (The Sabine River enters the Gulf of Mexico)
9. N26, W96 (The Rio Grande enters the Gulf of Mexico)

Trace a line between each number. The space between points 5 and 6 must be traced on the Red River. The space between points 7 and 8 must be traced along the Sabine River. The space between points 9 and 1 must be traced along the Rio Grande.

Now locate the following metropolitan areas on your map. Place a dot for each coordinate and label the city. (All longitude and latitude coordinates have been rounded to the nearest whole degrees.)

- Austin N30, W97
- Amarillo N34, W101
- Brownsville N25, W97
- Corpus Christi N27, W97
- Dallas N32, W96
- El Paso N31, W106
- Fort Worth N32, W97
- San Angelo N31, W100
- San Antonio N29, W98



ASSESSMENT

Short Answer Questions

1. List 4 advantages and 3 disadvantages to photovoltaic systems.
2. Locate your hometown on the map and assess its insolation rate for installing photovoltaic power.
3. What is the largest possible number for latitude?
4. How far is the sun from the earth?
5. Where is the Prime Meridian?

Multiple Choice Questions

1. A solar-powered instrument you have probably used is:
   a) a car
   b) a calculator
   c) a washer
   d) an iron

2. PV power currently is:
   a) cheaper than ever before
   b) used in over 400,000 homes
   c) depends on wood
   d) a and b only

3. PV usage is growing:
   a) only in Australia
   b) ten times faster than oil usage
   c) extremely slowly in space
   d) only for producing cars

4. PV is used for:
   a) telecommunications
   b) water pumps
   c) gate openers
   d) all answers a, b, c

5. The greatest site for placing PV modules may be:
   a) caves
   b) Alaska
   c) rooftops
   d) landfills

6. Some small solar electronic devices include:
   a) solar watches
   b) solar calculators
   c) solar battery chargers
   d) all answers a, b, and c

7. One of PV's useful qualities is:
   a) reliability
   b) flexibility
   c) can be used anywhere
   d) all answers a, b, and c

8. You would be willing to use solar power in your future home:
   a) yes
   b) never
   c) only if someone else pays for everything
   d) perhaps

9. The greatest possible latitude is:
   a) 90 degrees
   b) 10 degrees
   c) 50 degrees
   d) 44 degrees

10. Solar energy is less efficient with the presence of:
    a) particulate matter
    b) islands
    c) water vapor
    d) a and c

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Financial Acknowledgement This publication was developed as part of the Renewable Energy Demonstration Program and was funded 100% with oil overcharge funds from the Exxon settlement as provided by the Texas State Energy Conservation Office and the U.S. Department of Energy. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

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