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EXPLORATION 2: SOLAR ENERGY

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Phenomenon

Production of electrical power by solar cells reduces carbon dioxide from coal-burning power plants. However, maximum electrical output from solar cells depends on solar insolation (the amount of available sunlight in watts per square meter), the solar cell–sun angle, and temperature.

Guiding Question

How could solar energy be used to provide electricity in your community?

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Solar Energy

After exiting the wind turbine, Maja escorts your group to a waiting tour bus. “We will be going to *Selterhof Solar Farm* next.”

Your chaperone takes attendance as Maja turns on the microphone. “So, you have seen the *Windpark*, now we will be going to the *Selterhof Solar Farm*. *Selterhof* was a former East German military base, and it was used as a telecommunications center until 1994.”

“To build the solar park, our energy cooperative had to find an eco-friendly way of removing eighty-five buildings and a refueling station. The goal was to restore the original environmental conditions” (Neue Energien Forum Feldheim, n.d.).

“Construction of the solar park started in 2008. Today there are 9,844 photovoltaic modules mounted on 284 trackers. The annual output amounts to 2,748 megawatt hours, enough to supply the annual power requirements of 600 four-person households. All the solar power is sold to the national grid” (Neue Energien Forum Feldheim, n.d.).

“Although we call solar power a renewable resource, it is a perpetual resource. Who can tell me why?”

“We can’t use up the sun.”

“The sun can provide energy for billions of years.”

“Sunlight doesn’t grow back like a tree.”

“Perpetual is forever like the sun.”

Maja nods her head, “Okay so you know that we won’t run out of sunlight for the foreseeable future. The Earth receives 108 trillion megawatt hours of energy from the sun each year. Year to year, this is almost 10,000 times the total global primary energy needs. Every 8 minutes the sun supplies all the energy consumed by humans in one year.”

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“Solar insolation is the term for how much sun reaches the Earth’s surface. Solar insolation is measured in kilowatt hours per square meter. Solar insolation in colder regions of Germany, like the north, average 900–950 kilowatt hours per square meter annually. In sunnier regions, like southern Germany, solar insolation averages 1,000 kilowatt hours per square meter annually. Even with these less than ideal values, Germany can harness enough solar power to supply 6.1% of its total power consumption. This is expected to increase as we take advantage of the higher productivity of solar farms in southern Germany.” “What do you think the advantages of solar power are?” Maja asks.

“Jobs.” “Less greenhouse gases.” “Free sunlight.”

“Now you’re getting it. Yes, new jobs have been created in the manufacturing, installation, and maintenance of the solar arrays. Definitely there is a reduction in greenhouse gas emissions. The estimated savings in carbon dioxide equivalents per year is 4.3 million tons. Although sunlight is free, it does cost money to capture sunlight and convert it to electricity.”

Maja continues, “There is a life form that can directly use energy from sunlight. Any ideas?”

Someone calls out, “Plants!”

“Yes. Plants use sunlight for photosynthesis. As humans, we need photovoltaic technology to harness the power of the sun for electrical power. Okay, we are here, bring everything with you in your daypack.”

Exiting the bus, you see a dirt road cut into a field of grass and wildflowers. Butterflies, bees, and dragonflies flutter, fly, and dart among the plants. Lining both sides of

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the road are large arrays of solar panels mounted on pedestals. You hear birds chirping and, in the distance, the sound of a mower.

"Please look at the diagram of a photovoltaic module on your organizer. Each module has multiple ultra-thin layers of either cadmium telluride or copper-indium-selenide deposited on glass plates made of silicon. Photons that make up sunlight excite electrons in the thin layers of elements on the glass plates. The flow of electrons is electricity. The electricity generated is collected and transferred through wires. The power generated at the solar farm is transmitted to the utility company through the national grid."

"The output from the solar cells is affected by factors like temperature, amount of light, and angle of the cell with the sun. Wiring the modules in series affects voltage, and wiring the modules in parallel affects the current." Maja continues, "Let's test the effect of the angle of the sun on voltage. Find a partner." Maja hands out a small box to each pair of students. Inside the box is a low-voltage solar cell, wires, ruler, protractor, and a voltage meter. "The meter only measures voltage. Your data will be in volts. Connect the wires of your solar cell to the multimeter clips. If the needle goes backwards, just reverse the wiring. See what happens in shade and full sun, and try to find the angle that produces the greatest voltage. Record your data."

"Will we be shocked if we touch the solar cell?" your partner Stephen asks.

"No. The current from a single small cell like this one is low. The peak voltage is less than 1 volt and the current is also low," Maja replies.

Maja and your chaperone check results with each pair. Everyone's graph showed that the highest voltage was produced when the solar panel was at a 90° angle with the sun.

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“Please remember that although it shows us that the highest voltage was produced when the solar panel was at a 90° angle from the sun, here at the *Selterhof*, this is not always true and depends on the time of the day, time of the year, and where in the world you are located,” Maja adds.

“Earlier, I mentioned factors that affect the performance of the solar modules. What are some questions that you could answer using data from an experiment you do in your classroom?”

Mehedy volunteers, “How does the type of circuit affect voltage and current?”

Carla suggests, “How does temperature affect solar cell output?”

Stephen adds, “How does light intensity affect solar cell performance?”

“Those are all interesting questions that could be used to collect data. Please pack up the solar kits and return them to the chest.” Maja secures the kits for the next group.

“Follow me.” Maja leads the group to one of the solar tracker units. “Turn to your partner and describe what you see. Please stay on the road and do not touch the solar modules. The modules produce higher voltages than the small solar cells. Not only could you be harmed, but you could damage the module.”

Stephen turns to you, “it looks like there are 34 modules on the tracker.”

That’s the number I counted,” you reply. “Each module has sixty smaller units.”

“The open space in the center looks like it’s attached to an arm.” Stephen adds, “I think that might move the whole array up and down.”

“It is called a tracker, so that sounds good. I wonder if it’s controlled by a computer?” you and Stephen turn your attention back to Maja. The sound of the mower grows louder and you see someone cutting the grasses and wildflowers under the tracker.

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Maja begins, “Each tracker is programmed to move with the calculated path of the sun during the day. If it is a sunny day, we have maximum power generated. If it is cloudy or raining, production decreases. Of course, no power is produced at night.”

“Why is the man mowing the grass under the tracker?” you ask.

“We need to keep the area around the tracker clear to prevent fires from starting,” Maja answers.

“Why not let the cows graze here?” Stephen asks.

“Cows are a bit large, and they might damage the modules. We tried using sheep, but they seemed to find the vegetation too tough,” Maja explained.

Another student asked, “What about goats?”

“Well, goats are definitely less picky, but there were two problems with goats. First, they chew everything, including the electrical wires. Second, they will likely jump up and damage the solar modules and themselves,” Maja says.

“Why is it safe for the man using the mower?” you ask.

“When the field is being mowed, the tracker is shut down. After the mowing is finished, the tracker is put back online,” Maja answered.

“Okay, let’s finish your organizer while we eat lunch. When the bus returns with the next group, we’ll ride back to the education center for a bioenergy investigation.”

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