2.3 RENEWABLE ENERGY SYSTEMS

This lesson is part of a Connect Science unit. For information about other Connect Science lessons and professional development opportunities, **visit connectscience.org**

Lesson Summary

Students will be able understand how electricity is made from the sun. They will be able to draw diagrams to communicate models of how energy systems work to make electricity. They will be able to use observations from their investigation to support an explanation of how energy might flow through a solar energy system.

(Approx. total time: 90 minutes)

Standards

NGSS Cross Cutting Concepts

Energy and Matter

Energy can be transferred in various ways and between objects.

Systems and System Models

A system can be described in terms of its components and their interactions.

NGSS Disciplinary Core Ideas

PS3.A: Definitions of Energy

Energy can be moved from place to place by moving objects or through sound, light, or electric currents. (4-PS3-2)

PS3.B: Conservation of Energy and Energy Transfer

Energy is present whenever there are moving objects, sound, light, or heat. (4-PS3-2), (4-PS3-3)

Energy can also be transferred from place to place by electric currents, which can then be used locally to produce motion, sound, heat, or light. (4-PS3-2), (4-PS3-4)

NGSS Science and Engineering Practices

Planning and Carrying Out Investigations

Make observations to produce data to serve as the basis for evidence for an explanation of a phenomenon or test a design solution.

Developing and Using Models

Modeling in 3–5 builds on K–2 experiences and progresses to building and revising simple models and using models to represent events and design solutions.

Use models to describe phenomena.

Objectives

By the end of the lesson, students will

Know (facts/information):

- The sun is an energy source that can produce electricity.
- A system is needed to convert an energy source into electricity.
- Models represent ideas.

Understand (concepts, big ideas):

- Energy is present in different forms as it moves through natural and human-made systems.
- Systems thinking can be useful in understanding interactions in the world and designing solutions to challenging problems.

Be able to do (skills/behaviors/scientific and engineering practices):

- Draw a diagram of a simple energy system.
- Give evidence and observations to support their ideas.
- Listen actively to one another.
- Respectfully communicate with one another.

Vocabulary

- **energy source:** a material that can be used to produce electricity or heat for human needs
- **renewable resource**: a resource that can be replaced or restored naturally in a lifetime
- **model**: a representation of an object or a system that is used to communicate ideas

Materials

- Student Materials:
  - Chart paper and markers (optional)
  - Solar Panel with wire and alligator clips
  - DC motor
  - Fan blades
  - Solar Energy System Worksheets
  - Solar Power video https://www.pbs.org/video/nova-solar-power/
  - Active Listening Anchor Chart
  - Respectful Communication Stems Anchor Chart

Instructional Strategies

Link to Prior Knowledge (15 minutes)

Review systems thinking.

Does anyone remember when we explored the lamp as a system? What were the other systems? What are some of the words that we use to describe a system? How were the systems similar? How were they different?

Make sure that students mention each type of system and tell you that the inputs were all the same (electricity), but the outputs were all different. They may also indicate that some components were the same, like the plug and the cord, but other components were different, like having blades or a speaker. For extension, relate the different components to different outputs. Sound came from a speaker, motion came from blades, light came from the bulb, and heat came from a heating element.

Write the words on the board or refer to the word wall as students provide them: energy system, components, evidence of energy (light, heat, sound, and motion), input and output.

Today we are going to talk about a system that produces that input that so many things use—electricity. We are going to learn about the renewable energy system that uses the sun to make electricity. Instead of talking about electricity as an input, today we will talk about it as the output and part of an energy system.

Instruction (60 minutes)

Model the solar power system together.

Get the video about solar power ready: https://www.pbs.org/video/nova-solar-power/

We are going to watch a video about solar power together. I want you to listen closely to how the sun makes electricity. Think about the input, the output, the components and the evidence of energy in the system. Also, think about where energy changes from one form, or evidence to another.

Point to the words written on the board from the prior knowledge. Point to the active listening anchor chart and review what active listeners look and sound like. Play the video to minute 1:22.

Note to teacher about the video: This video about solar energy includes words like electrons and protons. The standards do not require students to understand this level of detail, so you can use electricity or the flow of electricity to refer to this process. It is more important for the lesson to focus on the input, components, where energy changes form, and the possible outputs discussed below.

Can anyone name a component of the solar energy system? Can anyone name the input? What are some evidences of energy? Those are great ideas, but we need to be absolutely sure. Let's watch part of the video again.

Write down their suggestions (any suggestion, right or wrong) on the board next to systems words from the prior knowledge section. Play the video again.

Turn to your partner and discuss how you think this energy system works. Talk through the input, components and output. At what points does one kind of energy change into another kind of energy? (allow 5 minutes of discussion). So now we are going to draw a model together of the energy system and try to explain it. ***A model is a representation of an object or a system that is used to communicate ideas.***

On a whiteboard or chart paper draw the house model from the video add the solar panels and wires going into the house as students suggest them. Go through the suggestion of inputs and components, asking the class if those should be included. Also, ask about the function of each component they mention. Where a function is to convert energy from one type to another, label that also. Label the model as you discuss. Generally, the system should include sunlight as an input, the solar panel, wire, and where energy is converted to one form from another. There is an example of what this may look like at the end of your whole class discussion in the teacher handout for this lesson.

The question of OUTPUT should be discussed after the initial labeling of the more straightforward elements of the system. The output is electricity in the video, but there is no 'evidence' of it as the students currently understand evidence of energy. A better question for this system is where should electricity be present. Discuss how the video claims there is electricity, but that we need evidence of energy to know if there is because we cannot see electricity.

For example, sunlight shows the presence of energy. The solar panel captures sunlight and turns it into electricity, so one change of energy form is sunlight to electricity, but we cannot see that resultant electricity. The wires simply carry the electricity so there is no change of form there, but when the wires are connected to a lamp the electricity turns into light (and a little heat). The evidence that sunlight turned into electricity is the downstream appliance it is hooked up to. That appliance is another point of energy changing forms, but this is not shown on the video. A common emerging student understanding with solar energy is that the light travels through the wires then shines out of light bulb. Going over the changes of forms will help extend their understanding.

Guide a discussion asking: What do you think the OUTPUT of the system is? Ask questions like: What could we look for to see if the solar panel was actually making electricity? If a solar panel is on a house, how would we know it is working? Ask where energy changes forms and label those sites as students explain. Recap with the following:

The system uses sunlight (the input) as an energy source to make electricity. ***An energy source is a material that can be used to produce electricity for human needs****. Sunlight is one type of* ***renewable energy source meaning that we can use it and it will not run out.*** *The sunlight is the energy source, and we know it has energy because we can see the light. The purpose of the solar panel is to make electricity, but electricity is not one of our types of evidence of energy. So think about what kind of evidence we need so we can know that there is energy in the system. Remember that each component has a function, and many components in energy systems function to convert one type of energy to another. The solar panel converts sunlight to electricity. This is why sunlight cannot make electricity without this system.*

Have students model the solar energy system.

Now we are going to build, use, and draw a model of our very own solar energy system. Here are the components that you will use to build your system.

Give each pair of students a solar panel with wires, the motor and the blades and the worksheet. Allow them to touch and talk about what they think each component is and what function each component might have. Then give them time to assemble the components together and draw a model of the system. Have them draw the model on the solar energy systems worksheet. Make sure they include the input, output, and components.

Now your system is put together, is it working? What evidence do you have to support your claim? What do you think we need to get this to work? Right! We need sunlight. We need to go outside to make it work.

While we are outside, I want you to observe like a scientist. Take in details and ask yourself questions as you observe. Ask questions like: When is the system working and when is it not working? Does the system work better under some conditions than other? Make sure that you have specific evidence to answer those question. That evidence comes from your observations. For example, we said that the system is not working inside. What observation did you make that supports what I said? Right! The blades are NOT moving or in other words there is not evidence of energy in the system so I know the system is not working. Take your science notebook with your solar energy system so that you can write down some of your observations.

Take the class outside as the solar panels will not work as well and often not at all in artificial light. Go to each group and ask them how they think the system is working: What is the energy source? What is the purpose of the solar panel and the motor? How do they know when the system is working (what is the output)? For students farther along, have them change the angle of the panel to the sun or cover up part of the panel. Ask them what the different blade speeds mean. Return to the classroom.

Now we are going to complete your model. Your model is not just a picture of the system it should communicate how the system works. Specifically, your model should answer the question: How does the solar energy system make electricity and how do we know it is working?". Make sure to label the input, the output, the name of all the components, where energy changes form, and where electricity is flowing. On the other side of the worksheet write the name of each component and write a sentence about what you think its function might be. Other students are going to be looking at your model so make sure that all your system parts are drawn clearly. When we display the models, use one partner's worksheet to show the diagram and the other partner's worksheet to show the sentences.

Have the students hang their model up around the room for a gallery walk. Ask students to walk around the room with their partners and talk about how some of the models are the same and some are different. Circulate with them and note differences in the models with the students. Bring them back together as a class.

Now that we have seen every group's model, are there any questions that you have about how this system might work? A good way to start this is to would be to use some of the "asking questions" stems from our respectful communication chart.

Point to the respectful communication stems and remind students to use respectful communication as they discuss each other's work. The 'asking questions' section is a good place for students to start. Allow the students to ask specific questions about the models, and allow the other students to answer. Only guide enough to keep them on track with the concept "how does the solar energy system make electricity".

This is an important part of building their conceptions. It is not yet important that they 'get it right'. It is more important that they try to understand, ask question and give explanations on their own. Both the models and the discussion acts as a formative assessment allowing you to see how their ideas about systems and energy are developing. As you guide make sure to look for points to expand on their emergent understanding. When they make claims with no evidence ask them to tell you more, or elaborate on why they are making that claim. Your aim is to bring some of the forming ideas to the forefront of the class so that they can talk through their emerging concepts together much like scientist do. Once you have worked through the major differences seen in the displayed models ask them:

From our discussion about "How does the solar energy system make electricity?", would you want to make any changes to your current model?

Here you may either lead a discussion about what those changes might be, or you can allow them some time to make those changes on their worksheets. If you decide to allow the change making, encourage them to cross out their old ideas with one line so they can still be seen. Tell them that this is exactly what scientist do. They make observations, construct a model, discuss the model with others and come up with new ideas. Scientists are always revising models; no model is perfect.

Closing (15 minutes)

Lead a discussion that recaps the major components of the renewable energy system.

Ask students to have their model drawings out. Start by leading a discussion about the solar energy system.

Some discussion points might be: What is the source of energy? Where does energy change form? Does change of form from one type of energy to another take special components? Why would we want to use solar panels if we already have electricity made in other ways?

Who would like to volunteer to draw a model of the solar energy system and explain how it works to make electricity?

Allow a student to take the class through the system one more time. Either have them draw a new model larger on the board or project their current model to aid in explanation. Ask students to listen actively for use of science words like energy source, renewable energy, component, function, input and output. Once the student is done explaining, ask if the group has anything they would like to add to the explanation.

Alternatively, depending on time and where you think your students are at the end of this lesson, you could draw and summarize the solar energy system on a piece of chart paper. Generally, you might want to say:

The solar energy system that we made uses the renewable energy source, sunlight, to make electricity. First, sun light hits the solar panel and the solar panel turns the sunlight into electricity. Then that electricity flows down the wires to the motor where the motor turns the electricity into a spinning motion. We can easily see the evidence of energy, the output, as the blades spin. When the blades spin faster there is more energy in the system and when the blades spin slower there is less energy in the system.

Assessment

Listen to pair dialogue looking for use of vocabulary and science principles particularly as they do their gallery walk and during the whole class discussion. Look at diagrams and explanations at all steps.

References

Assaraf, O. B. Z., & Orion, N. (2010). System thinking skills at the elementary school level. *Journal of Research in Science Teaching, 47*(5), 540-563.

Crissman, S., Lacy, S., Nordine, J., & Tobin, R. (2015). Looking through the energy lens. *Science and Children, 52*(6), 26 – 31.

National Research Council. (2012). *A framework for K-12 science education: Practices, crosscutting concepts, and core ideas.* Schweingruber, H., Keller, T., & Quinn, H. (Eds.). Washington, D.C.: National Academies Press.

Nordine, J. (Ed.) (2016). *Teaching energy across the sciences.* NSTA Press.

Robertson, B. (2015). Science 101: How Should We Label Different Kinds of Energy?. *Science and Children, 52*(6), 68.

Science Literacy Maps, Systems (n.d.). Retrieved from http://strandmaps.dls.ucar.edu/cms1-2/jsapi/map_images/E2E8F6/4/100/SMS-MAP-1594.PDF

QESST (April, 13, 2012). *Lesson plan: Designing a solar amusement park*. Retrieved from https://qesst.asu.edu/lesson-plan-designing-a-solar-amusement-park.

*Solar materials provided by QESST at Arizona State University.

Solar Power (2018). PBS Nova. Retrieved from https://www.pbs.org/video/nova-solar-power/

Planning Page

Students will be able to make a model of a renewable energy system and use observations as evidence to support their ideas.

Link to Prior Knowledge (15 minutes)

Review systems thinking.

Instruction (60 minutes)

Model the solar power system together.

Have students model the solar energy system.

Closing (15 minutes)

Lead a discussion that recaps the major components of the renewable energy system.

SOLAR ENERGY SYSTEM

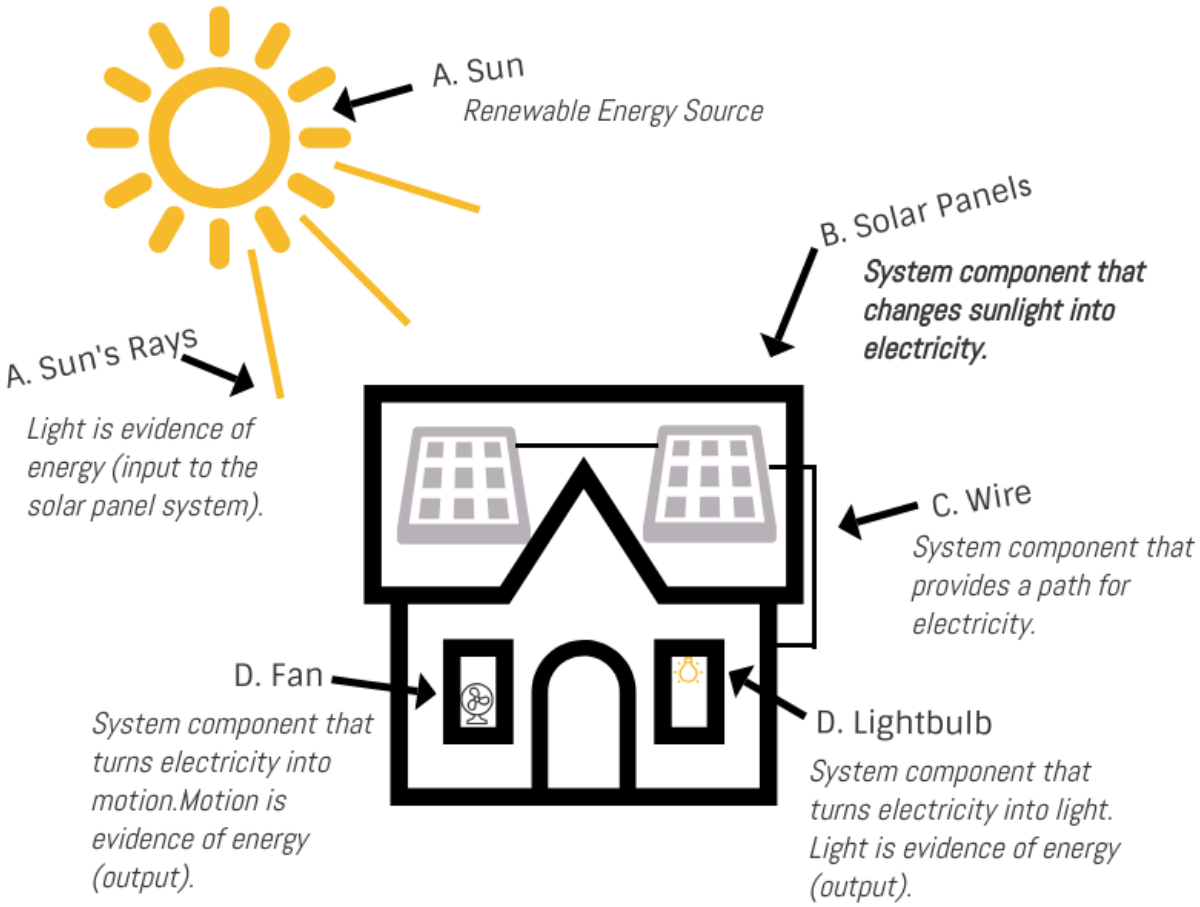
Draw your solar energy system model. Make sure to label all of the components. Label the input and the output after you take the system outside.

2.3 SOLAR ENERGY SYSTEM

Write one sentence for each component and the input, describing the job that each does to make the system work. Then, write a summary telling how the solar energy system works to make electricity.

2.3 SOLAR PANEL EXAMPLE

Solar Panel Example with Various Outputs



If you follow A-D, you can follow the flow of energy through the system. The outputs at D could be more than just the lightbulb or the fan, and your students may suggest many. A solar panel system on a house can provide electricity for many appliances at once, and those may each may have a different evidence of energy (light, motion, sound, or heat).