STEM Careers Coalition

CLASSROOM ACTIVITY

Sharing Sunlight

OBJECTIVES

Students will be able to:

- **Understand** how photovoltaic cells transform sunlight into electricity.
- **Apply** their understanding of solar power in a brainstorming session about how solar energy could be transferred from sunny places to colder places.
- **Create** a prototype system that could collect, transport, and dispense solar energy.

OVERARCHING QUESTION

How can we transfer solar energy collected from sunny places, like the desert, to cities with less sunlight?

ACTIVITY SUMMARY

In this activity, students play the role of solar engineers to solve a design challenge: how can we collect solar energy in places with nearly continuous sunlight, and transport it to places with less sunlight? Students will begin by researching technologies related to solar energy, such as photovoltaic cells. Next, they will work in groups to review case studies about efforts to build solar energy into the national energy infrastructure. After reviewing a design challenge prompt, they will brainstorm ways to effectively move solar energy from its collection point in Yuma, Arizona, to less-sunny San Francisco, California. Then, students will develop prototypes of solar energy transfer systems that meet the parameters of the design challenge and share their designs with the class for feedback. Finally, students will reflect on the potential of solar energy to reduce carbon emissions and explore exciting advancements in green energy.

TEACHER BRIEF

This activity is a great way to introduce students to a world of careers in STEM. To increase the impact and relevance of the activity, consider having an outside subject matter expert visit with your class. If you'd like to arrange for an AES STEM professional to host a 30-minute to one hour conversation with your students, please contact Tawechote Wongbuphanimitr at STEM@aes.com.

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MATERIALS

- Optional: photovoltaic cells to pass around the classroom (These can be found inexpensively at craft stores or online; you may also have solar-powered items at home with photovoltaic cells on them, like toys or calculators.)
- Devices with QR code readers and access to the internet (at least one per student group)
- **Sharing Sunlight: Solar Technology** student capture sheet
- The TED-Ed video "How do solar panels work?" (approximately 5 minutes; show in front of the class or have students watch on devices)
- **Sharing Sunlight: Solar Energy Algorithm Cards** (cut these up and distribute one set to each student group)
- **Sharing Sunlight: Pros and Cons** student capture sheet
- **Sharing Sunlight** design challenge prompt
- Slideshow/presentation software, like Microsoft PowerPoint, Canva, or Google Slides
- **Sharing Sunlight** design challenge rubric

NATIONAL STANDARDS

Next Generation Science Standards

- Engineering Design
  - MS-ETS1-1. Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.

C3 Framework for Social Studies Standards

- D2.Eco.3.3-5. Identify examples of the variety of resources (human capital, physical capital, and natural resources) that are used to produce goods and services.

Common Core English Language Arts

- Writing:
  - W.4: Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.
- Speaking and Listening:
  - SL.1: Prepare for and participate effectively in a range of conversations and collaborations with diverse partners, building on others' ideas and expressing one's own clearly and persuasively.
  - SL.2: Integrate and evaluate information presented in diverse media and formats, including visually, quantitatively, and orally.
  - SL.9-10.4: Present information, findings, and supporting evidence clearly, concisely, and logically such that listeners can follow the line of reasoning and the organization, development, substance, and style are appropriate to purpose, audience, and task.

- Common Core Math
  - CCSS.MATH.CONTENT.HSF.LE.A.2: Construct linear and exponential functions, including arithmetic and geometric sequences, given a graph, a description of a relationship, or two input-output pairs (include reading these from a table).

CHALLENGE

1. Begin by asking students to raise their hands if they have ever seen a solar panel before. Look around the room and get a sense of how many students have seen a solar panel. One third? One half? Nearly everyone?
2. Inform students that today's activity will focus on solar electricity. The goals of the activity will be to:
   a. identify pieces of technology involved in generating solar power
   b. understand how electricity is generated from sunlight
   c. explore places where solar technology is working well and identify areas for improvement using real-life case studies
   d. create a prototype of a solar power system that can transfer solar energy from Yuma, Arizona (the sunniest city in the world), to rainy San Francisco, California
   e. understand the potential of solar energy to reduce reliance on carbon emissions

   Explain that, in these activities, students will take on the role of solar engineers. These professionals design, develop, and maintain solar power systems.
3. Inform students that before diving into the lesson, they are going to learn some key terms:
   a. Power Grid: A system that moves energy from a power plant to communities
   b. Transmission System: A mechanism that controls power, determining when power should move along the grid, and how much
   c. Solar Energy: Electricity derived from sunlight
4. Distribute one copy of the **Sharing Sunlight: Solar Technology** capture sheet to each student. If you have them, pass around the photovoltaic cells for students to investigate. (If you don't have them, direct students to scan the first QR link on the capture sheet to see what a photovoltaic cell looks like.) Inform students that they are looking at something called a "photovoltaic cell" and ask them to think about the word "photovoltaic" as they observe the cell. Explain the term using the following information:

   Photo - volta - ic

   Photo = light, sunlight

   Volta = reference to Alessandro Volta, the inventor of the electric battery

   ic = suffix meaning "of or pertaining to"

   Put it all together and you get "pertaining to sunlight and electricity."

5. Invite students to take a close look at the cell and record their observations on the **Sharing Sunlight: Solar Technology** capture sheet. Explain that this cell is a smaller version of what they might see on a solar panel.

6. Divide students into groups of 3–4. Instruct students to work with their teammates to complete the **Sharing Sunlight: Solar Technology** capture sheet. To do this, they will need to scan the QR code next to each piece of solar technology and read the information on the link. They should then record the information on their capture sheet. Give students a choice of how they'd like to complete the capture sheet: groups can work on each piece of technology together, or each student in the group can research one and share his or her findings with the group.

7. Provide groups with 5–10 minutes to complete their capture sheets. When they are finished, check for understanding by asking the following questions:

    a. How do the different pieces of solar technology use electricity?

    b. Why are inverters so important to solar energy systems?

    c. When would you choose to use a concentrating solar power (CSP) system instead of solar panels, and why?

DESIGN

1. Direct students to count off by fours. Redistribute students into four groups according to their numbers.

2. Explain that students will now watch a video that explains how solar panels turn light into electricity. Inform students that when the video is finished, they will have to take a set of cards representing the steps in the process and put them in the correct order. As they build this step-by-step instruction guide for how to make electricity from sunlight, students are using the computational thinking strategy of developing algorithms. Algorithms are sets of rules and guides for how to accomplish tasks. We use algorithms to help us accomplish lots of things, like navigating with GPS systems or cooking with recipes. In order to proceed to the next challenge, each group should have completed the solar energy algorithm correctly.

3. Play the TED-Ed video "How do solar panels work?" (approximately 5 minutes).

4. When the video ends, hand out one set of **Sharing Sunlight: Solar Energy Algorithm Cards** to each group. (You will have cut these up and shuffled them ahead of time.)

5. Give groups 5 minutes to put their cards in order. When they are finished, go around the room and check each group's algorithm. Encourage students to try again if they missed a step.

6. When their algorithms are correct, have students find a partner from within their group. If there are an odd number of students, one partner group can have three members.

7. Distribute one copy of the **Sharing Sunlight: Pros and Cons** student capture sheet to each student. Invite students to think about the TED-Ed video they just watched. At the end of the video, the narrator discussed some of the biggest challenges and innovations happening in the realm of solar energy. Instruct students to take a few minutes to process their thoughts and answer the first section of the capture sheet, marked "before reading the case studies."

8. After about 3–5 minutes, instruct students to work with their partners to read the case studies on solar energy that are linked to the capture sheet. Explain that these case studies explore specific ways solar energy systems have been deployed in communities, and that they include successes and areas for improvement. Share that students can choose to split up the reading with their partner, with each student reading one case study.

9. Provide students with 15–20 minutes to read the case studies and complete their capture sheets. When they are finished, ask students to discuss the following question with their partners: if you wanted to transfer solar energy from Yuma, Arizona (the world's sunniest town), to foggy San Francisco, California, what are the first steps you would take? Give students 2–3 minutes to discuss with their partners.

SOLVE

1. Encourage student pairs to come back together with their larger groups. Ensure that each group has access to presentation software, such as Microsoft PowerPoint, Canva, or Google Slides.
2. Distribute one copy of the **Sharing Sunlight** design challenge prompt to each group and put it up on a screen in front of the class. Read through the prompt, pausing to highlight the criteria and constraints.
3. Once you are finished reading the prompt, provide students with 45–50 minutes to complete their design challenge.
4. When the groups have finished, encourage them to deliver their design challenge presentations to the class. Give each group a copy of the Sharing Sunlight design challenge rubric to use in assessing their peers.
5. After all groups have presented and received their feedback, conclude the lesson by asking a series of reflection questions:
   - **a.** What were the most challenging aspects of the project, and why?
   - **b.** Why is the work of solar engineers important?
   - **c.** What is one idea or suggestion for how we could overcome a logistical or political barrier that is standing in the way of expanding solar energy?

Instructions: Use a device with a QR code reader to scan the code under each piece of solar technology. Visit the link, read the article, and complete the sentences in the table.

Photovoltaic Cell

	It looks like:	
	It works by:	

Concentrating Solar Power (CSP)

	It looks like:	
	It works by:	

Lithium-Ion Battery

	It looks like:	
	It works by:	

Microgrid

	It looks like:	
	It works by:	

Mounting Structures and Building-Integrated Photovoltaics (PV)

	It looks like:	
	It works by:	

Inverter

	It looks like:	
	It works by:	

SHARING SUNLIGHT: SOLAR ENERGY ALGORITHM CARDS (TEACHER MATERIALS)

Teacher Instructions: Print out one sheet per student group. Cut the cards out, mix up the order, and give one set to each group to put in order.

Instructions: Put the cards in the correct order to convert light into electricity. By lining up these steps in a set of instructions, you are creating an algorithm for how solar panels work. Algorithms are used by scientists and engineers in many different fields. They help us do everything from tagging our friends in photos to developing recipes.

Two layers of crystalline silicon (an n-type with extra electrons and a p-type with holes) are sandwiched between conductive layers to form solar cells. Electrons flow across the p-n junction of the cell.	A photon strikes a silicon cell with enough energy to knock an electron from its bond and create a hole. Now, the negative ion and positively charged hole can move around.
The electric field at the p-n junction sends the negatively charged electron to the n side and the positively charged hole to the p side.	Thin metal fingers at the top of the cell collect the mobile electrons.
The electrons flow through external circuits and can do electrical work.	Electrons travel through the conductive aluminum sheet on the back of the cell.
The electron returns to its original place.	By stringing solar cells into modules, you can create enough electricity to power devices and even buildings.

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Instructions: In this activity, you will think about the challenges and benefits of using solar power. Complete the first table of questions before you read the two case studies. Then, use a device with a QR code reader to access the case studies. After you read, discuss with your partner and answer the remaining questions on the capture sheet.

Before reading the case studies:

What are the benefits of solar energy?	What are the drawbacks?
1. 2. 3.	1. 2. 3.

Case studies:

Small City Sets Example for Floating Solar, Empowered by NREL Data Set: A First-Ever Approach to Municipally Owned Floating Solar Emerges in Upstate New York (2022)	New Partnership Will Boost Low-Income Community Solar Subscriptions (2022)

After reading the case studies:

What are the benefits of solar energy?	What are the drawbacks?
1. 2. 3.	1. 2. 3.

What do you think is the biggest challenge in expanding solar energy? Why?

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What innovation in solar energy is the most exciting to you? Why?

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Why is it so important that we invest in green technology like solar power?

If you wanted to convince people in your neighborhood to convert their home to solar energy, what would you say?

SHARING SUNLIGHT DESIGN CHALLENGE PROMPT

Instructions: Work with your group to create a presentation that addresses the criteria and constraints outlined in the design challenge prompt. Be sure to use what you learned in previous activities and read the prompt carefully!

Imagine that you are a solar engineer who works for an energy company. Your company has just been selected to submit a proposal for one of the most massive solar energy projects ever: a solar energy "pipeline" between sunny Yuma, Arizona, and rainy San Francisco, California. Your proposal must meet the following criteria and constraints:

Criteria:

1. Presentation must be a slideshow of 5–10 slides.
2. Presentation must offer a solution for transferring energy from Yuma to San Francisco. This could take many different forms: circuits, batteries, etc. This solution must be made visual through a picture, map, or other artifact.
3. The presentation must feature at least two pieces of solar technology that **are currently in use**. Refer to your Solar Technology capture sheet for ideas.
4. The presentation must feature at least two pieces of solar technology that **do not currently exist**—these represent innovations or ideas your group has on how you could potentially solve the challenge.
5. The presentation must include a map showing the distance between Yuma and San Francisco and at least four photos of solar technology that are referenced.
6. The presentation must reference at least one real-life case study.

Constraints:

1. The presentation must be clear, convincing, and persuasive.
2. The presentation must cite at least three sources.
3. The presentation must credit all photos and media used.
4. The presentation may not include fewer than five slides or more than 10 slides.

SHARING SUNLIGHT DESIGN CHALLENGE RUBRIC

Instructions: Evaluate your peers' design challenge presentations using the rubric below.

Feedback **How can this presentation be improved?**	**Baseline** How does this presentation meet expectations?	**Exceeded** **How does the presentation exceed expectations?**
	Content The plan identified in the presentation makes sense and is well thought out.	
	Style The presentation is clear and easy to understand.	
	Accuracy The presentation and plan it outlines include accurate information and cited sources.	
	Format The presentation shows appropriate preparation and uses visual aids and tools as necessary.	
	Criteria and Constraints The presentation adheres to all criteria and constraints listed in the challenge prompt.	