3-5

STEM WEEK CHALLENGE

brought to you by

PROJECT LEAD THE WAY PLTW

MASS STEM HUB

A program of the one8 FOUNDATION

At Project Lead The Way, we are committed to empowering students to thrive in our evolving world. That's why we're excited to partner with Mass STEM Hub, TD Garden, Dell Technologies, and the Massachusetts Department of Environmental Protection to bring the STEM Week Challenge to more than 60,000 students and teachers across the Commonwealth.

By participating in this unique experience, you will bring real-world learning to your classroom. You will engage students in projects and problems that center on the theme of zero waste, which is an important issue for Massachusetts and our nation. Reducing, reusing, and recycling waste not only makes Massachusetts greener, it creates jobs and fuels the economy. During Mass STEM Week, your students will help solve one of our greatest environmental challenges as they develop their abilities to think critically and creatively, collaborate, and communicate.

I wish you the best of luck during the STEM Week Challenge and look forward to seeing you and your students in action.

Sincerely,

Vince M. Bertram

Vince M. Bertram, Ed.D., MBA
President and Chief Executive Officer

Dear Educators,

We are very excited to welcome you to the STEM Week Challenge with Project Lead The Way. We hope you find that the training, activities, and projects will support a relevant, fun, and thought-provoking educational experience for your students. PLTW helps students experience STEM in an authentic and valuable way as students tackle real-world problems with the STEM knowledge and skills they learn.

Thank you to our industry partners for dedicating their expertise, time, and resources to make the STEM Week Challenge a meaningful, engaging experience for K-12 educators and students across the Commonwealth. Our industry partners provided critical context used by students to tackle real-world zero waste challenges we are all facing today. Recognizing the creativity and perspective from students, our partners are eager to see how these challenges are addressed by the innovative solutions students design and prototype.

We are proud to partner with TD Garden, Massachusetts Department of Environmental Protection, and Dell Technologies:

TD GARDEN PROUD HOME

We are excited to collaborate with TD Garden, who shows us that sustainability is not only about operational metrics, but also about being a positive community presence. Through learning from TD Garden experts, students will see that STEM is every-where. The bulbs lighting up the stadium as the Celtics take the court are efficient. The screens fans turn to to watch the Bruins' instant replay are thoughtfully sourced and replaced. And the pizza you order at the concession stand contains ingredients that were carefully stored and prepared for maximum freshness and minimal food waste.

We are appreciative of Massachusetts Department of Environmental Protection's partnership. MassDEP provided foundational scientific knowedge about clean-energy opportunities and tackling emerging contaminants. MassDEP put these challenges into the context of our Massachusetts ecosystem. Through virtually visiting locations across the state such as a solar farm converted from a landfill and a reservoir that supplies Massachusetts residents, students will gain insights into the energy they consume and the water they drink.

MassDEP
Commonwealth of Massachusetts
Department of Environmental Protection

DELL Technologies

We are thrilled to collaborate with Dell Technologies as they are leading the way in e-waste diversion and creating a circular economy. Dell Technologies does this through modular design, recovering used electronics, providing recycling solutions for customers, and using sustainable materials in their products. High-school, students will have the unique opportunity to break open Dell technology, experiencing for themselves the impact of modular design on extending a product's life cycle, and greatly reducing the e-waste created.

Again, we welcome your partnership in what we hope will be a wonderful educational experience for all. Please take the time to complete our survey at the end of STEM week so we have your feedback on how to improve future events like this. Your opinion counts!

With Great Regard,

Joanna Jacobson, One8 Foundation

Katherine Skrivan, Mass STEM Hub

PROJECT LEAD THE WAY
PLTW

ENERGY WASTE

Teacher Guide

ZERO WASTE

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STEM Week Challenge Teacher Survey

Thematic Overview

What is the Zero-Waste Initiative?

The zero-waste movement promotes reducing and eliminating resource waste related to production, consumption, reuse, and recovery of products, packaging, and materials.

Why Zero Waste?

Most of our students know about the three Rs (reduce, reuse, recycle) and likely recycle at home, at school, or both. They'll have an opportunity to dig deeper and look in depth at the goods and energy we consume. Through hands-on activities anchored in STEM, students will learn how to apply their collective creativity and innovation to solve a real-world waste challenge. Through their problem-solving efforts, students will forge relationships with local community and industry partners as they pursue zero-waste solutions.

As part of this 10-hour experience, K-12 students will:

- Recognize the impact that individuals can have on waste-related issues;
- Understand the diverse forms that waste can take;
- Formulate a solution to a waste-related issue;
- Analyze the interdependencies of systems contributing to waste-related issues;
- Advance a culture of sustainability within the school, community, and state;
- See themselves in STEM-related careers;
- Adopt a community approach to solving problems through partnerships and collaboration.

PROBLEM

ACTIVITIES	PROJECT(S)	PROBLEM
Knowledge & Skill Acquisition →	Meaning Making & Investigation →	Application & Transfer

Well-defined — *Open-ended*

Activity 1

Straight to the Source
Students define energy and work together to learn about energy sources. They complete a simulation that addresses common energy sources and their origins and highlights the longevity of renewable versus nonrenewable resources.

Activity 2

Knowledge is Power
Students develop an understanding of their use of energy, particularly electrical energy. They conduct an energy inventory throughout the classroom to identify places where electricity is being used.

Activity 3

Going Solar
Students assemble a solar power system, observe solar energy collection, and learn how solar energy transfers to power. Students explore energy emitted from the sun and focus on the collection of light energy to create solar electricity.

Project

Fun in the Sun
Students investigate factors that affect the way a solar power system works as they learn how scientists systematically find answers to questions. After building a solar power system, students explore what angle a solar panel should face and how direct or indirect sunlight affects the system.

Problem

Harnessing the Sun's Energy
Students demonstrate their understanding of solar energy by following the design process to explore, sketch, build, and evaluate a solar-powered invention of their choice. Students upcycle materials to build their design prototype.

Essential Questions

1 How can a step-by-step process help me design or improve a solution to a problem?

2 How can I reduce my waste?

3 How does my use of energy resources affect my community and the environment?

Introduction to the Module

In *Zero Waste: Energy Waste*, students are introduced to the concept of zero waste, specifically in the context of energy. They explore sources of energy and learn about the differences between renewable and nonrenewable sources of energy. Students use their understanding to learn more about a common type of energy we use daily—electricity. They apply their knowledge and skills by performing an inventory of electricity use in the classroom as well as various real-world scenarios. Students use their understanding of energy sources to learn more about one type of renewable energy—solar. They assemble a solar power system and predict and test various variables that affect the system's performance. Students use all their knowledge and skills to explore, sketch, build, and evaluate a solar-powered invention of their choice.

PLTW Launch Logs

- As students progress through the module, they use PLTW Launch Logs to record their thinking, ideas, observations, and designs. The PLTW Launch Log is not a traditional workbook or a collection of worksheets; rather, it's designed to be an age-appropriate version of an engineering notebook. In the PLTW Launch Logs, students record their learning as they draw their ideas and write words, if they're ready to do so.
- As the teacher, you can easily use this record of student ideas for formative assessment by evaluating students' demonstrations of their thinking and conceptual understanding. Allowing students to explain the thinking behind their responses to prompts is an invaluable way to uncover misconceptions and guide students to conceptual understanding. To gain a deeper understanding of the purpose and use of PLTW Launch Logs, access the "Using PLTW Launch Logs" professional development resource.

Developing Vocabulary

Vocabulary learning has been found most effective when active engagement with a term goes beyond just knowing the definition. Rather than being presented in isolated lessons, vocabulary is introduced within the context of the activities, project, and problem.

Differentiation Strategy: Vocabulary slides provide images and text to introduce students to vocabulary terms.

General Preparation

- Consider using recycled paper for all printables.
- Print one *Zero Waste: Energy Waste* Launch Log for each student before beginning the module.
- To gain a better understanding of how solar energy is used in your area, make connections with local industry partners. Identify any resources or specific solar energy examples in your classroom, school, and community.
- Review the Instructional Procedure for each activity, project, and problem before facilitating.
- Use the *Zero Waste: Energy Waste* presentation to present information to students throughout the module. Review the slides for each activity, project, and problem before facilitating.
- Determine how you will divide your class into groups. Students can be in groups of two to four.

Community and Family Connections

Family and community relationships are encouraged throughout the module. A Family Letter is provided to introduce Project Lead The Way to families; ask for donations to complete specific activities, projects, or problems; and encourage families to support students' learning of concepts at home. PLTW recommends that you send this letter to families before you begin a module to let them know what their students will be learning in school.

Consider ways in which you can establish community relationships throughout the *Zero Waste: Energy Waste* module. To encourage career connections in the classroom, you might invite speakers, such as engineers, scientists, conservation officers, solar engineers, and electricians, to talk about energy, electricity, and how your community uses renewable resources, specifically solar energy.

Tips for Community Guests:

- Bring items for students to touch.
- Use visuals.
- Keep dialogue short and simple.
- Introduce new terms.

Introducing the Problem

Harnessing the Sun's Energy

Chapter 1—Zero Waste

Angelina, Mylo, and Suzi were in class completing their morning work before starting the school day. "Class, I have a big announcement for you today!" said their teacher, Ms. Morales.

"What is it?" asked Mylo. "I can't wait to hear!"

"You'll have to wait until our assembly this afternoon," said Ms. Morales. "We have a special guest speaker coming to share it with you!"

The three friends were walking to the gymnasium for the assembly. "What do you think the big announcement is?" asked Suzi.

"I think we're going to do a school-wide service project!" said Angelina. "I love to volunteer, so it'd be fun to do something with everyone."

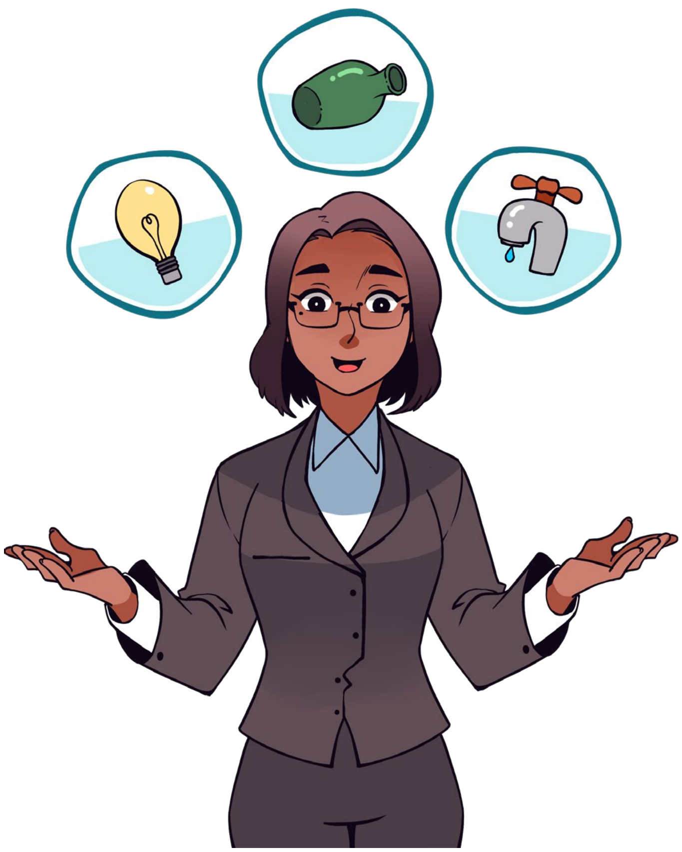
"I think they're going to renovate our playground!" said Mylo. "Have you noticed there's been construction workers looking at our building lately?"

"That's true, Mylo!" said Suzi. "I wonder if the construction workers are here to fix something at school."

"I can't wait to find out!" said Angelina.

As the assembly started, a woman began to speak. “Hello! My name is Yasmin, and I’m a scientist for the Department of Environmental Protection. I study the environment so that I can help protect it. I am so excited to announce that your school has chosen to work toward ‘zero waste.’ Does anyone know what that means?”

Mylo raised his hand. “Is it similar to going green?” he asked. “We learned about going green when we talked about reduce, reuse, and recycle in class.”



“That’s definitely part of zero waste!” said Yasmin. “But it’s much more than that. Zero waste includes the conservation of all resources, so we do not threaten the environment or human health.”

Suzi raised her hand. “What does ‘conservation’ mean?” she asked.

Yasmin explained, ‘Conservation’ means protecting our resources. When we conserve things, we only use what we need. For example, you can conserve water by turning off the sink when you brush your teeth. You can conserve food by refrigerating leftovers and having them for a meal the next day. Or you can conserve electricity by turning off the lights when you leave a room.”

“Oh, we conserve materials all the time in class!” said Suzi. “We use materials like cardboard, bottles, and cans when we build models to solve problems.”

“That’s called ‘upcycling,’” said Yasmin. “Upcycling is to reuse old or unwanted materials to make something new and useful.”

Angelina said, “This sounds great! So how can we help achieve zero waste in our school? I’m excited to help protect our community and the environment!”

“I’m so glad you asked!” said Yasmin. “You’re going to start noticing changes happening around your school. Your class will explore additional ways you can help achieve zero waste. Are you ready?! Let’s sing a chant to get excited!”

Zero waste!
Let’s make haste!
Zero waste!
I can’t wait!

Chapter 2—Solar Energy

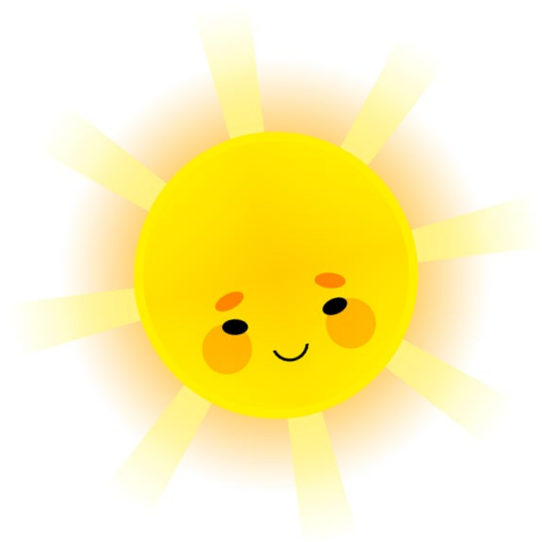
“Okay, class!” said Ms. Morales. “It’s our turn to help our school achieve zero waste.”

“What are we going to do?” asked Suzi. “There are so many ways we can help with the conservation of resources; it’s a little overwhelming.”

“I’m glad you asked!” Ms. Morales said. “I thought we could think about where energy comes from, since that’s what we’ve been learning about in class. Remember, an energy source is something such as oil, coal, or the sun that is used to provide power.”

“That reminds me of something I did at camp last summer!” said Angelina. “We built a solar car that was powered by the sun’s energy.”

“That sounds so fun, Angelina!” said Mylo. “How else can solar energy be used?”



“I’m glad you asked!” said Ms. Morales. “Have you seen the construction workers outside lately? They’re installing solar panels that convert solar energy into electricity for our school! This will allow us to use renewable energy for our school’s electricity.”

“I have a solar calculator at home!” said Suzi. “Instead of batteries, it has a solar cell. It works anytime I’m in a lit room or outside in the sun.”

“That’s a great connection, Suzi!” said Ms. Morales. “And there are so many other ways we can use solar energy, so we don’t waste resources. It will take all of us to come together to make a difference.”

“We need to help our school achieve zero waste,” said Angelina.

“Let’s use what we’ve learned to create a solar-powered device of our own,” said Mylo.

“We can use the design process to solve this problem,” said Ms. Morales.

Can you help the three friends use solar energy in a design?

ACTIVITY 1

Straight to the Source

Introduction

In this activity, students define energy and begin considering energy sources that are available to us. They work together to learn about various energy sources. Finally, students complete a simulation during which they encounter common energy sources, learn where each energy source originates, and understand that some energy sources are renewable while others are nonrenewable.

Knowledge and Skills

KS1.2.2: Make observations to draw conclusions of phenomena.
KS1.2.3: Analyze data to look for patterns or to test whether data are consistent with an initial prediction.
KS2.1.1: Define energy and identify multiple energy sources.
KS2.1.2: Recognize the difference between renewable and nonrenewable energy sources.
KS4.2: Reason abstractly and quantitatively.
KS4.3: Model with mathematics.
KS5.1: Generate ideas as a team.
KS5.2: Value the contributions of each team member.
KS5.3: Demonstrate collaboration through effective communication.
KS6.1: Document work in an organized notebook.
KS6.2: Explain findings and justify evidence-based conclusions with others.
KS6.3: Present data and information accurately and effectively.
KS7.1: Engage in and maintain positive interactions and relationships with other children and adults.

Equipment

- *Zero Waste: Energy Waste* Launch Log (one per student)
- *Zero Waste: Energy Waste* presentation (Activity 1 slides)
- Energy Source images (one image per group)
- Energy Source simulation cards
- (Optional) Upcycled paper bags, boxes, containers, etc.
- Chart paper
- Markers
- Pencils or colored pencils for sketching

Teacher Preparation

- Read through the Introduction Story, "Harnessing the Sun's Energy."
- Ensure that you have printed a *Zero Waste: Energy Waste* Launch Log for each student.
- Part 1. Think Energy
  - » Print one Energy Source image for each group.
  - » Create the "Energy Sources" table on a piece of chart paper or whiteboard. This table is also in the *Zero Waste: Energy Waste* Launch Log. Use the table to document as students share information about their energy source.

Energy Sources

Energy Source	Where does it come from?	What is it used for?	Will it ever run out?
Coal			
Hydropower			
Natural Gas			
Oil			
Solar			
Wind			

- Part 2. Energy Sources Simulation
  - » Ensure that you are prepared to model a simulation round for students.
  - » Determine the number of student groups. (Students should work in small groups of two to four.)
  - » Prepare one energy bank for each group. Each energy bank should contain a total of 72 Energy Source cards.
    - › Print and cut enough cards for your class.
    - › Place the cards into their energy banks. This can be a small upcycled box, container, or a brown lunch bag.
  - » Create the "Energy Data Collection" table on chart paper or whiteboard. This table is also in the *Zero Waste: Energy Waste* Launch Log for students and includes a range of ten years. Use the table to document as you model the round for students.

Energy Data Collection

	Renewable Energy Sources			Nonrenewable Energy Sources		
	Hydropower	Solar	Wind	Coal	Natural Gas	Oil
Year 1						
Year 2						

Instructional Procedure

Time: 105 minutes

Vocabulary

energy source	Something such as oil, coal, or the sun, which can be used to provide power.
nonrenewable energy source	Fuels that cannot be easily made or renewed. We can use up nonrenewable fuels. Oil, natural gas, and coal are nonrenewable fuels.
renewable energy source	Fuels that can be easily made or renewed. We can never use up renewable fuels. Hydropower (water), solar, and wind are renewable fuels.
solar energy	The process of how the sun is used to generate electricity.

Procedure

Introduction Story (20 minutes)

1. Before you begin Activity 1, read to students the Introduction Story, "Harnessing the Sun's Energy."

2. Use the guiding questions within the story to engage students in thinking about ideas and concepts throughout the module. Use this time of discussion to uncover what your students already know about the concepts, what they are curious about, and what misconceptions they may have. Consider how this formative assessment of students can guide you as you facilitate the activities, project, and problem in this module. To set the purpose for the learning experiences to come, it's also important to guide students to identify the problem.

3. Throughout the module, you can reread the story to students to remind them of the problem they will be solving.

Part 1. Think Energy! (30 minutes)

4. Use the "Activity 1" slide to provide students an introduction.

5. Assess students' prior knowledge by asking them what they think of when they hear the word *energy*. As students share energy examples, use effective questioning to guide students as they make connections. Address any student misconceptions at this time. Sample prompts:
   - What is your energy example used for?
   - Where does that energy come from? Is it difficult or easy to access? Why do you think that?

6. Use the vocabulary slides to introduce the vocabulary terms *energy source*, *renewable energy source*, and *nonrenewable energy source.*

As you introduce each term, refer to the earlier examples shared by students to make connections to each new term.

7. Use the “Energy Source” presentation slides to lead a discussion about energy. During this discussion, introduce the six energy sources (coal, hydropower, natural gas, oil, solar, and wind).

> Note: While many other energy sources exist, we have chosen six specific sources for this module.

8. Distribute the *Zero Waste: Energy Waste* Launch Log to each student. Students use Launch Logs to keep a record of their work as they progress through the module. They may take notes as they research, create sketches, and answer conclusion questions in this notebook.

9. Guide students to locate the page titled “Activity 1: Straight to the Source” in their Launch Logs.

10. Provide each student group with one Energy Source image.

11. Direct students to discuss the image with their group. Encourage students to take notes in their Launch Log as they conduct their group discussion. Sample prompts:
    - Are they familiar with this energy source?
    - What do they know about it?
    - Where does it come from?

12. Use the “Let’s Think About It” slide to present procedure steps to students.

13. Ask students to share their findings with the class. Invite each group to place its Energy Source image on the “Energy Sources” class table.

14 Record student answers on the table as each group summarizes its conversation.

Energy Data Collection			
Energy Source	**Where does it come from?**	**What is it used for?**	**Will it ever run out?**
Coal			
Hydropower			
Natural Gas			
Oil			
Solar			
Wind			

15 Lead a discussion to help students understand what it is that makes an energy source renewable vs. nonrenewable. Sample prompts:

- Describe one way that renewable and nonrenewable resources are different.
- Of all the energy sources, which one do you think should be used the most? Why do you think that?

Differentiation:

- If your students have access to digital devices, consider having them further "research" their energy source during group conversation and share an interesting finding with the class.
- For older students, consider adding more complex columns to your classroom table (e.g., When might it run out? What does it power? How much does it cost? How much does a person/state/country use on average?).

Cross-Curricular Connection: As a renewable energy literature connection, you can read the children's book *The Boy Who Harnessed the Wind* to your class. The book is based on the true story of William Kamkwamba who helped bring wind energy to his village in Malawi. The story is also available as the 2019 Netflix film *The Boy Who Harnessed the Wind*.

Part 2. Energy Sources Simulation (40 minutes)

16 Distribute a prepared energy bank to each group.

17 Guide students to locate the page titled "Part 2. Energy Sources Simulation" in their Launch Logs.

18 Explain the simulation instructions provided below.

19 Use the "Energy Supply Table" slide for students to view the change in energy sources available.

20 Model two rounds for students using the "Energy Data Collection" table to demonstrate data collection.

Simulation Instructions (also provided in the Launch Log)

- During this activity, your group will simulate the amount of energy used by your school over the next ten years.
- For each round, you will draw 12 units of energy from your energy bank. Each round represents one year.
- As you draw energy units from the bank, record each energy unit on the data chart in your Launch Log.
- At the end of each round:
  I. Set aside any nonrenewable resources that you pulled. They should not be returned to your energy bank.
  II. Return any renewable energy units back into the energy bank. Since they can be renewed, they will be available to you year after year.

Differentiation Strategy: Consider having students create a graph in their Launch Log that illustrates the changes in resource availability over time.

21 Lead a discussion with students on their findings. Consider using the following prompts:
- What do you notice about the energy usage over time?
- Is there a difference between the amount of renewable and nonrenewable energy that you pull from the energy bank in later years? Why do you think that?

Career Connection: Energy Engineer
Energy engineers solve problems related to energy efficiency and energy use. They are working daily to identify energy-saving opportunities. They design, build, and evaluate entire buildings for energy efficiency and energy-related products, such as lighting, heating and air systems, and electrical systems.

Part 3. Energy on the Scene (10 minutes)

22 Guide students to locate the page titled “Part 3. Energy on the Scene” in their Launch Logs.

23 Use the “Energy on the Scene” slide to present procedure steps to students.
- Instruct students to draw or label each of the six energy sources they have been exploring in a location where it might be collected.
- Direct students to create a key that identifies each energy source as either renewable or nonrenewable.

Conclusion Question (5 minutes)

Assessment Strategies: Conclusion questions offer an opportunity for formative assessment. You may use them as a whole-class discussion, or you may have students record ideas in their Launch Logs. Use the “Conclusion Question” slide to present the following question:

1. Why is it important to use renewable energy sources? Use what you learned in the simulation to support your answer.

Student responses should demonstrate an understanding of conservation and energy sources. Responses might include “I learned through the simulation that it’s important to use renewable energy sources because they do not run out,” Nonrenewable resources will run out over time.”

ACTIVITY 2

Knowledge Is Power

Introduction

In this activity, students develop an understanding of their use of energy, particularly electrical energy. They conduct an energy inventory throughout the classroom to identify places where electricity is being used.

Knowledge and Skills

KS1.2.2: Make observations to draw conclusions of phenomena.
KS2.1.3: Analyze the amount of energy consumed by different electrical devices.
KS3.1: Understand the importance of conserving energy.
KS3.2: Identify ways they can reduce energy usage in their lives.
KS4.1: Make sense of problems and persevere in solving them.
KS4.2: Reason abstractly and quantitatively.
KS4.3: Model with mathematics.
KS4.4: Use appropriate tools strategically.
KS5.2: Value the contributions of each team member.
KS5.3: Demonstrate collaboration through effective communication.
KS6.3: Present data and information accurately and effectively.

Equipment

- *Zero Waste: Energy Waste* Launch Log (one per student)
- *Zero Waste: Energy Waste* presentation (Activity 2 slides)
- Energy Consumption scenarios (one scenario per group)
- Kilowatt Meter
- Items in a classroom that use electricity and can be measured with a Kilowatt Meter
- Chart paper
- Markers
- Pencils or colored pencils for sketching
- Calculators (optional)

Teacher Preparation

Part 1. How Much Energy Do We Consume?

- To locate your state's current cost of kilowatt/hour visit the following website: https://www.eia.gov/state/. Provide this number to students if you plan to have them complete the extension of calculating the total cost of kilowatt usage in each scenario.
- Print out a different Energy Consumption scenario for each group.

Part 2. Plug It In

- Take an inventory of items using electrical energy in the classroom to identify areas using energy that students may not notice.

Instructional Procedure

Time: 60 minutes

Vocabulary	
electricity	The flow of electrical power or charge
inventory	A list of items belonging to a person or space
watt	The unit of power that measures electricity

Part 1. How Much Energy Do We Use? (30 minutes)

1. Use the “Activity 2” slide to provide an introduction to students.

2. Set the stage for today’s activity about electrical energy consumption in everyday life by asking students what energy they’ve already used today.

The following scenario may help to get them started with ideas:

When you wake up in the morning, what are some of the first things you do? You might wake up, turn on the light, take a shower, brush your teeth, and eat breakfast. Along the way, you use energy to turn on lights, showers, and toasters. Energy is what helps turn things on. We need to be sure we aren’t using more than we need. Let’s figure out how much energy we use in our everyday lives.

3. Use the vocabulary slide to introduce the term *electricity.*

4. Lead a discussion with students to determine if they know where electricity comes from. As they provide their thoughts, use chart paper and markers or a whiteboard to draw the path electricity takes. For example, begin with a light bulb or other device that uses electricity. Have students provide their thoughts on the path the electricity took to get to that point, all the way back to where the electricity was first collected.

5. Provide a review of energy sources from Activity 1 and how we use energy daily.

6. Remind students that all energy has the potential to become electricity.

7. Use the “Electricity Path” slide to take students through the journey of energy as it becomes electricity that powers our homes and schools. Share that today students will look at how much energy is used during a task.

8. Use the vocabulary slide to introduce the term *watt* (W).

9 Guide students to locate the page titled "Activity 2: Knowledge is Power" in their Launch Logs.

10 Use the Class Scenario: Baking Cookies to model how students will calculate and graph the amount of electricity used in their assigned scenario. Encourage students to record the data in their Launch Log.

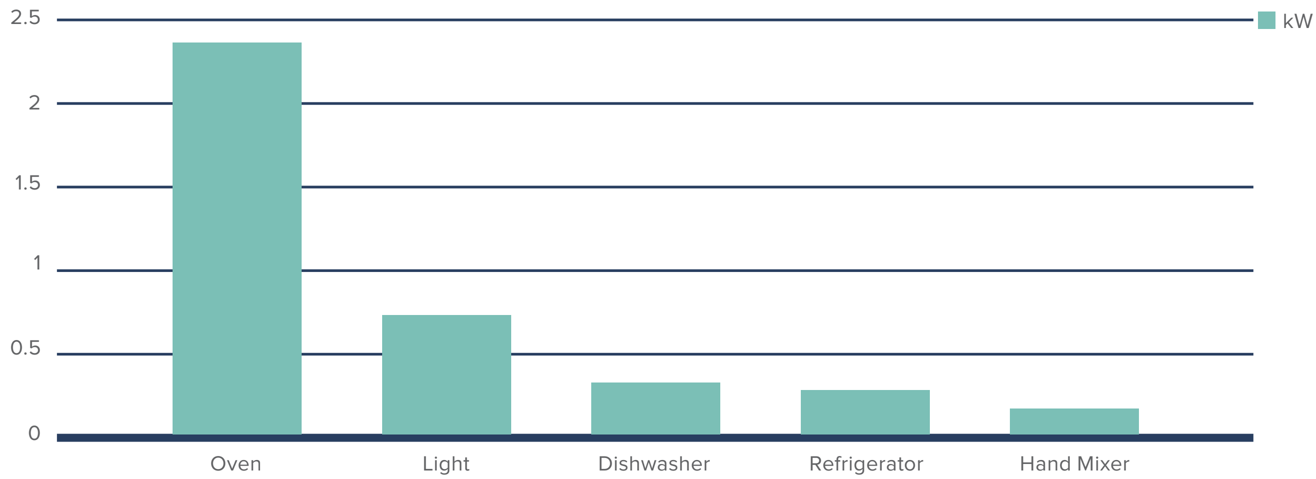
11 Use the "Energy User Key" slide to locate the wattage for each device used.

Class Scenario: Baking Cookies (1 hour total)

1. Turn on the light in the kitchen.
2. Preheat oven.
3. Collect ingredients from pantry and refrigerator.
4. Combine ingredients using hand mixer for 15 minutes
5. Clean the dishes by running the dishwasher for 1 hour.
   a. Calculate how much electricity is used to make cookies.
   b. Record your findings in your Launch Log and create a bar graph to show energy consumption.
      - Light (1 hour)
      - Oven (1 hour)
      - Refrigerator (1 hour)
      - Hand Mixer (15 mins)
      - Dishwasher (1 hour)

Class Scenario: Baking Cookies Answer Key

Energy User	Total Wattage	Converted Wattage/1000 (kW)	Hours Used	Converted Wattage x Hours Used	OPTIONAL: Approx. Cost (.22/kWh) kWh x .22Wh
Light	660	.66	1	.66	
Oven	2400	2.400	1	2.400	
Refrigerator	225	.225	1	.225	
Hand Mixer	200	.200	.25	.05	
Dishwasher	330	.330	1	.330	
TOTAL	X	X	X	3.775	



Differentiation Strategy: The final column used (calculating the cost) in each scenario is optional. If you choose to have your students complete this column, challenge them to think about how often they do this activity and how much it would cost annually. You may have students use calculators.

12 Guide students to locate the page titled “My Scenario” in their Launch Logs.

13 Distribute a different printed scenario to each group.

14 Guide students to work with their groups to complete the calculations on their scenario in their Launch Log.

15 Use the “Let’s Think About It” slide to lead a discussion. Sample prompts:

- What were some of the electronics that used the most energy?
- Why do you think that was?

Part 2. Plug It In (25 minutes)

16 Explain that as a class, students will apply to their own classroom what they learned in the scenarios.

17 Use the vocabulary slide to introduce the term *inventory*. Ask students if they know where else in life an inventory might be used.

18 Guide students to locate the page titled “Part 2. Plug It In” in their Launch Logs.

19 Inform students that they will take an inventory of items that use electricity in the classroom.

a. Using a kilowatt meter, they will measure the amount of electricity used by electrical devices in their classroom.
a. They will add their findings to the graph in their Launch Log.

For your use, the following definitions may be helpful:

kilowatt meter	A device used to measure electrical energy in kilowatt-hours
standby/phantom energy	Electricity that is being used by a device when it is turned off

Possible Misconception: Students may think that even when a device is turned off or in sleep mode it is no longer using electricity. Some devices use phantom energy, which means they are still using some energy, even when they are off.

Career Connection: Electrician, Lineworker, Meter Reader
There are a variety of careers that work with electricity. An electrician must be knowledgeable about electrical equipment on a variety of scales; they install and repair electrical systems. A lineworker is someone who installs and repairs the electrical lines that run from a power plant and extend out to homes and buildings. An electricity meter reader gathers data on the exact amount of electricity that is used in a particular home or building.

20 Ask each team to identify one device in the classroom they would like to measure with the kilowatt meter.

a. With each group, measure the device's phantom energy and energy when the device is active.
b. Have the group share their results with the class. As the class goes through the classroom, have them complete a scenario table and bar graph in their Launch Logs.

21 Use the "Let's Think About It" slide to lead a discussion about energy use in the classroom. Sample prompts:

a. Were you surprised at how much energy was being used in your classroom? Why do you think that?
b. Were you surprised at how many different things use electricity? Why do you think that?

Extension Opportunity: Encourage students to inventory their electricity use at home and share their results with the class. Have them identify ways their family can agree to (or they will independently) conserve electricity/energy.

Conclusion Questions (5 minutes)

Assessment Strategies: Conclusion questions offer an opportunity for formative assessment. You may use them as a whole-class discussion, or you may have students record ideas in their Launch Logs. Use the "Conclusion Questions" slide to present the following questions:

1. How can we reduce the amount of electricity that we use at school? At home?
   Responses might include turning off the lights when leaving the room, shutting off the water when brushing their teeth, and unplugging items that use phantom electricity.

2. How can reducing electricity use help conserve energy?
   Responses might include making sure we don't harm the planet, using resources that can be used repeatedly, and saving money in the long run.

ACTIVITY 3

Going Solar

Introduction

In this activity, students assemble a solar power system, observe solar energy collection, and learn how solar energy transfers to power. Students explore the types of energy emitted from the sun—light and heat—and focus on the collection of light energy that can create solar electricity.

Knowledge and Skills

KS1.2.1: Ask and identify questions to gain knowledge or solve problems.
KS2.1.1: Define energy, and identify multiple energy sources.
KS2.1.2: Recognize the difference between renewable and nonrenewable energy sources.
KS2.2.1: Assemble and use a solar power system to power a device.
KS2.2.2: Explore the transfer of solar energy to electric energy.
KS2.2.3: Identify the input and output of a solar power system.
KS5.3: Demonstrate collaboration through effective communication.
KS6.1: Document work in an organized notebook.
KS6.3: Present data and information accurately and effectively.
KS7.1: Engage in and maintain positive interactions and relationships with other children and adults.

Equipment

- *Zero Waste: Energy Waste* Launch Log (one per student)
- *Zero Waste: Energy Waste* presentation (Activity 3 slides)
- Materials from the Elenco® Solar Energy Kit (one set of materials per group of three to four

> Note: The kit contains more materials than those listed here. Set aside the additional materials. Student groups will use them throughout the remainder of the module.

  - Solar cell
  - Motor
  - Motor base holder
  - Motor holder
  - Wrench
  - Fan
  - 4 Jumper wires
- Pencils or colored pencils for sketching

Teacher Preparation

Part 1. What Is Solar Energy?

- View the Energy Forms and Changes / Phet Colorado Simulation prior to facilitating this activity. Make sure that you understand the simulation functionality so that you can demonstrate it for your students.

Part 2. Shine Down on Me

- Prep the necessary materials from the Elenco® Solar Energy Kits. Students work in groups of three to four for this activity, so organize the necessary materials into the correct number of groups for your classroom. (See the Equipment list for the specific materials needed for this activity.)

> Note: Students will continue to use these materials and the additional materials in the kit throughout the remainder of the module.

- Consider the following classroom space requirements:
  - » Make sure you have designated table space where student groups can construct their solar-powered fans.
  - » Ensure students have access to an outdoor location for solar power system testing.
  - » Determine guidelines for how students will use the materials, clean up, and store them for the remainder of the module.

- Assemble the solar power system and fan to ensure you're comfortable with the procedure.

Instructional Procedure

Time: 120 minutes

Vocabulary	
solar cell	A device that converts solar energy to electricity.
solar panel	Solar cells linked together in order to absorb solar light as a source for generating electricity.
solar power system	At least one solar panel connected to conductors to form an electric current in order to power a device. The more panels you add, the more power you can create.
upcycle	To reuse old or unwanted materials to make something new and useful.

Procedure

Part 1. What Is Solar Energy? (50 minutes)

1. Use the "Activity 3" slide to provide an introduction to students.

2. Refer students to the "Energy on the Scene" image they labeled in Activity 1 and the "Electricity Path" graphic reviewed in Activity 2.

3. Discuss the six primary sources for electrical energy, ensuring students recall the difference between renewable and nonrenewable resources. Sample prompts:

   - Which power sources are renewable and which ones are nonrenewable?
     Answer: renewable—wind, solar, hydro; nonrenewable—oil, natural gas, coal.

   - What are some of the reasons we might want to use renewable sources for our electricity? Possible student responses: helps the environment; conserves resources that we will not be able to get back.

4. Use the "Let's Think About It" slide to present the fun facts about solar energy below. Read the facts and prompt students to guess what type of energy they will learn about.

   - Can you guess which renewable energy source the following sentences describe?
     - » This type of energy was first used in space to provide power on spaceships.
     - » It is the most abundant energy source on earth.
     - » Enough of this energy reaches the earth in an hour to meet all human needs for an entire year.

     Answer: solar energy

5. Ask students to think about their own prior knowledge of solar energy using the following question:
   - Can you think about ways humans may have used the sun as energy in their homes in the past?
   - Possible student responses: light, heat their homes, cook, heat water, light fires, tell time (sundial)

6. Use the "Introduction to Solar Energy" slides to discuss examples of how solar energy is used. The slides include older examples, such as a sundial and starting a fire, and more modern examples, such as solar calculators, garden lights, and solar panels on a building or street sign.

7. Use the vocabulary slides to introduce the terms *solar cell*, *solar panel*, and *solar power system*.

8. Ask students if they have seen solar panels on buildings before or if they have solar panels at their house. Remind students that they might have solar panels at home and not even realize it, such as outdoor lights and calculators.

9. View the **Upcycling: From Landfill to Solar Farm** video. Luba Zhaurova, Sustainability Project Manager for the City of Worcester, shares about the innovative placement of a solar farm in Worcester, Massachusetts.

10. Lead a discussion on the concepts covered in the video. Sample prompts:
    - What uses of solar energy did you see in the video?
    - What are your thoughts on the benefits of using solar energy in a community?

11. Use the vocabulary slide to introduce the term *upcycle*.

12. Lead a discussion on how the landfill was upcycled in the video.

Cross-Curricular Connections:

You can explore the following art connections with your students:

- A complaint with solar fields is that they are ugly. Artists are being called in to artfully install solar panels so they look beautiful in addition to helping the environment. (https://landartgenerator.org/blagi/archives/75833)
- There are examples of works of art powered by the wind—art on recycled solar panels as a canvas. (https://artistsandclimatechange.com/2018/05/17/solar-panels-as-artistic-canvas)

13 Use the **How Does Solar Energy Work?** animation to help students explore solar panels and how they function in a solar power system.

For your use, the following term may be helpful:

volt (V)	The standard unit of measure for electric potential (voltage)

Possible Misconception: High temperatures do not improve performance of solar panels. Extreme heat can negatively affect their performance and damage solar cells.

Possible Misconception: It is a misconception that solar energy costs a lot of money to install and use. While initial installation can be costly, the cost has drastically decreased over the last 20 years, and long-term savings are significant.

14 Display the following solar energy simulation. You may choose to have your students access the site directly or project it on a screen for the entire class to view together. While students observe the simulation, ask them to share what they are observing.

Energy Forms and Changes / Phet Colorado Simulation
PhET Interactive Simulations
University of Colorado Boulder
https://phet.colorado.edu

Instructions to access the solar energy simulation:

a. Select Systems at the bottom of the screen.
b. Select the image of the sun from the input menu on the bottom left.
c. Select the image of the solar panel from the system menu in the bottom middle.
d. Check the Energy Symbols box in the top-right corner.
e. Rotate through any of the four output items on the bottom right to demonstrate how the light energy from the sun processes through the solar panel to produce different types of energy in different devices.

Differentiation Strategy: Some students may absorb the information better on a personal device. If possible, provide opportunity for individual or small group exploration of the simulation. While visiting with individuals or small groups, reteach the information on the functionality of a solar panel and prompt further thinking for advanced learners.

Extension Opportunity: Take a deeper dive into electric current generation and how it takes place on a solar panel.

Part 2. Shine Down on Me (65 minutes)

15 Guide students to locate the page titled "Activity 3: Going Solar" in their Launch Logs.

16 Distribute the Activity 3 kit materials to each group.

17 Ask students to refer to the Equipment list in their Launch Log to make sure their group has the necessary materials.

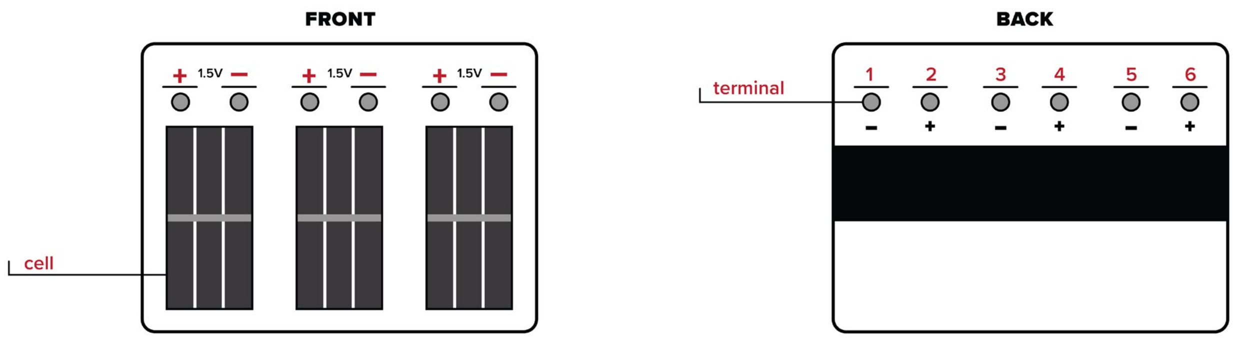
Note: This activity only requires some of the kit parts. See the Equipment list for the specific list.

18 Guide students to explore the solar panel so they can familiarize themselves with the parts.

19 Direct students to label parts on their Solar Panel Diagram in their Launch Log. They should label the following items:

a. Front: three photovoltaic **cells** with **positive (+)** and **negative (-)** sides. Each cell produces 1.5V of power and 100mA of electric current.
b. Back: six **terminals** with positive and negative sides. Label the terminals **1-6** from left to right. It will help students with their assembly.
c. Input is the **solar light**.
d. Output is the **electricity**.

Student responses:

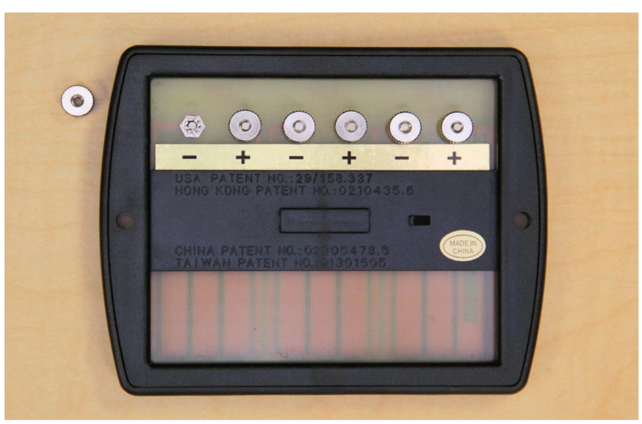


20 Assist student groups in the assembly of their solar-powered fans. The following instructions are also printed in the student Launch Logs.

> Differentiation Strategy: Different groups will require varying levels of support with the build. Move around from group to group,comma assisting those who need it and prompting deeper thinking on different solar-powered devices for advanced learners.

Simulation Instructions (also provided in the Launch Log)

a. On the back of your solar panel, unscrew the nuts across all six terminals.

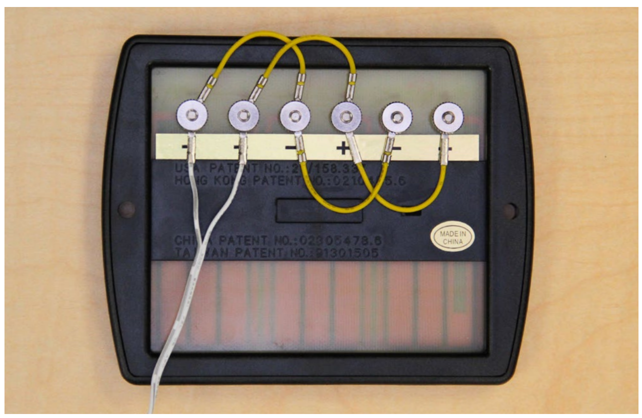


b. Attach the four jumper wires, connecting the negatives to negatives and the positives to positives.

   I. Attach one jumper wire across terminals 1 and 3.
   II. Attach one jumper wire across terminals 2 and 4.
   III. Attach one jumper wire across terminals 3 and 5.
   IV. Attach one jumper wire across terminals 4 and 6.

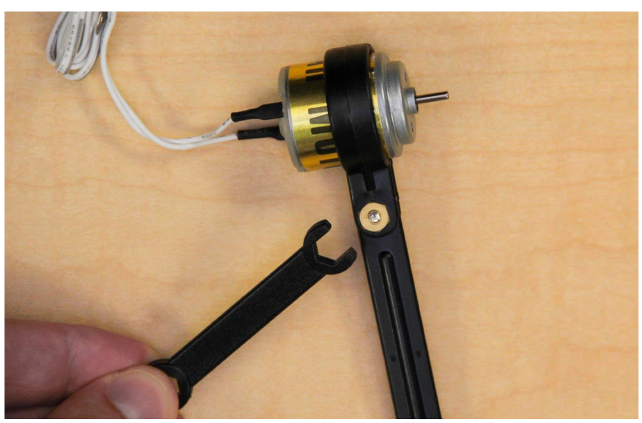
c. Attach the motor wires to terminals 1 and 2.

d. Screw the nuts back across all six terminals to hold the wires in place.



e. Use the wrench to slightly loosen the screw on the motor holder.

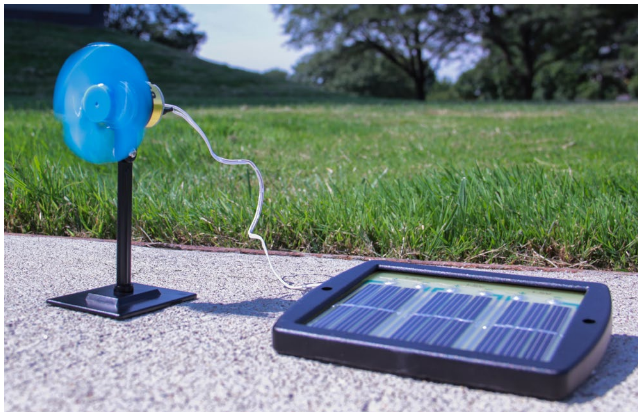
f. Slide the motor through the ring and then tighten the screw.



g. Slide the fan onto the motor.

h. Insert the motor holder onto the base and then twist the holder to lock it into place.

21 Guide your students to carefully take their assembled panel and fan outside and ensure the panel is facing up toward the sun. The fan should start spinning immediately!



Career Connection: Solar Energy Technician

Solar energy technicians install, maintain, and operate equipment and systems that use solar energy. These technicians require high school diplomas and experience that demonstrates the ability to learn the technology or education certification in solar energy.

22 Have students sketch their completed, functioning solar-powered fan in their Launch Log on the graph paper.

> Differentiation Strategy: Some students might require more time than is available to complete this task. Allow flexible time to complete the sketch.
>
> Differentiation Strategy: Another option to sketching might be to allow a student to provide you with a written or verbal description of the solar-powered fan.

23 Let your students know they will have the opportunity in the project and problem to test more functionality with the solar panel. This is just the beginning of their solar energy exploration!

24 Lead a discussion on the solar power system. Sample prompts:

- Describe how a solar panel works.
- Describe how the sun makes electrical energy we can use.

Conclusion Questions (5 minutes)

Assessment Strategies: Conclusion questions offer an opportunity for formative assessment. You may use them as a whole-class discussion, or you may have students record ideas in their Launch Logs. Use the "Conclusion Questions" slide to present the following questions:

1. Identify something that might benefit from running on solar energy. How would you modify the item for it to be solar powered?
   Responses might include the idea that electricity for the whole school or a house could run primarily on solar energy. At a smaller scale, lighting, charging electronics, and specific appliances, like a washer and dryer. It would require rewiring the device in order to connect to a solar panel.

2. What are the benefits of using solar energy?
   Student responses should demonstrate an understanding of renewable and nonrenewable resources. Responses might include the idea that it would help the environment by conserving nonrenewable energy sources.

PROJECT

Fun in the Sun

Introduction

In this project, students investigate factors that affect the way a solar power system works as they learn how scientists systematically find answers to questions. After building a solar power system, students explore what angle a solar panel should face and how direct or indirect sunlight affects the system.

Knowledge and Skills

KS1.2.1: Ask and identify questions to gain knowledge or solve problems.
KS1.2.2: Make observations to draw conclusions of phenomena.
KS1.2.3: Analyze data to look for patterns or to test whether data are consistent with an initial prediction.
KS2.2.1: Assemble and use a solar power system to power a device.
KS2.2.2: Explore the transfer of solar energy to electric energy.
KS2.2.3: Identify the input and output of a solar power system.
KS5.1: Generate ideas as a team.
KS5.2: Value the contributions of each team member.
KS5.3: Demonstrate collaboration through effective communication.
KS6.1: Document work in an organized notebook.
KS6.2: Explain findings and justify evidence-based conclusions with others.
KS6.3: Present data and information accurately and effectively.
KS7.1: Engage in and maintain positive interactions and relationships with other children and adults.

Equipment

- *Zero Waste: Energy Waste* Launch Log (one per student)
- *Zero Waste: Energy Waste* presentation (Activity 3 slides)
- Elenco® Solar Energy Kit
- Pencils or colored pencils for sketching

Teacher Preparation

- In this project, students use the scientific inquiry process. This process is similar to the design process; however, there are distinct differences. The scientific inquiry process:
  - » is brought into PLTW Launch modules to provide exposure and experience for students to think and work scientifically;
  - » is included in the modules whenever students need to collect data and answer testable questions;
  - » helps students learn how to approach a testable question and set up an experiment to collect the necessary data;
  - » Plan for students to complete the investigation on a sunny day to ensure the solar cells will gather enough sunlight to make the device work.

Note: If needed, you may use a 100W light bulb as an alternative to the sun. Do not leave the panel in this position for more than three minutes. Provide safety cautions and procedures to students to ensure they do not touch the light bulb as the light bulb can become extremely hot.

- Refer to the Elenco® Solar Energy Kit booklet for more information regarding the use of the solar panel.

- (Optional) When using the light bulb as a component in a solar power system, there are two recommendations.
  - » When using the solar panel outside, it may be difficult to see the light bulb light up in the sunlight. it is recommended to place the light bulb in a box or enclosure that allows students to see the light bulb light up.
  - » Another option is to use a 100W light bulb and place the solar panel five inches away from it. Note the precautions listed above for using the 100W light bulb.

Instructional Procedure

Time: 110 minutes

Vocabulary	
scientific inquiry process	A process that scientists use to explore observations and answer questions
scientist	A person who asks questions, makes observations, and investigates ideas to acquire knowledge and/or solve problems

Procedure

1. Use the “Project” slide to provide an introduction to students.

2. Ask students what they think scientists do.

3. Use the vocabulary slide to introduce the term *scientist*.

4. Discuss with students that scientists are people who ask questions, make observations, and investigate ideas to acquire knowledge and/or solve problems. Tell students that they are now going to act as scientists to learn more about solar energy.

> Extension Opportunity: To encourage career connections in the classroom, you could invite guest speakers who are scientists to talk about their work and their use of the scientific inquiry process.

> Cross-Curricular Connection: Consider appropriate read-alouds that focus on individual scientists and their work.

5. Explain to students that they are going to use the same process scientists use when asking questions about the world around them.

6. Use the vocabulary slide to introduce the term *scientific inquiry process*.

7. Guide students to locate the page titled “Project: Fun in the Sun” in their Launch Logs.

8. Present the **Scientific Inquiry Process** video as an introduction to scientists and the scientific inquiry process. Direct students to fill in the steps of the scientific inquiry process in their Launch Log.

9. Use the “Let’s Think About It” slide to lead a discussion about what students learned from the Scientific Inquiry Process video. Sample prompts:
   - Why do scientists use the scientific inquiry process?
   - How do you think the scientific inquiry process helps scientists in their work?
   - Why is it important to ask questions as you work through the scientific inquiry process? Why do you think that?

10. The first step in the scientific inquiry process is **Ask:**
    a. Lead a discussion about the following questions.
       - What conditions are necessary for a solar power system to operate successfully? Possible student responses:
         » Amount of sunlight available
         » Tilt of panel toward the sun
         » Cleanliness of the panel

> Possible Misconception: Students may assume that if it is cloudy, solar systems can’t run. Or if you live in a darker climate, solar energy isn’t possible.

- Why do you think this?
- Do you think any of these factors would need to change depending on the device you want to power? (fan, light bulb, music player, rotating disc)
- Why do you think this?
- How do you think we can test this?

> Extension Opportunity: Students may also test the fan and the light bulb components. Guide students to create additional tables in their Launch Logs to record their predictions and observations for this extension.

11 The second step in the scientific inquiry process is **Predict**:

a. Guide students to predict how the solar power system will work for each variable.
   - For the “Amount of Sunlight” variable, guide students to consider the following amounts: no sunlight/in full shade, partial sunlight/some clouds, full sunlight.
   - For the “Tilt of Panel” variable, guide students to consider the following placements: away from the sun, in the sunlight but not directly, directly toward the sun.

b. Have students record their predictions in their Launch Logs.
   I. Encourage students to include sketches and written notes for their predictions.
   II. Ask students to label the input and output for each solar-powered device.

12 The third step in the scientific inquiry process is **Investigate**:

a. Guide each group to test the rotating disc and the music player.

13 The fourth step in the scientific inquiry process is **Observe**:

a. Guide students to observe and record what happens when the solar cell receives different amounts of sunlight.

b. Guide students to observe and record what happens when they tilt the solar panel in different directions related to the sun.

14 The fifth step in the scientific inquiry process is **Explain**:

a. Use the “Let’s Think About It” slide to lead a discussion about what students observed during the investigation. Ask students to explain their thinking as they share their thoughts. Sample prompts:
   - Why do you think the solar-powered device worked the best in a sunny location?
   - How was this different than the solar panel being placed in a shady location? Why do you think this?
   - How might the weather impact the way a solar-powered device works? Use evidence from your investigation to support your thinking.
   - Why do you think the solar-powered device worked the best when the panel was tilted directly toward the sun?
   - How was this different than the solar panel being placed in the sun, but not directly pointed toward the sun? Why do you think this?

Possible Misconceptions: Student may think that solar power can only be used in warmer climates. Solar energy is produced from sunlight, not heat. The amount of sunlight a solar panel receives is the primary factor of how well a solar panel functions. Solar panels can still gather energy in the cold winter months.

15 Present the **The Current and Future State of Solar Energy** video. Luba Zhaurova, Sustainability Project Manager for the City of Worcester, identifies solar energy challenges and the need for future innovations.

16 Lead a discussion on the concepts covered in the video. Address any student misconceptions.

Career Connection: Solar Power Materials Engineer
Material engineers in the solar industry develop and test materials for use on solar panels, solar power systems, and in the construction of solar power plants.

17 Guide students to answer the conclusion questions. Lead a discussion for students to share their thoughts.

Conclusion Questions

Assessment Strategies: Conclusion questions offer an opportunity for formative assessment. You may use them as a whole-class discussion, or you may have students record ideas in their Launch Logs. Use the "Conclusion Questions" slide to present the following questions:

1. If you could place a solar panel on your house, where would you place it and why?
   Responses might include "By placing the panel on the roof of my house that is facing the sun will allow the most sunlight to shine on the solar panel. I would not want to place it on the side of my house that faces away from the sun or on the end that has a tree that shades the roof."

2. How would you hope to see solar energy used in the future?
   Student responses should demonstrate an understanding of conservation, natural resources, and the advantages of solar energy. Responses might include "Using a renewable resource, such as solar energy, conserves our nonrenewable resources. By using solar energy, we use fewer fossil fuels. I hope to see more individuals and businesses using solar panels on their homes/businesses and in their homes/businesses in the future as the cost of solar panels drops."

PROBLEM

Harnessing the Sun's Energy

Introduction

Students demonstrate their understanding of solar energy by following the design process to explore, sketch, build, and evaluate a solar-powered invention of their choice. Students upcycle materials to build their design prototype.

Knowledge and Skills

KS1.1.1: Define a simple design problem reflecting a need or a want.
KS1.1.2: Brainstorm possible solutions to the problem.
KS1.1.3: Evaluate a solution through observations and/or measurements and consider what revisions to the initial solution are needed.
KS2.2.1: Assemble and use a solar power system to power a device.
KS2.2.2: Explore the transfer of solar energy to electric energy.
KS2.2.3: Identify the input and output of a solar power system.
KS3.1: Understand the importance of conserving energy.
KS3.3: Identify ways that upcycling can be used to reduce waste.
KS5.1: Generate ideas as a team.
KS5.2: Value the contributions of each team member.
KS5.3: Demonstrate collaboration through effective communication.
KS6.1: Document work in an organized notebook.
KS6.2: Explain findings and justify evidence-based conclusions with others.
KS6.3: Present data and information accurately and effectively.
KS7.1: Engage in and maintain positive interactions and relationships with other children and adults.

Equipment

- *Zero Waste: Energy Waste* Launch Log (one per student)
- *Zero Waste: Energy Waste* presentation (Activity 3 slides)
- Elenco® Solar Energy Kit
- Aluminum foil
- String
- Masking tape
- Glue
- Pencils or colored pencils for sketching
- Recyclables such as:
    - Cardboard
    - Paper
    - Cans
    - Styrofoam
    - 2-liter pop bottles
    - Milk jugs

Differentiation Strategy: Plan for diversity by considering all the different types of students and families in your classroom and encouraging your students to bring in recyclables from products they use at home.

Teacher Preparation

- Ensure that you have collected plenty of recyclable materials for students to use for their designs. Have these materials in a location that students can easily access.
- Refer to the Elenco® Solar Energy Kit booklet for more information regarding the use of the solar panel.

Note: When using the light bulb (optional for this project) as a component in a solar power system, there are two recommendations.

» When using the solar panel outside, it may be difficult to see the light bulb light up in the sunlight. It is recommended to place the light bulb in a box or enclosure that allows students to see the light bulb light up.

» Another option is to use a 100W light bulb and place the solar panel five inches away from it. Do not leave the panel in this position for more than three minutes. Provide safety cautions and procedures to students to ensure they do not touch the light bulb as the light bulb can become extremely hot.

Instructional Procedure

Time: 205 minutes

Vocabulary	
constraint	A limitation or a restriction. Constraints can include limits on time, materials, or size.
criteria	Guidelines or rules used to judge or make a decision about something.
design process	A step-by-step way to solve problems.
engineer	A person who asks questions, observes, and gathers information to create new products or make old products better.
prototype	A working model than can be tested and evaluated.

Procedure

1. Use the “Problem” slide to provide an introduction to students.

2. Review the Introduction Story, “Harnessing the Sun’s Energy” with students. Remind students that their challenge is to design a prototype of a solar-powered invention.

3. Use the vocabulary slide to introduce the term *prototype*.

4. Ask students what they think engineers do.

5. Use the vocabulary slide to introduce the term *engineer*.

6. Discuss with students that engineers are people who ask questions, make observations, and gather information to create new products or make old products better.

7. Use the vocabulary slide to introduce the term *design process*.
    a. Ask students to share examples of how they’ve used a step-by-step process to complete a task. Examples include:
        - Getting ready for school
        - Brushing teeth
        - Solving a math problem
        - Making a snack
    b. Explain to the students that they are going to use the same steps that engineers use to design new items and improve existing items.

8. Distribute Launch Logs to students. Direct them to the Problem page.

9. Present the **Design Process** video as an introduction to engineers and the design process. Direct students to fill in the steps of the design process in their Launch Log.

10. Lead a discussion about what students learned from the Design Process video. Use the “Let’s Think About It” slide to present the following questions:
    a. Why do engineers use the design process?

b. How do you think the design process helps engineers in their work?
c. Why is it important to ask questions as you work through the design process? Why do you think that?
d. In the video, we learned that it is important to understand the problem before looking for a solution. Have you ever identified a problem and then looked for a solution? Allow students to share their thoughts.

11 Guide students to locate the page titled "Solving the Problem" in their Launch Logs. Students use this section to take notes as they work through the design process to design a prototype of a solar-powered invention. Remind students to include details that provide evidence for their thinking.

Note: Students should upcycle materials to create their designs. Students may need to creatively design ways to incorporate these materials into their inventions for the solar power system to function. Student inventions should reflect new thinking and innovative ideas. Their designs should be more than turning an existing device that uses electricity into a solar-powered device

12 The first step in the design process is **Ask**.

a. Guide a discussion where students ask questions to gather information that will help them define the problem.
b. With support and guidance, the students define the problem, "What solar-powered invention can we design?"
c. Use the vocabulary slide to introduce the terms *criteria* and *constraint*.
d. Introduce the criteria and constraints of the design.

Criteria	Constraints
• The group must design, build, and test an invention that uses solar energy. • The group must be able to identify the input and output. • The solution must successfully convert solar energy into electricity. • The solution must be testable with the available equipment.	• Time • Materials

e. Guide the students in a discussion to consider the problem, criteria, and constraints.

Note: It is important to discuss how the solar panels that are used for testing their design are larger and may not be ideal for every design. Explain to students that the panels are for testing purposes only. If their design ideally includes a smaller solar panel to allow it to function in a certain way, this is fine and will just need to be explained when they share.

f. Guide students to record their responses in the Ask step of their Launch Logs.
g. Have students complete the self-reflection at the end of the Ask section in their Launch Logs. Guide students to circle one statement in each row. Assess student understanding and record comments as needed.

Note: At the end of each stage of the design process, students complete a self-reflection. This self-reflection is intended for students to provide honest feedback about where they are during each stage. They're not expected to be "advanced" in all areas all the time. Explain to students that this self-reflection is intended to help them grow as problem solvers.

13 The second step in the design process is **Explore**.

a. Guide students to research how others have tried to solve a similar problem. Encourage students to research a variety of ways engineers have tried to solve this problem in the past. When looking at the work of engineers, support students to identify specific design features that address the task they have chosen to solve.
b. Have students record their research findings in the Explore section of their Launch Logs.
c. Guide students to brainstorm several ideas that may solve the problem. Students may use the skills and knowledge they gained from the activities and project in this module, as well as any information they gathered from their research.
d. In the corresponding section of their Launch Logs, students record ideas and label sketches for their solution.
e. Guide students to share their initial ideas with their group. Encourage them to add any new ideas by writing or sketching in their Launch Logs.

f. Have students complete the self-reflection at the end of the Explore section. Assess student understanding and record comments as needed.

14 The third step in the design process is **Model**.

a. Introduce a decision matrix to decide on the best solution. Using the Decision Matrix, students rate each group member's design based on a 0–1 scale for each category. If the design does not meet the criterion in a category, it receives a 0 in that category. If the design does meet the criterion, it receives a 1. The design with the highest total score offers the best solution from the group.
b. Guide students to use the chosen design to build their prototype.
c. To facilitate design prototyping, circle around the room and assess student progress. Ask students to share their ideas and their thinking with you as they work.
d. Guide students to add a drawing of their model in the corresponding section of their Launch Logs.
e. Have students complete the self-reflection at the end of the Model section. Assess student understanding and record comments as needed.

15 The fourth step in the design process is **Evaluate**.

a. Explain to students how they will conduct a fair test to determine how well their model solves the design problem. Students will use the following steps:
   - Support students in identifying what conditions will indicate the success of their solutions.
   - Have students record the results of their tests.

Note: Due to the open-ended design, testing and data collection can vary significantly from group to group.

b. Encourage students to discuss the results to decide whether their model solved the problem.
c. Guide students to reflect on strengths and weaknesses of their designs and record them in the corresponding section of their Launch Logs.
d. Have students complete the self-reflection at the end of the Evaluate section. Assess student understanding and record comments as needed.

16 The fifth step in the design process is **Explain**.

a. Guide students to present their results to the class. The presentation should include all aspects of the design process, such as:
   - **Ask**: Describe the solar-powered invention you designed.
   - **Explore**: Display sketches and describe the important features of the designs.
   - **Model**: Share how you chose the model design using the decision matrix.
   - **Evaluate**: Show sketches of the solution before, during, and after testing. Describe how you tested the design. Explain whether the design provided a solution to the problem.
   - **Explain**: Discuss the strengths and weaknesses of the design and ways to improve the design.

b. Provide time for students to share their presentations.

c. After all presentations, lead a discussion about the features, strengths, and weaknesses of the different designs. Sample prompts:
   - Describe how your invention is powered by solar energy.
   - What design features did you incorporate in your solution?
   - How did you test your solution to evaluate its effectiveness?
   - If you could improve anything in your solution, what would you improve? Why would you improve that?

d. Guide students to complete the Explain section of their Launch Logs. Have students provide suggestions for improvement for their design and support those with evidence.

e. Have students complete the self-reflection at the end of the Explain section in their Launch Logs. Assess student understanding and record comments as needed.

17 Guide students to answer the conclusion questions. Lead a discussion for students to share their thoughts.

Conclusion Questions

Assessment Strategies: Conclusion questions offer an opportunity for formative assessment. You may use them as a whole-class discussion, or you may have students record ideas in their Launch Logs. Use the “Conclusion Questions” slide to present the following questions:

1. Describe your invention and how solar energy enabled it to function. Support your answer with the evidence you recorded in your Launch Log.
   Student responses will vary.

2. List two changes you would make to improve the design. Why do you think these changes would improve your invention?
   Student responses will vary.

References

The following references were used in the creation of this module.

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Appendix

- PLTW Curriculum Framework
- Zero Waste: Energy Waste Family Letter
- Introduction Story: “Harnessing the Sun’s Energy”
- Energy Source Images
- Energy Source Cards
- Energy Consumption Scenarios
- Massachusetts State Science and Technology Engineering Standards Alignment