HAWAI`I STATE ENERGY OFFICE

RENEWABLE ENERGY LABS

GRADES: K-2

State of Hawai‘i

Department of Business, Economic Development, and Tourism

Hawai‘i State Energy Office

CLEAN ENERGY EDUCATION CURRICULA and TOOLKITS

The purpose of the Hawai‘i State Energy Office (HSEO) is to promote energy efficiency, renewable energy, and clean transportation to help achieve a resilient clean energy economy by 2045. HSEO is developing a statewide clean energy public education and outreach program to empower teachers', students', and their families' participation in Hawai‘i's transition to a decarbonized economy; and to encourage Hawai‘i's K-12 students to become the next generation of clean energy leaders.

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Developed by MEDB STEMworks for the Hawaiʻi State Energy Office

Curriculum at a Glance	
Grade Levels	K-2
Time Required	Estimated: 5 Days
Group Sizes	3 - 4
NGSS Performance Expectations	K-PS3-1, K-PS3-2, 1-PS4-3 , 2-PS1-2, K-2-ETS1-1,K-2-ETS1-3 Evidence Statements
Activity Title	**Guiding Questions**
Kilo Exercise: Nature Walk in Sun and Shade	What do I see? What do I feel? What do I smell? What do I hear?
Reading Exercise: Energy Physical Science for Kids	What is energy? What things need energy?
Lab 1: Light and Shadow Adventure	How does the sunlight affect my shadow? How long is my shadow? Why does my shadow grow taller or shorter throughout the day? What patterns do I see? How do observations and data help me answer my questions?
Lab 2: Heat from the Sun	How does the sun make me feel? How does the sun change the water temperature? Do some items get hotter than others faster? If so, why? How do observations and data help me to answer my questions?
Lab 3: Solar Oven Engineer - Cooking with Sunlight	What happens to different materials in the solar oven? How can science help me make a better solar oven? What time of day will my solar oven work the best? How can I modify my solar oven design to improve it?
Online Extension Activity: TinkerCAD	What tools do engineers use? How do engineers create 3D designs (or models)
At Home Extension: Solar Water Purifier	What did I observe? How could this device be useful?

Summary

This renewable energy curriculum guides young learners (K-2) through the process of exploring and experimenting with light, heat, and energy through hands-on interactive lab activities. This curriculum begins with a kilo exercise to allow students the opportunity to practice making observations, recording observations, and sharing their observations. Next, a reading exercise brings the topic of energy to life, and encourages critical thinking around what energy is. The three laboratory activities included herein provide students with hands-on learning opportunities to advance energy literacy in our young people. These labs also meet NGSS performance expectations (see growth objectives below). Students will have a chance to engage in the engineering design process at an age-appropriate level and learn about STEM careers throughout the lessons. All three laboratory exercises walk students through the process of making observations, asking questions, collecting data, analyzing their data, and more, in a collaborative environment with their teammates and classmates. In Lab 3, students will further practice the engineering design process using a solar oven kit to explore the process of design, how to test strengths and weaknesses of their designs, and how to make modifications to their designs, if needed, to improve performance. ***This renewable energy curriculum aligns to Next Generation Science Standards (NGSS).***

Growth Objectives

After completing this curriculum, students should be able to:

- Make observations of a phenomenon (with guidance).
- Ask questions based on observations to find out more about how the world works.
- Plan and conduct investigations (with guidance) collaboratively to generate data.
- Organize and analyze data obtained from testing different materials (builds on collecting, recoding, and sharing observations).
- Feel that sunlight warms the earth's surface.
- Recognize that events have causes that generate observable patterns.
- Observe that sunlight warms different materials differently.
- Describe (with guidance) that certain materials absorb or reflect energy to create heat more efficiently using white objects and black objects as examples. Some objects get warmer, some are cooler (qualitative measures, quantitative when appropriate).
- Share how scientists use different tools and methods to study the world.
- Use scientific knowledge to generate a design solution.
- Using given materials and tools to design and build a device that solves a specific problem (build an efficient solar oven to capture sunlight).
- Describe different features of their design solution.
- Compare the strengths and weaknesses of different design solutions.
- Practice collaboration, teamwork and communication to design, build, and evaluate a solution.
- Identify that different properties are suited for different purposes (identifying relationships).

NGSS Condensed Practices for Teachers

Career Connections

Scientists

Scientists are people who make observations, ask questions, and use the scientific method to do research to find answers to many questions that few people know about. There are more than 50 kinds of scientists. Some examples are:

- Astronomers - Study the universe, the stars, planets, and everything in outer space
- Biologists - studies living things
- Botanists - studies plants and algae
- Chemists - studies materials and chemicals
- Earth Scientists - studies the earth, earth resources, climate, and natural hazards (volcanoes)
- Oceanographers - scientists who study the ocean (biology, geology, chemistry, physics)

In this curriculum, students will have a chance to think like astronomers, earth scientists, and energy scientists.

Engineers

Engineers use science and math to design and create products, buildings, machines, instruments, and more for human use and benefits. They are great problem solvers. Engineers go through the process of design, prototyping, and modifying their designs (sometimes many iterations of this) until there is an optimal solution. Note there will usually be many possible solutions to a single problem. Oftentimes, engineers need to work in teams made up of people with different subject matter expertise.

Just like scientists, there are different kinds of engineers:

- Aerospace engineers - design airplanes, jets, rocket ships, and satellites
- Mechanical engineers - design mechanical and thermal devices (engines, tools, machines)
- Electrical engineers - make sure the electricity works
- Biomedical engineers - create medicines, and machines for the body
- Chemical engineers - solve chemical, food, and medicine production problems
- Civil engineers - design, build, and maintain infrastructure (roads, bridges, sewer systems)
- Environmental engineers - solve environmental problems (waste, water and air pollution)

In this curriculum, students will have a chance to think like mechanical and environmental engineers as they work collaboratively to build a solar oven to cook foods or melt objects to avoid creating air pollution.

Introduction to Energy and Light

Aloha e Energy Explorers!

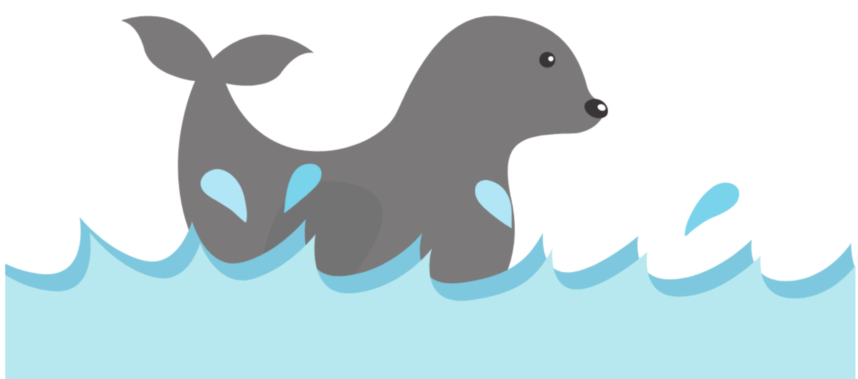
My name is **Pāʻanaakalā** (sunshine), and I will be your guide as we dive into this learning adventure about **energy** and **light**.

Name	Pāʻanaakalā
Superpower #1	I live on land *and* at sea.
Superpower #2	I am a “living fossil”.
Superpower #3	I love to soak up sunshine.

But first, I would like to know more about who I am adventuring with:

Your Name	
Superpower #1	
Superpower #2	
Superpower #3	

Alright friends, let’s dive in!



Kilo Exercise: `Āina-based learning nature walk *(one class period or less)*

“**Kilo**” means to watch, observe, examine, or forecast. You can practice kilo by paying deep attention to the world around you. Let’s go outside for a nature walk to practice kilo and make some **observations**. In this activity, you will first kilo an area in full sun, and then kilo an area in the shade. To improve your clarity of mind before you kilo, take five deep breaths.

1-2-3-4-5

KILO PRACTICE

A technique that connects you with phenomena
by exploring nature through your senses.

Instructions: Sitting or standing, take a deep breath in, and complete the following questions.

1	Find a spot in the sun	
2	Things you can feel	
3	Things your can hear	
4	Things you can smell	
5	Things you can see	

1-2-3-4-5

KILO PRACTICE

A technique that connects you with phenomena by exploring nature through your senses.

Instructions: Sitting or standing, take a deep breath in, and complete the following questions.

1 Find a spot in the shade

2 Things you can feel

3 Things your can hear

4 Things you can smell

5 Things you can see

So friends, what did you observe during your kilo practice?

Post-Kilo Assessment: *Once you come back inside, have students collaboratively share their observations in small groups, then make a collective list together. You may want to toss Pāʻanaakalā around as a means to take turns sharing. If they notice that they felt warmer in the sun and cooler in the shade, highlight that observation. At the end, share with them that everything around them that they observed using their senses requires* ***energy*** *to exist and function. But what is energy?*

Extra Kilo Resource

What is energy?

Energy is all around us. It is the power that makes things go, including **you**. What gives you energy? (Draw three pictures or write three sentences about things that give you energy.)

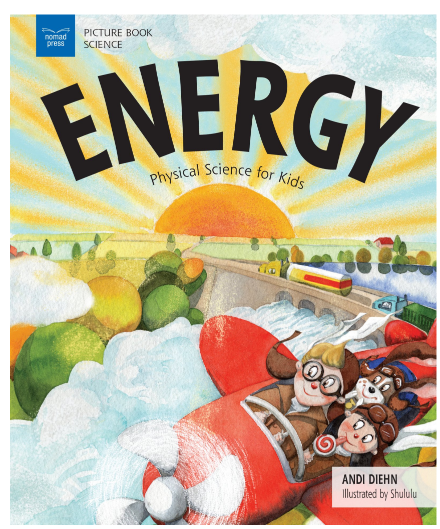
1. ____

2. ____

3. ____

Energy comes in many forms. You get energy from the foods that you eat and the liquids you drink. Have you ever noticed how much energy you have after a sugary treat?

But what about other animals? How about plants? How about your iPad or Chromebook? How do they get energy? Let's read a book together to learn more.



Reading Activity: Energy Physical Science for Kids

(one class period or less**)**

Read this book out loud in your classroom. For older students, you may want them to read to themselves, or with a partner. This book will help young learners discover different forms of energy including chemical energy, light energy (solar), and electrical energy.

You want students to engage with the text by reflecting and communicating like scientists and engineers. They should use *information in the text and pictures to find evidence and discuss and record their questions, predictions, claims, and conclusions.*

Suggested Commentary:

- **Page 6:** *Emphasize "Food and rest produce energy in people and animals".*
- **Page 14**: *Emphasize "Plants get energy from drinking water and absorbing sunlight."*
- **Page 15**: *Ask: "What else do you think uses chemical energy?"*
- **Page 21**: ***Optional Activity:*** *1. Get a ball. 2. place the ball on the ground, what does it do? (sits still) 3. Give it a nudge. Now what does it do? (it moves) 4. When did the ball have energy? It always has energy - potential energy at rest and kinetic energy when it is in motion.*
- **Page 21**: *Emphasize that "energy from sunlight is called light energy". You may want to introduce the word "solar" here as well.*
- **Page 22**: *Emphasize "electrical energy". They have now been introduced to chemical energy, light energy, and electrical energy. It is important to know qualitatively that there are different kinds of energy.*
- ***Page 25**: Do the **Try This**" activity. This will be referenced later on in a lab activity. To have students generate heat, show them how to rub their hands together as fast as they can and make observations about how they feel.*

Post-reading assessment: *Younger students may need to answer these questions verbally or by drawing pictures. Older students should practice writing their answers out.*

Questions from the reading

4. Do trees, plants, and grass need energy? If yes, where do they get energy from?

 ____

 ____

 ____

5. What is energy from the sun called?

 ____

 ____

 ____

6. What does it mean when something is **invisible**?

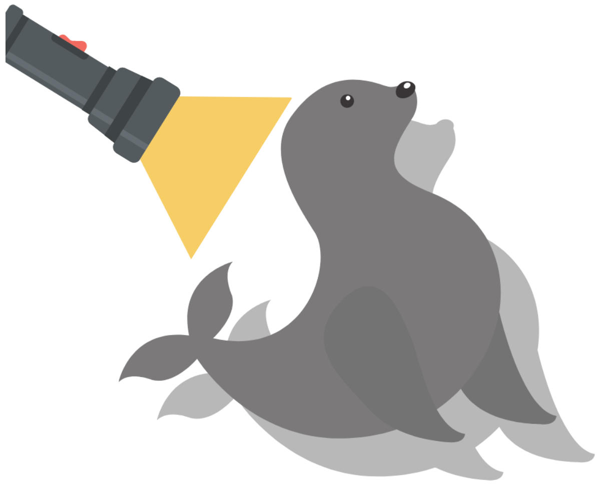
 ____

 ____

 ____

This energy stuff is really interesting. Are you ready to go back outside to learn more about sunlight, light energy, and heat? Luckily in Hawaiʻi, we have a lot of sunlight. Let's go, Energy Explorers!

Lab 1: Light and Shadow Adventure *(periodically throughout one day)*



NGSS Performance Expectations		
K-PS3-1 Make observations to determine the effect of sunlight on Earth's surface. *In this lab, students will go outside and record the effects of sunlight on earth surface by using their bodies as an object to create shadows. They should notice a pattern that their shadow changes throughout the day. They may also notice while standing in the sun, they begin to feel hot. These observations will be important foundations for Lab 2.*		
1-PS4-3 Plan and conduct investigations to determine the effect of placing objects with different materials in the path of a beam of light. *Students will use their body to block sunlight from reaching the earth's surface, resulting in a shadow. They will repeat this experiment several times throughout the day to observe how their shadow changes as the angle of the sun relative to the horizon changes. You may want to have them bring out other objects such as transparent, translucent, or reflective materials to compare how sunlight interacts with these objects. *Be cautious with mirrors.*		
This exercise focuses on the following three dimensional learning aspects of NGSS		
Science & Engineering Practices	Disciplinary Core Idea	Crosscutting Concepts
Planning and Carrying Out Investigations Planning and carrying out investigations to answer questions or test solutions to problems in K–2 builds on prior experiences and progresses to simple investigations, based on fair tests, which provide data to support explanations or design solutions. Plan and conduct investigations collaboratively to produce evidence to answer a question. Make observations (firsthand or from media) to collect data that can be used to make comparisons.	**PS4.B: Electromagnetic Radiation** Some materials allow light to pass through them, others allow only some light through and others block all the light and create a dark shadow on any surface beyond them, where the light cannot reach.	**Cause and Effect** Simple tests can be designed to gather evidence to support or refute student ideas about causes. Events have causes that generate observable patterns.
HĀ outcomes practiced: 1. Belonging - students will actively participate, and practice communication skills. 2. Responsibility - students will be active learners, encouraged to ask for help, set goals and complete tasks with their team. 4. Aloha - students should learn to appreciate the gifts and talents of their team members, make others feel welcomed and heard, be respectful of all ideas, and share work responsibilities		

Prerequisite Knowledge

Before going outside to work on this lab, students should have a basic understanding that light shone at an angle onto a solid object creates a shadow. If they do not, you may want to demonstrate this by shining a light onto different objects including something transparent (light can go through), translucent (light can partially go through), reflective (light bounces back) and solid/opaque (light cannot go through). To help, we have included small mirrors, plastic wrap, and wax paper in this kit for you. You can also share this video: bit.ly/LightandShadows4Kids.

Before the Activity

- Divide students into groups of 3 for collaboration (**teams**).
- Direct students to select a **role** *(deciding on roles ahead of time helps to facilitate teamwork and collaboration skills).* Who will be the body that creates the shadow (**shadow maker**), who will trace the shadow (**shadow tracer**), and who will record the observations (**data keeper**)?
- Have students gather their lab materials.

Materials List

For this activity, each group will need:

- 3 pieces of sidewalk chalk of a different color (*included*)

- Sunny spot where students can safely draw their shadow
- Data sheet to record observations (*included; need to print*)
- Pencil (*not included*)
- Watch or time-telling device (*optional; not included*)
- Tape measurer (*optional; not included*)

Potential Safety Issues

- *This activity will take place in direct sunlight. To prevent sunburns, you may want to ask parents ahead of time to send in a hat, sunglasses, full-spectrum, reef-safe sunscreen, or anything they want their child to use to protect their skin from sun exposure.*
- *Remind students to never look directly at the sun, and do not point the small mirrors at the sun.*

Potential Obstacles

- *Students will need to select a spot that is free from shade. Note - as the sun moves throughout the day, a clear spot at the start of their experiment may become shady (they may not be able to see their shadow). You can choose to use that as a learning lesson, or ideally, help them select locations that you know will not be in the shade at any point in the day.*

Pre-activity Assessment: *Have students make a **hypothesis** on their data sheet. Ask, "How do you think your shadow will change over time today?"*

Procedure

Step 1: Setup

1. Select a location for your experiment.
2. Use a piece of chalk to mark an X where you want the **shadow maker** to stand. When you repeat this step, it is important that s/he stands in the same spot each time.

Step 2: Trace Your Shadow

3. Have the **shadow maker** stand in the center of your team's mark (X).
4. Have the **shadow tracer** trace the shadow on the ground using a piece of sidewalk chalk.

Step 3: Record Observations

5. The **data keeper** should record the time of the observation. (*can be general such as early AM)*
6. Write down (*or mark with crayon*) the color of chalk you used for this observation.
7. Describe the shape and length of your shadow (*qualitative*). *If you are using a tape measure, measure how far the shadow extends from the center point of the standing mark (quantitative).*

Embedded Activity Assessment: *Prediction*: *As a class, after each shadow tracing, join together and have teams share about their data. This helps to build their communication skills and to learn from each other. Have them make a prediction about what will happen to their shadow next. Answers will vary.*

<Repeat Steps 1-3 two more times> *Suggested times - 10am, 12pm, 2pm*

Step 4: Analyze your results

8. Do you notice a **pattern** in your data? ____

____

____

Post-activity Assessment

Discussion Questions: *Solicit and summarize student responses on a whiteboard, blackboard, or jamboard. For older students, you may want them to write their responses out below.*

1. How did your shadow change over time (for example: did it grow or shrink)?

   ____

   ____

2. Why? *(If they don't understand why, you can demo the changing angle of the sun by shining a flashlight onto a globe or ball at different angles)*

   ____

   ____

3. Was your first **hypothesis** correct? (*answers will vary)*

   ____

   ____

4. Were any of your predictions after making observations **validated**? (*answers will vary)*

   ____

   ____

5. What did you learn during this activity? (*answers will vary)*

   ____

   ____

Key Concepts: As the sun moves throughout the day, the angle that direct sunlight hits solid objects on the surface of the earth, in this case your students, changes. This results in changes to their shadow's shape and length. Early in the day, and later in the day, the sun appears lower in the sky relative to the horizon, and an object's shadow will be longer (taller) than at noon. At noon, when the sun is directly overhead, your students' do not block as much light, so their shadow is shorter or even directly under them. You can demonstrate or reinforce this concept with a flashlight and a solid object in your classroom.

Renewable Energy Connection: The angle of the sun and the tilt of a solar panel are really important factors in solar panel efficiency. Solar panels produce maximum energy when the sunlight is directly perpendicular to them.

Suggestion: Extra Fun *- If you are teaching anything about ancient history or cultures in your classroom, this would be a great opportunity to add in a lesson on sundials.*

PRINT Lab 1: Light and Shadow Adventure Data Collection Table

Hypothesis: What will happen to your shadow throughout the day?	
Observation #1 **Time**: _____________	
Observation #2 **Time:** _____________	
Observation #3 **Time:** _____________	
Data Analysis: Do you see a pattern?	

Use this space to write or draw your notes:

Lab 2: Introduction

In the first lab adventure about **sunlight** and **shadows**, you learned through making **observations** and collecting **data that** the sun sends **light energy** to the earth. As the sun moves across the sky, your body blocks more or less light depending on where the sun is. You hopefully **observed a pattern** that your shadow gets taller and shorter, and may change shape at different times during the day.

The sun makes another kind of energy (other than light energy). Can you guess what it is? *(**heat energy**)*

How did your skin feel when you were standing outside in the sun tracing your shadow? *Ask students, have you ever used shade to cool down? What kinds of things can be used for shade?* You might have wanted to retreat to the shadow of a tree to cool down. All objects on earth, including you, can **reflect** or **absorb** sunlight. Let's go outside and try a fun experiment to test out what happens to objects that reflect light energy and objects that absorb light energy. **Scientists**, are you ready to go?

Lab 2: Heat from the Sun Science *(one class period)*

<table>
<tr><th colspan="3">NGSS Performance Expectations</th></tr>
<tr><td colspan="3">2-PS1-2 Analyze data obtained from testing different materials to determine which materials have the properties that are best suited for an intended purpose.

In this lab activity, the intended purpose is to use sunlight to heat a container of water up efficiently. Students will take multiple temperature measurements (data collection) for a container of water over white cardstock and a container of water over black cardstock. From their data, they should see that white cardstock reduces the warming effect of sunlight on water through the process of reflection, while black cardstock increases the warming effect of sunlight on water through the process of absorption and conversion of electromagnetic energy into heat. Younger students may only understand “materials” as being fabric. This is a chance to expand the meaning of this word for them.</td></tr>
<tr><td colspan="3">This exercise focuses on the following three dimensional learning aspects of NGSS</td></tr>
<tr><th>Science & Engineering Practices</th><th>Disciplinary Core Idea</th><th>Crosscutting Concepts</th></tr>
<tr><td>Planning and Carrying Out Investigations
Planning and carrying out investigations to answer questions or test solutions to problems in K–2 builds on prior experiences and progresses to simple investigations, based on fair tests, which provide data to support explanations or design solutions.

Make observations (firsthand or from media) to collect data that can be used to make comparisons.</td><td>PS3.B: Conservation of Energy and Energy Transfer
Sunlight warms Earth’s surface. (K-PS3-1),(K-PS3-2)</td><td>Cause and Effect
Events have causes that generate observable patterns. (K-PS3-1),(K-PS3-2)</td></tr>
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</table>

Prerequisite Knowledge

- *Students should be able to use and read a thermometer. Test the thermometers in the classroom before going outside.*

Before the Activity

- Select groups of 3
- Decide on team roles *(students carrying the glass container should only carry that item and nothing else to avoid dropping the container).* One person to set up the white cardstock and water, one person to set up the black cardstock and water, and one person to record the data
- Gather materials

Materials List

For this activity, each group will need:

- Two glass cups (*included*)
- One measuring cup (*included*)
- One sheet of black cardstock (*included*)
- One sheet of white cardstock (*included*)
- Thermometer (*included*)
- Datasheet (*included; you need to print*)
- Pencil (*not included*)
- Water (*not included*)

Potential Safety Issues

- Be *careful with the glass containers. Make sure students only carry one item at a time and place the containers down carefully, on a flat spot.*
- *Students may get sunburned if in direct sunlight for too long. You may want to have parents send in a hat, sunglasses, or full spectrum, reef-safe sunscreen for this activity.*
- *Remind students to never look directly at the sun.*
- *Do not point thermometers at the sun.*

Potential Obstacles

- *You may have students who place one or more glass container(s) in the shade or a partially sunny area. Make sure that teams select areas with full-sun exposure for best results.*
- *Note the thermometers included in the toolkit have a very limited temperature reading range and water temperatures may quickly exceed the max temp. Low or Hi will appear.*

Pre-Activity Assessment: *Ask the students to write down, draw, or verbalize their hypothesis prior to going outside.* Which container of water will get hotter; the one over the white cardstock or the black?

Procedure

Lab Step 1: Setup

1. Select a flat, sunny location for your experiment.
2. Put the white cardstock and the black cardstock down on the ground.
3. Set one glass container on top of each piece of cardstock.
4. Using your measuring cup, fill each glass container with *exactly* 1 cup of water. A good scientist cares about **accuracy**. (*Younger students may need help).*

Lab Step 2: Data Collection

5. Record your start time.
6. Use the thermometer to take your first measurement right away. Point the thermometer 1-inch from the cup of water over the white cardstock and take a measurement. *It will probably say "Lo"*
7. Record the temperature measurement in your data table.
8. Point the thermometer 1-inch from the cup of water over the black cardstock and take a measurement.
9. Record your temperature measurement for the black cardstock in your data table.

Younger students may need to draw qualitative pictures instead of numbers such as a ***o*** *for cooler and* ***x*** *for hotter. If they cannot use/read the thermometer, you can also just try just having them touch the water to make observations. The first few measurements should have similar results.*

10. Wait two minutes.

You may also want to have some activity planned to keep their attention between measurements.

11. Record the time for your second set of measurements.
12. Use the thermometer to take your second temperature measurement for each cup of water.
13. Record your temperature results for each cup of water in the observation data table.
14. Look at your data and think about your observations.

Activity Embedded Assessment: *Ask the students after a few measurements:* Do you want to change your hypothesis? If so, go ahead and write that down. If not, that is okay too. *(answers will vary)*

<Repeat Steps 1-14 several more times until you record a "Hi" temperature>

Lab Step 3: Analyze Data

15. Dump out the water in a drain, on a plant, or in the grass.
16. Gather your materials and return to your classroom.
17. Once at your desk, look at your data table with your teammates.
18. Think about the numbers recorded in your table, do you see any **patterns**? *(black got hotter faster)*

Post-Activity Assessment: *Gather, and summarize student responses.*

1. How long did it take for the water to start getting hotter? (*time or how many measurements*)

   ____

   ____

2. Which container of water got hotter faster?

   ____

   ____

3. Would your results be different if the water was in the shade? (*reference kilo practice. You may test this in the shade if you have time following the same procedure)*

   ____

   ____

Key Concepts: Young learners often think the sun heats things up directly and that it heats up all things up in the same way. In reality, it is the amount of light energy (radiation) that is absorbed by objects that results in objects heating up at different rates. Each material has unique physical and chemical properties that affect how much radiation is absorbed. Thus, how fast and how much a material heats up varies. The black cardstock absorbs more of the sun's light energy and converts it to heat than the white cardstock which reflects the sun's light energy away. This is why the water over the black cardstock heats up faster. This is also why it is better to wear a white shirt on a sunny day. When an object absorbs electromagnetic radiation, that energy is transferred to the atoms that make up that material. These atoms begin to move very quickly, releasing the energy as heat. An analogy here would be like when your students rubbed their hands together quickly during the reading exercise to produce heat - the faster their hands moved, the hotter they got. Same thing with atoms.

Renewable Energy Connection: Not all solar panels used to generate electricity are the same. Some are blue (polycrystalline) and some are black (monocrystalline). Blue panels tend to be cheaper, but given what you have learned in this lab, which panel do you think would be most efficient? Having a black surface naturally allows monocrystalline solar panels to be more efficient at absorbing light than the polycrystalline blue solar panels. Resource

More Efficient

Less Efficient

PRINT **Lab 2: Sunlight and Heat Datasheet** *(you may want to print a several of these if taking say 15 measurements)*

Hypothesis: Which bowl of water will warm up faster?				
Time	**Full Sun**		**Shade** *(Optional Extension)*	
	White Cardstock	**Black Cardstock**	**White Cardstock**	**Black Cardstock**
Observation #1 Start Time:				
Observation #2 Time:				
Hypothesis 2: Now that you have made an observation, do you want to change your hypothesis?				
Observation #3 Time:				
Observation #4 Time:				
Observation #5 Time:				

Notes:

Brainstorm: Now that you have seen the power of the sun's light energy to heat up water, **what else do you think you could use light energy for?** *(Have students brainstorm and draw pictures or write sentences)*

Lab 3: Introduction

Cool Fact: Did you know that the amount of energy the sun sends to the earth in one day is *more* than the amount of energy the *entire world* uses in a year! Wow! In Lab 2, you discovered that you can use sunlight to heat up water. **What else could you use the sun for?** (choose one idea from your brainstorming session)

____

____

There are many things that we can use sunlight for. One of them is to cook food! Surprised? When we use the sun to cook, we do not create any smoke like we would if we used coal or wood. Think about the smoke you see and smell when you are barbecuing food at the beach. Some smoke that you can see is called **air pollution,** and it can be harmful to our health and to our planet. Let's build our own **solar oven** to capture light energy and see how well it works to heat up our food!

Lab 3: Solar Oven Engineer - Cooking with Sunlight *(two-three class periods)*

NGSS Performance Expectations
K-2-ETS1-1 Ask questions, make observations, and gather information about a situation people want to change to define a simple problem that can be solved through the development of a new or improved object or tool. *After building their solar oven, students will ask questions about their initial design, and gather information that they have learned so far to make improvements to their design through the development of new feature(s) for their oven. The new feature(s) should serve to make the oven more efficient - we want it to cook or melt an object faster.*
K-2-ETS1-3 Analyze data from tests of two objects designed to solve the same problem to compare the strengths and weaknesses of how each performs *Students will collect data (temperature and or cooking time) for both their original solar oven and their second, enhanced/modified design. Both solar ovens are designed to cook or melt an object efficiently. They will compare the strengths and weaknesses of how each model performed and determine which design was better. Ideally they will be able to articulate why one design performed better than the other. They will have limited tools and materials.*

<table>
<tr><th colspan="3">This exercise focuses on the following three dimensional learning aspects of NGSS</th></tr>
<tr><th>Science & Engineering Practices</th><th>Disciplinary Core Idea</th><th>Crosscutting Concepts</th></tr>
<tr><td>Analyzing and Interpreting Data
Analyzing data in K–2 builds on prior experiences and progresses to collecting, recording, and sharing observations.

Analyze data from tests of an object or tool to determine if it works as intended.

Asking Questions and Defining Problems
Asking questions and defining problems in K–2 builds on prior experiences and progresses to simple descriptive questions.

Ask questions based on observations to find more information about the natural and/or designed world(s).

Define a simple problem that can be solved through the development of a new or improved object or tool.

Constructing Explanations and Designing Solutions
Constructing explanations and designing solutions in K–2 builds on prior experiences and progresses to the use of evidence and ideas in constructing evidence-based accounts of natural phenomena and designing solutions.

Use tools and materials provided to design and build a device that solves a specific problem or a solution to a specific problem.</td><td>PS1.A: Structure and Properties of Matter
Different properties are suited to different purposes.

PS3.B: Conservation of Energy and Energy Transfer
Sunlight warms Earth’s surface.

ETS1.A: Defining and Delimiting Engineering Problems
A situation that people want to change or create can be approached as a problem to be solved through engineering.

Asking questions, making observations, and gathering information are helpful in thinking about problems.

Before beginning to design a solution, it is important to clearly understand the problem.

ETS1.C: Optimizing the Design Solution
Because there is always more than one possible solution to a problem, it is useful to compare and test designs.</td><td>Cause and Effect
Simple tests can be designed to gather evidence to support or refute student ideas about causes.

Events have causes that generate observable patterns.

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Connections to Engineering, Technology, and Applications of Science

Influence of Engineering, Technology, and Science, on Society and the Natural World:
Every human-made product is designed by applying some knowledge of the natural world and is built using materials derived from the natural world.

People depend on various technologies in their lives; human life would be very different without technology. (1-PS4-4)</td></tr>
<tr><td colspan="3">HĀ outcomes practiced: 1. Belonging - students will actively participate, and practice communication skills. 2. Responsibility - students will be active learners, encouraged to ask for help, set goals and complete tasks with their team. 3. Excellence - students will utilize creativity and imagination to problem-solve and innovate their solar oven designs. 4. Aloha - students should learn to appreciate the gifts and talents of their team members, make others feel welcomed and heard, be respectful of all ideas, and share responsibility for the work.</td></tr>
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Prerequisite Knowledge

Prior to this lab, students should know or learn about the Engineering Design Process including the importance of failure. An infographic is included in this laboratory. Ideally, students should use what they learned in Labs 1 and 2 to consider the angle of the sun, materials that reflect sunlight and materials that absorb sunlight to generate heat to inform their design.

Before the Activity

- *Ask students: “Have you ever solved a problem by creating or building something?” Collect answers and inform them that if so, they are already engineers!*
- *If you want to avoid students waiting for aluminum foil or plastic wrap, pre-cut a 12” x 15” piece of each for each team and a 10cm x 10cm square of foil for each team.*
- *You may want to semi-pre-assemble the ovens for kindergarteners.*
- *Divide into students into 8 teams* (*your kit includes enough for 8 groups*)

Materials List

For this activity, each group will need:

- Aluminum foil, ~12” x 25” (*included*)
- Cardboard box (*included*)
- Black construction paper or card stock (*included*)
- Plastic wrap (*included*)
- Paper clip (*included*)
- Masking tape (*included*)
- Wood skewer (*included*)
- Thermometer (included)
- Ruler (*not included*)
- Scissors or craft knife (*not included - you may want to pre-cut*)
- Food item or object to melt (*not included*)
- Glue (optional; *not included*)
- Timer (*not included*)
- Pencil (*not included*)

Potential Safety Issues

- *Use caution when cutting with scissors or a craft knife. Always cut away from yourself. Teachers may want to pre-cut the boxes for younger learners.*
- *Use caution with the point of the skewer, it is sharp.*
- *Students may get sunburned if in direct sunlight for too long. You may want to have parents send in a hat, sunglasses, or full spectrum, reef safe sunscreen for this activity.*
- *Remind students to never look directly at the sun.*
- ***Do not try to cook raw meat!***

Potential Obstacles

- The environmental conditions are a critical factor in successful solar cooking. Ideally the sky should be clear, and the students’ shadow should be shorter than their actual height *(this links back well to concepts learned in Lab 1).* Have them check their shadow to determine if it is a good time to use their solar oven.

Lab Tips

This lab is more involved than Lab 1 and Lab 2. Here are some tips to help you out:

- *Allow enough time for students to brainstorm, construct and test both designs.*
- *If time is a factor, small pieces of chocolate are a good food item to test. Depending on the type of chocolate, it will melt at 30–45 °C. Mini chocolate bars, chocolate chips or Hershey’s Kisses are good choices. The oven should get hot enough to melt milk chocolate in 15 minutes. Make sure you use the same food item of the same volume to compare the two oven designs. Otherwise you are comparing “apples-to-oranges”.*

- *If you are going to make smores, note that marshmallows will get soft, but they will not turn brown. They will take longer to melt than the chocolate.*
- *The solar ovens may also be tested without food if there are allergy concerns in your classroom. A fun activity is to melt crayons, to create crayon art. Make sure the crayons do not have the paper wrapper on and are broken up into small pieces. Place the crayon pieces on cardstock or a piece of cardboard.*
- *Consider giving older students a list of constraints for their modified designs.*

Procedure

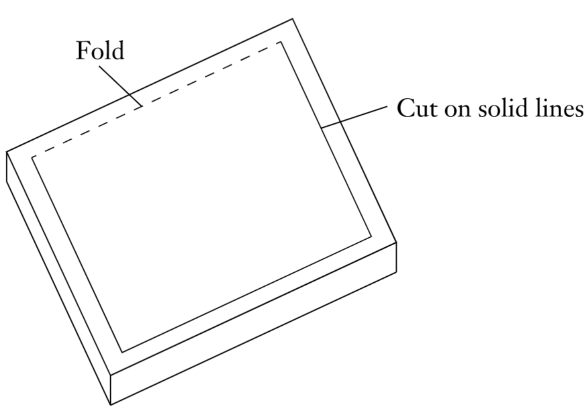
Present the students this challenge/problem: "Uh oh! The power has gone out and you cannot use your stove, oven, microwave, toaster, or rice cooker to cook dinner for tonight. These things all require electrical energy. Using the materials we have here in the classroom, design a tool that you can use to cook your food using only light energy. Consider what you learned in Lab 1 and Lab 2." You may want to lead a brainstorming activity with sketches. Have each engineering design team choose an idea from the class brainstorming activity to design their solar oven. Let them know that they will all test a standard design first, and then their own modified design second to determine which design worked the best and why.

Pre: Build a solar oven

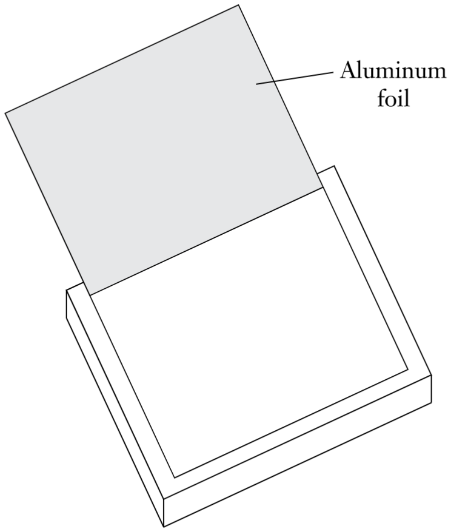
- Select or allow students to choose their group.
- Ask them to come up with a name for their "engineering company".
- Have students gather the materials.

Lab Step 1: Build a standard solar oven

1. Assemble the cardboard box by folding in the sides and securing with the side flaps.
2. Use the ruler and a pencil to mark a 3-cm border around the edge .
3. Cut the two side lines and the front line. **DO NOT CUT THE BACK FOLD LINE.**



4. Create a flap by folding backward along the fold line (pull the flab outward).
5. Cover the inside of the flap with foil.Make sure the shiny side faces outward.
6. Smooth out the foil and glue or tape it to the flap.



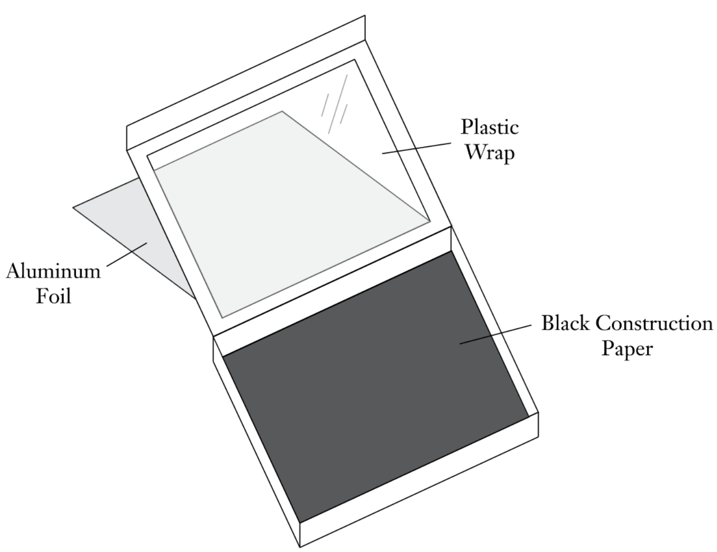
7. Place a piece of black construction paper inside the box. You may need to cut it or fold it to fit nicely.

Activity Embedded Assessment: *Ask your students:* “What do you think the foil will do in the sun? Why do you think we are using black construction paper inside of our solar ovens? *Hint:* Think back to what you learned in Lab 2.”

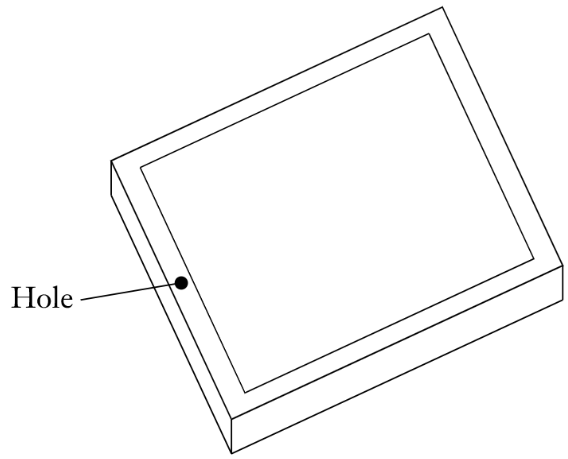
8. Fit a piece of plastic wrap over the top of the box. Make sure the plastic extends beyond the edges of the opening so that the hole in the box is sealed well.

Connection to Lab 1: transparent plastic wraps allow sunlight in, but it also helps to trap heat from escaping out of the box.

9. Use masking tape to secure the plastic wrap to the underside of the opening. Pull it tight so that it is smooth.



10. Make a hole in the middle of one side border of the box top. *You may need to help younger students with this step. Warn students to be careful not to poke themselves.*



11. Cut a square of aluminum foil and place in the bottom center of the solar oven. The foil will be a "plate" for your food item (~10 cm x 10 cm).

You may want to pre-cut the foil to save time, but for older students, this is a good chance to practice taking measurements.

Lab Step 2: Test Design (Datasheet Part A)

12. Go outside and place your solar oven on a flat surface in a sunny location.
13. Record the starting time on your datasheet.
14. Open the box and place a food item (or crayons) on the foil "plate".
15. Close the box lid with plastic wrap on it and open the flap that is covered in foil.
16. Turn the solar oven so the sun reflects off the foil-covered flap and into the oven.

Caution: Never look directly at the sun or reflected sunlight, even when wearing sunglasses.

17. Insert the pointed end of the skewer into the hole in the top of the oven to prop it open.
18. Tape the flat end of the skewer to the flap to keep the flap at the correct angle.
19. Start the timer and record your visual and/or temperature observations every minute until the food item is cooked or until it has melted *(~15-30 minutes).*
20. Open the oven and remove the aluminum foil square with the item you cooked or melted.

Caution: the item may be very hot.

Lab Step 3: Engineering Design Challenge *Review the engineering design process.* (EDP Planning Sheet)

With your engineering teammates, put on your hard hats, and discuss the following questions:

1. Your solar oven is designed to trap heat. How could you improve your design to make it trap heat better, or to heat up the food faster? (**Ask**)

***Teacher Tips**: The bigger the box is, the more energy the oven will capture from the sun and the more efficient it would be. The more airtight a box is, the more heat it will trap. Some modifications students might come up with - they could build a bigger box around their solar oven and fill it with insulating materials like newspaper, they could color the box all black inside and out, they could wrap the whole box in plastic wrap or tape up the sides to make it airtight, they could use a magnifying glass to direct more sunlight into the box.*

2. Think about what materials you have in your classroom. Using only those materials, sketch out a plan for an improved solar oven design.(**Plan**) Use the EDP worksheet.

All materials have different properties, and you may want to review some examples with your students. Younger students may only understand materials as "fabrics". You'll need to help expand this vocabulary word for them.

3. Work with your team to build an improved solar oven. (**Build**)

Note, if they change many variables, it is hard to know what variable makes their design better or worse.

4. Test the solar oven with the same item used the first time in the same amount to see if your new design works better (**Test**). Follow the same procedure, and write your data in the second data table. (Datasheet Part B)

**If melting chocolate, be sure to use the same size/type of chocolate as you did in the first solar oven test. Have students time how long it takes the chocolate to melt. If it melts faster, the solar oven may be more efficient, or you might have stronger incoming solar radiation at that time.*

5. Was your new design better? If not, that is okay! How might you re-engineer your design if you could use any materials (**Improve**)?

Make sure your students know that it is okay to fail. Failure is a big part of the engineering design process and students should learn that failure is one step towards growth. This helps them to build confidence and a growth mindset. In engineering, it is very common for engineers to fail dozens of times before they create a successful design. Rosie Revere, Engineer by Andrea Beaty is a fantastic picture book to introduce young learners to engineering. STEMworks has a curriculum available for this book.

PRINT **Lab 3: Testing Your Solar Ovens Part A** (Original Design)

Time (minutes)	**Temperature (*°C or °F)***	**Observations**
Start Time:		
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		
16		
17		
18		
19		
20		

How much did the temperature increase in 20 minutes? ___________________________________

How long did it take for your item to cook or melt?____

***PRINT* Lab 3: Testing Your Solar Ovens Part B** (Modified/Second Design)

Time (minutes)	Temperature *(°C or °F)*	Observations
Start Time:		
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		
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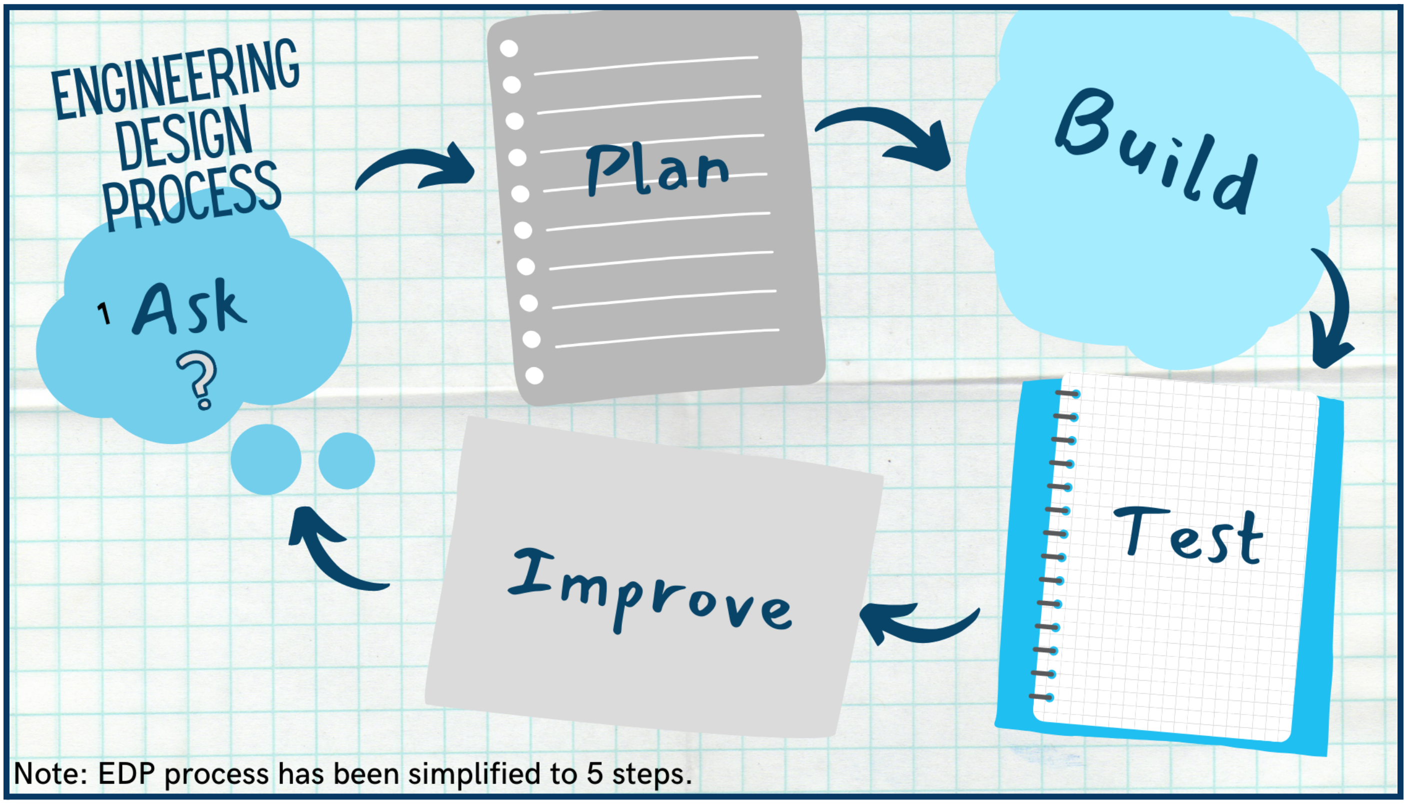
20		

How much did the temperature increase in 20 minutes? ___________________________________

How long did it take for your item to cook or melt?____

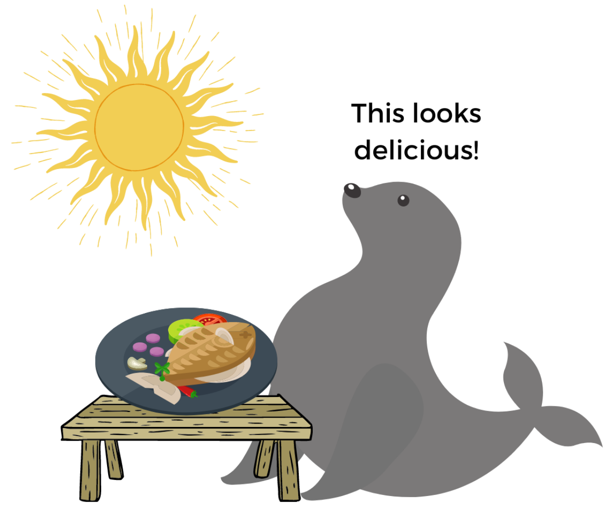
PRINT **Lab 2: Step 3 - Engineering Design Process Planning Sheet**



Use this space to sketch out your plan

Lab 3: Post-Activity Assessment

Discussion Questions: *Solicit and summarize student responses to the following questions:*



1. Look at your data for Part A and Part B. How did your second solar oven design work compared to the first? (*answers will vary*)

2. Which design change do you think was a good choice or a bad choice? (*answers will vary; for example if they put foil in the bottom of the box, that is probably a poor design change. If they used more foil to direct sunlight into the box from more angles, that is probably a positive design modification*).

3. What are some **advantages** (positive/good things) and **disadvantages** (negative/bad things) about using solar energy to cook food? (*answers will vary. Students should recognize that a solar oven will not work at night or work well on a cloudy day.)*

4. How can science help you design a better solar oven? (*answers will vary. Students should recognize the science of materials is important to understand.)*

Key Concepts: Your students' improved designs may have included more black paper to increase absorption, more plastic wrap to prevent radiative heat loss, more foil pointing downward like a funnel to capture more sunlight, or more insulating materials around the cardboard box to name a few examples. There are many possible design improvements they could have made. These solar ovens work because they collect rays of electromagnetic radiation hitting the earth at an angle and trap the heat energy from escaping. The foil works to reflect the rays into the opening of the box. The plastic wrap lets the light in, but traps the heat. This is known as a "**greenhouse effect**".

The **greenhouse effect** is an important concept in climate science, and a big reason why we want to transition to 100% renewable energy by 2045. Certain gases (including carbon dioxide and methane) created by burning fossil fuels, get trapped in our earth's atmosphere and heat up our planet.

Renewable Energy Connections: Solar energy is a renewable resource, and one of the biggest sources for renewable energy in Hawai'i. At present, and well in the future, our state will have a demand for engineers who understand how to install, maintain, and repair solar panels. It is important to introduce students to engineering early to prepare them for this career pathway. One drawback to solar generated energy, just like you observed with the solar ovens you built, is that solar panels work best on sunny days. This is why we need batteries to store solar energy as chemical energy and/or supplemental energy resources such as wind generated energy, for those cloudy days.

Conclusion

One of the most wonderful things about living in Hawaiʻi is that we have abundant sunlight that we can use not only to make shadows, heat water, or cook food, but also to power our homes and electronics. When we harness sunlight to create electricity, we call this **solar power**. Solar power is one of our fastest growing **renewable energy** sources. The best part is, just as you saw with your solar ovens, solar power does not create air pollution. You will have a chance to learn more about solar power in 3rd-5th grade.

Learn more about Hawaii's Clean Energy Initiative by visiting: ***[| Securing the Renewable Future (Hawaiʻi.gov)]*** **energy.Hawaiʻi.gov**

Thank you for joining me on this energy adventure, friends! I hope you learned a lot about the sun, light, heat, science, and engineering. If you want to learn more, please enjoy the online extension activity and the do at home activities below. Aloha!

Your friend,
Pāʻanaakalā

Color Pāʻanaakalā your favorite color.

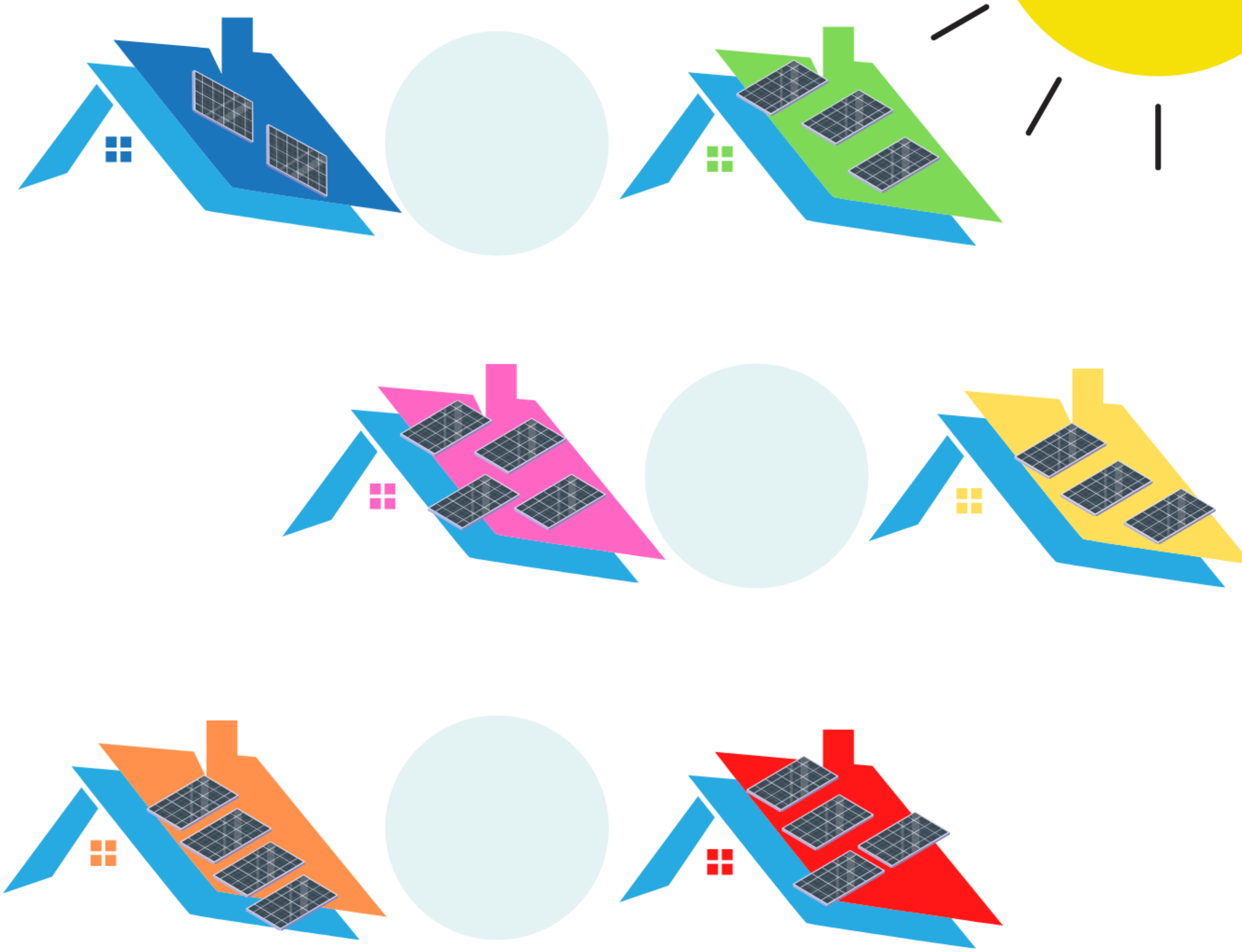
Important Words

- **absorb:** to soak up
- **accuracy*:*** a measurement that is correct or very close to the true value
- **advantages:** something beneficial or positive
- **air pollution:** when smoke and chemicals are put into the air in large doses that make it harmful for humans, animals, and the environment. Some forms of air pollution can be seen - like smoke from burning coal. Some are invisible gases.
- **data:** information and facts
- **Disadvantages:** something that makes it more difficult to succeed
- **engineer:** A person who uses science and mathematics to create things for the benefit of humanity and our world
- **energy:** the power to grow, move, and to do things (work)
- **greenhouse effect:** a process that occurs when gases in Earth's atmosphere trap the Sun's heat. This process makes Earth much warmer than it would be without an atmosphere.
- **hypothesis:** what you think will happen; a prediction; an educated guess
- **heat energy:** energy that comes from tiny particles that start moving quickly when they get hot
- **invisible:** unable to be seen
- **light energy:** energy that comes from light.
- **pattern**: something happens the same way more than once. A pattern may increase or decrease regularly - up, up, up, or down, down, down or happen in a repeated way such as up, up, down, down, up, up, down, down .. .. …. …. .. .. …. …. .. .. *(clap a pattern to demo)*
- **reflect:** to throw back
- **scientist:** a person who makes observations, asks questions, and does research to find answers to questions few people know about.

Sunny Mathematics!

LET'S LEARN THE EQUAL, LESS & GREATER THAN SYMBOLS

Count the solar panels on the house and write down the correct number. Then, compare the number and write > , < or = to show which house has more, less, or equal number of solar panels

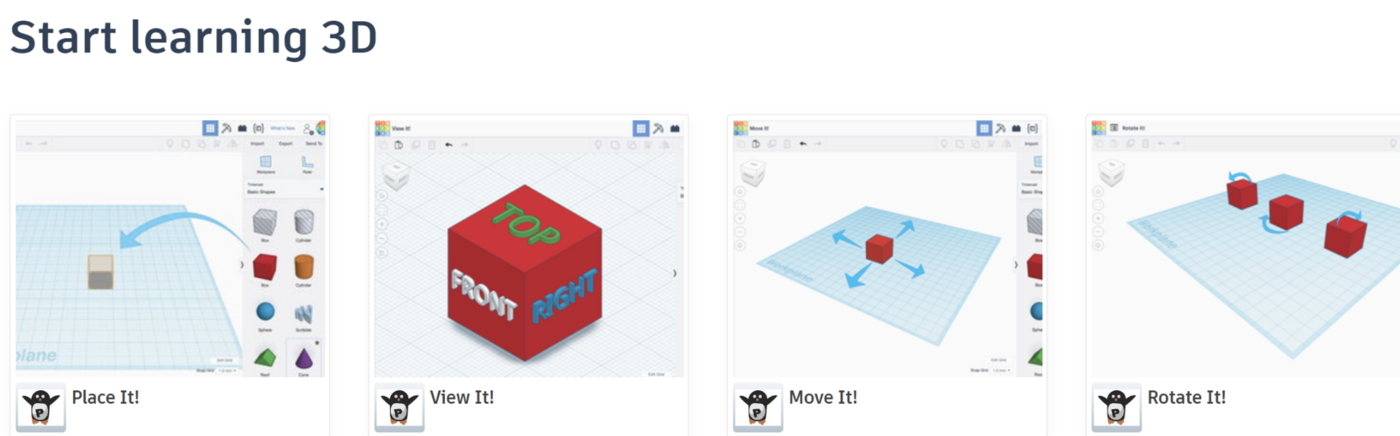


Bonus: Which house has the least number of solar panels?

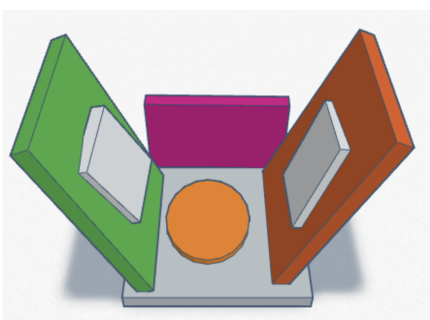
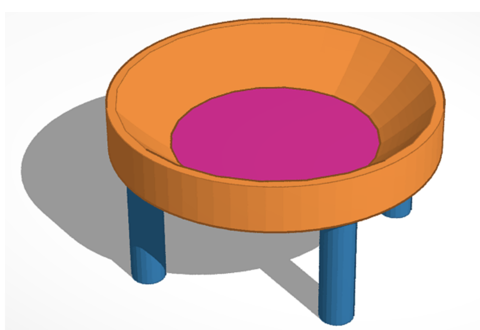
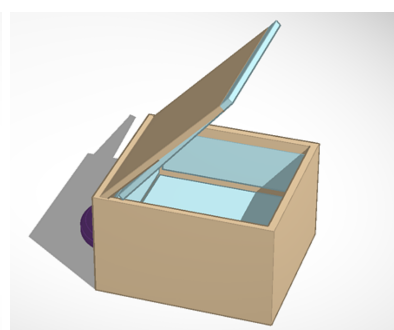
Online Extension Activity: [Tinkercad | Create 3D digital designs with online CAD | Tinkercad]

During Lab 3 of this renewable energy curriculum for K-2, students learned about engineering and the engineering design process. While sketching designs is a great first step, most engineers need help from a type of computer software called CAD. CAD stands for "computer-aided design". CAD software allows people to create, modify, analyze or optimize a design in 3D!

It is very easy to get started with CAD. TinkerCAD is a free and safe website where children of any age can design, draw, and make things in 3D. Students under 13 years old can create an account with their parent's or guardian's permission. You can also create a classroom account. To try it out, visit [www.tinkercad.com/learn]



Here are some examples of solar ovens designed in TinkerCAD by students like you!

Student Activity: Put on your creative thinking hat! If you were an engineer, what would you like to build? Using tinkerCAD, sketch out your design for your invention. Who would your invention help? What problem would you solve? What tools and materials would you need?

At Home Extension Activity: Solar Powered Water Purification

For Parent(s) and Guardian(s): *At school, your young learner learned about the power of the sun to create shadows, heat up water, and to cook food or melt objects like crayons using a solar oven they designed, built and tested. Here is a fun activity you can do together to show your child how the sun can be used to purify water.*

When seawater evaporates, it leaves behind sea salt. If you were stranded on the beach with no fresh water to drink, you could use the sun to purify **(distill)** ocean water.

Materials List:

For this activity, you will need

- Water
- Salt
- Large bowl
- Measuring cup
- Short glass
- Plastic wrap
- Tape
- Weight such as a rock

Procedure:

1. Add salt to two cups of water and stir until it **dissolves** (you cannot see it). *Do not use real seawater - it may have contaminants in it that you do not want to drink.*
2. Pour water solution into the large bowl.
3. Place the short glass in the center of the bowl. It needs to be shorter than the rim of the bowl, but higher than the saltwater solution. You could use another smaller bowl if needed.
4. Cover the bowl with the cup in the center with plastic wrap.
5. Tape the edges of the plastic wrap to the bowl. Try to create a very tight seal. Masking tape works best, but you can use duct tape, or clear tape as well. *The plastic wrap is what is going to help trap the evaporated water from escaping into the air.*
6. Put the bowl outside in the sun for a few hours.
7. Once there is water in the cup, remove the plastic wrap.

Ask your child: *What is your hypothesis for this experiment? Will the water in the cup taste pure or salty?*

8. Taste the water to test if it is salty. :)

Key Concepts: The plastic wrap allowed the light to hit the water in the bowl, but prevented the heated water from escaping the bowl as a gas. Through the process of **evaporation**, the water turned into a gas, rose, hit the plastic wrap, condensed into water droplets (just like how clouds form), and then the water droplets “rained” back down into the cup. The salt is too heavy to turn into a gas, and it gets left behind in the bowl. The water in the glass has been **distilled** (purified) and it is fresh enough to drink.

EXTERNAL RESOURCES ON PERFORMANCE EXPECTATIONS

How to Read the Next Generation Science Standards

NGSS Webpage that allows you to search for Performance Expectations based on grade, discipline, SEP, DCI, and/or CCC

Evidence Statements (describe a detailed look at the NGSS performance expectations)

NSTA Performance Expectation Finder

www.stemworkshawaii.org energy.hawaii.gov