GREAT LAKES LEARNING

LESSONS & ACTIVITIES BASED ON THE MONTHLY GREAT LAKES NOW PROGRAM

EPISODE 2402 | BIG FISH AND GRAY SKIES

SOLAR POWER IN EVERY SEASON

OVERVIEW

This lesson will explore the phenomenon of **seasonal changes in sunlight** in the Great Lakes and why that presents challenges to the adoption of solar sources as a renewable energy solution. While the Great Lakes region may not have as many sunny days as San Diego, the capacity for solar energy to be a viable source of power in the Great Lakes remains strong. However, it will take some adaptations to cloudy days and snow cover that other regions of the country do not have to contend with.

LESSON OBJECTIVES

- **Know** how solar panels work
- **Understand** the challenges associated with using solar power in the Great Lakes region
- **Be able to** graph and analyze the seasonal changes in sunlight in a Great Lakes city

WHAT YOU'LL NEED

- Computer or mobile device with Internet access to view video and online resources
- Notebooks and pencils
- Chart paper
- Sticky notes
- Markers
- Lab supplies (see individual activities for a full list)
- Copies of the Student Handouts

INTRODUCTION

Everyone knows that sunny days are a precious commodity in the Great Lakes—especially in the winter. Just as the sun's energy powers natural processes like photosynthesis, solar power is increasingly a basis for a renewable energy source in modern technologies. But because the sunlight is so inconsistent throughout the year, can solar power be a viable option for the Great Lakes region? By investigating how scientists take into account seasonal variations in sunlight, as well as how to harness solar energy even in winter, students will gain insights into sustainability and the impact of renewable energy solutions in the Great Lakes, fostering critical thinking and environmental awareness as well as scientific inquiry along the way.

This lesson includes multiple activities, including lab activities, that can span the course of several sessions or be adapted to fit the needs of your group's meeting format.

Some prior knowledge* with which students should be familiar includes:

- energy
- kinetic molecular theory
- temperature
- measurement
- properties of light and heat

Follow this QR Code or hyperlink to the Episode Landing Page!

Check out our full collection of lessons for more activities related to topics like these.

*****The sequence of these activities is flexible, and can be rearranged to fit your teaching needs.***

NGSS CONNECTIONS

Phenomenon: Seasonal Changes in Sunlight

- MS-PS3-3
- MS-PS4-2
- MS-ESS3-3
- MS-ETS1-1
- SEP 1
- SEP 2
- SEP 3
- SEP 4
- SEP 5
- SEP 6

During the course of the lesson, students will progress through the following sequence** of activities:

- Class discussion to elicit and activate prior knowledge about **sunlight and solar panels**
- Teacher notes on **solar energy**
- Watch a segment from *Great Lakes Now* about the use of solar panels in winter
- Class discussions to debrief the video
- Read about **the death of a solar panel**
- Conduct an experiment with **temperature and incandescent light**
- **Map the amount of available sunlight** in a Great Lakes city throughout the year
- **Engineer a solar oven** to warm food

The lesson progresses through three major sections: **launch, activities, and closure.** After the launch of the lesson, you are ready to begin the lesson activities. Once finished with the activities, students will synthesize their learning in the closure. You can select the activities that are best suited for your learners and teaching goals, and then sequence them in a way that makes sense within your learning progression and the scaffolds of the lesson.

If you use this lesson or any of its activities with your learners, we'd love to hear about it!

Contact us with any feedback or questions at: ***GreatLakesNow@DPTV.org***

TEACHER BACKGROUND INFORMATION

by Gary G. Abud, Jr., Great Lakes Now Contributor

**This information can be presented by the teacher as notes to students at the teacher's discretion.*

When you think about the role the sun plays in our world, it is seemingly endless. From providing light to illuminate our activities to fueling the photosynthesis of plants, affecting weather patterns and seasons, and so much more, without the sun we would be, well, in the dark!

Understanding the energy we get from sunlight is essential to appreciating the technology behind solar power, particularly in the design and efficiency of **solar panels**.

The sun is a giant chemical reactor, and as various chemical reactions and processes take place, light is emitted as **photons** are released in all directions. These tiny particles of light travel at an extremely high speed—**the speed of light** actually—or 300,000,000 meters per second, or about 670,616,629 miles per hour. Streams of photons travel in rays and have different **wavelengths**, each associated with unique colors.

As these photons reach their final destination, they can collide with atoms and either excite their electrons—called the **absorption** of light—sometimes causing the eventual **emission**, or release, of photons at a different frequency than was absorbed. This accounts for the various colors we see when we look at illuminated objects.

Solar panels work by taking advantage of he absorption of light, using the energetic photos from sunlight (which is also known as electromagnetic radiation) to dislodge electrons in the atoms of the solar panel's material. Those liberated electrons then flow through the wires—known as **electric current**— of the solar panel and can be transported to power electric devices or stored in solar cells for later use.

When sunlight hits a solar panel, it makes tiny particles inside move faster, which heats up the panel. Solar panels work best when they absorb sunlight effectively and don't get too hot (or too cold).

Engineers use different materials to capture sunlight's colors, including the ones in the **visible spectrum** (e.g., the colors of the rainbow) and those we can't see like infrared and ultraviolet light. Managing heat is important to keep panels working well. Some panels have cooling systems that help with this.

Just like how a light bulb can change color and brightness when it gets hotter, solar panels can work better or worse depending on their temperature. Different types of panels also react differently to sunlight's different colors, which affects how well they turn light into electricity. Understanding these things helps scientists design better solar panels.

So what happens to solar panels when there is cloud cover? When there are clouds covering the sun, solar panels don't stop working; rather, less sunlight reaches the solar panels. Since solar panels need a lot of sunlight to generate electricity, they produce less power when it's cloudy. This is because clouds block some of the sunlight from reaching the panels. However, modern solar panels are designed to still generate electricity even on cloudy days, although not as much as on sunny days. But in the Great Lakes, snow cover poses a unique challenge as it sits on the solar panels and blocks the light from getting through. That's why scientists have designed solar panels to either melt snow quickly or be tilted at an angle that allows the snow to slide off, ensuring they can still generate electricity efficiently after snowfall. Scientists are always working on improving solar panel technology for all kinds of conditions.

LESSON LAUNCH

A. Warm Up

The warm up is intended to be structured as teacher-facilitated, whole-group student discussion activities. It helps students to begin thinking about the topic at the center of the lesson.

1. Ask students to list out on a piece of paper five things that come to mind when thinking of **sunlight**.
2. Have students pair up with a partner to share their five ideas with each other. If any ideas appear on both lists, have students circle those.
3. Then, engage students in a whole-group discussion to ask them to share any ideas that were circled.
4. Generate a list of the circled ideas.
5. Ask for volunteers to share any ideas that were not circled that they think are really important to include in this topic.
6. Generate a separate list of those ideas.
7. At the end of making the two lists, have students copy down one single list of all the circled ideas and important ideas in their notebooks or on their paper.
8. Ask students individually to rank the ideas in the list from most to least relevant.
9. Ask for some students to share which term should be most relevant and why they think that is. Engage the whole group in discussion to arrive at consensus about the most relevant idea related to **sunlight** that they already know about or that came to mind during this exercise.

B. Bridge to Learning

After the warm-up, show students a photo of a solar panel and ask them to consider how a solar panel works. Invite them to do some brainstorming with a partner and draw a quick sketch that makes their thinking visible. Invite some responses and discussion from the class and attempt to draw a diagram for everyone to see that captures the consensus thinking.

C. Close Reading a Video

Show this PBS LearningMedia video of **photovolatic cells** and ask the students to consider why we don't use solar power for all our energy needs in the world. Before students respond, have them do the following with a partner:

- **Review the video** and take notes on key points, visuals, and any questions or observations that arise.
- **Summarize the main content** of the video and identify the primary themes or messages it conveys.
- **Discuss the visual elements**, e.g., angle, lighting, etc., used in the video and how they contribute to its storytelling impact.
- **Explore the concept** of sunlight in the video.
- **Engage in a discussion**, sharing insights, reactions, and interpretations of the video as it relates to the question.
- **Answer the question** in a class discussion, allowing partners to talk with other students and share ideas or ask follow-up questions to one another. Facilitate the discussion to arrive at a consensus about how solar panels work and compare to their prior predictions.

D. Background Information Notes

Explain that you will be investigating more about **sunlight** in the Great Lakes and the use of solar panels there before providing notes from the **Teacher Background Information**.

ACTIVITY 1: WATCH A GREAT LAKES NOW SEGMENT

This activity is a video discussion of a *Great Lakes Now* episode segment.

First, inform students that they will be watching a *Great Lakes Now* segment discussing the use of solar panels during the winter months in the Great Lakes. During the video they need to jot down four things they took away from the video using the **4 Notes Summary Protocol**.

Then, if students are not already familiar, introduce them to the 4 Notes Summary Protocol, which they will use after they finish watching the video, where they write down one of each of the following notes:

- **Oooh!** (something that was interesting)
- **Aaah!** (something that was an ah-ha moment)
- **Hmmm...** (something that left them wanting to know more)
- **Huh?** (a question they have afterward)

Next, have students watch the segment from episode 2402 of *Great Lakes Now* called **Can Solar Panels Even Work Here?**

Last, have students complete their individual 4 Notes Summary and then discuss those in groups of 3-4 students.

***Teaching Tip*: Use the Student Handouts to help students organize their thinking in writing around each of the lesson protocols.**

Post-Video Discussion

After the groups have had time to go over their 4 Notes Summaries, invite a handful of students to share out some of their notes, eliciting at least 1-2 of each of the 4 Notes and listing those somewhere for the whole group to see.

Ask students to turn back and talk with their groups to make connections between the *Great Lakes Now* video and what they remember from the warm-up activities.

How is what we saw in the video related to what we discussed earlier during the lesson launch activities?

After giving the groups some time to talk, bring the whole group back together for a shareout and discussion of ideas.

In this culminating discussion, the goal is to help students make connections between the video segment and what they discussed during the launch activities earlier in the lesson about what they knew about **sunlight**?

Once the discussion finishes, have each student write a "**Sum It Up**" statement in their notebooks. This is a single sentence that captures the big idea of what was just learned.

Have 2-3 students share out their **Sum It Up** statements before concluding this activity.

ACTIVITY 2: READ ABOUT THE LIFE SPAN OF SOLAR PANELS

What happens when solar panels are no longer usable? Despite increased interest in recycling, the disposal of solar panels predominantly occurs in landfills, with a mere 10% currently being recycled. That's because recycling the panels is a complicated process. Despite challenges, the solar recycling industry is anticipated to expand due to advancements in technology. As they read, students will learn about the disposal process of solar panels that have reached the end of life.

In this activity, students will use a **Think Pair Square Protocol** for discussing what they will read about this very topic.

First, have students partner up and distribute the article **Where Do Solar Panels Go to Die?** from Interlochen Public Radio. Allow time for students to individually read the article, and have them jot down three things they took away from the article using the **Rose Thorn Bud Protocol**—in their notebook or using the handout.

Then, give students time after reading to discuss the article that they read with their partner. Have students share their rose, thorn, and bud with each other, including how those points connect to each other. The pair should come up with a statement to summarize all of their article takeaways.

Next, have two student pairs join up, standing near each other to form the four corners of a square, to discuss the article and what they talked about in their pairs. Encourage them to come to a consensus about which point they found most important or interesting in the article.

Last, have each group craft a summary statement of the most important point from their discussion and ask for a volunteer in each group to share that key point with the whole group. As student groups share their most important point, record their ideas on the board and have students copy the list of student ideas down into their notebooks. Once the shareout is complete, ask students to return to their groups and discuss one last question based on the article:

Based on the benefits and challenges associated with solar panels, would you choose to have them at your home: why or why not?

You can keep this as a class discussion based on the article itself or, after giving the groups some time to discuss this question, invite them to further research the topics, points of interest, or themes discussed in the article by generating a research question, identifying additional sources, and presenting their findings.

Teaching Tip:
If the reading level of the article is going to be tough for some students to read individually, have partners or small groups read the article together aloud while each follows along, or the teacher might read the article to the entire class.

ACTIVITY 3: TRACKING SEASONAL CHANGES IN SUNLIGHT

The purpose of this activity is to help students understand how the amount of daily sunlight changes throughout the year in the Great Lakes region.

Materials:

- Access to weather databased such as: timeanddate.com/astronomy/usa
- Graph paper* or graphing software (e.g., Excel, Google Sheets)
- Paper, ruler, pencil; alternatively, chart paper or large whiteboard and markers

First, inform students that they will investigate and graph the average daily minutes of sunlight per week over the course of a year in a city in the Great Lakes region. They will then work with their partner(s) to analyze seasonal variations in sunlight duration and explore how these variations impact energy availability for solar technologies.

Then, have them partner up in groups of up to 4 students and select a city in the Great Lakes region to obtain data for. Alternatively, you can assign each group a different city or provide options from which to choose. Make sure there are cities at different latitudes so that you can discuss how that affects the sunlight later on.

Next, have them partner up and obtain the supplies needed for the activity and then begin recording data from the online database. You may wish to review the calculations for how they will obtain the average daily minutes of sunlight per week, since the databases typically provide the total minutes of daylight by day for each month.

***Teaching Tip:** If your students are less experienced with graphing, you can graph an example city together first.*

Provide them the data table to write their calculations and record their data. Alternatively, if they are using digital tools (e.g., a spreadsheet) you can show them how to use a formula to calculate the average of the data and have them enter the data directly from the source online database into their spreadsheet.

Be sure to monitor their data collection, calculations, and graphing to ensure you're providing support where needed based on the level of experience and math abilities of your learners.

Last, facilitate a class discussion that allows each group to see the other groups' graphs. First have them compare and make connections between their graphs and those of other groups. Discuss the significance of the graph's shape and encourage comparisons between groups' data. How does the available sunlight throughout the year impact the ability for that city to harness solar power?

Be sure to focus on the maximum, minimum, slope, and cyclical pattern shown on the graphs. Encourage students to connect what they see on the graphs to the physical implications of the graph for the region of the Great Lakes from which their data comes. In other words, how does what happens in the graph correspond to physical reality during different points in the year?

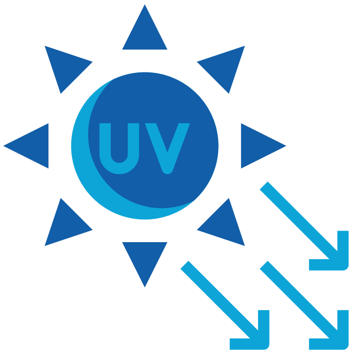
Discussion Extensions

Depending on the ability and experience of your students with graphing, you could consider additional discussion questions, such as:

1. Why does the slope of the graph change?
2. Why does the graph not start at zero?
3. How does the amount of sunlight relate to the latitude of the city?
4. What would the graph look like if we plotted multiple consecutive years of data side by side?

**Note: you can use the data table and graph handouts for this activity available at the end of this lesson*

ACTIVITY 4: HOW LIGHT AFFECTS AIR TEMPERATURE



The purpose of this activity is for students to observe and measure how the temperature of the air near an incandescent bulb changes with different levels of brightness.

Materials:
- Incandescent light bulb (preferably unfrosted for better visibility)
- Lamp socket with a variable dimmer switch
- Thermometer with a digital probe or an infrared thermometer
- Ruler or measuring tape
- Safety goggles / sunglasses (optional but recommended)
- Cardboard box large enough to fit the lamp without it touching any side

Note: this can be done as a whole group experiment, or (if you have enough setups) in small groups.

Setup: orient the box with the open end facing you. Set up the lamp socket with the incandescent bulb in a stable position inside the box without it touching any side. Take the temperature of the air inside the box, before the bulb is turned on, and measure the distance between the temperature probe and bulb. Record these baseline measurements. Connect the lamp socket to the variable dimmer switch and plug in the lamp/switch, ensuring the switch is on the lowest setting initially.

First, inform students that they will be investigating how light affects air temperature.

Next, demonstrate how to set up the experiment. If conducting the experiment as a whole group, involve students in each of the setup steps; otherwise, you can set it up to show them and narrate your steps along the way.

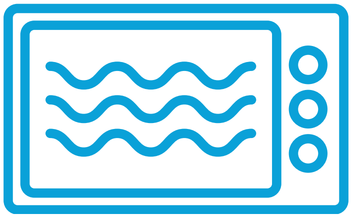
Then, have students set up their own apparatus, or prepare to collect data from your setup.

Data Collection Procedure:
1. Record the initial temperature of the air near the bulb using the thermometer and measure the distance between the thermometer probe and the bulb (for consistency in subsequent measurements).
2. Turn on the lamp at the lowest setting on the dimmer switch and let the air stablize for 2-3 minutes before recording observations of the bulb itself and taking the next thermometer reading at the same distance as the initial measurement.
3. Gradually increase the brightness by adjusting the dimmer switch in small increments (e.g., 10% increase in brightness each step), allowing the same amount of time for the air temperature to stabilize at each brightness level before taking temperature measurements.
4. Note qualitative observations of the bulb.
5. After stabilizing at each brightness level, record the air temperature near the bulb using the thermometer, ensuring the thermometer probe remains at the same distance from the bulb for consistent readings.
6. Create a table to record the brightness setting (% of maximum) and the corresponding air temperature readings.
7. Plot a graph of relative brightness setting (%) versus air temperature (˚C) to visualize the relationship.

Post-Lab Discussion:
Last, facilitate a whole-group discussion about the results. Ask students to note any observations about changes in the bulb's brightness or color as the dimmer switch is adjusted. Analyze the data to observe how the air temperature changes with increasing brightness levels of the bulb. For groups who did the experiment at different distances, how did their temperature data compare? What conclusions can you draw for the relationships? What do these findings reveal about sunlight?

<u>Teaching Tip</u>: Set this up and test this experiment out ahead of time, possibly even recording a video of your set up steps to use if you teach more than one class in a day.

ACTIVITY 5: BUILD A SOLAR OVEN TO MAKE S'MORES



The purpose of this activity is for students to design a device that can utilize the energy from sunlight to warm or cook food.

Materials:
- Pizza box (standard size)
- Aluminum foil
- Plastic wrap (clear)
- Black construction paper
- Tape (preferably duct tape or strong adhesive tape)
- Scissors or a craft knife
- Kebab skewers
- Thermometer or temperature probe (to measure temperature inside the oven)
- Food items for cooking (e.g., s'mores ingredients

First, pose a challenge to students to consider and discuss with a partner: can you cook a s'more without using fire or electricity? After eliciting some responses and engaging in a brief discussion, inform students that they will be engineering a device that can utilize sunlight to cook s'mores.

They will partner up with 1-2 other students to build their device. Provide the materials for them to do this activity in class, and give them time to explore what materials are available and brainstorm a design.

Next, give students time to research and develop a design plan for their solar oven. You might show a video clip for inspiration, like **this one from Science-U on PBS LearningMedia**.

Then, give students time to build their solar ovens. You can challenge them to come up with a design that will cook the s'mores fastest or achieve the highest internal oven temperature. Monitor their progress and supervise students to provide support as they engineer their designs.

Optionally, guide students through the design process or provide procedural steps:
- Line the inside bottom of the pizza box with aluminum foil to reflect sunlight onto the food.
- Attach the black construction paper to the bottom of the box to absorb heat.
- Cut an opening in the top of the box lid and create a clear plastic lid using plastic wrap or a clear plastic sheet to cover the opening of the box.
- Use tape to secure all materials and ensure a tight seal to retain heat.
- Place a thermometer inside the oven to monitor temperature changes.

Last, allow students to get feedback on their designs from classmates and make any adjustments they want. Encourage students to think about the angle at which they prop open their ovens to maximize reflectance of the light. You could use a light source to test the temperature inside the solar ovens using a temperature probe or regular thermometer as an additional way for them to optimize their design.

Look ahead on the weather forecast for a day that will be warm and sunny to test the solar ovens in class by taking them outdoors with the ingredients to make s'mores and cooking together as a group Alternatively, if class time does not permit you to do the cooking, you can have students demonstrate their solar ovens cooking the s'mores outside of class by recording a video of their experiment. Make sure that they take the internal oven temperature periodically during cooking and graph the temperature over time to show how well their ovens worked.

Discussion:
Facilitate a discussion to get students to understand how their design harnessed sunlight to cook their s'mores. Ask what design changes they would make if they did this again.

***Teaching Tip*: Create a working solar oven of your own ahead of time to have a model to demonstrate.**

LESSON CLOSURE

After the conclusion of all the activities, help students to make connections* between everything they did in the lesson and what they learned overall.

A. Free Recall

Group students in pairs or triads (e.g., in groups of 2-3 partners) and distribute the **Free Recall Protocol handout**, Alternatively, you can have students do this in their notebooks. Set a 3-min timer and have students generate a list of everything they can remember learning about in this lesson related to the central topic of the lesson. This doesn't have to be in depth, just whatever each group can call to mind. Have them draw lines between any terms that relate to one another. After the timer finishes, give groups a chance to volunteer to share aloud 2-3 things from their free recall lists and any of the connections that they made with those. Jot down any ideas that come up multiple times during the shareout for the whole group to see.

B. Lesson Synthesis

Give students individual thinking and writing time in their notebooks to synthesize their learning, by jotting down their own reflections using the **Word, Phrase, Sentence Protocol.**

In the Word-Phrase-Sentence Protocol, students write:

- A **word** that they thought was most important from the lesson
- A **phrase** that they would like to remember
- A **sentence** that sums up what they learned in the lesson

C. Cool Down

After the individual synthesis is complete, students should share their synthesis with a partner.

After sharing their syntheses, have students complete a **3, 2, 1 Review** for the lesson with their partner, recording in their notebooks or, optionally, on exit ticket slips to submit, each of the following:

- **3 things** that they liked or learned
- **2 ideas** that make more sense now
- **1 question** that they were left with

Invite several students to share aloud what they wrote in either the synthesis or 3, 2, 1 Review.

Lastly, ask one student volunteer to summarize what has been heard from the students as a final summary of student learning.

**Optionally here, the teacher can revisit the learning objectives and make connections more explicit for students.*

***Teaching Tip:** Use the Student Handouts to help students organize their thinking in writing around each of the lesson protocols.*

NAME: ____________________

A Word, Phrase, Sentence Protocol

What is a **word** that you thought was most important from this lesson?

What is a **phrase** that you would like to remember from this lesson?

What is a **sentence** that sums up what you learned in this lesson?

3, 2, 1 Review Protocol

What are **3 things that you liked or learned** from this lesson's activities?

-
-
-

What are **2 ideas that make more sense** now to you?

-
-

What is **1 question that you were left with** after this lesson?

-

NAME: ______________________________

Free Recall Protocol

With 1-2 partners, generate a list of everything you can remember learning about in this lesson related to the central topic of the lesson. Draw lines between any terms that relate to one another.

NAME: ______________________

4 Notes Summary Protocol

OOOH!
Something that was interesting to you

AAAH!
Something that became clearer; an "ah-ha" moment

HMMM...
Something that left you wanting to learn more

HUH?
Something you questioned or wondered

Sum It Up Statement:
Summarize your group discussion about your 4 Notes Summaries below:

NAME: ______________________________

Think Pair Square Protocol

THINK

Write down your own individual ideas

PAIR

Summarize what you and your partner discussed

SQUARE

Summarize what your group discussed

NAME: ______________________

Rose, Thorn, Bud Protocol

ROSE

Something that "blossomed" for you in your learning

THORN

Something that challenged your thinking or was difficult to understand

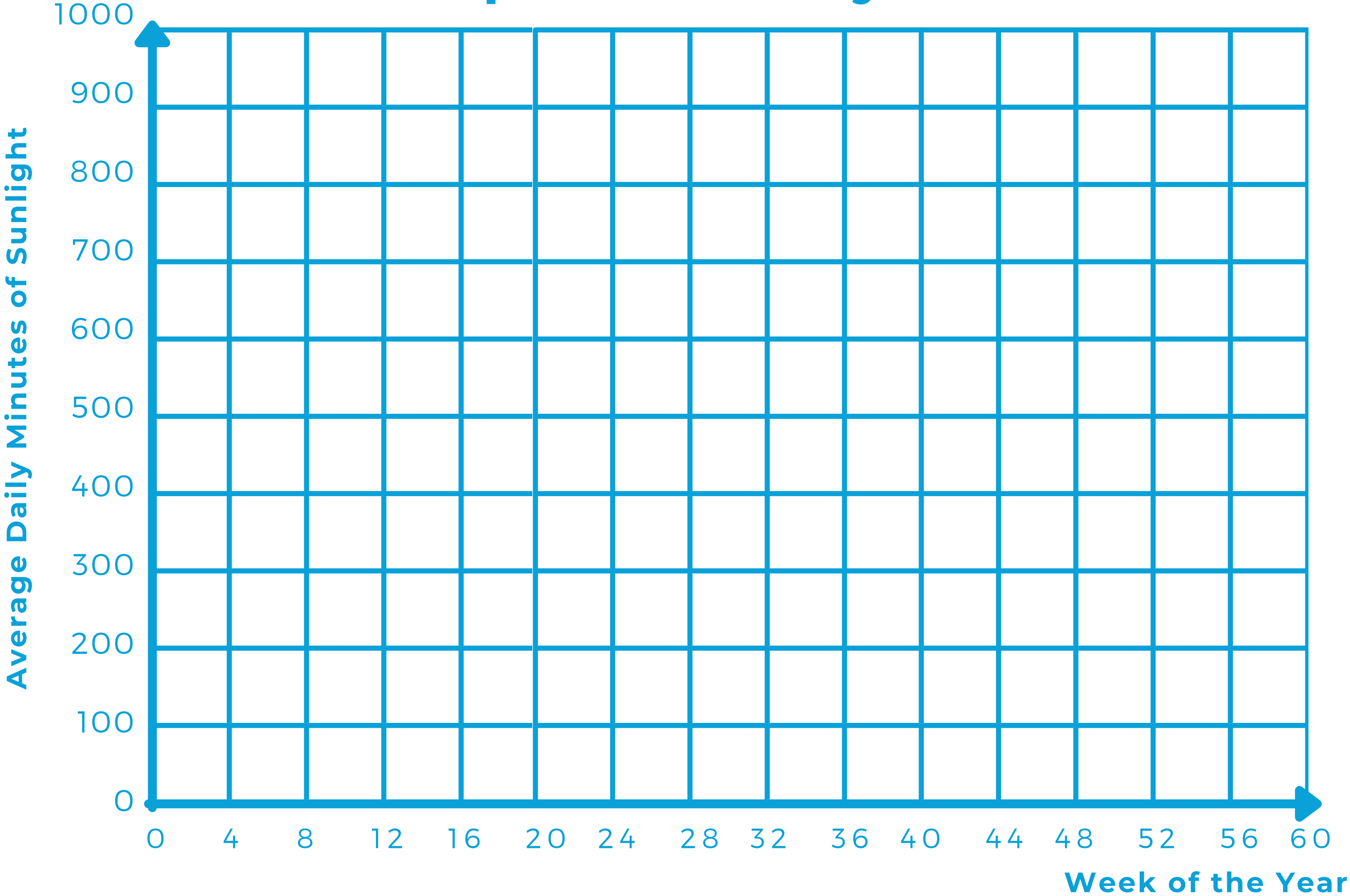
BUD

Something that's new and growing in your mind — a "budding" idea

Seasonal Changes in Sunlight Data Table

Week	Average Minutes of Sunlight	Week	Average Minutes of Sunlight	Week	Average Minutes of Sunlight	Week	Average Minutes of Sunlight
1		14		27		40	
2		15		28		41	
3		16		29		42	
4		17		30		43	
5		18		31		44	
6		19		32		45	
7		20		33		46	
8		21		34		47	
9		22		35		48	
10		23		36		49	
11		24		37		50	
12		25		38		51	
13		26		39		52	

Seasonal Changes in Sunlight Graphical Analysis



Analysis Questions:

- Describe the general shape of your graph and explain its significance.
- When did your graph reach its maximum and minimum? What is happening at those times of year in the city your data comes from?
- What does the slope of the graph tell you about the average daily minutes of sunlight over time throughout the year?
- How does the available energy from the sun change throughout the year?