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Lesson Title: **SOLAR SITE ANALYSIS: THE SOLAR PATHFINDER**

Grade level: High School

Lesson length: 1-3 hours, depending on coverage and emphasis.

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Instructor's Guide

Learning Goals:

- Students will understand that the electricity produced with a solar photovoltaic system is generated renewably.
- Students will understand how to use a standard solar industry tool--the Solar Pathfinder.
- Students will use a Solar Pathfinder to measure the percentage of sunlight available for a specific site in a relevant setting.
- Students will collect and analyze relevant data to draw valid conclusions.
- Students will understand basic characteristics governing the site selection and placement of a solar PV array.
- Students will learn solar characteristics that must be maximized to install solar panels for best performance.
- Students will learn and use relevant earth science and solar photovoltaic vocabulary.
- Students will understand, use, and interpret diagrams and data that display the sun's location in the sky throughout the year.

Materials, Resources, and Technology Required:

- At least one Solar Pathfinder™ and / or associated Sunpath Diagrams
- Computer with internet connection for class projection purposes (or students in computer lab or students with laptop computer)
- Presentation unit and screen
- Sunpath Diagrams for student use

Thoroughly acquaint yourself with this lesson before using it for the first time.

As written, **Solar Site Analysis: The Solar Pathfinder** assumes your students have little or no background in Solar PV. We have provided extensive teaching materials for your classroom use (**Student Introduction to the Solar Pathfinder** PowerPoint, **Solar Pathfinder Site Examples** PowerPoint, and more). As always, you are encouraged to edit and alter our lesson and instructor materials to suit your situation, your students, and their background knowledge (read our copyright statement).

Introduction to the activity:

There are many good ways to introduce **Solar Site Analysis: The Solar Pathfinder**. Developing discussion about what might make for a good location to place solar panels could work for an introduction. Simply getting out the Solar Pathfinder and talking about it generally (before getting into specifics later) may work as well. Reviewing meteorological data at Timeanddate.com (part of the lesson later in the activity) can be used as an introduction.

However, taking students outside with small demonstration solar modules can be a great way to introduce this lesson (see photo, below). Wire the modules to a multimeter to quantify Watts produced ($\text{Volts} \times \text{Amps} = \text{Watts}$). As an alternative (and often more fun for students), wire it to a motor with a propeller to have students qualitatively assess energy production. Doing either of these and waiting for the natural questions that follow is a great introduction to this lesson and solar renewable energy in general. Where is the motor getting its energy? Where is it plugged in? Weaving terms that follow in the lesson into the natural discussion that takes place outdoors with your demonstration solar panels will improve your introduction even more.



As written, the lesson is divided into six sequential parts. The PowerPoint titled **Student Introduction to the Solar Pathfinder** contains instructional materials for you to use in teaching each part to your students.

Part 1: Introduction to the Solar Pathfinder™ by the Manufacturer

Show or have students watch these short videos describing the Solar Pathfinder and how it's used. The lesson is written to have students write critical notes on the photos and illustrations provided for them in the student lesson.

- Solar Pathfinder, Pathfinder Overview (5:18): <http://www.solarpathfinder.com/video/2>
- Solar Pathfinder, Fast Accurate Solar Site Analysis (4:34): <http://www.solarpathfinder.com/video/6>

Part 2: Introduction to the Solar Pathfinder™ by your Teacher

Once again, the **Student Introduction to the Solar Pathfinder** PowerPoint is designed to help you teach this material.

Show and identify all the parts of a Solar Pathfinder. If you have one available, demonstrate how it's used, including the selection and placement of the correct Sunpath Diagram. Have students take notes on these topics.

Review a Sunpath Diagram. If you don't teach between 43-49° North Latitude, print and distribute blank copies of a Sunpath Diagram for your specific latitude for your students (**Your Latitude Sunpath Diagrams** document). Students are expected to take notes on the features of a Sunpath Diagram right on the images provided within the lesson.

Provide practice using the Solar Pathfinder. You may do one or both of the following:

- a. Stake out locations to place the Pathfinder in advance of class. Take your class outside and move from one predetermined location to another. Qualitatively assess each location for available sunlight. Work vocabulary from the lesson into discussion and questions that arise.
- b. View the Google Slides titled **Sunpath Diagram Examples** available for this lesson. Qualitatively assess each example for available sunlight. Work vocabulary from the lesson into discussion and questions that arise. This may be done in place of taking students outside, especially if there are issues with the weather.

Part 3: Critical Solar Vocabulary

Develop discussion around the following terms, or have students research them. Why are they useful and important for those in the solar industry to know? Move students to adopt definitions that are substantially like those that follow. This information once again, is found in the **Student Introduction to the Solar Pathfinder** PowerPoint we encourage you to use.

Latitude: The angular distance of a location north or south of the earth's equator. Latitude ranges from 0° at the Equator to 90° at either North or South Pole. Lines of latitude run as circles parallel to the equator. Latitude enables us to specify an exact north or south position on the surface of the Earth (0° - 90° North Latitude or 0° - 90° South Latitude).

Longitude: The angular distance of a location east or west of an established prime meridian (passing through Greenwich, England) that runs from the North Pole to the South Pole. Longitude enables us to specify an exact east or west position on the surface of the earth (0° - 180° East Longitude or 0° - 180° West Longitude).

Solar azimuth: Solar azimuth is the compass degree (0° - 360°) that describes the position of the sun along the horizon at any given time.

Solar altitude or solar elevation: The vertical angle formed between the horizon and the center of the sun's disc at any given time.

Solar noon: The moment during the day when the sun reaches its highest point in the sky--its maximum elevation or zenith. This is also the moment during the day when the sun is due south--its azimuth is 180° on a compass dial. At this moment, the length of time from sunrise to solar noon is equal to the length of time from solar noon to sunset. Solar noon is usually close to, but is seldom the same as clock noon.

Solar window: (definition used most commonly in the solar PV industry): The critical hours of 9am to 3pm that are the most important for the conversion of sunlight into electricity for well-positioned, fixed solar array.

Part 4: Extending What You've Learned

Provide your students with blank copies of a Sunpath Diagram for your latitude.

Then take your students, or have your students navigate to

<https://www.timeanddate.com/sun/>.

Have students answer the questions in this section. Assist as needed. Check for understanding and completion.

Guide students in making connections between the seasons, the data on the site about sunrise, sunset, solar noon, and day length, and the vocabulary introduced earlier. Draw connections between the information from timeanddate.com and the Sunpath Diagram.

Part 5: Shade and Sun Evaluation for a Specific Site

In this section of the lesson, students will evaluate and compare Sunpath diagram tracings from different sites. This is a natural activity to perform, and a natural lesson closure activity.

Duplicate enough Sunpath Diagram tracings (**Student Sunpath Diagram Blanks** document in the Instructor Materials) to perform this activity the way you would like it to be completed (individually, or groups of 2 or 3). There are ten tracings, labeled First through Tenth Streets.

Have students determine the percentage of sunlight available at the site on their assigned street. Use the **Student Introduction to the Solar Pathfinder** PowerPoint to teach your students how to do this efficiently.

Each tracing yields a different percentage of sunlight available. Students will be naturally curious to see which site “wins.” You may want to make the claim that banks will only finance (lend money to) people at locations that can prove a percentage of sunlight available of 90% or higher.

Student sites may be reviewed several different ways (answers follow, are located in the **Student Introduction to the Solar Pathfinder** PowerPoint and are also found in a document titled **Student Sunpath Diagram Answer Keys**). You are encouraged to take advantage of your students' natural curiosity and media / presentation skills by having them review sun and shade dynamics at their site with classmates before revealing the correct answers.

The question posed at the end of this section may be used for lesson assessment, or for good discussion and review.

Answers to Sunpath Diagram tracings: Note answers are included in brackets.

Street	Number of numbers from the Sunpath Diagram (12 months X 100% each month)	Numbers in the shade from the Sunpath Diagram	Numbers in the sun from the Sunpath Diagram	Math to calculate the percentage of sunlight available at this location	Percentage of Sunlight Available at This Location
First	1200	[- 195]	= 1005	$(1005 / 1200) \times 100$	[84 %]
Second	1200	[- 164]	= 1036	$(1036 / 1200) \times 100$	[86 %]
Third	1200	[- 168]	= 1032	$(1032 / 1200) \times 100$	[86 %]
Fourth	1200	[- 27]	= 1173	$(1173 / 1200) \times 100$	[98 %]
Fifth	1200	[- 270]	= 930	$(930 / 1200) \times 100$	[78 %]
Sixth	1200	[- 187]	= 1013	$(1013 / 1200) \times 100$	[84 %]
Seventh	1200	[- 175]	= 1025	$(1025 / 1200) \times 100$	[85 %]
Eighth	1200	[- 143]	= 1057	$(1057 / 1200) \times 100$	[88 %]
Ninth	1200	[- 116]	= 1084	$(1084 / 1200) \times 100$	[90 %]
Tenth	1200	[- 58]	= 1142	$(1142 / 1200) \times 100$	[95 %]

5-1. The people who own the residence where your tracing was made need a loan to cover most of the purchase and installation costs for the solar PV system they want to install. Imagine you are a bank loan officer. Do you believe the percentage of sunlight available for the year at this location is enough for you to approve the loan? Answer yes or no, then provide your reasoning with reference to actual data from your Sunpath Diagram site tracing.

*** Students may answer this question yes or no, depending on their site and other information they have learned or researched. However, it is important for them to demonstrate some of the economic dynamics behind most solar PV installations in their answer.**

Many people cannot install a PV array without a loan. Banks will always have requirements behind the use of their money. One of those requirements may be to show that the array they are loaning money for receives most of the sunlight available during the year, perhaps 90 or 95%. In this way, the array can be expected to pay for itself in a short period of time. Failing that, the array should at least be able to decrease the electric bills of the owner, who then has the savings available to put toward making monthly payments on the loan.

Part 6: Show What You Know

Select from the questions available in this section those you might wish to use to assess your students. Or alternately, they may be removed from the Student Activity Guide and used as quiz or test assessment questions.

6-1. Demonstrate what you've learned in this lesson in answering the following question. How does the Solar Pathfinder enable most people (buyers, installers, bankers) to make good, site-specific decisions about where to locate a solar PV system?

*** The Solar Pathfinder shows everyone involved where to locate and position solar panels to maximize their exposure to the sun. Exposure to the sun is key to Solar PV electrical generating performance. Everyone involved in the process will want to see that a PV array is generating as much electricity as it possibly can.**

Good, site-specific decisions about where to locate a solar PV system are always needed. Serious economic dynamics were just reviewed in the previous question. In addition, it's simply a waste of valuable resources and money to put a solar PV array where it will do little good.

6-2. The Solar Pathfinder provides data on the percentage of sunlight available for the year at a given site. Develop a paragraph that describes at least three additional factors that often make a difference in determining whether or not a solar PV system makes sense for most people to install.

*** More answers are possible than can be reviewed here.**

- **The cost of the solar panels and “balance of system” equipment (charge controller, inverter, wiring, grounding circuit, fuses, safety disconnects, outlets, metal structures for supporting the modules, and more).**
- **How much the electricity can be sold back to the utility for.**
- **Rebates or subsidies that may or may not be available for installing a solar PV array.**
- **The rate of interest required on a loan from a lending institution.**

6-3. Describe the most important idea, concept, principle, or fact you learned while completing this part of the lesson. Explain why it is important for you (and probably other people) to know and understand.

*** This is a reflection and judgement question. Student reasoning and reaction should be evident in a good answer. No two student answers should be the same.**