sei STRATEGIC ENERGY INNOVATIONS

Grade: 9-12

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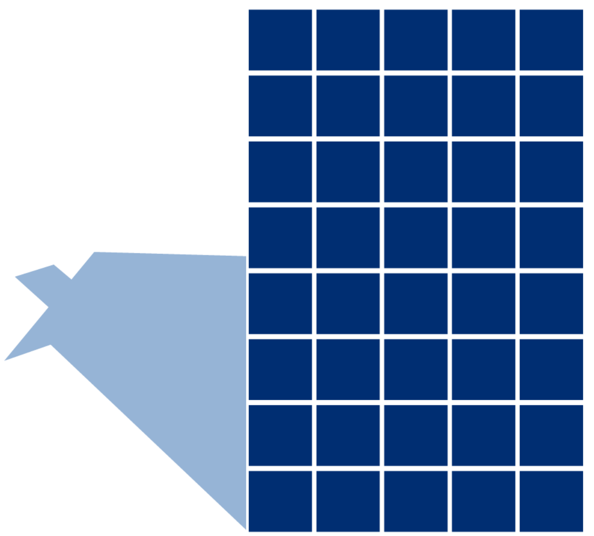
Home Solar Analysis



Design, size, and site a home solar system while learning solar science and building career skills

Table of Contents

Sizing and Optimizing a Home Solar Electric System

Table of Contents

Lesson 4.1 Overview

Estimate Time:
45 minutes

Standards:
NGSS: HS-ESS3-4, HS-ETS1-2
CCSS ELA Literacy: 2, a Language: 1,6
CCSS Math: A-SSE-4
CTE Energy, Environment & Utilities: B1.0, B7.0 Engineering & Architecture: D2.0, D2.1

Objectives: Students will be able to:

- Size a solar system for their home

Handouts:

- 4.1.1 Sizing a Solar Electric System

Prep Time:
1 hours

Materials:

- Internet Access
- Home electricity usage data

Lesson 4.1: Sizing a Home Solar Electric System

In this lesson students size a solar electric system large enough to meet 80% of their home's (or a sample home's) energy use.

KEY WORDS

Solar Module: A collection of solar cells wired together to produce electricity

Solar Array: A collection of solar modules strung together to produce electricity

Solar Racks: Equipment used to support and secure solar modules to a rooftop, the ground, or other surface

Inverter: An electronic device that converts direct current (DC) from solar panels into alternating current (AC), the form of current used in homes and businesses that are connected to a utility grid

Utility grid: The infrastructure facilitating the transmission and distribution of power from power plants to the customer

Insolation: Incident solar radiation – the amount of solar power on a given area over time, measured in kilowatt-hours per square meter (kWh/m^2)

Full Sun: A measurement of when solar radiation is 1kW/m^2 at a given time

Peak Sun Hour: The average number of hours per day of "full sun" at a location, calculated over a year's time (hr/day when solar radiation is 1kW/m^2)

Derate Factor: A metric used to account for inefficiencies and energy losses in delivery of electricity to the end user

SETTING THE STAGE: SIZING A SYSTEM

Derate Factors

- A **derate factor** is a metric used to account for inefficiencies and power losses that occur between the electricity production at a solar panel and the delivery of electricity to the home (or customer). The Sizing a Solar Electric System Handout includes calculations around the derate factors covered below.

  - Production tolerance: Panel performance is assessed using standard tests in a laboratory, but actual performance of panels once installed in the real world will differ; this derate factor accounts for the expected variation.

  - Higher temperature: Panels are less efficient at producing electricity when the temperature is higher; this derate factor accounts for the temperature variation expected at the location of the system.

  - Dirt and dust: The collection of dirt and dust on the modules reduces the amount of light that reaches the PV cells; this derate factor accounts for the loss of performance of the panel due to soiling.

  - Module mismatch: All panels are slightly different, and since the panels are strung together sometimes power is lost as it moves through the array; this derate factor accounts for a minimal, but expected, amount of mismatching.

  - Line loss: As the current moves through the wire, there are losses (in the form of heat) due to the resistance of the wire and other electrical connections in the system. This derate factor accounts for these energy losses.

Insolation

- The amount of energy a solar system can generate depends on the amount of sunlight the region receives.

  - The amount of solar energy reaching your school is affected by the season, the time of day, the climate, and air pollution.

Insolation, incident solar radiation, is the amount of solar radiation striking a given area over time, measured in kilowatt-hours per square meter (kWh/m^2). The map below shows insolation in different parts of the United States. You can see that insolation in the southwest is higher than in the northeast.

Lesson 4.2 Overview

Estimate Time:
90 minutes (Two 45 minute periods)

Standards:
NGSS: HS-LS2-7, HS-ESS3-4, HS-ETS1-2, HS-PS3-3
CCSS Math: A-SSE-4
CCSS ELA Literacy: 1, 4 Language 1, 6; S&L 1
CTE: *Energy, Environment, Utilities* A8.3
Environmental Engineering D2.0-2.1

Objectives: Students will be able to:

- Identify what makes a site optimal for solar
- Determine whether or not a real rooftop is suitable for solar and design a solar electric system

Handouts:

- 4.2.1 Rooftop Solar Site Assessment
- 4.2.2 Solar Proposal
- 4.2.3 Solar Proposal Letter Outline

Prep Time:
1-2 hours

Materials:

- Solar Toolkit: Mini solar panel, mulitmeter, electrical leads, protractor
- Compass
- Internet access

Lesson 4.2: Optimizing Home Solar Performance through Design

A site assessment is a critical step in understanding a rooftop's potential to generate electricity from the sun. In this lesson, students will learn the fundamental steps for conducting a solar site assessment and designing a rooftop system. Students will continue their solar assessment and design project from Lesson 3 and either design the system for a sample California home's rooftop or their own home.

KEY WORDS

Azimuth: The angle, in a clockwise direction from north, that the solar modules face

Latitude: The distance, in degrees, north or south of the equator

Orientation: The placement and alignment of solar modules to face the sun. To capture the greatest amount of sunlight, the preferred orientation for solar is due south when array is located in the northern hemisphere

Shading: Shadows from manmade or natural features that block direct solar radiation from reaching the solar PV modules and diminish the production of electricity

Site: A location, such as a piece of land, parking lot, or a rooftop, where solar can be installed

Tilt: The angle of solar modules; optimal tilt, to capture the greatest amount of sunlight, is the same the latitude of the array location

Usable Area: The area of a roof that can support solar panels. This area takes into consideration the offset from the edge of the roof and any shading or mechanical systems that limit the area that can support productive PV panels

HANDOUT: HOME ROOFTOP SOLAR SITE ASSESSMENT

Name: ____ Date: _______________ Period: ____

In this worksheet, you will continue the assessment of your home to determine how optimize the performance of your home solar system through design.

Step 1. System Size

In the Sizing a Solar Electric System Handout from Lesson 3, you determined the DC size a system would need to be to offset 80% of your home's electricity consumption.

___________________ $kW_{size\ needed}$ determined in Sizing a Solar Electric System

This handout will use the National Renewable Energy Lab's PVWatts Calculator:

- http://pvwatts.nrel.gov

Step 2. Address

Enter your full address in the "Get Started" cell in the upper left corner of the page.

Check that the location the website uses for your weather data is located near your home. If not, click "Change" and select the closest weather station. Why is weather an important factor for how much a home solar system can produce?

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Step 3. Roof Selection

Click "Go to system info" to continue your home assessment.

In the System Info section, click "draw your system" to select the roof you want your system to go on. Recall from the Maximizing Solar Production Handout, south is the optimal orientation for the solar array, but you can still produce plenty of power from a solar array on a flat rooftop or a rooftop facing southwest or southeast. Remember to consider shading and other rooftop structures when selecting a roof.