

# SunPower School Solar Monitoring

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**Developed by Strategic Energy Innovations in  
collaboration with SunPower Corporation**



**SUNPOWER®**

## **Welcome to the Solar Monitoring Curriculum**

This package:

- Includes three interactive lessons designed for the high school level (grades 9-12)
- Provides hands-on training in solar energy and solar system monitoring
- Addresses Next Generation Science Standards and Common Core State Standards

The Solar Monitoring curriculum was developed by Strategic Energy Innovations (SEI), a non-profit organization that provides energy efficiency and renewable energy consulting and related services to the cornerstones of all communities - schools, local governments, the workforce and the housing sector. For more information, visit <http://www.seiinc.org>.

## **Acknowledgements**

Special thanks to SunPower Corporation for sponsoring the development of this curriculum. For more information on SunPower's education programs, visit <http://us.sunpower.com/commercial-solar/k12-higher-education/>.

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# Academic Content Standards

Instructors can address the standards listed below by guiding students through two stages: understanding the background material on climate and solar science and tracking and analyzing solar performance.

## Next Generation Science Standards (NGSS)

### PS2: Motion and Stability: Forces and Interactions

HS-PS2-5 Plan and conduct an investigation to provide evidence that an electric current can produce a magnetic field and that a changing magnetic field can produce an electric current

### ESS2: Earth's Systems

HS-ESS2-4 Use a model to describe how variations in the flow of energy into and out of Earth's systems result in changes in climate.

HS-ESS2-6 Develop a quantitative model to describe the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere.

## California's Common Core State Standards (CCSS) Math

The curriculum addresses the eight Standards for Mathematical Practice that “mathematics educators at all levels should seek to develop in their students”.

- 1) Make sense of problems and persevere in solving them
- 2) Reason abstractly and quantitatively
- 3) Construct viable arguments and critique the reasoning of others
- 4) Model with mathematics
- 5) Use appropriate tools strategically
- 6) Attend to precision
- 7) Look for and make use of structure
- 8) Look for and express regularity in repeated reasoning

### Number and Quantity: Quantities:

N-Q-1 Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.

N-Q-2 Define appropriate quantities for the purpose of descriptive modeling.

### Functions: Interpreting Functions

F-IF-4 For a function that models a relationship between two quantities, interpret key features of graphs and tables in terms of the quantities, and sketch graphs showing key features given a verbal description of that relationship.

F-IF-5 Relate the domain of a function to its graph and, where applicable, to the quantitative relationship it describes.

### Statistics and Probability: Interpreting Categorical and Quantitative Data

S-ID-1 Represent data with plots on the real number line (dot plots, histograms, and box plots).

S-ID-2 Use statistics appropriate to the shape of the data distribution to compare center (median, mean) and spread (interquartile range, standard deviation) of two or more different data sets.

S-ID-3 Interpret differences in shape, center, and spread in the context of the data sets, accounting for possible effects of extreme data points (outliers).

## **California's Common Core State Standards (CCSS) ELA Literacy**

### Speaking and Listening Standards

1. Initiate and participate effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade level topics, texts, and issues, building on others' ideas and expressing their own clearly and persuasively.
  - a. Come to discussions prepared, having read and researched material under study; explicitly draw on that preparation by referring to evidence from texts and other research on the topic or issue to stimulate a thoughtful, well-reasoned exchange of ideas.
4. Present information, findings, and supporting evidence clearly, concisely, and logically (using appropriate eye contact, adequate volume, and clear pronunciation) such that listeners can follow the line of reasoning and the organization, development, substance, and style are appropriate to purpose (e.g., argument, narrative, informative, response to literature presentations), audience, and task.



## Lesson 3 Overview

### Estimate Time:

90 minutes (Two 45-minute periods)

### Standards:

CCSS Math: N-Q-1, N-Q-2, F-IF-4, I-IF-5, S-IS-1, S-ID-1, S-ID-2, S-ID-3

### Objectives:

 Students will be able to:

- Monitor solar production
- Determine necessary steps towards becoming a net zero school

### Handouts:

- 3.1 Analyzing Daily Production
- 3.2 Analyzing Environmental Impact
- 3.3 Action Plan Template

### Prep Time:

- Allow 1 month to request and receive energy use data
- Allow 2 weeks to request access to the SunPower solar monitoring website for your district
- 1 hour to review lesson and print materials

### Materials:

- PowerPoint presentation and projector
- The accompanying Energy and Solar Monitoring Tool
- Internet access
- Access to the SunPower solar monitoring tool for your school
- Electricity utility data for the last year (preferable three years)
- Handout 3.1 & 3.2 (one per student)
- Handout 3.3 (one per group)

### Resources:

- EPA:  
<http://www.epa.gov/reg3wapd/infrastructure/EnergyEfficiency/>

## Lesson 3: Tracking and Analyzing Solar Production

This lesson helps to engage students in using a school solar system as a learning tool and creates an opportunity for long-term solar energy monitoring. The lesson introduces students to online solar monitoring and how the tool can be used to track and analyze solar production. Students will then determine steps they can take to help their school become a Net Zero energy campus.

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### KEY WORDS

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**Cumulative Energy Produced:** (in kWh) the amount of energy the system has produced during the day. It is the sum of all daily interval energy produced values

**Max AC Power Produced:** (in kW) the amount of power the system can produce at any moment

**Interval Energy Produced:** (in kWh) the amount of energy produced in a specified time interval, such as 5 or 15 minutes

**Total Lifetime Energy Produced:** (in kWh) the amount of energy the system has produced over the course of its life

**Avoided Emissions:** the pounds of greenhouse gas emissions that would have been released without solar power, based on the emissions factor from your local utility (for example 0.39 pounds of CO<sub>2</sub> per kWh for the electricity mix of PG&E)

**Green Building:** a building designed to reduce environmental impacts and improve human health

**Net Zero Energy Building:** a highly energy efficient residential or commercial building that utilizes renewable energy to meet its minimal energy requirements

**Conventional Building:** a residential or commercial building typically designed to have the lowest upfront cost possible

**LEED Certification:** (leadership in energy and environmental design) is a set of rating systems for the design, construction, operation, and maintenance of green buildings, homes and neighborhoods developed by the US Green Building Council

**Energy Performance:** the energy consumption of a building compared to other buildings of a similar type. A building with excellent energy performance uses less energy per square foot than a building with poor energy performance

**Energy Use Intensity (EUI):** the energy per square foot used in a building

**Life-Cycle Cost:** The true cost of a building, product or system that takes into account purchase, maintenance, replacement and disposal costs

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## PREPARATION

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- Prior to the lesson, confirm that you have access to the SunPower solar monitoring tool for your school. Log in using your district or school login. You may have to ask a facilities manager or administrator for access. The tool is available at the website below:
  - <https://www.sunpowermonitor.com/partner/partner.aspx#>
- We recommend collecting and analyzing your school's electricity usage data, though it is not required in order to analyze solar energy production. This will allow students to evaluate the gap between their current energy consumption and production at their school, and consider energy conservation and efficiency measures to close that gap and become a Net Zero Energy school. In order to analyze usage versus production, gather a minimum of 12 months, but preferably three years, worth of electricity usage data for the school (can often be found online through the school's utility account). School administrators may have this data filed, or the login information for the account; alternatively, you may have to contact the facilities department at the district. Allow a month to request and receive usage data.
- Each student will need copies of Handouts 3.1 and 3.2. Students can work individually or in pairs to complete the Energy and Solar Monitoring Tool in the Excel spreadsheet on a computer.
- Each student group of 3-4 students will need a copy of Handout 3.3.

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## SETTING THE STAGE: USING THE TOOL

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- Use the PowerPoint and the background material below to cover the SunPower solar monitoring tool.
- Begin by introducing students to the website and analyzing graphs produced by the tool.
  - Go to: <http://commercial.sunpowermonitor.com/Commercial/Login.aspx>
  - Log in using your assigned login. You may have to ask a facilities manager or administrator for access. Allow at least two weeks to gain your username and password.

## School Solar Monitoring Lesson 3: Tracking and Analyzing Solar Production

- Click on your school in the list at the bottom half of the screen.
- On the map, click “View Details.” You will be directed to your school’s production information.
- The graph below (Figure 1) is similar to what will appear on your screen. The image shows production for the current day.

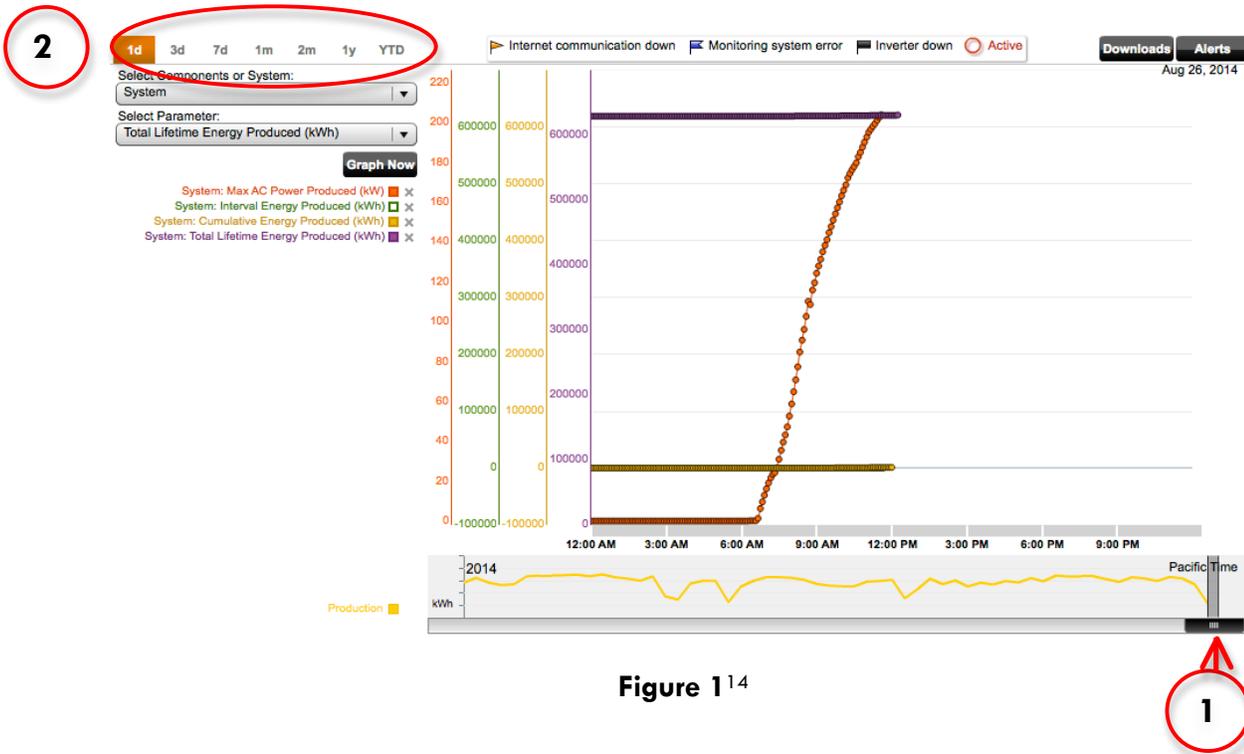


Figure 1<sup>14</sup>

1. To view a past time period, use the scroll on the bottom of the screen.
  2. To change the duration of time the graph shows, click on the available time frames to the left of the graph.
- There are four different parameter graphs of production produced on the home page of the tool. The image below (Figure 2) is a larger view of the axes and graphs types featured in the image above.

<sup>14</sup> Source: Courtesy of SunPower Corporation