LESSON PLAN

The 50 Year Energy Plan Project

Lesson 4: Scaling up to Power Production Let's use Data to Optimize the Performance of a Solar Cell Array

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DESCRIPTION:

Somewhat similar to the first part of the wind turbine project from Lesson 3, students are tasked with optimizing the performance of a photovoltaic system. This objective both allows students to apply the engineering-design process they absorbed in previous lessons, while also addressing NGSS performance expectation HS-PS4-3 that states:

"Evaluate the claims, evidence, and reasoning behind the idea that electromagnetic radiation can be described either by a wave model or a particle model, and that for some situations one model is more useful than the other."

Students meet this standard by using their understanding of solar radiation and position of the sun to inform decision making while designing an effective solar array.

ACTIVITY LENGTH

2 90 minute periods

LEARNING GOAL(S)

1. Design, build, and refine a system that most effectively converts energy from

the sun into electrical energy.

CONTENT BACKGROUND

STUDENT BACKGROUND

- Background on energy, energy transformations and basics of electricity as gathered from Lessons 1 and 2 of this Unit
- Understanding of parallel and series circuits from Lesson 2
- Experience using Vernier Labquests; Labquest 2s; or GoDirect Sensors from Lesson 3
- Understanding of the U.S. Power Grid, Transmission, Social Energy Needs, Environmental Impacts of Generation from prior Lessons in this Unit.

EDUCATOR BACKGROUND

Educators wanting to be prepared should read through the EMPP Unit Slides for Lesson 3 or found online at https://goo.gl/EYCyT2). Moreover, click through to explore videos and resources embedded within those slides

Have understanding of the basics of Solar Power generation and contemporary US power production methods →

- Learn about Solar and Photovoltaic basics and gain an introduction to Renewable Energy through Solar Energy International's free online course: www.solarenergy.org/courses/introduction-to-renewable-energy/
- Read the most recent Oregon Energy Plan, as it provides a lot of relevant, real-world background information. Another tool is the official State of Oregon's interactive, online "Electricity Mix in Oregon" map found here (https://www.oregon.gov/energy/energy-oregon/Pages/Electricity-Mix-in-Oregon.aspx).
- Explore the U.S. Energy Information Administration website for more background, including the U.S. Overview map to find information on another state.

Activity-Specific Background Resources:

- Gain or have experience using Vernier Labquests; Labquest 2s; or GoDirect Sensors – information can be found on the provider’s website: www.vernier.com/products
- Use this online tool to generate a Sun Path Chart used in PV installation and calculations for specific geographic locations: http://solardat.uoregon.edu/SunChartProgram.html
- Learn how to use a Sun Path Chart with this instructional video from Solar Schoolhouse here www.youtube.com/watch?v=OR8EQ0DWpPw

MATERIALS NEEDED

HANDOUTS/PAPER MATERIALS

- Unit Packet
- Interactive Notes for Solar Optimization

CLASSROOM SUPPLIES

- General Audio Visual Equipment
- 4 Vernier Solar Cells of varying voltages
- 4 Vernier Labquests, Labquest 2, or GoDirect Sensors
- 4 Vernier Variable Loads
- 4 Vernier Energy Sensors
- Light sources – natural and man-made can work well to compare and contrast power output
- Access to internet-connected device

ACTIVITY SUPPLIES (PER GROUP OF 3-4 STUDENTS)

Note the classroom list above as well as the Supply List in the unit materials for sourcing.

LESSON PROGRESSION

PLANNING AND PREP

Review the Unit Slides and calendar for days 10 and 11. Review the Unit Slides 187-219 as well for context surrounding the engineering challenge and background content information.

LESSON SEQUENCE

DAY 1

- **Guiding Phenomenon**: Why is there a difference in mounted solar arrays between Oregon (mounted at a 45 degree angle), Alaska (mounted at 85 degrees) and the Galapagos (mounted at 0 degrees)?

- **Discuss** with the class Earth's curve and how that impacts different angles of "incoming" sunlight at different points on the Earth and how that changes at different times of the year
- **Question**: "Why is the sun at a different angle in the sky between June 21st and December 21st in Oregon, but not in Ecuador (hint, Oregon is at the 45th parallel and the Galapagos Islands are near the equator at 0 degrees, discuss latitude differences and seasonality tilt of the Earth's orbit)
- **Watch**: NOVA video "Solar Power" www.youtube.com/watch?v=m74bMrxhBkw&feature=youtu.be
- **Engineering Activity:**
  - **Problem Definition:** Our school wants to apply for a Photovoltaic array to be installed on the facility buildings. Most criteria, constraints and supplies for the project are already set, BUT students can determine the ideal angle and placement of the PV system to take advantage of sun hours in our local area
  - **Question – What factors should we consider for selecting the location of the school's solar array?**
    - (NOTE – the EMPP Unit Slides are created to use Beaverton, Oregon as the specific latitude for this example, but this activity can be customized to fit your local community. Use this online tool to generate a Sun Path Chart used in PV installation and calculations for specific geographic locations: http://solardat.uoregon.edu/SunChartProgram.html
    - Learn how to use a Sun Path Chart with this instructional video from Solar Schoolhouse here www.youtube.com/watch?v=OR8EQ0DWpPw)

DAY 2

- **Design Exploration:**
  - Connect a solar cell to a Vernier Labquest, Labquest 2 using a Vernier Energy Sensor. Also connect a Vernier Variable Load to the circuit. If using a Vernier Go Direct, an Energy Sensor and Variable Load are not necessary elements to measuring energy output from PV panels.
  - Point PV panels towards a light source – either the sun's rays or a strong incandescent lightbulb and measure the angle of the PV panel with a protractor. Set light exposure time and data collection rates on Labquests to 5 second intervals and find the average voltage and amperage of light energy harvested from each trial. Student teams can use the same light sources while testing different exposure angles and

locations. Or all teams can test the same exposure angles and locations, averaging the class' entire data pool to determine the optimal angle and location for the school's new solar array.

        - Use this real-life data to graph and communicate findings either verbally or in writing.
        - Use student graphs and new understanding to return to initial lesson question regarding different localities – go through EMPP Unit Slides for Lesson 4 and ask about how graphs of energy output change for different site variations

- **Science and Engineering Practices – Skeleton of a Conclusion**
    - Use this investigation to discuss how scientists and engineers make educated conclusions to answer questions or problem solve
        - **Claim** - Clearly state your claim
        - **Evidence** - Explain how data you cite supports this claim
        - **Mathematical Model** with **Reasoning*:* the Constant, the Pattern, and General Equation** - Communicate the mathematical model that behaves the same as the system you investigated. Along with the model you need to describe your **reasoning** about **1) what the A-value represents in the real world** and **2) why the pattern makes sense.** Be sure to also include **3) the generalized equation (communicated verbally and in writing, not just in equations!)**
        - **Prediction -** Communicate how the system you behave for the scenario presented at the beginning of the experiment.
        - **Confidence with Justification -** Explain your thinking for your confidence in using your data to predict the future behavior of the system.
        - **Limitations** - Evaluate the limitations of either your procedure to collect data or of the model your created of the system you investigated.

- **Watch:** Vox.com video "The 'Duck Curve' is Solar Energy's Greatest Challenge" https://www.youtube.com/watch?v=YYLzss58CLs&feature=youtu.be

ASSESSMENT AND EXTENSIONS

FORMATIVE ASSESSMENT

Students should be tracking their data and findings in various methods throughout this unit, whether it be in worksheets provided along with the curriculum or through their own engineering notebooks. Teachers are encouraged to determine as many open-ended methods for observing student understanding formatively as they engage with content in an exploratory manner.

SUMMATIVE ASSESSMENT

"Optimize a Solar Cell Array" Engineering Portfolio

UNIT EXTENSION

Apply student experience and knowledge of PV systems and basic circuitry to build various solar powered small vehicles or passive solar architecture to develop creative, fun, hands-on student engagements.

Lesson 4 is also a great opportunity for local utility partners or renewable energy installers to come work with your classroom. Professionals may act as guest presenters, observers, or project judges. Local Electrical Utilities often already have outreach programs in place and will be happy to work with you to determine how to best meet the needs of your students. Try using the online Professional Mentor – Classroom connection tool Oregon Connections from the education group, Nepris, to get in touch with Solar Professionals in your area – either in person or for a virtual classroom meetup. For more information visit www.OregonConnections.nepris.com