# Teacher Guide

Engineering Tomorrow

# Renewable Energy: Building Solar & Wind Systems

**NEW FOR 2025-2026!**

- ★ An alternate **mission-focused version** of the student workbook has been developed featuring **an actual renewable energy project completed by Engineers Without Borders** allowing students to connect this lab to the real world. The alternate workbook is linked in this guide in the Teacher Notes section below.
- ★ Clarified wiring configuration for different models of solar PV panels

## PLANNING FOR THE CHALLENGE:

| **SUGGESTED LESSON PLAN - 50 minute periods** | |
|---|---|
| **Total Time ~100-130 minutes**<br>• ~43 minutes to watch the lab introduction video (MAIN LAB portion)<br>• ~45-50 minutes to design a hybrid wind and solar structure and circuit<br>• ~10-20 minutes for students to test their structure and record results<br>• ~0-15 minutes for a closing activity or discussion<br><br>Optional Extensions<br>• Extension Video: Power Grid ~20 min video<br>• Multimeter, Series/Parallel Circuits<br><br>*(Note: An optional 30-45 minutes can be scheduled to do a Wrap-Up and QA with an Engineer and College Mentor at Teacher's discretion).* | |
| **Hook / Essential Question** | How can we design clean energy solutions that meet the needs of their users? |
| **Resources to Have Ready in Class** | ET Renewable Energy Kit materials can be found at the end of this document.<br><br>Additional Items to Consider Having on Hand:<br>• For creating the building structure:<br>  ○ Scraps of cardboard<br><br>**NOTE**: Some sites referred to in the workbook may be blocked by school internet protocols. Please request admin access for the sites **below** in advance so that you students will have access before they begin working through the student workbook/worksheet<br><br>Extractable Power from Solar Panels<br>• https://pvwatts.nrel.gov/pvwatts.php<br><br>*(Optional- If completing Extension #3)* Power Grid<br>• https://www.next-kraftwerke.com/virtual-power-plant-vpp-simulation/?lang=en<br>• https://credc.mste.illinois.edu/applet/pg<br><br>The videos **below** should be unblocked for **teachers-only** if presenting the student workbook to the whole class OR for **all students** if they are completing the student workbook on their school devices<br><br>Main Workbook |

| | |
|---|---|
| | • https://www.youtube.com/watch?v=1kUE0BZtTRc<br>• https://www.youtube.com/watch?v=EYYHfMCw-FI<br>• https://youtu.be/xKxrkht7CpY?si=yPyLcfFAIqPEgvXS<br>*(Optional- If completing Extension #3)*<br>• https://www.youtube.com/watch?v=VbRvBhLWxyQ<br>• https://www.youtube.com/watch?v=9eAFEU7pMwU<br>If completing the alternate Engineers Without Borders USA Mission version:<br>• https://youtu.be/UPKSl9cjSW8?si=fD95715bgNMJN99q |
| **Optional Pre-Work** | • Watch the first 5 minutes and 31 seconds of Engineering Tomorrow: Renewable Energy Intro Video (found on the Engineering Tomorrow website on the Renewable Energy page) either as a class or assign background section as pre-work.<br>• Work through slides 1-7 in the Student Workbook. |
| **Class #1** | • Watch the Engineering Tomorrow: Renewable Energy Intro Video (found on the Engineering Tomorrow website on the Renewable Energy page) and have students work through associated questions in the workbook or abridged worksheet as appropriate.<br>• Student teams begin to design their hybrid wind and solar structure<br>Research designs, review materials, generate an initial design concept and describe in their workbook or abbreviated worksheet (1 workbook or worksheet per team suggested) |
| **Class #2** | • Student teams finish assembling their initial design and test it<br>• Students modify their design for improved performance and make changes as needed<br>• Students measure the performance of their cell by determining how much voltage it can produce using the provided LED color chart<br>• Student teams summarize and reflect on their final cell design and performance in the workbook or worksheet |
| **Possible Extension Activities** | Choose from our variety of possible extension activities (20 mins). Detailed instructions can be found in the student workbook.<br>• Learn how to use a multimeter to measure circuits<br>• Combine multiple solar cells in series and parallel circuits to make a solar panel or run a fan, and measure the voltage in your circuits using a multimeter<br>• Use an online simulator to understand the concept of a power grid<br>• Make larger blades for your wind turbine to capture more wind and integrate gears to make your generator spin faster to generate more voltage, and measure it with a multimeter |
| **Possible Closing Questions and Activities**<br><br>**Part of Class #3** | • Class Discussion Question: As the nation transitions to cleaner energy sources such as wind and solar energy, how can engineers make sure that these types of energy are accessible and powerful enough nationwide and worldwide?<br>• Watch the recorded Renewable Energy keynote speaker, Alex Coleman, a civil and environmental engineer and business woman who speaks about her career in engineering construction and the renewable energy sector (found on the Engineering Tomorrow website on the Renewable Energy page) |

# Teacher Guide: Renewable Energy

## INTRODUCTION TO ENGINEERING TOMORROW:

- Click here to see an introduction of what Engineering Tomorrow can do for your students.

## INTRODUCTION TO THE ENGINEERING DESIGN PROCESS:

- Students should complete the Engineering Design Process Introduction Activity before starting the lab
    - NOTE: This activity only needs to be completed before the student's **first** ET lab, not repeated for every lab.

## TEACHER NOTES:

- Students will work through the **Renewable Energy** Student Workbook, the **NEW** EWB Mission Student Workbook or the Abbreviated Student Worksheet.
    - When assigning this lesson on Google Classroom, first make a copy of the slides to save within your Google Drive, then assign so that each student has their own copy.
    - The workbook and worksheet are designed to be interactive so that students can type directly into the files. It is suggested that the workbook or worksheet be completed over a few class periods (as the information is delivered to students).
    - Students may work individually or within groups (at the discretion of the instructor).
- The solar cells can be fragile, therefore, as a precaution to ensure the soldered wires remain intact, it is recommended to **place a piece of masking tape over the connections on the back of the cell** as additional support for the wires.
- There are 3 different brands of solar cells that may be included in your kit. The student workbook explains how to wire each option and those instructions can also be found here.
- Time stamps for sections of the introduction video can be found here. These timestamps are also listed throughout the Student Workbook and Abbreviated Student Workbook for reference while completing the lab.

## ASSESSMENT:

- Informal assessments can be completed by looking at the reflection slides within the Student Workbook and/or the discussion questions in the Abbreviated Worksheet.

- **Answer Keys** can be found here for:
    - Abbreviated Worksheet Answer Key
    - Student Workbook Answer Key
    - EWB Mission Student Workbook Answer Key

## TROUBLESHOOTING TIPS:

- If the material is not listed on the material cost slide, the teacher gets to decide the pricing
- For Solar Troubleshooting:
    - Make sure the structure is directly facing the sun.
    - If it is not completely sunny outside, the solar panel might not obtain enough energy to power the turbine. Try this lab on a sunny day in the early afternoon for best results.

- Shadows will also affect the solar panel.
- For Wind Troubleshooting - if the student's LED isn't lighting up:
  - Test both the fan and LED with an AA battery individually, make sure the positive goes to the positive and negative to negative. This will help determine if the LED or motor just isn't working
  - Double check wiring connections
  - Try reversing positive and negative connections on the LED/motor
  - Make sure the fan is spinning/try to spin it the other direction.

## POST WORK:

- Competition between students to see who had the cheapest turbine that successfully lit up the LED.
- Potential discussion questions:
  - Is it realistic to have wind turbines powering individual buildings? What about solar panels?
  - What are potential barriers to institutions and households installing solar panels?
  - If you are interested, you can do more research into the growth of renewable energy and how much of the US and global energy consumption it makes up.

| LESSON SUMMARY: | LESSON OBJECTIVES: |
|---|---|
| In this lab, students are introduced to renewable energy, where they will learn about the benefits of renewable energy sources in contrast to the dangers of non-renewable energy sources. Students will learn how to build their own solar-powered and wind-powered turbine prototype, while trying to keep their costs as low as possible. This reflects how today's engineers work to lower the cost of renewable energy sources in order to make them more appealing to the public.<br><br>**Curriculum Connections**:<br>• Environmental Engineering: using math, science, and engineering concepts to protect the living organisms on Earth | **Students will be able to:**<br>• Analyze real-world problems and use critical thinking skills in order to solve them<br>• Explore & describe renewable energy<br>• Design and build a solar-powered turbine<br>• Design and build wind turbine blade prototypes<br>• Collect and analyze data<br>• Explain the engineering process as it pertains to their design<br><br>**Content Vocabulary/Terms:**<br>• Renewable Energy: energy extracted from a naturally-replenished source.<br>• Power: the amount of energy transferred per unit of time that can also be thought of as the rate at which work is done.<br>• LED: a light-emitting diode. For those who are unfamiliar with this, it can be thought of as a light bulb.<br>• DC Motor (Generator): A rotary electrical motor that converts direct current electrical energy into mechanical energy (or vice versa) |

## NEXT GENERATION SCIENCE STANDARDS:

HS-ETS1-1. Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.

HS-PS3-3. Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy

HS-PS3-3. Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy

## MATERIALS:

| TEACHER'S KIT | | |
|---|---|---|
| *Materials will be distributed throughout the class.* | | |
| **Item/Link** | **Quantity** | **Photo** |
| Spare Generators | 3 |  |
| Spare Solar Panels | 3 |  |
| Spare Jumper Wires | 6 |  |
| Duct Tape | 1 |  |
| Masking Tape | 1 |  |

Materials Cont.→

| CLASSROOM EXTRAS | | |
|---|---|---|
| **Item/Link** | **Distribution** | **Photo** |
| Scissor | 1 for Every 10 Students |  |
| Glue Guns | 1 for Every Other Lab Group |  |
| Glue Sticks | ~2 Sticks per Lab Group |  |
| 6" Popsicle Sticks (sizes may vary) | ~60 Sticks per Lab Group |  |

| STUDENT KIT ITEMS | | |
|---|---|---|
| *1 kit: 3 students* | | |
| **Item/Link** | **Quantity** | **Photo** |
| Turbine Blade | 1 |  |
| Generator & Holder | 1 |  |
| LED lights | 4 |  |
| Solar Panel | 1 |  |
| Jumper Wires | 4 |  |