# Teacher Guide

# Green Hydrogen

## Exploring Hydrogen Power & Electrolysis

### PLANNING FOR THE CHALLENGE:

| **SUGGESTED LESSON PLAN - 50 minute periods** | |
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| **Total Time 100-120 minutes**<br>• ~29 minutes to watch the lab introduction video<br>• ~20-30 minutes to design, build and test electrolytic cell<br>• ~20-30 minutes to measure the hydrogen gas collected<br>• ~15 minutes to answer questions in Student Workbook or Abbreviated Worksheet<br>• ~15 minutes for closing activity or discussion at teacher's discretion<br><br>[Note: It is best to wait 24 hours to measure the gas collected as the chemical process happens slowly.]<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** | What is green hydrogen? Is it good or bad for the environment? |
| **Supplies to Have in Class** | ET Green Hydrogen Kit materials can be found at the end of this file.<br><br>Additional Items to Consider Having on Hand:<br>• Water or access to water for use in creating the water bath<br>• Empty water bottles<br>• Tape, Glue guns, or putty to help seal the straw<br>• Additional nickel coins for experimentation |
| **Introduction and Procedure** | Watch the Engineering Tomorrow: Green Hydrogen Intro Recording (found on the Engineering Tomorrow website on the Green Hydrogen page) either as a class or assign background section as pre-work.<br>Suggested discussion questions:<br>• Brainstorm and discuss what your initial idea of decarbonization is (@1:10, right before what is decarbonization slide comes on)<br>• MCQ: Which category do you think emits the most $CO_2$? Options: Electricity, **Industry,** Buildings, Transport, Agriculture/land use/landfill (@7:18)<br>• Discuss some ways $CO_2$ emissions can be reduced (@8:20)<br>• Brainstorm different sources of energy that companies use today. Compare and contrast their advantages and disadvantages (@9:55) |
| Optional Prework | Optional Pre Work assignment - students watch the first 10 min of the intro video independently and then answer questions on slides 1-13 in their workbook or the Introduction part of the worksheet. |

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| **Work Time** | Students build their electrolytic cell and complete associated slides in their workbook or worksheet. **Note**: The cell produces hydrogen slowly. It is recommended that students take measurements after the cell is started and then again after it has been allowed to sit for 24 hours or next class meeting. |
| **Testing** (24 hrs later or next class) | Students take measurements and perform calculations to assess the volume of $H_2$ produced and complete slides for Step 5, the testing part of the challenge. |
| **Closing**<br><br>At teacher's discretion | **Possible Closing Questions and Optional Activities**<br>• Why does the water in the straw not drain out when placed in the water?<br>• What factors impact $H_2$ generation rate? Salt concentration? Battery voltage? Electrical current? Water temperature?<br><br>**Potential Extension Activities (Choose) - 20 min**:<br>• Design a reactor to capture all the hydrogen produced<br>• Discuss the economics of green hydrogen<br>• Read this article to learn more about the future of hydrogen as an energy source<br>• Watch this video to learn how hydrogen-powered cars work<br>• Play this Quizlet to review concepts concerning green hydrogen and decarbonization |
| **Optional Post-work** | Optional Post Work assignment - students can research additional Green Hydrogen uses and report uses in this assignment. |

### 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 **Green Hydrogen** 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).

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### TROUBLESHOOTING TIPS:

- Make sure the pencils are properly sharpened at both ends– there should be graphite visible that the jumper cables can attach to
- Make sure the jumper cables are attached to the correct terminals of the battery and pencils (the pencil that goes in the straw should be connected to the negative terminal on the battery)
- Ensure that the end of the straw that is not in the water is fully sealed so that no gas or water can escape
- Once the electrolysis cell is finished, there may not be an immediate reaction– this does not mean the cell isn't working as it may take some time to see gas being produced (especially if you are using tap water)

### 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 the :
  - Abbreviated Worksheet Answer Key
  - Student Workbook Answer Key

- **ZiroAI** - If students have any additional questions pertaining to this lab, a ZiroAI Green Hydrogen is available.

### ADDITIONAL TEACHING RESOURCES:

**Curriculum Connections**:

- Chemistry: Redox reactions, electrolysis
- Environmental Engineering: using math, science, and engineering concepts to protect the living organisms on Earth
- Environmental Science: Greenhouse gasses, decarbonization, climate change
- Chemical Engineering: using math, science, and engineering concepts to produce solutions using chemical processes

**Students will be able to -**

- Analyze real-world problems and use critical thinking skills in order to solve them
- Work through and understand the engineering design process
- Produce green hydrogen by building an electrolysis cell
- Collect and analyze data

**Content Vocabulary/Terms:**

- Renewable Energy: energy extracted from a naturally replenished source.

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- Decarbonization: The reduction or elimination of carbon dioxide (or equivalent atmospheric impactful gas) emissions from a process such as manufacturing or the production of energy.
- Climate Change: long-term shifts in temperatures and weather patterns.
- Green Hydrogen: zero-carbon hydrogen fuel generated using renewable energy.
- Electrolytic Cell: an electrochemical device that uses electrical energy to facilitate a non-spontaneous redox reaction.
- Redox Reaction: a type of chemical reaction that involves a transfer of electrons between two species.

### 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

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Engineering Tomorrow

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KIT ITEMS: 1 item per 3 students

| Kit Item | Photo | Link (if applicable) |
|---|---|---|
| 1 x Plastic Water Bottle (not in kit - provided by classroom) |  | |
| 1 x Clear Straw |  | link |
| 1 x 9v Battery |  | link |
| 2 x Pencil |  | link |
| 2 x Jumper Wire |  | link |
| Masking Tape |  | link |

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- Each group of 3 students must have an empty water bottle (e.g. standard 16.9 oz, not provided) that will be cut so that only the bottom half is used.
- Students may opt to use glue guns when creating their setup for the electrolysis cell if available in the classroom
    - An alternative (tape) is provided for groups within their kits.
- Water must be used to fill up the water bottle halves.
- **Optional**: Students may add table salt (not provided) to their electrolysis solution