

# Alternative Energy for Transportation: Hydrogen and Fuel Cells

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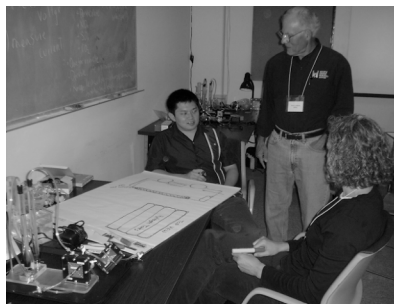
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Curriculum Website: [sepuplhs.org/hydrogen](http://sepuplhs.org/hydrogen)

Connecticut Sales Reps: Ruth Ann McDougall

# HyTEC: Hydrogen Technology and Energy Curriculum

- Funded by U.S. Dept of Energy
- “Introduction to Alternative Energy: Hydrogen Fuel Cells”
- Developed by a team of scientists, engineers, curriculum developers, teachers, and other educational leaders
- Development process includes extensive classroom testing and feedback
- High School Chemistry (or Physics & Envi. Sci.)



## Partners

- Lawrence Hall of Science



Schatz Energy Research Center



AC Transit



FilmSight Productions



LAB-AIDS, Inc.



Teachers and students from SF Bay Area, Washington, Ohio, California, Connecticut, Georgia, New York, and South Carolina

## Issue-Oriented Science

- Engages students in learning science and applying it to make evidence-based decisions.
- In most cases, does not advocate a particular decision, but does advocate the use of scientific evidence and concepts in the decision-making process.
- Encourages students to look at various sides of an issue and evaluate the trade-offs involved in a complex decision.

## Hydrogen and Fuel Cells in Connecticut

- Connecticut Hydrogen Fuel Cell Coalition: A collaboration of over 30 companies and agencies
- Connecticut is one of the top 5 fuel cell states, according to Fuel Cells 2000 (along with California, New York, Ohio, and South Carolina), and home to major manufacturers, high profile installations, supportive funding policies
- Connecticut has a fuel cell bus demonstration program in Hartford

## Activity #1: Hydrogen for Transportation?



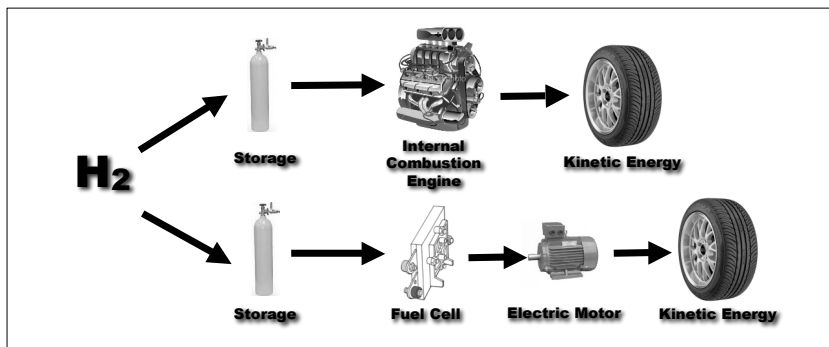
## Hydrogen

- Hydrogen is the most common element in the universe.
- The sun is composed mostly of hydrogen gas.
- Where is hydrogen found on Earth?
- Hydrogen occurs naturally as a component of water, air, and hydrocarbon fuels like coal and natural gas.

## How do we get Hydrogen?

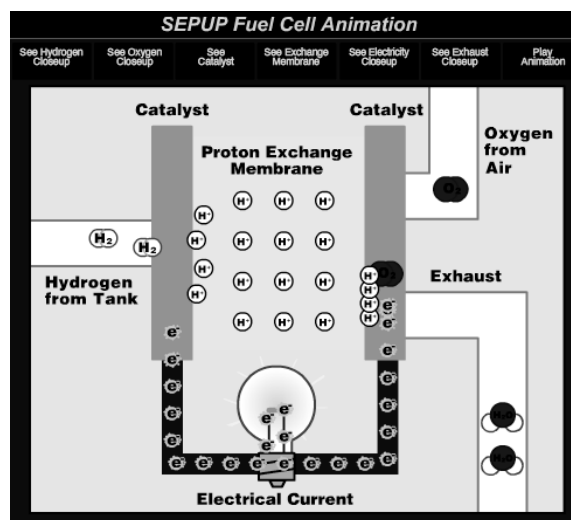


## What do we do with Hydrogen?

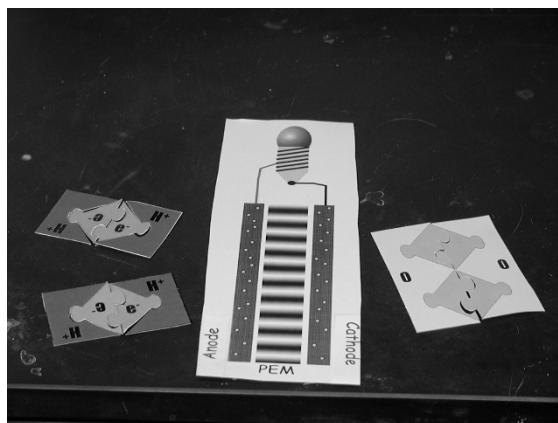


- A way to store energy (like a battery)
- A way to move energy (like electricity)
- NOT an energy source and NOT free

## Activity #4: Modeling the Fuel Cell Reaction

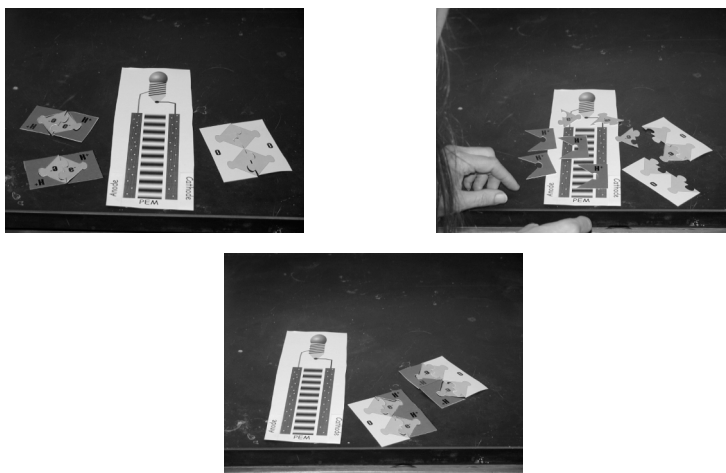


## Modeling the Fuel Cell Reaction



Now use the puzzle pieces to model what happens in the fuel cell.

# Modeling the Fuel Cell Reaction



## Student Activity The Fuel Cell Half Reactions

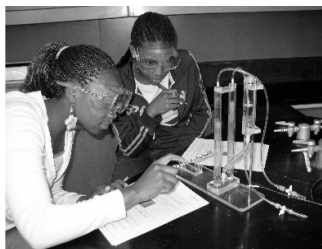
- The half-reactions:
  - Oxidation:  $\text{H}_2 \rightarrow 2\text{H}^+ + 2\text{e}^-$
  - Reduction:  $4\text{H}^+ + \text{O}_2 + 4\text{e}^- \rightarrow 2\text{H}_2\text{O}$
- Adding the half-reactions:
  - Oxidation:  $2\text{H}_2 \rightarrow 4\text{H}^+ + 4\text{e}^-$
  - Reduction:  $4\text{H}^+ + \text{O}_2 + 4\text{e}^- \rightarrow 2\text{H}_2\text{O}$
- ---
- $2\text{H}_2 + \text{O}_2 \rightarrow 2\text{H}_2\text{O} + \text{energy (electricity)}$

## The HyTEC Curriculum

- Six activities take approximately two weeks of instructional time.

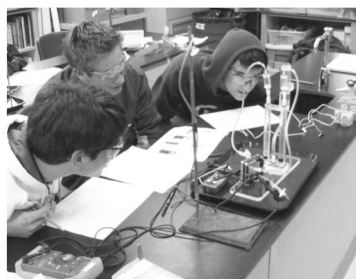
1. **Energy for Transportation** - Students examine trade-offs of various fuel/vehicle combinations.

2. **Obtaining Hydrogen through Electrolysis** - In this hands-on lab, students generate hydrogen and examine the required energy input, stoichiometry, and electrochemistry involved in the process.



## The HyTEC Curriculum

3. **Putting a Hydrogen Fuel Cell to Work** - Students generate  $H_2$  and  $O_2$ , and use a single cell fuel cell to perform work.



4. **Modeling a Fuel Cell Redox Reaction** - Students use model pieces and a fuel cell simulation to explore the fuel cell reaction.



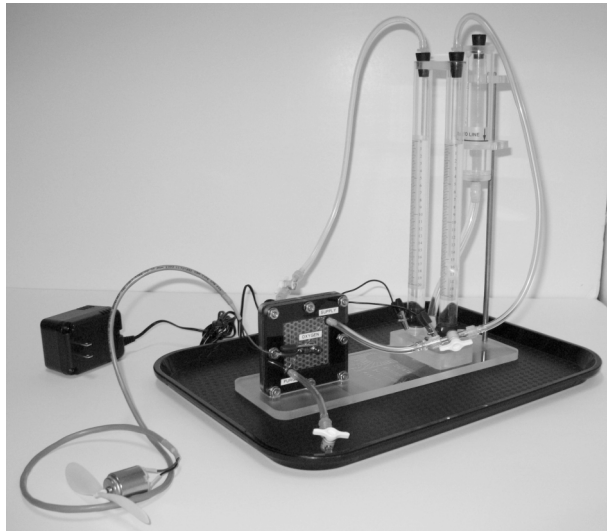
# The HyTEC Curriculum

**5. Fuel Cell Efficiency** - In a hands-on lab, students measure fuel cell efficiency.

**6. Hydrogen for Transportation** - Students conduct research and engage in a simulated City Council Meeting to present the advantages and challenges of using hydrogen and fuel cells for a city bus program.



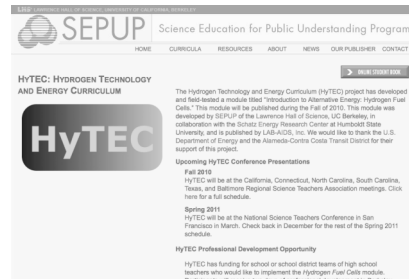
## Prototype Kit



# Website and Videos

Hydrogen Fuel Cell website:  
[sepuplhs.org/hydrogen](http://sepuplhs.org/hydrogen)

- Simulation of Fuel Cell
- Clips from video field trip
- Web Resources
- Info on fuel cells



# NSES Addressed

## **Structure of Atoms:**

- Matter is made of minute particles called atoms.

## **•Structure and Properties of Matter:**

- Atoms interact with one another by sharing or transferring electrons

## **•Chemical Reactions:**

- Chemical reactions occur all around us
- Chemical reactions may release or consume energy
- A large number of reactions involve transfer of electrons
- Catalysts lower activation energy necessary for reactions

# Connecticut Standards

## **9-10 Core**

D Inq.8 Use mathematical operations to analyze and interpret data and present relationships between variables

D7 Describe the availability, current uses and environmental issues related to the use of hydrogen fuel cells. . .to produce electricity

D 11 Describe how atoms combine to form new substances by transferring or sharing electrons

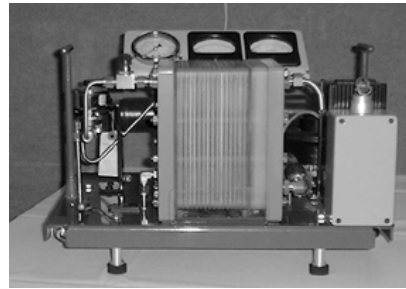
## **Chemistry**

Chemical bonds

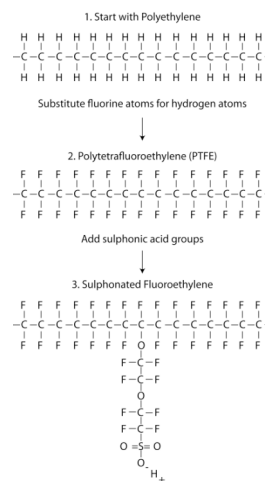
Conservation of Matter and Stoichiometry

Reaction rates (catalysts)

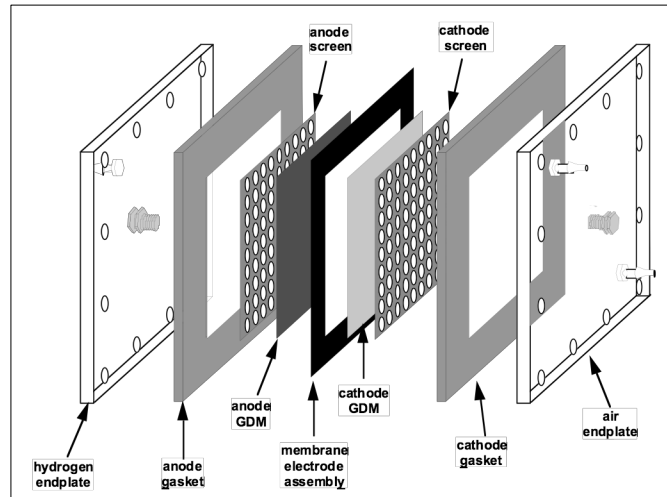
- Video highlights
- Fuel cell bus in Oakland, CA
- Portable applications: video camera, computer
- Production from hydrogen using renewable sources
- Production of hydrogen from landfill gas



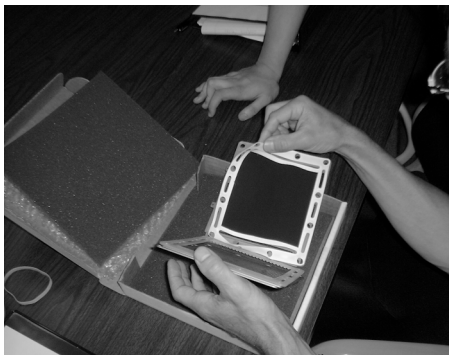
- Modified polyethylene hydrocarbon chains
- Fluorine substitutions create polytetrafluorethylene (PTFE: teflon®)
- To make it electrolytic: side chains with hydrophilic sulphonate ( $-\text{SO}_3\text{H}$ ) groups are added



## Fuel Cell Parts - Form and Function



## Challenges to Hydrogen Economy



- Developing infrastructure and improving technology
- Reducing cost
- Addressing public concerns about safety
- Production of hydrogen from water using renewable energy sources

## Get Involved!

- Professional Development: Berkeley, Jan. 14-15, 2011
- Contact SEPUP
  - [chris\\_k@berkeley.edu](mailto:chris_k@berkeley.edu)
  - [bnagle@berkeley.edu](mailto:bnagle@berkeley.edu)
- Power point and handouts
  - [sepuplhs.org/news.html](http://sepuplhs.org/news.html)
- Curriculum Website
  - [sepuplhs.org/hydrogen](http://sepuplhs.org/hydrogen)
- LAB-AIDS Booth