Alternative Energy for Transportation: Hydrogen and Fuel Cells

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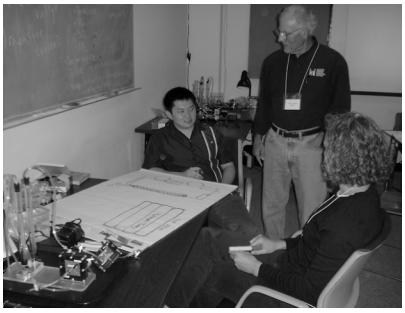
HyTEC: Hydrogen Technology and Energy Curriculum

- 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

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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 the U.S.

- Fuel Cells 2000: Online Fuel Cells Information Resource: www. fuelcells.org
- Top 5 fuel cell states, according to Fuel Cells 2000: South Carolina, California, Connecticut, New York, Ohio

Activity #1: Hydrogen for Transportation?

Hydrogen

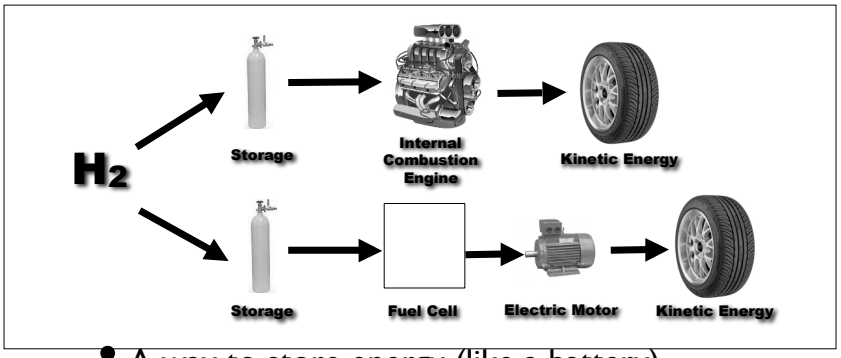
- Hydrogen is the most common element in the universe.
- The sun is composed mostly of hydrogen gas.
- Where is hydrogen found on Earth?
- Hydrogen occurs naturally as a component of water, air, and hydrocarbon fuels like coal and natural gas.

How do we get Hydrogen?

Hydrocarbon + Heat → **Reformer** → Hydrogen + CO_2

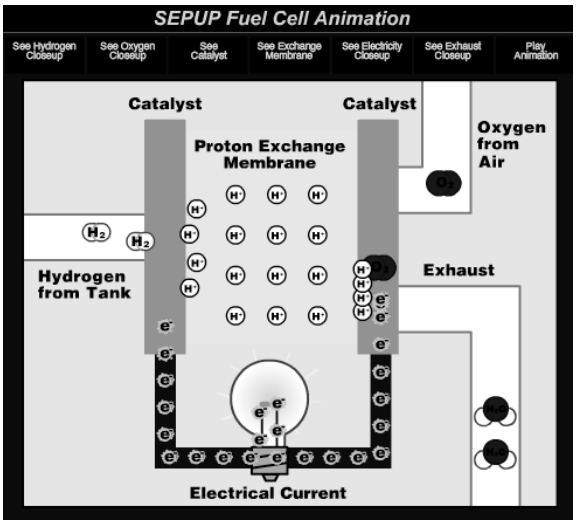
Water + Electricity → **Electrolyzer** → Hydrogen + Oxygen

What do we do with Hydrogen?

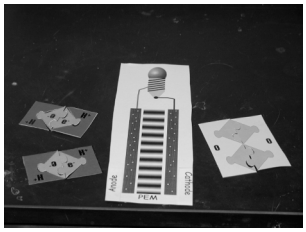


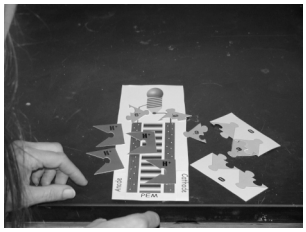
- A way to store energy (like a battery)
- A way to move energy (like electricity)
- NOT an energy source and NOT free

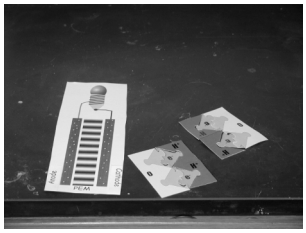
Activity #4: Modeling the Fuel Cell Reaction



Modeling the Fuel Cell Reaction







Student Activity
The Fuel Cell Half Reactions

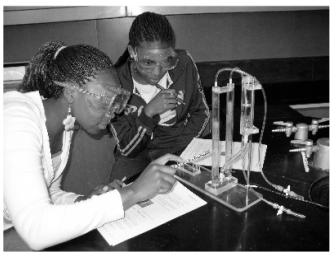
- The half-reactions:
  - Oxidation: $H_2 \rightarrow 2H^+ + 2e^-$
  - Reduction: $4H^+ + O_2 + 4e^- \rightarrow 2H_2O$
- Adding the half-reactions:
  - Oxidation: $\mathbf{2}H_2 \rightarrow \mathbf{4}H^+ + \mathbf{4}e^-$
  - Reduction: $4H^+ + O_2 + 4e^- \rightarrow 2H_2O$
- _____
- $2H_2 + O_2 \rightarrow 2H_2O$ + 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.



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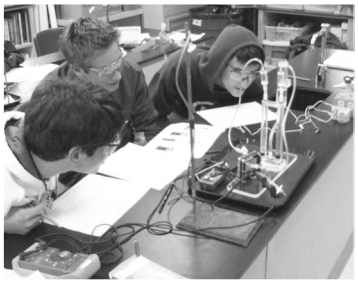
3. **Putting a Hydrogen Fuel Cell to Work** - Students generate H_2 and O_2, and use a single cell fuel cell to perform work.



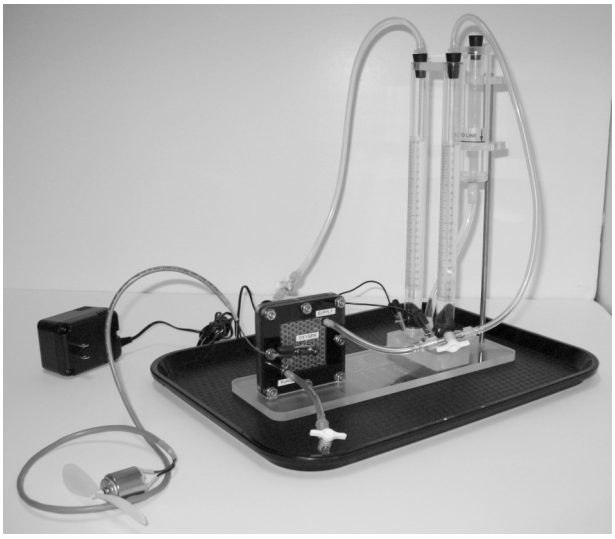
4. **Modeling a Fuel Cell Redox Reaction** - Students use model pieces and a fuel cell simulation to explore the fuel cell reaction.

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.

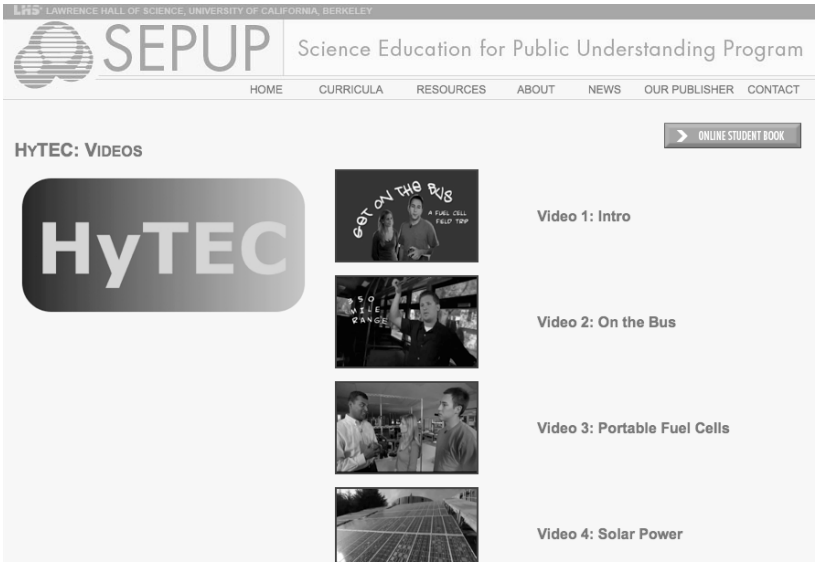
Prototype Kit



Website and Videos

Hydrogen Fuel Cell website:
sepuplhs.org/hydrogen

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



Challenges to Hydrogen Economy

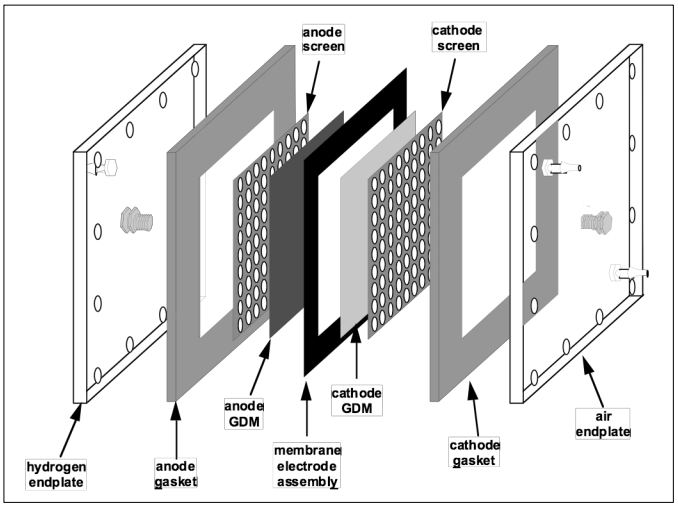
- Developing infrastructure and improving technology
- Reducing cost
- Addressing public concerns about safety
- Production of hydrogen from water using renewable energy sources

Get Involved!

- Professional Development: Berkeley, Jan. 14-15, 2011
- Contact SEPUP
  - chris_k@berkeley.edu
  - bnagle@berkeley.edu
- Power point and handouts
  - sepuplhs.org/news.html
- Curriculum Website
  - sepuplhs.org/hydrogen
- LAB-AIDS Booth

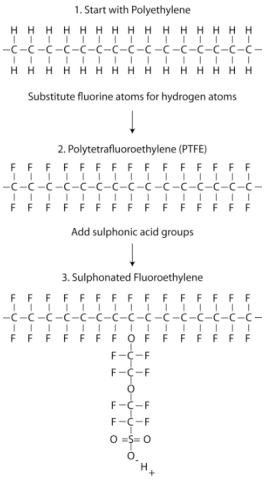
Additional Information

Fuel Cell Parts - Form and Function



The Proton Exchange Membrane (PEM)

- Modified polyethylene hydrocarbon chains
- Fluorine substitutions create polytetrafluorethylene (PTFE: teflon®)
- To make it electrolytic: side chains with hydrophilic sulphonate (-SO_3H) groups are added



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