Teaching Chemistry with Hydrogen Fuel Cells

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St. Louis, Missouri
March, 2007

For More Information

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Power point will be posted at www.sepuplhs.org/new

Why do we need alternative energy sources?

HyTEC: Hydrogen Technology and Energy Curriculum

- Funded by U.S. Department of Energy
- Developed by a team of scientists, engineers, curriculum developers, teachers, and other education leaders
- Development process includes extensive classroom testing and feedback
- Partners:
  - Lawrence Hall of Science's SEPUP Program
  - Schatz Energy Research Center
  - AC Transit
  - FilmSight Productions

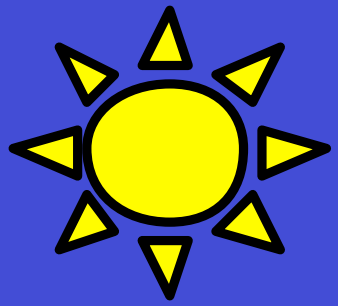
NSES Addressed

- 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 chemical reactions involve the transfer of electrons (oxidation/reduction)
  - Catalysts, such as metal surfaces, accelerate chemical reactions

Hydrogen

Hydrogen is the most common element in the universe.

The sun is composed mostly of hydrogen gas.



Hydrogen occurs naturally as a component of water or hydrocarbon fuels like coal, oil, and natural gas.

But…Hydrogen Isn't an Energy Source

Hydrogen is a way to move energy (like electricity)...

…and a way to store energy (like a battery).

And…Hydrogen Isn't "Free"

It's not a primary fuel like oil, coal or natural gas.

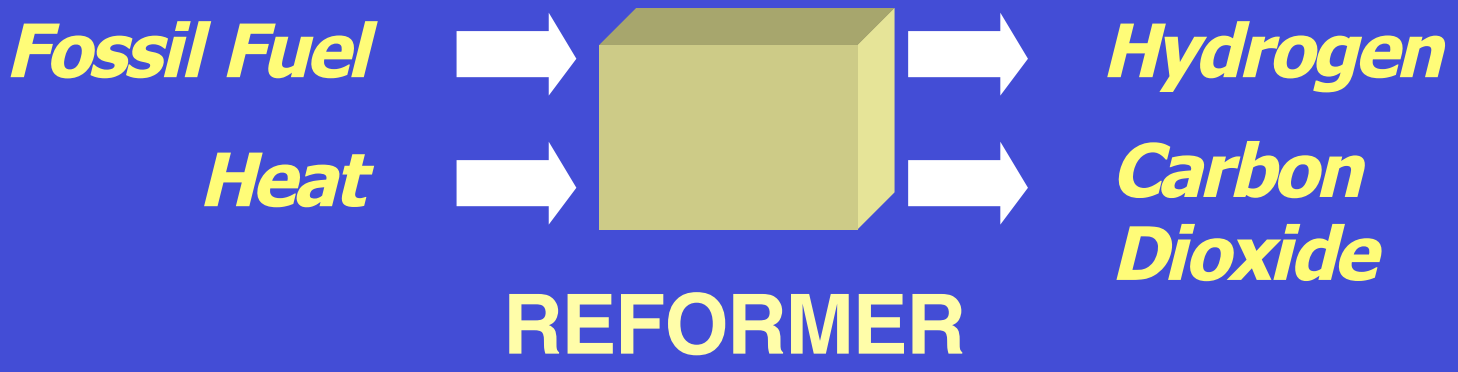
There are no hydrogen wells or hydrogen mines.

We won't be "running our cars on water."

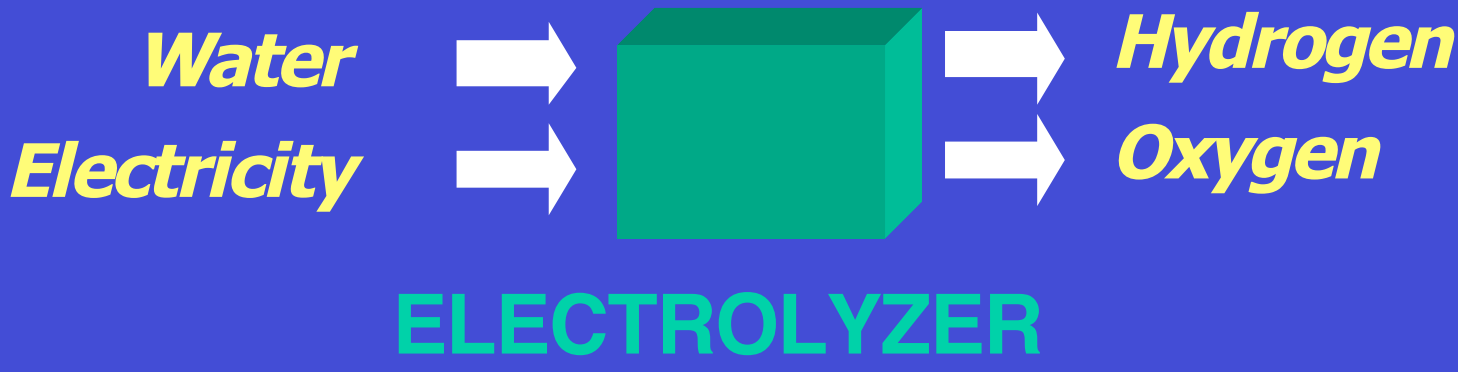
We have to produce the hydrogen.
It takes energy to make hydrogen.

Sources of Hydrogen

Hydrogen can be produced from any fuel that contains hydrogen…



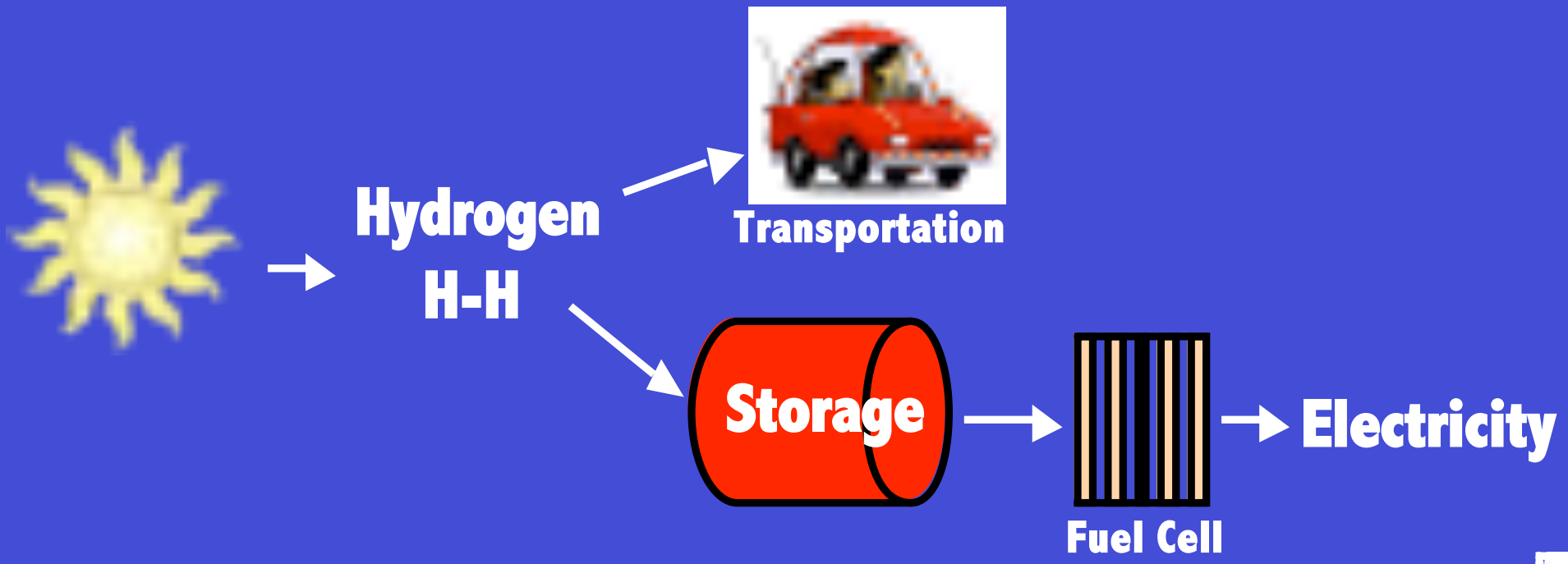
…or water (plus electricity from any source)



Why Hydrogen?

Hydrogen can be used to:

1) Store intermittent renewable energy sources, such as solar or wind power
2) Convert renewable electricity into a transportation fuel



California Hydrogen Highway


AC Transit

- Governor signed Executive Order S-7-04 in April 2004
- Established the CA Hydrogen Highway Network
- Designated 21 interstate highways and urban centers (SF, Sacramento, LA)
- Building a network of hydrogen fueling stations
- Working with key stakeholders to establish infrastructure and make hydrogen vehicles available

California Fuel Cell Partnership

- Collaboration of 31 companies and agencies
- Includes automobile manufacturers, oil/energy companies, state and federal agencies, transit agencies, hydrogen and fuel cell technology companies
- Working to promote the commercialization of hydrogen fuel cell vehicles
- To date >100 passenger vehicles have driven >220,000 miles on CA roads
- Near term focus is on fleet vehicles

AC Transit

CAFCP

CAFCP

California Fuel Cell Bus Demonstrations

AC Transit

- Three transit agencies participating (AC Transit, SunLine Transit, Santa Clara Valley Transit)
- Seven fuel cell buses operating in regular service
- Two year demonstration program

AC Transit

AC Transit

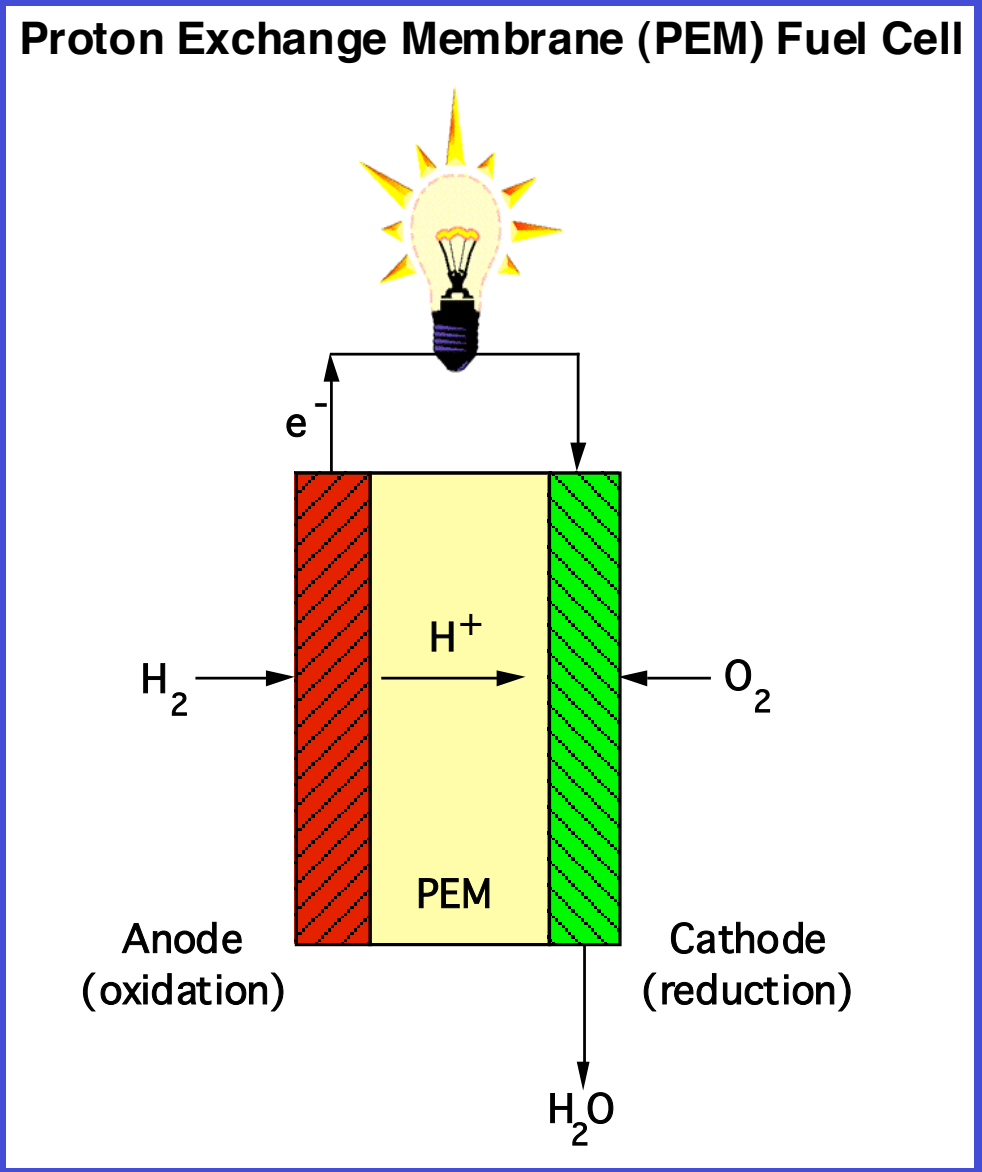
SCAQMD Hydrogen ICE Vehicle Demonstrations

- Five municipalities in SoCal participating (Santa Ana, Burbank, Ontario, Riverside, Santa Monica)
- Each site has a hydrogen fueling station
- Each site operates five hydrogen powered Toyota Prius hybrids

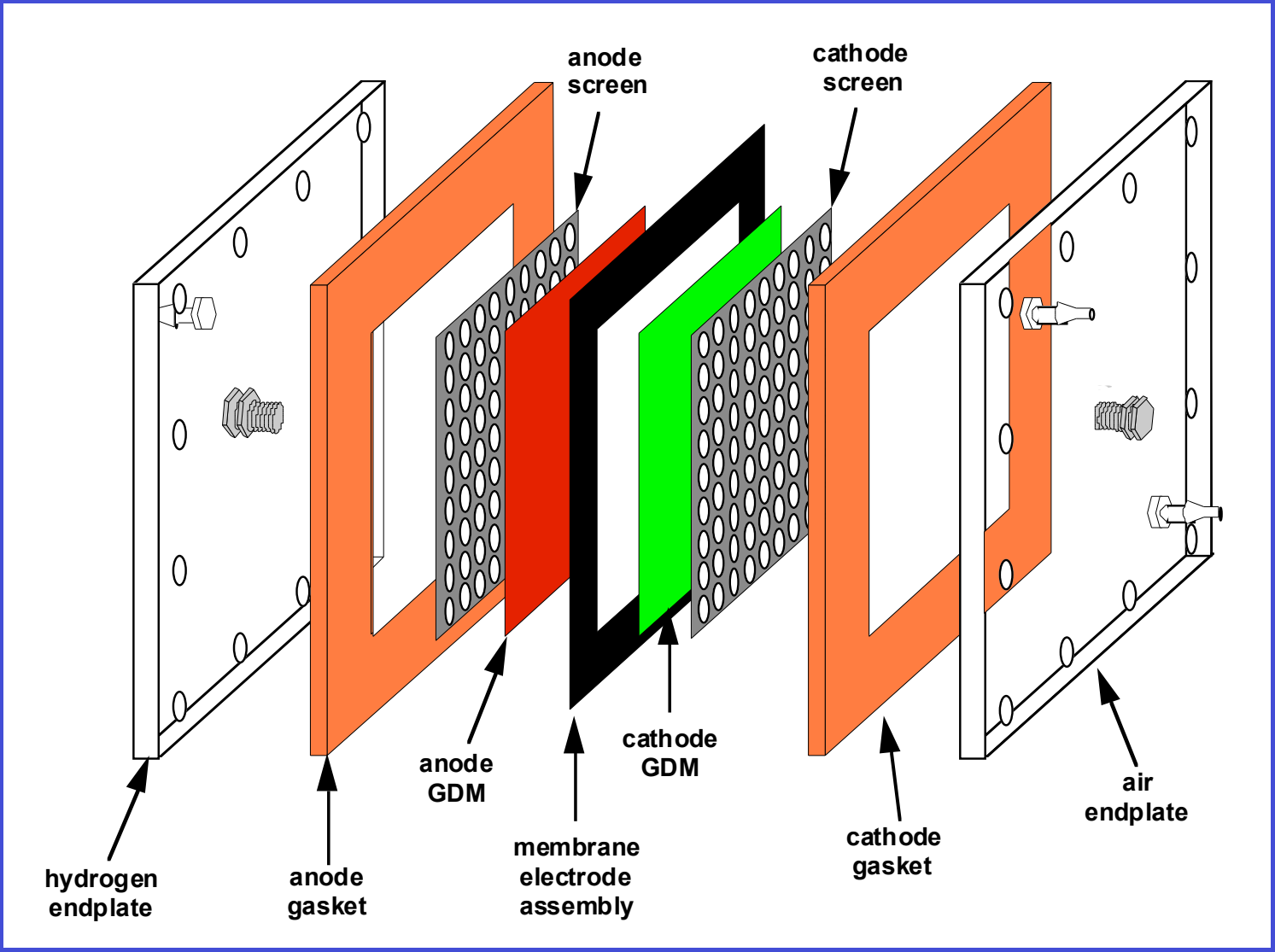
For information on your state

- http://www.fuelcells.org/

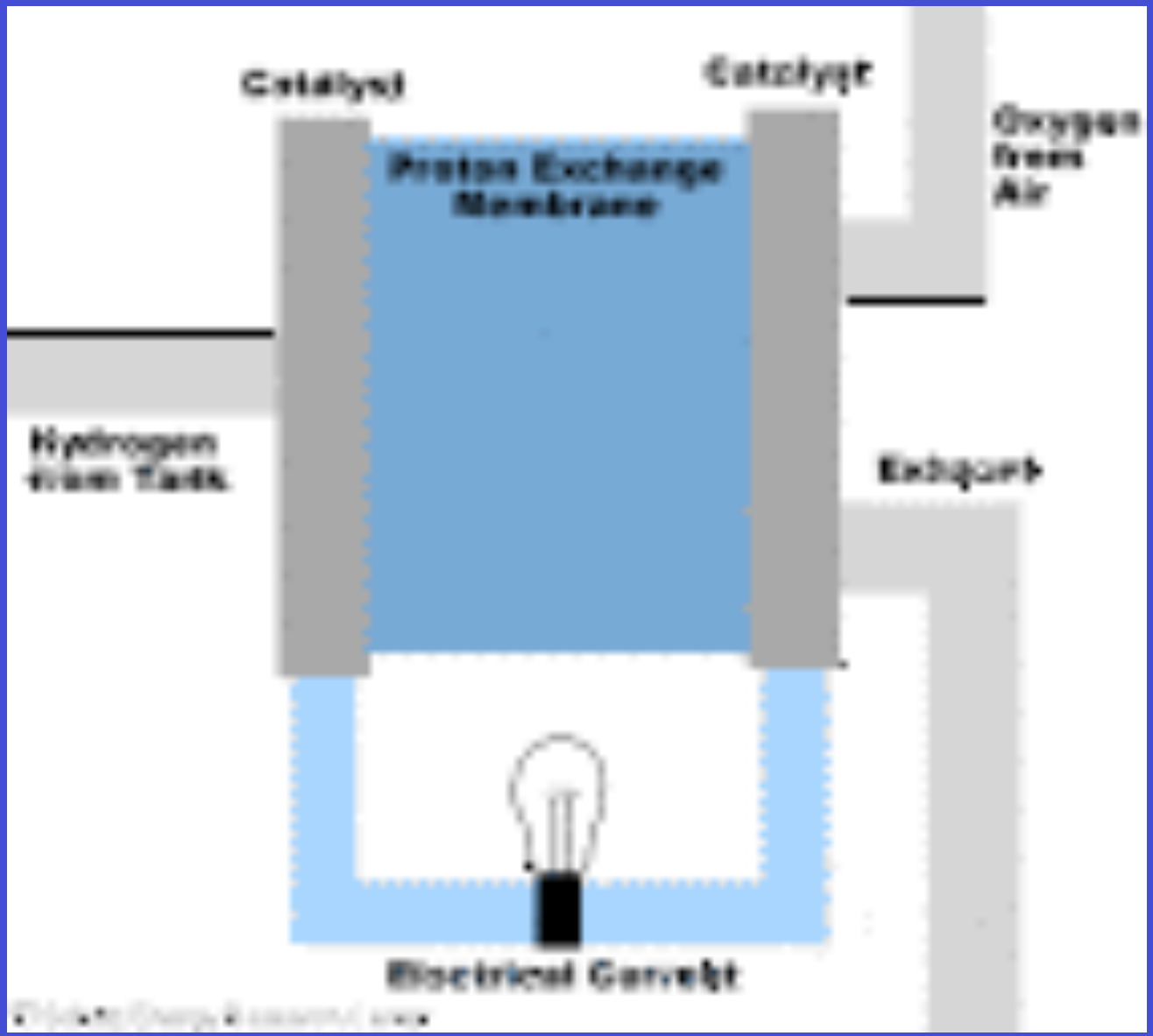
How does a fuel cell work?



Fuel Cell Parts - Form and Function



How does a fuel cell work?



HyTEC Lab Activity

Kit includes:

- PEM fuel cell
- Alkaline electrolyzer
- DC motor (fan or gear-set with pulley)
- DC power supply
- Multimeters
- Gas tubing and valves

Lab activities:

- Make hydrogen via electrolysis
- Operate fuel cell to power DC motor or lift a 0.5 kg weight
- Measure hydrogen consumed
- Measure electrical energy produced or work done lifting the weight
- Calculate fuel cell efficiency

Student Activity: Modeling the Fuel Cell Reaction

- Introduce use of the models
- Introduce oxidation-reduction, or “redox” reactions
  - Oxidation half-reactions release electrons
  - Reduction half-reactions accept electrons

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: $2H_2 \rightarrow 4H^+ + 4e^-$
- Reduction: $4H^+ + O_2 + 4e^- \rightarrow 2H_2O$

$$2H_2 + O_2 \rightarrow 2H_2O + \text{energy (electricity)}$$

Do the Activity …

- Skim page 1
- Do the procedure
- Review the analysis questions

Modeling the Fuel Cell Reaction

1. Reactants approach fuel cell

2. Redox reaction takes place

3. Products are formed

Website to Be Developed

Components:

- An interactive simulation of the fuel cell reaction for students
- Video clips of the fuel cell bus and other applications
- Additional resources

Video

- Produced to accompany curriculum
- Clips from video will be included on www.sepuplhs website
- Two segments:
  - Introduction
  - Video field trip showing applications
    - Fuel cell bus in Oakland, California
    - Portable applications
    - Production of hydrogen from water using renewable energy
    - Production of hydrogen from landfill gas


SEPUP

Challenges to hydrogen economy

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

How To Get Involved …

- Field testing anticipated next year
- Contact Barbara Nagle

  bnagle@berkeley.edu
- Check www.sepuplhs.org for updates
  - under SEPUP News
  - under middle school and high school materials

Acknowledgements

- Jim Zoellick of SERC for collaboration on this presentation
- Staff of SERC and SEPUP
- AC Transit
- Department of Energy