

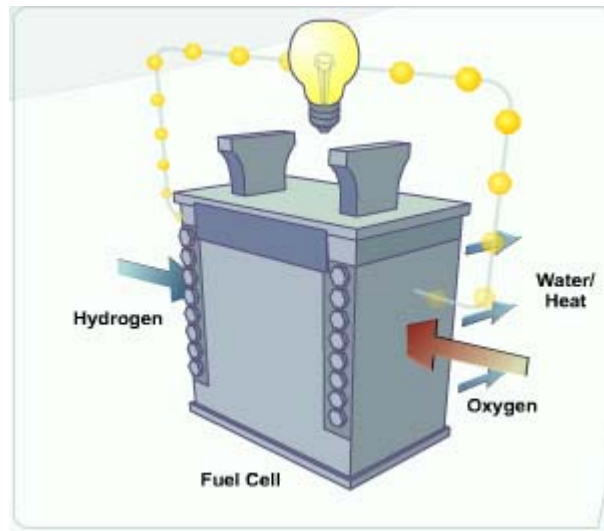
## The Future of Hydrogen Fuel Cells

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Introduction: As the world's oil reserves are used up gradually, the world scrambles for another renewable source of energy. Even now, with peak oil production still 10-20 years on the horizon, the world's oil production levels are not increasing as fast as demand escalating the price of this black gold. An alternative is a necessary step, and the sooner, the better. One alternative energy source that has been held up as a very realistic possibility is hydrogen fuel cells. The mechanism behind this technology is rather simple; from a simplified point of view, hydrogen fuel cells collect the energy released when hydrogen and oxygen molecules combine.

There are several flavors of hydrogen fuel cell: Polymer Electrolyte Membrane (PEM), Direct Methanol, Alkaline, Phosphoric Acid, Molten Carbonate, Solid Oxide, and Regenerative fuel cells. They all work by the same basic principal. A porous anode and cathode are separated by a porous membrane. Hydrogen is injected into the negatively charged anode, and with the help of a catalyst (usually platinum) the hydrogen atoms have their electrons removed and are now simply  $H^+$  protons. These electrons cannot travel through the membrane towards the positively charge cathode, so they travel in a circuit creating a current – this is where the electricity is generated. These electrons are combined with oxygen at the cathode end of the cell, and the electronegative oxygen ions absorb these electrons. The charged oxygen and hydrogen permeate through the membrane and combine to form  $H_2O$ , or water.



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### Comparison of Fuel Cell Technologies

Fuel Cell Type	Electrolyte	Operating Temperature	Applications	Advantages	Disadvantages
Polymer Electrolyte membrane (PEM)	Solid organic polymer polyperfluorosulfonic acid	60–100°C 140–212°F	<ul style="list-style-type: none"> <li>• electric utility</li> <li>• portable power</li> <li>• transportation</li> </ul>	<ul style="list-style-type: none"> <li>• Solid electrolyte reduces corrosion &amp; management problems</li> <li>• Low temperature</li> <li>• Quick start-up</li> <li>• Cathode reaction faster in alkaline electrolyte so high performance</li> <li>• Up to 85% efficiency in cogeneration of electricity and heat</li> <li>• Can use impure H<sub>2</sub> as fuel</li> </ul>	<ul style="list-style-type: none"> <li>• Low temperature requires expensive catalysts</li> <li>• High sensitivity to fuel impurities</li> </ul>
Alkaline (AFC)	Aqueous solution of potassium hydroxide soaked in a matrix	90–100°C 194–212°F	<ul style="list-style-type: none"> <li>• military</li> <li>• space</li> </ul>	<ul style="list-style-type: none"> <li>• Up to 85% efficiency in cogeneration of electricity and heat</li> <li>• Can use impure H<sub>2</sub> as fuel</li> </ul>	<ul style="list-style-type: none"> <li>• Expensive removal of CO<sub>2</sub> from fuel and air streams required</li> </ul>
Phosphoric Acid (PAFC)	Liquid phosphoric acid soaked in a matrix	175–200°C 347–392°F	<ul style="list-style-type: none"> <li>• electric utility</li> <li>• transportation</li> </ul>	<ul style="list-style-type: none"> <li>• High efficiency</li> <li>• Fuel flexibility</li> <li>• Can use a variety of catalysts</li> </ul>	<ul style="list-style-type: none"> <li>• Requires platinum catalyst</li> <li>• Low current and power</li> <li>• Large size/weight</li> </ul>
Molten Carbonate (MCFC)	Liquid solution of lithium, sodium, and/or potassium carbonates, soaked in a matrix	600–1000°C 1112–1832°F	<ul style="list-style-type: none"> <li>• electric utility</li> </ul>	<ul style="list-style-type: none"> <li>• High efficiency</li> <li>• Fuel flexibility</li> <li>• Can use a variety of catalysts</li> </ul>	<ul style="list-style-type: none"> <li>• High temperature enhances corrosion and breakdown of cell components</li> </ul>
Solid Oxide (SOFC)	Solid zirconium oxide to which a small amount of yttria is added	600–1000°C 1112–1832°F	<ul style="list-style-type: none"> <li>• electric utility</li> </ul>	<ul style="list-style-type: none"> <li>• High efficiency</li> <li>• Fuel flexibility</li> <li>• Can use a variety of catalysts</li> <li>• Solid electrolyte reduces</li> </ul>	<ul style="list-style-type: none"> <li>• High temperature enhances breakdown of cell components</li> </ul>

[http://www.eere.energy.gov/hydrogenandfuelcells/fuelcells/pdfs/fc\\_comparison\\_chart.pdf](http://www.eere.energy.gov/hydrogenandfuelcells/fuelcells/pdfs/fc_comparison_chart.pdf)

One of the challenges confronting hydrogen fuel cells is the source of fuel. Where and how will the hydrogen that powers these devices be produced? There are many solutions out there, but one of the most promising and seemingly infinite sources is electrolysis of water by photoelectric panels. In this system, solar panels converts sunlight to energy and splits water molecules as following –  $\text{H}_2\text{O} \rightarrow \text{H}_2 + \frac{1}{2} \text{O}_2$ . Another benefit of this system on top of not using any precious resources (unless we exhaust the world's water supply) is that it is a small enough technology that could hypothetically be implemented in a household.

Project Goals: To successfully implement a Polymer Electrolytic Membrane Reversible hydrogen fuel cell system in a mini working model house, and gather from results the usability of this technology on a larger scale.

### **Laboratory Journal for Matt Sprague - Progress**

10/5/05

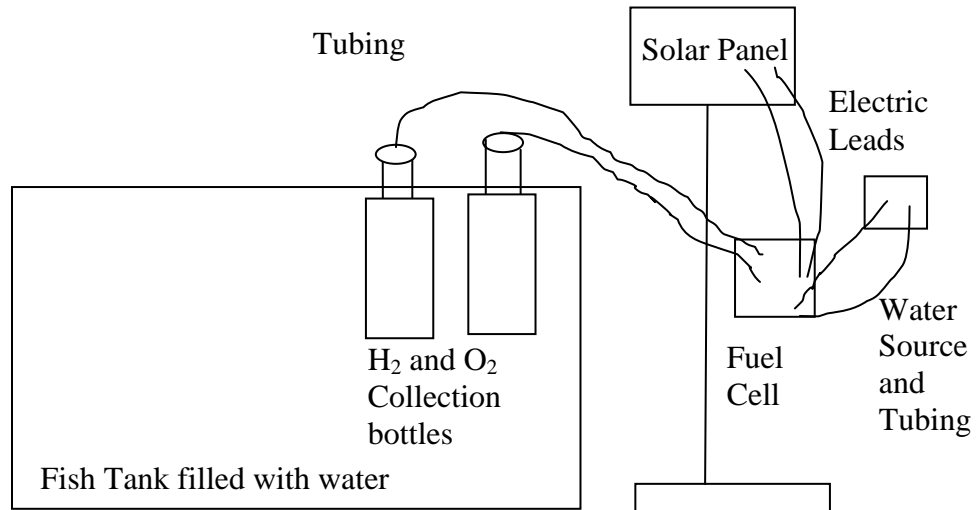
I have evaluated exactly the parts I am going to need to set up a working fuel cell model and have acquired some of the parts this week. From Mr. Marsden, I obtained 2 rubber bottle stoppers with holes and the correct rubber tubing to attach the stoppers to the cell. I am going to need a ring stand with clamps to hold the water above the fuel cell, along with a small screwdriver and soldering iron to refit the broken contact wires (they were cheaply made).

10/12/05

I have almost completed the setup for the larger Hydrogen fuel cell model – this week, with the assistance of another chemistry teacher, I've obtained a ring stand with ring and 3 clamps and set up the arrangement of the cell. Next Tuesday, I will begin re-solder the contact wires and will be on track to set up the experiment. One thing that I had not taken into account is that, if the H<sub>2</sub>O source is mounted above the fuel cell, then converting it into H<sub>2</sub> will be easy enough, but will the backwards reaction work with some weight of water pushing down? One might say to not make a hole in the H<sub>2</sub>O storage container, but this would allow a vacuum to form when the water drips out, thus limiting the amount of H<sub>2</sub>O that could be used. It seems to be a double edged sword. I would say that if I could drill a hole in the H<sub>2</sub>O bottle and collect newly forming water in a different bottle with a water height activated mini pump (using electrolytes to conduct a current from a battery when water height reaches a certain level might be feasible) I could avoid this problem. However, for now I will have to empty the other H<sub>2</sub>O bottle ever so often.

10/19/05

Only 2 more pieces are required to complete the setup of the hydrogen fuel cell system: I need 2 glass tubes, which I will ask Mr. Marsden for. There was a fish tank lying around for another one of the experiments which is now my gas collecting tank. The final setup should look something like this:



Finally, the flashlight that charges by shaking did not arrive in the mail, so I will have to buy one at Sharper Image in the coming days.

Picture:

References:

<http://www.eere.energy.gov/>

<http://www.fuelcellstore.com/>

<http://www.fuelcells.org/>