

The Hydrogen Economy

- Energy sources
 - Hydro
 - Fossil (oil, methane and coal)
 - Solar
 - Wind
 - Geothermal
 - Tidal
 - Hydrogen

Hydrogen

- The most abundant element in the universe (>90%)
- The lightest element on the periodic table
 - Three isotopes Protium, deuterium and tritium
 - MP -259C, BP -253, density 0.09

Hydrogen

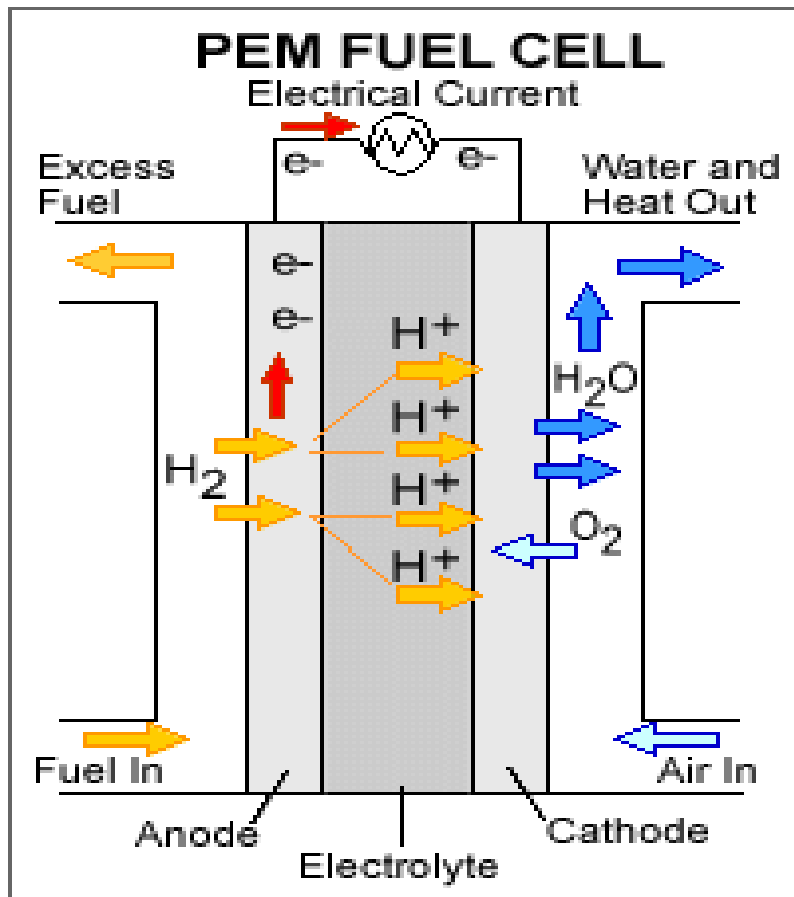
- colorless, odorless gas
- sparingly soluble in water
- does not support respiration (not poisonous).
 - weakens the voice and raises its pitch
- a better heat conductor than other gases (5X air)
- easily reacts with most elements.

Hydrogen : uses

1. reduction of oxide ores,
2. refining of petroleum and hydrogenating petroleum fractions,
3. production of hydrocarbons from coal,
4. to fill balloons and airships (He)
5. as a fuel in Oxy-Hydrogen blowpipes,
6. hardening of vegetable or animal oils

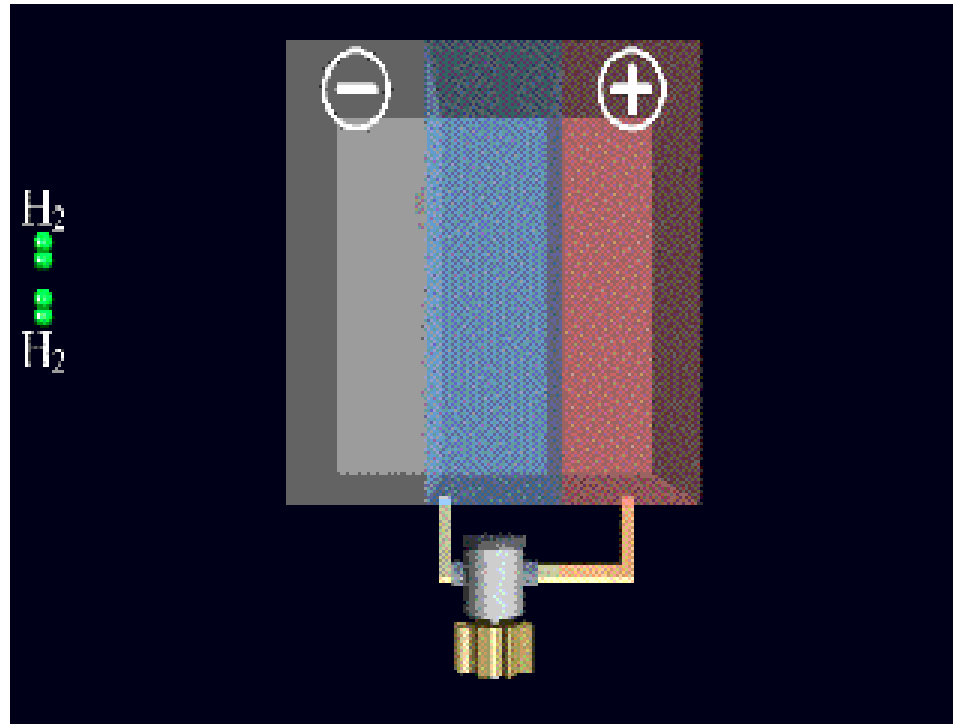
Fuel Cells

- First fuel cell developed in 1839 by William Robert Grove
- Hydrogen + oxygen = water + electricity
 - Electrodes required
 - Platinum catalyst used at each electrode



- electrochemical
- compact
- high electrical efficiency
- no pollution
- converts H to water, heat and electricity
- scalable to any size

Cathode side



Anode side

On the cathode catalyst, oxygen molecules react with the electrons (which have traveled through the external circuit) and protons to form water.

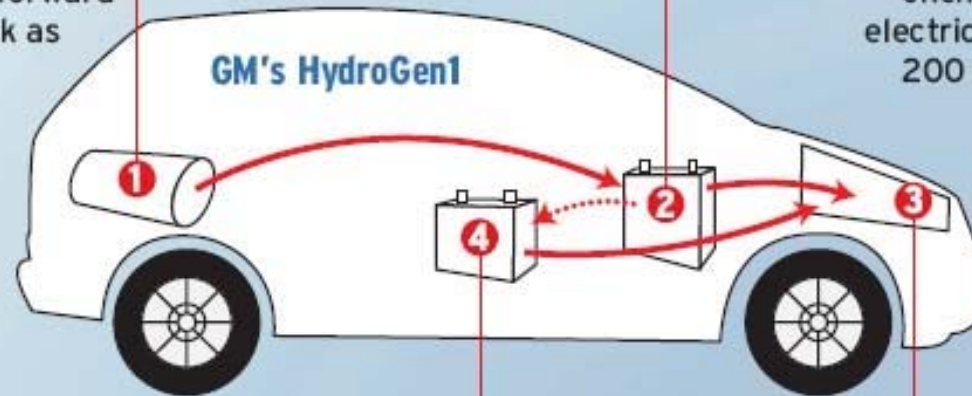
Anode side, hydrogen diffuses to the anode catalyst where it dissociates into protons and electrons. The protons are conducted through the membrane to the cathode, but the electrons are forced to travel in an external circuit (supplying power).

Hydrogen cars

- Two types:
 - Combustion
 - Fuel cell conversion

FUEL TANK

Liquid hydrogen is stored in a tank at the rear of the car and is pumped forward to the fuel cell stack as required.



FUEL CELL STACK

When the hydrogen is combined with oxygen in a fuel cell a chemical reaction creates electricity. Between 150 and 200 fuel cells are stacked together to garnish enough electricity to power the car.

BATTERY PACK

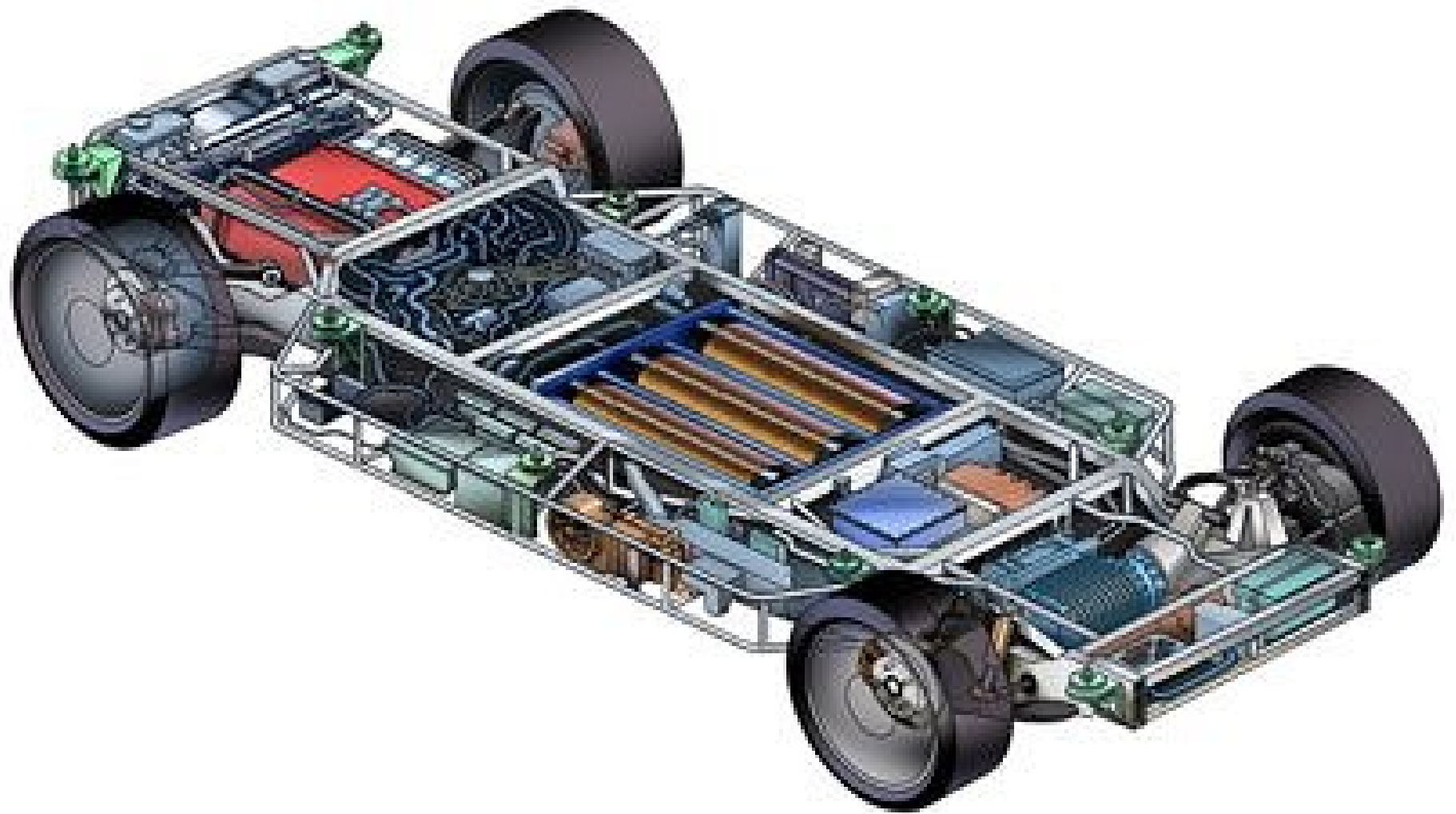
A battery pack is periodically recharged by the fuel cell. The power from the battery pack is used to provide rapid acceleration.

ELECTRIC MOTORS

The stack provides energy for the electric motor that powers the vehicle.

- GM's concept Hy-wire car combines fuel-cell propulsion with by-wire technology. Its fuel cell stack produces a continuously available power of 94 kilowatts and a top speed of 160 kmh. Not only is the car powered by hydrogen but its steering, braking and other systems can be controlled electronically rather than mechanically.





Hydrogen cars

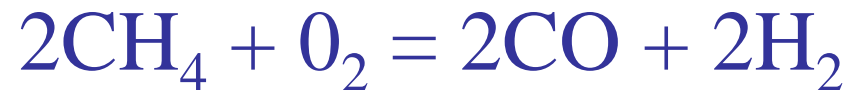
- Packaging (hydrogen storage)
- Reliability
- Safety
- Consumer acceptance
- Refueling
- Manufacturing issues

Hydrogen sources

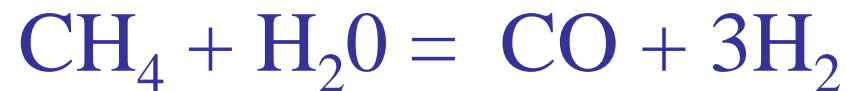
- Purest form made from electrolysis of water.

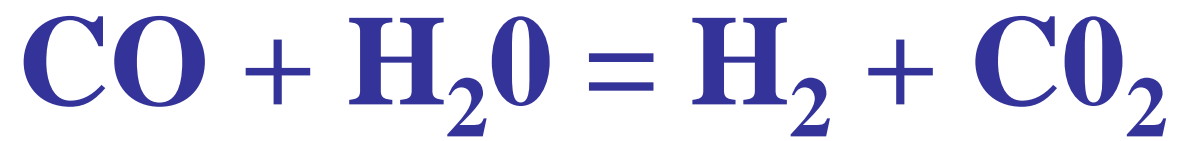


- Reformation of methane (partial oxidation)



- Steam methane reformation





Hydrogen Storage

- Liquified H
- Compressed H gas cylinders
- Metal hydrates

Fuel Cell Types

- Alice: today's lab

Fuel Cell efficiency

- Compressed hydrogen: 22%
- Liquified hydrogen 17%
- Pipeline natural gas 50 - 70%
- Phosphoric acid fuel cells >80%