

HYDROGEN ENERGY



- Hydrogen - 3rd most abundant element on earth's surface; found primarily in water [H₂O] and organic compounds and generally produced from hydrocarbons thru *reforming* and water thru *electrolysis*.
- When burned as fuel or converted to electricity, it joins with oxygen [O₂] again to form water.



Hydrogen Resources

- In the same way that there is a naturally occurring carbon cycle ($C + O_2 \rightarrow CO_2$), there is also the hydrogen cycle which forms water during combustion and becomes an infinite source of hydrogen thru **electrolysis**:

Combustion/Fuel Cells



Electrolysis



- Thru “**reforming**” process, hydrogen may be produced from hydrocarbons such as gasoline, propane, methanol and mostly from natural gas.

Hydrogen Basics

- Hydrogen is high energy, yet an engine that burns pure hydrogen produces almost no pollution.
- NASA has used liquid hydrogen since the 1970s to propel the space shuttle and other rockets into orbit. The hydrogen fuel cells power the shuttle's electrical system, producing a clean byproduct – pure water.
- Some believe that hydrogen will form the basic energy infrastructure that will power future societies, replacing today's natural gas, oil, coal facilities to become the pillar of the “**hydrogen economy**”.

Hydrogen Production Technologies

- **Thermo-chemical** – steam “**reforming**” process is used to produce hydrogen from fuels like natural gas, coal, methanol, gasoline, propane, or from renewable resources thru gasification or pyrolysis of biomass
- **Electrolysis** – water produces hydrogen by passing an electrical current through it
- **Photo-electro-chemical (PEC)** – hydrogen is produced in one step, i.e. splitting water by illuminating a water-immersed semi-conductor with sunlight
- **Photo-biological** – the natural photo-synthetic activity of bacteria and green algae is used to produce hydrogen.

Transport and Storage of Hydrogen

- Hydrogen is currently stored as a **compressed gas** or **cryogenic liquid**.
- The tanks can be transported by **truck** or the **compressed gas** can be sent across distances of less than 50 miles of pipeline.
- **Solid-state methods** – for vehicles with on-board storage of hydrogen:
 - **Metal hydrides** – chemically reacting the hydrogen with a metal
 - **Carbon nanotubes** – gas-on-solids adsorption of hydrogen
 - **Glass microspheres** – changes in glass permeability with temperature to fill the microspheres with hydrogen and trapping it there.

Hydrogen Power



Daimler-Chrysler rolled out last November 2000 the fuel cell car - NECAR 5; peak velocity of 150 kph; 450 km per one tank of hydrogen fuel.

Hydrogen powered vehicles use a stack of fuel cells to generate sufficient electricity to drive its electric motors. H_2 combines with O_2 in the presence of platinum catalysts to produce pure water and electric current. If not used to drive motor, it may be converted from DC to AC and may be sold to the grid (“net metering”).

Risks Associated with Hydrogen

- **Technology risks** – The production of hydrogen from reforming and electrolysis are well known technologies; hence, *low risk*.
- **Safety hazard** – The production, storage, transport and utilization of an invisible and highly inflammable gas like hydrogen introduces *potential safety hazards* but have been addressed adequately by existing technology.
- **Economic risks** – The financial *risks are no more* than those associated with the technology used in utilizing hydrogen as fuel, primarily fuel cells for vehicles and for CHP applications for power, heat and potable water for buildings, commercial establishments and institutions.