

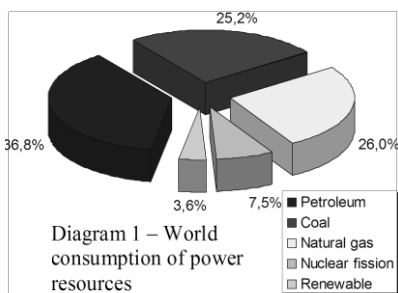
WORLD PERMANENT OIL CRISES: PATHWAYS FOR CHANGE TO SOLAR-HYDROGEN ECONOMY

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In Chinese, the word "crisis" or "wei-chi" translates into "danger + opportunity". We are living in "revolutionary" times, which provide many opportunities. Today's energy systems did not arise just through the hidden hand of market forces; although, markets played an important role. There are three concerns that

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compel us to rethink world energy strategy-our environment, our economy and our security.

urgency of global pollution and health effects requires that years, we must move to a level of 50-70% replacement of by solar energy to avert human and ecological disaster.

the signs of this stress on the ecosystem due to our large energy consumption. We have rising temperatures, more destructive storms, eroding soils, and disappearing species.

In 2005, the world produced 425 quad BTU (10^{15} BTU) from petroleum (primary level), coal, natural gas, nuclear fission, and renewable sources (*diagram 1*).

The best way to completely deny of our reliance on foreign oil is to create a solar-hydrogen economy (also known as liquid-hydrogen economy). Green plants use a similar process for over 3 billion years, so let me give you the scheme of transitioning from an oil-based economy to a liquid hydrogen-based one.

Similar to green plants, we would utilize the sun instead of letting its energy go to waste. Although absorbing sunlight can produce electricity, a liquid hydrogen economy would rely on sun's key byproducts.

New fuel economy is based on hydrogen because it has *many advantages*:

The first. It is the most abundant element in the universe, so we'll never run it out.

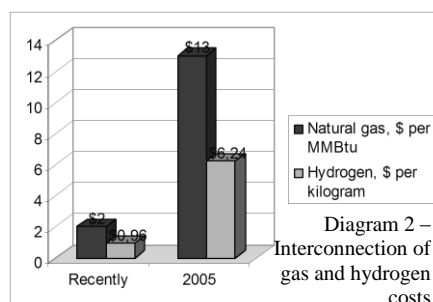
The second. It can be economically competitive with gasoline or diesel. The price on Hydrogen depends on how we make it. Until recently, the most inexpensive production method was using steam reformation of natural gas. When the cost of natural gas was about \$2 per MMBtu (Million Btu), hydrogen was produced for about \$1 per kilogram. In 2005, the cost of natural gas rose above \$13 per MMBtu, with the cost of

hydrogen rose proportionally (*diagram 2*). Other method is producing hydrogen from wind and solar farms. This is the cheapest way to produce hydrogen. Because this sources are free and completely renewable; again, we'll never run it out).

The third. The only emission from a liquid hydrogen engine is water vapor; no carbon, no pollution; just water.

And the last. Despite conflicting opinions, it's safe. Even NASA uses it to power the Shuttle engines from the middle of the XX century.

People, having a conflicting interest, sometimes say - how unsafe hydrogen is. For example, they site the burning of the Hindenburg, because it was filled with hydrogen. But outside it was the highly flammable paint that causes to airship disaster.



Many technologies convert chemical energy of hydrogen to electricity. But we interest to use a device that is quiet, compact, flexible, highly efficient and exceptionally clean. It's called fuel cell (*figure 1*).

A single fuel cell is generates about 0.7 volts of electricity, so hundreds of fuel cells are combined in a "stack" that generates enough electricity to power the electric motors.

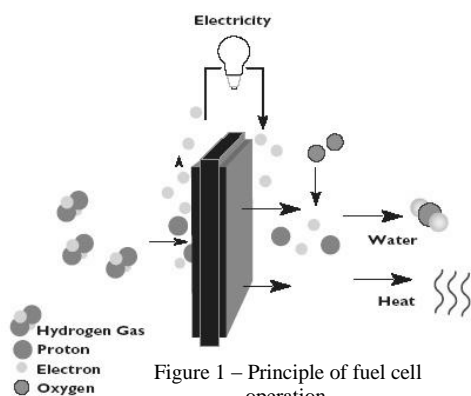


Figure 1 – Principle of fuel cell operation

At the anode molecule of hydrogen flows in. You see a thin layer of catalyst (its precious metal – platinum or palladium) that accelerates chemical reaction. It coats the proton exchange membrane. It looks like plastic wrap. At the cathode oxygen from air flows in and the water flows out as exhaust.

Today many visionary companies, such as Shell, BP, GM and BMW, see the remarkable possibilities of hydrogen as a clean fuel, and take business opportunities that go along with the evolution to the hydrogen economy. As such, those “petroleum companies” are becoming “energy companies.”

Having done technical and economic survey, it is obvious why we need a Solar-Hydrogen Economy *now* due to the following factors:

The first. The use of fossil fuel creates global warming and air pollution

The second. Air pollution creates degradation of forests, agricultural and human health and mortality

The third. Due to the rapidly increasing imported oil costs, it is necessary for the world energy market to convert from fossil sources to Solar-hydrogen sources to maintain a viable economy.