A Hydrogen Economy – Is it a Panacea? What Do We Know About $H_2$ and the Environment?

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U.S. RELIES HEAVILY ON OIL AND GAS FOR POWER
US OIL DEMAND, JANUARY 2002: About 18.5 million barrels per day, = 777 million gallons. If lined up in 1-gallon cans, **they would encircle the earth at the equator almost 6 times (about 147,000 miles of cans) — every day.** 55-60% of US consumption is imported at a cost of $50 billion+ per year, amounting to **the largest single element of our trade deficit.**
FOR SUSTAINABLE HYDROGEN ECONOMY
HYDROGEN = ELECTRICITY ...... So you need...
WILL YOU BE PAYING CASH, CREDIT, OR THROUGH THE NOSE?
AT LEAST THEY'RE HONEST...

REGULAR UNLEADED

PAY UP THE WAZOOS

PREMIUM

EMPTY YOUR WALLET
I thought the pumps only went 'ding' when the gas was flowing...

They used to! That's the price changing...
Coulda swore I heard a cry...

ALTERNATIVE FUELS
"WE CAN'T OPEN UNTIL WE DECIDE WHICH FAT CATS AND POLITICIANS GET FILTHY RICH FIRST!"
GREENHOUSE GAS

REGULAR DROUGHTS 2000
HIGHER-OCAN STORM SURGES 2025
SUPREME CLIMATE SHIFTS 2050

Speaking of the high price of gasoline...
DESPITE ALL OUR UPS AND DOWNS, I STILL LOVE YOU.
SOURCE OF AMISH LAUGHTER.
They were cheaper than buying gas for the mower.
GAS PRICES ARE SKYROCKETING.
THE SOLUTION: SLASH THE GAS TAX!!

YEAH!

AND RELEASE EVERY DROP OF THE STRATEGIC PETROLEUM RESERVE!!

YEAH!

AND TWIST OPEC's ARM 'TIL IT CRIES UNCLE!!

YEAH!

AND START DRIVING SMALLER CARS!!

HEY LET'S NOT GET EXTREME HERE, BUD
It's in case gas gets above $2.00 a gallon...
The Americans are upset that gas prices might reach two dollars a gallon.

Bloody whiners!!
Hey, your prices are pretty reasonable.

That's by the carafe.
How Hydrogen would work – Motor Vehicles

Chemistry of A Fuel Cell
Anode side:
\[ 2H_2 \rightarrow 4H^+ + 4e^- \]
Cathode side:
\[ O_2 + 4H^+ + 4e^- \rightarrow 2H_2O \]
Net reaction:
\[ 2H_2 + O_2 \rightarrow 2H_2O \]
These hydrogen fuel cell cars are entirely pollution free!
Hindenburg Factor!
PROBLEMS WITH HYDROGEN

DIFFUSIONAL LOSS TO ATMOSPHERE

REACTION WITH METALS – METAL EMBRITTLEMENT

SAFETY ISSUES – NOT MUCH DIFFERENT THAN GASOLINE…

STORAGE OF SIGNIFICANT FUEL LEVELS

HYDROGEN – IT’S A GAS!

METAL HYDRIDES – WEIGHT (BORON HYDRIDES?)
HYDROGEN – ATMOSPHERIC EFFECTS

TROPOSPHERE

H₂ + OH → H₂O + H \quad \text{(REDUCTION OF OH ?)}

H + O₂ → HO₂

HO₂ + NO → NO₂ + OH → SUNLIGHT → OZONE

HO₂ + HO₂ → H₂O₂ → SO₂ → H₂SO₄

STRATOSPHERE

5-10 YR HALF-LIFE WITH OH → SOURCE OF WATER IN STRATOSPHERE?

AMPLIFICATION OF OZONE DEPLETION
NATURAL SOURCES

OXIDATION OF METHANE

FORMALDEHYDE

\[ \text{H}_2\text{CO} + \text{SUNLIGHT} \rightarrow \text{H}_2 + \text{CO AND H + HCO} \]

MOLECULAR HYDROGEN IS APPROX. 0.5 PPM CURRENTLY

INDICATIONS OF INCREASE IN THE ATMOSPHERE?
L.P. Steele, P.B. Krummel and R.L. Langenfelds
Commonwealth Scientific and Industrial Research Organization (CSIRO), Atmospheric Research, Aspendale, Victoria, Australia, 3195
FORESTS?
ISOPRENE

Oxidation Products $\rightarrow$ Formaldehyde

Background Formaldehyde $\rightarrow$ 0.5 ppb from methane oxidation

Formaldehyde in Deciduous Forests $\rightarrow$ 10-50 ppb in 1982!

Wintertime $\rightarrow$ 3 ppb

Other VOC oxidations will give Formaldehyde!
Soils major sink... 70%?

\[ \text{H}_2 \rightarrow \]

So what does that do to the microbes?
ELECTRIC VEHICLES… Batteries – Lithium polymers?

300 miles on a charge? Need to go to higher Voltage systems.
FOR SUSTAINABLE ELECTRIC VEHICLES

ELECTRICITY…… So you need…
I have focused on the Motor Vehicle energy sources...but...similar conclusions arise from other analyses..
CURRENT CAPACITY and EQUIPMENT IS OLD
HYDROGEN AND FUEL CELLS
TRANSISTION TO ELECTRIC VEHICLES

STILL NEED ELECTRICITY
NUCLEAR
SOLAR
WIND
HYDRO

GROWING POPULATIONS WORLDWIDE AND GROWING DEMAND FOR HIGH QUALITY – HIGH TECHNOLOGY LIFE!

NEED GOOD SCIENCE AND PLANNING – AND IMPLEMENTATION
ALL ENERGY SOURCES HAVE THEIR PROBLEMS
SOME MORE THAN OTHERS

NEED TO THINK CRADLE TO GRAVE
ALSO NEED TO LOOK AT ALL OF THE IMPACTS

IMPORTANT FOR THE NEXT GENERATION OF SCIENTISTS
TO GET A BETTER HANDLE ON HOW THE EARTH SYSTEM
REALLY WORKS – AT ALL LEVELS..

CHEMISTS – PHYSICISTS – BIOLOGISTS – ECOLOGISTS, ETC..
AND EVEN THEN WHEN WE THINK WE HAVE THE ANSWER… ITS IMPORTANT TO REMEMBER THAT WE ARE ONLY HUMAN AND LIMITED BY OUR ABILITY TO MAKE OBSERVATIONS AND INTERPRET THEM CORRECTLY!

BLIND MEN AND THE ELEPHANT?

SO HAVE FUN LEARNING THIS SUMMER!