

Don Lancaster's

RESOURCE BIN

number eighty eight

The hydrogen scene: It's a gas.

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Hydrogen as a Resource

It seems reasonable to expect that hydrogen is probably going to play a big role in future transportation and energy developments. Hydrogen can make a great student paper or a nice research topic. And eventually might lead to a technical buck or two.

At the same time, there sure is a lot of hogwash and misinformation out there. Especially on the web. So, the more you know about real hydrogen resources, the more intelligently you can dismiss all the rest of them.

Just The Facts, Ma'am

Hydrogen today seems an odd mix of facts, fallacies, fictions, and frauds. We can replace some misconceptions with these hard facts...

Hydrogen on earth is not a fuel. It is only an energy carrier.

There is more hydrogen in gasoline than there is in liquid hydrogen.

Electrolysis is not usually your best way to generate hydrogen.

Hydrogen combustion emphatically does not implode.

The available energy in a hydrogen flame is very low.

No hydrogen flame has the ability to truly melt tungsten.

Solar electricity today is much too valuable to waste on hydrogen apps.

Equipment amortizations and time value of money engineering economics must be included in energy analysis.

So, today's oil is at least four times more "free" than solar energy is.

Hydrogen improperly burned in air creates polluting nitrogen oxides.

Hydrogen can rot metal through an embrittlement and will easily diffuse through most other materials.

A closed-loop electrolyzer stops a car in less than its coasting distance.

NEXT MONTH: Don looks at boat anchors and those who sink them.

Pulsing, ac, or sparking will only reduce electrolysis efficiency.

Water is not a fuel. It is an ash.

Normally, a monatomic gas only briefly exists in tiny amounts.

Hydrogen creates severe and largely unresolved safety issues.

Energy Carriers

Any intelligent energy discussion has to start with a crucial point. There are substances which are capable of delivering *net* energy to the economy. There are other substances that only can move energy around.

Let's use these definitions...

***fuel**— a substance which is capable of delivering net BTU's of new energy to the on-the-books economy.*

***energy carrier**— a substance that's only able to move a previously aquired energy from one place to another.*

Yeah, there's lots of free hydrogen on our sun and on other moons and planets. And a few rare gas wells do release some free hydrogen. But here on earth, *hydrogen is not a fuel!* At least not by our strict definition. Hydrogen is simply an energy carrier that you will have to fill with energy before you can empty it. Just like a lead acid battery or a flywheel.

No terrestrial non-nuclear means to produce hydrogen is known that does not consume more energy than it delivers.

So, you *always* waste energy when you create and use hydrogen.

Just how useful is hydrogen as an energy carrier? Here's how hydrogen compares against gasoline: Gasoline offers around 9000 watt hours per liter and 13,000 watt hours per kilogram of storage. Hydrogen at its normal STP pressures offers an outstanding 39,000 watt hours per kilogram. But only a pitiful 3.5 watt hours per liter.

We can immediately see the major problem here. Hydrogen uses up too much volume to be very useful as an energy carrier. Uh, compress it into a liquid? Well, yes, but you'll increase your costs and losses. Your efficiency goes down. Safety and infrastructure issues appear. And there *still* is four times less hydrogen in any gallon of liquid hydrogen than there will be in a gallon of gasoline.

So the key problem is finding a safe and dense way to store hydrogen. All sorts of methods are being explored. Some involve *hydrides* while others try mechanical carbon bonding. Sadly, *no means is known that makes hydrogen use practical for personal vehicles.*

The "best" way to make hydrogen is

through the reformation of methane. Commercial methane reformation can be around 68 percent efficient.

Naturally, the methane really has to want to reform.

A poorer way to make hydrogen is by the *electrolysis* of water. Apply a low dc voltage and you get hydrogen from one terminal and oxygen from the other. The best electrolysis is only 62 percent efficient.

Almost all commercial hydrogen is produced by reformation.

Besides new energy uses, hydrogen gets widely used to make ammonia, to stabilize fats, for welding, rocket fuel, acid manufacture, ore reduction, balloon filling, radioactivity studies, and cyrogenic research.

Fallacies and Frauds

Hydrogen sure attracts the wishful thinkers, the misguided "giving free energy to mankind for God" populist fanatics, those "science challenged", or the criminal fraud people. There are mountains of "not even wrong" urban lore out there...

The water powered car— This beast comes out of the woodwork every decade or so. It has attracted everyone from rock stars to Ohio con artists. Another name for an on-board closed loop auto hydrogen generator is a *dynamic brake*. One that, if activated, causes your car to stop in *much* less than its normal coasting distance.

There are *always* heat losses in all alternators, electrolyzers, and heat engines. All closing your engine to alternator to electrolyzer loop does is cascade these losses.

Brown's Gas— A normal optimum mix of hydrogen and oxygen has several unexpected and unusual properties. The colorless flame is nearly invisible, has remarkably low heat energy, and its temperature is exceptionally hard to measure. Tungsten melting illusions are easily created with side reactions. Illusions of implosion can be caused by a post-combustion condensation that always goes away as temperature increases and heat flow balances.

Using subtle differences that have never been explained, a *Brown's Gas* variant supposedly offers exceptional temperatures, long term monatomics, overunity operation, and radioactivity reduction. No credible evidence for these outrageous claims has ever been presented. Chalk this one up to bad labwork amplified by urban lore.

Pulse Electrolysis— A dc voltage near 1.28 volts might end up as one-sixth endothermic, meaning that some of the input energy comes from ambient heat, rather than the electricity. Below this optimum, you get no gas at all. Exceed the *thermoneutral* voltage of 1.47 volts and you start wasting heat.

Claims are made that pulses can greatly improve hydrogen generation. This flies in the face of these optimum dc levels. It is exceptionally hard to accurately measure any pulse power. Casual measurements end up wildly low because of differences between rms and average currents. Electrolysis current is wildly nonlinear.

More on these rms versus average measurement errors in [MUSE112.PDF](#) and [MUSE113.PDF](#).

The highly capacitive nature of an electrolysis cell reduces your "pulse" right on back into a dc level and a few very weak sinewave harmonics. These cells are inherently low pass filters.

Standard EIS instruments routinely measure the pulse characteristics of electrolytes. Details in [MUSE137.PDF](#). None of the EIS I've looked at shows anything unexpected here.

Yeah, it is possible to "resonate" a water molecule. But the frequencies involved are up in the microwave and infrared range. No energy advantages to doing so have been shown.

Underwater Arcing— Wild claims are made for underwater sparking. Well, it seems that there's many thousands of EDM underwater sparking tools in daily use by machine shops. Not one of them has reported their machines vaporizing or generating more than trivial amounts of hydrogen.

Catch the ongoing details in *EDM Today* magazine.

There is also a web scheme to arc underwater and collect the mixed gas. While this works, it flies in the face of thermodynamics. Which *demands* that an efficient process be *reversible*. And no way does introducing some mixed gas above water make an underwater arc. More on thermodynamics can be found in [HACK64.PDF](#).

Periodical Charts

Your first venture in exploring any chemical element should be with the periodical table of the elements.

You should find a really superb one at ww2.shef.ac.uk/~chem/web-elements Present are background info, physical properties, uses, isotopes, structures, compounds, and related info.

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Calif Energy Commission
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(202) 651-7500

Synergetics
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These folks like hydrogen so much they've even made it number one on their charts.

NASA Safety Site

Before you do anything else with hydrogen, be sure to *thoroughly* study the NASA hydrogen safety site found at www-osma.lerc.nasa.gov/lsm/lsm6.htm

Note that hydrogen will burn in air between 4 and 75 percent and burns in oxygen between 4 and 95 percent. It explodes violently in air between 18 and 59 percent and in oxygen between 15 and 90 percent.

The tiniest spark sets it off.

Other essential lab considerations include your use of flame arrestors to prevent back explosions into lines and tanks. And your choice of excessively sturdy materials that do not fragment during an explosion.

The bottom line is that hydrogen is nasty stuff and should not be casually messed with. Not in any way.

Peavey, Pyle, and Sandfort

There are all sorts of good books on hydrogen. I've placed a hotlinked list to www.tinaja.com/h2gas01.html

Start with Peavey's *Fuel From Water*. Yeah, this has an absurd title, is dated and is rather rough around the edges. But this remains your best homebrew hydrogen info available today.

The Solar Hydrogen Cronicles is a Walt Pyle book that consists mostly of

interesting [Home Power](#) reprints.

Sandfort's *Heat Engines* is a must read. While not hydrogen specific, it is an excellent text on thermodynamic fundamentals. Look for the *Doubleday Science Library* paperback.

Also be sure to read *Combustion* by Irwin Glassman.

Journal of Hydrogen Energy

This one appears to be the leading tech resource in the field. Published by all of the folks at that *International Association for Hydrogen Energy*. It seems a tad pricey at \$1470 per year, so you might want to pick up this one through your local technical library. But *Elsevier* does sometimes send free samples to professional requests.

Other important periodicals are the *Hydrogen & Fuel Cell Letter*; that *Fuel Cell Bulletin*; *Journal of Power Sources*; *CA Selects: Electrochemical Reactions*; or the *Electrochemical Society Journal*.

Rocky Mountain Institute

That *Rocky Mountain Institute* up at www.rmi.com also deserves a special mention. Here you will find objective studies for transportation and energy efficiency alternatives. Hydrogen and otherwise. Don't miss this one.

And the Rest of the Gang...

Other helpful hydrogen resources are the *American Hydrogen Association*, that *California Energy Commission*, the

Electric Power Research Institute, an *EV World* magazine, that *D.O.E. Hydrogen Infonet*, that *Breakthrough Technologies Institute*, *National Hydrogen Association* the *National Renewable Energy Lab*, that hydrogen man at his *Slip Net*, Shawn Carlson's *Society of Amateur Scientists*, or the *Society of Automotive Engineers*

The Web

The leading hydrogen newsgroup is sci.energy.hydrogen. Be sure to note that the professional decorum here is both expected and enforced. Utterly ridiculous pseudoscience hydrogen is seen at alt.energy.hydrogen and also at alt.energy.over-unity

Other newsgroups that might be of hydrogen interest are...

alt.energy.homepower
alt.energy.hydrogen
alt.energy.over-unity
alt.energy.renewable
alt.sciphysics.new-theories
alt.solar.photovoltaic
sci.chem
sci.chem.electrochem
sci.energy
sci.energy.hydrogen
sci.environment
sci.physics

Some Real Opportunities

Where is hydrogen research coming down these days? Here's several areas being actively explored...

Fuel Cells— These convert hydrogen and oxygen (or air) into electricity. In theory, they could bypass heat engine efficiency limitations. Big bucks are being thrown at this and only limited progress is being made. But problems do remain in membrane lifetimes and costs. *Ballard* is one proponent, while www.fuelcells.org is a useful website. A *Fuel Cell Bulletin* and a *Hydrogen and Fuel Cell Letter* give key info.

Carbon Nanofibers— Nelly Rodriguez and Terry Baker claim they can store 75 percent hydrogen by weight using carbon nanofibers. This clearly beats all known hydrogen storage systems and could lead to a 5000 mile gas tank for cars. But verification seems slow in coming. Start off with the February 1997 *Hydrogen & Fuel Cell Letter*.

Metalloradicals— No, their album has not gone platinum. These may be the long sought key to photosynthesis. A magic box where you pour water and solar energy into their top, hydrogen comes out one side and electricity out the other. Meanwhile, oxygen oozes out the bottom as a waste product. A key paper is Hoganson & Babcock in *Science* for September 26, 1997.

Direct Solar to Hydrogen— At present, solar electricity is way too expensive to waste on hydrogen apps. Caused by highly inefficient silicon being the wrong horse to bet on. But a first step towards direct solar to hydrogen has been taken by Turner & Khaselev in *Science* for April 17, 1998. Efficiency is in the 14 percent range.

Methane Oxidation— Methane is the best known hydride with a very high

25 percent hydrogen storage ability. This gas also often is "burned off" oil wells because there is no cheap way to transport it. Roy Periana and others describe the new 70 percent efficient methane-to-liquid conversion process. It appears in *Science* of April 24, 1998 starting on page 560.

Modest Injection— A "water powered car" is clearly absurd, but adding a little hydrogen to an otherwise stock gasoline engine seems to give you a few emission, economy, power, and lifetime benefits. Whether these can justify the added cost and complexity remains to be shown.

Ionic Filters— These are the magic new filters which can intelligently separate gas streams. Such as oxygen from air or hydrogen from carbon monoxide. Research here is mostly from *Argonne Laboratories*. Check their *Tech Transfer Highlights* vol. 9 #4 for details.

Welding Apps— Typical oxy-hydrogen torches give you an extremely clean but rather low energy flame having a precise control for jewelry and similar needs. Use of a hydrogen atmosphere during regular welding could create a reducing shield that stops oxidation. But one with *extreme* dangers.

Also Rans— A new type of dihydrogen bond was announced in the December 11, 1998 issue of *Science*. There is lots of interest in solid hydrogen, which demands extreme temperatures and pressures. *Bose-Einstein Condensates* a new form of matter that only happens at ultra low temperatures. Ongoing hydrogen developments are described in David Newton's Chemistry volume of the 1999 *Frontiers of Science* books.

For More Help

More info on any of these hydrogen opportunities can easily be found by entering chosen names and keywords into www.hotbot.com or your favorite search engine. Use www.dejanews.com to check for newsgroup mentions. I've also covered these on my website.

Speaking of which, I have built a hydrogen resources web page up as my www.tinaja.com/h2gas01.html Here you'll find tutorials, hot links to most of the players, recommended books, and newsgroup access links.

There's even a few links on *nitrogen* powered cars. These are a cute and an amazingly low technology alternate to electric cars. An approach which is *twenty times* cheaper than using lead acid batteries!

And one you can literally beat out on a brick in your backyard.

More detailed assistance involving hydrogen or any other technical topic is found at www.tinaja.com/info01.html or at www.tinaja.com/consul01.html ♦

Microcomputer pioneer and guru Don Lancaster is the author of 35 books and countless tech articles. Don maintains his no-charge US tech helpline found at (520) 428-4073, besides offering all of his own books, reprints, and consulting services. Don also offers free catalogs of his unique products and electronic bargains. The best calling times are 8-5 weekdays, MST.

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