

# Hydrogen Today



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*Hydrogen – It's not about the future anymore.*

## Show Me the (Cheap) Hydrogen



Enapter Anion Exchange Membrane Electrolyzer

With a kilogram of hydrogen (the energy equivalent of 1 gallon of gasoline) selling for \$16 on the street, not many of us are rushing to buy a fuel cell anything. Enapter (Pisa, Italy), formerly ACTA, manufactures a compact \$10,000 anion exchange membrane (AEM) electrolyzer. Recent improvements to their assembly line cut costs by 20%, but the big advantage of AEM technology is that none of the expensive platinum group metals are needed. As opposed to PEM electrolyzers where positive hydrogen ions (protons) pass through the membrane, in AEM the negative OH ions pass through.

Continued next page.....

## *“Quotations”*

“Negative people have a problem for every solution.” A. Einstein

“There is more stupidity than hydrogen in the universe.” Frank Zappa

“The only way to stop people from getting paid to destroy the environment is to pay them for not destroying it.” Michael Merrill, labor consultant

“The future is not what it used to be.” Arthur C. Clarke

## American Hydrogen Association Mission

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**\*\* SAFETY FIRST \*\***

Develop solar hydrogen technologies that will eliminate economic, environmental and energy hardships caused by burning one million years accumulation of fossil fuels every year *and*

Educate scientists, entrepreneurs and experimenters, parents and educators, CEO's, legislators, utilities, the media and farmers how to use solar hydrogen to create sustainable prosperity without pollution.

## Show Me the Hydrogen, cont...

### *Enapter AEM Electrolyzers*

The units are designed to scale up output by stacking.

#### EL-500 Specifications

- Production – 0.5 m<sup>3</sup>/hour hydrogen, ~1 kilogram/day
- Power – 4.8 kWh/m<sup>3</sup>
- Water – 0.4 liter/hour, rain or tapwater
- H<sub>2</sub> Pressure – 500 PSI
- H<sub>2</sub> purity – 99.999%, with optional dryer

Arno Tilsner, a self-sufficiency magazine publisher outside Munster, Germany has installed an Enapter system in his home. Five kilowatts of solar panels on his roof power the system and recharge electric vehicles. A fuel cell produces the electricity at night.



Enapters are being used for industrial processes and replacing diesel generators at off grid and remote sites. They would certainly work for cooking and water heating. As the company says, Hydrogen is ready for those who don't wait.

<https://www.enapter.com/>

## Editorial

On August 8<sup>th</sup>, after 20 years of very disruptive moves to 9 different locations, the AHA finally acquired a permanent home thanks to some super members. It's a few miles south of Phoenix, near Maricopa, Arizona; zoned industrial. The buildings are pretty old (one used to be a saloon), but the view of sunset over the Estrella Mountains is priceless. We've cleaned up most of the place and are now unpacking and organizing countless cardboard boxes of books, tools and parts & materials so everybody can get back to work on the hydrogen stuff. Solar electricity runs LED lights and keeps beverages cold.

What are your plans for the New Roaring 20's? Here at HQ, we're ramping up from just answering hydrogen questions to mobilizing – getting out in public as well as using social media. We expect to start HQ tours in April (50<sup>th</sup> anniversary of Earth Day) so anyone can see hydrogen in action. Later in the year we'll start some of the Hydrogen University classes and produce H2 how-to videos. Nikola's new hydrogen semi-truck factory will be built nearby.

Giuseppe Tomasi di Lampedusa said if you want things to stay as they are, then things will have to change. I like morning coffee, hot showers and Joe Pickett novels, but it could all go away because of wildfire, hurricane, flood, WW III or dying from inhaling car exhaust.

If you think one person can't change very much, remember Greta Thunberg, the Swedish 10<sup>th</sup> grader. By hitching rides on boats to avoid flying, she travelled around the world scolding world leaders for ignoring climate change. She was a Times magazine Person of the Year.

You can participate wherever you live. Join the AHA or renew your membership. The only pay any of us get is in fun. Give a copy of Roy's *Solar Hydrogen Civilization* to your local public library. Here are some projects we need help on:

- Nobody here has a PhD. in hydrogen safety (yet), but we're working on a hydrogen safety resource manual that will likely save somebody's life.
- Whole Hydrogen Catalog is a Whole Earth style list of every hydrogen product and service.
- Upgrade solar furnace tracker.
- AHA website teacher's resource pages.
- Digitize and upload 1000's of pages of hydrogen documents.
- Hydrogen cooking videos.
- Oxy-hydrogen welding manual.
- HHO kit evaluations
- Let all your elected officials know you want renewable energy.

If you are in the neighborhood, you can mess around with a wind turbine, bike repairs, an ethanol still, water from air, tiny homes construction, solar air conditioning, a 10" Dobsonian telescope, Arduinos, microbial fuel cell, hydrogen go-kart, tire and plastic to oil gasifier and Permaculture projects such as biochar, vermiculture, rain capture and bio-digesters.

Our objective is to motivate you to turn your knowledge and experience into a 'prosperity without pollution' career. Learn and earn.

New AHA Headquarters, Maricopa, AZ



Future AHA Maricopa HQ (Zimmer Design)



Starting to organize 2,000 book library



Stray kittens napping after drinking all our half & half

## Hydrogen Events

International Hydrogen and Fuel Cell Expo, 26-28 February, 2020, Tokyo, Japan. See fuel cell materials, production machinery and testing and hydrogen production and storage technology. Ticket is free. <https://www.fcexpo.jp/en-gb.html>

f-cell + HFC Hydrogen and Fuel Cell Event, 1-2 April, 2020, Vancouver, B.C., Canada. Conference and trade fair. Topics include bus, rail & marine, large-scale H<sub>2</sub> production and hydrogen infrastructure. Talk to Ballard and Toyota. \$980 USD. <https://hyfcell.com/>

Shell Eco-Marathon Americas, 1-4 April, 2020, Sonoma Raceway, CA. Student built gas, battery and fuel cell cars compete for ultra-high mileage. <https://www.shell.com/make-the-future/shell-ecomarathon/americas.html>



ACT Expo (Advanced Clean Transportation), 11-14 May, 2020, Long Beach, CA. For propane, natural gas, hydrogen and electric fleets. State of the art technology and best practices for fuel savings, emissions and maintenance. \$795. <https://www.actexpo.com/>

23<sup>rd</sup> World Hydrogen Energy Conference (WHEC), 5-9 July, Istanbul, Turkey. Concurrent with International Conference on Hydrogen Production and 5<sup>th</sup> International Hydrogen Technologies Conference. There's something here for everyone. Hydrogen from biomass, codes & standards, aviation, storage, hydrogen in ICE's, catalysts, safety, infrastructure, \$950 <http://whc2020.org/>

## Hydrogen on the Internet

Open Access Library – Enter keyword “hydrogen” in their search will get you 35,667 free, downloadable hydrogen articles. <http://www.oalib.com/> ->

Great Courses Plus– When I was a kid, I sent in a postcard for information on Great Books, a collection of classics including, Plato & Homer, Robinson Crusoe, Michael Faraday, Freud, DaVinci and Thoreau. I thought they were an essential foundation for a well-educated citizen. A nice lady showed up at the door and I found out the set cost \$995 more than I had.

Along came the Great Courses. Some of the country's best teachers taught dozens of classes on history, music, science, art, health and more. There are about 24 half-hour lectures per course and used to cost \$200-300. Many are now on sale for \$25 to \$50. Better yet, for \$20 a month, Great Courses Plus gives you access to most of the courses. Even better, my public library has lots of the videos online for FREE.

Radio Astronomy will tell you how waves from hydrogen atoms allowed us to see the universe through interstellar dust that blocked light from telescopes. Learn the chemistry of renewable energy and don't miss the one on stress. 14 day free trial.

<https://www.thegreatcoursesplus.com/>

American Climate – How does it feel when a wildfire or hurricane or flood destroys your community? InsideClimate News interviews 21 Americans. Their stories are different, but the looks on their faces is the same.

<https://insideclimatenews.org/american-climate>

## How I Discovered Hydrogen

By Dr. Addison Bain, NASA Hydrogen Engineer (ret.)

My first exposure to hydrogen was at a 1958 conference I attended in Los Angeles that was about rocket propulsion. I was a model rocket fanatic.

In 1962 I was working for Brown Engineering in Huntsville, Alabama that was under contract with NASA to design facilities for the upcoming Apollo Program. I was assigned the task of designing the high-pressure hydrogen facility and developing the specifications for a liquid to gaseous hydrogen converter. There was limited information but I had acquired and saved contacts and papers by the Air Force, the Bureau of Standards, and NASA facilities at Cleveland and Langley. With that help I learned more about the properties of hydrogen and system components which came in handy. With a secret clearance I was able to visit certain facilities in the US. Safety standards from companies like Union Carbide and Air Products and Chemicals helped.

My first hand on operation of hydrogen equipment was when I joined NASA in 1965 at Cape Canaveral.

## Books & Publications

Biohydrogen Production: Sustainability of Current Technology and Future Perspective, Singh & Rathore (editors), 2017. Springer India, 320 pages.

In the search for affordable hydrogen, experimenters are exploring hydrogen produced by living organisms. This book covers three main processes. In photosynthesis, algae breaks water directly into H<sub>2</sub> and O<sub>2</sub>. In dark fermentation, particular bacteria biodigest waste biomass into acetic acid and hydrogen. The process is stopped before proceeding to methane. In photo fermentation, anaerobic bacteria biodigest organic acids like acetic acid into H<sub>2</sub> and CO<sub>2</sub>.

This basic book covers many sources of feedstock. It also covers the challenges like low yields, hydrogen purity and converting woody biomass to digestible lunch for bacteria's. Apparently publishers these days are laying off their proofreaders. The text is a little gimpy at times.

Let There Be Water – Israel's Solution for a Water-Starved World, Seth Siegel, 2015. St. Martin's Press, 337 pages.

In a world where the quantity and quality of fresh water is running low, it's very encouraging to read about some real solutions. The state of Israel, in spite of being in the arid or semi-arid Middle East, not only thrives, but exports fruits and water to their desert neighbors. How do they do that?

1. Enormous pipelines move water from where it is to where it isn't.
2. Drip irrigation uses one half the water of flood irrigation *and* increases production.
3. Seawater desalinization plants.
4. Crops were found that grow well in slightly salty water.
5. Every drop of sewer and wastewater is purified and stored in reservoirs for irrigation.

The best minds in Israel developed many of the technologies which are now available to the rest of the world, but what really made them successful was their respect for water and their national will to protect it.

Soares Book on Grounding and Bonding, International Association of Electrical Inspectors, 2004. 400 pages.

Sooner or later your solar hydrogen project or tiny house will require a solid knowledge of electrical grounding to prevent lightning damage or a shock from ruining your day. This book has many drawings of details probably better learned by hands-on experience. The two basic principles are repeated over and over and over and over. When you need to learn this stuff, look elsewhere.

## The Rest of the Hydrogen Story

### Hockey and the Hydrogen IceBear

When mechanically refrigerated railroad cars cut into Frank Zamboni's ice-making business in southern California, he found a new opportunity in building ice skating rinks. However, sharp skate blades are tough on ice and it took four men an hour to scrape the ice smooth and spray on a new coat of water. Zamboni decided to build an ice surfacing machine. Starting with a WWII surplus jeep, he had a marketable machine by 1949. Today every hockey fan in the world knows what a "Zamboni" is.

In 2005, the U.S. Department of Energy was looking at new markets for hydrogen. It was known that carbon monoxide from propane-fueled ice surfacers occasionally poisoned fans and players. The DOE contracted with the University of North Dakota's Energy and Environmental Research Center to build a hydrogen fuel cell prototype. It took them only three months to convert an IceBear electric resurfacers with a Nuvera 5kW fuel cell and a Dynatek storage tank. Kraus Global provided a refueling station. The hydrogen IceBear first appeared at North Dakota Senator Byron Dorgan's Hydrogen Energy Action Summit in Grand Forks on December 7, 2005. For several years the IceBear was demonstrated at rinks all across North American. When funding was cut during the Obama administration, the IceBear was dismantled. The chassis was returned to Resurface Corp. in Canada and reconverted to battery electric operation. The fuel cell components are still being used for research at UND.





## Hydrogen University

### Greenhouse Gases

In 1898, Swedish physicist Svante Arrhenius, a distant relative of Greta Thunberg, calculated a doubling of atmospheric carbon dioxide (CO<sub>2</sub>) would increase earth temperatures by 5-6°C. Bubbles trapped in ice cores over tens of thousands of years tell us today how much CO<sub>2</sub> was in the atmosphere. Isotope ratios show whether the source was a tree, volcano, car or out of the ocean.

The only thing easy about greenhouse gases (GHG) is describing them. About half the energy arriving from the sun, in the form of ultraviolet and visible light, hits the surface of the earth. This energy warms the earth and is re-radiated back into the atmosphere as infrared waves. A GHG is one that absorbs these frequencies and traps life-sustaining warmth in our atmosphere. Increase the GHG's and your thermometer goes up.

There are dozens of GHG's, but we'll take an elementary look at only five major ones – water, CO<sub>2</sub>, methane (CH<sub>4</sub>), nitrogen oxides and ozone (O<sub>3</sub>).

Composition of greenhouse gases:

Water - vapor	50%
Water - clouds	25% (actually water droplets)
CO <sub>2</sub>	20%
CH <sub>4</sub> , NO <sub>x</sub> , O <sub>3</sub>	5%

Increases since 1750:

CO <sub>2</sub>	41%
CH <sub>4</sub>	152%
N <sub>2</sub> O	20%
O <sub>3</sub> (tropospheric)	42%

Water. Although water vapor and clouds are majority components of GHG's, amounts in the atmosphere are limited by temperature, not by how often you wash your car. Lower the temperature and it will rain or snow. Note there is positive feedback. Rising temperature increases the water content which in turn increases the temperature by trapping more heat. Yes, burning hydrogen produces some GHG.

Carbon dioxide. seems to be the black sheep of the greenhouse gases. Perhaps it's because for every 6 pounds of gasoline your neighbor burns, they're adding 19.8 pounds of CO<sub>2</sub> into your air. Americans produce 19.8 tonnes of CO<sub>2</sub> per year per capita. A mature tree absorbs 50 pounds a year.

->

Sources of CO<sub>2</sub> emissions:

Electricity generation	34%
Industrial processes – cement, steel	21%
Transportation - tourism	17%
Deforestation	14%
Commercial, residential - heating	9%
Fossil fuel production	5%

CO<sub>2</sub> ends up in three places. About one third goes into the atmosphere. Another third goes into the ocean where the CO<sub>2</sub> is used by plankton for photosynthesis or it forms carbonates which become shells or coral and eventually limestone. Another third is taken up by terrestrial plants and soil.

Methane. Forty per cent of CH<sub>4</sub> is produced naturally by volcanos and microbes in swamps and termites. The other sixty per cent is attributed to human activity.

Sources of methane emissions:

Agriculture – livestock, rice paddies	41%
Fugitive fossil fuel emissions – coal mines, gas wells, pipelines	35%
Landfills and wastewater – anaerobic microorganisms	16%
Biomass burning	4%
Residential, commercial	4%

NO<sub>x</sub>. The study of nitrogen oxides turns messy in a hurry. Nitric oxide (NO) and nitrogen dioxide (NO<sub>2</sub>), together referred to as NO<sub>x</sub> and produced by high temperature combustion in engines and boilers, are not really greenhouse gases themselves. Significant amounts of NO<sub>x</sub> are produced by lightning. NO combines with oxygen in minutes to form NO<sub>2</sub>. NO<sub>2</sub>, in the presence of ultraviolet light, begins a chain which produces ozone, a GHG (as well as smog and acid rain). Nitrous oxide (N<sub>2</sub>O), aka laughing gas, is a strong GHG. Sixty percent of atmospheric N<sub>2</sub>O is naturally occurring, mostly from microorganisms in soil or the oceans.

Sources of man-made N<sub>2</sub>O:

Soil bacteria and fungi on fertilizer, livestock manure and urine	42%
Fertilizer leaching	25%
Burning biomass	10%
Burning fossil fuel	10%
Decomposition of nitrogen compounds	9%
Sewage	5%

Ozone. Upper stratospheric ozone is beneficial by blocking much of the sun's damaging ultraviolet rays. Tropospheric O<sub>3</sub> near the earth's surface is derived from NO<sub>x</sub>. Ozone concentrated in urban areas may cause local warming. ->

For millions of years, nature has balanced the complex flows of matter and energy between forest, sunlight, soil, atmosphere and oceans. Burning a million years' worth of fossil fuels every year must have consequences. Researchers are building better instruments, taking more measurements and trying to share data. There is debate today over whether climate change is man-made or it isn't. The Truth is probably somewhere in the middle. It's OK to be wrong. It's not OK to refuse to listen to the other side. Self-education is a fundamental AHA principle. We study books, "do the math," question everything (and everybody), experiment, 'try it and see.' Instead of getting hung up on collecting numbers, we need to find out soon what, if anything needs to be done. We should be installing insulation, planting trees, growing our own food and making biochar and hydrogen. Just in case.

## Thanks

Claude C. – Gila River Earth Day, stain car hauler deck.

Emre V. – IJHE subscription.

Marie D., Clyde S., Claude C. – Install Kyocera PV system.

Warren H. – Deep-cycle batteries, solar LED, sofa, doors.

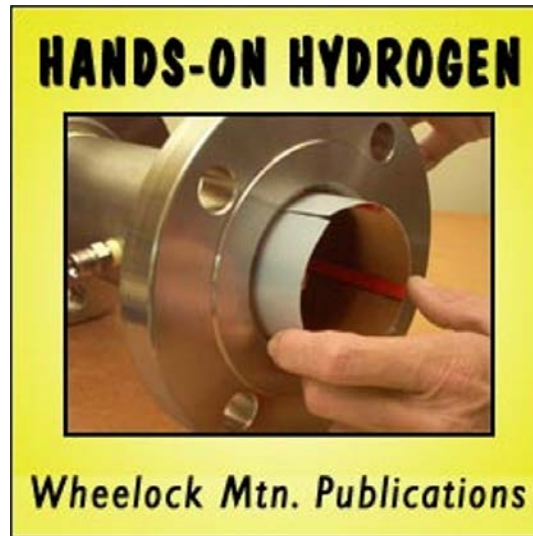
Ayfer V., Addison B. – many boxes of hydrogen books for the library.

John G. – High pressure compressor, pure sine-wave solar inverters.

Jon F., John G., Warren H., Clyde S., Dave H., Deek- \$\$\$\$ for Maricopa HQ

Jay A. and Rick S. – Icebear information.

Jack Z. – More drawings of future AHA HQ.



*Books for Do-It-Yourself Experimenters*

*By Phillip Hurley*

- Build Your Own Fuel Cells....\$16.95
- Build A Solar Hydrogen Fuel Cell System....\$16.95
- Practical Hydrogen Systems: An Experimenter's Guide....\$22.95
- Build Your Own Solar Panel....\$14.95
- Solar II....\$16.95
- Solar Supercapacitor Applications....\$11.95
- The Battery Builder's Guide....\$20.95

These are easy-to-follow directions for building your own hydrogen hardware. Hurley even gives you part numbers and throughout he stresses safety lessons.

Books are available in paperback on Amazon:

[https://www.amazon.com/Phillip-Hurley/e/B001K8XF3K/ref=sr\\_tc\\_2\\_0?qid=1545928563&sr=1-2-ent](https://www.amazon.com/Phillip-Hurley/e/B001K8XF3K/ref=sr_tc_2_0?qid=1545928563&sr=1-2-ent)

## AHA Membership Form

Name \_\_\_\_\_

Address \_\_\_\_\_

City \_\_\_\_\_ State \_\_\_\_\_ Zip \_\_\_\_\_ Country \_\_\_\_\_

Telephone \_\_\_\_\_ email \_\_\_\_\_

- Regular Membership- \$39.00/year (New members receive a free copy of Roy McAlister's "Solar Hydrogen Civilization").
- Student, Military & Senior (55 and over) Membership- \$25.00/year
- Sustaining Membership- \$100.00/year (autographed book and H2 bookmark)
- Life Membership- \$1000
- Corporation/Institutional Membership- \$1000/year
- "Solar Hydrogen Civilization" book only - \$24.95 postpaid.
- Email *Hydrogen Today* only
- "Hilda Hydro - Girls Go Green" - \$8.95 postpaid

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*Prosperity Without Pollution.*

AHA publishes *Hydrogen Today* to help educate the public about new developments in renewable energy and the science and people behind them. Join us in making a better world. You can help too by writing for *Hydrogen Today*. Tell others about your grassroots alternative energy projects, either scientific or social. Review a book, product, service or event. A picture is still worth a thousand words. The range should be approximately 300-1000 words. Mail to the above address or to the *Hydrogen Today* editor at [editor@clean-air.org](mailto:editor@clean-air.org) Thanks.