# HYDROGEN TODAY

**Official Publication of the American Hydrogen Association (AHA)**

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# U.S. CONGRESS SMOOTHS ROAD TO $H_2$ ECONOMY

Recent actions by the U.S. Congress indicate a growing awareness of the potential of hydrogen to become a clean, renewable energy source.

***Hydrogen R & D Program Act***

A bill originally introduced by the late Senator Matsunaga in 1989, entitled "Hydrogen Production and Use", was re-introduced and amended by Senator Johnston in late July of this year. This bill, retitled the "Spark M. Matsunaga Hydrogen Research, Development, and Demonstration Program Act of 1990", was passed by the Senate in September and approved by the House of Representatives October 24, 1990.

The bill provides for the establishment of a Hydrogen Technical Advisory Panel that will advise the Secretary of Energy on various research and development programs that might be undertaken under this act. Total funding for such programs, however, is meager: $3 million for fiscal year 1992; $7 million for FY 1993; and $10 million for FY 1994.

Accompanying this bill (and actually a part of the original Matsunaga hydrogen bill) was S. 2613, a bill to establish a hydrogen-fueled aircraft research and development program. This bill, introduced by Senator Ford, was referred to the Committee on Commerce, Science, and Transportation and has not been further acted upon to date by the full Senate. This bill calls for a total of $100 million, spread out over a 5-year period, to support a comprehensive program to develop a domestic hydrogen-fueled aircraft capability within "the shortest time practicable".

***Clean Air Act Amendments***

Finally approved by both houses of Congress and signed into law by President Bush last month was the Clean Air Act Amendments of 1990, the first comprehensive national legislation governing air pollution passed in 13 years. This is a complex and lengthy law (635 pages long) that is far too complicated to summarize in this newsletter. It does, however, include a number of new requirements that support a move towards hydrogen and other cleaner-burning fuels.

New, tighter air quality standards are imposed on cities, with stiffer, more-detailed remedial requirements and penalties for cities not complying. (Among suggested programs are state-sponsored research and test programs related to cleaner-burning fuels, vehicles, and stationary pollution sources.)

There are specific emissions standards established for all new motor vehicles that call for substantial reductions of non-methane hydrocarbon, carbon monoxide, and oxides of nitrogen in exhaust emissions in model years after 1993. The new emission standards are phased in over the 1994-1996 model years and apply to passenger cars and light-duty trucks. Also included in this new law are mandates requiring the production of "cleaner" gasoline starting in 1992 (that is, gasoline that results in lower emissions of ozone-forming volatile organic compounds, nitrous oxides, carbon monoxide, or aggregate emissions of hazardous air pollutants).

All new urban buses (those that primarily operate in a metropolitan area with a 1980 population of 750,000 or more) must be "clean-fuel vehicles" that exclusively operate on a clean alternative fuel after January 1, 1996. (A phase-in schedule is provided that requires a minimum of 25% of new buses in 1994 and 60% of those placed in service in 1995 to burn only clean fuels.) In addition, any old buses that have their engines replaced or rebuilt after Jan. 1, 1996, must also be converted to "clean-fuel vehicles". (Clean alternative fuels are defined to mean any fuel, including methanol, ethanol, or other fuel alcohols, reformulated gasoline, diesel fuel, natural gas, LPG, and *hydrogen* that complies with the new, tightened standards and requirements under this law.)

Throughout the document is the phrase "use of renewable energy/fuel sources".

***Global Warming Prevention Act***

A comprehensive bill that supports energy and natural resource conservation strategies appropriate to preventing the overheating of the Earth's atmosphere was introduced in early 1989 into the House of Representatives by some 50 sponsors (and later picked up by 50 additional sponsors).

This bill includes a major section on solar and renewable resources and provides a minimum of $200 million in support of solar R & D programs "of the Department

*(Please turn to U.S. LAWMAKERS on Pg. 3)*

## *FEATURED INSIDE*

# CALIFORNIA ACCELERATES PACE TO CLEAN FUELS; HYDROGEN

California environmentalists may have lost the battle to put into state law a comprehensive environmental protection program. (The program, nicknamed "Big Green", was voted down in the just-past elections.) They continue, however, to lead the nation with aggressive programs to clean up smog and pollution. Recent moves include a revolutionary program setting tough new tailpipe emission standards that was approved in late September by the California Air Resources Board. Under these standards, some new cars sold in the state starting in 1998 must be electric-powered. Two percent of the cars in 1998 must be electric, growing to 10% by 2003.

In addition, "ultra-clean cars" powered by fuel alcohols, compressed natural gas, or other fuels [hydrogen presumably is a candidate] will be required, beginning in 1994. At that time, new standards, rated the toughest in the world, will slash tailpipe emissions by 50% from current levels. These standards are progressively tightened over the next five years until every new car sold would be from 70% to 100% less polluting than cars sold in 1994.

*These new standards are expected to wield considerable influence beyond California and represent the first formal step away from fossil-fueled cars.*

Less than a month later, the California Energy Commission (CEC) released a plan to meet almost half the state's new electric-power needs with wind, biomass, solar, and geothermal generation. If the plan is approved by the state's Public Utility Commission (PUC), California will become the first state to require a specific portion of its power needs to be met by renewable energy sources.

Under the plan, renewable-energy companies would no longer have to compete head-on with fossil-fuel generating plants but would have a share of the business reserved exclusively for them. These "set-asides" are designed to ensure that the state continues to make sources; and it helps support a fledgling industry that is struggling to compete against still-cheap (and much dirtier) fossil-fuel energy sources.

The CEC plan is under review by the PUC as it prepares its Biennial Resource Planning Update, which will be released for review in February 1991.

## *L.A. HOST FOR CLEAN AIR CONFERENCE*

Distributors and manufacturers from around the country flocked to Los Angeles for a three-day California Clean Air and New Technologies Conference on October 15-17. Featured at the confab were vehicles powered by alternative energy sources. Included was a bullet-shaped solar-powered vehicle, a methane-powered garbage truck, a sleek battery-powered car, and a hydrogen-powered pick-up truck.

The $H_2$-powered truck was built by Dr. Robert Zweig, an engineer and long-time proponent of hydrogen energy who lives in Southern California.

## HYDROGEN DEMONSTRATION AT RIVERSIDE CC

Clean-burning hydrogen fuel will be produced from water and sunlight under a demonstration project sponsored by the South Coast Air Quality Management District (AQMD) and Ontario (Canada) Energy Ministry.

Electrolyser Corp., Ltd. of Etobicoke, Canada, will supply the photovoltaic hydrogen production facility, which will be installed at Riverside (CA) Community College to provide fuel for two pickup trucks converted to run on hydrogen. Current plans call for the trucks, for this demonstration, to use compressed hydrogen storage.

The demonstration-scale hydrogen project has a budget of $600,000, with up to $150,000 funded by the Ontario Energy Ministry and $150,000 provided by AQMD. Under a separate $180,000 contract with AQMD, Riverside Comm. College District will use the facility to produce hydrogen for the trucks.

Students will be trained how to convert vehicles to run on hydrogen and to produce and handle this super-clean fuel. Hydrogen-powered vehicles will be evaluated over a two-year period.

The project has additional support from the American Lung Association's Inland Empire Chapter and the International Association of Hydrogen Energy.

A ceremonial meeting to kick off the project was held on October 17 and attended by AHA member Joe Sparling. Speakers at the event included Dr. Robert Zweig (who delighted the press with a demonstration of his $H_2$-powered pickup truck); Sandy Stewart of the Electrolyzer Corp. (who had a table-top demonstration of a photocell-powered electrolysis system that split water into its hydrogen and oxygen components); and Dr. William D. VanVorst, professor emeritus from U.C.L.A. and a long-time supporter of hydrogen.

## *In Germany:*

## WORLD'S FIRST SOLAR $H_2$ PROD'N. PLANT OPENS

Bavarian Prime Minister Max Steibl presided over the formal opening of the world's first solar hydrogen production facility in Nuernberg, Germany. The opening on September 25, 1990, marks a milestone in the development of a hydrogen-based economy.

This facility utilizes photovoltaic cells and is rated as a 300 Kw-sized power plant capable of producing 50,000 cubic meters of hydrogen annually. Although the facility is relatively small-scale, it does represent the first formal solar-based plant to generate hydrogen for commercial

AZ ENERGY POLICY

# PLAN COMMITTEE RESPONDS TO WORKSHOP SUGGESTIONS

In response to a number of suggestions and comments presented by interested parties at a series of Regional Workshops held during the month of October, the Advisory Committee on Arizona Energy Policy and Planning has published a series of implementation ideas. (Refer to "New Arizona Energy Policy in Development" in the Sept.-Oct. issue of *Hydrogen Today* for background and some comments offered by members of AHA attending these workshops.)

Listed as "Priority Action Area 1" is a recommendation to increase state funding of solar R & D, education, and technology transfer. Specific actions suggested included encouraging scholarship support for education in the field of solar energy; and surveying the industry to determine the current state-of-the-art of solar energy.

Also identified as a high-priority action area is to improve the utilization of the existing transportation infrastructure. Measures to alter the behavior of automobile users should be implemented through a variety of programs ranging from rewarding the use of existing mass transit (buses) and ride-sharing, raising state gasoline taxes, imposing commuter taxes, mandating staggered work hours and weeks for businesses in major metropolitan areas, and charging higher parking fees.(and possibly eliminating public parking). Of greater potential impact but requiring legislative action were suggestions to implement laws to encourage alternatives to fossil fuels and an increase in the tax on gasoline to raise funds that would be dedicated to mass transit.

The Priority Action Area 3 recommendation is to implement the use of alternative transportation fuels. The state should, according to this suggestion package, develop a long-term plan for the conversion of all government-operated fleets and vehicles to the most cost-effective, environmentally-benign alternative fuels in order to stimulate market demand for such fuels. Recommended legislative actions include the development of specific goals and timeframes to reduce the use of fossil fuels (e.g., have a 5% reduction per year with an end goal for a specific year) and legislated subsidies for renewable fuels.

Another "priority action area" cited is to implement an emission tax for all stationary and mobile sources of particulates, NOx, CO, $CO_2$, and SOx pollution throughout the state based on quantity and quality of emissions.

The draft of these (and other) implementation ideas are to be reviewed by the Advisory Committee before being presented to the legislature early next year.

## *FEDERAL ENVIRONMENTAL LEGISLATION:*

- ✔ Hydrogen R & D Act
- ✔ Clean Air Act Changes
- ❑ Global Warming Prevention Act
- ✔ Renewable Energy Act
- ✔ Fuel Cell Acts

✔ = Passed; ❑ = Pending

# U.S. Lawmakers Focus On Cleaner Fuels

*(Continued from Page 1)*

of Energy" in FY 1991. Further funding of $265 million is slated for FY 1992, $340 million in FY 1993, and $435 million in FY 1994. All such funds are to remain available until expended. (The bill requires funding or in-kind contributions from private sources in support of at least 50% of the total costs of all projects proposed for FY 1991.)

In addition, $5 million is also set aside for research to develop technologies to use renewable energy sources, including wind and solar energy, to produce hydrogen for use in fuel cells and/or to use fuel cells employing methane gas generated from various forms of biomass.

Another entire section of the bill is dedicated specifically to R & D on the production of Solar Hydrogen Fuels, with funding under this section totalling $20 million for FY 1991; $30 million in 1992; $40 million in 1993; $50 million in 1994; and $60 million in 1995.

This bill also covers a wide range of other energy and environmental issues, ranging from energy conservation and forest and agriculture policies to recyclable materials. It also addresses matters outside the U.S. with sections on international initiatives and world population growth. The bill has been tabled for the year-end break and is now scheduled to come before the House in January 1991.

***Renewable Energy Act***

Although there has been a flurry of recent Congressional action related to energy and environmental concerns, a law passed late last year (Dec. 11, 1989) supports the increased use of renewable energy technologies. This law, formally entitled Public Law 101-218, "Renewable Energy and Energy Efficiency Technology Competitiveness Act of 1989", authorizes the Secretary of Energy to pursue "an aggressive national program of research, development, and demonstration of renewable energy and energy efficiency technologies in order to ensure a stable and secure future energy supply. Specific goals are established for wind, photovoltaic, and solar thermal energy programs. Hydrogen Energy Systems Program funding is established at $4 million for FY 1991, with an additional $5 million and $6 million for FYs 1992 and 1993.

***Fuel Cell Legislation***

Also, in late June, 1989, two separate acts were signed into law relating to fuel cells. The first, the "Renewable Energy / Fuel Cell Systems Integration Act of 1989", appropriates $5 million for FY 1990 for research programs to develop technology using renewable resources such as wind and solar energy to produce hydrogen for use in fuel cells. The second act, the "Fuel Cells Utilization Act of 1989", encourages the adoption of fuel cells.

*Research by Irv Jorgenson*

## Technology Review:

# FUEL CELLS: CHEMO-ELECTRIC POWER

*Roy McAlister, P.E.*
*President, AHA*

In 1837, William Grove made a cell that combined hydrogen with oxygen to produce electricity and water. Grove's discovery -- "fuel-cell technology" -- has great importance to the modern world. Fuel cells are electrochemical devices that are technically capable of being more efficient than heat engines. In theory, it is possible to build fuel cells that convert more than 80% of the chemical potential energy of hydrogen into electricity.

Fuel cells are deceptively simple. Consider, for example, the following solid-polymer electrolyte type of fuel cell: Against both sides of a special sheet of plastic called a "semi-permeable membrane" are pressed two electrode grids such as nickel-plated wire. This assembly is housed in a canister that provides for hydrogen to be fed into one of the electrode grids. Oxygen or air is fed to the other electrode. At the hydrogen electrode, diatomic hydrogen ($H_2$) is broken into individual hydrogen atoms (H), each of which transmits an electron to the grid as it enters the semi-permeable membrane as a proton (H+).

Electrons from the hydrogen are used in an external circuit that is in series between the two electrode grids. The electrons do work by powering a device such as a light bulb, motor, toaster, etc. The protons diffuse through the semi-permeable membrane to the other grid, where oxygen has collected electrons that have passed through the external circuit. The protons react with the electron-rich oxygen to form water ($H_2O$).

Operation of a fuel cell to produce electricity does not require combustion or moving parts. Fuel cells are simple, noiseless, vibration-free devices. Most fuel cell types, including the solid-polymer electrolyte cell described above, have a much smaller metal content than an engine-generator set of equal electricity-production capacity.

Table 1 compares the operating temperatures of several fuel cell types.

Types of fuel cells vary greatly in many respects, but all have in common a pair of electrodes on both sides of an electrolyte where electrochemical reactions are facilitated.

Figure 1 shows the direction of ion travel, characteristic reactions at the electrodes, and other features of some fuel cell types.

***Hydrogen Solid Polymer Cells:***

Early in the U.S. space program, proton exchange fuel cells were chosen to provide electricity and water for on-board use in manned rockets because the chemical propellants were hydrogen and oxygen. These same reactants could be used in a hydrogen solid-polymer electrolyte fuel cell (like the one described above) to provide both electricity and water -- at a much lower lift-off mass than batteries and water.

In order to expedite the reaction shown in Figure 1, catalysts were often used. Early space travel used proton exchange fuel cells with expensive catalytic electrodes such as heavily platinum-coated tantalum. New developments in proton exchange fuel cells, however, provide higher reaction currents using carbon electrodes with very low platinum loadings.

These new carbon electrodes are quite inexpensive and provide an important opportunity to utilize the carbon and hydrogen products of recycling municipal wastes and sewage with bioremediation techniques. In addition, high-density storage of hydrogen can be achieved in activated carbon "adsorption storage tanks" fo

*(Please turn to Fuel Cell ... - Next Page)*

**Figure 1.**
**Fuel Cell Operation**

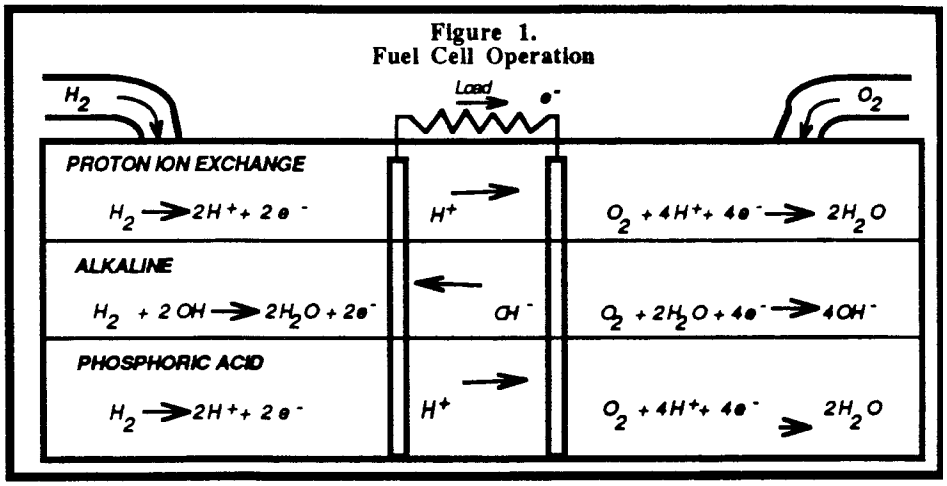


***Table 1.***
***Operating Temperatures of Various Fuel Cell Types***

| Type | Electrolyte | Operating Temps.* | Notes |
|---|---|---|---|
| Biological | Sodium Chloride | Ambient | Organic Cell |
| Proton Exchange | Semi-Permeable Polymer | 50 - 100 | 1st In Space |
| Alkaline | Potassium Hydroxide | 50 - 100 | Nat'l. Gas to H2 |
| Direct Methanol | Sulfuric Acid or Polymer | 50 - 120 | Methanol |
| Phosphoric Acid | Orthophosphoric Acid | 190 - 210 | Nat'l. Gas to H2 |
| Molten Carbonate | Lithium/Potassium Carbonate | 630 - 650 | Carbon Fuel |
| Solid Oxide | Stabilized Zirconia | 900 - 1,000 | Metal Fuel |

* *(Degrees Centigrade)*

# FUEL CELL TECHNOLOGY EXPLAINED

*(Continued from Previous Page)*

more compact, higher-range transportation applications.

Leading companies in these type of fuel cell developments in the U.S. are United Technologies Corp., Dow Chemical, General Motors, DuPont Chemicals, and Perry Engineering Systems of Florida. In addition, Ballard Technologies of Canada, Vickers Ship Building & Engineering of England, and Daimler-Benz of Germany have significant proton-exchange fuel cell development programs.

A joint program to develop a road vehicle powered by a proton-exchange fuel cell has been announced by the U.S. Department of Energy, Los Alamos National Laboratory, and United Technologies Corp. Hydrogen will be produced from methanol or petroleum gas using light-weight reformers. General Motors has announced a similar program to produce hydrogen for fuel cells using petroleum fuels. (See also the accompanying article on the Billings "LaserCel" fuel cell.)

*Roger Billings*

# "Breakthrough" Fuel Cell Unveiled

Dr. Roger Billings, who developed the first hydrogen-powered car 25 years ago, announced late last month a "breakthrough" in hydrogen technology that makes it cheaper to operate a car on hydrogen than on gasoline. This development, called "LaserCel", is a hydrogen fuel cell that reportedly overcomes the high cost of hydrogen by utilizing the fuel in a more-efficient engine and by facilitating the use of inexpensive off-peak electric power to make hydrogen from water. Billings claims that this new fuel cell, which replaces the conventional internal combustion engine in a car, can convert 60% to 80% of the hydrogen energy put into the cell into electricity. This compares with the thermal efficiency of a conventional internal-combustion engine that is less than 30%.

In addition, like Grove's cell of 1837, the "LaserCel" can be operated in reverse; instead of consuming hydrogen to make electricity and water, the fuel cell can be operated as an electrolyzer. An electrolyzer uses electricity to split water into its hydrogen and oxygen components.

At night, the owner of a vehicle can, therefore, connect electricity and water to his car and make hydrogen to fuel his car the next day. Since many power companies have excess generating capacity at night, they will often offer a special discounted rate for this "off-peak" power. Hydrogen generated in this way could, according to Billings, cost consumers as little as $.46 per gallon of gasoline equivalent.

***"We cannot wait any longer for leadership at a national level to develop an energy strategy that frees us from dependence on foreign oil."***

... Pennsylvania Lt. Governor Mark S. Singel

Billings and his associates at the American Academy of Science in Independence, MO, have entered into a contract with the Pennsylvania Energy Office to install a prototype LaserCel in an automobile. Pennsylvania Energy Office Chairman, Lt. Governor Mark S. Singel, said,"We cannot wait any longer for leadership at a national level to develop an energy strategy that frees us from dependence on foreign oil. We have to have some faith in ourselves, and we must be willing to invest in leading-edge technologies. Pennsylvania is committed to projects that will bring about the transition to clean alternative energy in this decade."

In the prototype automobile being converted for Pennsylvania, the hydrogen will be stored as a metal hydride. "The heavy weight of hydride tanks has historically limited the range of hydrogen cars; because this new fuel cell enables the car to go twice as far on the same charge of fuel," Billings explained, "we can now offer consumers a safe and pollution-free car with adequate range."

The "LaserCel" is fabricated by a high-power laser. It is also being tested for application in underwater vehicle propulsion systems in a joint project with Lockheed Missiles and Space Co.

# U.S. Department of Energy Responds To AHA Member Letter

*(Charlene Underberg, a AHA member from Phoenix, AZ, wrote a letter to the U.S. Department of Energy suggesting that more emphasis should be placed on hydrogen in U.S. energy policy. Below is a reprint of the response from D.O.E.)*

"Dear Mrs. Underberg:

This is in response to your letter of September 22, 1990, to Secretary Watkins suggesting increased use of hydrogen.

We agree with you that hydrogen has potential for use in the future as an energy medium. It is clean burning and can serve many applications now being satisfied by petroleum fuels or natural gas. However, unlike petroleum and natural gas, which can be extracted from nature's storage pools and caverns using a tiny fraction of the energy they deliver, production of hydrogen from water requires dedicated plants that consume several times the energy represented by the resulting hydrogen product. In this sense, hydrogen is similar to electricity: large quantities of a relatively low value energy source (for example, coal or the sun's rays) must be consumed to produce a lesser amount of a more valuable energy product (electricity or hydrogen). In each case, the principal question is what energy source is to be consumed to provide the valuable energy end-product.

We believe that renewable energy sources, particularly certain conversion approaches using solar energy, are important candidates for providing the raw energy needed to produce hydrogen. The renewable-hydrogen combination has attractive environmental characteristics. However, the performance of most of today's renewable energy systems results in delivered energy products -- hydrogen or electricity -- that are not economically competitive with conventional means of production. For this reason, we are currently placing greater emphasis on improving renewable and solar energy conversion devices than on hydrogen production. As renewable systems improve, increased attention can be placed on hydrogen.

We appreciate your concern for improving the Nation's energy future.

Sincerely,

Robert L. Martin
Deputy Assistant Secretary
for Utility Technologies
Conservation and Renewable Energy"

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## Editorial

# ARE YOU READY?

*By Sherwin N. Berger*

Transition to a hydrogen economy is a staggering task on a scale almost too large to grasp. It is in reality the structuring of a Second "Clean" Industrial Revolution. In anticipating such sweeping changes, we must be prepared with progressive, humane mechanisms to ameliorate the disruptions and dislocations that will inevitably occur. As in any massive social or economic change, there will be those who will bitterly oppose this Revolution. They will do so out of ignorance or to protect some perceived (often inaccurately perceived) vested interest. They will attack with lies, half-truths, and the most clever and manipulative sophistry that wealth and Madison Avenue can conceive. Be assured that this opposition will be more motivated by money than by principles.

It must also be emphasized, as forcefully as possible, that any negative connotation associated with the hydrogen energy transition will be more than offset by massive employment opportunities. These opportunities will consist of involvement in hydrogen technologies directly as well as in hundreds of industries and construction projects required to build the mechanisms and to site, operate, and maintain the equipment. Beyond direct involvement will be the indirect support contributed by research, development, engineering, teaching, transportation, etc. The sophistication level of hydrogen technology today can accurately be likened to the sophistication of the Model-T Ford versus a modern-day vehicle. The changes have been vast in automobiles as they surely will be with hydrogen technologies as they adapt and give way to more advanced engineering concepts, modifications to improve efficiencies, etc.

It is thrilling to be involved with promoting these dynamic concepts. We are uniquely positioned literally to change the world for the better. The responsibility is ours; our posterity demands it. Our sense of pride, purpose, and community creativity demand it.

Planetary and family continuity are the most meaningful treasures we can leave as our legacy. With a sense of compelling urgency, we must reclaim our individual and collective environmental rights. A legacy of planetary defilement and personal torment for our children and their children is truly unthinkable.

But are you ready? Will you devote your time, thought, efforts, and some funds to help propel this wave-of-the-future technology to its logical and desperately-needed conclusion? Will you "take the heat" of criticism, ridicule, and accusations of being "taken in" by a bunch of tree-hugging crazies or worse?

If you <u>are</u> ready, then join the thousands of researchers, engineers, chemists, biologists, physicists, architects, mathematicians, philosophers, and general citizenry who are already convinced that the continued viability of our biosphere is a cause mighty enough for a massive display of collective conscience ... and for meaningful actions to bring about a clean new world.

If you are one of us in spirit, *NOW* is the time to become one of us in fact. Make yourself more knowledgeable about hydrogen and a Hydrogen Economy. Become a member of AHA. Send for our list of available publications and video tapes. Buy them, read them, watch them; and then "take to the streets" to force the issue by voicing your passions for environmental and economic sanity.

## *A Philosophical View*

# HYDROGEN : THE GREAT HOPE

*By Janet L. Fox*

Man's presence on Earth has been for but a microsecond in the shadow of the cosmic eternity in which our planet evolved into a perfectly balanced, synchronized system that has supported life in millions of forms for eons.

Yet Man has developed a sense of serene omnipotence -- one that is hardly justified by history or the course of current events. While nuclear holocaust appears less of a threat now that the "Cold War" has thawed, we are beginning to focus more on other real and present dangers, ones that are just as life-threatening. We realize that we may not go out with a nuclear bang, but rather with a gasp or a whimper.

We see our planet's lungs, the rain forests, rapidly shrinking; our air supply becoming increasingly poisoned; large holes appearing in the ozone layer that serves as our UV umbrella; and our oceans becoming fouled with garbage and oil spills.

THERE IS BEFORE US THE SIMPLE BUT SAD TRUTH -- THE TRUTH THAT WE ARE SURELY ANNIHILATING OURSELVES WITH OUR ENERGY POLICIES ... AS SURELY AS IF WE WERE TO PUSH THE TRIGGER ON A NUCLEAR WAR.

Yet, for all our ill-guided actions, there remains a great hope for our survival. It walks in harmony with all existing life support systems. It is not a radical idea or even unusual. *That hope is hydrogen.*

We must join together and swiftly enact, to enable, to uplift, and to arm others with knowledge of this great hope.

Our action -- or the lack of it -- will most certainly determine our outcome as a species. We must opt for a system that correlates to everything living or non-living. This is the greatest calling to date upon the resources and energy of the human race. We can use hydrogen as the means to a better world -- a world unified by an energy form that can be made from virtually anything, even sewage. We will be able to run our homes, businesses, our transportation systems on this marvelous substance -- that is, to create a hydrogen economy that is virtually without pollution and is inexhaustible.

# HYDROLOGY ASPECTS OF SOLAR HYDROGEN PRODUCTION

*By Irving R. Jorgenson*

Since motor vehicles produce up to 80% of pollutants in our cities, and the majority of our population resides in these urban areas, arguably the first priority should be the production of hydrogen for an automotive fuel.

What, from a hydrology standpoint, would be required for a state like Arizona to produce all its own transportation fuel? 1988 Department of Commerce data show that Arizona has 3,210,021 registered vehicles for a population of 2,716,546, or an average of 1.2 vehicles per person. About 1.7 trillion gallons of gasoline is consumed in Arizona each year, resulting in the production of more than 18.7 million *TONS* of carbon dioxide and tons of other pollutants (benzene, formaldehyde, other unburned hydrocarbons, unstable oxides of nitrogen, and carbon monoxide).

*No wonder we have such smog and pollution in our major cities!*

Assuming an average of 2.3 gallons of water to produce one equivalent gallon of hydrogen, we need:

1.7 trillion gal. of gas X 2.3
= 3.9 trillion gal. water
+ 325,851 gal./acre feet of water
( which is one acre
covered by one foot of water)
= 11,000 AF per year
+ 365 days/year
= 33 AF per day on average.

Where do we get this amount of water? One alternative would be to use catch basins located around mountainous outcrops to collect rain water; but this requires a very large amount of land and catch-basin area.

Another much more feasible option, however, is to use effluent water collected in storm drainage systems of Arizona's largest cities. This water, for the most part, currently is drained off into flood plain areas and evaporated. Using this otherwise-wasted source of water would also be environmentally sound and would not have a need to file for or fight for water rights to this usable water resource.

This water could be piped into the production site and into holding tanks. (Tanks would be needed, because of the high rate of evaporation that occurs in desert areas.) I envision that we would need a distillation farm to take impurities out of this water such as the one depicted in the schematic above.

Using rain water also has the advantage of providing us with a source of relatively pure, unsalted water. Using ground or river water (or importing ocean water) would require desalination and purification processes to remove the salts prior to using it in the electrolyzer.

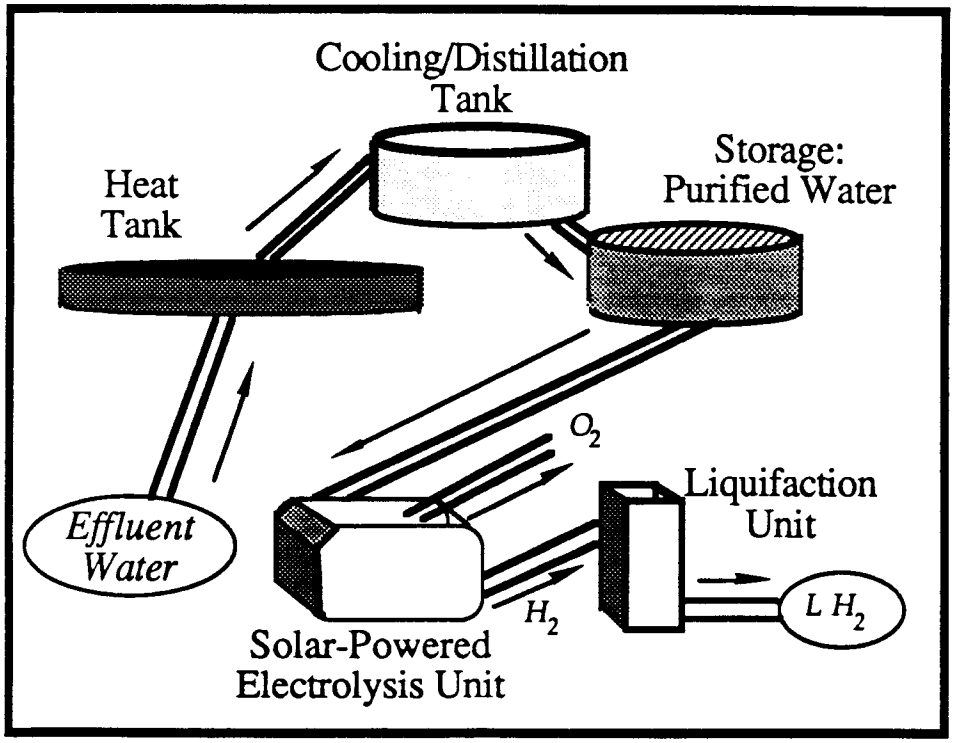


*Figure 2. Schematic Drawing of Possible Water Handling System for Hydrogen Plant.* Effluent water from city storm sewers is piped to large, dark-colored heat/storage tanks, where the water is heated to steam. The steam vapors are transferred to cooling tanks (which are either underground or coated with white or high-reflective surfaces). The steam cools and recondenses as pure water, where it is stored in tank farms for use as necessary in the solar-powered electrolysis system to produce hydrogen.

## Canadian Hydrogen Association Formed

The Canadian Hydrogen Association, based in Toronto, Ontario, has been organized as an affiliate of The Hydrogen Association (an international "holding organization" that coordinates activities among independent hydrogen groups such as the American Hydrogen Association).

The CHA will adopt the basic principals of AHA -- specifically, that its primary goal should be to educate the general public about hydrogen and develop "grass-roots" support for clean solar-hydrogen.

The founder, Michael Low, has already started stimulating grass-roots support for hydrogen by arranging for videotapes of the Solar Hydrogen Economy (originally produced by Harry Braun and AHA) to be provided to every high school, public or private, in the province of Ontario. In total, this represents 958 schools. "By 1999, these students will be 24-26 years old. If we are going to make a significant transition to a hydrogen economy by the year 2000, these are the people we need to get on the program today," said Mr. Low.

The group projects that it will have 600 members within the next 6 months.

# COMING EVENTS

**November 1:** Roy McAlister - Pres. of AHA - Guest Speaker on Hydrogen at the Global Town Meeting on Renewable Energy Technologies, Univ. of NM, Albuquerque. Led by U.S. Senator Bingaman and radio broadcast statewide: 6:30 PM
**November 6:** Roy McAlister, Speaker at Dinner Meeting with SAE Chapter, U. of A., Tucson: 6 PM
**November 9:** Harry Braun - All-day Seminar at NAU , Flagstaff

**November 12-16:** DLR/AHA Display at Univ. of Calif., Berkeley
**November 14:** ASU On-Campus Debate (12 Noon) and Booth in Mall (all day). Speaker is Roland Darr, Pres. of ASU Chapter of AHA. On ASU Campus, Tempe
**November 14:** Roy McAlister, Panel Discussion on "Social Implications of Technology" at GM Proving Grounds, Mesa
**November 14:** ASU-AHA Monthly Meeting: Guest Speaker is Mark Ginsberg from AZ Energy Office. Other speakers include Herb Hayden, "Hydrogen Products for the Marketplace" and Wayne Talbot, "Pollution and You". Room 218 Bus. Adm. College Building, ASU Campus, Tempe: 7 PM
**November 15:** Roy McAlister, Presentation at Texas A& M Univ., College Station
**November 16:** Bob Liden and Irv Jorgenson, Panel Discussion on Alternative Energy Systems at Hearst Mining Bldg., Univ. of California, Berkeley: 6 PM

**November 20:** Roy McAlister, "Hydrogen and ENSCO Plant Issue", at Western Int'l. University, Phoenix: 6 PM
**November 22:** *Thanksgiving Day*

**November 25-28:** 1990 Fuel Cell Seminar, Phoenix

**December 4:** *(Tent.)* DLR/AHA Display at the Calif. Energy Commission to commemorate CEC's 15th Anniversary, Sacramento
**December 5:** ASU-AHA Monthly Meeting: Room 216 Bus. Adm. College, ASU Campus, Tempe: 7 PM
**December 6:** Herb Hayden, forum on Alternative Vehicle Fuels, 11th Annual AZ Energy Management Conference of ASME, Hotel Park, Tucson: 3:30 PM

**December 10-12:** Annual Congress of Cercle Mondial Du Consensus, "Environment-Compatible Energies", Hotel Zurich, Zurich, Switzerland
**December 11/12:** *Hanukkah*
**December 14:** AZ Greenpeace Benefit Concert, featuring Bonnie Raitt and Kris Kristoffersen, Mesa Amphitheater, 7 PM
**December 15:** Wayne Talbot, AZ Republican Breakfast Club, Phoenix.
**December 17:** Anniversary of the Wright Brothers' historic flight at Kittyhawk. Unveiling of formal plans by Michael Low to make transcontinental U.S. flight in hydrogen-powered airplane.

**December 25:** *Christmas Day*

## American Hydrogen Association Members Busy Spreading Word

Although the American Hydrogen Association is less than ten months old, it has already become involved in a wide variety of different educational and related activities. Momentum is rapidly picking up as well, with an increasing number of members becoming actively involved on the speaker circuit.

The organization was publicly launched during the Earth Day celebrations this past Spring. AHA members attended events in Scottsdale, Tempe, Phoenix, Avondale, Cave Creek, and Prescott during the months of March and April, generally with booth displays and featuring a growing number of visual aids, hand-outs, and other promotional materials.

The pace continued during the Summer, with ten members of AHA venturing to Hawaii for the Eighth World Hydrogen Energy Conference.

In August, AHA acquired the elaborate DLR "Solar Hydrogen: Energy Carrier of the Future" display and presented it in shows during the next two months at the Arizona State Capital Building, Arizona State University, downtown Phoenix, and the University of Arizona. (The display is now on its way to California with Irv Jorgenson for shows at Berkeley and Sacramento.)

Members also were active in the ENSCO Toxic Waste Plant debates and initiative drives, in reviewing and commenting on the new proposed Arizona Energy Policy, and in participating on related radio talk shows and press conferences.

Several members have also presented speeches at various technical conferences, forums, and classrooms at grade schools through university level. The calendar above confirms that this work is continuing at an ever-greater pace.

# HYDROGEN NOW!

*By Herb Hayden, P.E.*

*Hydrogen is the energy alternative that can solve our energy, environmental, and economic problems today, using current technology and American industry.*

The Hydrogen solution has been overlooked by a lack of public awareness, dismissed as a technology that is twenty years in the future or discounted as uneconomical.

The truth is: on-going research and development since the energy crisis of the '70's, though slowed during the past decade, has produced breakthroughs in solar energy conversion using solar dish generating sets, in advancements in recovery of fuel from wastes, and in development of wind and ocean energy systems. In addition, costs of energy due to the depletion of resources and degradation of the environment will inevitably increase ... while the technologies of renewable energy will continue to improve.

Clean Hydrogen Energy is clearly the solution that best fits the economics and environmental challenges of the future. The most economical time to begin the transition is now. Several points must be made clear, to illustrate how the technology fits the issues:

**Hydrogen is economical and everlasting.** Hydrogen can be made from domestic renewable energy sources such as the sun, wind, and ocean energy by electrically separating water into hydrogen and oxygen. This allows any energy source to be efficiently stored, sold, and transported.

Renewable sources include solar dish generating sets (Stirling gen-sets) that are cost-effective and mass-producible now. Photovoltaics are also rapidly becoming more competitive. Offshore ocean wind power and ocean-thermal generators can economically produce fresh water while making hydrogen. Sewage and solid waste can be decomposed using bioprocesses and pyrolysis to make low-cost hydrogen while reducing the wastes to natural, useful materials.

**Hydrogen will benefit our economy.** By adopting renewable hydrogen energy, we will create jobs and eliminate dependence on imported energy. The money saved on imported oil will eliminate the trade deficit, and there will be no need to wage wars over oil.

**Hydrogen is non-polluting and non-toxic.** When burned, hydrogen combines with oxygen, forming pure water as its exhaust product. Com-bustion engines burning air always have a potential to form oxides of nitrogen, because of all the nitrogen naturally present in air, but these can be avoided or minimized in a hydrogen engine through proper design. With hydrogen, however, none of the other pollutants and components of smog such as carbon monoxide, carbon dioxide, and unburned hydrocarbons are created at all. In the event of an accident or fuel leak, hydrogen is non-toxic and rapidly dissipates. In the case of a fire, hydrogen burns quickly but with a very low radiation of heat and no toxic vapors.

**Hydrogen is very versatile and efficient.** It can be used to make electricity using fuel cells, and in engine generators. It can be used in automobiles, trucks, and aircraft. Existing engine designs can be effectively adapted by adding direct injection of the hydrogen fuel and changing the fuel system. These engines can also be multi-fuel, allowing them to run on hydrogen as well as petroleum or natural gas fuels. A hydrogen-electric vehicle is as practical as a battery-electric car, with less weight and no battery replacement costs.

**Hydrogen can be efficiently stored and transported.** Current technology favors liquid hydrogen, which has been demonstrated in several liquid hydrogen vehicles and filling stations. Emerging technology is providing developments every year in hydrogen storage as a room-temperature solid hydride and as a compressed gas. These new developments can be readily integrated into the use of hydrogen this decade.

The key point is: we have problems now, in energy security, pollution, and in an uncertain economy. Spending billions in oil wars and oil spill cleanups will not solve these problems. The answer is to avoid the costs of pollution and shortages.

To solve these problems, we must focus on the issue. The technologies are known, but without public demand there is a lack of direction and resolve. The public must learn that the future lies in clean, renewable energy, and that hydrogen and key solar technologies are available now to make it happen.

It will take much work and investment and involve all of today's industry; but the payoff is great. We need to get started now to secure that future for our children and ourselves.

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*"Never doubt that a small group of thoughtful, committed citizens can change the world: indeed, it's the only thing that ever has."*

--- Margaret Mead

# *SEASONS GREETINGS*

*From the Hydrogen Association Board of Directors and Staff*

*May this Holiday Season Be Filled with a Spirit of Thanksgiving for All Our Many Blessings;*
*May Joy, Hope, and Celebration Fill the Air;*
*And May 1991 Find Us Working with Renewed Spirit and Commitment*
*To Make Every Day Bright and Clean.*

## Join the American Hydrogen Association And Help To Make a Transition To Renewable Resources.

A transition from fossil and nuclear energy sources to solar-hydrogen technologies could fundamentally resolve many of the most serious environmental problems including global greenhouse warming, acid-rain, oil spills, sewage and trash recycling, stratospheric ozone depletion, urban air pollution or the production of additional radioactive wastes.

Take part in the most important transformation in history. Become a member of the American Hydrogen Association and help make a transition from the fossil depletion economy, to a renewable solar-hydrogen economy that will last forever. Do it for the children; do it to preserve the remaining wild animals that are struggling to survive in the vanishing wilderness areas; do it for yourself; *but do it soon. The time to stand and be counted is rapidly slipping away. . .*

*(Tear Or Cut At Dotted Line)*

*** * * MEMBERSHIP APPLICATION * * ***

❑ ***Yes,*** *I want to join and help make a transition to clean, renewable solar hydrogen energy.*

New Member Name: _____

Address: _____

City: _____ State: _____ Zip: _____

Telephone: Home: (  ) _____ Office: (  ) _____

Occupation and/or areas of special interest: _____

❑ Student Membership ($15/year)
❑ Regular Membership ($30/year)
❑ Corporate Sponsor ($1,000/year)
❑ Seniors (60 +) Membership ($15/year)
❑ Sustaining Membership ($100/year)
❑ Foreign Government ($1,000/year)
❑ Family Membership ($40)
❑ Life Membership ($1,000)
❑ Other Gift (specify amount) _____

Signature: _____ Date: _____

**Enclose check or money order and mail to:** American Hydrogen Association, 2026 West Campus Drive, Tempe, AZ 85282