

The Developing Hydrogen Economy Corridor

Southern California

The South Coast Air Quality Management District (SCAQMD), suffers from the most severe air pollution problems in the United States. This same area also offers the greatest potential for development of hydrogen fuel to overcome the problem of air pollution. Ozone and particulate matter (PM10) are the most dangerous pollutants identified in the district. Replacing fossil fuel combustion (FFC) with hydrogen would completely eliminate both of these pollutants. Hence, we have derived a master plan for the purpose of demonstrating the hydrogen energy system project. "The Integrated Hydrogen Infrastructure Corridor" will extend from the Pacific Ocean at El Segundo, California to the desert area of the Air Pollution District in Palm Desert, California.

Hydrogen: Energy Carrier for a Sustainable Society

Renewably generated hydrogen's unique qualities are its absence of pollutants and its inexhaustible supply. This makes hydrogen projects very attractive as potentially inexpensive, renewable, non-polluting sources of energy. Replacing fossil fuels with non-polluting renewables, including hydrogen, will result in less dependency on foreign oil, reduced air pollution and reduced health care costs. Hydrogen technology has significant support within the scientific, engineering, environmental and public health communities, and there is agreement that renewably generated hydrogen is a safe, clean, economical alternative to carbon based fuels.

Hydrogen has the ultimate potential to supplant all fossil fuels in transportation, household, and industrial applications. Hydrogen will also play an important role in the electric utilities peak power storage/management strategies, with regards to their solar, wind, geothermal, and hydroelectric capacity.

Uses and Benefits of Hydrogen

Transportation - It has been estimated that transportation is responsible for more than 60% of Southern California's air pollution and 50% in the San Francisco Bay area. The simple elegance of hydrogen is that it is derived from water and becomes water once again when burned or used in a fuel cell. Promoting hydrogen as a vehicle fuel will create jobs domestically while reducing the automobile's impact on the environment and public health. Hydrogen can be used as a clean burning fuel in internal combustion engines, hydrogen hybrid vehicles, and fuel cells for electric vehicles.

Industry: Stationary sources are responsible for over 40% of the pollutants which lead to degraded air quality in Southern California and the San Francisco Bay Region, most of which are associated with energy systems which could be converted to hydrogen. Hydrogen can be used to provide electric power and process heat for a variety of industrial applications. Because it can be stored indefinitely without degrading it can be used to effectively replace batteries for remote power storage and generation.



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Energy Independence: Nearly half of our national energy supply is imported causing a critical trade deficit. Fostering domestic renewable energy sources eliminates the effects of price shocks attributable to fluctuations in supply.

Employment & Commence: Large scale production of hydrogen in California would create high paying new jobs, increase exports and make California the world leader pollution free energy production.

Political Independence: Domestic energy independence would eliminate the effects of oil embargoes, political instabilities and the politics of scarcity, allowing this country to take an honest and firm approach to foreign policy.

"Free-Marketizing" Energy: Renewably derived hydrogen would begin to open up the energy industry to an authentic free market, where energy costs and policies would be dictated by production costs and not cartels.

Immediate Markets:

- **Corporate:** Strict new federal and state clean air laws mandate the use of clean fuel fleets for large companies located in the Los Angeles and San Francisco regions. These purchases represent a great potential market for purpose built and converted hydrogen vehicles.
- **Government:** Municipal purchases are an enormously important catalyst for the acceptance of emerging technologies. Clean Air Now will actively court municipal fleet purchasers to demonstrate converted and purpose built hydrogen vehicles in their zero and ultra-low emissions vehicle fleets.
- **Public Utilities:** California's electric utilities are increasing their use of wind, solar, and geothermal produced electricity. Unfortunately these forms of electrical generation are subject to natural forces, while consumer demand is not. Hydrogen and fuel cells are effective peak power storage and load leveling mechanisms. Operators of natural gas power plants can also be counted among prospective customers, as Hythane can help them meet air quality requirements without costly emissions controls.

ECONOMICS OF HYDROGEN:

Advancements in fuel cell development, and declining prices for solar, wind and geothermal electricity have made renewably generated hydrogen increasingly attractive. As the manufacture of these technologies improves, the costs will continue to decrease.

When produced with electricity from advanced wind turbines, hydrogen can be produced for as little as \$1.16 per gallon of gasoline equivalent. While this is a competitive price by itself, one should consider the absence of any pollutants from production or use and that hydrogen is three times as efficient an energy carrier as gasoline.

Infrastructure Projects in Southern California:

- **Clean Air Now - Xerox Solar Hydrogen Vehicle Project** - Currently, CAN is administering the installation of a solar hydrogen refueling facility and fleet vehicle conversion program for Xerox Corporation at its facilities in Southern California. This facility will be the largest demonstration site of its kind in the United



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States and, as such, will be of paramount importance with regards to increasing public awareness and acceptance of hydrogen as a transportation fuel and energy storage medium.

Ultimately, Clean Air Now proposes a 100MW solar hydrogen production facility in Southern California, and a 60MW facility in the San Francisco Bay region. These sites would provide fuel for hydrogen vehicle fleets and serve as clean-energy production facilities. The initial phases would consist of a 2-3 MW solar facility at ETEC (see below) and a 1-2 MW solar facility at one of the San Francisco area military bases due to be closed.

- **Energy Technology Engineering Center (ETEC)** - Canoga Park. This center is a national laboratory that is made available through the Department of Energy (DOE) to assess the necessary engineering quality control, safety and environmental aspects of new hydrogen demonstrations in the SCAQMD.
- **City of West Hollywood** - West Hollywood. The city will be utilizing a hydrogen vehicle in its city fleet. The "demonstration vehicle" approach is an integral part of efforts to increase public awareness and understanding of hydrogen technologies.
- **South Coast Air Quality Management District (SCAQMD)** - Diamond Bar. The SCAQMD Office of Applied Technology (OTC) under the leadership of Chief Scientist Dr. Alan Lloyd is considered a prime candidate for coordinating the entire regional demonstration project.
- **Praxair Hydrogen Production Plant** - Ontario. This plant is able to produce enough hydrogen, utilizing natural gas steam reforming, for the entire corridor during the initial phase of the demonstration project. This will be the only merchant facility utilizing fossil fuel hydrogen. Praxair will continue to supply hydrogen until the basin can be completely converted to solar production.
- **University of California Riverside (UCR)** - Riverside. This institution has an ongoing hydrogen research, development, and demonstration program. The facility produces solar hydrogen for use in campus fleet vehicles. UCR College of Engineering Center for Environmental Research and Technology (CE -CERT) is available for emissions testing on all hydrogen and alternative fuel vehicles in the SCAQMD. Future plans call for further expansion of the UCR hydrogen vehicle fleet.
- **Advanced Machining Dynamics (AMD)** - Highland. This small business has been active for over 20 years in converting internal combustion engines from fossil fuels to hydrogen, beginning with the original Zweig Dodge D50 truck.
- **City of Palm Desert** - Palm Desert. Several planned hydrogen programs include: - Electric golf cart conversion from batteries to hydrogen fuel cells. - Hydrogen / Natural Gas (Hythane) bus conversions by Hydrogen Consultants Incorporated - Hydrogen production by electrolysis utilizing wind power available at the San Geronio Pass or photovoltaic systems.

With the development of hydrogen related infrastructure, the progress of hydrogen demonstrations will be expedited. With the cooperation of and in coordination with all of the above mentioned parties, the SCAQMD is poised to become a showcase for the entire world regarding the use of hydrogen as a transportation fuel which will play a critical role in alleviating the health and environmental problems that are a direct result of



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fossil fuel combustion. Hence this plan is proposed to start-up a "Hydrogen Integrated Energy System" in California.

Development of an Integrated Hydrogen Infrastructure in Southern California:

California has been a pioneer in the use of hydrogen as a clean burning fuel. The South coast Air Quality Management District (SCAQMD) is a living laboratory for testing benefits of hydrogen utilization as a healthful, environmentally safe fuel. A historical review of hydrogen programs will highlight significant milestones of hydrogen system development.

- 1970 - Under the direction of Professor Van Vorst and the late Alfred Bush, an American Motors Corporation "Gremlin" was converted at University of California Los Angeles to utilize high pressure gaseous hydrogen. Later a United States Post Office jeep was converted to utilize liquid hydrogen.
- 1972 - Paul Diegas and Ben Minnick, of Perris, CA, developed a hydrogen vehicle utilizing liquid hydrogen and liquid oxygen on board a small truck. The pilot vehicle was operated by remote control and had a limited lifespan, but did demonstrate the feasibility of hydrogen vehicle conversions. Diegas and Minnick went on to convert two more vehicles, which were driven on public highways.
- 1973 - Dr. James Pitts, Director of the California State Air Pollution Research Center at University of California Riverside (UCR) proclaimed that the use of hydrogen as "the universal fuel" would eliminate all of California's air pollution problems.
- 1973 - California engineering schools clean fuel rally demonstrated various alternative fuel vehicles at the Riverside International Raceway. The committee found hydrogen to be the cleanest of the alternative fuels.
- 1975 - A Helioscience Conference was held in Palm Springs to investigate the feasibility of utilizing solar energy to produce various energy carriers, such as hydrogen.
- 1976 - The city of Riverside operated a 19 - passenger hydrogen bus, which was evaluated by the California Transportation Authority (CALTRANS). Their conclusion: "The hydrogen bus utilized its fuel very efficiently and could reduce air pollution in the South Coast Air Basin (SCAQMD); therefore, hydrogen vehicle technology should be pursued further."
- 1978 - A United States Department of Energy (DOE) study entitled "Energy Needs in Riverside, California" was performed by Battelle Columbus Laboratory. Their conclusions and recommendations are as follows: "Two synthetic fuels not dependent on petroleum appear to be feasible as substitutes for petroleum-based fuels. These are hydrogen in liquid form and methyl fuel. A satisfactory large scale demonstration of the feasibility and problems associated with the use of these alternative fuels could be conducted with the city of Riverside fleet vehicles."
- 1980 - A solar hydrogen conference was held at UCR. It was there that a new conversion was presented. This vehicle was a Dodge D50 truck converted by Clean Air Now, Denver Research Institute and Ergenics. It was driven from Denver to Riverside, refueling from a tube trailer supplied by Air Products Corporation.



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- 1990 - A solar hydrogen program was established at Riverside Community College, which was later transferred to the University of California Riverside(UCR). The University plans to have three vehicles running on hydrogen fuel. As the project continues, the staff will implement and test modifications, perform vehicle demonstrations for the AQMD, and conduct ongoing engine analyses.
- 1994 - During a meeting of the task force committees for the Department of Energy and AQMD regarding hydrogen, both organizations recommended that more demonstration and education programs be pursued to educate the public and elected officials about the beneficial use of hydrogen as an alternative fuel.
- 1994 - Sandy Thomas, Former Legislative Assistant for U.S. Senator Tom Harkin reported on the need for "Sustainable Energy." His recommendations are as follows: "To speed the development and utilization of hydrogen in the near-term, and to prepare for the eventual widespread use of renewable hydrogen, we propose the creation of regional 'Sustainable Energy Centers.' These centers would provide engineers and technicians with 'hands-on' experience in the safe production, storage and use of hydrogen. They would also serve as demonstration centers to educate and familiarize the public with the advantages of hydrogen. New hydrogen production, storage and utilization devices could be tested at the centers, and new hydrogen applications developed."
- 1994 - Eleven California State Legislators recommend to the California Transportation Authority (CALTRANS) that all new alternative fuel vehicles developed in the state of California be operated in Riverside and San Bernardino Counties. "Concentrating the vehicles in one region will encourage private business to locate fueling stations and other alternative fuel vehicles there."
- 1994 - Dr. Alan Lloyd, Chief Scientist with the SCAQMD, testifies before Congress about the benefits of hydrogen and the need for additional research and funding.
- 1994 - Clean Air Now (CAN) was awarded \$1.2 million from the White House Technology Reinvestment Project and \$250,000 from the SCAQMD through AB2766, a state fund for alternative fueled vehicles. The project involves the construction and installation of the largest application in the U.S. of a solar hydrogen generating facility and fueling station, as well as a fleet of Xerox utility vehicles converted to run on hydrogen.

The South Coast Air Basin is the site of many developmental hydrogen programs. These programs are designed to share data and encourage proliferation of viable technology for mass production and utilization of hydrogen. In this way we can move to an energy system comprised of non-polluting renewable sources with hydrogen used as a fundamental energy carrier and storage medium. By doing this we would alleviate many health problems, create good jobs, move toward domestic energy independence, and protect our fragile planet from disastrous climate changes.