5. PRELIMINARY REPORT ON A PROPOSED E/HV FUEL CELL PROGRAM

ハワイ大学マノア分校にある自然エネルギー研究所からアドバイザーの一人である太田本会会長へ送られた予備レポートです。

会員のご参考までに載せますが、無断転載を禁じます。

OBJECTIVES

- To develop an extended range electric hybrid vehicle powered by a battery fuel cell system.
- To initiate a program to provide transportation fuel from non-petroleum sources--biofuels/hydrogen (methanol, and other liquid or gaseous fuels that can be produced from renewable energy).

BACKGROUND

The Hawaii Natural Energy Institute (HNEI) of the University of Hawaii plays a lead role in the research and development of renewable energy in Hawaii (Ref. 1). In addition to conducting R&D involving the primary renewable resources (biomass, geothermal, ocean thermal, solar and wind energy), HNEI has active programs in alternative transportation, hydrogen, biofuels, energy storage, and material sciences.

Hawaii is dependent upon imported oil for about 90 percent of our energy supply. More than 50 percent is used for tansportation. Hawaii's abundant renewable energy resources has been shown to quite readily produce electrical energy. However, even though non-electrical needs represent the predominant need, on a relative basis, very little R&D funds have been spent on transportation fuels. A re-prioritization of emphasis has been made and an expanded effort has been initiated for biofuels.

ELECTRIC VEHICLE IMPROVEMENT PROGRAM

A Progress Report on HNEI's Electric Vehicle Program (Ref. 2) has just been completed. In brief, during the first three years of the EV program in Hawaii, the operational results were very poor for a variety of reasons. However, just during the past year, the EV improvement program funded by the USDOE has produced very positive results showing great promise.

Modifications have been made to several of HNEI EVs and a more reliable and efficient EV is now available with better drivability, longer range (up to 50 or more miles per charge), and so far, minimal road failures. The van (Dodge-Jet 1400 120 Volt), for example, had less than a 1,000 miles of use during its first three years, but since the gel-cells and new charger have been installed, in one month, over 1,000 trouble free miles have been driven, at an average energy consumption of .5 to .6 kWh per mile (less than

half of the original energy usage). Also, with three short term recharging cycles, in one day, the van traveled a total of 120 miles.

In fact, the current EVs can theoretically meet the daily driving requirement of over 50 percent of the cars on Oahu (where 80 percent of Hawaii's population lives). However, it is clear that an extension of the present range of 30-50 miles per charge would greatly enhance EV acceptability, as well as their ability to fulfill longer missions (e.g. delivery van, taxi, etc.). Hawaii has ideal climatic and utilization conditions for EV operation, and is understandably progressing as a major national test center to develop advanced concepts in E/HV technology.

FUEL CELL TECHNOLOGY

Although fuel cells have been considered a promising technology to produce electrical energy for utility use, stand-alone applications including hybrid systems with renewable energy technology, and for possible transportation uses, progress in real world applications has been slow. Los Alamos National Laboratory has played a lead role on behalf of the U.S. Department of Energy (Ref. 3 and 4). The Electric Power Research Institute and Gas Research Institute have also supported fuel cell research.

Hawaii's Pacific Resources Inc. (in cooperation with the Gas Research Institute (GRI) and USDOE) installed a 40 kW fuel cell at the Ilikai Hotel that has been on line for a several months now with good operating performance producing both electricity and hot water. The Englehard Corporation in New Jersey has successfully powered a fork lift truck with a fuel cell (Ref. 5).

A fuel cell manufacturer in Connecticut, however, indicated that the state-of-the-art of fuel cell was not yet ready for highway vehicles. Soleq, a manufacturer of improved EV control electronics (controller with regenerative braking, etc.), nevertheless felt that their system could effectively operate with the dual energy source (fuel cell and battery), indicating that a ten kW fuel cell could operate a van indefinitely (as long as fuel was available). Curtis-PMC, which manufactures a reliable and efficient transistorized controller (five of which are installed in HNEI improved EVs) also indicated that their controller unit could handle the fuel cell and battery power system in parallel. In short, there has been encouragement to pursue the fuel cell hybrid option.

Finally, U.S. Senator Spark Matsunaga, in September 1985, introduced two bills (S. 1686 & S. 1687) for fuel cell R&D and one to support research on hydrogen production from renewable energy (S. 1685). A Senate hearing on the subject has been announced.

SUMMARY OF HNEI RENEWABLE ENERGY HYDROGEN AND BIOFUEL PROGRAMS

HNEI has been involved with biofuels and hydrogen research since the mid 1970's. However, a special focus was initiated upon the arrival of Michael Antal, the Coral Industries chairholder, who has conducted fundamental research in biomass gasification.

HNEI sponsored the first International Symposium on Hydrogen Produced from Renewable Energy in 1984, and will hold the third meeting in 1986.

Since the 1984 symposium, HNEI has received $50,000 in two grants from Brookhaven National Laboratory and a $196,000 grant from USDOE through the Solar Energy Research Institute for a technology status assessment of "Hydrogen Energy From Renewable Resources" in cooperation with the Florida Solar Energy Research Center. Highlights of this research effort include:

a. A documentation of the present Hawaiian energy economy as a base case.
b. An assessment of conventional hydrogen production technology which could be adapted to the present, primary energy supplies in Hawaii to produce hydrogen.
c. An assessment of renewable hydrogen production technology options.
d. A system study which integrates hydrogen production, storage, distribution, and utilization options for the island economy.
e. A scenario for assimilating various levels of renewable energy produced hydrogen.

Also, HNEI is considering the installation of a small electrolyzer to produce hydrogen in Hawaii as part of a renewable energy storage test (REST) program. Two recent reports on HNEI hydrogen programs are available from HNEI (Ref. 6 and 7).

To re-initiate the expanded biofuel effort, HNEI hosted a high-level workshop in November 1984 [the proceedings in two volumes are available from HNEI (Ref. 8)]. In brief, the mission was to identify the most promising fast growing tropical species as feedstock for the production of solid, liquid or gaseous fuels. This program has drawn support from many sources, including the inclusion of a $500,000 appropriation in the FY 86 USDOE budget by the U.S. Congress for the Hawaii Biofuels Program. A parallel project under consideration is a proposal to build a gasifier pilot plant that could convert 50 tons a day of biomass into a medium BTU gas, which can then readily be converted into methanol. A university-industry team is being formed to respond to an expected USDOE solicitation. In the meantime, the Hawaii Legislature will consider up to $2 million of cost match for this and related programs. These programs to produce hydrogen and methanol will form the foundation for Hawaii's future transportation systems. The Governor's Transportation Fuels Task Force, chaired by Michael Antal, identified these options as critical for our long-term needs.

PROPOSAL

An improved EV van (Dodge-Jet 1400 with 120 Volt system) will be retrofitted with a 5 kW fuel cell. The van will be outfitted with either a PMC controller/gel-cell & Lester smart charger or a Soleq controller which has a regenerative braking feature; either an existing 120V charger and "wet" lead acid batteries or the next generation gel-cell system (which has a 10 percent increased energy density); and a next generation GE 60hp DC motor.

The vans will be outfitted with a DC to DC converter (120 Volt to 12 Volt) to ensure sufficient energy in the accessory battery to operate the controller, lights, horn and power-vacuum assist-brakes. This later feature is needed as an anticipated 600 to 1,000 additional pounds of weight may be added by a 5 kW fuel cell and its "fuel tank". As noted previously, the van is now consuming .5 to .6 kWh per mile of careful driving (100 to 150 amp

average draw), or a 40 to 50 mile range per full charge. Hence, a 5 kW fuel cell could add about 8 to 10 miles of range per hour of operating time, or 80 to 100 miles added range from 50 kWh of fuel cell energy over a ten hour day. Additional short charge cycles could add to this total potential of 130 to 150 miles if needed.

The fuel cell and battery pack would be placed in parallel, with the primary energy source for powering the car provided by the fuel cell, with supplemental energy from the traction battery pack. The surplus or unneeded energy from the fuel cell (when not needed by the motor or when the car is not operating) would be used to charge the batteries. This load leveling role of the batteries ensures a reserve energy level to return to home base and ensures the full utilization of the energy output of the fuel cell. If the Soleq system is installed, the regenerative braking feature would also provide a recharging element and improve the overall performance by an estimated 10 to 20 percent.

The phosporic acid fuel cell (PAFC) is the most advanced and suitable fuel cell for the initial project. Other fuel cell options might show longer term promise, but they all seem not yet advanced to the field test stage. HNEI will, of course, be open to considering them at the appropriate time. Of special interest would be those systems that have a higher electrical energy efficiency and lower thermal output.

The issue of hydrogen versus methanol (or other feed stock) fuel for the fuel cell will be studied. While hydrogen is the preferred fuel, and would eliminate the need for the reforming cycle, the three options for storing hydrogen present problems or limitations. For example, a standard 1A size tank of compressed hydrogen (about 4.5 feet long) contains only 200 cu. ft. of hydrogen , which could power a five kW fuel cell only for one hour. Hydride storage might be suitable, but there is a weight and cost problem that needs to be examined. Cryogenic or liquid hydrogen might have the least weight per BTU and kWh of energy, but availability of such a system is limited at this time. We will be checking with Dr. Furuhama of the Musashi Institute in Tokyo, who has pioneered work in hydrogen powered EVs using liquid hydrogen.

Methanol, on the other hand, presents an easier solution, as a ten gallon tank can fuel a 5kW fuel cell for ten hours providing an additional 80 to 100 mile range. Methanol might be easier to obtain and the cost at 60¢ per gallon would be comparable to gasoline (e.g., 5¢ to 6¢ a per mile) as well as electrical energy currently at 10¢ a kWh in Honolulu, which also works out to a 5¢ to 6¢ mile cost. HNEI will explore these various alternatives from interested industry participants.

CONCLUSION

HNEI has initiated a cooperative program to develop a better hybrid EV with government researchers (Los Alamos National Laboratory), private research agencies (EPRI, GRI, Electric Vehicle Development Corporation), industry, and researchers from other Universities. This proposal seeks to address certain strengths of EVs and fuel cells to together reduce the limitations of each.

The present improved EV is operationally sound but has a limited range that could be tripled by a five kW fuel cell. The fuel cell shows real promise as an efficient technology to produce electrical energy but currently has operating limitations that can be compensated for by a traction battery pack. Also, present fuel cells can not be turned on and off efficiently so a hybrid system with a 120V traction battery pack would minimize this problem. The cost of this hybrid concept test can be minimized as the EV van is already available and has sufficient space for installing the hybrid system.

Best of all, this proposal provides an excellent opportunity to create a vehicle that could fulfill many missions that currently can not be readily fulfilled by EVs nor by a fuel cell powered vehicle. The hybrid vehicle project being initiated can serve as a path finding solution to the transportation problems faced by Hawaii and the nation. Should this option prove to be successful, and important alternative will be developed to better utilize renewable energy for transportation.

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