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VOLUME 3

Energy Systems
Renewable Energy Resources
Environmental Impact
Policy Impacts on Energy

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OPERATION OF THE 25 kW NASA LEWIS RESEARCH CENTER SOLAR REGENERATIVE FUEL CELL TESTBED FACILITY

Gerald E. Voecks, Naresh K. Rohatgi, Darrell L. Jan, Ned W. Ferraro and Sonya H. Moore*
Jet Propulsion Laboratory (former employee)*
4800 Oak Grove Dr.
Pasadena, CA 91109
(818) 354-6645, (818) 393-4057 FAX

Marvin Warshay and Paul R. Prokopius (Consultant)
NASA Lewis Research Center
21000 Brookpark Road
Cleveland, OH
(216) 433-6126, (216) 433-8311 FAX

H. Sam Edwards, Garyl D. Smith
Naval Air Warfare Center
China Lake, CA 93555
(619) 939-6561 , (619) 939-7366 FAX

ABSTRACT

Assembly of the NASA Lewis Research Center (LeRC) Solar Regenerative Fuel Cell (RFC) Testbed Facility has been completed and system testing has proceeded. This facility includes the integration of two 25 kW photovoltaic solar cell arrays, a 25 kW proton exchange membrane (PEM) electrolysis unit, four 5 kW PEM fuel cells, high pressure hydrogen and oxygen storage vessels, high purity water storage containers, and computer monitoring, control and data acquisition. The fuel cell and electrolyzer subsystems' installation was carried out by the Jet Propulsion Laboratory (JPL). The photovoltaic arrays and electrical interconnect to the electrolyzer were provided by the U. S. Navy/China Lake Naval Air Warfare Center. JPL is responsible for conducting the testing and operations at the LeRC facility.

There are multiple objectives for this program. The near term objectives are: (1) design, assemble, and test the solar RFC power plant system to serve as a pre-prototype operational testbed facility; (2) evaluate performance criteria of the total system, subsystems, and components against various operational duty cycles; and (3) develop automation and controls commensurate with advanced system operating requirements. The long term objectives are: (1) develop a highly reliable, long life, highly efficient solar RFC power system for future manned space missions; and 2) demonstrate the dual use aspects of RFCs applicable to commercial and military applications. The system description and initiation of system testing constitute Phase I of multiple activities planned to take place in the next few years. System modeling is being performed in parallel with the experimental testing and will be used to determine the most efficient system design, from the standpoint of weight, volume and cost of electrical power.

INTRODUCTION

The National Aeronautics and Space Administration (NASA) has continued to pursue the exploration of space via both robotic and human missions. As human exploration tasks grow in length of time in space, a variety of problems are encountered, one of which is the provision of power for operating the human habitat. Small nuclear-based power generators have been shown to provide long term sustainable power on satellites sent on exploration missions to the outer reaches of our Solar System and beyond. However, the use of large nuclear power plants, necessary for providing kilowatts of power for life support systems, has not been completely agreed upon for future human missions for a variety of reasons, including the concerns about how safely they may be integrated into the life habitat operations. Unlike MIR and the future Space Station, a Lunar operation would require considerably more power over a vastly different operating duty cycle, suggesting the need for a reliable electric power plant that can be closely integrated into all functions of the habitat, including the heat produced from the electrical power generation or consumption. A Solar Regenerative Fuel Cell (RFC) system provides this possibility, and coincidentally furnishes a backup supply of oxygen and water available to the inhabitants in the event of emergencies or unforeseen problems.

The design of a Lunar habitat solar RFC power plant is made up of a combination of subsystems: photovoltaic (PV) panels for solar-to-electric power generation during the cyclic daylight period, approximately fourteen earth days; an electrolysis unit that uses DC electricity from PV to electrochemically convert water into hydrogen and oxygen and low grade heat; fuel cells that electrochemically convert hydrogen and oxygen into DC electricity, water and low grade heat during the cyclic night period, approximately fourteen earth days; storage tanks for pure water and high pressure hydrogen and oxygen; and automated controls. One approach for operating such a system would require the PV to supply both the habitat electrical and thermal energy needs during sunlight hours, as well as electrical needs for generating adequate hydrogen and oxygen to be used by fuel cells during hours of darkness. For this type of system, two candidate technologies have the greatest potential for adaptation to a