V.B.2 UNIGEN® Regenerative Fuel Cell for Uninterruptible Power Supply

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Objectives

Demonstrate hydrogen fuel cell based uninterruptible power supply with:

- Economic viability
- Real-world applications
- Regulatory code compliance

Achieve performance goals:

- Power output 3+ kW
- Storage capacity of 50 hours
- Instantaneous operation upon grid failure
- Maintain digital equipment with continuous electrical supply

Technical Barriers

This project addresses the following technical barriers from the following sections of the Hydrogen, Fuel Cells and Infrastructure Technologies Program Multi-Year Research, Development and Demonstration Plan:

Technology Validation

- I. Hydrogen and Electricity Coproduction

Education

- B. Lack of Demonstrations or Examples of Real World Use

Hydrogen Codes and Standards

- O. Insurance Companies Recognize Current Standards

Approach

- Fabricate UNIGEN® Regenerative Fuel Cell (RFC) Uninterruptible Power Supply (UPS) using modular components allowing flexibility in power output, run time, and recharge time
- Demonstrate technology performing useful work in a high visibility location with access to decision makers positioned to enable realization of the common usage of hydrogen based systems
- Obtain permits for siting and operation of the UNIGEN® RFC UPS unit through co-authoring of new code with local authority

Accomplishments

- Completed final design phase and development testing
- Completed fabrication of UNIGEN® RFC UPS and acceptance testing
- Completed system validation testing with unit sited at Proton
- Achieved modular architecture
- Achieved system performance goals, verified by test at Proton
- Installed system at the Mohegan Energy, Environmental, Economics Education Center demonstration site

Future Directions

- Obtain permit to operate system following final Mohegan Tribal Building Department inspections (early July 2004)
- Perform live demonstrations as part of environmentally friendly technology tours held at Mohegan Energy, Environmental, Economics Education Center demonstration site

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Introduction

The UNIGEN® Regenerative Fuel Cell (RFC) for Uninterruptible Power Source (UPS) project was initiated in October of 2002 as part of the U.S. Department of Energy State Energy Program (DOE/SEP). The objective of the project is to demonstrate a fuel cell based UPS with economic viability. The UPS is required to provide 1kW to 5kW of high quality electrical power to digital equipment without interruption in case of a power outage in a real world application. The UNIGEN® RFC UPS being fabricated by Proton Energy Systems as part of the project provides 3kW of electrical power without interruption during a loss of grid power using a Proton Exchange Membrane (PEM) fuel cell that utilizes pure hydrogen for power generation and a PEM electrolyzer for refilling the hydrogen storage system after the grid has returned to normal.

Approach

The project has three separate goals each requiring its own approach. The goals and the approach taken to meet each of them are summarized in the following paragraphs.

Economic Viability

The three key parameters of the Regenerative Fuel Cell Power system for use in a backup power scenario are power output, run time, and recharge rate. The power output is determined by the size of the fuel cell. The runtime is determined by the capacity of the hydrogen storage portion of the system. The recharge rate is determined by the output rate of the electrolyzer used to generate the hydrogen. The approach of the Proton UNIGEN® system is to separate these attributes into modular components. The modular system components allow flexibility in meeting the particular needs of future end users by easily accommodating different output powers, backup times, and recharge times. Modular component systems are fitted to the customers' needs in a building block approach enabling a "buy as you need" scenario. Modular components also allow capability for future expansion with maximum reuse of hardware, avoiding the need for total system reconfiguration. Modular components greatly simplify maintenance, as field repairs become simple module swaps.

Real World Applicability

One of the significant challenges facing the common use of hydrogen-based technology is the general reluctance based on lack of understanding and the negative safety perception of hydrogen. Demonstration outside the laboratory where the technology is performing useful work in an observable and hospitable setting is key to breaking down these barriers. The approach to this aspect of the project is to site the RFC UPS where the potential for educational impact is greatest. The Mohegan Energy, Environmental, Economics Education Center provides a unique opportunity for showcasing the technology in a real world application. The Center receives about 1,000 visitors annually with

the majority being professionals, governmental, and academics involved in the use, research, and industrial deployment of alternative energy technologies. Educating these decision makers is the first step in realizing the hydrogen economy future.

Regulatory Code Compliance

As with any new technology, one of the significant challenges is acceptance by local officials that are responsible for ensuring safety of the general public. This is also the case with the UNIGEN® Regenerative Fuel Cell UPS. Local safety and fire officials are familiar with the regulations outlined in documents published by the NFPA. They use these guidelines when assessing the installation and operation of equipment at their facility. Since hydrogen technology-based equipment is relatively new, the current regulations do not provide the needed guidance in all areas. The approach used in this project is to co-author a regulation with the local safety and fire officials, pulling applicable provisions from established regulations as they apply to the UNIGEN® RFC UPS. Having the demonstration at the Mohegan Sun facility offers a unique opportunity to accomplish this. The Mohegan Tribe is a recognized sovereign nation with its own governing body. As such, the Tribe has the ability to generate a new regulation that will be applicable to its facilities. The number of agencies and cognizant parties is small so the drafting and adoption process has a shorter cycle time than would be the case for regulations at state or national levels.

Results

The UNIGEN® Regenerative Fuel Cell for Uninterruptible Power Source demonstration project has achieved nearly all of the goals established for it. The fabrication and validation of the modular system is complete, the high value demonstration site has been modified and the system installed, and the permitting process is proceeding although no separate code for the UNIGEN® RFC UPS system has been generated.

The detailed design of the modular system was completed in November 2003. The system architecture was achieved with hydrogen generation, hydrogen storage, and fuel cell power generating functions in separate modules. The modules operate in semi-autonomously with self-diagnostics of their operating states and conditions and independent shutdowns in the presence of faults. Each of the modules reports its condition onto a common communication bus. Other modules interpret these status words so the entire system aligns itself to work in one mode or the other based on the conditions of each module. As an example, the hydrogen storage module issues a status that it requires refilling. The hydrogen generating module, if ready to produce gas, goes into its generating mode until the storage module stops requesting refill. Modules of each type can be added or deleted from the system, as customer needs change, with minimum system reconfiguration.

The UNIGEN® Regenerative Fuel Cell Uninterruptible Power Supply has been installed at the high value Mohegan Energy, Environmental, Economics Education Center (MEEEEC) demonstration site. Achievement of this installation was not without some schedule delays, however. As of the end of February 2004 the system had completed the required validation testing at Proton and was ready for installation. The indoor portion of the unit was installed within the planned time of about three weeks. The unit caught the attention of several groups that visited the education center even though it was not operating at the time. The UNIGEN® RFC UPS system is a centerpiece of the MEEEEC's overall environmental protection demonstration program and is the first hydrogen-based system on a reservation. The installation of the rooftop mounted hydrogen storage system,by contrast, involved some unanticipated impediments. Significant modifications to the roof structure were required due to the weight of the hydrogen storage system. Weather delays impacted the modifications for about seven weeks. Once the weather was cooperating and the roof was opened discrepancies between the site drawings and the as-built configuration of the building became apparent. This created an additional delay while modifications were designed and manufactured. The result was that the hydrogen storage unit was installed on June 22, 2004.

The permitting process for the system went smoothly once agreement was reached that the storage cylinders would be ASME rated steel tanks. Proton had originally proposed the use of advanced

carbon fiber tanks for weight and volume considerations. The carbon fiber tanks were not did not conform to NFPA 50 and the Mohegan Tribal Building authority would grant no exception. Generation of a new standard was anticipated but not timely achieved so as to be of use for the installation. Instead, it was agreed to generate the permit for installation and operation based on interpretation of existing codes.

Conclusions

The UNIGEN® Regenerative Fuel Cell for Uninterruptible Power Source project has broken new ground in the acceptance of hydrogen based systems. A modular system architecture was achieved and all of the system performance goals were met. A high value real world application has been established and the educational aspects of the demonstration are proving meritorious. The installation delays have taken away from the length of the demonstration as proposed for the project. However, the merits of the project have not gone unnoticed. Non-federal funding for additional system capabilities and continued demonstration into 2006 is likely. This continued support will enable the demonstration to go beyond the end of the DOE supported activity, which ends in September of 2004.