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16. Abstract (MAXIMUM 200 WORDS)

The U.S. Coast Guard (USCG) operates several hundred remote communications stations, radio navigation stations, weather stations and aids to navigation stations. Often these sites draw power from aging, inefficient power sources or unreliable underwater power lines, which are costly to repair and frequently out-of-service. Some of these sites are in environmentally sensitive areas, and in many instances, historical restrictions limit the use of solar panels. In the past few years, low power fuel cell systems have emerged as a potential option in the suite of remote power technologies. Fuel cells are highly efficient, environmentally benign devices that combine hydrogen and oxygen to create electric power.

In order to assess the potential of fuel cells in an operational marine environment, the USCG Research and Development Center conducted a demonstration at the Cape Henry Lighthouse in Virginia Beach, VA. The Cape Henry installation used a three-kW direct methanol fuel cell. Placed in operation in March 2002, the system ran for approximately six months. Performance data such as fuel consumption, power output, and reliability were collected and compared with conventional technology. An evaluation of costs, safety, training, fuel logistics, etc., was conducted to assess the potential for future use of fuel cells at other Coast Guard operational sites. Results of this demonstration were mixed. Several problems with fuel supply and overheating were experienced. It was concluded that fuel cell systems were not ready for unattended remote operation at Coast Guard sites. However, the technology has significant promise and should be closely monitored by the USCG as manufacturers introduce more reliable systems.

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EXECUTIVE SUMMARY

Responding to the U.S. Coast Guard's need for clean, reliable and economic electric power at several hundred remote sites, the U.S. Coast Guard Research and Development (R&D) Center undertook an evaluation of low-power fuel cell systems. At the time that this project was initiated in early 2000, several fuel cell manufacturers had demonstrated prototype systems primarily for residential applications. These systems ran on either natural gas or methanol, and provided a power output of 3-7 kilowatts, which is typical of a residential load, and roughly the power load of many Coast Guard remote sites. The R&D Center's objective was to evaluate whether these emerging fuel cell technologies could provide a superior product within the existing Coast Guard suite of power technologies (i.e., diesel generators, solar, wind, submerged cables).

In early 2002, with partial support from the Department of Energy, the Coast Guard R&D Center contracted with Fuel Cell Energy (FCE), Inc. of Danbury, CT, to install a three-kW direct methanol fuel cell at the Cape Henry Lighthouse located at U.S. Army Fort Story in Virginia Beach, VA. This site was selected as an operational site because it closely replicated that of a remote site, i.e., the oil building that would house the fuel cell and ancillary equipment had no electricity, heat or running water. The building was close to the ocean and it was logistically supportable during the prototype demonstration for fuel deliveries and servicing. In order to maintain continuous navigational lighting, the fuel cell system powered a separate lighting system identical to that of the adjacent lighthouse. The prototype system was operated for a period of approximately six months during which technical performance data, including fuel consumption, power availability, and stack temperatures, were recorded. Operational performance data such as installation costs, fuel costs, training, and safety were also evaluated during this period.

Safety emerged as an important and time-consuming issue for this project because the fuel, a mixture of methanol and water, had not been used by the Army and was not included in their handling systems. A preliminary hazard analysis was completed at the R&D Center to identify the most likely causes of catastrophic failure. This analysis and the engineering of the fuel delivery/handling system for the fuel cell resolved the safety concerns.

Results from this fuel cell demonstration were mixed. On the negative side, the initial cost of the fuel cell was many times higher than that of a comparably-sized diesel generator. The fuel cell was also considerably larger and heavier. The cost per BTU of the methanol/water fuel mixture was higher than that of diesel fuel (partly due to the small quantities used); a greater fuel volume is required for equivalent energy. Several problems with fuel supply were initially experienced, causing the fuel cell to shut down day after day during the first few weeks of operation. In two instances, equipment overheated and caused shutdowns. Operator error caused the system to shut down twice. There was only one occurrence of an internal failure to the fuel cell and that was with the fuel injector. Once recognized, each problem could be easily fixed. The system shutdowns caused the system to be off for 14 percent of the time. These problems demonstrated that, for the chosen system, overall reliability was insufficient for actual Coast Guard operational requirements.

On the positive side, the system efficiency for the total running time of 4090 hours was calculated to be 37.2 percent. The highest efficiency calculated was 39.6 percent. For comparison, a small diesel generator in the five-kW range would have efficiencies around 20 percent, while a diesel generator in the 300-kW range might approach 39 percent. An additional aspect relating to the fuel cell efficiency is that, throughout the entire test, the building was heated by the fuel cell exhaust (temperature 120 ºC), which was vented to the outside. If this waste heat could be recovered productively, a conservative estimate would add five to ten percent to the overall efficiency, bringing it up to 43 percent. Once the system problems were identified and corrected, the system achieved reliable power

output. The fuel cell component of the overall system ran flawlessly. The system was safe, and maintenance was not beyond the level of a trained technician. The fuel cell produces fewer harmful emissions than a diesel generator.

Overall, the fuel cell system offered significant potential. As manufacturers commercialize fuel cell products, the Coast Guard should continue to monitor their progress. It is anticipated that, over the next few years, fuel cell power systems will become less expensive and more reliable. When the technology is fully developed, the Coast Guard should re-evaluate adding fuel cells to its existing power options.