dti

PROJECT SUMMARY NO PS249

CHARACTERISATION OF 5kW FUEL CELL BASED UPS

Figure 1. Picture of the Gencore® fuel cell system

OBJECTIVES

- Prove by testing that a 5kW Gencore Fuel Cell system can constitute a viable and technically sound UPS system.
- Test and document the design integrity of the BOC's hydrogen system
- Characterise the dynamic and transient response of the system from gas to load
- Test and analyse as many fault conditions as possible
- Test the power electronics interface between fuel cell, battery and inverter (system uses a 10 minute autonomy battery for start up)
- Test and characterise the start up sequence and measure the reliability and effectiveness of the battery to fuel cell transition
- Obtain accurate, auditable and verifiable test data to verify the above.
- Produce a complete and detailed life of product cost model testing cost effectiveness with consideration to capital costs, maintenance costs, gas delivery costs, system reliability and end of life disposal as compared with the incumbent battery technologies.

SUMMARY

- A detailed description of the gas storage and delivery system is included in the report.
- The influence of temperature and stack power over start-up time was studied.

- To establish the dynamic operation of the fuel cell, load-switching tests, both of active and reactive nature, were carried out.
- The fuel cell has proven capable to equal the performance of a battery bank powering an AC load through an inverter
- Battery support is generally required for load transients greater than approximately 1.2kW.
- Efficiency is calculated using derived values, which confirms with values associated with this class (PEM) of fuel cell.
- Life cycle modelling is done to investigate the economic viability of choosing a fuel cell UPS over an equivalent battery operated UPS.
- A life cycle analysis is included to ease the decision of choosing a UPS based on autonomy and lifetime.
- Both capital cost comparison and operating cost comparison favour the fuel cell system when extended autonomy is considered.
- Tax breaks and capital allowances offered for other low carbon and low pollution technologies could be extended to fuel cell UPS equipment.

CONTRACTOR

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COST

The total cost of this project is £47,523, with the Department of Trade and Industry (DTI) contributing £31,538, and 15,985 the balance.

DURATION

13 months – March 2005 to April 2006.

BACKGROUND

- The contractor, siGEN Ltd have previously characterised a 1kW UPS along with DTI support. Some of the findings pointed to product limitations and need to study a 5kW system to achieve market penetration.
- A commercial scope for the 5kW system was seen in many practical applications for it offered significant technical and economical benefits over a battery or diesel systems

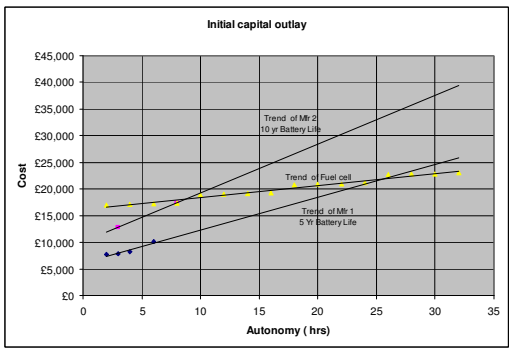
THE WORK PROGRAMME

- The fuel cell used in this investigation is from Plug Power, USA; model Gencore® 5B48 Fuel cell system
- The true online double conversion UPS mode defined in IEC 62040-3 is the preferred for systems of higher power rating.
- The inverter used is of Unipower Telecom's INV5000-HS-50, 5000 VA with a wide input DC voltage range (42VDC – 56VDC), and 230VAC 50 Hz output.
- The rectifier unit chosen is of Unipower Telecom RRS series consisting of two modules of 50A each with hot swap capability. The output can be varied using potentiometers from 47VDC to 57VDC.
- Since infrastructure exists for the storage and delivery of compressed hydrogen cylinders, they are a practical choice for the UPS.
- HAZOP analysis was carried out to minimise risks due to accidental leaks and misuse.
- A foam insulated stainless steel cabinet fitted with cylinder racks typically holds four cylinders.
- The cylinders are divided into two banks, with one as reserve. A bank consists of two cylinders, a vent valve, high pressure gauge, and isolation valve, leading to the automatic changeover regulator.
- Changing of a cylinder bank involves isolating the bank using the cylinder valves and, and replacing the cylinders. Cylinders can be replaced even when the fuel cell is in operation.
- Load banks, both resistive and capacitive, were constructed to simulate real life inverter loads.
- Testing was carried out to verify the operation of the fuel cell and establish its performance with respect to a battery-operated UPS.

Figure 2. Hydrogen storage cabinet with vent pipes

CONCLUSIONS

- The testing program addresses the concerns associated with a new technology by successfully evaluating the performance of the fuel cell against that of a battery bank.
- Operation has been verified throughout the output range using resistive and reactive loads applied to the inverter.
- Dynamic operation of the fuel cells is also tested using load-switching techniques
- Tests on inverter verify the stable transition from mains to backup and vice-versa.
- When annual operating costs are taken into account over a period of 10 years, the net present value of the fuel cell is significantly lower than a battery operated UPS.
- Economic analysis demonstrates the viability of the fuel cell above a certain autonomy period over an equivalent battery operated UPS.



POTENTIAL FOR FUTURE DEVELOPMENT

- The use of fuel cells as 'virtual power plants' for exporting power during peak demand to grid has a great potential combined with renewable energy. This would require testing in accordance with regulations such G83/1 and G59/1.
- The scalability of fuel cell systems for an increased power output could be tested for performance and reliability.

For further information about renewable energy please visit the DTI website at www.dti.gov.uk/renewables.

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