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By Frank Booty

Cell Generation

As the Government ponders a return to large scale nuclear power, Frank Booty examines the progress of fuel cell technology which has long promised to generate energy for individual buildings as well as towns and cities.

FUEL CELLS convert the energy from a chemical reaction directly into electricity and heat and could provide the future combined heat and power (CHP) solution for buildings. Although most fuel cells are still under development, they seem certain to play a large part in providing CHP in the hydrogen economy. For building applications, fuel cell systems offer modularity, and high efficiency across a range of loads with minimal environmental impact. Stationary fuel cells are ideal for power generation, either connected to the electricity grid to provide supplemental power and backup for critical areas, or installed as a grid-independent generator for on-site services.

The global value of fuel cell business could rise to £13bn per year by 2025 with global stationary fuel cell electricity generating capacity rising to over 15GW by 2011 from 75MW in 2001. Over 200 stationary fuel cell systems have been installed all over the world-in hospitals, nursing homes, hotels, office buildings, schools, power plants and an airport terminal. According to Phil Jones, chairman of the CIBSE CHP group, "CHP is the single biggest measure for reducing buildings-related carbon dioxide emissions. There's a range of CHP technologies including micro CHP up to 5kWe such as Stirling engines, reciprocating engines; small scale CHP up to 1MWe such as spark ignition, small-scale gas turbines (typically 500kWe), micro-turbines (30-100MWe); largescale CHP above 1MWe such as gas turbine, large reciprocating engines; and fuel cells which constitute another form of CHP-and may be small (1.5kWe) or large-scale (250kWe)."

Beacon Woking Borough Council has been awarded Beacon Council status by ODPM and has received numerous other awards for its Energy Services activities in the development of local sustainable community energy systems. Woking has the first small-scale CHP absorption chiller system and first CHP and photovoltaics system in the UK.This scheme was overseen by Allan Jones, now the chief development officer of the London Climate Change Agency. Ken Livingstone, Mayor of London says his challenge is to "Replicate what he achieved in Woking on London's world-city sized stage." CHP is important as 70 per cent of the UK's non-transport energy needs are thermal and most renewables are electricity generation only. CHP fuel may initially be a low carbon fuel such as natural gas, but this can be replaced later by a renewable fuel such as biomass or hydrogen when the primary energy generator is replaced.

"In environmental and sustainability terms the more island generation and local discrete-private wire networks are interconnected together, the more a city like London becomes sustainable in energy," says Allan Jones. "If other towns and cities did the same thing, there would be no need for large centralised power stations and the national grid. Overlapping local island generation networks would be the future grid."

Potential hydrogen projects in London include a huge property portfolio. Indeed embedded generation (CHP/renewables) is capable of providing all the UK's energy needs. What's needed is a progressive move towards this goal in parallel with the existing national grid until it is no longer needed.

Jones continues: "Hydrogen will be the energy carrier of the future deriving its energy from renewable sources. Fuel cells and the hydrogen economy derived from renewable fuels is the only technology/fuel that can meet the UK's future electricity, thermal and transport energy needs. The barriers to this are not technical but regulatory and vested interest." What are the practicalities of placing fuel cells in buildings, leaving aside for the moment the issues of cost and payback periods? Firstly, no flues are required and there are no combustion products at all. The unique advantages of fuel cells are:

- high electrical efficiency both full and part-
- pollutants are zero or negligible
- modular/flexible
- reliable/durable (no or few moving parts)
- low running costs.

At the heart of a working fuel cell power plant is the fuel cell stack which may contain several/hundreds/thousands of individual connected cells stacked together in layers. The cells each contain bipolar plates and an electrolyte similar to a battery (although the cells within a fuel cell require gas feeds whereas the fuel in a battery is contained within a depleting electrolyte). Stack designs depend on the type of fuel cell electrolyte, the material selection and operating temperatures. Fuel cells of all types use a range of recyclable materials including plastics, metals, ceramics and catalysts.

Fuel cells generate electricity by combining a fuel such as hydrogen with oxygen from the air to form water and heat (the reverse of electrolysis). In order of increasing operating temperature, cell stack technology for stationary fuel cell (FC) applications is: polymer electrolyte membrane (PEMFC), alkaline (AFC), phosphoric acid (PAFC), molten carbonate (MCFC) and solid oxide (SOFC). The operating temperature is important because lower temperatures give better response and start-up times, higher temperatures enable internal reforming of fuel. Lower temperature requires a higher grade of hydrogen (dictating the need of a reformer within the system).

Steven Glaser, consultant at the Greater London Authority's London Hydrogen Partnership, says, "Costs currently are about $10,000/kW of power which to put into scale compare with about 10 times less for a home boiler.

Logan Energy's John Lidderdale says, "We are installing a 5kW CHP unit in a facility for the US Embassy in London, a first for the UK." Logan Energy installed 30 projects at 21 locations in the US in 2004 and so far this year has taken on 15 new projects in the range 5kW-1MW.

"Acquisition costs are higher than alternative approaches now, but in the life-cycle costs area fuel cells do quite well," he explained. But how does this technology actually work in buildings? Shawn Galliers, senior consultant at Future Energy Solutions, explains. "Electrical applications are remote power supply, backup power, reliable power, parallel to the grid and grid-connected. Thermal applications are hot water, space heating, boiler make-up, swimming pool heating, heat source for absorption chiller and process steam applications."

Longer life Galliers cited several case study examples, such as four 200kWe PAFC-technology configuration for space heating, dehumidification and snowmelt where the cost of the fuel cells is negligible compared to the consequences of losing power; a fuel cell/gas turbine hybrid- 180kWe SOFC-technology configuration with pressurised fuel cell and high temperature heat exchangers providing an average electrical efficiency of 53 per cent; and CHP applications with a 250kWe MCFC-technology system giving a total system efficiency of 55 per cent. Key issues are what's required for successful implementation-the impact of the local electric utility rate structure, the utility interconnect requirements and the cell stack replacement costs. According to Galliers, stacks need to last longer, but Martin Fry, chairman of ESTA (Energy Systems Trade Association) reports that they should soon be working at 40,000 hours lifetime, with 80,000 hours is "not too far away."

More Info
www.cibse.org/chp
www.lhp.org.uk
www.loganenergy.com
www.bsria.com
www.aeat.co.uk
www.mtu-cfc.com
www.europeanfuelcell.de

The Woking system's cost was $900,000 at the factory gate-$4,500/kW-or £650,000. Installed cost was £1m. But in the period '1990/91- 2003/04, there were 31.3 per cent savings in energy and water budgets, 43.8 per cent savings in water consumption, 90.9 per cent saving in sulphur dioxide emissions, 78.6 per cent savings in nitrogen oxides emissions, 77.4 per cent savings in carbon dioxide emissions and 48.6 per cent savings in energy consumption.

So, fuel cells for buildings? Yes, once several key issues have been overcome, notably a manufacturing and support infrastructure in Europe, reduction in physical size of the overall systems and components, and economies of scale. The issue of ownership arises too. Do users own and maintain them, or do utilities buy them from manufacturers and lease (and maintain) systems to users?

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