Fuel for thought

Gail Rajgor reports on the development of fuel cell technology and asks how this technology can help the UK meet its climate change goals.

Last month saw the commissioning in the US of a 250kW Direct Fuel Cell power plant, while later this year a field trial of a simliar sized fuel cell plant is planned in Europe. But what is fuel cell technology and why is it being hailed by many as key in the fight against climate change.

The NECAR III fuel cell car from DaimlerCrysler uses a reformer to convert methanol on-line into hydrogen. Source: Ballard Power Systems Inc.

Speaking last October at the March for Peaceful Energy in Washington, Bernadette Geyer, deputy executive director of Fuel Cells 2000 claimed that the world was "on the verge of a revolution. A revolution in the way we drive. A revolution in the way we power our homes." This revolution, she added, "will challenge our idea of energy interdependence."

The development of fuel cell technology will, she said, make this revolution a reality. "Imagine a future where there are no powerlines, no fear that the lights will go out during a thuderstorm, no bills from the electric company," she said. "You will be your own electric company. Imagine a future where your car will be able to provide power and heat to your home along with clean drinking water.

"Just as the cellular phone has freed us from the tethers of the telephone cord, in the future you will have a portable personal power source to free you from the restraints of the power grid. In the future, there may be no power grid."

This future, she claimed, was not far away. Fuel cells provide heat and water for the space shuttle, but recent advances in the technology have brought it to the verge of commercialisation for everyday applications. (The first fuel cell was actually built in 1839 by Sir William Grove, a Welsh judge. Serious interest in the technology, however, did not surface until the 1960s when it was used in the US space programme.)

The technology is now being used at schools, hospitals, airports and office buildings as well as within cars, buses, and utility vehicles. They generate electricity using hydrogen from waste gases. "Clean, efficient fuel cells will reduce our need for fossil fuels," Geyer claimed. "Just 10,000 fuel cell vehicles running on renewable hydrogen or other, alternative fuels would save seven million gallons of gasoline per year."

Significantly, fuel cell technology can also be used in cogeneration units - such units are over 25 per cent more efficient than the utility grid on average. Fuel cell power plants emit 99 per cent less nitrogen oxide and 93 per cent less carbon monoxide than the average utility.

"And best of all fuel cells can be combined with other renewable energy technologies," Geyer added. "Hydrogen can be extracted from water using solar or wind-powered electrolysis or we can use hydrogen from biomass or ethanol."

She stressed: "Only by moving to a more efficient and sustainable way of generating and using energy will we be able to ensure the stability of our world in the next century. Fuel cells and other renewable and energy efficient technologies are our hope for a sustainable future."

Gary Acres, consultant to Johnson Matthey, a leader in the development of fuel cell technology and application, agrees. Fuel cell technology, he stressed, is "non-polluting and potentially more efficient than traditional power generation."

Although companies such as Shell and BP led the way in fuel cell technology development it is overseas companies such as DaimlerChrysler and Energy Research Corporation (ERC) that are now really taking the technology into practical applications. It was ERC which commissioned the 250kW plant in Connecticut last month and which plans to launch the field trials in Europe within the next few months - a project to be conducted in collaboration with its European partner, MTU (a subsidiary of DaimlerChrysler).

The reason for this overseas progress, Acres told SED, is due to the substantial funding support from their respective Governments for commercial application of the technology. "Unfortunately, here in the UK there is a serious gap between R&D and commercialisation of the technology," he said. "In the US, Japan and in other parts of Europe, you find that Governments are doing work to close the innovation gap. In the US, for example, commercialisation has been driven by legislation and Government-funded programmes. In the UK, the fuel cell programme to date has been limited to R&D. We are sadly lagging behind."

There is some good news, however. Woking Council does have an application of fuel cell technology which is currently being tested, while SED has learnt that one of the UK's largest generators is planning a major fuel cell project - an announcement is expected shortly, and of course, SED will bring you the full details. ■

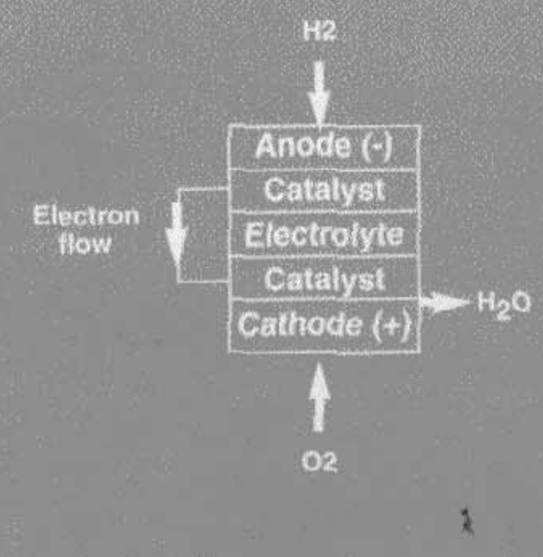
What is a fuel cell?

In principle, a fuel cell operates like a battery, although unlike a battery it will not run down or require recharging. It will produce energy in the form of electricity and heat as long as fuel is supplied.

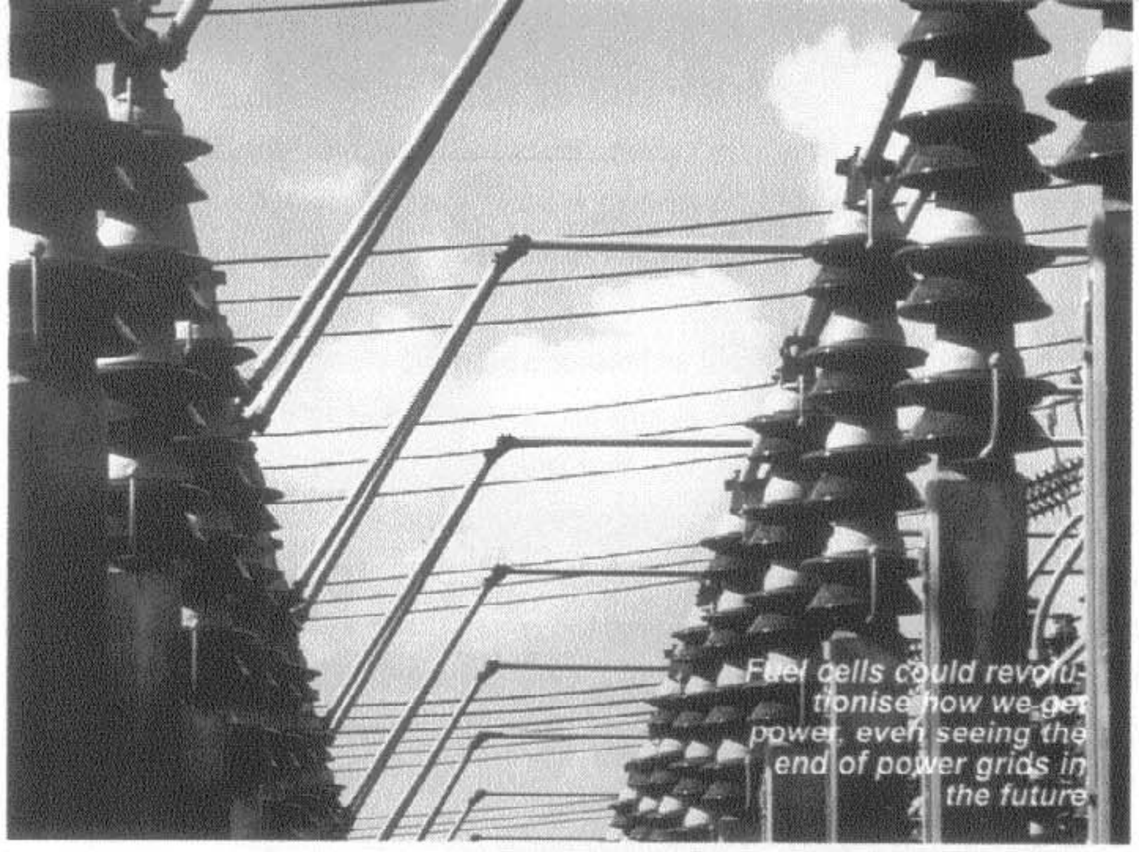
A fuel cell consists of two electrodes sandwiched around the electrolyte. Oxygen passes over one electrode and hydrogen over the other, generating electricity, water and heat.

Hydrogen fuel is fed into the anode of the fuel cell. Oxygen (or air) enters the fuel cell through the cathode.

Encouraged by a catalyst, the hydrogen atom splits into a proton and an electron, which take different paths to the cathode. The proton passes through the electrolyte. The electrons create a separate current that can be utilised before they return to the cathode, to be reunited with the hydrogen and oxygen in a molecule of water.



A fuel cell system which includes a 'fuel reformer' can utilise the hydrogen from any hydrocarbon fuel - from natural gas to methanol, and even gasoline. Since the fuel cell relies on the chemistry and not combustion, emissions from this type of a system would still be much smaller than emissions from the cleanest fuel combustion processes.



Fuel cells could revolutionise how we get power, even seeing the end of power grids in the future

Types of fuel cells

Phosphoric Acid

This is the most commercially developed type of fuel cell, most commonly fuelled by natural gas. Producing virtually zero emissions, it is already being used in such diverse applications as hospitals, nursing homes, hotels, office buildings, schools, utility power plants, and an airport terminal. Phosphoric acid fuel cells generate electricity at more than 40 per cent efficiency - and nearly 85 per cent if the steam this fuel cell produces is used for cogeneration - compared to 30 per cent for the most efficient internal combustion engine. Operating temperatures are in the range of 400^{O}F. These fuel cells can also be used in larger vehicles, such as buses.

Proton Exchange Membrane

These cells operate at relatively low temperatures (about 200^{O}F), have high power density, can vary output quickly to meet shifts in power demand, and are suited for applications, such as in cars, where quick startup is required. They have been hailed as the best potential candidate for light-duty vehicles, buildings, and potentially smaller applications such as replacements for rechargeable batteries in appliances such as video cameras.

Molten Carbonate

These promise high fuel-to-electricity efficiencies and the ability to consume coal-based fuels. It operates at around 1,200^{O}F. Suitable for bigger uses (10-100MW) where steam generation is involved for heat.

Solid Oxide

This can also be used in big, high-power applications such as industrial and large-scale electricity generating stations. Some developers also see its use in motor vehicles. This system usually uses a hard ceramic material instead of a liquid electrolyte, allowing operating temperatures to reach 1,800^{O}F. Power generating efficiencies could reach 60 per cent.

Alkaline

Long used by NASA on space missions, these cells can achieve power generating efficiencies of up to 70 per cent. They use alkaline potassium hydroxide as the electrolyte. Until recently they were too costly for commercial applications, but several companies are examining ways to reduce costs and improve operating flexibility.

Other Fuel cells

Direct methanol fuel cells (DMFC) are a relatively new development. The anode catalyst here draws the hydrogen from the liquid methanol, eliminating the need for a fuel reformer.

Regenerative Fuel Cells are very much in their infancy but would be attractive as a closed-loop form of power generation. Water is separated into hydrogen and oxygen by a solar-powered electrolyser. The hydrogen and oxygen are fed into the fuel cell which generates electricity, heat and water. The water is then recirculated back to the solar-powered electrolyser and the process begins again.