

FUEL CELLS: THE FUTURE IS NOW



FUEL CELLS: AN INTRODUCTION

A fuel cell is a device which generates electricity directly from electrochemical oxidation, usually of a hydrogen-rich fuel. The fuel cell structure separates the reaction into two distinct steps and it is this separation that allows the electrons to be captured and used to drive an outside circuit. Although the specific technology used in a fuel cell may vary, all are based around this fundamental design. Fuel cells can be used to power any device that requires electricity, from a mobile phone to a power grid, and have the advantage of operating with zero emissions, low noise and high efficiency. The electrochemical reaction in a fuel cell also produces heat which can be captured and used in heating buildings or generating hot water.

Although the first fuel cell was demonstrated in 1842 by Sir William Grove, it was not until the 1960s that fuel cells came to wider prominence, through their use as generators on board the Apollo spacecraft. Since then, and particularly in the last 20 years, substantial developments have increased the efficiency of fuel cell units, successfully demonstrated their use in a variety of applications and lowered their cost, making them commercially available in a variety of everyday applications.

Although fuel cells have long promised clean, efficient power generation, it is only in the last five years that the first applications have become truly commercialised. While light duty vehicles represent the largest single market for many fuel cell developers, it is in the immediate opportunities for stationary power generation and niche vehicles that fuel cells are seeing the most commercial traction. Most of the fuel cells sold to date contain pgm, which are used to give unique durability, power density and efficiency. Total demand for platinum in fuel cells reached 20,000 oz for the first time in 2010.

PGM IN FUEL CELLS

Fuel cells typically consist of two electrodes, a negative anode and a positive cathode separated by a solid or liquid electrolyte. Platinum group metals are frequently used at the electrodes to catalyse the electrochemical reactions that, overall, convert hydrogen and oxygen into water. Almost all of the fuel cells sold to date use platinum, with smaller amounts of ruthenium, and the use of pgm in fuel cells gives unique characteristics of durability, power density and efficiency.

The most commercially successful type of fuel cell in use today is the proton exchange membrane (PEM) fuel cell, which uses a polymer membrane as the electrolyte, with platinum coated electrodes. To date, this type of fuel cell has mainly been used in small stationary applications such as providing back-up power to buildings or infrastructure, in forklift trucks, and in demonstration fleets of fuel cell cars.

A variation on the PEM fuel cell is the direct methanol fuel cell (DMFC) which uses a polymer electrolyte membrane and a platinum or platinum-ruthenium catalyst, and is fuelled directly with liquid methanol. DMFCs have been miniaturised for use in powering small portable devices such as mobile phones and laptop computers.

THE CURRENT MARKET – AUXILIARY POWER

The camping and boating market has seen tens of thousands of units sold to date: mainly as DMFCs in luxury camper vans. A fuel cell can run continuously and independently of an electrical grid for as long as it is provided with fuel, and has the additional environmental benefits of low noise, low emissions and high efficiency.

Another current market for fuel cells is that of auxiliary or back-up power for stationary installations where the fuel cell offers a unique combination of high efficiency, low pollution and autonomous operation over long periods of time. Such units typically use PEM technology fuelled by hydrogen, LPG, methanol or natural gas. Cellular telephone operators are beginning to take advantage of fuel cell technology by installing the units for emergency back-up power at sites vulnerable to grid failure, or for primary power where the grid is not available. There are significant opportunities for fuel cell units in developing countries, where grid security is not guaranteed, and in places prone to natural hazards, where a reliable telecommunications infrastructure can aid relief efforts.

COMBINED HEAT AND POWER (CHP)

Fuel cells are being deployed around the world in CHP applications where the advantages of high electrical efficiency, low emissions and the co-generation of electricity and heat are an attractive proposition. Over 13,000 small PEM units have been installed to date in Japanese homes, where the government-supported large-scale residential fuel cell demonstration programme has encouraged their uptake.

A number of electronics and gas utility companies have joined forces to sell residential fuel cell CHP in Japan under the brand name of 'Ene-Farm'. These PEM units use natural gas or town gas and typically reduce household energy consumption by a third, and CO₂ emissions by half, compared with supplying electricity from a power station and heat from a gas fuelled boiler. Outside Japan, residential fuel cell CHP is also growing in popularity, with thousands of units currently installed in Europe and North America.

MATERIALS HANDLING VEHICLES

Many of the world's major car manufacturers are looking to release fuel cell cars commercially on a limited scale in 2015. Thereafter, these will form an important part of the world's vehicle pool. However, niche vehicles such as materials handling vehicles, including forklift trucks, are already commercial with thousands of vehicles deployed in warehouses, factories and airports around the world.

Forklift trucks powered by PEM or DMFC technology enable zero emissions and silent operation – often important in a warehouse environment. The crucial advantage that fuel cell materials handling vehicles have over their battery powered equivalent is that the vehicles can go on running over extended periods of time and do not require prolonged recharging. Fuel cells can be refuelled by hydrogen or methanol in minutes, rather than the hours required for batteries. Furthermore, operating a fleet of fuel cell materials handling vehicles eliminates the need for recharging infrastructure and the capex and storage space for multiple battery packs. This 'value proposition' of fuel cell materials handling vehicles has been realised by operators around the world, although further cost reduction is needed to make them truly competitive with battery or combustion engine vehicles.

FUEL CELLS ARE COMMERCIAL

Fuel cells offer genuine advantages over incumbent technologies, and their use in a number of commercial applications over the last five years has demonstrated their unique characteristics. Commercialisation in a number of niche early markets has been successful, and fuel cells are becoming increasingly mainstream. The implications for pgm demand are significant: many of the unique characteristics of fuel cells come from the nature of pgm catalysed reactions and, as the global market for fuel cells grows, they will form an increasingly important part of industrial demand for platinum.

