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THE ROBERT GORDON UNIVERSITY ABERDEEN

School of **Engineering**

Energy Storage & Renewable Power Systems

RECENT ADVANCES IN FUEL CELLS TECHNOLOGY

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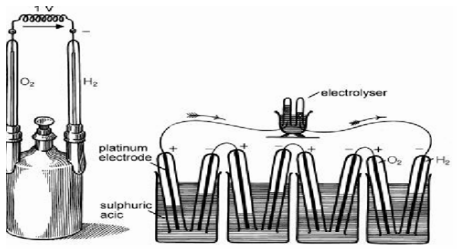
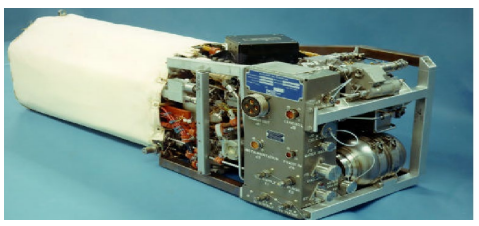
The 21st Century will be the **Dispersed generation** or decentralized power systems (wind turbines, photovoltaic, fuel cells FC) century. Fuel cell is an emerging energy efficient technology with zero carbon emission to replace engines and batteries saving millions of tonnes of carbon emissions. As Fuel cells reduce the dependence on fossil fuels, thus they have a significant environmental and national security.

WHAT IS FUEL CELLS AND HYDROGEN TECHNOLOGY

A fuel cell is a device that directly converts the chemical energy of a gaseous fuel (Hydrogen) into electrical energy, water and heat in a constant temperature process. **Overall reaction: $2H_2 + O_2 \rightarrow 2H_2O$**



Grove's gas battery (1839), voltage of 1V. First fuel cell



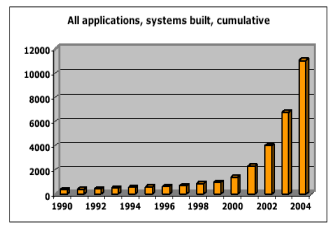
NASA's space shuttle Orbiter fuel cell.

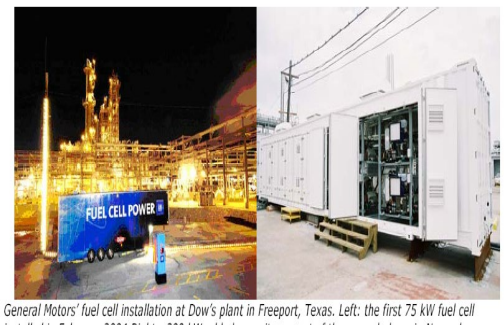
A fuel cell cogeneration power plant for residential applications, 5kW.

PEM plant, provides 250 kW enough to power a small building as a school or a community of up to 50 houses.

DEVELOPMENT & CURRENT APPLICATIONS OF FUEL CELLS:

- **William Grove** developed the first fuel cell in **1839**.
- **Francis Bacon** at Cambridge University produced the **first practical fuel cell in 1950.**
- **In the 1970's,** combination of low weight, reliable supply of electricity and heat and the drinking water production gave fuel cells considerable advantages in space applications so International fuel cells developed a more powerful alkaline fuel cell for NASA's space shuttle Orbiter.
- **Stationary applications:** because of the efficiency & reduced emissions of fuel cells compared to traditional fossil fuels-based supplies.
- **Military service power needs:** the efficiency, versatility, extended running time and quiet operation make fuel cells ideal.
- **Transportation:** the introduced legislation by the National & State authorities around the world that forces automobile manufacturers to supply vehicles that produce greatly reduced emissions, introduced the use of fuel cells.
- **Residential applications** (below 50 kW)
- **Portable applications:** miniaturised fuel cells offer key advantages over conventional batteries in (increased operating times, reduced weight and ease of recharging).





General Motors' fuel cell installation at Dow's plant in Freeport, Texas. Left: the first 75 kW fuel cell installed in February 2004 Right: 300 kW added capacity as part of the second phase in November

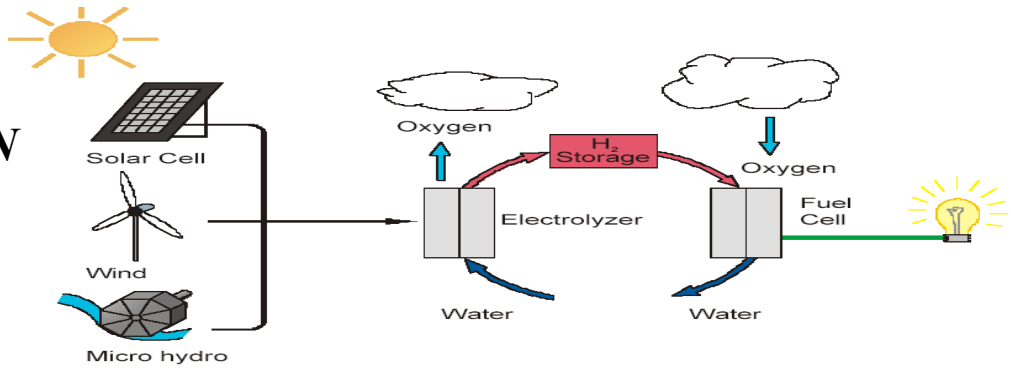
General Motors Project, 4 PEMFC to power 75kW (left), & 300kW (right)

WHY FUEL CELLS?

- The resulting efficiency is double that of an internal combustion engine.
- Lower CO_2 emissions
- They are quiet so no noise pollution.
- They can be made in a huge range of sizes, from portable applications up to high powers for electric power stations.
- They contribute to energy security.
- Store electrical energy when no energy is needed, thus there is no power loss.
- Provide automotive applications for better environmental considerations.
- Supply several times energy per equivalent unit weight than batteries, with easier re-fuelling.
- They can supply some buildings which need constant power supply (as a back-up power).
- They can be used as an emergency power supply or even a stand alone power for uninterruptible power supply (UPS) .
- More suitable for deserted regions of the world.

WHERE WILL HYDROGEN COME FROM?

- **Reformation of hydrocarbons**
- **Biological Methods**
- **Renewable Energy Systems**



FURTHER RECOMENDED RESEARCH

The development of a model that simulates the typical characteristics of a fuel cell stack as well as its design parameters that needs regulation, would help in the improvement of the fuel cell manufacturing cost and performance. As Solid Oxide fuel cell (SOFC) represent the second most developed fuel cell after PEM fuel cells, and as they are reaching pre-commercialization with hundreds of residential stationary power units (1kW) tested and larger units (250kW) being evaluated worldwide, and finally emerging as a power option for hybrid electrical vehicles (HEV) thus it became the market intensives making SOFC attractive (cost & performance) for a wide range of applications. A computer simulation of a SOFC plant, that can exhibit most of the basic fuel cell properties, is suggested as a further work.