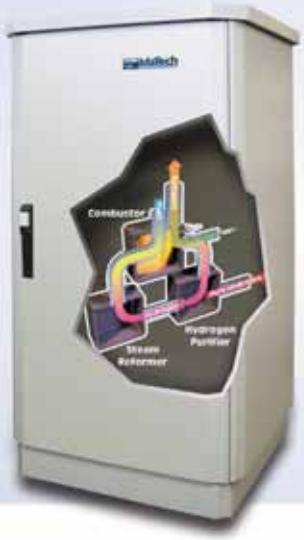
Has the hydrogen economy reached the data centre?



An exploration of state of the art power generation by fuel cell systems.

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With a field proven upper power rating of 10kW the hydrogen fuel cell is barely in a position to supply one IT cabinet, let alone an entire data centre, but the technology points to the future with a more confident finger than ever before. Higher power cells are planned to be increasingly economical as the cost (or scarcity) of fossil fuels increases and, ultimately, when fossil fuel stocks are so low as to be reserved for essential chemical feedstocks, the fuel cell will reign supreme.

What is a fuel cell? A fuel cell is a device that generates electricity by a chemical reaction. Hydrogen and oxygen (air) are the two "fuels" within that reaction and the great appeal of fuel cells is that they generate electricity with very little local pollution. Much of the hydrogen and oxygen used in generating electricity ultimately combines to form harmless by products - water and heat - critically with no carbon dioxide.

The hydrogen economy is the term used for a society that burns hydrogen instead of fossil fuel for all energy consumers (creating electricity for power, heating, cooling, transport etc.) The underlying principle is very simple; there are no carbon emissions to contribute to global warming or climate change. However, therein lies a key point. The source of the fuel (hydrogen) must come from renewable sources, for example using electricity from wind or solar power generation to electrolyse water. Even if the hydrogen fuel is derived from fossil fuels the technology still has one application; city centre generation or transport fuel without local emissions, the clean city air schemes.

A data centre, in its truest form, requires a high fidelity electrical power supply (normally an Uninterruptible Power Supply (UPS)), a short term energy storage system to bridge between the mains supply failing (most often a high voltage chemical battery) and a long term on site power source (typically a diesel powered generator system). In this way the **critical power system** can supply the entire data centre for several days even in the rare event of total grid power failure lasting for longer than a few hours.

There is still confusion over the question: is a fuel cell a battery or a diesel genset replacement? The answer, if one exists, is buried in the way the fuel cell operates in its present development phase. It is best described in terms of a black box, rather than a detailed treatise on the chemical reaction that takes place:

Hydrogen and air is pumped into the cell and out comes (low) DC voltage, water and heat (the reaction is about 50% thermally efficient). The heart of the system is a permeable membrane that allows the chemical combination. This membrane will last about 3-4,000 hours in continuous service. In this respect the fuel cell is akin to the genset, used as a standby power source and not suitable for continuous running.

So, in normal operation, the fuel cell has to sit in standby mode, seemingly like a lead acid battery on float charge. However, unlike a battery, when called upon to generate power it takes several tens of seconds (typically less than 2 minutes) to reach full power. Again, this is more akin to today's diesel genset. The start up delay means that some other form of bridging power is required, be that a battery (>5 minutes), a flywheel (<15 seconds) or ultra capacitors (<2 seconds).

Circumstances may have conspired to link the fuel cell to the lead acid battery rather than the diesel generator:

- The output is DC and the typical -48VDC telecom power is easily within technological application for remote sites where diesel generator starting reliability may be problematical
- Lead acid batteries (particularly in North America and Southern Europe) have had issues with predictability and short service life. So the long service life (few moving parts and higher temperature tolerance) of the fuel cell appeals
- The comparison of clean technology with hazardous lead can be raised, although this only applies where lead recycling is neither regulated or established, e.g. in USA. This is not an issue in Northern Europe.

We should now consider four remaining application issues:

Low voltage DC output

This is no problem for single phase low power UPS (<3kVA) as 48V is a common battery voltage and the fuel cell can be connected in parallel with a standard battery. For three phase and high power UPS the DC voltage will have to be boosted to, typically, 400VDC. The matter of voltage output is easily solved with an electronic converter (boosting DC-DC chopper) and boosting is likely to be more practical and economical than paralleling hundreds of fuel cells.

Heat output when generating power

For the present 5-10kW applications, and bearing in mind the limited duration of emergency generation, this is worth taking into account but hardly a problem. In the future, when fuel cells of several hundred kW ratings are applied the 50% thermal efficiency will dictate an external positioning where the rejected heat can be transferred directly to the environment without the need for any emergency mechanical cooling.

Fuel supply

Until the hydrogen economy is well established and the necessary infrastructure for piping high pressure hydrogen into facilities is operational, the fuel supply for fuel cells will be logistically problematical. Hydrogen is a very light and volume hungry fuel. Even at 200Bar the cylinders required for just a couple of hours at 10kW take up a considerable footprint. Some Facilities Managers are also nervous about high pressure, inflammable gas storage. A far more practical solution is available from Chloride and its technology partner IdaTech in the form of storage of a liquid methanol/water mix (wood alcohol) and a reformer. The reformer action adds marginally to the start up time but the advantages of footprint and absence of high pressure gas far outweigh the disadvantages. It goes without saying that the overall fuel cell solution is only green and/or sustainable if the fuel comes from a renewable source. Today the most common source of methanol is natural gas reforming.

Reliability

The simplicity of a lead acid battery cannot be matched by any form of fuel cell and hence the reliability of fuel cell technology cannot be compared favourably with a battery, it must be lower. There is, however, a case to be made on grounds of higher predictability rather than reliability, especially if the battery is of a poor quality, of an automotive derived design or if badly maintained. There is no question that under certain circumstances (e.g. redundant fuel pumps, valves and electronic controller) the fuel cell can be considered to be of superior starting reliability to a diesel fuelled reciprocating compression engine.

So where does this leave us today for 230V/50Hz IT applications? Clearly it is important to demonstrate the technology and continue to develop the application, making ready for the day when fossil fuel costs force the economics of the situation.

There are, even at today's costs and limited power ratings, situations where the fuel cell can be successfully applied, e.g. where the application demands a long autonomy (typical telecom related 4-8 hours, life safety or security systems) and no diesel genset power is available. For the low power applications that suit the current 5-10kW fuel cell rating the 48VDC output can be run in parallel with a short autonomy battery and can provide a perfectly clean power generation system. Such applications can include city centre locations where hours of genset operation are not possible through either noise or exhaust emissions, or both - not forgetting that the fuel cell itself is whisper quiet and only emits waste water and heat.

It is clear that at some time in the future the economics, due solely to the cost of fossil fuels, will be in the favour of fuel cell technology. In real terms fossil fuel derived energy is still cheap and certainly undervalued. As for the present economics; it is only financially viable if limited to the 5kW/8 hour autonomy/15 year life span type of application. Under most other circumstances the diesel supported system will always be lower in cost at today's energy prices. However, early adopters of new technology have always made decisions not based on pure economics and that is generally how technology has advanced so quickly in the past century or two.

The fuel cell may be at an embryonic stage in its life cycle but it is definitely here to stay and will, in many forms including stationary standby power and mobile transportation, form the basis of our future survival on this fragile planet.

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With over 36 years experience of writing technical articles for leading companies and institutions, Ian is a world renowned author and speaker and an expert in all aspects of critical power and building services.

Footnote : Chloride and its technology partner IdaTech offer a commercially available solution in the form of storage of a liquid methanol/water mix and a reformer. Systems can be demonstrated in operation in both the UK and France to anyone wishing to explore the possibilities.