From CO_2 to H_2O: Telecommunications go green

By Rainer Bücken – freelance journalist, Berlin, Germany

The telecoms sector is investigating the use of fuel cell systems to provide backup power for base stations. The NOW organisation in Germany is coordinating several demonstrations of various fuel cell technologies in telecom applications, through the Clean Power Net alliance of industry, federal and state government, and research institutes. This article reports on some of the projects, and highlights the collaborative nature of the initiative.

Where the normal power supply fails, autonomous technology is the only answer. This is needed more than ever for base stations for general mobile telephony, but also for public safety authorities and organisations (collectively referred to in Germany as BOS) in particular. When their power runs out, at best some supply would continue in so-called 'Direct Mode'. Clean technology in the form of fuel cells is regarded as the incarnation of clean energy supply. Where they can be used appears to be limitless – from heat and electricity supply for residential housing and businesses, from factories to cars, trains, computers, mobile phones, and not least base stations for mobile communications – in short, for 'green' telecommunications.

A base station's power supply must always work. The German Federal Agency for Digital Radio of Security Authorities and Organisations (BDBOS) says the network availability of a network cell is 98.5%. In the case of public mobile communications the requirements are less strict.

Nevertheless, today's usual combination of diesel engines and energy storage devices is largely seen as antiquated, since aside from electricity, they produce noise, smell, heat and CO_2. In addition, there are tight restrictions on installation and operation – not a drop of diesel is to seep into the ground, especially not in nature reserves and water protection areas.

A small fuel cell system being installed. [Photo: Hoppecke Batterien]

Mostly, lead-acid batteries are used for energy storage. Lithium-ion batteries are far too expensive, costing 10 times as much. This is where fuel cell technology comes in: by combining hydrogen and oxygen, they generate only electricity, heat, and water.

But clean fuel cell technology is some way off. That's why the German federal government, industry, and the scientific community established the National Innovation Programme for Hydrogen and Fuel Cell Technology (NIP) in 2006. This 10-year programme is tasked with drastically accelerating the market preparation of products of this technology. The costs of the total budget of €1.4 billion (US$1.75 billion) made available for the programme will be split equally between the federal government on the one hand, and participating industry on the other.

The NIP is subdivided into three programme areas: transport and hydrogen infrastructure, stationary energy supply, and special markets. NOW GmbH (National Organisation Hydrogen and Fuel Cell Technology) is responsible for the coordination and management of the NIP, as well as the Electromobility Model Regions Programme. 'Special markets' can access a total of €60 million ($75 million) over the period from 2011 to 2016. A portion of this is set aside for public safety authorities and organisations.

Projektorganisation Digitalfunk BOS Brandenburg didn't need to be told this twice. It has 140 base stations that have to be integrated and equipped with an uninterruptible power supply (UPS), provided they are not located on police property. Of these, 116 base stations will be supplied with UPS provided by fuel cells as soon as possible. Selecting the specific technology is no easy feat – four systems have been tested so far. By remote monitoring and control, power outages lasting from a few seconds to a maximum of three days were simulated.

Tendering

At present, the tendering procedure for the creation of these 116 units is being prepared, at which point the funding will follow through NOW GmbH. In total a project volume of €6.6 million ($8.3 million) is planned. In the meantime those from Brandenburg's BOS will have received the grant notification for almost €3.2 million.

The requirements involved for the largest of the new federal states are challenging: fuel cells must be both UPS and emergency power systems, and outages of up to 72 hours must be bridged – a requirement that not all federal states have taken on. At least three providers are to be given an opportunity by 2013, involving the widest possible range of fuel cell technologies. According to NOW, it will not necessarily be the least expensive offer that is granted funding.

Lower Saxony is also attempting to obtain funding for BOS base stations. From the 430 systems to be built, one is already operating with a fuel cell, in Stadersand on the River Elbe. Here 600 litres of hydrogen last for up to 74 hours. Another unit is to be added this year in Rinteln, on the River Weser, with another three by June 2013 in the district of Harz. The project budget is €365 000 ($458 000), with a funding portion of €175 000.

North Rhine-Westphalia is also preparing itself for the era of BOS fuel cells, with 20 systems planned. According to the BDBOS, Bavaria is also pursuing fuel cell emergency power systems. Rhineland-Palatinate is going for diesel engines, although no final decisions have been made. None of the projects are to achieve a similar scale to that in Brandenburg.

With a nationwide total of around 4500 base stations to be built, the fuel cell industry anticipates a lucrative business over the long term, even if the funding no longer applies everywhere. Many base stations must be built in isolated areas which are difficult to access in snow, flood, or storm conditions. Furthermore,

the trend is veering away from batteries – capacitors are adequate for the bridging time until the fuel cell gets going. Knürr is to deploy a 400 V_{ac} facility with a particularly secure future for a BOS base station in Karlsruhe. It supplies the entire location, i.e. not just 48 V for the radio equipment, and it also provides additional light and heat. However, a 'full supply' is not always required – an output of between 2 and 6 kW is enough for transmission and emergency lighting.

Is the goal an entirely autonomous base station?

The German mobile phone operator E-Plus has come up with an interesting project: it put Europe's first energy-autonomous base station into operation in Versmold in North Rhine-Westphalia in April 2012. The required power will be obtained by photovoltaic systems (Solar Tracking System, 8.7 kW), wind power (vertical wind turbines on the top of the antenna mast, 10 kW), batteries, and a fuel cell (Rittal with FutureE, 2 × 2 kW). The fuel cell system alone can cover 250 hours. In total, 24 hydrogen bottles – each with 50 litres of hydrogen gas at 300 bar (4350 psi) – are available, as well as a massive battery capacity. This will allow 7.88 tonnes per annum of CO_2 to be saved by means of renewable energies.

'E-Plus is to operate 13 such CO_2-free sites later. Through the Federal Transport Ministry (BMVBS), we are financing the fuel cell portion as well as energy management and interface with €2.3 million from the NIP,' explains Wolfgang Axthammer, Head of Programme at NOW GmbH. Deutsche Telekom planned but did not implement a similar autonomous base station in Hannover.

At the 2012 Hannover Fair, FutureE together with Emerson Network showcased such an autonomous system – with solar power and electrolysis – and with an efficiency of almost 50%. Up to 5 standard litres of hydrogen are generated per minute at 30 bar (435 psi), or 2 kWh of storable hydrogen from 4 kWh of solar power. If there is neither sun nor wind in winter, this gas must be converted into electricity via the fuel cell, which again has an efficiency of 50% – so that, from the original surplus of 4 kWh, 1 kWh remains. This means that the overall efficiency is approximately 25%.

'The big advantage is that the 1 kWh is then electrically available when it is needed,' says Mark-Uwe Oßwald, co-founder and Managing Director of FutureE. 'What is more, this kilowatt-hour is produced completely emission-free.'

Nevertheless, the demand for such energy-autonomous systems is limited in Germany. But for further afield, where there is no hydrogen delivery infrastructure, FutureE holds promising prospects. The industry estimates a worldwide demand of 3 million units.

Good investment

Prices for fuel cells vary widely, and the pure investment costs are already almost comparable with diesel units. But the manufacturers struggle when it comes to concrete data as there are many parameters to consider, such as output class, type of housing, fuel, technology, and installation.

While a diesel engine must be started manually onsite on a monthly basis for a test run, and always runs under full load in operational phase, fuel cells can be remotely fired up and all the parameters checked. Power is only produced in so far as it is 'consumed'.

Dirk Weniger from B+W assumes that from a Total Cost of Ownership (TCO) perspective, in three years' time a fuel cell system will already be cheaper than a diesel engine. He sees three reasons for the integration of fuel cells: the TCO perspective (the break-even point); the ecological aspect; and the approach that says, 'whatever the cost, the technology must be modern and reliable.'

Pure hydrogen is probably the most expensive and also most elaborate variant. It is also the cleanest and least complicated to operate. However, only experts are permitted to transport and connect hydrogen bottles. 'We have our own service company, and could supply pure hydrogen ourselves,' says Michael Tausch, Key Account Manager for IT/Telecom at Hoppecke Batterien. 'Reformers don't come into consideration for us; they use up too much energy and slow the startup of the fuel cell.'

In choosing the optimal system, the most different basic technologies and the choice

Germany's first energy-autonomous mobile antenna station in Versmold saves 7.88 tonnes of CO_2 per annum. Rafal Markiewicz is the proud owner. [Photo: E-Plus]

Heliocentris is focused on Acta's electrolysis technology, and plans zero-emission solutions in the telecommunications sector. [Photo: Heliocentris]

PEM fuel cell module rated at 1.5–6.2 kW. [Photo: Proton Motor Fuel Cell GmbH]

of current media supply play a decisive role. Pure hydrogen or hydrocarbons like propane, methanol, ethanol, bioethanol, natural gas, LPG for cars or diesel combined with a reformer – all of these require extensive analysis.

The Fraunhofer Institute for Solar Energy Systems ISE can help in this regard. Whether pure hydrogen is delivered and used, or hydrocarbons are 'reformed' onsite (that is to say, split into H_2 and CO_2) depends on the conditions of use. Ulf Groos, Head of Department for Fuel Cell Systems, thinks reformers are more vulnerable because of their high complexity. 'Most users therefore get pure hydrogen delivered, especially when consumption is minimal,' he says.

In using hydrocarbons – in whatever form – heat and CO_2 are produced in addition to H_2O. However, Dirk Weniger from B+W Electronic Systems sees advantages. 'Methanol is simpler to handle, can be delivered in 25 litre canisters, and refuelled by users themselves,' he says. But the material is hazardous – just 30 ml can be fatal. Rittal and SFC Energy want to work together on the development and distribution of direct methanol fuel cells, and recently introduced the first EFOY ProCabinet as a grid-remote power outlet.

Dr Martin Konrad, co-founder and Technical Director of FCPower Fuel Cell Power Systems, is enthusiastic about propane gas as an energy source: 'It's available everywhere, simple to transport, and can be connected by the user,' he says. '72 hours bridging time at 6 kW equals 10 bottles at 11 litres.' However, the fuel cell system needs around 15 minutes until the electrical power capacity is fully available, as the reformer must first be warmed up. Furthermore, propane is easily substituted by 'green' gas.

Fuel cell technologies have very cryptic acronyms, such as PEMFC (proton-exchange membrane fuel cell), HT-PEM (high-temperature PEM), DMFC (direct methanol fuel cell), SOFC (solid oxide fuel cell), AFC (alkaline fuel cell), MCFC (molten carbonate fuel cell), PAFC (phosphoric acid fuel cell) and so on, and there are many areas of application. 'Field testing should lead to better next-generation appliances – ones which are optimised with a view to current application specifics,' according to version 3.0 of the National Innovation Programme (NIP). In total 2000 systems are planned for public safety authorities and organisations, which will be co-financed through a market introduction programme.

A further issue for outdoor systems is housing with a resistance class of WK4 and fire resistance class of F30. These are 'not possible for diesel engines,' explains Michael Mansfeld, Key Market Manager for Tetra/BOS at Emerson Network Power – Knürr. The manufacturer is focusing on the FutureE hydrogen PEMFC, which has already reached its full capability after approximately 1–2 seconds.

Still no standard provision

It will take time for fuel cells to be operational in most telecom facilities. Their service life is often indicated as ranging from 1000 to 5000 hours. 'For emergency use this number is insignificant, as the 1000 number will at least in this country, never be reached,' asserts Bernard Krüsemann, Head of Development at HyPower GmbH.

The market for fuel cell systems is far from being a foregone conclusion. 'There is, however, a very welcome and strong movement, which also is being pushed through by the industry and research network Clean Power Net,' according to Ulf Groos at Fraunhofer ISE. It was initiated through NOW GmbH, under the NIP heading 'Critical power supply/UPS'. Above all, the so-called onsite hydrogen supply with solar, wind, and battery-operated energy supply – as well as electrolysis for isolated operational locations – is of course the technological outlook. But the path to this has only just begun.

For more information, contact: Dipl.-Ing. Wolfgang Axthammer, NOW GmbH, Fasanenstrasse 5, D-10623 Berlin, Germany. Tel: +49 30 31161 1620, Email: wolfgang.axthammer@now-gmbh.de, Web: www.now-gmbh.de/en

National Innovation Programme Hydrogen and Fuel Cell Technology (NIP): http://tinyurl.com/9bu7o8g (BMVBS) or http://tinyurl.com/9hs2n3n (NOW)

Federal Agency for Digital Radio of Security Authorities and Organisations: www.bdbos.bund.de/EN

Hoppecke Batterien: www.hoppecke.com

Projektorganisation Digitalfunk BOS Brandenburg: www.digitalfunk-brandenburg.de (in German)

E-Plus Group: www.eplus-gruppe.de/english

Rittal GmbH: www.rittal.com

FutureE Fuel Cell Solutions: www.future-e.com/en

Heliocentris Energy Solutions: www.heliocentris.com

Fraunhofer ISE, Fuel Cell Systems: http://tinyurl.com/bub3pj6

B+W Electronic Systems: www.b-w.com

SFC Energy: www.sfc.com

FCPower Fuel Cell Power Systems: www.fcpower.de (in German)

Emerson Network Power – Knürr: www.knuerr.com

Proton Motor Fuel Cell GmbH: www.proton-motor.de

HyPower GmbH: www.hypower.de

Clean Power Net: www.cleanpowernet.de (in German)

Research Trends

Infrared thermography for rapid detection of PEMFC catalyst layer thickness variations

N.V. Aieta et al.: *J. Power Sources* **211** 4–11 (1 August 2012).
http://dx.doi.org/10.1016/j.jpowsour.2012.02.030

3D cubic ordered mesoporous carbon as Pd catalyst support for formic acid oxidation

T. Maiyalagan et al.: *J. Power Sources* **211** 147–153 (1 August 2012).
http://dx.doi.org/10.1016/j.jpowsour.2012.04.001

Direct DME fueling of HTPEMFC at 150–200°C

J.O. Jensen et al.: *J. Power Sources* **211** 173–176 (1 August 2012).
http://dx.doi.org/10.1016/j.jpowsour.2012.03.039

Cr poisoning in (La,Sr)(Co,Fe)O_3 cathodes after 10 000 h SOFC stack testing

J.A. Schuler et al.: *J. Power Sources* **211** 177–183 (1 August 2012).
http://dx.doi.org/10.1016/j.jpowsour.2012.03.045

Partitioning of coal contaminants in components of liquid tin anode SOFCs

B.C. Nielsen et al.: *J. Power Sources* **211** 192–201 (1 August 2012).
http://dx.doi.org/10.1016/j.jpowsour.2012.03.057

Electrochemical properties of composite (Sm,Sr)(Co,Cu or Mn) cathodes for IT-SOFCs

Y.-P. Fu et al.: *J. Electrochem. Soc.* **159**(8)