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event report

Hydrogen and Fuel Cells in the Nordic Countries

Malmö, Sweden

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The flags of the Nordic counties: Norway, Sweden, Finland, Iceland and Denmark
Miguelb

Introduction

The fourth conference in this series was held in the southern Swedish city of Malmö on the 25th and 26th of October 2011. It was arranged by the non-profit fuel cell and hydrogen organisations of the five Nordic Countries: The Danish Partnership for Hydrogen and Fuel Cells; Hydrogen Sweden; Icelandic New Energy Ltd; VTT Technical Research Centre of Finland; and the Norwegian Hydrogen Forum. The conference provides a forum for Nordic collaboration in fuel cells and hydrogen, and allows the countries to benefit from shared experience.

This report will not cover every presentation at the conference but will pick out some key themes and give an overview of the Nordic programmes under discussion. A more comprehensive and detailed overview of all Nordic fuel cell activity will be published in a forthcoming Fuel Cell Today survey.

The conference programme and many of the presentations can be accessed through the conference website at: http://www.malmokongressbyra.se/hydrogen_and_fuel_cells_conference.

Hydrogen and Renewable Energy

The production of hydrogen and its integration into renewable energy systems was something of a central theme at the conference. It underlies the commercialisation of fuel cell vehicles, the use of hydrogen storage to balance the grid, and issues of energy security and flexibility – all of which are being given much attention in the Nordic countries.

Hydrogen from Electrolysis

The production of hydrogen by water electrolysis has a long history in Norway, with large quantities of industrial hydrogen being produced this way for decades. NEL Hydrogen is prominent in this area and Atle Taalesen told us that the company is drawing on its eighty-year legacy to develop electrolytic hydrogen as an energy carrier. It sees opportunities in transportation, grid energy storage, isolated energy systems and energy independence. To realise these opportunities, electrolysers must have flexible load operation with ultra-fast response time. After extensive testing at the Energy Park test facility in Porsgrunn, NEL Hydrogen is now releasing a new alkaline electrolyser which starts up immediately from standby, has a response time of <1 s and an operational range of 5–100%.

PEM electrolyser technology is also receiving attention. Magnus Thomassen of SINTEF brought us up to date on the NEXPEL project; that is, the 'development of a next-generation PEM electrolyser for sustainable hydrogen production'. The project aims to improve efficiency and lifetime while reducing cost. Progress is being made through the development of novel materials (including membrane ionomers and oxygen evolution catalysts), identifying cost-effective materials for bipolar plates and current collectors, and improved stack and system design. A stack demonstration is planned for late 2012, also at the Energy Park in Porsgrunn.

Hydrogen and the Grid

In his presentation, Raymond Schmid of Hydrogenics showed that hydrogen storage can be applied to more than peak-shaving: fast-response electrolyser technology can enable grid frequency regulation. Hydrogenics has demonstrated that a network of electrolysers can match the grid signal second-by-second. Following the load this closely is highly efficient, so that a 1 MW electrolyser could, in theory, be the equivalent of a 2.7 MW gas turbine. Overcapacity hydrogen would be used in refuelling stations.

John Nuttall

The perspective of the grid operator was offered by Kim Behnke of Energinet.dk, the independent public enterprise which supplies Denmark with electricity and natural gas. Behnke discussed the challenge of integrating large amounts of renewable energy, an issue that is increasingly pressing in Denmark. The Government's energy strategy is ambitious: for example, wind power was to constitute 50% of the electricity generation mix by 2025, but this target has now been pulled forward to 2020. The country already has ~25% wind power in the electricity supply. What this has done is to create a large, and growing, market for regulating power, for which the use of electrolysers and fuel cells is being actively investigated.

Flexible Energy Systems

In moving towards fully renewable energy generation, Behnke emphasised the need for a coherent energy system with high flexibility. He advocates a smart grid fully integrated with heat generation and transportation, areas where hydrogen and fuel cells have obvious application. Biomass and organic waste must also be used in an intelligent way – are they best combusted, converted to biofuel, upgraded to methanol, or used to produce hydrogen? All these options are being explored.

ZEG Power in Norway is building a pilot plant to co-produce hydrogen and electricity from biomass, with integrated carbon capture. According to Managing Director Bjørg Andresen, the company's proprietary process has an efficiency of over 80% and the carbon capture is accomplished at low cost. Any hydrocarbon fuel can be used, and the proportions of electricity, hydrogen and heat generated are flexible. The process uses advanced sorption-enhanced steam methane reforming (SE-SMR) and SOFC technology. The pilot is being built in conjunction with HyNor Lillestrøm at Akershus Energy Park near Oslo.

HyNor Lillestrøm is both a company and a project. At Akershus it will establish and operate a hydrogen station with on-site renewable hydrogen production and storage. Managing Director Jan Carsten Gjerløw told us that the renewable energy system will include both solar power and biogas and that state-of-the-art technologies for hydrogen production, compression and storage will be tested, including SE-SMR and metal hydride compression from HYSTORSYS.

In the demonstration project, the hydrogen will fuel Think Hydrogen cars (H2EV Gen2) that have been customised by H2 Logic and IFE (the Norwegian Institute for Energy Technology). Commissioning of the refuelling station is expected in the first quarter of 2012 and the facility can be visited from early next year.

Overview of Nordic Programmes

The Scandinavian Hydrogen Highway Partnership

The SHHP has existed since 2006 and comprises the three bodies which coordinate hydrogen activities within their respective countries: Hydrogen Sweden, Hydrogen Link Denmark, and HyNor. Its aim is to ensure that Scandinavia will be one of the first regions in the world where hydrogen-fuelled vehicles (primarily fuel cell vehicles) are introduced. Mikael Sloth, Business Development Manager at H2 Logic, provided an update on the Partnership's strategy.

The SHHP emphasises that the commercial introduction of FCEVs, slated for 2015, requires early infrastructure to be in place well ahead of 2015. It is working to achieve this in Scandinavia through a number of demonstration projects (the major ones being H2 Moves Scandinavia, CHIC–Oslo, and Next Move) and the creation of clusters of hydrogen stations in urban centres, with a few smaller stations interconnecting these. The 'highway' has 47 vehicles in operation and nine stations, with a further three under construction (of these, the Oslo station will open this month – see below). Many more are under consideration.

The SHHP's next step will be to get overt government backing for early hydrogen infrastructure. By sending a clear signal that the market will be supported until it becomes self-sustaining,

governments can create a favourable environment for the introduction of FCEVs. Without this assurance, it will be more difficult to attract early deployments by the various vehicle OEMs.

H2moves Scandinavia

More detail on this project was given by the coordinator, Dr Ulrich Bünger of LBST consultancy, who highlighted the importance of continuity in hydrogen demonstration activities to maintain momentum in cooperation.

H2moves will assess and build customer acceptance of the newest generation of hydrogen fuel cell vehicles, rolling out ten Mercedes-Benz B-class F-CELL and five Think Fuel Cell City Cars (Think battery electric vehicles that have been retrofitted with fuel cell range extenders by H2 Logic). These could be joined by four more cars of an unspecified make (the contract has not yet been finalised). In June 2012, a European tour will be undertaken to demonstrate the vehicles, accompanied by a mobile hydrogen refueller.

The project has also seen the construction of a hydrogen refuelling station in Oslo, which will be officially opened on the 21st November. The station will dispense precooled hydrogen at 700 bar, with a filling time of less than three minutes (the design was piloted by owner/operator H2 Logic in Holstebro, Denmark, where its first station of this type opened in June this year). Much of the demonstration activity will be centred on Oslo: southern Norway was already a 'hydrogen hub' and this position has been consolidated by the addition of the Oslo station.

Think Fuel Cell City Car
Source: H2moves Scandinavia

The Danish Partnership for Hydrogen and Fuel Cells

Virtually every Danish stakeholder is a member of the partnership, with competencies in the whole value chain represented. It is also very successful at attracting funding, with a major part of this coming from Denmark's Energy Technology Development and Demonstration Programme (EUDP). However, Director of the Partnership Aksel Mortensgaard pointed out that this fund is focused on demonstration, and that it is less easy to find funding past demonstration to market introduction.

The Partnership's broad strategy encompasses R&D and smaller demonstration projects to 2014, large demonstrations between 2014 and 2020 (for which funding must be identified) and commercial deployment from 2020 onwards. It is however working on a fairly major roll-out of fuel cell back-up power systems across Denmark, a market in which Mortensgaard sees considerable demand should costs come down sufficiently.

The Danish residential combined heat and power (micro-CHP) project will see 100 systems demonstrated by 2013, after which it is hoping to deploy a further 10,000 systems in a large-scale demonstration. Materials handling is another area of interest, with a cost reduction of around 30% through economies of scale deemed necessary before full commercialisation can occur.

The Finnish Fuel Cell Programme

Jari Ihonen of VTT provided an update of the Finnish fuel cell programme running from 2007 to 2013. The programme is coordinated by Tekes, the Finnish Funding Agency for Technology and Innovation, and includes over 60 companies and in excess of 400 participants.

The Fuel Cell Finland Industry Group (FCF) operates in parallel to Tekes, but in August 2011 a joint demonstration project was launched, called Demo2013, which is working towards a major fuel cell demonstration in the Port of Helsinki. Increased public acceptance is a key aim, as is awareness of the viability of the technology among policy makers.

The demonstration will encompass a 50 kW stationary SOFC system, hybridised PEMFC trucks and forklifts, light-duty fuel cell vehicles and associated hydrogen refuelling (from Woikoski Oy), and demonstration of fuel cell APU by Wärtsilä using natural gas as fuel. A fuel cell back-up power system by Finnish Company T Control, based on a Dantherm system, will also be tested. The project partners would like to test materials handling vehicles from various suppliers in the heavy-duty environment of the harbour, as they see considerable potential for fuel cell powered cargo-handling.

Icelandic New Energy

The Icelandic Government's first hydrogen policy measures were taken in 1998 and Icelandic New Energy (INE) was established as a non-profit organisation in 1999. The world's first commercial hydrogen refuelling station opened in Iceland in 2003 and fuel cell demonstrations have been running on the island ever since. A wealth of experience has been gained, and INE General Manager Jón Björn Skúlason wants to disseminate this as widely as possible. He is not alone: its Government intends Iceland to be an international platform for testing the technology.

Steps towards establishing a hydrogen/electric mobility economy on Iceland were taken through the SMART-H_2 demonstration of FCEVs and marine fuel cell APU that ran from 2007 to 2010. Battery electric vehicles were added to the demo at the Government's request and the project was extended through 2011. All information, including impact and technical assessments, will feed into Icelandic policy.

The stringent requirements of the Icelandic fishing fleet mean that further testing of fuel cells in this application has been deferred until the technology is more mature. By contrast, the performance of the fuel cell vehicles and the hydrogen refuelling station exceeded expectations. However, Skúlason says that 'stamina' is needed: commercialisation is taking longer than anticipated and growing the FCEV fleet on the island is difficult due to the limited number of vehicles available.

The North Atlantic Hydrogen Association

NAHA was founded in 2006 and brings together key players from Iceland, Greenland and the Faroe Islands, the east coast of Canada, and the Norwegian Hydrogen Forum. Again, its focus is to disseminate information on hydrogen technology, while building on RD&D and supporting policy makers. A workshop to share experience between the members is held each year: the chosen focus for 2010–11 has been wind energy applications.

Chairman Christopher Kloed described two demonstrations currently being run by NAHA members. The Ramea Island wind–hydrogen–diesel energy project is running off the coast of Newfoundland and a hydrogen storage project is underway in Nuuk, Greenland. In the latter, hydroelectricity is stored as hydrogen via water electrolysis and then used in a fuel cell for CHP, all within a modular plant from H2 Logic. The concept is being tested as Greenland is investigating the use of hydrogen as an energy carrier on the island.

Other Demonstration Projects

HyLIFT-DEMO

The HyLIFT project involves a two-year demonstration of at least 30 hydrogen fuel cell forklift trucks (FLTs), aiming to build the business case and facilitate market introduction from 2013. The FLTs, with lifting capacities ranging from 2.5 to 3.5 tonnes, will be supplied by DanTruck and fitted with a fully integrated, 8 kW PEMFC by H2 Logic. Three end-user sites will be chosen for demonstration of refuelling infrastructure.

Mikael Sloth of H2 Logic anticipates that fuel cell forklifts in the European market will predominantly be competing with internal combustion engines rather than battery-powered variants, as the industry tends to opt out of battery power where it can due to the associated inconvenience of charging. Fuel cell forklifts can thus actually expand the use of electric propulsion in European materials handling. This may be a relatively small market, but with a significant impact: one heavy-duty diesel FLT can emit as much carbon dioxide as eight cars.

There is no doubt that hydrogen will be able to compete with diesel or LPG on cost but, like the US market, a support mechanism is necessary to grow volumes in Europe before the business case can be fully realised. The HyLIFT project partners already have plans to follow up the first demonstration with a larger one, involving as many as twenty refuelling stations and 200 FTLs from a number of OEMs.

HyNor Oslo Bus

Ruter

HyNor is the national project established to coordinate hydrogen infrastructure development in Norway. The Oslo Bus project comes under this umbrella and is being run in partnership with Ruter, the public transport authority for Oslo. It also falls under the European CHIC project.

Johanna Stigsdotter of Ruter outlined the company's motivation for involvement with this demonstration. Ruter's planning extends to 2060, and it has to cater for an anticipated doubling of trips by 2030. At the same time, it intends to be carbon neutral by 2020. Already over a quarter of its buses run on biofuel and/or have energy consumption reduced by 30%. It now wants to add fuel cell technology to its portfolio.

Five fuel cell buses will run on route 81A, from outside Oslo to the city centre. These are Van Hool buses that have been fitted with Ballard HD6 Velocity™ fuel cell modules. Air Liquide is supplying the refuelling station at the bus depot, construction of which has now started. The buses are expected to start operation in late March/April 2012.

In his presentation, Pierre Gauthier of Air Liquide Hydrogen Energy said that Air Liquide has been active in demonstrations of hydrogen refuelling for some time and is now moving to the next stage – hence, it considers the hydrogen station it is supplying for the HyNor Oslo Bus project to be a commercial installation. Its focus now is on developing carbon-free production of hydrogen: the intention is for the hydrogen at the Oslo bus station to be primarily produced on-site by renewably-powered electrolysis.

Concluding Remarks

There were many other interesting developments reported at the conference, including updates from PowerCell Sweden, Catator, Topsoe Fuel Cell and posters from HYSTORSYS and Danish Power Systems. In parallel sessions, a number of fundamental technical advancements made recently at Nordic research facilities were described.

There is a great deal of commitment to fuel cells and hydrogen in the Nordic countries. What I find particularly exciting is the extent to which these technologies are being explored as part of a complete 'clean energy system', as a future without carbon emissions is envisaged.

Michael Pereckas

However, it is also clear that despite the similarities between the five countries they are very much distinct entities with differing energy requirements. The role that fuel cells and hydrogen will play in each country will vary, leading to a diversity of solutions.

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