DRAFT AS OF 21 JULY 2006

2050 UK Hydrogen Vision

This document defines a possible UK stakeholder vision for the use of hydrogen by 2050.

The UK government's energy review confirms that the UK's four primary energy policy objectives are;

- Reduction of carbon emissions of 60% by 2050.
- Security of supply (including reliability and diversity)
- Competitive energy industry
- Every home to be adequately and affordably heated.

These policy objectives are all equally important (they have not been ranked). The UK energy review is focused on *how* to meet these objectives. A white paper will be published at the turn of the year, which will set how the Government intends to take forward the energy review recommendations.

Key issues being looked in depth as part of the review include: commercialising innovative technologies, transport energy requirements, energy efficiency, carbon capture and storage - particularly for fossil fuel chains, and the role of nuclear fission power.

It is widely accepted that there is no single solution to the UK's energy needs (there is no 'magic bullet') and that in order to meet the policy goals identified above a mix of technologies and approaches will be needed. The role of nuclear fission in this mix is a controversial question in the UK and two very broad energy scenarios are foreseen -one with nuclear fission power and one without. The conclusion of the energy review with regard to nuclear is that nuclear electricity generation is likely to have an important role by providing 20 - 30% of the UK's electricity demand. That is to say, broadly that the current nuclear contribution should be maintained over the long term.

The role of fossil fuels

Fossil fuels (including natural gas and coal) still meet a large demand of the UK's energy needs. Whilst there is some debate as to when fossil fuels will (have) 'peak(ed)' it is likely that fossil fuel energy generation will be an important part of the UK's energy for stationary and power generation for the next 2-3 decades at least.

The challenge for Governments is to ensure that this resource is used in a sustainable/low carbon way. To this end the UK Government has developed a Carbon Abatement Technologies Strategy (http://www.dti.gov.uk/energy/sources/sustainable/carbon-abatement-tech/page19502.html). This strategy promotes a twin track approach: more

efficient plant producing lower emissions; together with carbon capture and storage to deal with the emissions that remain.

The role of microgeneration

In UK terms, microgeneration technologies in UK terms are defined as having a power output of less than 50kw (less than 45 kw for solar thermal). Such technologies could include: biomass, biofuels, fuel cells, photovoltaics, water (including wave and tidal), wind, solar power, geothermal sources, combined heat and power systems.

The UK's Microgeneration Strategy sets out the potential role that microgeneration technologies will play in the future. Underpinning analysis for the strategy conducted by the Energy Savings Trust suggests that upto 30 -40% of the UK's electricity demands could be met through microgeneration technologies by 2050.

. The strategy can be found at:
http://www.dti.gov.uk/energy/sources/sustainable/microgeneration/strategy/page27594.html

Government has also supported the introduction of the Climate Change and Sustainable Energy Act 2006 which seeks to encourage the uptake and availability of information about microgeneration technologies.

Hydrogen

Hydrogen, like electricity is an energy carrier and has to be made using energy. In some ways the UK is already a "hydrogen economy". Hydrogen is a common industrial gas in the UK it is used in many industrial and chemical processes including oil refineries. It is produced deliberately from natural gas on an industrial scale to be used as a chemical feedstock for common products such as nylon, polyurethane and polyester. There are also a number of industrial and chemical processes that produce hydrogen as a by-product of their core process. However, the hydrogen as it is currently used does not contribute substantially to energy policy goals.

This by-product hydrogen is either extracted (and purified) for chemical use or it is burnt as a conventional fuel. If a major commercial demand for hydrogen is found then it is highly likely that this existing fuelled hydrogen will be extracted.

It is not just the consumption of hydrogen that is important to the concept of a hydrogen economy, but also its production. While most hydrogen production in the short term will be from fossil fuels, it is the use of electrolytic hydrogen production as a controllable load that allows significant deployment of renewable energy sources

onto the grid, thereby enabling substantial decarbonisation of the whole energy system (including grid electricity and transport).

The role of hydrogen - transport

Analysis conducted on behalf of DTI by the energy consultants E4tech, Element Energy, and Eoin Lees Energy was published in December 2004. The key message from the analysis is that for the UK, the use of hydrogen as a transport fuel offers significant opportunities for cost-competitive CO2 reduction by 2030.

Six different types of transport energy chain have this potential and also offer increased energy security. None is readily available today and each would require significant changes to the energy system. However, they are sufficiently promising to be worth pursuing as energy options for the UK.

The energy chains are defined by their primary energy source: renewable electricity, nuclear electricity, natural gas with carbon capture and storage (CCS), coal with CCS, biomass with optional CCS and novel hydrogen production technologies.

Assuming the technological barriers are overcome it is estimated that by 2030 20% of the UK vehicle fleet could operate on hydrogen fuel by they fuel-cell or H-ICE

The role of hydrogen - stationary power

The analysis by E4Tech, Element Energy, and Eoin Lees Energy also considered the potential for hydrogen for use in stationary power generation by 2030. The analysis indicated that this would be of greatest benefit in remote/Island communities not connected to the grid.

The UK Government recognises that the use of hydrogen in stationary power applications to produce electricity could be of real value for remote/off grid island communities. For example, in situations where there are substantial renewable energy resources but the export of electricity to the grid is constrained, the production of hydrogen may enhance the viability of renewable energy projects. This could apply to the Western Isles, the Northern Isles and parts of the Highlands.

The use of hydrogen for mainland on-grid power generation is not anticipated to be economic by 2030 (whereas electrolysis, as an important energy sink, will be). Beyond 2030, technological breakthroughs in some of the more novel research areas and the anticipated increase in costs of conventional fuel sources may allow for hydrogen to be used in this way.

Achieving the Vision

It is recognised that at the moment the main drivers towards the use of hydrogen in the UK are mainly public good ones. National government is interested because of carbon emissions and security of supply, urban regional governments such as London are interested in technologies that can improve air quality and reduce noise pollution.

UK regions are keen to build on their individual existing strengths for example as in Scotland integrating renewable energy and hydrogen on Island communities (cf: http://www.pureh2.co.uk/)

The commercial conditions for hydrogen aren't so well developed at the moment, although many regions and industry are keen to use and develop their existing expertise as progress towards a hydrogen economy is made.

So UK stakeholders have many different reasons for playing in a future hydrogen economy. The majority of those present at the workshop were neither especially "hydrogen believers" nor "hydrogen sceptics". Rather most players were positioning themselves so that they were ready to engage, as a UK hydrogen economy becomes an increasingly realistic prospect.

The role of the public sector

Given the public good arguments for hydrogen it is not surprising that the UK public sector is engaged at a number of levels. Basic research is supported through the research councils via DTI's science budget which is managed by the Office of Science and Innovation - this includes the SUPERGEN programmes in particular - the UK Sustainable Hydrogen Energy Consortium.

The DTI's Technology programme offers support for precommercial, collaborative research and development projects in a number of sustainable energy technologies including hydrogen and fuel cells.

The most deeply felt need is for a UK wide demonstration scheme for hydrogen and fuel cell projects. The DTI Carbon Abatement, Hydrogen, and Fuel Cell demonstration programme is expected to be launched in Autumn 2006.

Funds for hydrogen and fuel cell projects are also made available through regional initiatives – for example the Scottish Executive has announced it will be making support available for demonstrations in Scotland. Regional development agencies, the Carbon Trust, and Energy Savings Trust also have a range of funding mechanisms that can be accessed to support hydrogen and fuel cell projects.

However, policy development is also focusing on socio-economic barriers as well as technological ones. For example, London's congestion charge favours environmentally friendly vehicles and the Renewable Transport Fuels Obligation (RTFO) which is expected to be operation in 2008 could in the future be applied to hydrogen fuel produced via renewable sources.

UK stakeholders also participate in a wide range of international activity beyond individual projects such as HyWays the UK participates in the International Partnership for the Hydrogen Economy and various tasks and implementing agreements with the International Energy Agency.

The role of the private sector

The private sector is following developments with interest; the global automotive manufacturers which have a significant presence in the UK are pursuing research in a number of vehicle technologies in order to deliver improved environmental performance without comprising speed/range and consumer desirability. The energy and industrial gas companies are looking at how they can provide the necessary hydrogen to the consumer. The Low Carbon Vehicle Partnership in the UK brings the different players together on this - hydrogen operated vehicles are generally seen as the end game of these efforts. A Centre of Excellence for Low Carbon Vehicle and Fuel Cell has been established at Loughborough University, which will assist in the commercialisation of these technologies.

There are three key trade associations in the UK that have a stake in the development of a "hydrogen economy". The UK Hydrogen Association, Fuel Cells UK, and the Scottish Hydrogen and Fuel Cells Association.

Industry is positioning itself to ensure it is in a good position should a hydrogen economy take-off.

The Near Term View (present - 2012)

The UK could be characterised as being in the early demonstration phase of hydrogen and fuel cell technologies (and a number of other emerging energy technologies). The UK is an excellent position to capitalise on its strong and innovative R&D base to assist in the commercialisation of these technologies.

The CUTE hydrogen bus trials in London are well known and the UK's first hydrogen refuelling station for these buses is operated in Hornchurch, Essex. The PURE project in Scotland has already been referred. Also the HARI project in the East Midlands regions (hydrogen and renewably integration) is also of considerable interest. (http://www.beaconenergy.co.uk/news.html). In 2005 there were some 20 fuel cell installations in the UK.

The UK's government fund for demonstration projects is expected to become live by the end of this year. The Scottish Executive has also announced a fund for demonstration projects in Scotland. The date 2012 is significant as London is hosting the Olympics in that year and the UK as a whole is keen to use the Olympics to showcase environmentally friendly technologies. The UK is keen to ensure that the "Olympic legacy" is not just about when the games are shown but that the investment going forward now delivers something that is of lasting benefit to the UK.

It is expected that a number of demonstrations will be supported and that regional "clusters" of hydrogen and fuel cell technologies will begin to grow.

Post 2012 - 2020

This will be a crucial phase for the development of a potential hydrogen economy for the UK. Lessons from the earlier demonstration projects should now being begun to feed in and assist in the development of early commercial projects.

In terms of transport; the UK has the largest new vehicle market in Europe. 50% of this market are fleet operators. Therefore, given regional policy objectives it is expected that early uptake is expected in public transport fleet vehicles, in particular buses and taxis; probably building on earlier demonstrators. Local political leadership, and concerns on local air and noise pollution are likely to be significant factors in encouraging public fleet vehicles to switch to alternative low carbon fuels.

Further uptake may be driven by private operators of urban delivery vehicles, for example, supermarkets. As well as operating their own fleets Supermarket retailers account for a large number of petrol retail outlets - the UK's first bioethanol fuel pump is operated by the supermarket retailer Morrisions. Such decisions by retailers are likely to be driven by reputational considerations to be seen as "green" and/or socially responsible.

In terms of stationary power, it is anticipated that this will still apply mainly to niche applications such as remote communities. Increased uptake will largely be driven by increases in fossil fuel prices and technological breakthroughs. It is possible that two or three Island hydrogen communities could develop over this phase.

2020 - 2030

At this point it is assumed that most of the proof of concept technology challenges relating to hydrogen and fuel cell vehicle technologies will have been met and that early infrastructure will have grown out from the regional clusters.

At this point in time - individual consumers, are expected to be able to purchase hydrogen-fuelled cars. The challenge for the industry is do they want to? There is something of a "petrolhead" culture in the UK - hydrogen cars will be expected to perform well and be a desirable product (look good).

Hydrogen for stationary power is still envisaged to apply to niche applications. However, technology breakthroughs in hydrogen production capability could begin to challenge this - and a case for "ubiquitous" hydrogen may able to be sustained.

Assuming government targets for the introduction of renewable energy production are met, hydrogen production via electrolysis will, by this stage, be starting to play an important role as a grid balancing mechanism as it can be considered a deferrable load. At this point in time, electrolyser technology is expected to have fallen significantly in cost and will be better suited to the dynamic operation that this role demands.

2050

Six potential hydrogen scenarios have been identified through work led by the UK Sustainable Hydrogen Energy Consortium these are:

- Central Pipeline
- Forecourt Reforming
- Liquid Hydrogen
- Synthetic Liquid Fuel
- Ubiquitous Hydrogen
- Electricity Store

The policy studies institute (PSI) is looking at what the potential transition pathways might be for each.

At this point hydrogen fuelled vehicles are seen as the mainstay of vehicle applications and are the norm. Further technology development would have lead to improved performance across a range of automotive applications.

Electrolysis for hydrogen fuel production is one of the major demand-side management tools for coping with the dynamic and intermittent output from large amounts of renewable energy supplies (or in the inflexibility of nuclear) on the grid. This duel role of hydrogen is central to the hydrogen economy concept and significantly enhances the cost effectiveness of hydrogen technologies as enables duel revenue streams for electrolyser operators.

Stationary power and electrolytic hydrogen production balancing renewables in niche applications is seen in the majority of the Scottish Islands.

Further expansion of hydrogen for stationary power needs is now the subject of an energy review!

Appendix

Links to capability guides
Trade associations
Project websites
KTN