Is hydrogen energy the future?

16/01/2020

Environment analysis: Hydrogen-sourced energy offers an environmentally-friendly, cost-effective option for the UK government as it plans to transform into a net-zero economy by 2050. As hydrogen is increasingly discussed in the media, Amanda Lyne, chair of the UK Hydrogen and Fuel Cell Association, considers the economic and environmental benefits of the UK embracing and developing a 'hydrogen economy'.

How does the technology for hydrogen-sourced energy work? What are the benefits? How could it be used?

Hydrogen can either be burnt in an engine, turbine, hob or boiler to create heat or mechanical energy or used in a fuel cell to generate electrical energy. Hydrogen contains no carbon so the by-product of its exothermic (energy releasing) oxidation processes are only heat and water. Hydrogen is also the most abundant chemical element, which although often not found in nature on its own as pure hydrogen, can be made from a massively wide range of routes, and also using a wide variety of applications. The benefits are zero carbon, ultra-low emission routes to creating and using energy.

How important is hydrogen going to be in the future for delivering net zero? Is there scope for a 'hydrogen economy'?

Our position is that hydrogen is essential in delivering net zero. This is because developing an effective, flexible hydrogen energy system will unlock the significant challenges of decarbonising the hard-to-transform sectors such as heat, industry and heavy transport (HGVs, rail, marine etc). The recent Committee on Climate Change (CCC) reports (Net Zero–The UK's contribution to stopping global warming and on net zero and Net Zero–Technical Report) highlight this.

The 'hydrogen economy' that will facilitate the delivery of net zero, will link a diverse range of energy generation sources—renewables, energy from waste and decarbonised methane gas—with the various components of energy demand that it is almost impossible to decarbonise otherwise. Hydrogen is the only zero carbon energy vector that can provide the flexibility, connections and networks to make the new energy system work cleanly and cost effectively, through short term and long term (seasonal) renewable energy storage, providing clean fuel for transport, and offering a solution to decarbonised heat and beyond.

For instance, at present over 1 Terrawatt hours (TWh) of renewable electricity is curtailed in the UK—this is when renewable energy facilities (like wind farms) are told to switch off by the National Grid because there is nowhere for the electricity to go—which is unproductive and prevents this capacity fully decarbonising the energy system. This will increase even further as wind and solar penetration grows. Battery based energy storage can provide short term (<4hrs) mechanisms to address proportions of this wasted capacity, however this is still limited by grid distribution and transmission constraints. If this generation was used to make hydrogen via electrolysis, taken away from the electricity grid, to be used in the other energy systems (heat and transport) then these constraints are avoided, at the same time as providing a zero-carbon route for energy in these other demand sectors.

What are the main drivers for a hydrogen economy?

The main driver for a hydrogen economy is the immediate need to deliver decarbonisation where electricity alone will not deliver. For instance, it is currently impossible to see how we can reduce to zero the carbon content of industrial heat systems, without using hydrogen. Biogas and waste can be renewable and carbon saving in this application, which will help get us a long way on the roadmap, however these energy vectors still emit greenhouse gases (GHG) into the atmosphere at the point of use. To achieve net zero the carbon in these energy vectors needs to be captured and used or stored, before it is emitted, with hydrogen therefore being the actual source of energy in these applications.

Similarly, for heavy duty or long-range transport, battery technology requires too many compromises in practical use to allow these applications to fully decarbonise. For instance, it requires eight tonnes of batteries to enable a truck to travel 300km, which reduces the payload capacity of these vehicles as well as being highly unproductive to charge, whereas hydrogen technologies would be <1.5 tonnes for the same range and could be refuelled in the same time as conventional fuels.

In time as well as this, the additional benefits of the potential improved efficiency in use from fuel cell technology as electrochemical routes to creating electricity, as opposed to combustion/mechanical energy, will be needed. For instance, fuel cell technologies offer the most efficient routes to distributed, localised generation which in itself reduces energy transmission losses and allows for use of combined heat and power (CHP) at point of demand.

What kind of regulation/framework would be required for an effectively hydrogen economy to operate? How would you suggest implementing these?

There are many aspects of the regulatory frameworks that need changing to open up the opportunities for hydrogen to be economical. On a high-level, immediate action is required through a long-term strategy that takes a whole systems approach. On a more granular level, this includes:

• changes to gas distribution rules to allow an increased percentage of hydrogen to be blended into the system (see HyDeploy 1&2)

• changes to Contracts for Difference and other valuation mechanisms in support of renewable generation technologies so that capacity can be used to make hydrogen

• improvements to the Renewable Transport Fuel Obligation to facilitate hydrogen fuel use

• changes to the current incentives for vehicle tax and or ultra-low emissions vehicle (ULEV) support schemes to encourage take up

Are there any economies already leading the charge with hydrogen?

The UK is actually leading in terms of strategic thinking on the role that hydrogen can play in heat and industry, although other countries are more advanced in deployment of technology such as South Korea and Japan. In transport applications places like California, Germany and China are probably much further ahead in either vehicle numbers and/or infrastructure. Countries like Denmark, the Netherlands and Germany are probably acting fast on integration with renewables such as offshore and onshore wind. Scotland has a world leading energy strategy that firmly places the role of hydrogen in its vision for delivering decarbonisation, and some highly innovative cities and communities such as the Orkney's and Western Isles that are demonstrating real examples of how the hydrogen economy can be developed.

In your opinion, how much is this area likely to be worth to the UK economy?

There are different opportunities available through the following areas.

Delivering CO2 reduction, air quality improvements and economic benefits through hydrogen and fuel cell powered transport

For instance:

• hundreds of millions of pounds could be created for the UK economy by 2025 by hydrogen road transport applications, including passenger cars, light commercial vehicles, buses, heavy duty vehicles and taxis

• there is a wide range of applications for fuel cells in non-road transport, including aviation, marine and rail propulsion, auxiliary power in aviation / maritime vehicles, tractors, forklifts and unmanned aerial vehicles (UAVs)

• by 2025, fuel cell UAV sales could generate up to £100m in added value for the UK, and hundreds of jobs

• up to 30% of the European transport fleet could use hydrogen by 2050. This would correspond to a saving of over 30 MtCO2/year in the UK compared with today's vehicle fleet

• fuel cells for marine and rail applications are gaining momentum. By way of example, Alstom's hydrogen fuel cell train is already in operation in Germany and Norway is focused on hydrogen and fuel cells for ferries

Delivering system balancing and optimized use of renewables through electrolysis and the opportunity for medium to long term energy storage

For instance:

• at present over 1TWh of renewable electricity is being curtailed in the UK and this will increase as wind / solar penetration increases, due to both transmission and distribution constraints and growing grid stability concerns

• if electrolysers were deployed to help utilise rather than waste this renewable electricity, then significant contributions could be made to the heat and mobility sectors

• 1TWh of electricity produces nearly 18,000 tonnes of hydrogen, which is sufficient to fuel 90,000 fuel cell (FC) cars each travelling 12,000 miles per year, while causing zero local emissions and carbon dioxide

Delivering local air quality benefits, CO2 reduction and economic growth through decentralised fuel cells for CHP and power only

For instance:

• deployment of large FC CHP units could create up to £150m in the UK economy by 2025

• the installed costs of FCCHP systems have fallen to around £12,000 for 1kW residential systems and £1m for 400kW commercial systems, and continue to further reduce at a rate of 10–15% per year

• with appropriate support, it is anticipated that 90,000 FC micro-CHPs could be deployed in the UK by 2025

• stationary FCs can nearly fully eliminate local emissions of pollutants such as nitrogen oxides and sulphur oxides as well as particulates and significantly reduce carbon dioxide emissions

Interviewed by Samantha Gilbert.

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