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A Perspective on Hydrogen and Smart Grids

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The term 'hydrogen economy' is now widely in use and commonly understood to indicate the potential role of hydrogen in our energy future. But what form would the hydrogen economy take? How would it operate? What would its component parts be? And is it a serious prospect?

I recently had a discussion along these lines with Dr Rupert Gammon of the Institute of Energy and Sustainable Development at De Montfort University, who is well-placed to offer a perspective on these questions, having run a 'hydrogen economy in miniature' while working on the Hydrogen and Renewables Integration (HARI) project. HARI ran from 2003 and involved the integration of an electrolyser, hydrogen storage and fuel cells with an existing renewable energy system at West Beacon Farm in Leicestershire, UK. The project will be formally ended in a few weeks' time by the handover of the equipment for use in Loughborough University's hydrogen refuelling station.

While HARI successfully demonstrated the use of hydrogen in energy storage, there was a caveat: reporting on the project in 2006, Gammon wrote that one of the clear messages of the HARI project was 'that the efficiency of passing through the cycle from electricity to hydrogen and back to electricity is poor'. While some of the loss can be designed out and will decrease with improvements to the technology, specifically electrolyser and hydrogen storage technology, he thinks there are better ways to exploit hydrogen's potential as an energy carrier.

Dr Gammon first makes the point that grid electricity, vehicle propulsion and heat should not be viewed as distinct 'energy silos'. Hydrogen is a means of energy storage and there is no reason why this stored energy cannot be harnessed in any of those three forms.

As Jonny described in a recent analyst view, energy storage is necessary to balance the grid when supply exceeds demand. Balance is typically restored by bulk storage of excess energy at the point of supply. However, balance can also be achieved by feeding the excess energy through the grid as electricity and storing it in distributed form locally, by generating hydrogen via water electrolysis at various points of use. But – and this is Gammon's second point – the demand at these points is for energy, not necessarily electricity, and the hydrogen can be used directly for motive power in fuel cell electric vehicles (FCEVs). This removes the need to convert it back to grid electricity when demand increases, and hence minimises the inefficiencies inherent in the process. (FCEVs are of course also subject to inefficiency in the conversion of energy but this should be offset against the much larger inefficiencies of internal combustion engines.)

Equally, the use of the hydrogen to feed fuel cells in local applications where product heat is harnessed, i.e. combined heat and power (CHP), allows for more efficient use of the stored energy than if it were simply converted to grid electricity.

From this viewpoint, the grid now takes on a role as the major means of energy distribution and supply – for electricity, heat and transportation – and by removing the distinctions between these three sectors overall energy efficiency is greatly increased. It is the combined use of fuel cells, electrolysers and hydrogen that makes this possible.

It is clear that the transportation sector can be positioned to benefit substantially from the increasing proportion of variable renewable energy (VRE) in the generation mix. Variations in supply will dwarf demand-side variability and grid balancing will become more challenging, with planning for longer weather events becoming critical. During periods of high winds, for example, it is possible that the grid will see oversupply for a period of several days and bulk storage capacity will rapidly be exceeded. By using the excess VRE, which would otherwise be wasted, to generate hydrogen for transportation, low-value energy is converted into high-value propulsion. Gammon describes a scenario where numerous, smaller electrolysers on filling station forecourts spring into action to bleed the grid during periods of excess capacity at special tariffs.

This is of course very similar to the demand-side management that can be offered by battery electric vehicles (BEVs) and he is keen to point out the synergy here: the advent of EVs is opening the discussion of how the transportation and power generation sectors can mesh, with storage of electrical power facilitating grid load-shifting. With BEVs the stored energy is carried on the vehicle, and load shifting is practical over a period of hours. Hydrogen, in conjunction with FCEVs, allows demand-side management for higher proportions of VRE and longer weather events, over days or even weeks, and shares the storage burden between vehicles and fuel suppliers.

It is due to this synergy that Dr Gammon's focus has moved from hydrogen to smart grids. He advocates the inclusion of hydrogen in the discussion of smart grids, where it has seen relatively little attention to date, and has at times been viewed as a competitive technology.

Regarding the future of energy, Gammon says there will be no single silver bullet but a 'technological ecosystem' of complementary 'species' which will be dominated by the symbiotic partnership of electricity and fuel. To derive maximum benefit from the partnership, the fuel should be derived from non-dispatchable electricity rather than – as it is today – the source of dispatchable electricity. It must also be carbon-neutral. He emphasises that there is actually no uncertainty over whether hydrogen will feature: there is only one candidate that can meet these requirements. With the need for clean transportation fuel and additional market pull created by smart grids and the management of VRE, Gammon sees the reluctance of certain governments to back hydrogen as less a failure of funding than failure to seize a major investment opportunity.

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