SONE
Supporters of Nuclear Energy

Nuclear - The green route to secure and reliable power

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The Hydrogen Economy

This is one of a series of briefing notes prepared by SONE for its members and the public on energy policy matters. These notes seek to put individual issues in perspective, given the marked tendency today for energy causes to be espoused without regard to practicality or economics.

The hydrogen economy is one of those issues that excites enthusiasm even though it is as yet hypothetical and is beset with problems which this note explores. However, if it were to come to pass, it would require a large nuclear power industry to sustain it.

Potential

As with renewable sources of energy and energy conservation, the **potential** of hydrogen as a fuel is immense. But again the problem lies in economically unlocking that potential.

Hydrogen is the most abundant element in the universe but rare in pure form. It is almost always combined with other elements and, to be useful, has to be separated from other substances. It is relatively light – that is, it has a good weight/density ratio that makes it very attractive - though it has to be compressed and liquefied to provide adequate driving range for vehicles. Like petrol, it is portable. Theoretically, it can be used in a variety of ways – as a combustible fuel in engines, as the fuel in fuel cells for producing electricity for use as required or, produced on a large scale, even as a means of helping to balance supply and demand on the National Grid. And its only by-product is water – no greenhouse gases.

Superficially, it has a lot going for it. Unfortunately, the need to separate it from other substances requires energy, and its manufacture requires more energy than it is possible to get out of the hydrogen itself. This means three things:

1. using fossil fuels to manufacture it is no solution to an energy crisis;
2. it is always going to be more expensive than the energy required to manufacture it.
3. the separation process may produce carbon dioxide (CO_2).

Since there are fears, so far unconfirmed, that oil resources are reaching their peak, if they have not already done so, hydrogen is seen predominantly as a possible successor to oil and its derivatives as a means of transport propulsion. Without oil for transport, other forms of energy storage would certainly be needed and this could be secured most efficiently through the generation of electricity and its use in batteries and other devices.

One thing is certain: if hydrogen is to be a helpful proposition in energy and environmental terms, it needs to be manufactured with low or zero carbon sources of energy – from nuclear power or renewables.

How can Hydrogen be Manufactured?

Hydrogen is already manufactured on a commercial scale predominantly for two purposes: the production of ammonia for fertiliser and for converting heavy oil into lighter fractions. Something like 50 million tonnes a year are produced globally, mostly from gas and oil, and demand is growing. The energy potential of that amount is equivalent to 170m tonnes of oil, and in 2005 it was worth about $135 billion. The USA made about 20 per cent of the world's hydrogen.

Hydrogen is produced in two ways:

1. from water by electrolysis - i.e. splitting water electrically into hydrogen and oxygen - or in the future by high temperature dissociation of water; and
2. by chemically reforming natural gas.

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Electrolysis requires a great deal of water – nine kilograms (kg) of water to produce one kg of hydrogen – and reformation requires natural gas - 2 kg of it, plus 4.5 kg of water, to produce one kg of hydrogen. Moreover, the residue from the reformation process is entirely CO_2 – and a lot of it: 5.5 kg out of every six of the natural gas/water feedstock.

A hydrogen economy would thus require vast amounts of clean water when parts of England, at least, are already short of water and there seem to be immense difficulties in transferring water across the nation from areas with plenty of it. Moreover, few people are queuing up to offer their valleys for the construction of reservoirs.

The other route to the hydrogen economy requires large amounts of natural gas at a time when it is considered unwise for the UK to become dependent on imported gas for up to 80-90 per cent of its foreseeable requirements. That same route would also greatly increase the amount of CO_2 to be sequestered in the strata below ground if the hydrogen were not to exacerbate global warming.

Norway's Statoil Sleipner field strips CO_2 out of the natural gas it produces and claims to dispose of one million tonnes of it a year geologically. There are proposals to separate gas from the Miller Field in the North Sea into hydrogen and CO_2 and use the hydrogen to generate electricity at the Peterhead power station, while the CO_2 is pumped back into the offshore gas field. But these are relatively small projects associated with gas production. Sub-sea sequestration of CO_2 from scores of power stations on the scale envisaged remains unproven, let alone reliably costed. Some estimates suggest it could double the price of electricity.

It is true that one kg of hydrogen would do the work of about four litres of gasoline. But the requirements for and consequences of its manufacture present formidable problems. Hydrogen is no solution to constraints on energy supply or global warming unless it is generated by nuclear or renewables electricity.

Here there are compensations. It could be manufactured at night when there could be surplus electricity or by using intermittent renewables electricity. But none of this has yet been proven. Nor have the requirements and cost of the infrastructure for the hydrogen economy been worked out. *Time* magazine has suggested that the USA would need to double its generating capacity – now 442 GW – simply to provide the fuel for US vehicles even before it is distributed.

Dimensions of the Problem

One engineer has produced a graphic illustration of the requirements of the hydrogen economy in the form of the operations of a single airport.

Assuming that jet aircraft could be converted to fly on hydrogen fuel, he has examined the requirements of Frankfurt airport in Germany, which in 2004, handled 520 jet departures a day, including 50 jumbo jets.

He calculates that the jumbo jets alone would need 22,500 cubic metres of water a day and the output of eight 1000 MW power plants to produce, prepare and transport the hydrogen to the aircraft.

In other words, he argues that at least 25 nuclear power plants and the entire daily water consumption of Frankfurt would be needed to get the 520 jets leaving Frankfurt on just one day into the air. And that is only the daily traffic at one major – but by no means the busiest – airport in the world.

Energy Losses along the way

This startling illustration of the massive requirements of a hydrogen economy does not reveal the losses in energy along the hydrogen production and distribution route.

There are, of course, losses in energy entailed in all processes. In the case of hydrogen, about 25 per cent of the energy input is lost in electrolysis or some 16-17 per cent in natural gas reformation. A further 40 per cent of energy could be expended in the liquefaction and distribution of the hydrogen.

Overall, the laws of physics dictate that you get from hydrogen only half and from fuel cells only a quarter of the energy supplied by electricity from the grid.

A Niche Provider

This does not mean that hydrogen has no future. Indeed, over and above its use in manufacturing, it may find a niche in the transport sector.

Surveys in Germany have found that 85 per cent of all car rides cover no more than 20 kilometres, with half of them shorter than five km. So the main need in tackling the use of the car at least is to find an alternative to local mobility. But, as a means of propulsion, there are at least seven more efficient alternatives, including lead acid and other more advanced batteries, compressed air and flywheels. Moreover, the infrastructure exists or could relatively easily be provided for charging electric vehicles from the grid.

Conclusion

Hydrogen is always going to be an energy-intensive and high-cost option. So the hydrogen economy, with no past or present, does not look to have much of a future. Two things are clear:

1. the hydrogen economy would be no answer to the depletion of fossil fuels and global warming unless hydrogen were manufactured by electrolysis solely by nuclear power and low-carbon renewables;
2. as yet, we have no comprehensive understanding of the scale of the adaptation required by a hydrogen economy, still less its cost.

The Moral of this Tale

If the same amount of effort were expended in developing nuclear power as there is in promoting alternatives to it, Britain would have greater security in its energy supplies, substantially reduce its use of fossil fuels and be making a greater contribution to combating global warming.

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