The hydrogen economy - what price and when?

Will hydrogen bring about the revolution many in the energy industry predict?

By Dan Lewis
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Many still associate hydrogen with exploding airships, but today there is a new vision of its role - The Hydrogen Economy – which in some circles has become a mantra. The Hydrogen Economy, it is argued, will bring about a new energy revolution of the 21st Century. It will be sustainable, non-polluting and based on the emergence of a decentralized world-wide energy web. Indeed, because everyone, even households, will be trading hydrogen, it will spell the end of the "evil" multinational oil companies. A brave new world then. But is it just around the corner?

Of all the fields of alternative energy, the public expectations of hydrogen have run way ahead of the economic realities. Even policy-makers who should know better, have been all too ready to confuse the technologically feasible with the economically viable. Yet world-weary readers of Power Economics know that prices and payback periods trump sophisticated costly energy technology every time. The truth is that Hydrogen is coming, but it will be much further into the future and in unexpected areas first. So what do the economics tell us about the prospects for hydrogen in the current and near future?

The framework of the hydrogen economy

The great promise of hydrogen as an energy carrier, is that it could replace electricity, heating and transport fuel through an electrochemical reaction with no more waste products than water and heat. But there are major economic issues to address at the three stages of a hydrogen economy. These are production, transportation and storage and the new hydrogen-powered generator, the fuel cell.

Hydrogen production costs

Hydrogen Production is already a long established business. Globally some 500 Billion Nm3/h (Normal Cubic Metres of Hydrogen) are produced each year. It is however not used for hydrogen fuel cells, but for the production of fertilizers, petrochemicals and other chemical products.

There are two major methods used to produce hydrogen, reformation of fossil fuels and electrolysis. 96 per cent of it is produced by the Reforming or Oxidization of Fossil Fuels, particularly Natural Gas, Oil and to some extent, coal. Environmentalists like to call it Black Hydrogen. The remaining 4 per cent is produced by electrolysis, the stripping off of hydrogen atoms from water. This is the idealised route especially if it is produced using renewable electricity sources such as wind and solar power. Consequently, its advocates refer to it as Green Hydrogen.

There is a key economic reason why so little hydrogen is produced from electrolysis. Quite simply, electrolysis-produced hydrogen costs at least five times as much as reformed hydrogen. Electrolysis requires electricity which must be paid for. That's why for some time, a move to a hydrogen powered economy will not be possible without the significant input from oil and other natural resource companies. Yet the current price of hydrogen for hydrogen vehicles sourced from reformed fossil fuels, still comes in at 11 times higher than that of petroleum or diesel. Granted, there are economies of scale here that have yet to be exploited for hydrogen production compared to petroleum. Even so, the price of oil in the face of growing world demand and unrest in the Middle East, seems set to rise faster than incomes for some time.

Such a price differential in the production costs of hydrogen alone augur ill for a near-future change to a Hydrogen Economy. So what about Green Hydrogen?

Jeremy Rifkin, author of "The Hydrogen Economy" anticipates that a fall in the cost of wind-generated electricity to 1.5 cents a kilowatt-hour would make wind-generated hydrogen economically viable. However this would necessitate a fall in windpower costs of 80 per cent from the current 5 cents in the USA. Whilst a 40 per cent drop is anticipated in the next 15-20 years, a further 40 per cent may be decades away, if achievable at all.

Hydrogen transportation and storage costs

Hydrogen is so tiny at the atomic level, that it can penetrate almost any structure built to contain it. This has enormously boosted the cost of hydrogen storage compared to say, oil.

Transporting Hydrogen through pipelines comes at much greater cost than that of transporting natural gas. Natural Gas can be transported in cheap PVC pipes which are too porous for hydrogen. H2 pipelines must be made of steel, at an increased pressure of up to 20 bar instead of 4 bar. All of this of course, does come at a higher cost.

Hydrogen fuel cell costs

Fuel Cells are electrochemical conversion devices that convert hydrogen and oxygen into water and in the process create electricity. Measured by size, there are 3 classes that have been promising to break into the marketplace; Portable, Stationary and Vehicle Class.

Portable Fuel Cells up to 1 kw in size, are the most immediately promising and will appear on the market in 2005. Prototype portable fuel cells can deliver up to 350 watt hours per kilo compared to an absolute best battery performance of 150. These fuel cells will be throwaway units based on methanol. Prices have not yet been set, but mass production is now gearing up. The early impact will be on the world's nearly 2 billion portable devices, specifically digital cameras and telephones. Fuel cells for laptops because of their power requirements remain some way off, requiring perhaps 1000 watt hours per kilo to run all day without

Contact results 'in line with forecast'

New Zealand's Contact Energy announced a net surplus after tax of $144 million for the year to 30 September 2004.

"This is a satisfying result, achieved in very different market conditions from 2002/03, and in line with the forecast published at the time of the Origin Energy takeover offer in September," said Contact's chief executive, Steve Barrett.

The Grant Samuel Independent Advisers Report on the Origin takeover offer included a forecast net surplus after tax of $143 million.

"While the solid financial result is pleasing, the most significant achievement in the last year was Contact's success in refuelling almost every major component of its generation fleet," said Barrett.

Meanwhile, a joint study by Contact Energy and Genesis Energy into the feasibility of liquefied natural gas (LNG) has established it is a viable backstop fuel option for New Zealand that can provide added security of electricity supply.

Barrett and joined Genesis Energy chief executive Murray Jackson in issuing a statement saying that it was vital that New Zealand had more certainty on fuel replacements after the Maui gas field runs down in 2009.

Maui produces around two thirds of the country's natural gas and is used to generate around 25 percent of the country's electricity.

"The rundown of Maui and increasing demand for energy threatens to put New Zealand into energy deficit at the end of this decade. From the study, we now know liquefied natural gas is a feasible and practical option for meeting the looming gap in New Zealand's energy supply, should new sources of New Zealand natural gas not become available at a pace sufficient to meet demand growth.

"Our clear preference is for sufficient new sources of New Zealand natural gas to be discovered and brought to market.

Northern Ireland battered by storms

Severe storm force winds with isolated gusts up to 100mph battered Northern Ireland yesterday and it was widely predicted the severe weather would cause damage to the electricity network, particularly in rural and coastal areas.

Hundreds of extra Northern Ireland Electricity engineers, linesmen, call handlers and administrative staff reinforced normal capability to restore supplies, night and day, following any severe weather damage, and provided regularly updated information to customers. The NIE Incident Management Centre at Craigavon was fully staffed throughout the period.

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recharging. A key barrier however to portable fuel cells remains the agreement of civil aviation authorities to allow them on to a plane. This has still not been fully resolved.

Stationary Fuel Cells, from 1 kw to 1 Mw are most likely to come next, probably from 2008. The biggest part of the market will be the 5 kw fuel cell for Combined Heat and Power. At the moment, stationary fuel cells cost $3000 to $4000 per kw. It has been estimated that to be competitive, this needs to fall to between $1000 and $1500. Such a price fall is conceivable with mass manufacturing. More often than not though, these fuel cells, usually a Proton Exchange Membrane type, will be running off more available gases like propane rather than expensive industrial grade hydrogen. Still, this would be the first stage to a distributed generation and a genuinely two-way electricity grid.

But it is with Vehicle Class fuel cells that have long been creating a stir, though these face the greatest economic hurdles of all. The competition – the internal combustion engine – has been mass-produced and continuously improved for almost a century. That's why the price is so low, perhaps $50 per kilowatt of power or 1.3 horsepower. At the moment, the price for a vehicle class fuel cell is stuck at $3000 per kilowatt. This means that a good sized engine for a family car will set you back $300,000 !

What is fascinating here is the massive strategic error made by Ford, Mercedes-Benz and General Motors by investing billions in a technology that is still such a long way from delivering on cost. The only people who can afford this or are willing to pay now for it are the research divisions of the American Military and certain high-spending European Governments for their domestic bus fleets.

Toyota on the other hand took the opposite view and decided that the economics of Hybrid cars were far more promising than hydrogen. They have been roundly vindicated. The Toyota Prius - a petrol-electric vehicle - is now being mass-produced, is car of the year 2005 and unusually for an alternative fuel vehicle, competes without a subsidy. Now all the major vehicle manufacturers are belatedly developing their own hybrids, with many models forecast to come to market in the next few years. Sadly for many investors, Hydrogen vehicles really are a long way off, perhaps 2040, because the economics are so prohibitive.

So as for the when, the Hydrogen Economy belongs firmly to tomorrow. That's not to say that it's all a waste of time, oil was for example, far more expensive than coal for decades. The Hydrogen Economy is not coming soon. But in 2060, it's quite on the cards likely that most transport, electricity and heat will be powered by hydrogen – and at a reasonable cost.

Dan Lewis is a Research Director of the Economic Research Council.