The Role of Lignites in a Hydrogen Energy Economy

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SUMMARY:
Lignites should have a crucial role to play in bringing security to the energy future of New Zealand. The resource is vast and they are well suited for use in new high efficiency gasification technologies for production of hydrogen in a future hydrogen economy using the technology package being developed by CRL Energy. In the shorter term they can be gasified to produce other sellable products cleanly and efficiently including electricity or synthetic fuels and chemicals.

Our lignites are a huge energy resource – approximately 7 billion tonnes of known recoverable reserves with an energy equivalence more than 40 times that of the original Maui gasfield. Much of that resource is found in Southland. Many, if not all, of the Southland lignites appear to be extremely well suited to hydrogen production using technology based on one of the new advanced high efficiency clean coal gasification technologies currently being commercialised internationally. This hydrogen will be required to run fuel cell powered vehicles and for other applications in a future hydrogen based energy economy. CRL Energy is currently developing the proof of concept of the lignite to fuel cell grade hydrogen technology package at its laboratories in Gracefield, Lower Hutt.

The new technology package and the role of lignite in a future hydrogen economy is the focus of this presentation but an equally important point to bear in mind is that we do not need to wait for the hydrogen economy to arrive before utilising the lignites. The initial result of lignite gasification, the first step on the route to hydrogen, is syngas. This is an extremely versatile product that can be used in existing commercially available technologies to generate products as diverse as electricity or synthetic fuels, chemicals or fertilisers. So in the near term a lignite gasification plant, or plants could be built and commissioned for any one of these applications and later when the demand is sufficient, a portion of the syngas stream can be diverted and treated to produce hydrogen.

So what exactly is a hydrogen energy economy – and why bother changing to one?

A hydrogen based energy economy is an energy system and, like every energy system ever devised it is a means of using the energy sources provided by nature (coal, gas, solar, wind, biomass, large bodies of water) to deliver the services required by humanity (food, drink, transport). Whereas our current energy system revolves around electricity and petroleum to carry the energy once produced to our houses and vehicles, a hydrogen energy system uses electricity and hydrogen as energy carriers. Both are readily interconvertible and the implications of having a highly flexible and integrated energy system are profound.

One major outcome is the prospect of greatly increased energy security – hydrogen can be made from a wide range of indigenous energy sources. Another outcome is clean energy – essentially water is the only waste product produced when hydrogen is converted to energy by means of fuel cell technology.

Internationally there is an enormous push towards developing hydrogen energy. There are already many hydrogen vehicle refuelling stations and demonstration vehicles on the road in cities throughout Europe, North America and Asia. Perth, in Western Australia also has a hydrogen bus demonstration project in operation. The International Partnership for the Hydrogen Economy (IPHE) is an inter-governmental agreement and between them, the fifteen original signatories to that Partnership account for 85% of the world's GDP. They range from small countries such as Iceland through to large economies including the USA, Germany, UK, Japan, Italy, France and Brazil. The aim of the Partnership is to enhance the development of hydrogen economies worldwide. New Zealand has recently joined the IPHE – the first country to do so after the initial formalisation. New Zealand has also recently become a member of the International Energy Agency Hydrogen Implementation Agreement.

In order to provide sufficient hydrogen to meet the needs of a future fuel cell powered fleet, New Zealand will be required to produce approximately 1.5 million tonnes of hydrogen per annum (about 10% of the amount currently generated and transported in the USA every year).

This raises the question "Where will this hydrogen come from?" If we wish to fully benefit from the energy security offered by switching to a hydrogen based energy economy, then we will need to produce it from our indigenous energy sources.

All countries are faced with the same question. Each will solve it in their own way. One recurrent realisation among the international community is that while ultimately the aim is to produce all the hydrogen required from renewable energy sources, there will be a transitional period, expected to last for decades, during which fossil fuels will play a major role in hydrogen production. The reasons relate to maturity of technology, cost and reliability of resource. These reasons are every bit as relevant to New Zealand as they are to the rest of the world.

For New Zealand, fossil fuels basically mean coal. It is estimated that we have sufficient lignite to generate hydrogen to satisfy the needs of a future full fledged fuel cell based transport fleet for over 400 years. In contrast, if we continue to make gas discoveries at rates recently predicted by the Ministry of Economic Development there will be sufficient gas available to satisfy that same fleet for about 3 months. Even another gas find the size of Maui will only bring security for a decade or two. It is also estimated that between them, the economically viable capacity of the renewables (biomass, solar, wave, wind and geothermal) will be sufficient to meet about 33% of per annum hydrogen demand. In terms of costs of production, economic studies based on predicted (near term) future technologies show hydrogen production from coal to be significantly less than those associated with production from renewables.

The production of 1.5 million tonnes of hydrogen per annum requires the gasification of approximately 10 to 15 million tonnes of lignite. Advanced coal gasification technologies are an established and growing technology. Gasification capacity worldwide grew by 50% during the 1990s and this growth trend is continuing. Historically the use of gasification was for petrochemical production while more recently attention is turning toward electricity and hydrogen generation.

The package we are developing at CRL Energy for converting lignite to high purity hydrogen begins with a gasifier followed by a clean-up line to extract the hydrogen in a highly pure form from the syngas mix. When the syngas product emerges from the gasifier it contains approximately 17% hydrogen and similar amounts of carbon dioxide and carbon monoxide. The remainder is nitrogen along with a very small amount of sulphide gases. There are also particulates entrained in the syngas. There are well established cost effective technologies for conversion and removal of each of the non-hydrogen contaminants – the challenge is to combine them into a technology package and integrate them with the gasifier to produce a low cost lignite to fuel cell grade hydrogen conversion package.

The research programme is being carried out in partnership with Industrial Research Limited – who have expertise in fuel cells and power conditioning – with investment from the government through the Foundation for Research Science and Technology, Solid Energy and the Coal Association. The programme is overseen by a Governance Panel that includes high level representatives of Solid Energy, Meridian Energy and BP New Zealand.

The clean-up line produces two gas streams – one of pure hydrogen, the other comprised mainly of nitrogen and carbon dioxide. In order to have a clean, "zero emissions" hydrogen production package it is necessary to manage the carbon dioxide stream. There are several options including sequestration within geological formations (deep aquifers, depleted oil and gas wells and deep unmineable coal seams) and deep ocean storage. All are the subject of extensive international research and the three geological sequestration options are already being safely demonstrated at large scale. International studies have already identified sufficient geological sequestration capacity to accommodate almost 400 times the current global energy related CO_2 emissions. The deep oceans are of essentially unlimited capacity but there are some major environmental issues associated with exercising that option. It is essential that New Zealand identifies its own best geological storage options.