The Oil Drum: Australia & New Zealand
DISCUSSIONS ABOUT ENERGY AND OUR FUTURE

The Hydrogen Economy and Peak Platinum

Posted by Big Gav on August 13, 2008 - 10:05am in The Oil Drum: Australia/New Zealand
Topic: Alternative energy
Tags: hydrogen, peak minerals [list all tags]

One Bullroarer at TOD ANZ a week or two ago featured an article from the ABC on the possibility of mining low grade Australian platinum reserves to supply rising demand for catalytic converters and hydrogen fuel cells - World 'needs Australia's platinum to build cleaner cars'.

> An Australian researcher has warned that the drive to put cleaner, hydrogen-fuelled cars on the road will stall unless new reserves of platinum are found. Platinum is one of the key components of catalytic converters, catalysing carbon monoxide from exhaust fumes. It is also a critical component of fuel cells for hydrogen-powered cars. However 80 per cent of the world's reserves come from just three mines.
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> John Mavrogenes says a team of geochemists from the Australian National University has identified new methods to detect platinum deposits. They are simulating the intense heat and pressure of the Earth's magma to discover whether platinum can be extracted from other minerals. "This work may help geologists find new reserves around the world in places that haven't been searched before," he said. Professor Mavrogenes says if the platinum price remains at its current high, Australia could mine lower-grade deposits. ...
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> The three major mines that produce platinum are in South Africa, Siberia and the United States. "If we go to more and more uses of platinum we're going to need more than they can produce," Professor Mavrogenes said. "Existing reserves would meet less than 20 per cent of the world's platinum demand if all cars went hydrogen."

The Hydrogen Economy

The dream of the hydrogen economy is one that has been around since the 1970's, and has been heavily hyped by sources ranging from Wired (as a key component to their long boom vision), the European Hydrogen Association and Jeremy Rifkin to George W Bush (who seemed primarily interested in supporting the gas and nuclear industries).

The term was originally coined by chemistry professor John Bockris (also an alchemist, cold fusion researcher and winner of the Ig Nobel prize).

The basic vision is that hydrogen is used to fuel vehicles containing hydrogen fuel cells, rather than internal combustion engines, creating no pollution other than water.

Global hydrogen production is currently derived from natural gas (48%), oil (30%), coal (18%) and electrolysis of water (4%). Given that hydrogen is currently largely derived from fossil fuels, the first obstacle facing the "hydrogen economy" dream is shifting away from these sources to extracting hydrogen from water.

Hydrogen is also used for producing ammonia and cracking heavier grades of oil, which means that peak oil and gas pose a number of problems to the hydrogen dream - the primary sources of present day hydrogen become less plentiful, and demand for hydrogen increases as we resort to heavier grades of oil (and coal to liquids) to keep the habit going.

Criticisms of the hydrogen economy

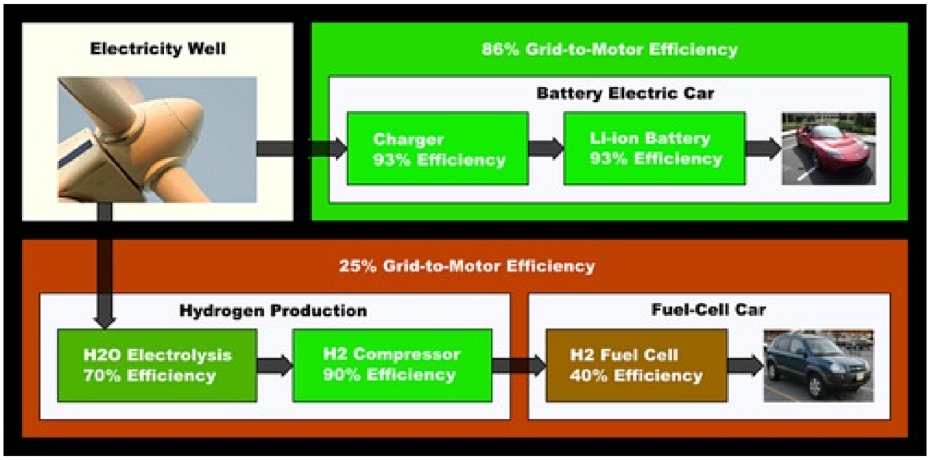
Critics of the hydrogen economy aren't hard to find, with frequently raised objections including:

* The use of natural gas (both from a global warming point of view and a depletion point of view)
* The inefficiency of electrolysis techniques in converting other forms of energy into hydrogen
* The difficulty of distributing and storing hydrogen
* The cost of setting up a hydrogen based infrastructure to replace the existing oil based infrastructure
* Safety concerns about storing hydrogen on board vehicles
* The cost and complexity of hydrogen fuel cells
* Availability of platinum for large scale use in fuel cells

Amory Lovins' Rocky Mountain Institute (pdf) argues that many of these objections are either myths or can be overcome.

Fuel cell expert Ulf Bossel and energy commentator Joe Romm (author of The Hype About Hydrogen) are probably the most frequently cited critics, arguing that the inefficiency of the hydrogen conversion process is wasteful and compares unfavourably to alternatives - specifically the "electron economy" where electricity is the energy carrier of choice.

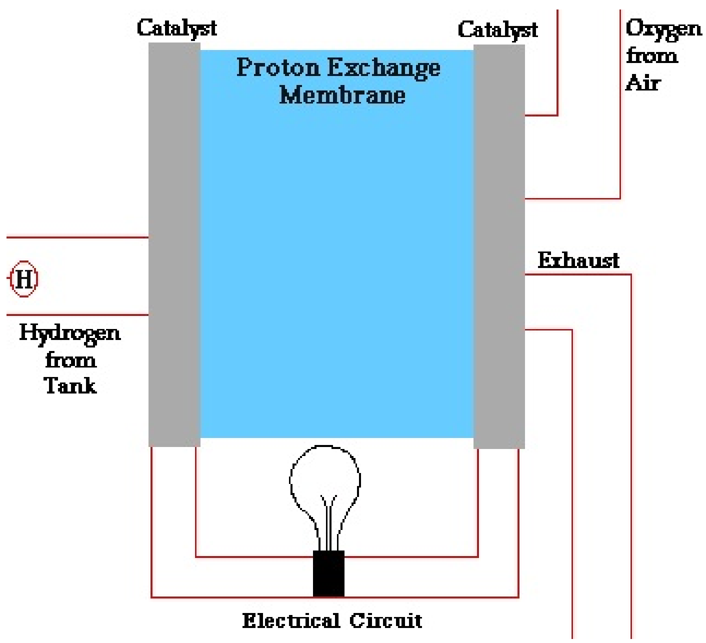
Bossel says "In a sustainable energy future, electricity will become the prime energy carrier. We now have to focus our research on electricity storage, electric cars and the modernization of the existing electricity infrastructure".



The diagram above shows that both the efficiency of electrolysis and the efficiency of fuel cells are key factors in making hydrogen as a transport fuel less attractive than the electric transport option.

Peak Platinum

Even if we assumed that hydrogen fuel cells could be made significantly more efficient, and thus more competitive with the electric vehicle option than they are currently, we still have the issue of the scarcity (and thus the cost) of platinum to deal with, as platinum is the material traditionally used as the catalyst in cells.



In 2005, South Africa was the top producer of platinum, accounting for around 80% of world production, followed by Russia and Canada. Significant deposits are also found in Zimbabwe, the United States and, as noted in the introduction, Australia. South Africa has been expanding production rapidly to take advantage of soaring prices - causing some controversy in affected townships.

When discussing rare metals, the subject of peak minerals is usually quick to arise. The idea has been covered at a number of venues in recent years - including The Oil Drum, New Scientist (with some good graphics here and here) and WorldChanging.

The New Scientist article estimated that there are 360 years of platinum reserves available if we continue to extract it at the current rate of production - however this drops to 15 years if predicted growth in demand is taken into account.

One analyst at Resource Investor has predicted that we may have already reached "peak platinum" production, though this seems to be predicated on the belief that production of hybrid and electric vehicles will remove the demand for both fuel cells and catalytic converters in future years, rather than a firm belief in supply constraints.

Another analyst at the UK Department For Transport, looked at the platinum supply situation for fuel cell vehicles and concluded:

> The above projections, coupled with the statements from Cawthorn (1999) about accessible platinum reserves in South Africa, suggest that platinum availability should not be a constraint to the introduction of hydrogen fuel cell cars. If South Africa alone can deliver up to 5% per year additional platinum supply between 2000 and 2050, this equates to an additional 13.6 million oz in 2030, 24.8 million oz in 2040 and 42.9 million oz in 2050, which is sufficient to meet demand under any of the scenarios considered.
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> However there are many important assumptions and uncertainties built into this model. For example, this additional South African platinum supply would be insufficient to meet worldwide platinum demand by 2040 under Scenario 2 (realistic penetration) if any one of the following alternative assumptions is made:
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> * South African supply can only be increased by 4% per annum instead of 5%.
> * Jewellery demand grows at more than 2% per annum - it is currently assumed to remain constant but grew by an average of 6% per annum between 1994 and 2001.
> * Fuel cell stacks require more than 0.3 oz of platinum per car in 2040 - it is currently assumed that only 0.2 oz will be required but this is a factor of 10 less than current stack technology.
> * The demand for cars grows by more than 55% per decade - it is currently assumed to increase by 45% per decade based on USDOE projections.
>
> The platinum loading for fuel cell stacks is an important factor in determining the commercial viability of fuel cell cars as well as determining potential platinum demand constraints. The price of platinum is not likely to be a constraint to the introduction of fuel cell vehicles if the expected reductions in platinum loadings are achieved. At current platinum prices and the target platinum loading of 0.2 oz per car, the platinum required for a single car would cost about $90 or $1.5/kW, compared to a cost target of $50/kW for the whole fuel cell engine.

In the wake of the New Scientist article, the Wall Street Journal noted that if the most dire predictions are true, recycling of rare metals will be the only way to manufacture some types of machinery. Hazel Prichard, a geologist at the University of Cardiff in the UK, is developing ways to extract platinum from the dust and grime of city streets - apparently, urban grit contains 1.5 parts per million of platinum.

Its worth noting the contrarian view of metals depletion, expressed by Herman Kahn in his book "The Next 200 Years", which points out that reserves data for minerals is often very dubious when there is sufficient known supply available to meet hundreds of years of demand - and that recycling can change the picture dramatically in any case.

Either way, the platinum supply concern may not be an insoluble problem, as recent reports from Japan claim Nisshinbo Industries and the Tokyo Institute of Technology have developed a platinum-free, carbon-based catalyst for fuel cells which they hope to commercialise in 2009 (first for home use, later for use in vehicles). Their catalyst is made from nanospheres of carbon. While 10 times as much carbon is required compared to the platinum equivalent, the cost is one 10th of using platinum. Diahatsu also claims to have a platinum free catalyst, using cobalt or nickel.

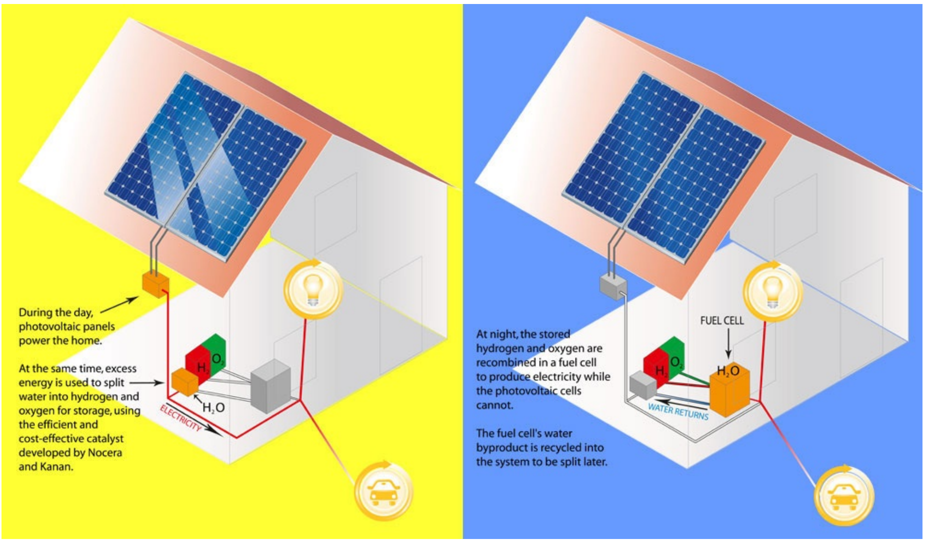
Another platinum free alternative being pursued is being researched at Monash University, where chemist Bjorn Winther-Jensen is looking at layering an active conducting polymer onto Gore-tex to make a cheap catalyst.

Alternative Methods For Producing Hydrogen

The discussion following the Australian platinum supply article at TOD ANZ noted the recent, highly publicised, research into a new catalyst for electrolysis at room temperature using cobalt and phosphate which MIT modestly described as a "'Major discovery' from MIT primed to unleash solar revolution". The process also requires platinum, which seems to limit the potential for cheap and universal application of the technique.

The news was covered extensively pretty much everywhere - see Technology Review, Green Car Congress, The Guardian, The Press Association, Wired, Renewable Energy World, EE Times and Scientific American, with much of the coverage being heavy on hype and short on facts and accuracy.

Joules Burn at The Oil Drum was less impressed, cynically commenting on the story in Local Scientist Splits Water, Saves World, Gets On TV. Bruce Sterling didn't see what the big deal was either, and nor did Joe Romm, who was positively scathing about the news.



There are other schemes for generating hydrogen that don't require electrolysis, at various stages of maturity.

A group at the University of Birmingham in England is looking at using microbes to produce "biohydrogen" from waste, and claim their technology has an added bonus - leftover enzymes can be used to scavenge precious metals from spent automotive catalysts that can then be used to make fuel cells.

Another biotechnology based approach to hydrogen generation is being pursued at the University of Queensland and Berkeley University, in this case using algae.

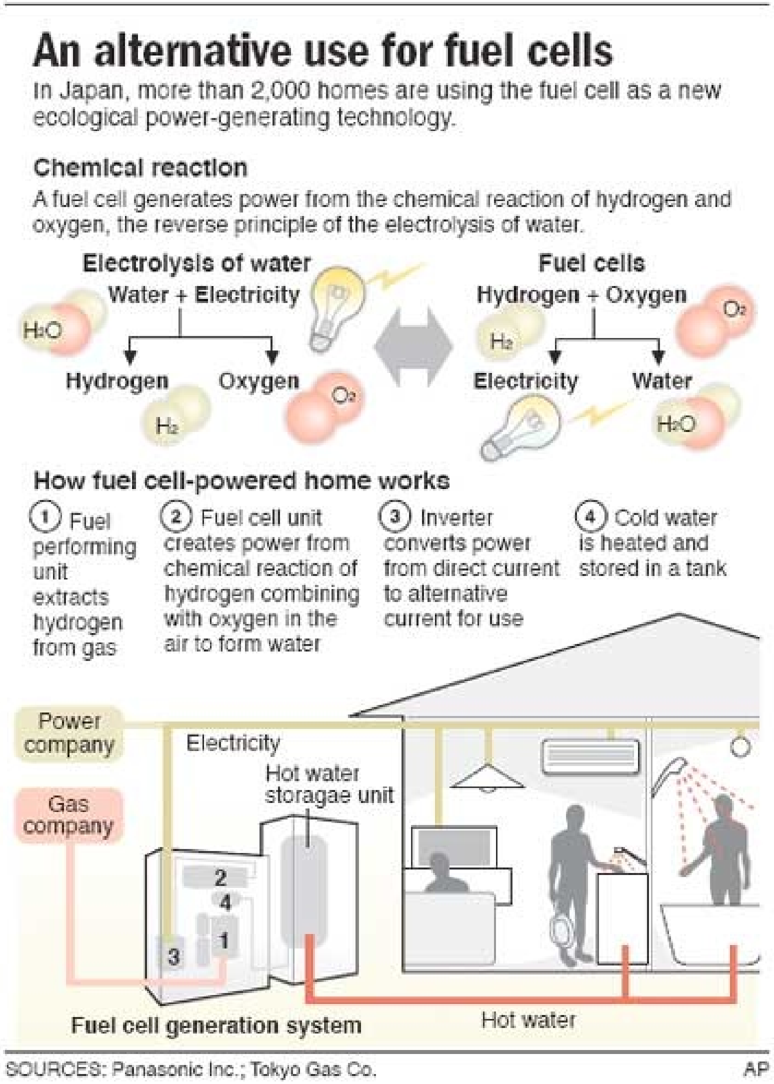
So Is Hydrogen Worth Pursuing At All ?

Whether or not the MIT discovery, or any of the other alternatives, really does lead to cheap, abundant hydrogen seems open for debate for the time being.

If we assume for a moment that it is possible to generate hydrogen on a large scale in a reasonably cost effective manner, the issues around distribution, storage and fuel cells still remain - particularly when comparing a hydrogen fueled transport system to one using electric cars.

The car industry, apart from BMW and Honda, seems to have pretty much given up on using hydrogen for vehicles, but enthusiasm remains for using fuel cells in some niche applications where problems are minimised, such as buses, which are refueled at a central location and have fewer concerns about weight and storage size.

Another niche where distributed hydrogen generation may be applicable is cogeneration (CHP) at home, something Jamais Cascio noted in his comment on the MIT announcement. Japan would seem a likely candidate for proving this on a large scale given that they seem to be the most enthusiastic about using hydrogen at home.



The other likely candidate for using hydrogen is energy storage in renewable energy generation - though perhaps not for home scale PV the way Nocera has been suggesting. An Australian company called WHL (previously Wind Hydrogen) has been looking at building wind farms which store excess energy in the form of hydrogen and use it to generate power later, when the wind isn't blowing. The Lolland Hydrogen Community in Denmark has been experimenting with a similar concept, as has a ship called the Hydrogen Challenger.

Melbourne based company Solar Systems is also looking to combine hydrogen energy storage with a solar power plant, using excess heat to improve the efficiency of electrolysis.

Cross posted from Peak Energy.