Submission to Senate Inquiry on Australia's Future Oil Supply
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To:
The Secretary
Senate Rural and Regional Affairs and Transport
Parliament House
Canberra ACT 2600
rrat.sen@aph.gov.au

Submission written by:
Peter Flanagan
405 Barkly Street
Brunswick. Vic. 3056
Tel. (03) 9387 6035

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I would like to address my remarks to issues of reducing reliance on oil through efficient use of existing fuels and on the potential for alternative fuels to be used. I would also like to identify some measures that the government could employ to encourage fuel efficiency and direct the market away from some of its anomalies and perverse subsidies.

In this submission I have made frequent mention of electricity and the fuels or methods used to generate it. I suggest that this is relevant to your considerations, as some of the oil-replacement fuels that have been touted use electricity in their production. Thus, the source of the electricity is relevant for consideration of efficient transformation of energy and for greenhouse emissions.

Future Demand for and Price of Oil-based Fuels

Declining Oil Production World-wide

It has been contended that the world oil production will peak as soon as 2010 (some say that it has peaked already), and natural gas production soon after ('New Scientist', 2 August 2003). See also article in 'The Christian Science Monitor' of 29 Jan 2004, "Has Global Oil Output Peaked ?", ref http://csmonitor.com/2004/0129/p14s01-wogi.html

Over the past decade, oil production has been falling in 33 of the world's 48 largest oil producing countries, including 6 of the 11 members of OPEC. In the continental United States, production peaked 35 years ago at 8 million barrels per day, falling to less than 3 million barrels per day now. Among the other major oil-producing countries where production is declining are the United Kingdom and Indonesia. Ref http://www.alternet.org/story/30653/

Another issue is that oil reserves may have been systematically overstated for years and the 'crunch' of declining production will come faster and be steeper than expected. A recent report by industry newsletter Petroleum Intelligence Weekly (PIW) suggested that Kuwait's oil reserves (10% of the global total) may be only half of what had been previously stated. Ref http://today.reuters.com/business/newsarticle.aspx?type=tnBusinessNews&storyID=nL20548125&imageid=&cap

Similar statements have been made about Saudi Arabia and its oil production not being sustainable and its reserves being overstated. Ref 'The New York Times', October 27, 2005

Declining Oil Production in Australia

The latest global oil production data from the Energy Information Agency (USEIA 2004) includes a significant revision for Australian production. The EIA now estimates that in 2003 Australian oil production fell by 18%, and that in the first four months of 2004 it is down by 15% in comparison to the same period in 2003. Ref http://www.energybulletin.net/971.html

This news is worse than older Geoscience Australia and Australian Bureau of Agricultural & Resource Economics (ABARE) estimates. Geoscience Australia estimated that, "Australian stocks of crude oil (in the ground) will be exhausted in 8 (now 5) years if the current rate of production is maintained and there is no discovery of new reserves" (GA 2001a). There have been no significant discoveries in Australia since that time.

The ABARE study, conducted by Woodside Energy p/l Managing Director John Akehurst, said: "Projections by Australian Government forecasting agencies indicate that Australia is facing a rapid decline in liquid petroleum production over the next decade. Liquids self-sufficiency is expected to decline from an average of 80-90% over the past decade to less than 40% by 2010." (Akehurst 2002)

Australia's peak production of natural gas (for domestic and export uses) is expected to occur between 2020 and 2026, about the same time as the peak in world gas production. Projections have not been done beyond this date. Ref
http://wwwistp.murdoch.edu.au/publications/projects/oilfleay/06australian.html#6.4

Increasing Oil Consumption

China has now overtaken Japan as the world's Number 2 oil consumer. The International Energy Agency expects Chinese oil imports to *double* to some 4 million barrels a day by 2010. By 2030, China is expected to be importing about 10 million barrels a day, roughly what the US imports now. Domestic oil output in China remains flat. (Reference - Sydney Morning Herald – 3 Dec 2003 - http://www.smh.com.au/articles/2003/12/03/1070351656784.html)

Rapid industrialisation in both China and India will give rise to large increases in the numbers of passenger and transport vehicles. Higher use of oil in a static or declining world production environment must give rise to higher prices. China's rise as a super-buyer will have big implications for the oil market, the environment, and world politics.

Last year, China overtook Japan to become the world's second-largest auto market after the United States with almost 6 million units sold (Ref 'The People's Daily' - 16 Jan 2006. Sales this year of all vehicles are expected to grow another 10-15%. Passenger vehicle sales are growing even faster (last year 21% growth) despite government action to cool an overheating economy.

By 2025, world conventional oil production could be about 60% of current levels and Australia will be wholly dependent on oil imports in a fiercely competitive market. Ref
http://wwwistp.murdoch.edu.au/publications/projects/oilfleay/06australian.html

Future Price of Oil and Human Behaviour

In the context of declining oil production and increasing demand for oil, something has got to give. Consumption cannot be greater than production for long. Emergency supplies will be run down to nothing and prices must rise to shake off the excess demand to bring about a balance. If in 2025 we are looking at only 60% of current production and two-three times current demand, from where will the short-fall come ?

Many studies have shown a fair degree of inelasticity of transport fuel consumption to price. For many people, having bought their car (or cars), the capital and standing costs are much higher than their running costs (eg $200 a week versus 30 cents an additional kilometer). Dearer petrol or diesel will not change their behaviour much in the short term.

What this means is that prices, when they start to rise, will tend to rise fast. Some pundits are predicting oil rising from the current level $60 US a barrel to $200 US a barrel within five years. I remember just two years ago motor industry spokesmen saying that petrol in Australia would be back to below 90 cents a litre within 12 months. Any rise was seen then as a short-term anomaly caused by supply interruptions in Iraq.

Our petrol and diesel fuel is now about $1.20 a litre. In Europe, it is priced at over $2.00 a litre and yet people seen to live happy and productive lives there. What would have to change for us to live as Europeans do ?

Australian Infrastructure Inadequacies

Some of the reasons for Australian people not reducing their fuel consumption with price increases relates to infrastructure. In Victoria, the public transport network can only be regarded as 'adequate' in the inner and middle suburbs of Melbourne. In the outer suburbs it is non-existent or only present until about 7pm or 8pm on weeknights. Mostly public transport in these suburbs is sparse on Saturdays and is unavailable on Sundays. Even in 'peak' periods, the frequency of public transport services is inadequate. Public transport has to provide a real alternative for people. Also walking and cycling have to become safe choices, with hazards from other road users reduced somewhat.

The location of destinations such as schools, shops, and work are important, too. In the outer suburbs, there is no such thing as the 'corner shop'. Any retail purchase requires travel to a regional shopping centre. Many of these were built on 'greenfield' sites far from public transport. Trends to 'choice' mean that people are prepared to work, play, and study far from home. They then demand a high speed transport connection to get them there and back. Mostly this is seen as a 'freeway'. Pay for use toll roads are becoming more common and their users are becoming reluctant to pay for them. I would say that the real costs of providing infrastructure and non-payment for externalities have been hidden from them for too long.

Developers seem to have quite a lot of influence at government levels and continue to be granted extensions to their regional shopping centres, despite the inadequacy of the transport infrastructure. Development of retail and commercial enterprise around transport hubs, however well supported by government policy (eg Melbourne 2030), seems to be lagging behind. New higher density housing continues to be concentrated in inner suburbs, while large building blocks and large houses, consuming much land and material resources, continue to be built in the public transport-poor outer suburbs.

Land use planning will become critical as the oil dries up and becomes too expensive for many families. Sparse settlement will make provision of public transport too expensive. The outer suburbs will become slums with nice houses. People will find it difficult to get to work, school, or the shops. They will be trapped in their 'transport poverty'.

Fuel Efficiency

The easiest way to reduce Australia's reliance on imported fossil fuels is to make their use more efficient. A second method is by changing Australia's industry to be one that is more service oriented than manufacturing oriented. That is, one that is less 'energy dense' in terms of energy use per dollar of added value. Both of these approaches are visible in trends in Europe.

The two main energy use streams that I would like to consider are:

1. Electricity Generation
2. Motor Transport

Electricity Generation

Quite a few of Australia's electricity generators are over 40 years old and coal fired and few generators with any substantial capacity are younger than 20 years. Recently installed generators in Australia tend to be of smaller capacity and gas-powered, built to cope with peak demand only.

Coal fired power stations in Australia tend to be inefficient by world standards, with little incentive for the owners to improve fuel efficiency. Some plants might have a thermal efficiency of 38%, while best practice can be as high as 55%. Ref http://www.australiancoal.com.au/cleantechAus.htm

Both black and brown coal in Australia is cheap and electricity generated from them is cheap as a consequence. One result of this is an ever expanding Aluminium refining (export) industry, 'fuelled' by low cost electricity. In a sense we are exporting cheap electricity.

The price of electricity in Australia is about one-half of the price of that of the USA and about one-third of the price of that in Japan. One wonders how those countries can still be competitive given these relative disadvantages against Australia. I would suggest they have used their electricity efficiently and where it would provide the best value-add.

Another issue for efficient use of fuels is at the end-use of the electricity and gas and not just at the generator level. The star rating on appliances and houses is good. It could be extended to retail, commercial, and industrial sites. By encouraging everyone to have a much more energy efficient home and work environment, then we would be consuming our scarce resources more slowly and requiring less frequent expansions of generator capacity.

Some Options

The federal government could set an emission target for CO_2 through a minimum energy efficiency target for any new fossil fuel powered generator and set a timetable for existing power stations to meet world's best practice or retire. Many of them are old already and must come up for retirement in the next few years. Why not give them a 40 year life and then mandate retirement.

State governments could stop writing 'sweet-heart' deals that provide subsidised power to energy hungry industries and cheap coal to new generators. All users need to pay a fair price for their energy, which reflects the scarce resources being consumed.

Governments could expand their star ratings to cover a wider range of building types and the federal government could provide leadership, co-ordinate this, and issue standard tools to facilitate comparisons.

Motor Transport

By world standards, Australia's motor vehicles are elderly and inefficient. Moreover, even new passenger vehicles on sale in Australia, even the imported ones, are behind best practice in their fuel efficiency. At first glance, this would seem surprising given that much of Australia's car fleet is imported and that the same models are available overseas with better fuel consumption figures. The reason for the discrepancy is that Australia's fuel and emission standards are behind those used in other countries and the vehicles have to be modified (down-rated) for sale in Australia.

Further, Australian car manufacturers prefer to make larger vehicles, on which they have better profit margins. They have a vested interest in encouraging Australians to buy bigger, more powerful vehicles that consume more fuel per kilometre. The federal government's voluntary fleet fuel efficiency standards lag those set for Europe and are not mandated either. More details on this later.

State and federal governments in Australia tend to "buy Australian" and as a consequence tend to operate fleets of fuel guzzling large cars. The trend is slowly changing.

A series of perverse subsidies distorts the fuel efficiency of cars.

- Firstly, four-wheel drives are classified apart from passenger vehicles to have a lower import duty (5% versus 10% - fortunately this margin will disappear in 2010). This results in artificially lower prices for them. They tend to be less fuel-efficient and, in effect, the government 'subsidises' them. Ref http://www.aph.gov.au/library/pubs/rn/2003-04/04rn17.htm
- Secondly, the fringe benefits tax on company cars encourages unnecessary use. More kilometres travelled in a year means a bigger government subsidy. In the UK, the bigger subsidy goes to fuel efficiency and not bigger distance. The results there mean less unnecessary travel and bigger sales of fuel-efficient vehicles. Ref http://www.inlandrevenue.gov.uk/cars/cct_eval_rep.pdf

The voluntary fuel efficiency standards ('National Average Fuel Consumption Target') have not seen great advances in fuel efficiency. In fact, Australian car manufacturers have been marketing even more powerful vehicles strongly. They are not going to meet their easy voluntary targets and some degree of 'incentive' needs to be given.

Some Options

Opportunities for improving fuel efficiency could come through the following initiatives:

- Reviewing the Federal Government's purchasing policy for its car fleet (currently a low weighting is held against fuel efficiency and a higher one is given to cars manufactured in Australia);
- Discussing with Australian automobile manufacturers the issue of their concentrating on making large vehicles only. Given that 86% of large vehicles are bought for fleets, we contend that fleets would buy whatever was made in Australia and not that the manufacturers are just making what people want to buy. Given that in the light, small, and medium ranges of passenger vehicles, some 40-50% of the models have Euro 4 fuelled versions available, it seems that Australian manufacturers are holding everyone else back.
- Review the results for the environment of the current fringe benefits tax system in its favouring of the inclusion of motor vehicles in salary packages, whereby encouragement is given to higher levels of private use of those vehicles;
- Assess the economic and environmental impacts of speeding up the implementation of the voluntary fuel efficiency standards ('National Average Fuel Consumption Target') and/or making them mandatory; and
- Develop incentive/penalty packages to encourage owners of older vehicles to replace them with newer more fuel efficient and lower emission models. Without this, the benefits of new technology take too long to be achieved.
- Raise the import duty on four-wheel drive passenger cars to 10% to match that of other passenger vehicles.

Fuels Available

Electricity Generation

Brown Coal

Victoria has vast amounts of brown coal, almost all of it in the Latrobe Valley. The quantities are so large that there is sufficient supply to power Victoria's power generation at current levels for about another 500 years. Brown coal is a useful fuel for stationary uses (eg electricity generation), although it is not as energy dense as black coal. It does emit a lot of greenhouse gases per unit of electricity produced. It can also be converted to liquid fuels for transport, but at a high cost in the energy used up and greenhouse gases emitted.

Brown Coal is likely to be the main power generation fuel in Victoria for the foreseeable future. Whether or not the use of this fuel in Victoria expands will depend on two things:

- whether subsidised electricity will continue to be supplied to the Alcoa Aluminium plant in Portland when the current contract expires; and
- whether the use by this plant will expand with increased prices for electricity in other countries that are currently producing Aluminium.

Victoria's peak electricity use is rising much faster than its base load, mostly due to home air conditioner use. Peak load is being progressively moved to hydro and gas-powered generators as the base-load safety margin contracts (difference between what is generated and the 'safe' level of capacity 'on-line').

Black Coal

Australia has large quantities of black coal, mostly in Queensland and New South Wales, with smaller amounts in South Australia and Western Australia. Large quantities are exported from Queensland and New South Wales (250 M tonnes per annum – Ref http://www.australiancoal.com.au/ports.htm). I believe that Australia is the world's largest coal exporter and Newcastle is the biggest coal export port in the world. It will not be for much longer, as substantial upgrades to Queensland coal ports will overtake its capacity. For the foreseeable future, black coal is likely to be the major fuel for power generation in Australia.

Hydro-electric Power

With global warming, the sites of hydro-electricity generation in the Victorian Alps, the Snowy Mountains, and Tasmania are likely to be constrained by lack of incoming rainwater. North Queensland might be better off, but opportunities for generator sites there are not so good. Thus there is almost no prospect for economically expanding the capacity of hydropower generation. However, some benefits can be derived from systems where water is pumped back uphill for reuse (pumped storage) by electricity drawn from off-peak coal fired base power stations. This is already done in a number of sites. Ref http://www.austehc.unimelb.edu.au/tia/800.html

Wind Power

There are a number of windswept parts of Australia suitable for the installation of wind generators, mostly in coastal areas of the Southern states. Some areas have more consistent wind and this can be captured to feed electricity grid base load or to store energy somehow for peak use. It could even be used to produce a useful fuel (eg Hydrogen) or to charge batteries.

Denmark currently has 20% of its electricity from wind sources, rising to 28% in 2008 (Ref http://www.windpower.org/en/didyouknow.htm). To avoid some of the perceived aesthetic issues of 'damage' to landscape values, they have put some generator farms kilometres off the coast in shallow water. This may not be an option for Australia, as shallow water is rare in the windy areas.

There has been heated discussion in some rural communities in Australia about not wanting a wind farm on a neighbour's property, but it can be a good income for those who have one on their own property. In fact, it is a much better income than can be derived from farming. In the USA, some rural communities have been rejuvenated by the addition of this new 'cash crop' (the financial yield is about 10 times what can be derived from cattle grazing on the same area of pasture). In Denmark, half of the wind turbines are owned by local wind turbine cooperatives. Similar schemes are now being seen in the USA. Ref http://www.windustry.org/newsletter/2002FallNews.htm

Solar Cells

Photovoltaic or Solar cells are becoming much more energy efficient and so take up less surface area to generate the same amount of electricity as was previously the case. When the size of the roof areas of Australian houses are considered, much of the existing home electricity consumption could be supplied by this means. While its hours of operation are limited to daytime, it might help with peak load as air conditioners are often used during periods of bright sunlight. If the electricity generated can be stored for off-peak use or converted to a fuel, then this form of generation would be more useful.

Current commercial products in Australia require a 30 year payback period (at the current price of electricity, price and efficiency of solar cells, and the levels of government subsidy). However, they are very suitable for sites a long way from the national electricity grid.

Efficiency in the conversion of sunlight into electricity has improved quite a lot in recent years. Ten years ago, 15% efficiency was seen as good. Today it is 30%, with 50% and higher in the pipeline. Ref 'New Scientist', 8 December 2002. Work is ongoing to make solar cell material cheaper to make (using less energy) and in making them long lasting and rugged in the field.

Natural Gas

Australia has large amounts of natural gas on the North-West Shelf, Bass Strait, and in Central Australia. Note that Bass Strait gas will run short in the next ten years and gas demand in the Eastern states will require a pipeline to Western Australia by then. Huge quantities of gas are exported from the North-West Shelf and national gas production is not predicted to peak until between 2020 and 2026. It should be noted that the rate of extraction of gas is now accelerating with demand from Asia and the Americas. Ref http://wwwistp.murdoch.edu.au/publications/projects/oilfleay/06australian.html#6.4

Natural gas (Methane) is reticulated by pipeline to most capital (and many provincial) cities of Australia. It is used directly in industry and households, but also fuels power stations and some transport uses. Its produces less greenhouse emissions than coal for the same amount of energy, but it will run out long before the coal does. It is far more useful in producing petro-chemicals than in just being burnt to make electricity.

Conclusion: Coal will be the supplier of the vast majority of Australia's electricity for the foreseeable future. While renewable sources can be developed and might take up 20-30% of the overall electricity task, the only way for fossil fuel use to be reduced here is if the nation uses less electricity. This will mean major changes to commerce, industry, and to household use. Reducing greenhouse emissions by using more efficient power plants and by using more renewable energy sources should be pursued. At the moment, at current energy prices, there does not seem to be much interest or incentive in reducing energy use at the industry and consumer end.

Motor Vehicle Fuels

The ideal fuels for motor vehicles on land, sea, and air are those that are liquid at room temperature (meaning that they are energy dense and easy to deliver into a motor). Petrol and diesel are thus the ideal fuels for transportation users.

Fuels that are gases at room temperature have to be compressed or liquified to make them dense enough to give a suitable range for the transport user. The compression or liquification process in itself, can require a lot of energy, perhaps more than is embodied within the resultant fuel.

The range of fuels currently in common use for motor vehicles in Australia is:
1. Petrol
2. Diesel
3. Liquid Petroleum Gas (LPG)

In considering each of these fuels, we need to assess:
- The origin of the fuel;
- How they are to be prepared for use and distributed to users;
- How useable are they for the intended task; and
- What potential hazards exist from their use.

Petrol

Petrol is mostly produced from oil or as a condensate from natural gas. The majority of Australia's oil is imported and local oil production (mostly from Bass Strait) is declining quickly. It will be mostly gone within 10 years.

The oil is refined into petrol in Australia or the petrol is imported as the end-product from overseas. It is a very useful transport fuel and likely to be the main fuel used, along with diesel, for the next 20 years at least. It is very flammable and can cause serious fires, but fire fighters are used to dealing with it. Motor vehicles are generally designed to minimise the chances of a tank rupture.

Diesel

Much the same can be said for diesel, although there are a number of differences:
- It is slightly more energy dense than petrol;
- It is less flammable than petrol;
- It permits more fuel efficient engines to be built for motor transport; and
- Current model road and rail vehicles produce a high level of particulate emissions, although this will improve with newer models and newer fuels with lower Sulphur content (Euro 4 and Euro 5).

Recent reports show new diesel engines getting 20-40% better fuel economy than petrol vehicles and now diesel motors power more than half of all cars sold in Europe.

Diesel is produced from mineral oil, but can also be produced from recycled vegetable oils or canola, which can be grown specifically for that purpose. Where this is done in Europe and the USA, this is usually done from surplus food crops. In Europe, there is a subsidy at the growing, refining, and retailing stages of bio-diesel production. Mineral oil derived diesel is still too cheap for bio-diesel to be a serious competitor at current prices.

There is also the land use issue about whether to divert food crops into fuel or use marginal land for fuel crops. A social justice issue would arise if the food crops of third world countries were diverted into first world fuel use.

Demand for canola oil in Oct 2005 hit a high point with record prices being paid, as well as a large price premium over other oils. This is an indication of the demand for bio-diesel.

Liquid Petroleum Gas (LPG)

This is a by-product of petrol refining and is distributed through the usual petrol/diesel retail outlets. It does require special vehicle fuel tanks and more stringent procedures for refuelling. However, we seem to have mastered this and only have the occasional explosion from a road vehicle. This fuel is taxed at a lower level than petrol and diesel and is thus encouraged (subsidised) by governments for transport use. This may be distorting the market away from fuel efficiency.

Other fuels, not currently in wide use are discussed in the next section.

Alternative Fuels

I would like to examine the fuels that are getting a lot of publicity to identify whether they are ready for the tasks that are being suggested for them.

Electricity Generation

Nuclear Power

Some have advocated the use of Nuclear Power as a way of reducing greenhouse gas emissions from electricity generation. On the face of it, this looks a reasonable solution for reasons of import substitution and greenhouse gas reductions. Australia has large supplies of Uranium on hand (28% of the world's supply), mostly in South Australia and the Northern Territory. The quantities available, if not reserved for an expanded export programme, might last for a few decades. World supplies are rated at 50 years remaining life at today's prices. Ref http://www.uic.com.au/ne3.htm#3.3

To make nuclear power work for Australia would require a large amount of infrastructure to be developed in processing the Uranium into fuel, reprocessing spent fuel, and the storage of waste. A lot of the materials and technologies are not available in Australia and location and land use will be serious issues. Most communities would not want a reactor in their municipality at whatever benefits are offered to them.

Nuclear power reactors would make Australia a more 'useful' target for terrorists and a uranium fuel cycle would necessitate a large amount of curtailment of civil freedoms. It might be argued that the "War on Terrorism" might lead to this anyway. Ref Report for US Congress "Nuclear Power Plants: Vulnerability to Terrorist Attack", http://www.fas.org/irp/crs/RS21131.pdf

Worldwide there is not a great amount of easily mined Uranium. If oil becomes too expensive to use for transportation within 15 years, then Uranium substituted for it will be used up very quickly after that. Some are suggesting that if nuclear power is used to provide all the growth in electricity demand and to produce transportation fuels (making Hydrogen through the electrolysis of water), then it will all be gone in 20 years (ie by 2040). Then what ?

There are many dangers associated with nuclear power. Many of these have been experienced and reported around the world. Dangers such as spills of contaminated coolant, fuel rod melt downs, explosions in radioactive materials, and seepage of stored materials into ground water. There will be the ever present threat of accidents in transporting materials for reprocessing and the threat of terrorist theft of materials or damage to facilities. Nuclear power is an ongoing commitment with long term monitoring of closed sites and waste storage required, even if nuclear power is discontinued completely in the future. No nuclear power station site has yet to cleaned up and returned to a new use, not even the experimental ones in the USA from 60 years ago.

Around the world there has been mixed attitudes to nuclear power:
- The USA has not commissioned a new nuclear plant in 20 years, with the industry virtually frozen since the Three Mile Island accident in 1979;
- Sweden is expanding its infrastructure and building new plants to phase out dependence on oil;
- Canada is rebuilding two old nuclear plants and 14 new ones to replace old coal-fired generators;
- Other European countries (including Germany and Switzerland) are phasing out their old reactors and not replacing them;
- Worldwide, nearly 80% of the 441 commercial nuclear reactors currently in operation are more than 15 years old. Ref http://www.physicstoday.org/vol-59/iss-2/p19.html ;

- Some two dozen power plants are scheduled to be built or refurbished during the next five years in Canada, China, Finland, France, India, Iran, Pakistan, Russia, and South Africa.

In the USA, to certify a new nuclear plant involves a process costing $150M. While this sum can be amortised over the expected 60 year life of the latest model power plants (current models are only rated for 30-40 years), it is a big up-front cost. From the time a technology and a site are selected (and the various political battles fought with neighbours and local government), it would then take another seven years to have a new power plant in operation. Ref http://www.energy.gov/news/1538.htm

Nuclear power's biggest problems are economic: it is simply no longer competitive with other, newer forms of power generation. The final 20 U.S. reactors cost $3 to $4 billion to build, or some $3,000 to $4,000 per kilowatt of capacity. By contrast, new gas-fired combined cycle plants using the latest jet engine technology cost $400-$600 per kilowatt, and wind turbines are being installed at less than $1,000 per kilowatt. Ref http://www.worldwatch.org/press/news/1999/03/04/

Tidal Power

Few investigations have been carried out in Australia, but there are opportunities where:

- A tidal race channels a large current of water through a narrow opening; or
- Where the strong winds of the Southern Ocean consistently push rolling waves with much force from West to East onto the Coasts of Victoria, South Australia and Tasmania.

However, just as with wind power, this may not solve the peak power problem, but can be a useful form of augmentation of the coal-fired generators. While a number of proposals have been made, there are only three working examples of tidal power installations world-wide:

- The largest plant is located in France, in the estuary of La Rance near St. Malo. It has a capacity of 240 megawatts and generates on the incoming and outgoing tide.
- Annapolis Tidal (USA) has an output capacity of 20 megawatts. It uses the largest straflo turbine in the world to produce more than 30 million kilowatt hours per year - enough to power 4,000 homes.
- The smallest tidal plant is located at Kislaya Guba on the White Sea in Russia. It has a 0.5 Megawatt capacity.

Ref http://www.nspower.ca/AboutUs/OurBusiness/PowerProduction/HowWeGeneratePower/Hydro.html#ANN

Desire for a More Decentralised Power Network

National power grids around the world are becoming more complex, with many power generators, distribution networks, and loads being interconnected. Commercial considerations mean that ‘spare’ capacity is being soaked up as suppliers and distributors are delaying upgrades to generators and grids. The overall network becomes less robust and failures (natural, equipment failure, or sabotage) can then cascade to ‘black out’ large parts of a country.

In such an environment, it does seem to be a good thing to have a more decentralised approach to the generation of electricity. Many small scale generators may provide a more stable network than one with just a small number of co-located generators. In this context, wind and tidal power systems are useful additions to the national grid.

Motor Vehicle Fuels

The European Union has been looking for some time to find substitutes for oil-based motor vehicle fuels. A December 2003 report by the European Commission on alternative fuels identified natural gas vehicles (NGVs) as one of the most viable solutions. In its report *Market Development of Alternative Fuels* by the European Commission's Alternative Fuels Contact Group natural gas vehicles are identified as the only potential economically viable alternative fuel to replace well above 5% of petroleum in the transport sector by 2020.

The EC has a transportation policy that targets the substitution of 20% of petroleum fuel use by 2020 with 10% natural gas, 5% biofuels, and 5% hydrogen. Given that total use of transport fuels may rise higher than this level substitution, then where will the additional oil come from in 2020 ? Developments in motor vehicle fuel efficiency may attain a much larger significance.

The Executive Summary and the Full Report are available at
http://www.engva.org/view.phtml?page=pa.phtml and
http://europa.eu.int/comm/energy_transport/en/envir__en.html.

Compressed Natural Gas (CNG)

There is potential for CNG to be more widely used as a transportation fuel in Australia. It will be harder to handle as the fuel tank will need to be able to withstand higher pressures and refuelling may be more of a challenge. The range of the vehicle may not be as high as for a liquid fuel.

In California, there is now a push to have home filling of CNG fuelled cars from the home gas mains, using a specially designed facility. This may be an option for the future in Australia, although governments might be disturbed about the diversion of fuel from a use that is not taxed to one which they expect will be.

The concept is simple, a small Home Refueling Appliance (HRA), is fitted wherever a vehicle is parked for a reasonable period of time, a garage, carport or driveway at the home or workplace. The HRA is then connected permanently to the local natural gas and electricity supplies and provides fuel for the compressed natural gas (CNG) vehicle in the same manner as a refueling hose at a public station, pumping natural gas into the on-board CNG cylinder in the vehicle.

Where it differs slightly from normal refueling, is that the gas is pumped in over a longer period of time (eg overnight). The refuelling time varies depending on how much fuel is already in the vehicle, but generally a complete fill is achieved within a four to twelve hour period. As most vehicles are stationary for at least this period of time each day, the extended refueling time has little or no effect on the usability of the vehicle.

A report published earlier this year by the US National Renewable Energy Laboratory (NREL) provided an independent assessment of ‘Phill’, an HRA manufactured by FuelMaker of Canada. Such are the standards that the unit is manufactured to, that the report concluded that a person is more likely to be fatally struck by lightning (one in 686,000) or electrocuted by a different consumer product (one in 1.8 million) than they are to have an accident through either regular or misuse of the HRA.

As an indication of up-front costs, the ‘Phill’ unit mentioned above currently sells in California for around $US3,500 but State subsidies available currently reduce this figure by $2,000 (limited to first 400 units). Federal subsidies available from January 1 2006 will reduce the amount by $1,000. There the unit is cleverly marketed in tandem with the CNG powered Honda Civic GX. Ref NGV Global, 5 October 2005

Ethanol

Ethanol is usually made from crops (eg sugar cane, corn) or waste from crops. Its potential as a transport fuel is good. Today ethanol accounts for 40% of the fuel sold in Brazil.

Brazil leads world ethanol production in 2004, distilling 4 billion gallons (15 billion litres). The United States is rapidly catching up, however, producing 3.5 billion gallons last year, almost exclusively from corn. China's wheat- and corn-rich provinces produced nearly 1 billion gallons of ethanol, and India turned out 500 million gallons made from sugar cane. France, the front-runner in the European Union's attempt to boost ethanol use, produced over 200 million gallons from sugar beets and wheat. In all, the world produced enough ethanol to displace roughly two percent of total gasoline consumption. Ref http://earth-policy.org/Updates/2005/Update49_data.htm

The International Energy Agency has said that ethanol could make up as much as 10 percent of the world's gasoline mix by 2025. Ref http://earth-policy.org/Updates/2005/Update49.htm

The Australian federal government is keen to reduce the level of oil imports by stipulating a certain percentage of ethanol in petrol in Australia. If waste materials are used in ethanol production, then this may be good. However, if crops are grown with the sole objective of growing transport fuels, then we have serious problems. It will come down to a land and water use issue, with the vast majority of farming land already committed to food crops. Finding marginal land and spare irrigation water for fuel crops may just turn more of the country into desert.

Transport fuel consumption is huge and we could easily use a lot of our food just to power our cars. An assessment in the USA said that if all the soy and corn was converted to ethanol, this would satisfy the USA's needs for nine days a year.

Recent reports from Brazil indicate that the price of sugar, a raw material for Ethanol production, will have to rise with this new demand. This year, sugar prices are at a 25 year high and Brazil is running short of Ethanol for its own transport fuels. Ref
http://www.planetark.com/dailynewsstory.cfm/newsid/34983/story.htm

There are also issues of efficiency in the process of converting crops into fuel, relating to the fossil; fuels needed to grow and harvest the crops in the first place. Ref
http://earth-policy.org/Updates/2005/Update49.htm

Although ethanol's popularity is growing, today's inefficient production methods and conversion technologies mean that this fuel will only produce modest environmental and economic benefits and could impinge on international food security. The largest obstacle to bio-fuel production is land availability. Expanding cropland for energy production will likely worsen the already intense competition for land between agriculture, forests, and urban sprawl. With temperatures rising and water tables falling worldwide, global food supply and demand are precariously balanced. World grain reserves are near all-time lows, and there is little idle cropland to be brought back into cultivation. Shifting food crops to fuel production could further tighten food supplies and raise prices, pitting affluent automobile owners against low-income food consumers.

Placing greater emphasis on land efficiency-that is, maximizing energy yield per acre-will be essential to making the best use of ethanol. Though corn has broad political support as a feedstock in the United States, it is one of the least efficient sources of ethanol. For example, ethanol yields per acre for French sugar beets and Brazilian sugarcane are roughly double those for American corn.

Also important is the amount of energy used to produce ethanol. Growing, transporting, and distilling corn to make a gallon of ethanol uses almost as much energy as is contained in the ethanol itself. Sugar beets are a better source, producing nearly two units of energy for every unit used in production. Sugarcane, though, is by far the most efficient of the current feedstocks-yielding eight times as much energy as is needed to produce the ethanol. Given their positive energy balances and higher yields, it makes more sense to produce ethanol from sugar crops than from grains.

Agricultural residues, such as corn stalks, wheat straw, and rice stalks, are normally left on the field, plowed under, or burned. Collecting just a third of these for bio-fuel production would allow farmers to reap a sort of second harvest, increasing farm income while leaving enough organic matter to maintain soil health and prevent erosion. The agricultural residues that could be harvested sustainably in the United States today, for example, could yield 14.5 billion gallons of ethanol-four times the current output-with no additional land demands.

"Energy crops", such as hardy grasses and fast-growing trees, have higher ethanol yields and better energy balances than conventional starch crops. One likely candidate is switchgrass, a tall perennial grass used by farmers to protect land from erosion. It requires minimal irrigation, fertilizer, or herbicides but yields 2-3 times more ethanol per acre than corn does. Such crops could potentially be harvested on marginal land, avoiding the conversion of healthy cropland or forests to energy-crop production.

Hydrogen

A number of reports are summarised in the Appendices to this document.

Hydrogen is currently made from the processing of oil or gas at petro-chemical plants. It can also be produced by the electrolysis of water. It is not energy dense and is a very light gas. Any “spills” are easily dissipated. Storage requires a high pressure tank or liquifaction of the gas. Compression and liquifaction processes both require a lot of energy. In fact, for Hydrogen, there is much more energy consumed in liquifying it than there is in the fuel itself.

There may be a possibility for the future where hydrogen is produced at home from solar cells, but all steps of the process will be very inefficient.

Hydrogen is not a ‘fuel’, but a storage mechanism for energy. Most proposals for the manufacture of Hydrogen require extraction of natural gas or electricity generation to start it off. A lot of energy is required just to get the Hydrogen.

Hydrogen is mostly pushed as a transportation fuel by those who wish to advocate expanded electricity production by coal or nuclear power.

To give any range to a Hydrogen powered vehicle, the gas must be compressed or liquified. This requires a lot of energy and necessitates a heavy duty tank. The hazards of explosion of the fuel tank are quite high. It is said that there is many times the explosive force in the pressure of the tank than in the combustability of the gas in it.

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The International Energy Agency (in its recent report: 'Prospects for Hydrogen and Fuel Cells') has said that a number of major challenges need to be overcome to make Hydrogen a viable fuel option. Most hydrogen technologies are currently substantially more costly than their conventional counterparts and a transition to hydrogen would require huge infrastructure investment over several decades. In the next few decades, there needs to be a 3 to 10-fold reduction in the cost of hydrogen production and a 10 to 50-fold reduction in the costs of fuel cells. Ref *http://www.iea.org/textbase/npsum/Hydrogen2005SUM.pdf*

Given these huge challenges, with this solution, we should not be putting a lot of our effort in chasing this phantasm. It would be better to work on fuel efficiency in traditional fuels today. It will save us money, slow the rise in fuel prices and better prepare us for the future.

Fuel Cells

It is said that one of the major advantages of fuel cell-powered vehicles is their greater efficiency. Whereas a conventional gasoline internal combustion engine has a maximum Carnot efficiency of less than 25%, a fuel cell engine has a potential efficiency better than 30% and possibly higher. Just by comparison, a diesel engine might achieve 40% efficiency.

The issue here is what fuel is to be fed to the fuel cell. Most manufacturers are suggesting that Methanol or Ethanol be the fuel. Others are planning on Hydrogen. Which is the best fuel to use ? Also, is a fuel cell producing electricity to drive an electric car more efficient than an internal combustion engine running on Ethanol or an Ethanol/electric hybrid ?

Dr Ulf Bossel (ubossel@bluewin.ch) compared various fuels and engine types and compared 'well-to-wheel' efficiencies. By his calculation, a PEM fuel cell typically used in prototype fuel cell cars is, at best, 22% efficient if the hydrogen used in it is compressed and only 17%, if its liquified. By contrast, a hypothetical diesel hybrid similar to the new Mercedes-Benz F-500 concept vehicle has a well-to-wheel efficiency of 25%. And when he looks at the efficiency of battery electric cars, he comes up with a power plant-to-wheel efficiency of 66%, when regenerative braking is included.

From his perspective, battery electric cars make the most sense for local commuting, while biodiesel-fuelled hybrid-electric drives make the most sense for the family vehicle if maximum energy efficiency and cutting greenhouse gas emissions are the two top priorities.

With the exception of General Motors, virtually no auto-maker, supplier, energy company or government official expects fuel cell vehicles to be ready for mass production until at least 2020. Fuel cell researchers are making progress but still struggling with some tough problems. The cost per kilowatt hour is still about 10 times too high, cold-weather performance is not up to internal combustion engine standards and no one knows how to produce and distribute hydrogen (if that is the fuel of choice) in enough quantity to replace gasoline. Ref Automotive News / October 31, 2005.

This is also a long term solution with many challenges that will have to be solved.

Battery Power

Battery technology is advancing relatively quickly. The important issues are:

- The energy density – how much energy can be stored in the battery per kilogramme of battery;
- The life of the battery in years or in the number of charge/discharge cycles;
- The permitted temperature range at which the battery can provide useful power;
- The cost of the battery;
- Use of toxic materials in the battery and processes and efficiency of recycling them; and
- The efficiency of the charging – how much energy goes in to how much energy can come out.

For many proposals there is an issue in how is the battery to be charged. Californian citizens and local governments have been pestering Toyota about whether there will be a version of the Prius petrol/electric hybrid car that can be charged directly from the mains outlet in their garage. They say that if the car can be charged by off-peak electricity overnight, then this might be a cost-effective and environment friendly solution. Effectively, they want a battery car than can run on petrol when they are far from home.

However, if enough people do this, then the requirement for peak electric power will rise and the overnight period will then become the new peak period. This will lead to more electricity generator capacity required. This solution is worth a closer examination.

Most uses of batteries, beyond local journeys involve using a battery to store some of the excess energy produced by another system (eg battery/petrol hybrid).

Fuel Efficient Engines and Fuel Use

Much of the increase in transport fuels used in Australia is inherent in the design of vehicles in use here. The volume of fuel consumed by a vehicle has a direct relationship to its engine size. The proposed voluntary code of practice for vehicle manufacturers in Australia, announced by Minister Kemp on 15 April 2003, has set some targets for 2010, but these are fairly low by international standards.

European, Japanese and Korean car makers have committed to reduce CO_2 emissions from new passenger cars to an average of 140 grams per kilometre (g/km) in 2008 (2009 for Asian makers). The ultimate objective is to reduce emissions to 120 g/km in 2012, although this is looking unlikely and the 2008 voluntary target may not be met either. They are currently trying to claim offsets by using bio-diesel as a fuel (claiming that bio-diesel is a renewable energy source).

The Australian code has specified a ‘National Average Fuel Consumption Target’ for ‘new passenger vehicles’ of 6.8 litres per 100 kilometres travelled. Given that CO_2 emissions for petrol are 2.5 kg/litre of fuel, this translates to 170 g/km for the Australian standard. This is some 18% less efficient than the European 140 g/km standard and two years later.

I contend that the Australian target could be tighter and the implementation date for the standard brought forward. Australia is behind the EU and Asian manufacturers and is getting further behind. These unchallenging targets will also cause some problems for Australian automobile manufacturers in trying to sell our 'gas guzzlers' into export markets.

While Australian motor vehicle vendors continue to promote larger engines and additional power as desirable features of their vehicles, the average fuel consumption will continue to rise. The federal government through its fleet buying has the purchasing power to influence this.

I note with some concern that the USA has exempted SUVs (Sports Utility Vehicles) from their passenger car fuel efficiency standards. In the USA, about one-third of new ‘cars’ are now SUVs. There is a trend towards a similar situation here. We must include them in the fuel efficiency standards for passenger vehicles, given their intended use. They must not be allowed to masquerade as trucks (exempt from fuel efficiency standards) one minute and then as cars (eg no endorsement in the driver’s licence required) when this suits them. The Import Duty tax subsidy applying to the import of these vehicles needs to be removed as well, as it encourages fuel inefficient vehicles ahead of fuel efficient ones.

While the technology is evolving, I would like the government to study the opportunities for local manufacture and use of hybrid vehicles, especially in government fleets, and commence some trial projects. I note that the Victorian government has introduced Toyota Prius hybrid cars, as has the City of Melbourne. The City of Melbourne also has a policy of its car fleet operating at an average fuel consumption level of 8 litres/100 Km or less by 2005 (this is not too challenging, but it is a start).

Please note that in the push to find cleaner fuels to power transport, we need to examine the whole production cycle of that fuel. For instance, using electricity to produce ‘clean’ hydrogen is a ‘dirty’ process if the electricity is produced by burning coal. Producing it by ‘green’ electricity is not much better if it just displaces another use of that green electricity to a coal-fired plant. We would also contend that clean fuels that are used wastefully offer no great advantage to the environment.

That the Euro 4 standard is proposed for diesel engines in light vehicles is useful, as such engines are becoming more widespread in the passenger vehicle market and in four-wheel drives. Even this may not be enough. New Scientist (31 January 2004, page 15) states that “the next generation of ‘clean’ diesel engines, designed to deliver greater fuel economy and lower emissions of greenhouse gases will still create more smog-producing pollutants than their petrol-driven counterparts.” The issue here related to the interaction of NO_2 emissions with environmental hydrocarbons to produce Ozone.

Age of Vehicles will Constrain Improvements to Fuel Efficiency

The benefits from improving fuel quality standards to allow for more fuel efficient new cars will bring about change in average fuel consumption slowly, given the length of time that people retain their cars. The Australian motor car fleet is one of the oldest in average age in the Western world. There needs to be some incentive or disincentive applied to encourage older vehicles to be retired or refitted (if this is a viable option) so that the benefits of improved fuel efficiency can be delivered to the people of Australia.

Reducing Fuel Used through Reducing Kilometers Traveled

If Australia took a different approach to oil use, it might seek to set a priority in reducing greenhouse emissions, the total quantity of petrol and diesel fuel used in Australia, and the total distance traveled. Many car journeys could be substituted by alternative transport modes, leading to a healthier population and environment. These alternative modes include walking, cycling, and public transport.

A number of programmes have shown that that the car use reductions can be achieved without too much effort. Travelsmart has reduced car kilometers traveled by 10% in a number of locations and Smartbus has increased bus patronage on Springvale Road in Melbourne by 30%.

Victoria's Department of Health has stated that excessive car use leads to an overweight indolent population with higher medical bills. New fuels and vehicle technologies will not make our cities more livable. Even if zero emissions could be achieved, the anticipated future traffic levels, in themselves, will cause ill-health.

Finally, road freight is heavily subsidised by the transfer of costs to other road users and the general population. Rail freight is more energy efficient, requires fewer drivers, has a lower accident rate, and lower levels of emissions of some pollutants. This last point is offset to some extent by the ancient technology in use for some locomotives (for instance, there are no emission standards for exhaust pollution from rail locomotives in Australia). Overall, a true accounting would lead to a diversion of a lot of freight from road to rail.

Barriers to Change

The main barriers to the introduction of fuel-efficient vehicles in Australia are:

1 the reluctance of Australian manufacturers to introduce new technologies and their preference to build large vehicles only;
2. Manufacturers and retailers promoting power and 'launch feel' as the desirable aspects of a vehicle and not fuel efficiency;
3. While petrol and gaseous fuels are relatively cheap, fuel efficiency is not a consumer issue; and
4. Government (local, state, and federal) preference to Australian-made vehicles also means that larger cars are the most commonly purchased, as smaller vehicles are usually imported.

There will be limitations on what can be achieved unless the federal government gives some leadership and support. Currently it provides a subsidy (reduced Import Duty) to the purchase of four-wheel drive vehicles. These are increasingly being used for non-business and non-agricultural use. Four-wheel drive vehicles are also more likely to be fuel inefficient.

What Governments can do

We are on the point of a crisis and most solutions have a long lead time before they show significant benefits. We must find some simple solutions that can be introduced quickly. We may not have 10 or 20 years as some are hoping. By concentrating on *researching* solutions that are 20-30 years away (eg hydrogen power or fuel cells) and taking no action *today,* we may overlook solutions that are available now.

I would like to see the federal and state governments adopt a mandatory fuel consumption criterion in their purchasing policies. If these governments, as major purchasers of vehicles, were to specify a maximum fuel consumption level, then there would be economies of scale in manufacturing and importing such vehicles. Australian manufacturers might choose to make them and the general population would have access to buy them as a consequence.

The market power of government buying might be the catalyst to get things started. Following this, anything that government does to make a vehicle type more attractive to the public will add to the momentum. State governments could offer incentives to the owners of such vehicles, eg reduced registration or permission to travel in transit lanes. Reliability awards and publicity of positive experiences with hybrid vehicles might be useful.

It is important that state and federal governments not reduce fuel taxes on petrol. Market forces on 10 million households might achieve more for fuel economy than any number of government regulations and laws. Indeed, an argument can be made that governments should increase the taxes on diesel to make its use less attractive to small vehicle use and to partially offset the public health costs of its use.

Reference Documents

Limitations on hydrogen fuels

Hydrogen Fuel Crisis
Source: San Diego Union Tribune [Mar 22, 2004]

In his book 'The Hype About Hydrogen' Joseph Romm warns that Hydrogen may not be the best solution for transportation fuels. Romm notes that using electrolysis to produce hydrogen gas from water requires expending four units of energy to produce one unit of equivalent hydrogen energy. To produce a kilogram of hydrogen this way also would generate about 70 pounds of carbon dioxide [if the electricity is produced from the burning of coal].

US Panel Says Hydrogen Car Is 25 Years Down the Road
Story by Chris Baltimore (6/2/2004)

Though the Bush administration has pegged pollution-free, hydrogen-powered cars as the way to curb the nation's addiction to crude oil, a panel at the National Academy of Sciences on Wednesday said the vehicles won't be readily available for another 25 years. The administration wants to have the hydrogen cars on the market and available to consumers at an affordable price by 2020. "In the best-case scenario, the transition to a hydrogen economy would take many decades, and any reductions in oil imports and carbon dioxide emissions are likely to be minor during the next 25 years," said the academy, an independent group that makes scientific recommendations to Congress.

Practical, Clean Energy For Future Transportation
By F. David Doty, PhD

White paper on feasibility of hydrogen economy versus other energy options

Nobel Laureate George Olah (Chemistry) recently pointed out that a "Methanol Economy" seems much more practical than a "Hydrogen Economy". In recent years, very efficient methods of dehydrating bio-methanol into bio-ethylene (C_2H_4) and water have been developed. Ethylene, in turn, can be used to efficiently produce all hydrocarbon fuels and products currently obtained from fossil sources. Thus, bio-gasoline, bio-diesel, bio-kerosene, and bio-methane can be efficiently and safely produced, stored, and transported within our current infrastructure. Direct Methanol Fuel Cells (DMFC), which convert methanol directly into water and CO_2 while producing electricity, have advanced to the point that they are now beginning to appear in commercial products such as cellular phones, laptop computers, and some military equipment. Here, the power source only has to be competitive with lithium batteries (which is much easier than competing with diesel engines), but that is still an impressive achievement and a promising beginning.

While there will undoubtedly be some economically viable applications for fuel cells (especially DMFC, but also hydrogen), economically viable solutions for the following fuel-cell challenges in automobiles seem highly unlikely within the next four or five decades.

1. Fuel costs

Current U.S. H_2 production is enormous – about 2×10^{10} kg/yr. Yet, the current pre-tax cost of liquid hydrogen (LH_2) in the U.S, delivered in 15,000 gallon (4,300 kg) tankers to high-volume customers is about \$5/kg. The cost of pressurized H_2 for consumers has been in the range of \$100/kg (current dollars) for over forty years. Some studies have concluded mini-reformers (if mass produced) at corner filling stations could provide hydrogen at \$3.40-4.30/kg, assuming natural gas priced at \$5.00/GJ, but other data suggest the price would be four times higher at likely commercial prices for natural gas (\$14.00/GJ) 15 years from now. Moreover, current proven domestic natural gas reserves will last only 10 years, and there is increasing pessimism about future domestic discoveries. The price of natural gas has increased by a factor of 10 in the past 30 years and a factor of three in the last six years.

On the other hand, the current U.S. pre-tax cost of diesel for the individual consumer at the local station is about \$0.50/kg. Of course, we need 2.8 kg to equal the energy of one kg of H_2, but that still leaves an order of magnitude cost advantage for diesel per unit energy. Realistic estimates suggest the pre-tax price of bio-diesel from bio-methanol could ultimately be below \$0.60/kg, though it will be quite a while before bio-methanol competes.

2. Fuel-cell engine costs

The only possible type of hydrogen fuel cell for automotive applications is the proton exchange membrane fuel cell (PEMFC), (also called PEFC, polymer electrolyte fuel cell), as all other types are either far too massive or have unacceptably short lifetimes. The cost of PEMFC engines (fuel cells, power conditioning, electric motors, etc.) is often reported to be in the range of 3,000-8,000 U.S. dollars per kilowatt – 100 times that of the common diesel engine, or forty times that of the advanced diesel, which will soon exceed 58% LHV efficiency. Inspection of the sales and financial data from the largest current producer of PEMFCs for non-mobile use (Plug Power) suggests current costs of PEMFCs (not including real R&D) are actually in the range of \$15,000-\$30,000/kW. It is worth noting that polymer FCs have been in use and development for over forty years, and costs have not yet begun to drop significantly – notwithstanding many assertions to the contrary that use artificial costs from heavily subsidized projects or cite costs of massive, stationary fuel cells that are unsuitable for vehicles. Over the past ten years, Ballard Power has furnished 85% of all vehicle fuel-cell engines world wide. By some methods, one could conclude that the manufacturing cost, not including true R&D, of their latest fuel-cell engines has been well over $1M each.

3. Fuel storage mass, volume, and safety

Safety-approved low-cost compressed gas cylinders currently achieve 1.5% H_2 storage by mass at 34 MPa (5000 psi). A $15,000 carbon-fiber-wrapped fuel tank achieving 11% H_2 storage seems impractical for the small private car, and liquid hydrogen doesn't keep long. Moderate-priced tanks of aircraft-grade aluminum alloy are likely to be competitively priced and achieve 6% storage, and titanium-alloy tanks may eventually permit 9% storage at practical prices. Hence, the practical energy density of hydrogen, after including some extra structure needed for protection in the event of a collision, may be 15% that of diesel. At 5,000 psi, the volumetric energy density is only 10% that of diesel. Just the mechanical energy (forget the chemical energy) stored in the hydrogen tank may be 5 times that of a 50-calliber artillery shell, and the impact strength of light-weight tanks is not high. The risks associated with carrying this mechanical bomb around are probably two orders of magnitude greater than we are accustomed to accepting in our gasoline-powered cars today. The huge mass and volume penalties associated with practical H_2 storage seem likely to keep the mileage of hydrogen-powered automobiles (of acceptable range, acceleration, cost, and cargo capacity) relatively low, and the risks associated with either pressurized gas or cryogenic on-board storage are completely unacceptable for personal vehicles.

4. Fossil CO_2 release

The only economically viable sources of H_2 in the U.S. (and most other countries) are natural gas and coal. The nearly adiabatic partial-oxidation/reformation/shift reactions use 3 kg of natural gas (90% CH_4) to produce 1 kg of H_2 plus 9.5 kg of CO_2. Then, over 3 kg of coal must be burned (releasing another 10 kg of CO_2) to generate the 10 kWhr (36 MJ) needed to purify and liquefy 1 kg of H_2, which will usually be required for efficient distribution for at least the next two decades. The energy efficiency in producing LH_2 is under 50%. (This number has not budged in 15 years and will not in the next 50. We're near Carnot limits.) The energy content of 1 kg of H_2 is equivalent to 2.8 kg (1 gal.) of diesel, which contains only 2.3 kg of carbon.

At 70 miles per gallon, the advanced fossil-diesel hybrid achieves 7 miles per kilogram of total CO_2, while the bio-diesel vehicle could achieve infinite miles/kg of fossil CO_2. The production-grade hydrogen fuel-cell automobile won't get very good mileage because of the order-of-magnitude penalty in fuel energy density. At 40 miles per kilogram of hydrogen, it achieves about 2 miles/kg of total CO_2. Hence, when miles/kg of fossil CO_2 release ("fossil mileage") is more fairly calculated, the total CO_2 generated per mile by a hydrogen vehicle is likely to be 3.5 times that of a comparable fossil-diesel-powered hybrid vehicle. Interestingly, the hydrogen path recently advocated by the DOE (distributed, local reformation) is simply not compatible with CO_2 sequestration, and it would extend our intense dependence on fossil fuels as long as possible.

Hydrogen Vehicles Aren't a Clean Answer, Professors Say

Source: Sarasota Herald Tribune [Apr 05, 2004]

Inefficiencies in hydrogen production and fuel cells, along with use of fossil fuels, cited as biggest concerns

The Bush administration is pushing automakers to develop hydrogen-powered vehicles, which are said to be nonpolluting and are supposed to reduce our dependence on fossil fuels. Both these claims are totally misleading.

While hydrogen combustion is not polluting, hydrogen production is. The Department of Energy projects that 90 percent of hydrogen production will be from fossil fuels, mostly natural gas. The process (called "reforming") produces the same amount of carbon dioxide and other pollutants as would be produced if the primary fuel were burned directly for energy production.

In addition, hydrogen production is extraordinarily wasteful of energy. According to studies published by the National Renewal Energy laboratory, the energy efficiency of hydrogen production from natural gas is about 65 percent. In other words, 35 percent of the available energy is lost. Further, additional energy is required to compress the hydrogen to a useful density. All in all, the energy available from compressed hydrogen is about 50 percent of the energy required to produce it.

Ford and BMW are proposing to market cars with hydrogen-burning internal combustion engines. Because of the energy wasted in the production of hydrogen, the use of hydrogen by these engines will require twice as much fossil fuel as would be required if the fuel were used directly, and the process will produce twice as much atmospheric pollution.

GM, on the other hand, is planning to market electric cars driven by hydrogen fuel cells. Such cars will require roughly half the energy needed to power most of the currently made cars. However, because of the cost of hydrogen production, their consumption of fossil fuel will be roughly the same as that of current vehicles.

The BMW-Ford approach to the use of hydrogen in motor vehicles can be expected to double energy consumption and pollution; the GM approach will offer no improvement.

One way to avoid pollution is to use electricity from renewable sources (such as wind farms) to extract hydrogen from water and compress it, and then use fuel cells to convert the hydrogen back into electricity. Again the process is highly inefficient. After extraction and compression, only 50 percent of the original energy is available in the form of ready-to-use hydrogen.

According to the Department of Energy, "second generation" fuel cells are expected to have an energy efficiency of about 60 percent, so when they are used to convert the compressed hydrogen back into electricity only 30 percent of the original energy is recovered. In contrast, recovery of electrical energy stored in batteries can be as great as 80 percent. So storing electrical energy in batteries is between two and three times as efficient as storing it in the form of compressed hydrogen.

Since the use of hydrogen by automobiles can be expected to increase, rather than decrease, consumption of fossil fuels and the associated atmospheric pollution, and will require huge capital costs to establish a hydrogen production and distribution system, there is no reason to advocate the future use of hydrogen.

Indeed, one can argue that such advocacy is merely a diversion from taking immediate measures to reduce the use of fossil fuels, such as the production of more fuel-efficient automobiles. Such immediate measures would achieve what hydrogen utilization cannot, namely a reduction in both our dependence on foreign oil and the rate at which we are dumping carbon dioxide and other pollutants into the atmosphere.

A.R. Martin is Professor Emeritus and former Chair of Physiology at the University of Colorado College of Medicine and now lives in Fort Myers; Charles Edwards is Professor Emeritus of Biological Sciences at the State University of New York at Albany and now lives on Longboat Key.

Hydrogen Just Won't Fly

Source: National Post/Canada [Apr 05, 2004]

Forget about hydrogen power. It isn't going to work, at least not for decades. That's what BMO Nesbitt Burns analyst Brian Piccioni concludes after months of research, while initiating coverage on hydrogen fuel technology company Ballard Power Systems Inc.

"Despite near-universal optimism for the hydrogen economy, we believe it is improbable that hydrogen will become a major energy carrier within the next 25 years," Mr. Piccioni said in a 38-page report on Friday (excerpts of which were published in Saturday's Financial Post). He believes that future resources will be put to better use making existing fuel technologies, such as hybrid electric vehicles, more efficient.

The main problem, he said, is that hydrogen is an energy carrier, much like electricity, and that more energy will be needed to create, compress or liquefy and transport hydrogen than will be available at the point of consumption.

He initiated coverage of Ballard a "sector perform" rating and no price target because the industry is likely to never emerge and therefore does not lend itself to financial analysis or valuation.

The most common method of valuation in the sector is comparable valuation, he said, but this method fails to take into account that "all companies in the sector may be inappropriately valued" (such as happened in the dot-com era).

He states that he could provide "any target price one desires" through subtle adjustments in forecasting parameters, such cost as of capital, pace of adoption or selling prices. But he believes that companies in the sector are "un-analyzable."