

The biofuels promise: updated thinking

Biofuels seem an obvious alternative given the recent surge in fossil fuel prices and more emphasis on environmental impacts. However there are some serious implications of biofuels' wider use that need deeper consideration. Graeme O'Neill investigates.



It is far from clear that rapid expansion of Australia's nascent biofuels industry would deliver a cleaner, healthier, environmentally benign, renewable source of automotive fuel.

The latest flush of political, consumer and industry enthusiasm for biofuels – ethanol and biodiesel – rests on the prospect that they could reduce Australia's dependence on imported oil, and reduce fuel prices.

For Australia, biodiesel produced from oilseed crops, recycled cooking oil or tallow (waste animal fat) may be a better prospect than ethanol, given the nation's heavy reliance on road transport, and the growing popularity of fuel-efficient diesel cars. But the biodiesel industry is as vulnerable as the ethanol industry to the impact of Australia's weather and climate on agriculture. Paul Higgins, a principal of Canberra-based futurology company Emergent Futures, and an advocate for

biofuels, says volatile fossil fuel prices ultimately determine ethanol and biodiesel prices.

He said even if ethanol can be produced at a lower cost than petrol, from grain, sugar or cellulosic crops, it's economically naïve to expect producers to sell it at a significantly lower price.

Expansion of the biofuels industry will cause direct competition with the food and fibre industries for scarce arable land and water, and Australia's biofuels industry is not only influenced by fossil fuel prices, but by world grain and sugar prices.

Higgins says the recent massive expansion of the maize-based US ethanol industry is driven by a combination of government subsidies, low maize prices – around US\$1.80 a bushel – and the phase-out of the fuel-oxygenating agent methyl tertiary-butyl ether (MTBE).

Like ethanol, MTBE improves combustion efficiency, but is being phased out

Grain-based ethanol production, particularly in the US, may drive up maize prices, which would increase the price of other grains and make biofuels more expensive. Jonathan Vasata

because fuel leaking from underground storage tanks gives an unpleasant taste and odour to groundwater supplies.

'A year ago it cost US\$1 a gallon (3.785 litres) to build an ethanol plant, and US\$1 a gallon to produce ethanol,' Higgins said. 'Those numbers made it a pretty good business, and people piled money into it.'

'If you can double your money in two years, you don't care what happens in 10 years.'

Grain-based ethanol production is predicted to drive up maize prices to US\$3 a bushel. The US production increase of more than 11 billion litres will consume 30 million tonnes of coarse grain, used to feed livestock – around 30 per cent of the total world trade in coarse grain.

'If they do the same next year, it will be 60 per cent,' Higgins said.

He said the resulting price-equalisation process would drive up the price of grain-fed beef and pork, making them less competitive, and would increase the price of other grains as well, making biofuels more expensive.

Higgins says biofuels are a disruptive technology, whose impact on food prices will ripple through the global economy.

Similarly, political crises and natural disasters like Hurricane Katrina can affect the biofuels industry, by causing wild swings in global oil prices, thus making biofuel profit margins unpredictable and investment in production plants risky.

Health implications

Biofuels – particularly ethanol – come with potential health and environmental problems.

In a 2004 research review, Ethanol in gasoline: environmental impacts and sustainability,¹ environmental engineer and pollution expert Dr Robert Niven, of the University of NSW's School of Aerospace, Civil and Mechanical Engineering in Canberra, warned that increasing ethanol use may cause its own set of health problems.

As an oxygenating agent, ethanol increases emissions of nitrogen oxides that form photochemical smog, the brown haze that hovers over major cities like



For Australia, biodiesel produced from oilseed crops, recycled cooking oil or waste animal fat may be a better prospect than ethanol. Logan Buell

Melbourne and Sydney, spawning toxic ozone and causing respiratory problems.

The oxygenated fuel also accelerates rusting of underground storage tanks, polluting surrounding soil and groundwater with hydrocarbons. Because ethanol inhibits soil bacteria that normally break down hydrocarbons, leaking fuel will contaminate a larger volume of soil and water with long-lived compounds like benzene, a known carcinogen.

Because ethanol-petrol blends are more volatile, atmospheric emissions of benzene will also increase. Greater use of ethanol in

fuel blends will also increase emissions of the combustion product acetaldehyde, a suspected carcinogen.

In September this year, the government released a report of its Taskforce on Biofuels,² appointed to review a 2003 joint study by CSIRO, the Bureau of Transport and Regional Economics (BTRE) and the Australian Bureau of Agricultural Resource Economics (ABARE) on the appropriateness of a national target of 350 megalitres (ML) of biofuels by 2010.

Dr Tom Beer, of CSIRO Atmospheric Research, principal author of the 2003 report,³ says its findings need updating.

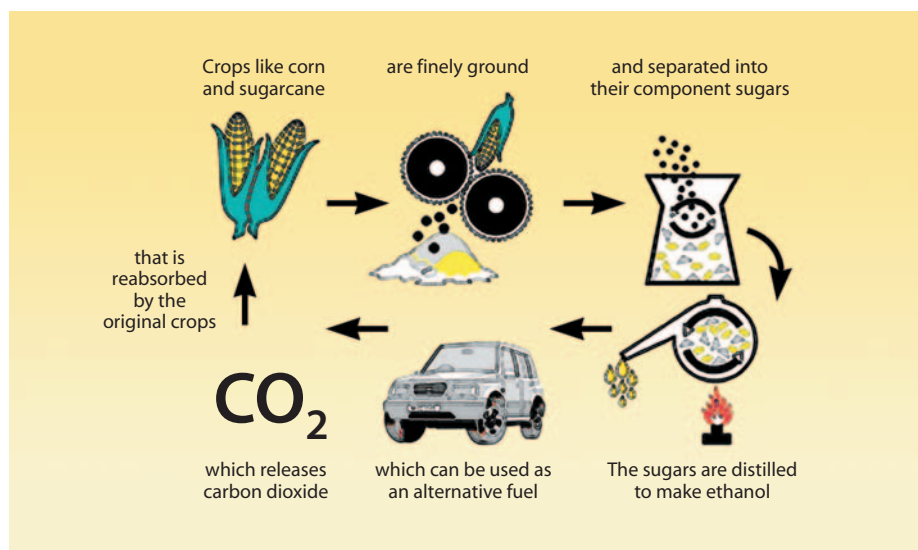
'We found a relatively small environmental advantage to ethanol in 2003,' Dr Beer said. 'E10 blends would reduce greenhouse gas emissions by 3 to 5 per cent.'

'There's a question mark over health benefits. A lot hinges on whether putting ethanol in petrol reduces fine particulate matter, a cause of pollution-related mortality.'

While it was much easier in 2003 to show environmental benefits from biodiesel, the assumptions used at the time may no longer be valid.

Beer and his CSIRO colleagues recently reviewed a paper by Californian air-pollution consultant Dr Gary Whitten, Air quality and ethanol in gasoline,⁴ which concluded that ethanol blends would improve air quality.

The CSIRO review found that reductions in ozone and secondary particles were 'less



Biofuels from crops recycle CO₂ – now experts say that some regular feedstocks can cause pollution and other environmental problems. Energy Information Administration, US

1 Niven R (2005). Ethanol in gasoline: environmental impacts and sustainability. *Renewable and Sustainable Energy Reviews* 9, 535–555.

2 Australian Government Biofuels Taskforce, 2006. www.pmc.gov.au/taskforce

3 Beer T et al. (2003). Final report to the Australian Greenhouse Office on the stage 2 study of life-cycle emissions analysis of alternative fuels for heavy vehicles. www.greenhouse.gov.au/transport/comparison/index.html

4 Whitten GZ (2004). Air quality and ethanol in gasoline. Presented at the 9th Annual National Ethanol Conference, 16–18 February 2004. www.oregon.gov/ENERGY/RENEW/Biomass/docs/FORUM/Whitten2004.pdf

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certain' than Whitten suggested, and the US data might not be applicable to Australia, with its different mix of vehicles and fuels.

On biodiesel, Beer said his 2003 conclusions assumed it would be used in diesel trucks at a 100 per cent concentration, tax-free. The government now favours a 5 per cent excise on fuel ethanol.

Beer says the social implications of biofuels are unclear, and questions claims they will create jobs.

'An ethanol refinery doesn't employ many people. We need to know how many extra jobs will be created for every person employed – ethanol advocates tend to use favourable multipliers.

'There's still no clear-cut answer. The CSIRO-led Energy Transformed Flagship has set up an alternative fuels research stream, to investigate.'

Flagship spokesman, CSIRO's David Lamb, said past conclusions had relied extensively on literature reviews; laboratory tests are now needed, to provide hard data.

'We're beginning to have serious doubts about the viability of alternative fuels, that we so readily embraced when the fuel crisis hit,' he said.

'We hear about plans to build new refineries, but even if you add up the total projected capacity, and then double it, it comes to only 10 to 15 per cent of Australia's oil consumption.

'Brazil produces around 70 per cent of its fuel needs from ethanol, and it's taken them 34 years to get there. The US is pursuing a 25-year program to get to 25 per cent.

'If we think all we have to do is to follow Brazil's example, we're kidding ourselves.'

Paul Higgins says Brazil has among the world's highest levels of brown haze, ozone and particulate-matter pollution.

'It's a complex issue,' he said. 'I'm a big believer in the ability of biofuels to play a role in reducing oil consumption, but I'm not sure people are properly assessing the risks.

'With the current drought expected to cut Australian grain production by as much as 50 per cent, grain-based ethanol becomes a much riskier proposition.'

Pricing the market

Higgins believes consumer expectations of substantially cheaper fuel prices are misplaced. If the cost of ethanol in E10 fuel blends were half that of petrol, it would yield savings of only 4c to 5c per litre at the pump.

'If Australia grew double-yield sugarcane (a new genetically modified varietal)

Biofuels Taskforce findings

The Taskforce concluded that, based on current settings and consumer demand, Australia is unlikely to meet its 350-megalitre target for biofuel production by 2010, because of commercial risks facing producers who enter the market early.

Meeting the target would require investment in new plant capacity to distil ethanol from grain and molasses in rural Queensland and NSW, and biodiesel capacity in South Australia and Victoria. Up to 648 new jobs would be created.

Biofuels would not yield greenhouse gas emissions reductions sufficient to warrant significant policy intervention when cheaper carbon-reduction options are readily available.

An analysis by the Australian Bureau of Agricultural and Resource Economics for the Taskforce concluded that Australian ethanol and biodiesel producers would remain commercially viable at least until 2015, when an effective subsidy in the form of

import duty is reduced.

But oil companies had no commercial reason to promote fuel blends, or surrender market share to competitors, so early investors in biofuel production face high commercial risks.



The expansion of the biofuels industry will cause direct competition between food and fuel producers for arable land and water. Rolf Weschke

I'm not sure it would halve the cost of producing sucrose.

'Global sugar prices are a very complex equation. I agree with the view that world sugar prices will be arbitrated through world ethanol prices, which are arbitrated in turn by oil prices.

'If we compare the Australian and US business models for ethanol, the US is aiming to produce 11 billion litres of extra capacity a year, bringing total production to 27 billion litres.'

A standard, modern ethanol plant produces 200 million litres a year. Higgins said that to sell this quantity as a component of E10 petrol, the producer would have to capture 10 per cent of the Australian petrol market.

In contrast, biodiesel doesn't require massive investment in infrastructure. 'A farmer in the wheatbelt can produce it locally,' Higgins said.

'But again, it comes down to the price of oil. What price will the various biodiesel feedstocks be?

'I have doubts about Australian producers importing palm oil from Malaysia or Indonesia and shipping it to Europe as biodiesel. Why not ship it directly to Europe from Asia?

'But if oil prices are high, the cost of palm oil goes up. The industry is being blamed for clearing Asia's rainforest, and causing forest fires that send smoke palls over South-East Asia, and cause respiratory problems.'

Higgins says several biodiesel companies in Australia are struggling. 'There are many risks in the industry, and world oil prices are likely to go down further.'

Second-generation biofuel technologies, such as distilling ethanol from biomass feedstocks like sugarcane bagasse or fast-growing, deep-rooted perennial grasses, and extracting biodiesel from algae, could be more viable alternatives.

'Biomass ethanol has a much better life-cycle analysis than ethanol from grain or sucrose. You're not putting in as much energy. But biomass ethanol and diesel are still three to five years away.'

Higgins says it will ultimately come down to whether people prefer cheap food to cheaper petrol.

CSIRO's David Lamb says the various feedstocks for ethanol and biodiesel all have different profiles in terms of land, water and fertiliser use, and refining and transport costs.

'We're in the process of developing a

calculator that will allow producers or consumers to compare, for example, the costs of producing ethanol from sorghum and methane produced from sewage.

'It will employ a wide range of criteria, including fuel security, local production costs, public acceptability and environmental profiles. We desperately need a means of comparing them, in the hope that the community and government will use it as a basis for making decisions.'

Lamb says most experts believe hydrogen is the ultimate answer to the fuel crisis, but the hydrogen economy is probably still 30 years away.

'The Federal Government seems to be aware that biofuels are no magic bullet. You can bet compressed natural gas (CNG) will be the next cab off the rank.'

'CNG is a sure thing for depot-based vehicles like garbage trucks and buses, but it's bulky and storage is very awkward. But if someone faces losing all the load space in the boot of their new car, I doubt they'll use CNG.'

Lamb believes that electric vehicles have a lot more potential than most people realise, and will become more popular as battery technology improves.

The greenhouse effect

Overshadowing purely economic considerations is the issue of whether biofuels will deliver real savings in greenhouse gas emissions.

For Australia, biodiesel produced from oilseed crops, recycled cooking oil or tallow (waste animal fat) may be a better prospect than ethanol, given the nation's heavy reliance on road transport, and the growing popularity of fuel-efficient diesel cars.

Murdoch University researchers Dr Phillip Calais and Dr Ralph Sims compared life-cycle emissions for biofuels with those of liquid and gaseous fossil fuels in the transport sector.⁵ They concluded biodiesel and ethanol could yield significant reductions in greenhouse gas emissions. Engines would require no modifications to run ethanol-petrol or ethanol-diesel blends up to 15 per cent, or any biodiesel-diesel blend.

In their 2004 full-cycle analysis of greenhouse gas emissions from light vehi-



Volatile fossil fuel prices ultimately determine ethanol and biodiesel pump charges. Konstantin Sukhinin

cles, CSIRO's Dr Tom Beer and Dr Tim Grant, of RMIT University's Centre for Design, found hybrid electrical vehicles like the Toyota Prius produce the lowest level of greenhouse gas emissions.

Diesel vehicles have less embodied greenhouse gas emissions – the sum of pre-combustion emissions and emissions at the tailpipe – than vehicles powered by petrol, liquid petroleum gas (LPG) or

compressed natural gas (CNG).

But Beer and Grant said diesel-electric hybrids would have even lower embodied emissions of CO₂, carbon monoxide and non-methanic volatile organic compounds. However, diesel engines emit more fine particulate matter than all other fuels.

A 1.7 tonne family car running on unleaded petrol emits the equivalent of 349 grams of carbon dioxide per kilometre. A petrol-electric hybrid of the same mass emits around 155 g CO₂/km, while a hybrid diesel-electric vehicle emits 129 g CO₂/km.

Calais and Sims found that 100 per cent biodiesel and fossil-fuel diesel emit similar levels of carbon compounds, but biodiesel, which produces no net increase in carbon emissions, emits far less sulphur by several orders of magnitude.

Like diesel, biodiesel would increase emissions of fine particulate matter – the carbon-rich diesel soot is a concern for the biodiesel industry, because it causes respiratory disease and contains known carcinogens.

Environmentally conscious drivers are buying hybrid petrol-electric cars like Toyota's Prius and Honda's Insight, but David Lamb says a recent article in a US magazine illustrates the complexity of the issue.

Headed 'Have you hugged your Hummer⁶ today?', it pointed out that a lot of embodied energy goes into making a Toyota Prius hybrid petrol-electric car, which has a lifetime of around 150 000 miles.

'It claimed that, with a life of 600 000 miles, the Hummer's embodied energy versus energy consumption ratio is superior,' David Lamb said.

'We're headed for trouble if we make our car-purchasing decisions on that sort of logic.'

More information:

Biofuels background:
www.industry.gov.au/content/sitemap.cfm?objectID=48A3B39B-20E0-68D8-ED6A35FE6FDB3B55

5 Calais P and Sims R A (1999). A comparison of life-cycle emissions of liquid biofuels and liquid and gaseous fossil fuels in the transport sector. *Renewable Energy Transforming Business*. Murdoch University, Perth.

6 The Hummer is a civilian version of the American military's HumVee all-purpose vehicle.