Australian Government
Rural Industries Research and Development Corporation

CSIRO

Biofuels in Australia – an overview of issues and prospects

Foreword

Demand for energy – transport fuels as well as electricity – has increased spectacularly throughout the world. There is growing debate about peak oil and oil prices have risen dramatically since 2002. Evidence is unequivocal that the Earth's climate is warming, very likely due to greenhouse gas emissions generated by human activities – including burning fossil fuel for energy. In response, there is a growing trend worldwide to look for alternative energy sources which are more secure and produce less greenhouse gases.

Biofuels have been promoted internationally as a major response to these drivers. They can offer the potential for improved fuel security, lower greenhouse gas emissions, and health benefits in cities. There are also potential benefits to rural communities in Australia. The benefits are, however, very sensitive to the particular production system, and are not universal.

The biofuels industry is in its infancy in Australia. Future development of this industry is subject to some critical uncertainties — most importantly, energy prices, consumer preference, Australian and international government policy, and technology shifts.

If domestically produced biofuels were to move beyond being relevant at the margins (2–5 % of transport fuel requirements) to become part of the main game (10–20 % of transport fuel requirements), there could be some major shifts in the agricultural and forestry value chains through to vehicle manufacture, fuel distribution and retail and the consumer.

Understanding the:

- potential changed structures of new value chains
- size and distribution of the benefits and costs of these potential new value chains, and
- role of biofuels in a transition to future alternative energy sources for Australia

requires a broad approach across the agriculture, forestry and energy industries.

A 'whole of agriculture' approach to the issue is of critical importance to the National Farmers' Federation. This report is a step towards synthesising a picture of the current situation for biofuels in Australia, and scoping some of the prospects and implications of industry growth.

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This document is a summary of the report *Biofuels in Australia — issues and prospects* (RIRDC Publication Number 07/071). The report contains the details and references on which this summary is based.

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Biofuels in Australia — issues and prospects

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Introduction

Demand for energy — transport fuels as well as stationary energy (electricity) — has grown dramatically throughout the world during the 21st century. Oil prices have risen dramatically since 2002. There is debate about how close 'peak oil' might be. The climate is changing — and greenhouse gas emissions must be reduced in order to avoid dramatic change to the environment. There has been a growing trend worldwide to look for alternative energy sources which are more secure and produce less greenhouse gases. Biofuels have been put forward as one of a range of alternatives with lower emissions and a higher degree of fuel security. There are potential opportunities for rural and regional communities to benefit, as well as urban communities through improving air quality and thus improving health in cities.

A move to full scale biofuel production in Australia — as has happened in other countries — offers many opportunities to Australian agriculture, but also some risks. This report by CSIRO was commissioned by RIRDC with the National Farmers' Federation to provide information which would enable an assessment of the levels of risks and opportunities — now and into the future. This report reviews and compiles available published data from a broad range of sources as well as new CSIRO data.

Findings related to the following central questions are summarised in this report:

- What are the drivers for a biofuel industry? To what extent can biofuels:
  - reduce greenhouse emissions?
  - provide for fuel security?
  - provide land and water benefits?
  - improve human health?
  - provide benefits to regional Australia?
- What is the nature of feedstocks for biofuel production — now and in the future?
- Will there be competition for crops with alternative markets?
- Will there be impacts on the livestock industry?
- What are the sustainability issues for biofuels?
- How comparable are biodiesel and ethanol to fuel reference standards?
- What infrastructure is currently in place for biofuel production? What infrastructure would be required in the future?
- Which policies affect biofuels?
- How can demand for biofuels be expanded?
- Are there options for encouraging future capital investment?

Each of these questions corresponds to a chapter in the report that examines in more detail the scale of the current industry, future potential, state, national, international contexts, and major unknowns that will require future research.

International context

The use of modern biofuels — ethanol and biodiesel — for transport in Australia is generating a lot of interest along the agricultural supply chain. Policy makers and consumers are also interested in developments in this area.

Using estimates of current production, this report shows that Australia is still in the early days of a biofuel industry. It is evident that other countries and regions have been at this much longer, and not surprisingly have solved a number of the challenges facing Australia.

We are seeing dramatic developments worldwide:

- rapid increase in diesel usage in Europe eg 30 % of cars in Europe now use diesel. These cars use 2/3 less fuel than cars run on petrol;
- massive increase in ethanol and biodiesel production in US and Brazil;
- pilot plants for lignocellulose to ethanol in US and Europe.

International developments in biofuels are not always able to be applied directly to the Australian situation. Australia's biofuel feedstocks have their own particular features that we are now beginning to understand — and much more work is needed.

Biofuel production capacity is ramping up — over 1.1 GL of both ethanol and biodiesel capacity is currently planned — and research is keeping pace with the industry's emergence. There is potential for changes in both first and second generation processes.

Benefits from biofuels extend beyond meeting part of our national fuel demand. Regional development and reducing environmental impacts have exciting potential, involving first and second generation processes. Lower particulate emissions from using biofuels can have health benefits. Ongoing support in research, development and production is required. This will identify transition pathways, likely sequences of technological and policy changes, by which future biofuel systems will emerge.

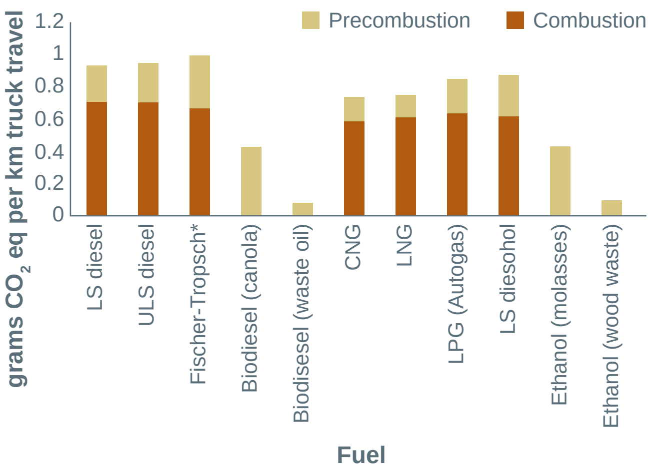
Future transport fuel needs in Australia will be met by a varied mix of fuels. Technology developments will continue to evolve, leading to new opportunities for biofuels — in areas from agricultural production through to vehicle engines and biofuel production plants. A start has been made. Now is the time to pursue the research questions that will help light the way to biofuels in Australia over the next 30 years.

Addressing the drivers of change

Greenhouse gas emissions

- The greenhouse gas benefits obtained from a renewable fuel such as ethanol or biodiesel are greater than the greenhouse gas benefits obtained from the use of a fossil fuel such as Compressed Natural Gas (CNG) or Liquified Petroleum Gas (LPG). However, the emissions are very sensitive to the feedstock production system and must take into account the complete lifecycle of the agricultural production system.

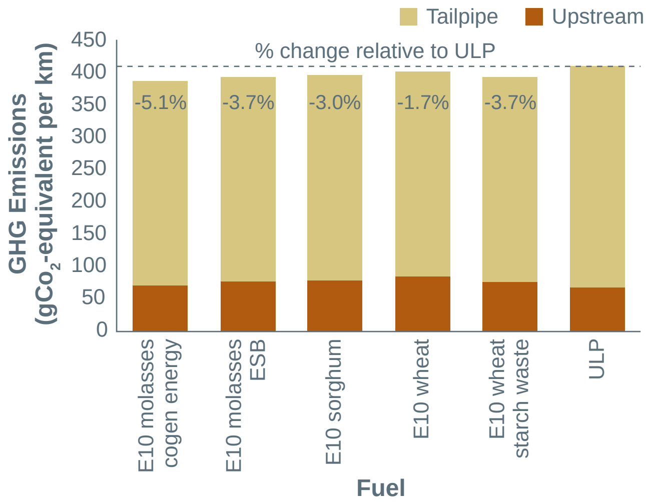
Figure 1 Comparison of greenhouse gas emissions across a range of alternative fuels against reference standards of Low Sulfur diesel (LSD) and Ultra-Low Sulfur diesel (ULSD) (Source Tim Grant CSIRO).



* from natural gas. European data for FT from biomass suggest GHGs comparable to lignocellulosic ethanol.

- Blends of E10, and B5, B20 and B100 are the most likely combinations to be used in Australia in the short term.
- When used in an E10 blend, greenhouse gases (compared to unleaded petrol) are lower by 1.7 % (from wheat) to 5.1 % (C-molasses using co-generation). There is no Australian passenger car data for E85 (using compatible methods) to directly compare against these E10 data, but the greenhouse gas emissions for E85 would be substantially lower than for E10 because there is less petrol in the blend.

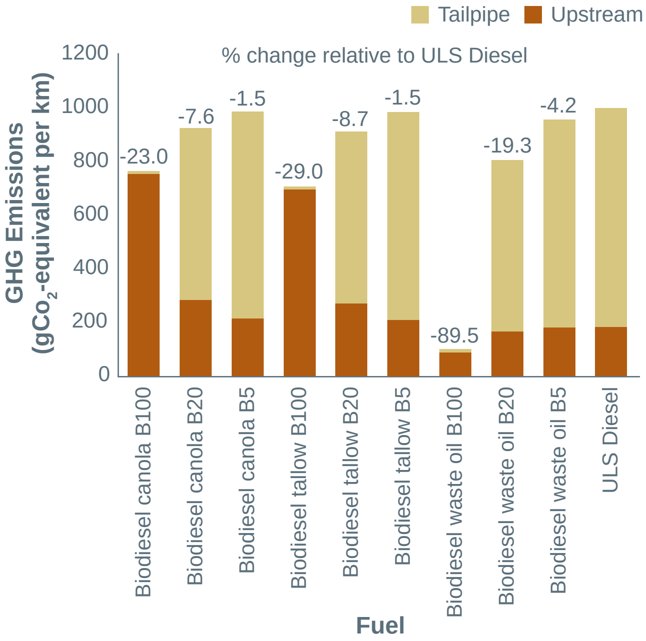
Figure 2 Life-cycle greenhouse gas emissions per km from the use of ethanol blends from various feedstocks and unleaded petrol (ULP) in a light passenger car. Upstream begins with biomass production; Tailpipe begins at the bowser.



(CSIRO, BTRE and ABARE. (2003). Appropriateness of a 350 ML Biofuels Target. Report to the Australian Goverment Department of Industry, Tourism, and Resources. *CSIRO Atmospheric Research; Bureau of Transport and Regional Economics; Australian Bureau of Agricultural and Rural Economics; Australian Government*, Canberra, Australia. Report no. ITR 2004/1.)

- Greenhouse gas emissions for biodiesel:
  - waste vegetable oil range from 89.5 % lower for B100 to 4.2 % lower for B5 as compared to diesel;
  - tallow range from 29 % less for B100 to 1.5 % less for B5 as compared to diesel;
  - canola range from 15 % less for B100 to 1.5 % less for B5 as compared to diesel.
- The benefits of biofuels are not fully realised when they are used in blends dominated by fossil fuels.

Figure 3 Full life-cycle greenhouse gas emissions per km for biodiesel and biodiesel blends in a rigid truck compared to Ultra Low Sulfur (ULS) diesel (sulfur content < 50 ppm). Numbers at the top of the bars represent the percentage change, compared to diesel.



(CSIRO, BTRE and ABARE. (2003). Appropriateness of a 350 ML Biofuels Target. Report to the Australian Goverment Department of Industry, Tourism, and Resources. *CSIRO Atmospheric Research; Bureau of Transport and Regional Economics; Australian Bureau of Agricultural and Rural Economics; Australian Government*, Canberra, Australia. Report no. ITR 2004/1.)

Fuel security

- Based on the last 10 years of commodity statistics in Australia, estimates for the upper limits of production from first generation processes (ie currently commercial and in use technologies) and domestic feedstock are:
  - Ethanol — Conversion of export fractions of wheat and coarse grains could theoretically have supplied upper limits of 11–22 % of Australia's current petrol usage (taking lower energy value of ethanol into account).
  - Biodiesel — Conversion of domestic waste oil, tallow exports and oilseed exports could have theoretically provided upper limits of 4–8 % of Australia's current diesel usage.
- If all of the ethanol capacity that is currently proposed was to be fulfilled by existing crops (principally wheat and sugar), or if a national E10 target were to be met (eg. by 5.5 Mt of wheat as the feedstock), it could force the import of wheat in drought years. There are biosecurity issues restricting the import of grain from overseas markets.
- There is potential for biofuels to have a role in achieving fuel security with second generation technologies based on lignocellulosic feedstocks, or from new trees and crops for biodiesel. Preliminary estimates show that upper limits for second generation biofuels

Figure 4 The ranges of upper limits of volume of biofuels produced from Australia's current resource base of commonly used first generation feedstocks, based on Australian Commodity Statistics 2000–2005.

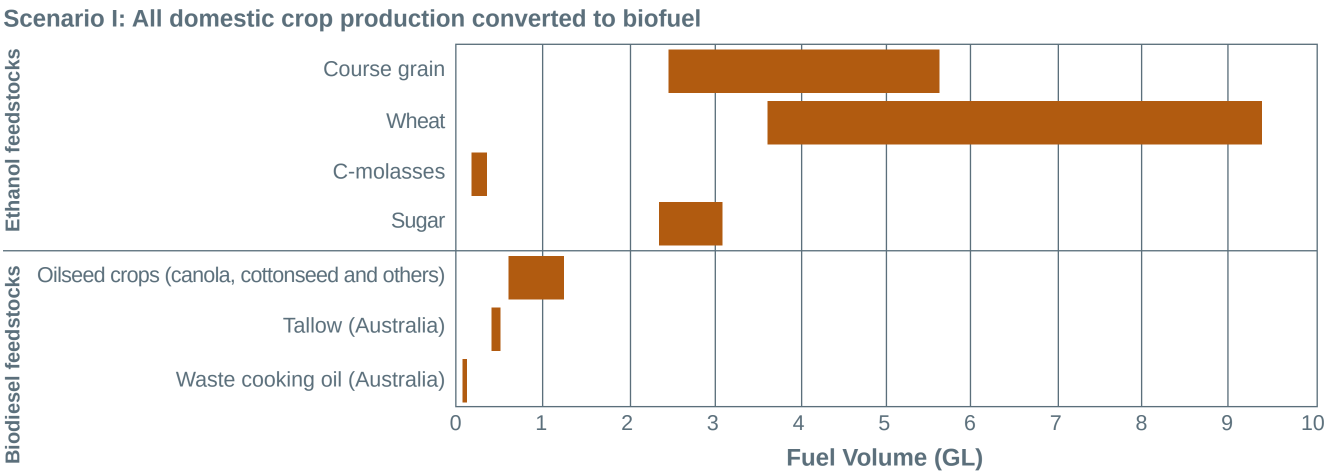


Figure 5 The ranges of upper limits of volume of biofuels produced from Australia's export fraction of current resource base of commonly used first generation feedstocks, based on Australian Commodity statistics 2000–2005.

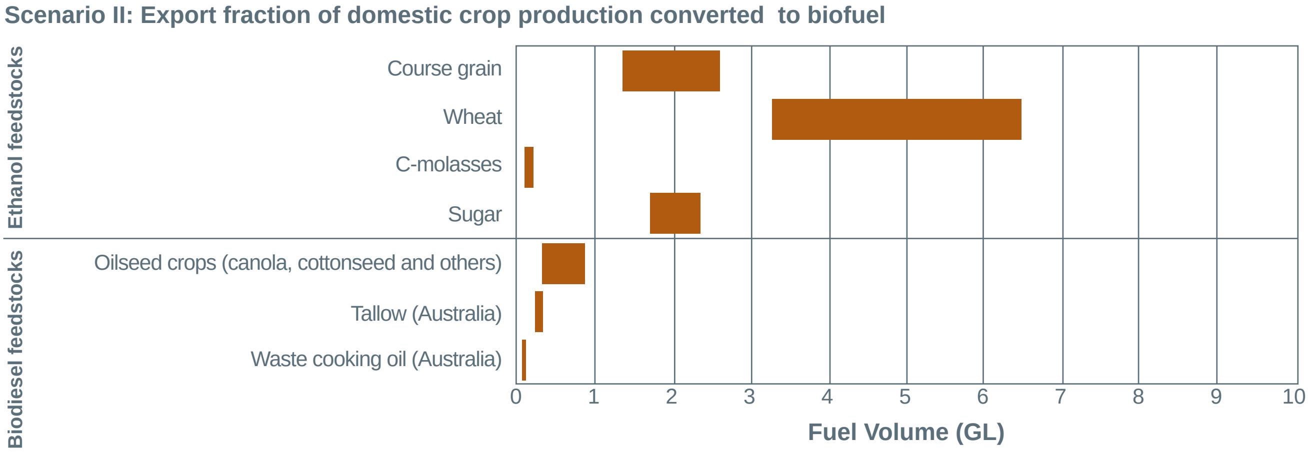


Table 1 Upper limits to production of ethanol using current domestic feedstock supply systems.

		Scenario I — All domestic crop production converted to ethanol			Scenario II — Export fraction of domestic crop production converted to ethanol		
Feedstock	Conv (L/t)	Australian production (Mt)	Ethanol ALL feedstock (ML)	Blend (% 04–05 petrol replacement[F])	Export (Mt)	Ethanol EXPORT feedstock (ML)	blend (% 04–05 petrol energy[F])
Sugar	560[E]	5.0 (4.2–5.5)[A]	2 800 (2 352–3 080)	E14 (9 %)	3.8 (3.1–4.2)[A]	2 128 (1 736–2 352)	E11 (7 %)
C-molasses	270–290[D]	0.6–1.2[B]	280	< E2 (0.9 %)	0.5[B]–0.82 E	140 - 220	< E1 (0.05 %)
Wheat	360[D]	20.6 (10.1–26.1)[A]	7 419 (3 648–9 408)	E38 (24.5 %)	14.8 (9.1–17.9)[A]	5 337 (3 278–6 432)	E27 (18 %)
Coarse grain	360	11.3 (6.9–15.6)[A]	4 083 (2 493–5 637)	E20 (14 %)	5.5 (3.8–7.2)[A]	1 978 (1 355–2 587)	E10 (7 %)
TOTAL			14 857	E78 (50 %)		9 690 (6 509–11 771)	E50 (E33–E60) (22–40 %)

[A] ABARE. (2006). Australian forest and wood products statistics: September and December Quarters 2005. *Australian Bureau of Agricultural and Resource Economics*, Canberra, Australia. [B] Biofuels Taskforce. (2005). Report of the Biofuels Taskforce to the Prime Minister. *Department of the Prime Minister and Cabinet, Australian Government*, Canberra, Australia. [D] Rutovitz, J. and Passey, R. (2004). *NSW Bioenergy Handbook*. Mark Ellis & Associates, Sydney, Australia. [E] Australian Cane Growers Council (2005). Submission to Prime Minister's Biofuels Taskforce. Submission No. 50 (June 2005). [online] http://www.pmc.gov.au/biofuels/report/appendices_all.pdf. [F] 2004–05 petrol useage of 19 500 ML. Note: The first figure reported describes the ethanol blend that could be supported, while the bracketed figure corrects for the lower energy content of ethanol relative to petrol (0.66).

Table 2 Upper limits to production of biodiesel using current domestic feedstock supply systems.

		Scenario I — All domestic crop production converted to biodiesel			Scenario II — Export fraction of domestic crop production converted to biodiesel		
Feedstock	ConvL/t	Australian production (kt)	Biodiesel ALL feedstock (ML)	Biodiesel blend supported[B]	Export (kt)	Biodiesel feedstock No domestic use (ML)	Biodiesel blend supported[B]
Waste cooking oil - Australia	870[A]	90–105 [A]	90–105 A	B0.6		90–105 [A]	B0.6
Tallow - Australia	894 [A]	500 Lo grade 260 Hi grade 240 [A]	447	B2	340 [A]	304	B2
Oilseed crops (incl. canola, cottonseed and others)	400	2 533 (1 532–3 094)[A]	1 013 (613–1 238)	B7	1 498 (887–2 189) [A]	599 (355–876)	B4
TOTAL for Australia			1 538 (1 132–1769)	B10		903 (659–1 180)	B6 (4–8 %)

[A] Beer, T., Grant, T. and Korn,W. (2005). Environmental Sustainability Issues in Relation to Biodiesel. *CSIRO Atmospheric Research*, Aspendale, VIC, Australia. Report no. Restricted Access Report HK58K/1/F3.5. [B] A correction for energy content is not required for biodiesel

to replace petrol may be between 10–140 % of our current petrol useage. The high uncertainty is due to lack of knowledge on ecologically sustainable and economically feasible production of lignocellulose feedstocks.

Energy content of ethanol compared to petrol

Ethanol has approximately two thirds of the energy content of petrol. Therefore more ethanol is required to drive the same number of kilometres, except in vehicles with higher compression ratios.

If the question is: Do we have enough ethanol to make all Australian petrol E10, then the *volumetric* figure is relevant — we just need to know that Australia can produce 2,000 ML of ethanol. This figure is represented by the ethanol blends that could be supported (eg E10).

If the question is: Could biofuels from domestic feedstock replace our stocks of diesel and petrol, then we need to know the *energy* figure for the transport task (number of vehicle kilometres travelled per year), not just a set volume of fuel. These figures are provided as percentages of the total fuel replacement.

Land and water benefits

- Land and water impacts will depend on the scale of the industry — a small industry based on diverting a proportion of our current crop production to biofuels would not change the current land use impacts, whereas a large scale industry might rely on expanding or intensifying cropping or forestry activities which would change the impacts.
- The impacts will also depend on where the biomass is grown, as well as the type of crop.
- The impacts may be neutral, for example in the case of ethanol based on existing grain or sugar production, because these activities will not significantly change the existing land use impacts.
- The impacts may be positive in situations were trees and shrubs are planted for biofuel production. There are many parts of Australia where planting large areas of woody perennials may have significant dryland salinity and biodiversity benefits. However, extensive tree planting may exacerbate water yield and river salinity in other areas and careful sustainability analysis will be needed.

Health

The benefits of biodiesel are

- all criteria air pollutants[1] except oxides of nitrogen (NOx) are significantly reduced when replacing low sulphur diesel with biodiesel.
- particulate matter emissions are significantly lower for pure biodiesel (B100) from tallow, canola and waste oil than for diesel.
- the benefits of lower particulate matter emissions are greatest for pure biodiesel, and lowest in B5 blends where the benefits are swamped by the diesel.

The benefits of ethanol, particularly in an E10 blend, are less clear.

- There may be benefits from reductions in particulate emissions from the tailpipe.
- However there are increased evaporative emissions of smog-forming organic compounds which may have a negative impact on air quality and lead to worse health outcomes in some circumstances.
- Rough estimates of the potential health costs avoided range from $3.3 million per year (1.4 c/L in 2003 dollars) to $90.4 million per year (30.4 c/L in 2004–05 dollars). Some of the assumptions are contestable and the Department of Environment and Water Resources (DEW) has in 2007 commissioned a project led by CSIRO and Orbital Engine Corporation to study the health impacts of E5 and E10.

[1] Listed in the Ambient Air Quality National Environment Protection Measures (NEPM) http://www.ephc.gov.au/nepms/air/air_nepm.html

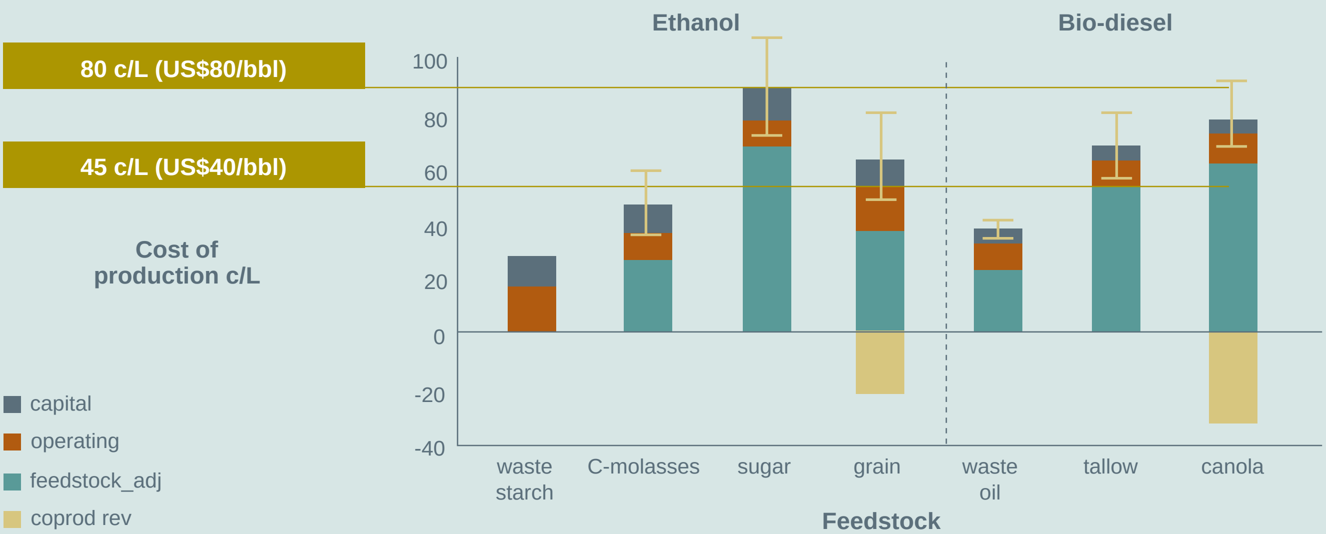
Benefits to regional Australia

- Local studies on ethanol plants in NSW showed for plant capacities ranging 50–80 ML/yr that there would be 6–34 permanent direct jobs, 125–357 permanent flow-on jobs, 49–68 construction direct jobs and 63–87 construction flow-on jobs. A case study for Sarina ethanol from sugar showed that the plant created 36 permanent jobs and 222 flow-on jobs, 389 construction direct jobs and 256 flow-on jobs, and added $7.7 million to household income in the region. However caution is required in extending the results more broadly across regions which do not take into account potential impacts on associated industries.
- New regional industries based on woody perennials and mosaic farming are being investigated. Woody perennial species and commercially viable production systems and industries have been identified, with bioenergy and biofuels as two of the key product markets.
- Work is underway in the sugar industry to assess potential opportunities including improvements in efficiency of supply chain logistics, and diversifying sugar cane products to energy (co-generation), biofuel and biorefineries/bioproducts.
- If the new structures of emerging value chains are to be realised or managed, a national understanding of location, type and size of regional opportunities is required for:
  - a diversified supply system (based on agriculture and forestry);
  - biofuel production;
  - blending and distribution.

Competition for crops with alternative markets

- Food, livestock and biofuel producers are competing for the same commodity crops in the international arena. About 61 % of the world's ethanol production comes from sugar crops. Corn-based ethanol production is growing by about 30 % per year in the USA.
- Impacts include doubling of USA corn prices in 2006–7; rising prices of milk, eggs, chicken and tortillas in China, India, Mexico and the USA; in Europe rapeseed (canola) oil prices doubling over the last five years and the price of cereals, starches and glucose increased by about 20 % in the last year.
- Biofuel induced increases in global grain commodity prices are having an impact on Australian agricultural commodity prices, particularly on our grain commodities. Non-grain agricultural commodity prices are also being buoyed by substitution of global planting area with biofuel crops.
- Competition with food producers for crops has thus far not been a significant issue for Australia's few ethanol producers — as current production is predominantly based on waste starch and C-molasses.
- Currently ethanol from waste starch and C-molasses, and biodiesel from waste oil can be produced at a cost less than 45 c/L (roughly competing with oil at US$40/barrel). Ethanol from sugar, and biodiesel from tallow and canola can be produced for less than 80 c/L (roughly competing with oil at US$80/barrel). High variability in cost of production is largely due to variations in the cost of feedstock.
- There will be increasing competition with grains for food, and with feedgrain for the livestock industry if the Australian ethanol industry expands to its planned production capacity and beyond. Likewise, expansion of Australia's biodiesel industry will increase competition with soap and detergent manufacturers for feedstock.
- There will be a whole new set of markets for second generation (lignocellulosic) feedstocks, which have not been developed or explored in Australia. Although some existing biomass sources do not have existing markets, they may have existing uses (eg retaining carbon in ecosystems, providing habitat).
- In the case of a large scale biofuel industry, there are likely to be competing markets not just for the feedstocks, but also the factors of production including land, water and labour which would then impact on many other industry sectors especially in regional Australia.

Figure 6 Indicative production costs in Australia, showing capital costs, operating costs, feedstock costs. The co-product revenues are shown as a negative cost.



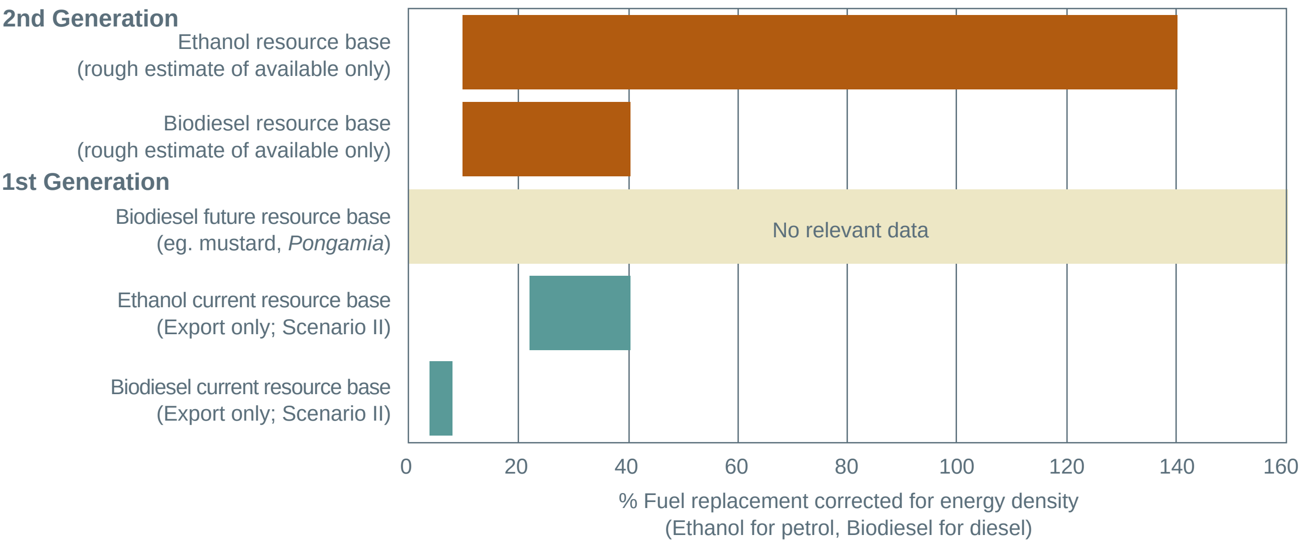
(Keating, B.; O'Connell, D.; Beer, T.; Dunlop, M.; Batten, D.; O'Connor, M.; Grant, T.; Poole, M.; Miller, T. and Lamb, D. (2006). Biofuels from Australian Agriculture - prospects and implications for R&D. In: *AIAST Biofuels: Paddock to Pump Symposium*, 19 October 2006, Canberra, Australia.)

Feedstocks for biofuel production

- Land and water will increasingly be contested for human food, animal feed, fibre, energy, water yield and environmental services. Evaluating the production capacity and sustainability (sustainable yield) of increased production or use of biomass resources is critical to underpin development of new biofuel or bio-based industries.
- Nonfood feedstocks outperform food-based feedstocks on energetic, environmental, and economic criteria. Trees, other woody plants, and various grasses and forbs (weeds), which can all be converted into synfuel hydrocarbons or cellulosic ethanol, can be produced on poor agricultural lands with little or no fertilizer, pesticides, and energy inputs. Their production rates will not be as high as when grown on richer agricultural land with high inputs.
- There are opportunities to transform Australia's agriculture and forestry sectors by moving towards a 'bio-economy'. Using biorefineries and other new processing technologies could open the door for agricultural and forest industries to expand their product bases into valuable industrial products.

The biomass resources in Australia can be categorised for the purposes of biofuels (or bioenergy):

Figure 7 The amount of biofuels that could be produced by Australian domestic feedstocks. Full analyses and assumptions provided in Chapter 4, of report.



Second generation biofuels

There are many different process pathways to obtain a range of biofuels from various biomass feedstocks. This report has focussed on ethanol and biodiesel as biofuels. But there are other fuels which may be of interest in Australia. A few examples are given here but this is not a comprehensive listing.

Butanol

Butanol is an industrial solvent and is also used as a perfume base. It is usually made from fossil fuels and can also be made from fermentation of biomass by bacteria. Recent improvements in the fermentation process have significantly increased the yield of butanol. In a number of important fuel properties, butanol is more similar to conventional petrol than the simpler alcohols such as ethanol and methanol. For instance, it has a volumetric energy density only slightly less than that of petrol. In common with the other alcohols, it is a clean burning fuel with low emissions.

Methanol

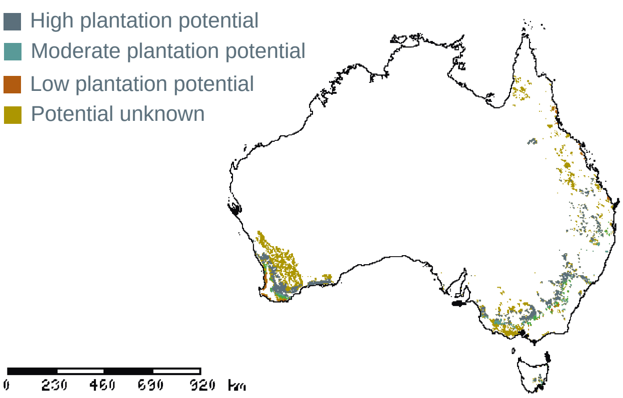
Methanol is a liquid fuel and can be used neat or mixed in any proportion with petrol and combusted in a traditional spark ignition engine. It is usually made from natural gas but it can be made by biochemical means. The energy density of methanol is approximately half that of the same volume of petrol. Methanol has a number of other favourable combustion properties such as a high octane number, a very high heat of vaporisation and a greater tolerance to lean fuel mixes than petrol. This means that dedicated methanol engines can be run at greater fuel efficiency and with lower emissions than conventional petrol engines. In part, this could compensate for the lower volumetric energy density.

Methytetrahydrofuran (MTHF)

This fuel can be created from biomass using a process called Biofine [2]. It has interesting prospects because the intermediate between lignocellulose and MTHF (called levulinic acid) can be reacted with ethanol to make a good quality biofuel called ethyl levulinate. Levulinic acid can be used as a 'platform chemical' to make things like nylon and synthetic rubber in addition to a host of agrichemicals and other products.

[2] Hayes, D. J., Fitzpatrick, S., Hayes, M. H. B. and Ross, J. H. R. (2006). The Biofine Process - Production of Levulinic Acid, Furfural and Formic Acid from Lignocellulosic Feedstocks; Biorefineries - Industrial processes and products. In: Biorefineries – Industrial Processes and Products – Status Quo and Future Directions. Kamm, B., Gruber, P. R. and Kamm, M., (Eds.), Wiley, Weinheim, 1: 139-164.

Figure 8 Potential for tree crops across areas across Australia on cleared land w ith high salinity hazard. High potential: 22 m^3 ha-1, moderate potential: 18 m^3 ha-1, low potential:12 m^3 ha-1, potential unknown: no information on plantation potential provided. Plantation productivity layers developed for the wood and industry strategy.



(Burns, K., Walker, D. and Hansard, A. (1999). Forest plantations on cleared agricultural land: a regional economic analysis. ABARE Research Report no. 99.11. Canberra.), salinity hazard mapping for the NLWRA (Bugg, A. L., Nuberg, I., Keenan, R. and Zimmermann, L. (2002). Bioenergy Atlas of Australia. A report for the Joint Venture Agroforestry Program and The Australian Greenhouse Office. *RIRDC*, Canberra, Australia. Report no. 02/137.)

- *current production base*
  - First generation feedstocks based on sugar or starch crops already widely grown in Australia for ethanol, or oilseeds and tallow for biodiesel.
  - Second generation feedstocks — lignocellulosics for ethanol, butanol, methanol, biogas or electricity including cereal crop (stubble) and sugar (trash and bagasse) residues, annual and perennial grasses, farm forestry crops such as oil mallee, forest products including native forest and plantation residues and thinnings, firewood, and waste streams such as urban woodwaste. Sustainability issues including effect of removal of crop and forest residues on ecosystem carbon, and biodiversity must be addressed.
- *future production base*
  - First generation — includes any expansions of crops (eg wheat could expand into higher rainfall areas, sugar beet, sweet sorghum, mustard).

Table 3 A scheme for assessing feedstocks for biofuels and bioenergy based on current and future production bases, and 1st and 2nd generation processing technologies.

	1st generation biofuels	2nd generation biofuels (or 1st and 2nd generation electricity)
Current production base	Box 1 Ethanol and biodiesel **Ethanol** • Sugar, C-molasses • Wheat • Barley • Oats • Sorghum • Maize • Sweet sorghum • Sugar beet **Biodiesel** • Used cooking oil • Tallow • Canola • Mustard	Box 2 Lignocellulosics for ethanol, butanol, methanol, biogas or electricity, as well as Box 1 crops in biorefining to produce multiple co-products including biofuels **Crop residues** • Sugar bagasse and cane trash • Cereal stubble **Grasses** • Annual and perennial grasses Farm forestry crops • Oil mallee • Short rotation coppicing trees **Forestry** • Wood harvested for sawlogs and pulpwood • Firewood • Residue currently left in native forests • Residue currently left in plantations • Increased forest thinnings **Waste streams** • Waste from wood processing facilities • Urban wood waste • Black liquor (byproduct of pulping) • Residues from food processing • Municipal Solid Waste
Future production base	Box 3 Ethanol and Biodiesel • Expanded production of Box 1 crops • GM crops • Tree crops with high production potential, largely untested in Australia eg *Jatropha*, *Pongamia*, *Moringa*, *Hura crepitans* • Algae	Box 4 Biorefineries for range of high value biobased products, with energy co-products **Forestry or farm forestry** • Expansion of current hardwood or softwood plantation forestry • Expansion of oil mallee industry • 'FloraSearch' type farm forestry — high value new wood products with energy as coproduct **Grasses** • Expansion or new grasses eg Switchgrass **Algae** **GM crops, grasses, trees** **Other unidentified 'biorefinery' initiatives**

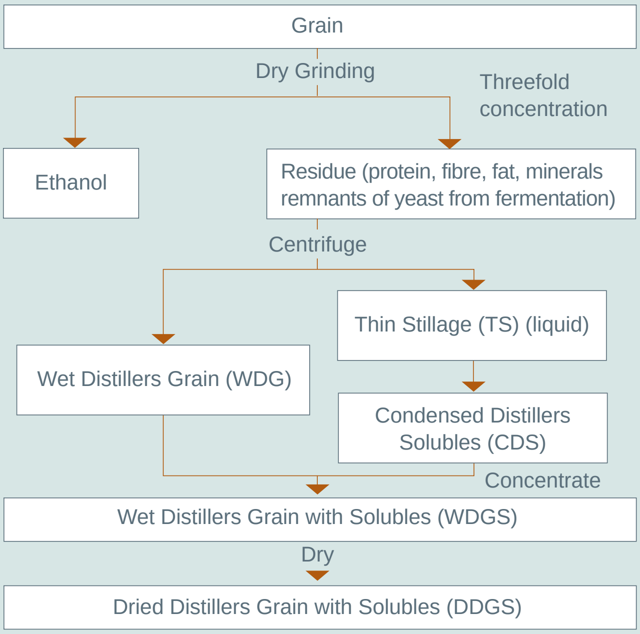
- Oil bearing trees such as *Pongamia pinnata* and genetically modified crops are also promising candidates.

– Second generation — biorefineries for range of high value biobased products, with biofuel and energy as co-products. The second generation feedstocks of the future could greatly expand supply – for example, large scale planting of oil mallee, other native woody species are being investigated for a range of new products including novel wood products, bio-based products as well as energy, grasses, GM crops, and algae.

Impacts on livestock industry

- A growing ethanol industry (that utilises grain) will affect the supply of feedgrain for livestock, particularly in drought years. This will place upward pressure on the price of grain. If quarantine allows, it may also induce more imports of grain in drought years. If E10 based on wheat were to be met in drought years such as 2001–02, import requirements might range from 2 550 to 5 640 kt. Planned expansion of ethanol production capacity in Australia of 897 ML will require 2 770 kt of grain. This requirement may not be met by export substitution alone in drought years.
- There may be some global expansion of grain supply in response to the increased demand, and economic theory predicts that the cost of the grain would stabilise slightly above the cost of production.
- There are some good opportunities for the intensive livestock producers to gain from biofuels production. These include:
  - Availability of high-protein meal should moderate the price of livestock feed protein.
  - *Dried Distillers Grain with Solubles* can be added to the diet at rates of 20–40 % in cattle, 10–25 % in pigs, 9–15 % in poultry, and 15–22.5 % in fish. Higher nitrogen excretion rates will require good management of animal waste.
  - High protein meal can supplement ruminants grazing low-protein pastures for survival during drought, and can also improve breeding and other production traits.

Figure 9 The process and co-products in first generation grain to ethanol conversion.



- Vertically integrated systems of cereal cropping, ethanol production and dairies or feedlots could be set up to use Wet Distillers Grains with Solubles, with economic benefits from co-location.
  - *Wet Distillers Grains with Solubles* could replace a portion of the grain (and offset lower supply of grain).
  - Integrated ownership could provide the ethanol producer with some surety for the disposal of wet co-products.

Sustainability

- Sustainability is a critical issue for the biofuels industry — there is no point in replacing one unsustainable system with another. A 'main game' (10–20 % of transport fuels) industry would place a large demand on biomass, which must be produced in a sustainable manner.
- There is international concern at the rapid growth in the palm oil industry due to biodiesel demand. From the 1990s to the present time, the area under palm oil cultivation has increased by about 43 %. Clearing rainforest not only endangers biodiversity and creates social conflict, but releases vast amounts of carbon and thus exacerbates the very problem that a move to biodiesel in Europe is seeking to address.

  The *Roundtable for Sustainable Palm Oil* (RSPO)[3] is an international group to promote sustainability through a Code of Conduct for its members.
- Australia has processes at various levels of government for dealing with sustainability issues. These include ecological sustainability criteria and indicators for agriculture and forestry, as well as mature processes for Environmental Impact Assessment and Social Impact Assessment for specific projects.
- If Australia develops the capacity to produce feedstock or fuel which can be certified as 'sustainably produced', it could be a potential market advantage in the future.

[3] http://www.rspo.org

Comparisons of biodiesel and ethanol with reference standards

- Ethanol and biodiesel must meet the standards set under the Fuel Quality Standards Act (2000) administered by the Department of Environment and Water Resources (DEW).
- Biodiesel made from tallow or palm oil will solidify in cold weather.
- Because of their difficulty in meeting the standards, the biodiesel industry seeks liberalisation of the Australian biodiesel standard.
- To receive the rebate that alternative fuel manufacture attracts, a certificate costing $3 000/batch to show the fuel meets the Australian fuel quality standard is required.
- The motor industry does not warrant vehicles for blends containing more than 10 % ethanol, and individual manufacturers may have warranty thresholds lower than this.

Infrastructure for biofuel production

- Ethanol from fermentation of starch/sugars, and biodiesel from transesterification of fats and oils are the two first generation biofuels currently produced worldwide. The existing and planned facilities in Australia use these technologies for conversion to biofuels.
- The current processing capacity for ethanol in Australia in 2007 is 140 ML, with planned capacity of 1155 ML. The current biodiesel capacity is 323 ML with a planned capacity of 1122 ML.
- There are a range of other second generation fuels for which new feedstocks and processes are being developed and commercialised. These are largely based on lignocellulosic feedstocks. Many of the new technologies are in demonstration phase, and not yet cost competitive although there is some indication that within 3–5 years some of these might become competitive with oil (within the oil price ranges experienced in 2005–2007).
- The USA government has announced the granting of US$385 million for the construction of six cellulosic ethanol pilot plants in the United States.
- Second generation processing relying on fermentation following enzyme processing of lignocellulosic material will be able to use the infrastructure of fermentation and distillation facilities for first generation ethanol production. Some modification — largely 'bolt-on' equipment — will be required to handle initial breaking down of the lignocellulose.
- However, second generation processing which requires high temperature and pressure equipment (eg gasification, pyrolysis) is not compatible with first generation infrastructure.
- For many new types of energy crops such as short rotation or coppicing crops, the harvesting machinery is not yet developed. Systems which can compact the large volumes into high density briquettes or pellets in the field or forest may help to overcome this problem. The logistics and economics of harvesting and transport in the Australian sugar industry are well understood. Transport distances much greater than 50 kms are difficult to justify from a financial perspective.
- B5 and E10 (provided that they meet the relevant diesel standard and petrol standard respectively) are considered equivalent to diesel and petrol and do not need any infrastructure changes. For marketing reasons, separate pumps are generally used. Blending of ethanol with petrol, and biodiesel with diesel, can only be carried out by licensed blenders.

Policies affecting biofuels

- Estimates of subsidies to fossil fuel use in Australia range from 2.2 to 10 billion dollars per year. These estimates include perverse subsidies which increase GHG emissions and reduce economic efficiency, and subsidies to motorists — which would still apply if the motorists were running their vehicles on alternative fuels instead of fossil fuels. These need clarification in terms of the categories, values and beneficiaries across the fossil fuel value chain.
- Assistance currently provided to producers includes (a) a production grant of 38.1 cents per litre (c/L), which fully offsets the excise paid on biofuels; (b) a capital grant for new facilities that effectively provides around 1 c/L in additional assistance over the lifetime of the plant.
- Assistance to biofuels is scheduled to fall to 12.5 c/L for ethanol and 19.1 c/L for biodiesel by 1 July 2015. A banded excise system will impose rates on different fuels, classified into high, medium and low energy groups. This strategy broadly keeps constant the excise payable per kilometre travelled by vehicles using the fuel, with biofuels retaining a 50 % discount on this excise.
- Ethanol imports are subject to both a general tariff of 5 % (zero if imports are from the USA) and the full excise of mid-energy fuels of 38.1 c/L. Between 2011–2015, the net excise payable on ethanol by domestic manufacturers will increase on a sliding scale from 0–12.5 cents per litre. From 2011, the effective excise cost imposed on imported ethanol will be also be reduced to be the same as that faced by domestic manufacturers.
- Recent changes in the *Fuel Tax Act 2006* have had a major impact on the biodiesel industry. Since the changes, off road users of biodiesel blends can no longer claim 38.1 c/L on the biodiesel component of the blend unless the fuel qualifies for the Australian Diesel Standard.

Options for expanding demand

Total demand has two components:

- Intermediate demand — purchasing patterns of intermediate producers such as oil companies, services stations, farming co-operatives etc who process, blend and distribute fuels for eventual sale to customers.
  - Only about 5 % of the 8 000 plus service stations across Australia are now selling ethanol or biodiesel blends.
  - Ethanol and biodiesel blends are provided mostly by independent, small scale fuel providers - oil majors are slowly increasing their involvement.
  - There is a lack of availability of E10 and B5 in southern and western states.
- Final demand — purchase by consumers. Consumer confidence is the major barrier. Motorists are concerned that ethanol will damage their engines. This concern is unfounded for modern cars running on E10.

Strategies to stimulate demand include industry -based information dissemination; more marketing and promotional activity; simplification of the Federal Chamber of Automotive Industries (FCAI) vehicle list on E10 suitability; further E10 vehicle operability testing; simplification and modification of the current fuel ethanol information standard; removal of demand barriers (such as lower consumer confidence and limited service station outlets); rollout incentives; price discounting; producing and/or mandating of flexi-fuel vehicles; tax, excise and import incentives.

Options for encouraging future capital investment

- Australia's policy platforms for biofuels differ significantly from Europe, America and other nations which actively promote the production and use of biofuels. Some of the intended and unintended consequences of these proactive policies are currently unfolding — eg increases in the grain price, and impacts for the human and livestock food supplies.
- There are opportunities to use targeted incentives in the area of biofuels. For example, if a set of criteria were developed based on a set of preferred outcomes (eg lower greenhouse gas emissions, improved energy input:output ratios, health or regional outcomes) then incentives could be targeted and scaled on this basis.
- An emissions trading scheme could promote the use of biofuels, if the sale of renewable fuels did not require the purchase of emissions allowances. Fossil fuel suppliers would be obliged to purchase such emissions allowances, in order to sell fossil fuels. There is currently a Prime Ministerial Task Group on Emissions Trading which will help to set the parameters for this discussion.

Conclusions

- This report has reviewed the positive and negative impacts of biofuels across the value chain. The emergence of a 'main game' biofuels (or bio-based products) industry (which contributes 10–20 % of transport fuels) has the potential to significantly shift agriculture, forestry, environmental and fuel value chains — towards the emergence of a bio-based economy.
- Likely benefits along these value chains have been quantified where possible, but many of these are poorly understood. Transition pathways to realise the potential benefits of these value chains are not well understood. Development of a financially viable and ecologically sustainable industry will require a better understanding of these so that policy measures

Figure 10 Potential benefits from economic and environmental value chains for biofuels.

ECONOMIC Value Chain	**Biomass producer**	**Processor**	**Distributor**	**Retailer**	**Customer**
Likely benefits:	Income stream from Non food products Lower production costs Possible investment in local processor	Feedstock cost less than price of oil Close to market production Lower exposure to environmental impacts	Price On seller of carbon mitigation More of them than trade oil	Unclear Little power needs support to assist with storage	Must be price driven Until environmental Concerns are valued
Likely benefits:	Drought tolerance Salinity mitigation Carbon credits	Closed loop production Fewer emissions More carbon credits	Better on shore energy security Product offering more environment friendly Better engine performance	Part of reduced footprint market	Must be price driven Reduced air pollution so better health outcomes Personal carbon miles mitigated
ENVIRONMENTAL Value Chain	**Sustainable Land Use**	**Low Fossil Fuel Use**	**Lowest Fuel miles/l**	**Preferred offering**	**Low or zero emissions**

(Adapted from (from Single Vision (2007). Prospects for a viable grain based Australian Biofuels Industry – there is no single solution. Green Paper, February 2007. Single Vision, Grains Australia. Canberra.)

can be taken to achieve the desired outcomes, and manage potential unintended consequences.

- Biofuels are only a part of the solution to our future transport and energy needs. A range of strategies will be required to address the drivers of environment, energy security, health, and regional opportunities. In the case of the major driver — greenhouse emissions and climate change — this will include mitigation (reducing emissions) and adaptation (preparing to deal with higher CO_2 levels in our socio-ecological systems).
- To be effective in achieving intended outcomes, these strategies will need to be embedded in a strategic alternative energy framework. A roadmap to focus disparate frameworks and goals, value chains, industry efforts, public benefit and government policy would provide a useful step forward.

Vehicles, engines and biofuels

This report is focussed on the potential role of biofuels in our future transport mix. This is because one of the strategies in response to climate change and energy security issues is to diversify the sources of fuel. The responses to these drivers from the vehicle industry include:

- Improving the fuel efficiency of vehicles. This may mean in the future that fuel standards will need to be tighter — which could pose difficulties for biodiesel with some feedstocks (eg tallow).
- Excellent technology already exists for electric vehicles - hybrids and 'plug in' hybrids (which can recharge from existing electricity infrastructure) are increasing sales. Battery technology is improving all the time. Use of electricity as an alternative fuel would circumvent fuel standards issues, because a blend of technologies in power generation would not impact upon the composition and quality of the fuel at all — electricity is a very standard product!
- The flexi-fuel vehicle can use a mix of ethanol or petrol up to 85 % ethanol. This type of vehicle is in common use in Brazil, with around 70 % of vehicles capable of operating on a mix of petrol and ethanol. The cost of production of these vehicles is in the order of $100 more expensive than a standard petrol vehicle — but the standard vehicles cannot be cheaply converted.
- At present the most likely scenario for future electric vehicles is that of fuel-cell vehicles with the fuel cell powered by hydrogen. Fuel cells use methanol for chemical reactions of hydrogen and oxygen to produce direct current electricity, with water as a co-product. The process is more efficient than combustion, with little waste heat produced. This technology is in the early stages of development.

This document is a summary of the report *Biofuels in Australia — issues and prospects* (RIRDC Publication Number 07/071). The report contains the details and references on which this summary is based. A copy of both this document and the report containing all references will be available on the RIRDC website **www.rirdc.gov.au**.

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