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Biofuels in Australia – issues and prospects

A report for the Rural Industries Research and Development Corporation

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Biofuels in Australia — issues and prospects

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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
- the size and distribution of the benefits and costs of these potential new value chains
- and the 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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Contents

List of Figures

List of Tables

List of abbreviations

A$	Australian dollars
ABARE	Australian Bureau of Agricultural and Resource Economics
ABS	Australian Bureau of Statistics
ACS	Australian Commodity Statistics
ADG	Average daily gain
AGO	Australian Greenhouse Office
ANTS	Analysis of the New Tax System
APPEA	Australian Petroleum Production and Exploration Association
B5	Blend of 5% Biodiesel in petroleum diesel
B10	Blend of 10% Biodiesel in petroleum diesel
B20	Blend of 20% Biodiesel in petroleum diesel
B80	Blend of 80% Biodiesel in petroleum diesel
B100	Fuel containing 100% Biodiesel
BRS	Bureau of Rural Sciences
BTRE	Bureau of Transport and Regional Economics
BTL	Biomass to liquids
C	Carbon
CAD	Canadian dollars
CARE	Centre for Agricultural and Regional Economics
CDS	Condensed Distillers Solubles
CH4	Methane
CIE	Centre for International Economics
CNG	Compressed Natural Gas
CO_2	Carbon dioxide
CSIRO	Commonwealth Scientific and Industrial Research Organisation
CTL	Coal to Liquids
CV	Coefficient of variance
DDGS	Dried Distillers Grain with Solubles
DE	Digestible energy
DEW	Department of Environment and Water Resources
DME	Di-methyl ether
E5	5% blend of Ethanol in Petrol
E10	10% blend of Ethanol in Petrol
E85	85% blend of Ethanol in Petrol
E100	Ethanol
EC	European Commission
EDR	Economic Demonstrated Resources
EPA	Environmental Protection Agency
ESD	Ecologically Sustainable Development
EU	European Union
FCAI	Federal Chamber of Automotive Industries
GHG	Greenhouse Gases
GL	Gigalitre
GM	Genetically modified
GRDC	Grains Research and Development Corp.
GTL	Gas to liquids

ha	hectare
IEA	International Energy Agency
ISO	International Standards Organization
J	Joule
kt	Kilotonne
L	Litre
L/t	Litres per tonne
LCA	Life-cycle Analysis
LNG	Liquefied Natural Gas
LPG	Liquefied Petroleum Gas
LSD	Low Sulfur Diesel
LWA	Land and Water Australia
MDBC	Murray Darling Basin Commission
MDG	Modified distillers grains
ML	Megalitre
MRET	Mandatory Renewable Energy Target
Mt	Megatonnes
MTBE	Methyl tertiary butyl ether
MTHF	Methytetrahydrofuran, also known as levulinic acid
Mtoe	Million tonnes of oil equivalent
NAD	No Appropriate Data
NEPM	National Environment Protection Measure
NIEIR	National Institute of Economic and Industry Research
NLWRA	National Land and Water Resources Audit
NOx	Oxides of Nitrogen
NREL	National Renewable Energy Laboratory
NSW	New South Wales
Mtoe	Million tonnes of oil equivalent
ODT	Oven dried tonnes
OECD	Organisation for Economic Co-operation and Development
ORER	Office of the Renewable Energy Regulator
PJ	Petajoules
PM10	Particulate matter below 10 µm diameter
PM2.5	Particulate matter below 2.5 µm diameter
Qld	Queensland
R/P	Resource to production ratio
REC	Renewable Energy Certificates
RIPA	Regional Industry Potential Analysis
RIRDC	Rural Industries Research and Development Corp.
RSPO	Roundtable for Sustainable Palm Oil
SWDGS	Sorghum wet distillers grain plus solubles
TMD	Total mixed diets
TS	Thin Stillage
TWh	Terrawatt Hours
UCO	Used cooking oils
UK	United Kingdom
ULP	Unleaded Petrol
ULSD	Ultra-Low Sulfur Diesel
USA	United States of America
VOCs	Volatile Organic Compounds
W	Watts
WA	Western Australia
WDG	Wet Distillers Grain
WDGS	Wet Distillers Grains with Solubles
XLSD	Extra low sulfur diesel

Executive summary

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.

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.
- 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.
- 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.

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 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.

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[i] 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.

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

- 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.

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.

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.
- 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.
- 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.

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

- *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).
    - 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.

- 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)*[ii] 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.

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.

ii http://www.rspo.org/

- 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.

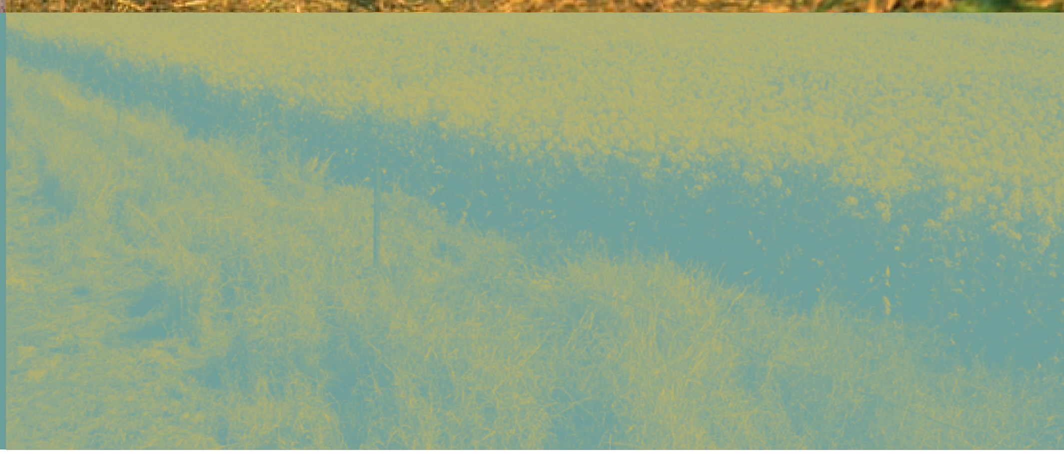
Options for encouraging future capital investment

- 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 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.

1 Addressing the drivers of change



1.1 Introduction

Demand for energy — transport fuels as well as electricity — has grown dramatically throughout the world during the 21st century. In the last 10 years, there has been a growing debate about whether oil - the feedstock underlying the petrochemical and transport fuel industries - may be close to its limit in terms of cheap extraction and politically and financially secure sources. There is growing evidence that this is indeed the case — although there is still a high degree of uncertainty. Oil prices have risen dramatically since 2002. The atmosphere, land and oceans cannot continue to absorb the greenhouse gases which are produced in using fossil energy without dramatic change to the environment.

There has thus been a growing trend worldwide to look for alternative energy sources which are more secure and produce less greenhouse gases. This can be achieved through energy efficiency combined with reduced demand, improved waste management, and 'clean, green' bio-based replacements for the energy and petrochemical industries.

1.2 Global and local production levels

- International biofuel production is increasing at an enormous rate, with over 18 Mtoe (million tonnes of oil equivalent) per year of ethanol mostly produced from sugar in Brazil and corn in USA, and 2.5 Mtoe per year of biodiesel mostly produced

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.

Table 1-1 Estimates of currentAustralian production of ethanol and biodiesel for 2006/7.

	Feedstock	Current capacity (ML/yr)	Estimated production	Percentage of total market
Ethanol	Waste starch and wheat & C-molasses	148	75*	0.4 % (volume) of current 19 500 ML petrol market
Biodiesel	Waste Oil & Tallow	323	50*	< 0.4 % (volume) of current 15 000 ML diesel market
Total		90	89*	

* CSIRO Estimates for 2006/7 financial year.

from oilseeds in Europe. The figure of 18 Mtoe of ethanol production world wide (756 PJ) is slightly higher than Australia's current petrol consumption of 20 GL (thousand million litres) or 680 PJ.

- The biofuels industry in Australia is in its early days, with a national production target of 350 ML by 2010 (about 1 % of current transport fuel usage). Different states are investigating biofuels and policy options at state level (section 10).
- Current production levels in Australia are approximately 75 ML ethanol, 50 ML biodiesel for 2006/7, which is less than 0.4 % of our transport fuel requirements (Table 1-1).

1.3 First and second generation biofuels

- First generation technologies are those which are currently commercially viable. They are based on ethanol from starch and sugar crops, biogas (largely methane) from wet wastes, biodiesel from waste cooking oil, tallow, palm oil and canola.
- Second generation technologies are being developed around the world, and may revolutionise the industry. They include conversion of lignocellulose (woody or fibrous plant material) to a range of fuels including ethanol and synthetic diesel.
- Use of second generation processes (based on lignocellulose) will minimise impact on food supplies for humans and animals.

1.4 Drivers for a biofuel industry

1.4.1 Greenhouse gas emissions and climate change

What difference can biofuels make?

Ethanol

- E10 blend is the most feasible option for ethanol in Australia in the short term. Different engines and fuel systems are needed if ethanol blends of significantly more than 10 % are to be used.
- When used in an E10 blend, greenhouse gases (as compared to unleaded petrol) are lower by 1.7 % (from wheat) to 5.1 % (C-molasses using co-generation) (Figure 1-1).
- 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.
- Improvements in the production systems (including growing the feedstock, and conversion technologies) may lead to further lowering of emissions — but the net benefits will be limited where the blends are dominated by petrol.

E10 represents a 10 % blend of ethanol in petrol. The strongest ethanol blend commonly used is **E85** which is 85 % ethanol in petrol.

B10 represents a 10 % blend of biodiesel in petroleum diesel. **B100** is 100 % biodiesel.

Life Cycle Analysis

Life Cycle Analysis is used to assess and compare the environmental impacts of products or services through their entire life cycle — from genesis to disposal. There is an international standard for Life Cycle Analysis (ISO 14040).

Care is needed in the interpretation of Life Cycle Analyses, as a range of results will be obtained. Analyses depend on the particular production system (including farming system, transport distances and processes for converting to a fuel). Results also depend on the exact Life Cycle Analysis method used. All of the Life Cycle Analysis results presented in this report have been done by CSIRO using a consistent method and are therefore comparable to each other. A study by CSIRO, BTRE and ABARE further describes the nature of LCA results[1].

For example, to assess wheat for biofuel in Australia (Figure 1-1), the following would be included:

- the fossil fuels used by the farmer in the preparation of land, maintaining the crop and harvesting the wheat;
- the fossil fuel content of fertilisers and herbicides and the transport of these to the region;
- the transport of the harvested grain to the ethanol facility;
- the inputs used in the conversion process of wheat to ethanol, including electricity, water, gas, and the energy which has gone into producing other inputs such as enzymes;
- the blending and distribution of the ethanol;
- the combustion of the fuel in the engine.

The impacts can be viewed in terms of upstream or precombustion impacts which happen before the fuel is used in the engine, and the combustion or tailpipe impacts which happen as the fuel is used in the vehicle. An LCA based on a very different production system eg a different crop, or the same crop in another country where the farm management and transport regimes are very different, or from the use of a very different type of technology in the conversion process (eg thermochemical compared to fermentation processes), or in different types of vehicle (eg a small passenger vehicle compared to a bus or truck) will give very different results.

Biodiesel

- Biodiesel blends of B5 and B20 and B100 can be used without a major change in vehicle fleets. These blends (as combusted in a rigid truck) are presented in comparison to diesel (in this case Ultra Low Sulfur diesel) (Figure 1-3).
- Greenhouse gas emissions for biodiesel based on waste vegetable oil range from 89.5 % lower for B100 to 4.2 % lower for B5 than diesel.
- Greenhouse gas emissions for biodiesel based on tallow range from 29 % less for B100 to 1.5 % less for B5 as compared to diesel.
- Greenhouse gas emissions for biodiesel based on canola range from 15 % less for B100 to 1.5 % less for B5 as compared to diesel.

1.4.2 Land and water impacts

What difference can biofuels make?

- The impacts on land and water would largely be through the production of the crops or biomass (for biofuels or electricity).
- The impacts will depend on the scale of the industry — a small industry based on diverting a proportion of our current crop

Figure 1-1 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[1]. Upstream begins with biomass production; Tailpipe begins at the bowser.

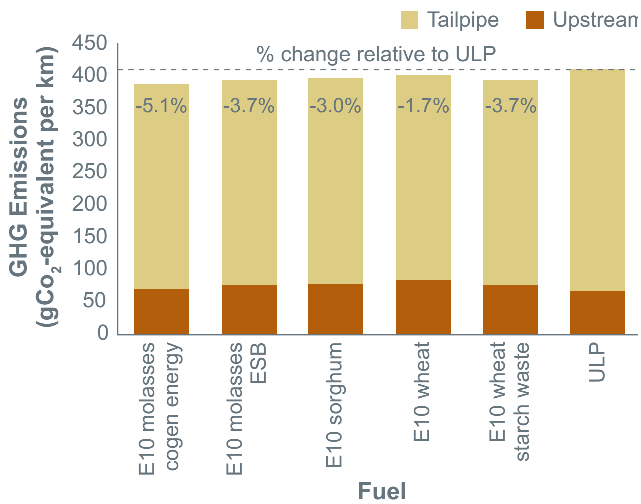


Figure 1-2 A process tree showing an LCA of ethanol from wheat. The upstream processes contributing to wheat production are shown, as well as the conversion of wheat to ethanol. The thickness of the arrows indicates the proportion of the GHG emissions from each step.

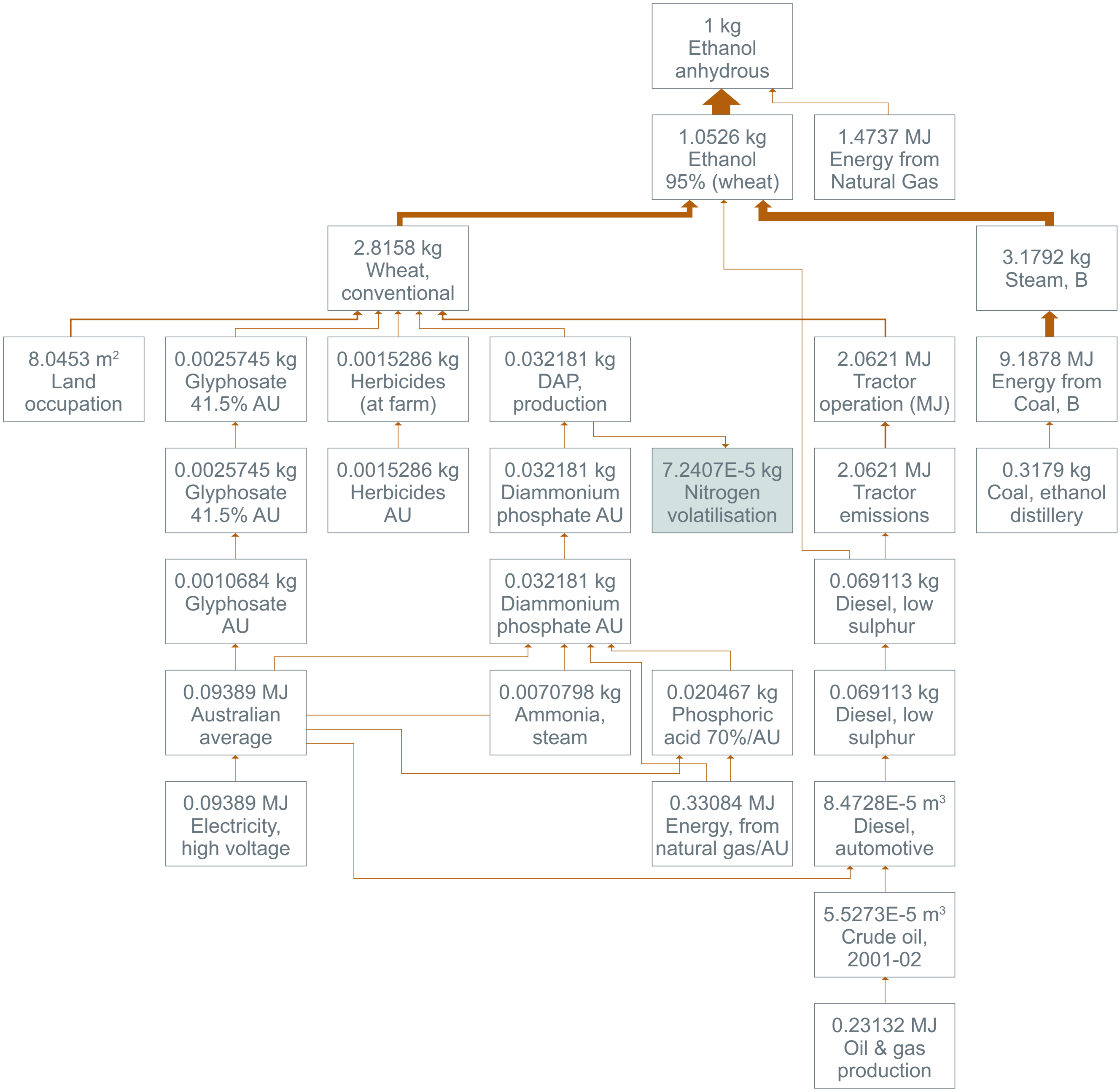


Figure 1-3 Full life-cycle greenhouse gas emissions per km for biodiesel and biodiesel blends in a rigid truck compared to Ultra Low Sulfur (ULS) diesel (sulfur content < 50 ppm). Numbers at the top of the bars represent the percentage change, compared to diesel [1].

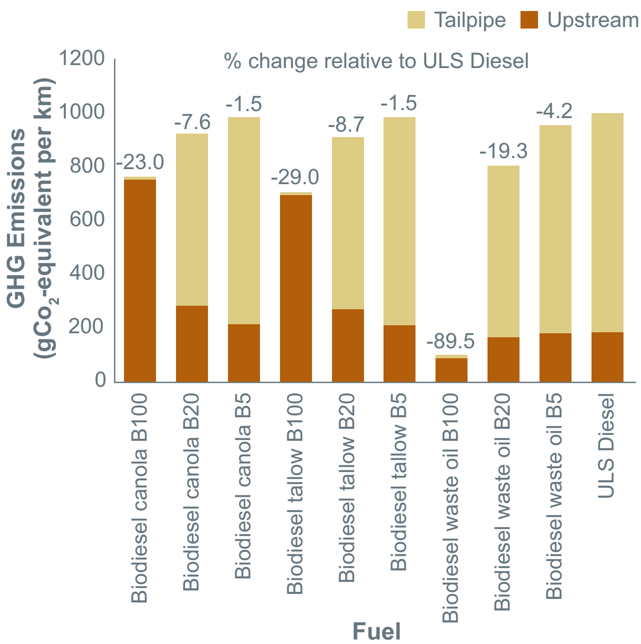
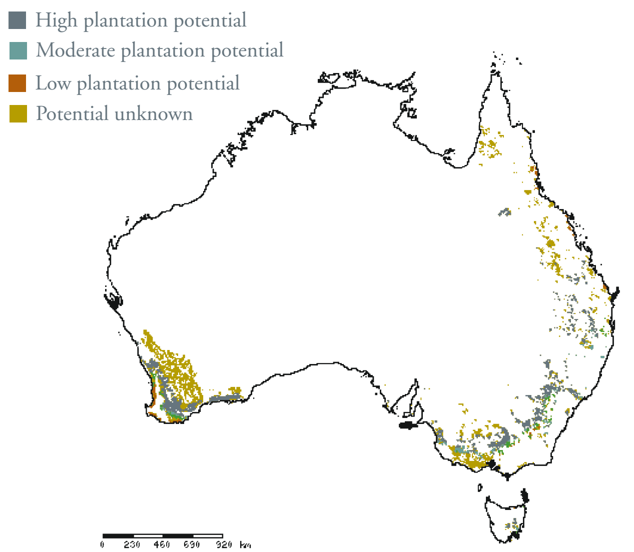


Figure 1-4 Potential for tree crops across areas across Australia on cleared land with high salinity hazard. High potential: 22 m^3 ha^{-1}, moderate potential: 18 m^3 ha^{-1}, low potential:12 m^3 ha^{-1}, potential unknown: no information on plantation potential provided. Plantation productivity layers developed for the wood and industry strategy [7,8].



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 in the case of ethanol based on the existing sugar production area in northern Australia because it will not change the existing land use impacts.
- The impacts may be positive if a large ethanol or bioenergy industry is based on oil mallee in low rainfall areas (< 500 mm/yr) because it may improve the salinity outcomes [2]. The *National Land and Water Resources Audit* [3, 4] estimated that the area of Australia at risk of being salt affected was 5.7 million ha, and will exceed 17 million ha by 2050 if no action is taken. It has been estimated that 70–80 % of the landscape may need to be planted with deep rooted perennial crops to mitigate this risk [5]. Capturing the salinity benefits relies on placing the trees carefully in relation to the hydrogeology of the catchment [6].
- The impacts may be negative in the case of a large scale industry based on ethanol from large scale reforestation in high rainfall areas (> 600mm) — for example in the uplands of the Murray River, large scale reforestation may reduce the water yield (ie runoff from the catchment to the river), which would mean less water in the river, and perhaps higher salt because there is less fresh water to dilute it [6].
- The *Bioenergy Atlas*[iii] collated some of these studies on potential for woody perennials to mitigate salinity risk (Figure 1-4). The analysis shows only plantation potential for regions where annual rainfall exceeds 800 mm only (which includes only a small proportion of areas with a high salinity hazard where oil mallees are likely to be established).

iii http://www.brs.gov.au/mapserv/biomass/

1.4.3 Fuel security

- The concepts of energy, fuel, food and water security have only recently entered mainstream discussion in Australia, and the potential contribution of biofuels (or any other alternatives) to our fuel security have not been systematically evaluated.
- Previous studies in Australia on the viability of a biofuels industry [1, 9] focussed on a target of 350 ML — which at 1 % of Australia's total transport volume of 35 000 ML is not at a scale relevant to energy security.
- In order for biofuels to play a significant role in Australia's energy security, an industry which could contribute perhaps 10–20 % or more of the total fuels mix would be necessary. There is limited capacity to produce first generation biofuels based on domestic feedstock without competing with domestic food supply. Full analyses are presented in section 4.

Energy content of ethanol compared to petrol

Ethanol has approximately two thirds of the energy content of petrol, and therefore more ethanol is required to drive the same number of kilometres. It does, however, have a higher octane value which partially offsets this decrease in energy content. Individual vehicles vary, but 2–3 % poorer fuel economy is typical when using E10.

Estimates based on simple assumptions of quantities of feedstock (Figure 1-5) are as follows

Ethanol

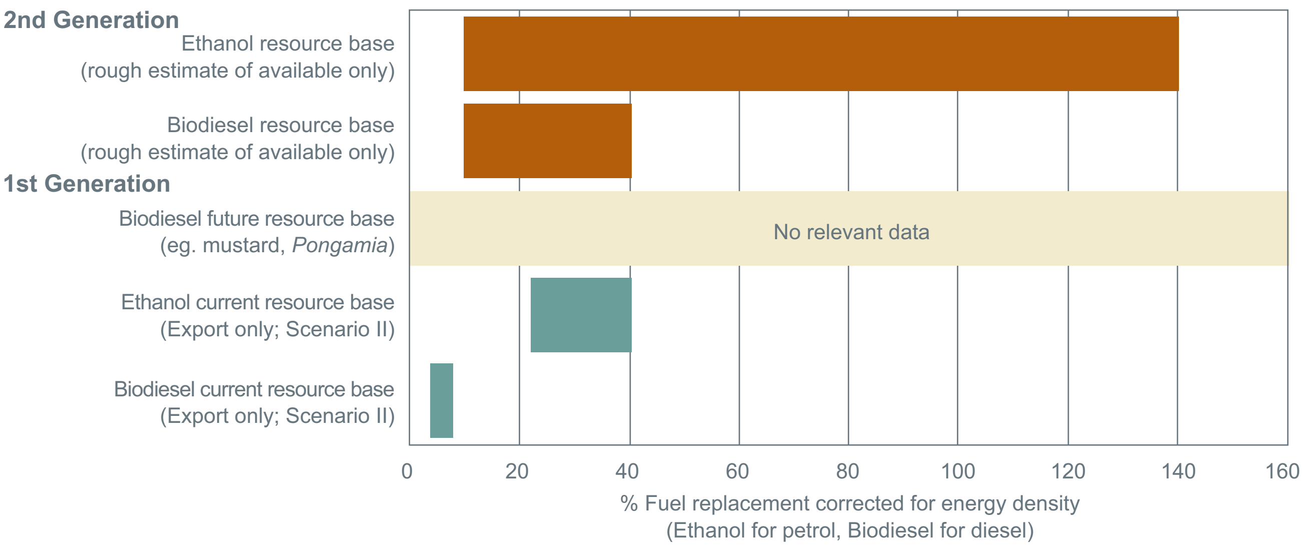
- *First generation technologies from current production base* [iv]. Based on averages of the last 10 years of Australian Commodity Statistics (2005), conversion of export fractions of wheat and coarse grains could theoretically have supplied an upper limit of 10–22 % of Australia's current petrol usage (taking into account lower energy content of ethanol).
- *Second generation technologies (ethanol from lignocellulosics) from current production base* - by some rough estimates provide an upper limit between 10–40 % of Australia's current petrol usage (taking into account lower energy content of ethanol).
- *Second generation technologies (ethanol from lignocellulosics) from future production base* (eg expansion of mallee or plantation forestry) — by some rough estimates provide an upper limit between 10–40 % of Australia's current petrol usage (taking into account lower energy content of ethanol).
- Servicing all of the proposed ethanol capacity (Table 9-1) with existing crops (principally wheat and sugar), or meeting a national E10 target (eg. by 5.5 Mt of wheat as the feedstock) could force the import of wheat in drought years (unless the wheat storage arrangements were changed to take account of new demands). There are legal obstacles to importing wheat, based on introducing a biosecurity risk.
- Gains over time in crop productivity, likely to increase fuel production per hectare, should be explored in future bioenergy scenarios.

Biodiesel

- *First generation technologies from current production base*. It is harder to provide reliable figures on biodiesel feedstocks, but estimates are based on domestic waste oil, tallow exports and oilseed exports. Conversion to biodiesel could have theoretically provided an upper limit of 4–8 % of Australia's current diesel usage.
- *First generation technologies from future production base* (eg new crops such as mustard, *Pongamia*) — insufficient data even for a rough estimate. Algae as a potential biodiesel feedstock, is to be developed by Victor Smorgan Group under licence from Green Fuel (USA).
- Clearly there is potential for biofuels to have a more substantial role in Australia's transport future, and contribute to fuel security with second generation technologies based on lignocellulosic feedstocks, or from new trees and crops for biodiesel. A reliable estimate of this potential requires a more robust assessment of:
  - the size of current and future lignocellulosic feedstock resources;

[iv] Current and future production bases are further explained in section 3, and the assumptions and calculations behind these numbers in section 4

Figure 1-5 The amount of biofuels that could be produced by Australian domestic feedstocks. Full analyses and assumptions provided in Chapter 4.



- the portion of this that could be retrieved in an ecologically sustainable and economically viable way;
- the potential for new biodiesel feedstocks such as Pongamia;
- the potential for 'biorefinery' technologies to create novel high value co-products along with biofuels;
- transition pathways to future fuel and transport needs.

1.4.4 Health

What difference can biofuels make?

The health benefits of using biofuels are mostly due to lower particulate matter emissions. Particulate emissions have a detrimental effect on human health — particularly the smaller particles (known as PM2.5) which accumulate on the surface of lung tissue and possibly affect cell division. In the case of ethanol this reduction in particulate matter emissions is from replacing metropolitan petrol refineries with regional ethanol production, and in the case of biodiesel from lower tailpipe emissions.

The benefits of biodiesel are:

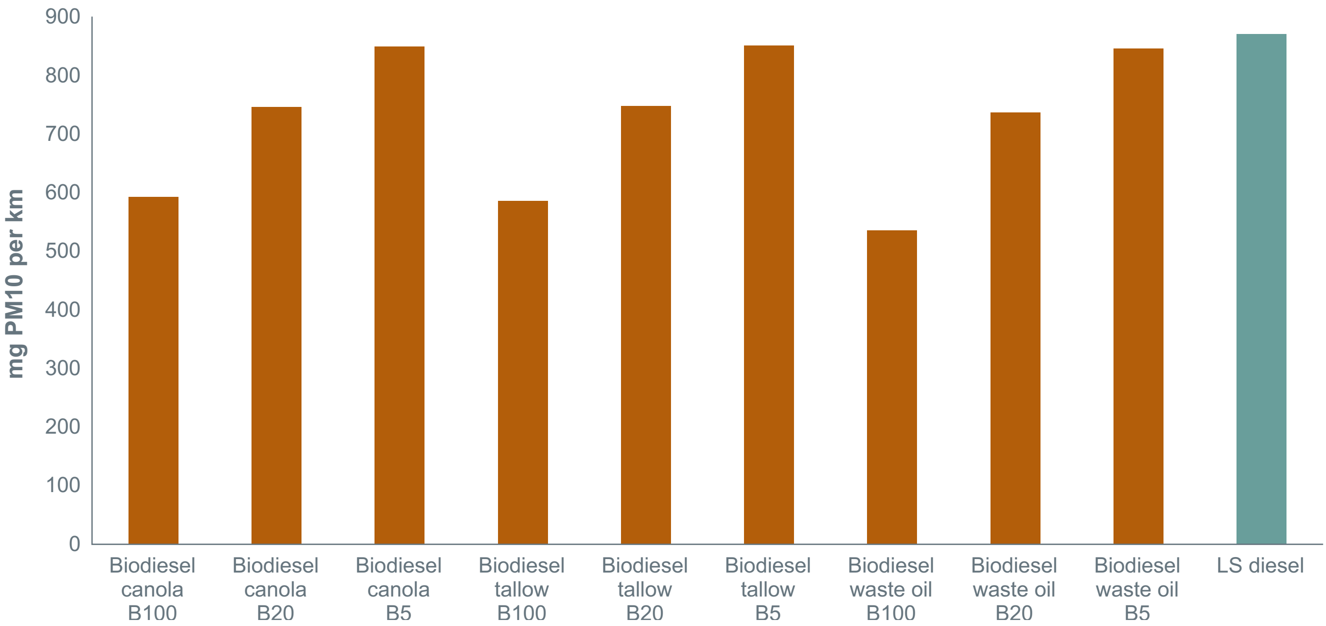
- all criteria air pollutants[v] except oxides of nitrogen (NOx) are significantly lower when replacing low sulphur diesel with biodiesel;
- particulate matter emissions are significantly lower for pure biodiesel (B100) for tallow, canola and waste oil than for diesel (Figure 1-6);
- the benefits of lower particulate matter emissions are greatest for pure biodiesel, and lowest in B5 blends where the benefits were swamped by the diesel.

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

- There may be lower 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 [9], which may lead to worse air quality outcomes in some specific circumstances.

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

Figure 1-6 Life-cycle particulate matter (PM10) emissions from low sulphur diesel (LSD) and the use of biodiesel from various feedstocks per km for articluated trucks[1].



- The high level of uncertainty in the level of particulate reduction from E10 does not permit a reliable estimate of the health costs and benefits of E10 use.
- Rough estimates of the potential health costs avoided range from $3.3 million per year (1.4 c/L in 2003 dollars) [1] to $90.4 million per year (30.4 c/L in 2004–05 dollars) [9]. These numbers were derived with a very specific set of assumptions about the locations of producing and using the fuels, under the scenario of 290 ML of ethanol and 60 ML of biodiesel by 2010, and assuming 40 % reduction in tailpipe emissions for ethanol. Some of the assumptions are highly contestable [9].
- Due to the uncertainty in the above estimates, 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[vi].

[vi] Project commencing mid 2007, led by Dr Tom Beer CSIRO

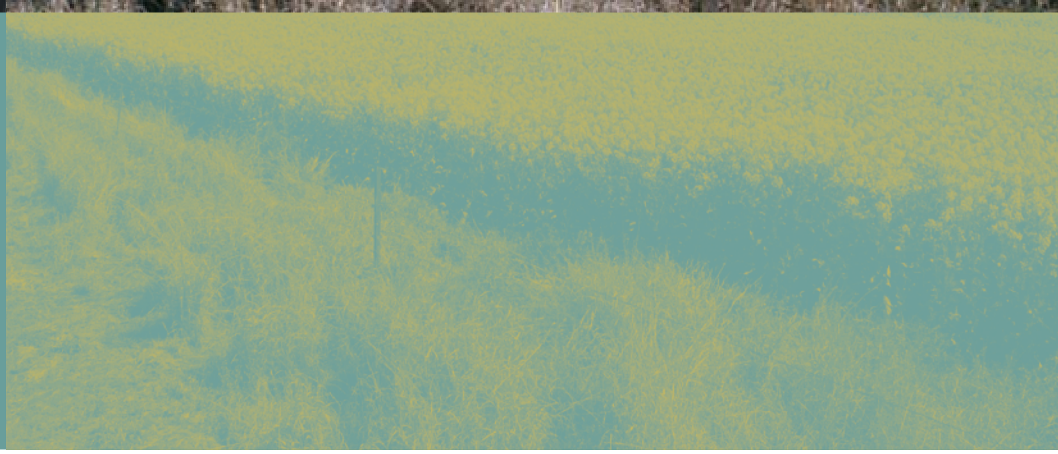
1.4.5 New opportunities for agriculture and rural communities

- The potential regional opportunities are explored in some detail in section 5.
- Biofuels (and more broadly bioproducts) may present new opportunities for regional Australia. The size, extent and chances of success of many perceived opportunities cannot be quantified for Australia based on existing studies. The economic view of regional impacts of biofuels is largely in terms of construction and ongoing operation of production plants rather than products themselves [9]. However benefit to one region or industry sector can come at a cost to another.
- Local studies on ethanol plants [10, 11] in NSW showed for plant capacities ranging 50–80 ML/yr that there would be 6–34 permanent direct jobs, 12–357 permanent flow-on jobs, 49–68 construction direct jobs and 63–87 construction flow-on

jobs [10]. 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 [11].

- However these estimates are considered optimistic [9] because of the high multipliers and lack of analysis across other regions and sectors. Caution is required in extending the results more broadly across regions. Net national effect could be positive or negative [9].
- There have been several studies in Australia over the last 15 or so years into developing new regional industries based on woody perennials and mosaic farming. Several have aimed to identify and develop woody perennial species and commercially viable production systems and industries, with bioenergy and biofuels as two of the key product markets [12-15]. A framework for Regional Industry Potential Analysis for these new woody species has also been developed for southern Australia [16].
- Limited case studies into biodiesel as a regional opportunity taking place in Victoria using various business models show some prospects for regional ownership and benefits to be obtained.
- Work is underway in the sugar industry to assess potential opportunities including improvements in efficiency of supply chain logistics eg [17, 18], adaptation to climate change eg [19, 20, 21], managing impacts on natural resources such as the Great Barrier Reef [22,23] and diversifying the products from the industry to energy (co-generation), biofuel and biorefineries/bioproducts [24-27].
- There may be significant opportunities for vertical integration of feedstock production, biofuels processing, and co-location of complementary industries (eg intensive livestock facilities and ethanol processors) which can maximise synergies.
- There is a fragmented approach with respect to quantifying and developing regional industry potential for whole-of-biomass supply — currently there are industry specific analyses of grain, oilseed or wood products in relation to transport and processing. If a national understanding of the location, type and size of regional opportunities of a unified supply system is required, further work will be needed to bring these elements together in a cohesive and robust framework.

2 Competition for crops with alternative markets



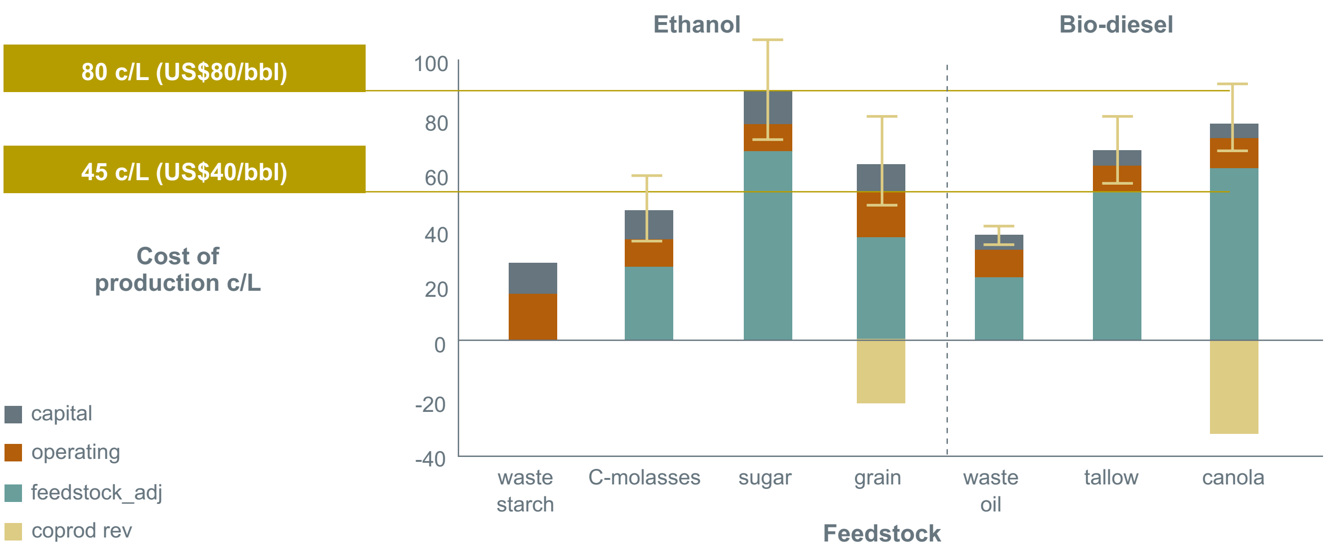
2.1 International situation

- Food, livestock and biofuels producers are competing for the same commodity crops in the international arena. About 61 % of the world's ethanol production comes from sugar crops — sugar cane, sugar beet or molasses. Most of the remaining ethanol is made from grains.
- Ethanol from USA corn costs more than twice that of Brazil's cane-based ethanol [28].
- Oil, ethanol and sugar prices may have become linked recently — through the ability of Brazil to shift from sugar to ethanol production in response to oil-sugar price margins. There is no hard evidence about of the degree to which they are causally linked however.
- Corn-based ethanol production is growing by about 30 % per year in the USA.
- Increased grain demand has caused USA corn prices to double in 2006–7. Rising grain prices may impact on as much as 30 % of the USA feed-based industries — eg pork and chicken [29].
- Prices of milk, eggs, chicken and tortillas have risen substantially in several highly-populated nations — like China, India, Mexico and the USA. Increases in global grain commodity prices are starting to have an impact in Australia.
- In Europe, rapeseed (canola) oil prices doubled over the last five years and the price of cereals, starches and glucose increased by about 20 % in the last year — possibly in response to the European Commission target of 10 % of vehicle fuel to be biofuel by 2020.

2.2 Australian situation

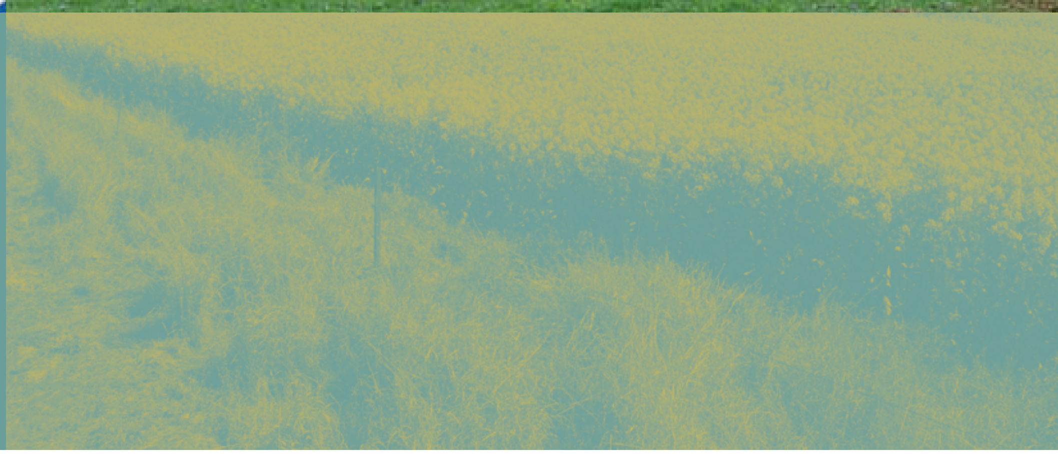
- Competition with food producers for crops has thus far not been an issue for Australia's few ethanol producers — as current production is based on waste starch and C-molasses
- Currently ethanol from waste starch and C-molasses, and biodiesel from waste oil can be produced at a cost less than 45 c/L (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 feedstock (Figure 2-1).

Figure 2-1 Indicative production costs in Australia, showing capital costs, operating costs, feedstock costs. The co-product revenues are shown as a negative cost [30].



- There will be increasing direct competition with grains for food, and indirect competition with feedgrain for the livestock industry as the Australian ethanol industry expands to its planned production capacity and beyond.
- Likewise, expansion of Australia's fledgling biodiesel industry will increase competition with soap and detergent manufacturers for input feedstock.
- There will be a whole new set of markets for second generation (lignocellulosic) feedstocks, which have not been developed or explored in Australia. These include:
  - *Lignocellulosic feedstocks with no competing markets, but existing competing uses* — eg forest and agricultural residues retain carbon in ecosystems.
  - *Lignocellulosic feedstocks with existing markets* — eg annual grasses and pastures, and firewood.
  - *Lignocellulosic 'waste stream' materials for which biofuels could form a market* — eg bagasse from sugar cane, from food or wood processing, urban wood waste.
  - *Dedicated energy/chemical lignocellulosic sources, which may be grown at large scale* — eg oil mallee or short rotation coppice trees.
- 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. Some proposed new ethanol facilities will rely on irrigated crops for feedstock — but parts of Australia are currently facing severely reduced water allocations.

3 Feedstocks for biofuels production



If the biofuels industry is to develop to being part of the 'main game' (10–20 % of Australia's transport fuels) or beyond, the full value chain from feedstock production through to vehicle use must be considered. This section focuses on the supply end of the value chain – feedstock production.

- Assessments of the capacity to supply sustainable feedstock to a biofuels industry are essential to underpin the development of any new industry.
- Land and water will increasingly be contested for food, fibre, and energy production, 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 bio-based industries (including biofuels). Sustainability is discussed in Section 7.
- The concept of 'green' and 'blue' water distinguishes between different water sources [31-33]. Blue water (which is the water that occurs in rivers, lakes and aquifers — traditionally regarded as water resources) differs from 'green' water (stored in the unsaturated soil). The tradeoffs that are currently occurring with respect to allocation of irrigation may eventually also apply to 'green' water.
- Previous reports on the viability of a biofuels industry at national scale in Australia [9] have examined in detail first generation feedstocks (waste oil, tallow, molasses, grains) and conversion technologies in terms of supply and economics. This report confirms conclusions of previous ones [29, 34-36] about the limits to the amount of biofuel that could be produced by first generation feedstocks.

Biorefineries

The bioeconomy has been defined (by the European Union) to "*cover all industries and economic sectors that produce, manage, and otherwise exploit biological resources including agriculture, food, forestry, fisheries and other bio-based industries*".

Biologically-based products, or bio-based products, refer to one part of the bioeconomy: the non-food use of biologically derived materials. This usually means substances derived from naturally grown or cultivated agriculture, and used to make materials such as plastics, textiles, paints, coatings, lubricants and absorbents. There are traditional uses for bioproducts such as wool fibre for textiles, forestry for timber or pulp and paper, but there are many future opportunities to find bio-based products that potentially replace products from non-renewable sources.

The next generational change in the use of bioresources will be based on the integration of new plant resources, bioproduct synthesis and production of biofuels and bioenergy [38].
A biorefinery could work in the same way as a petroleum refinery — which produces about 95 % of its output as fuels and just 5 % for chemical ingredients. The major non-fuel products from a biorefinery are expected to be solvents, plastics, lubricants and fragrances [39, 40]. The major difference between the two types of refineries is the nature of the feedstocks: simple hydrocarbons versus complex, oxygenated biomaterials — which may not require the same level of transformation as those of the much simpler, petroleum-based materials.

Phase I, II and III biorefineries have been described [41].

- Phase I biorefinery — a facility which has fixed processing capacity eg dry milling of grain for ethanol production.
- Phase II biorefinery — separates product streams and has some flexibility to produce different end products depending on product demand and value. A wet mill grain mill may produce starch, sugar syrup, ethanol and oil [40]. The Narrogin Mallee project is also good example of a Phase II biorefinery where a single product (Mallee eucalypts) is coppiced, leaves and wood are separated and product streams are obtained from all fractions including eucalyptus oil, charcoal, activated carbon and bioenergy [42].
- Phase III biorefinery — can accept a mix and range of agricultural feedstocks and varies processing methods to produce a mix of high and low value, high and low volume products and biofuels. A biorefinery that accepts whole crops, green material or lignocellulose are examples of Phase III biorefineries but most are still in the research and development stage.

- Internationally there is a substantial effort to estimate sustainable biomass production to support second generation biofuels industries. For example the potential for one billion tons of biomass supply (over and above what is currently produced) in the USA was assessed in order to underpin a biofuels target [37].

- There are opportunities to transform Australia's agriculture and forestry sectors by moving towards a 'bio-economy' (see Pullout Box p. 32). 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. Engineering valuable industrial traits into the cropping system can lead to lower production costs and improve production certainty, which may create new demand and increase the utilisation of biological sources.

3.1 Current and future production base for feedstocks

The biomass resources in Australia can be categorised for the purposes of biofuels (or bioenergy) as shown in Table 3-1. The feedstocks can be assessed in terms of

Current production base

- *Box 1* — first generation feedstocks based on sugar or starch crops already widely grown in Australia for ethanol, or oilseeds and tallow for biodiesel

- *Box 2* — 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 before some of these feedstocks will gain community consent (section 7) for their use.

Future production base

- *Box 3* — first generation includes any expansions of Box 1 crops. For example for ethanol, wheat could expand into higher rainfall areas. Currently minor sugar crops (eg sugar beet [43], sweet sorghum) could expand, as could mustard for biodiesel — which can grow in lower rainfall areas than canola[44]. It may include Genetically Modified (GM) crops which can feed into first generation technologies — although these have many sustainability hurdles including community consent (section 7) for their use in Australia. Oil bearing trees such as *Pongamia pinnata* are also promising candidates. *Pongamia* is leguminous and therefore does not require nitrogen fertilisers (thereby reducing fossil fuel input), tolerant of salinity and drought and produces yields of 2 t/ha oil which could be processed using current technologies for biodiesel [45]. These tree crops have very high yields of oil in overseas situations but have not been widely trialled in Australia (eg Pongamia, *Moringa oleifera* [46]. Some tree crops which look promising in terms of reported oil yield have undesirable characteristics (eg Jatropha is a declared noxious weed). Algae is also mooted for production of biodiesel [47]. GreenFuel[vii] Technologies in the USA have developed a bioreactor system that can be used to grow algae using flue gas as the major input.

- *Box 4* — second generation technologies — biorefineries for a 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 could replace a large quantity of Australia's fossil fuel requirements [13, 14, 48, 49] as well as address salinity, biodiversity and farm diversification issues in some regional areas. Native woody species are being investigated for a range of new products including novel wood products, bio-based products as well as energy [12, 15, 16]. Grasses such as Switchgrass are being investigated and are worthy of further investigation for Australia. Genetically Modified (GM) crops, trees and algae are also a potential future resource but have many technical and consumer acceptance hurdles.

- The quality and reliability of the information for each of the different boxes in Table 3.1 differs greatly. Existing assessments of the feedstock resource (in terms of land, production rates, environmental impacts and economic effects of removing material that is currently retained on site, and proximity to processing and markets, effects of markets and prices on availability) are reasonably reliable but have not been comprehensively collated for Box 1, less available and more uncertain for Box 2, and very scant with high levels of uncertainty for Boxes 3 and 4.

[vii] See www.greenfuelonline.com

Table 3-1 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**

3.2 Performance of crops on under-utilised land

- Non-food feedstocks outperform food-based feedstocks on all criteria — the 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 [50].
- Plants vary enormously in their ability to grow on poorer quality land both between and within species. For example, salt tolerant plants such as saltbush will grow well on marginally salty land where most plants fail. Tall wheatgrass will grow on land that is both intermittently waterlogged and mildly salty. Crops such as triticale are tolerant of acidic conditions. Oil mallees can produce biomass on soils that are unsuitable for many tree crops. Within a species large variation in adaptation characteristics exists and can be exploited, although breeding plants specifically for marginal situations commonly takes ten to twenty years. Crop plants within species vary widely in their tolerance to nutrient toxicities and deficiencies. Tolerance to high levels of aluminium and boron has been bred into crop and pasture plants to improve their range of adaptation.
- Each land situation must be examined on its merits and assessed for plants with potential for that particular site. It is beyond the scope of this report to explore the array of options available for different land situations in Australia. The following questions may be used as a starting point for assessing the suitability of plants for biomass production from under-utilised land:
  - What are the limiting factors that lead to under-utilisation of the land — saline, shallow, acidic, sodic, waterlogged, rocky, low rainfall, low water storage, low nutrients?
  - Are there several limiting factors acting together eg waterlogging and salinity, shallowness and water holding capacity?
  - Why is the proposed crop seen to be especially adapted to the above conditions?
  - How much development will the crop require to be able to cope with these conditions?
  - Will irrigation be required at any part of the production cycle, including establishment?
  - Does the crop grow in similar environments at its centre of origin or where it has been domesticated elsewhere?
  - Are there climatic extremes the crop must cope with low and erratic rainfall, frost, wind, heat shock?
  - Is the land in areas where support services may be lacking eg rangelands or tropical Australia — transport, water, power, labour?
  - Is the proposed crop domesticated to the point that its basic plant type and agronomy have been sorted out?
  - From an intellectual property viewpoint is there freedom to operate — is the plant type protected by PBR, patent, international agreements or indigenous rights?
  - Have harvesting and handling technologies been sorted out for the crop?
  - Is the crop safe to handle in farm, transport and food chains?
  - Is there a use nearby for co-products remaining after biofuel extraction?

4 Comparison of domestic supply scenarios

The scenarios in this chapter are very simple calculations of the amounts of ethanol or biodiesel that could be produced by using different portions of domestic supplies of feedstocks. They do not take into account any dynamic interactions, economics, policy or the probability of such a scenario occurring. The logic of steps in this approach is as follows:

1. What are the upper physical limits of the resource?
2. What fraction is likely to be available on a sustainable yield basis?
3. What is likely to be economically feasible now?
4. What might be economically feasible with technological innovation or with fundamental change in the economics ?

In this section, preliminary attempts at the first task are made, with some examples of how the analyses towards the second step might progress. The final two steps have not been attempted.

Four simple scenarios are defined

- Scenario I sets the upper physical limits to how much fuel could be replaced by converting ALL relevant crops into ethanol or biodiesel using first generation technologies and the current resource base.
- Scenario II sets the upper physical limits to how much fuel could be replaced by converting only those fractions NOT used domestically (either waste streams or export streams), so as not to impact on human food or animal feed supplies in Australia.
- Scenario III conducts a very simple investigation of the implications of a national E10 target.
- Scenario IV scopes potential ethanol (or electricity) production from a limited range of second generation (lignocellulosic) 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.

Figure 4-1 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.

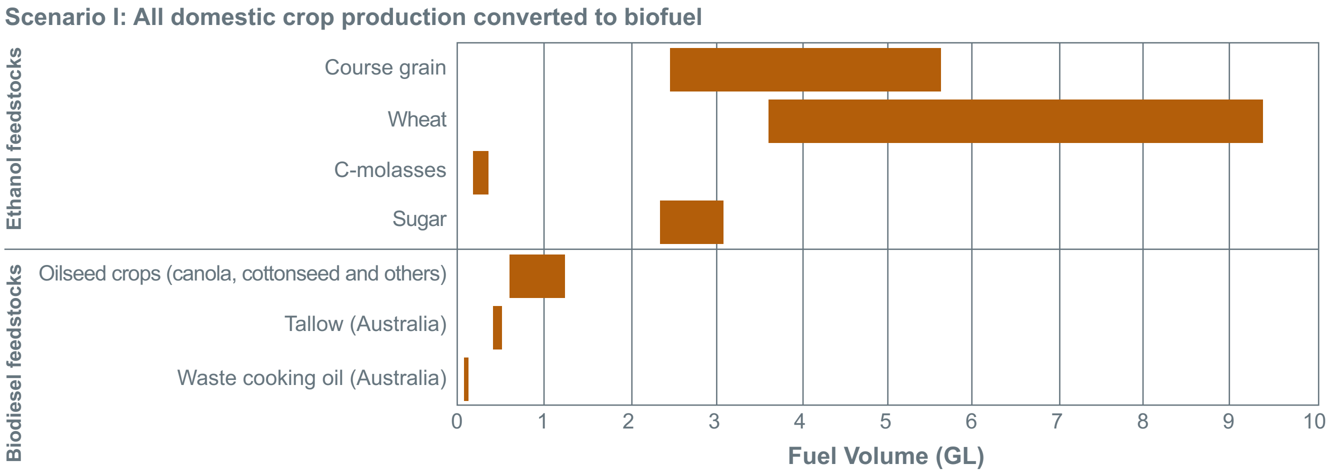


Table 4-1 Upper limits to production of ethanol using current domestic feedstock supply systems.

		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 Australian Commodity Statistics 2005, 2000–01 to 2004–05 data used[51]; [B] Beer et al 2003 [9]; [D] Rutowitz 2005[52]; [E] Australian Canegrowers Council 2005[53]; [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).

4.1 Scenario I (conversion of all relevant crops to ethanol and biodiesel)

- If all domestic sugar and grain were converted to ethanol, an E14 blend could be supported from sugar, < E2 from C-molasses, E38 from wheat and E20 from all other coarse grains. Conversion of all of these crops combined equates to a blend of E78 (equates 50 % replacement of 2004–05 petrol energy – see pullout box for explanation) (Table 4-1).
- If all domestic waste oil, tallow and oilseed crops were converted to biodiesel, an B0.6 blend could be supported from waste oil, B2 from tallow, B7 from oilseeds including canola, cottonseed and others). Conversion of all of these crops combined equates to a blend of B10 (which equates directly to 10 % replacement of 2004–05 diesel energy) (Table 4-2)

4.2 Scenario II (converting export fractions of crops to ethanol and biodiesel)

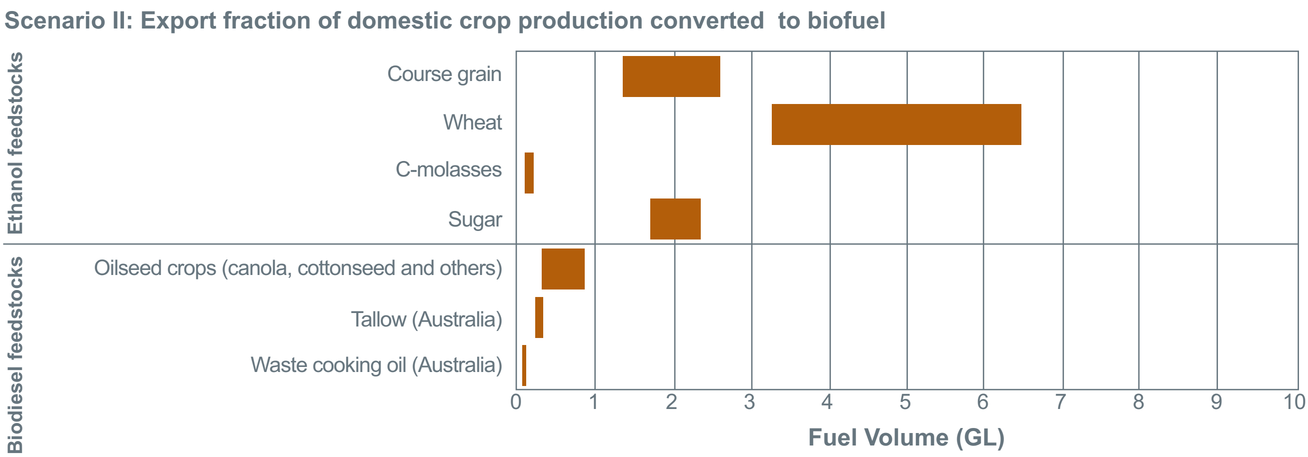
- If only the export fractions of Australian crop production in an average year were used, an E11 blend could be supported from sugar, < E1 from C-molasses, E27 from wheat and E10 from all other coarse grains. Conversion of all of these crops combined equates to a blend of E50 (equates to upper limits of 22–0 % of the 2004–05 petrol energy) (Table 4-1).
- A B0.6 blend could be supported from waste oil, B2 from export tallow, B4 from export oilseeds including (canola, cottonseed and others). Conversion of all of these crops combined equates to a blend of B6 (which equates to upper limits of 4–8 % replacement of 2004–05 diesel energy) (Table 4-2).
- The variability of ethanol based on grains could be very high due to seasonal variation (Figure 4-3). Managing wheat stocks differently, or combining ethanol production capacity from perennial crops may help to manage this variability.

Table 4-2 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 (1 132–1 769)	B10		903 (659–1 180)	B6 (4–8 %)

[A] Beer et al (2005)[54], [B] A correction for energy content is not required for biodiesel

Figure 4-2 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.



- These national estimates do not take account of variation in exports between states — for example Western Australia has higher exports than the eastern states.

4.3 Scenario III (a national E10 target)

- A national E10 target would require about 2 000 ML of ethanol (not adjusting for ethanol's lower energy content). Since there is only limited capacity to supply ethanol from C-molasses and waste starch feedstocks, this would mostly need to be from cereals — ie it would require some 5 640 kt of grain. In average years, this could be met. Scope for using B-molasses to meet this need should be researched.
- In drought years, however, producing 2 000 ML of ethanol could force the import of wheat. As an example, if an E10 target were to be met based on domestic wheat during the drought of 2001–02 (reported in 2002–03), imports could have ranged from 2 550 kt (consume entire surplus of 2 930 kt) to 5 640 kt (total import to meet needs of biofuel production, national wheat surplus not touched). There are legal obstacles to the import of grain due to biosecurity risks.

4.4 Scenario IV (a limited range of second generation feedstocks)

- Other countries are positioning themselves to use biomass lignocellulosic feedstocks. Australia has a potentially large resource. Australia could have sufficient lignocellulosic resource to go beyond the limits of first generation technologies and make significant contribution to Australia's transport future (and energy security).
- The data are very unreliable for the current production base, let alone a future production base. Examples to demonstrate the potential contribution of a subset of feedstocks (which comprise some of those categorised as Box 2, 3 and 4 in Table 3-1) are given.
- Estimates on the total current and future resource base, and some assumptions for a proportion that might be available are given in Table 4-3:
  - Current production base - crop residue 'hotpsots' estimate 30 Mt/yr (range 28–37Mt) in average years [29]. This would equate to upper limits of 28–37 % petrol replacement (corrected for energy content of ethanol).

Figure 4-3 Variability of potential ethanol production from 2000–01 to 2005–06 if total wheat crop (Scenario I) and export wheat crop (Scenario II) were used for biofuel.

  - Conversion of the entire current wood harvest to ethanol could yield 1.8–5.2 GL/yr while conversion of just that portion exported as woodchip could produce 0.9–2.0 GL/yr. Utilisation of residues from timber harvesting and processing could yield an additional 0.8–2.8 GL/yr while utilisation of urban wood waste and firewood could provide 1.4–6.5 GL/yr [59,58].
  - The recent rapid expansion of short rotation hardwood plantations is expected to increase the total amount of wood harvested by approximately 14 Mt/yr, 90 % of which is expected to be converted to woodchip. Utilisation of this resource for ethanol could produce 1.7–6.1 GL/yr [104].
  - There is considerable potential for large scale plantings of dryland woody crops such as oil mallee on less productive agricultural land for environmental, economic and social benefits [2, 13, 55, 56]. These could provide a substantial resource for any biofuel production system. The potential scale of any expansion will depend on a wide range of factors including markets for products, compatibility with competing land uses, as well as land availability. Broad estimates of the potential scale of such plantings range from 1–20 million ha over the next 25 years which could yield 2–100 Mt/yr. Conversion of this entire resource to ethanol could produce 1–30 GL/yr.

Table 4-3 Upper limits to production on estimates of second generation feedstock resources in Australia. Note the estimates are very uncertain as there are very limited existing data. Lignocellulose feedstocks can also be used for electricity generation and preliminary figures are provided here.

Feedstock	Conv. (L/t)	Australian production (Mt)	Ethanol from all feedstock (ML)	Reasonable available fraction (Mt)	Ethanol from reasonable available fraction (ML)	Ethanol blend (% 04–05 petrol energy)	Electricity (TWh)
Crop residues	300	53.1 (23.4–79.1)[A]	13,148 (5 852–19 561)[A]	30[B] (28–37)	9,000 (8 400–11 100)	E43–E57 (28–37 %)	
Annual and perennial grasses	300	10–20[B]	3 000–6 000	NAD but have assumed 5 % as there is already an existing market	150–300	E0.7–E1.5 (< 1 %)	
Sawlogs and pulpwood	200–280	14 (9–19)[C]	3,300 (1 800–5 200)	NAD but assume biomass currently exported as woodchip could be available	1,400 (900–2 000)	E5–E10 (3–7 %)	28 (13–120)
Urban wood waste	200–280	3.3–4[D]	660–1 200	No data but assume 30 % recovery	200–360	E1–E1.7 (< 2 %)	
Waste from wood processing facilities	200–280	1.3 (1–5)[E]	700 (400–1 000)	NAD but assume 50 % could be available	350 (200–500)	E1.8 (1)	1.3 (1.0–1.5)
Firewood	200–280	5.0 (4–22)[F]	1,200 (1 000–5 500)	NAD but assume 10 % as there is already an existing market	100–550	E0.5–E2.8 (< 2 %)	0.5 (0.1–2)
Plantation residues - current	200–240	2.1 (1.5–2.8)[G]	500 (300–700)	No data but assume 50 % can be colleted economically	250 (150–350)	E0.7–E1.7 (< 2 %)	3.1 (1.7–13.1)
Native forest residues	200–300	2.7 (1.6–3.7)[H]	300–1 100	No data but assume 50 % can be collected	150–500	E0.7–E2.6 (< 2 %)	4.1 (1.4–17.2)
Native forest thinning	200–300	2.5 (1–4)[H]	250–1 300	No data but assume 100 % would be used for biofuels	250–1 300	E1.3–E6.8 (1-4 %)	4 (1–20)
Black liquor		0.25 m^3	NAD				

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Table 4-3 (continued)

Feedstock	Conv. (L/t)	Australian production (Mt)	Ethanol from all feedstock (ML)	Reasonable available fraction (Mt)	Ethanol from reasonable available fraction (ML)	Ethanol blend (% 04–05 petrol energy)	Electricity (TWh)
New oilseed species eg *Pongamia, Moringa*		NAD	NAD	NAD	NAD	NAD	
Algae		NAD	NAD	NAD	NAD	NAD	
Future mallee-eucalypt crop	200–300[I]	(2–100)	(400–30 000)	NAD – assume all available	(400–30 000)	E2–E85+ (3–100 %)	18 (2–500)
Future hardwood plantation growth	240–300[J]	14 (7–24)	3,800 (2 000–7 000)	NAD – assume 25 % of pulpwood and 50 % of harvesting residue could be available	1,000 (500–2 000)	E2.5–E10 (1.7–7 %)	6 (2–31)

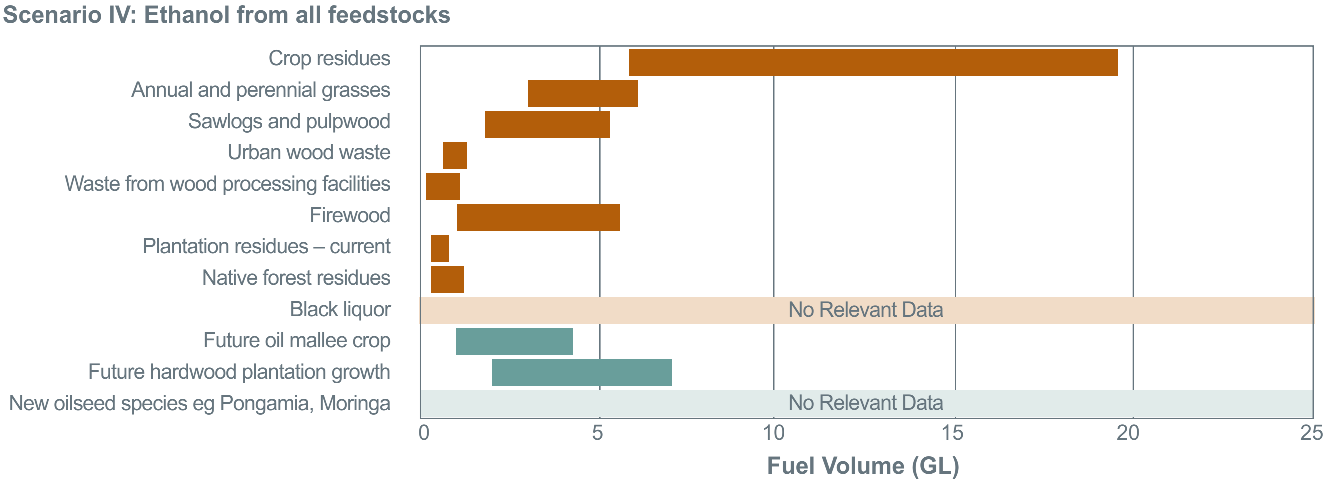
[A] CSIRO estimate from APSIM modeling *unpubl data*; [B] Higgins 2006 [29]; [C] ABARE 2006 [51]; [D] FWPRDC 2006 [57], MBAC 2004 [58]; [E] MBAC 2004 [58], Raison 2006 [59]; [F] Freudenberger et al 2004 [60]; [G] CSIRO, Ensis unpublished data; [H] Raison 2006 [59]; [I] Foran 1999[61], Bartle 2001, 2006 [2, 13], Grove etg al 2005 [56]; [J] Based on future expected harvest and residue amounts [104] minus current harvest and residue amounts [51]; NAD = No Appropriate Data

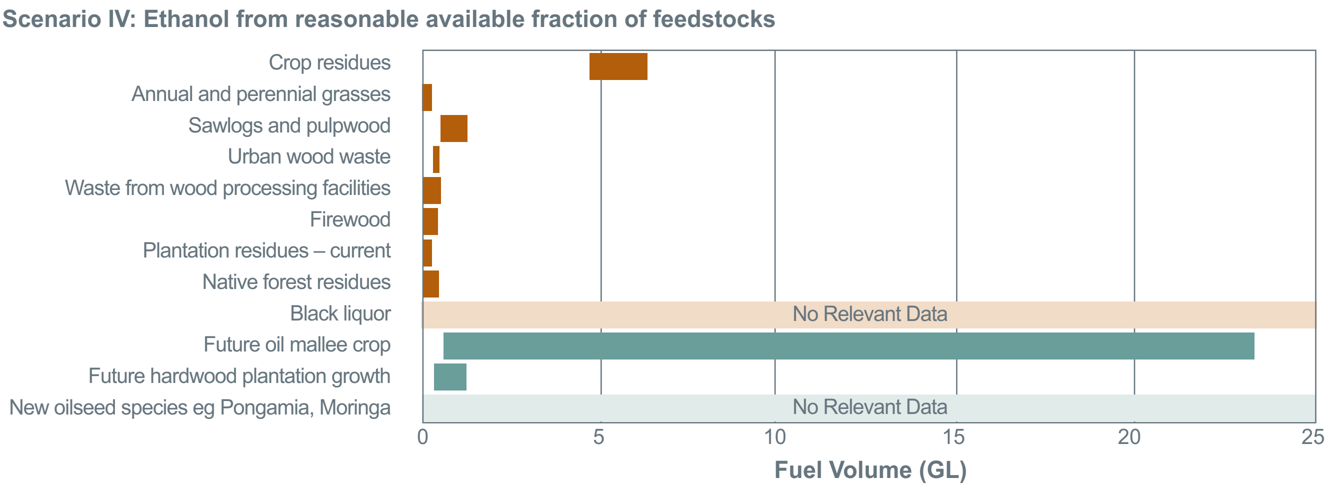
- Depending on which sources of feedstocks were used, this could equate to upper limits of between 10 and 140 % of current petrol usage. The very wide band indicates the degree of uncertainty in these data on annual production of biomass as well as levels of sustainable harvest and economic viability. This is in contrast to the agricultural data where the range in upper limits is largely due to seasonal variability and export markets — the underlying data are reliable.

4.5 Transitions to a sustainable future

- It is likely that biofuels based on first generation domestic feedstocks will remain at the margins of Australia's transport future (2–5 % of transport fuel needs). This is because high input agricultural systems which are geared towards producing food and animal feed will make the biofuel feedstock more expensive — especially given the upward pressure on grain and oilseed prices from the international impact of rapidly increasing biofuel production, as well as prolonged drought and impacts of climate change in Australia. First generation biofuels may however form a useful first step along a transition pathway to second generation biofuels.
- Biofuels could move beyond these limits and become part of the main game (greater than 10–20 %) or indeed the end game (> 20 %) of Australia's transport future if industries develop around second generation technologies.

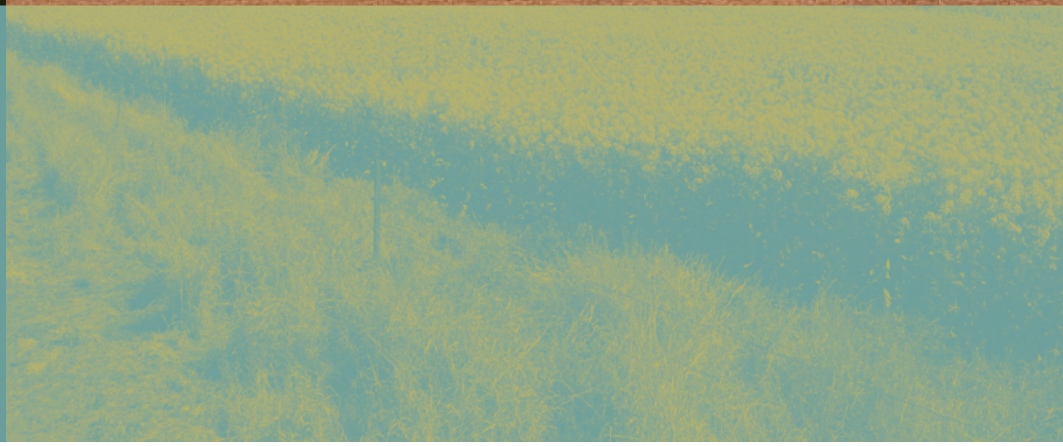
Figure 4-4 Upper limits to production on estimates of second generation feedstock resources in Australia. Note the estimates are very uncertain as there are very limited existing data. Based on data in Table 4.3.





- Confidence to invest in large scale industry based on second generation lignocellulosics must be underpinned by a robust assessment of resource asset of lignocellulosics — both in the current and future production base. The availability of the resource will be constrained by the cost of the feedstock, and the sustainability of producing and removing the biomass for biofuels.
- Biofuels will take their place in Australia's transport future alongside a range of competing alternatives for example gas-to-liquid and coal-to-liquid technologies are also being developed. Further exploration of scenarios must be done to ensure a sustainable future for the industry, and identify stable transition pathways to that future. Transition pathways describe plausible sequences of future events and innovations.

5 Opportunities for regional Australia



Biofuels (and more broadly bioproducts) may present new opportunities for regional Australia. It is difficult to quantify the size, extent and chances of success of many perceived opportunities based on existing studies.

There are some generic factors which can be considered to filter opportunities for successful independent region (Table 5-1).

5.1 Economic analyses of regional impacts of biofuels industries

- Economic analysis of regional impacts of biofuels is largely in terms of impacts of construction and ongoing operation of production plants rather than products themselves. Impacts on economic activity include levels of output, value-add, efficiency, employment and income [9]. Social impacts can include increased community confidence, social cohesion and social capital. Economic and social impacts are linked because greater community confidence and leadership attracts new business opportunities, economic activity and employment. Greater diversity in industry structure and agricultural crops can imbue a community with greater capacity to adapt to structural changes and price fluctuations [9].
- The economic impacts at a regional scale are almost always reported as being strongly positive. There are, however also a number of costs and risks to be considered eg benefit to one region or industry sector can come at a cost to another. If this is taken into account, net national effect could be positive, negative or neutral [9].
- For example, localised studies on ethanol plants in 3 case studies 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 [10]. A similar case study for Sarina ethanol from sugar showed that the plant created 36 permanent hobs 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 [11].
- However these results could be considered very optimistic [9]. Caution is required in setting high expectations about regional development because of methodological issues in these analyses - including high multipliers to estimate flow-on benefits, lack of analysis of net national impacts, extent to which benefits are new employment benefits vs displacing existing employment in other industry locations, and lack of transferability of results given the location specific nature of biofuel plants [9].

5.2 Regional opportunities for biodiesel

- From a farmer's perspective, a case study on biodiesel production based on average statistics for a region in Victoria demonstrates that farmers could meet their own fuel needs on approximately 7.6 % of their rotation, and that biodiesel could be produced for approximately $1.10/L given the assumed set of production costs [62]. This does not factor in any of the costs of testing to meet fuel standards or the capital costs, depreciation, finance or maintenance costs of the plant.
- From an economist's perspective, the break-even price of mineral diesel that would trigger a switch to on-farm production of biodiesel (using 2006 pool-prices for canola) is $1.96/L [63]. A similar calculation a few years earlier gave a break-even price of $1.15/L, but increases in price of canola have outpaced the increase in price of diesel since these figures were calculated.
- Farmer co-operatives have been proposed as a way of structuring regional biodiesel industries. As a business model, co-operatives have some serious shortcomings – mostly arising from treating capital resources as common property, and governance and control structures [64, 65]. Some of these shortcomings [64] could be overcome through:
  - efficient management of capital resource – in both raising and investing the capital;
  - well-defined business growth strategy to survive in the longer term;
  - strong governance and control mechanisms, with a range of business skills on the board of directors [64].
- Barriers include:
  - Challenges in meeting the Australian fuel quality requirements for biodiesel – especially when cheap feedstocks such as tallow are used. This is generally overcome by blending the resulting biodiesel with diesel

Table 5-1 Factors to consider when assessing regional opportunities for a biofuels enterprise or industry.

Feed stock type	• Is the feedstock type suitable for biofuel production? • Does it have any special characteristics that could cause problems?
Feedstock security of supply	• Is the feedstock available in sufficient quantities to meet factory demands economically? • Feedstock variability in supply within year - are there within year windows of supply which may cause logistics problems – eg all grain harvested in November/December? • Are there within or between year variations in feedstock quality due to biophysical conditions or between operators due to management? • How stable are supplies over years given swings in supplier sentiment? • What will be the specific regional impact of climate variability and change?
Feedstock cost of supply	• At what cost is the feedstock available and how volatile are these costs? • What are the competing markets for the feedstock?
Feedstock catchment area	• Does the designated biomass catchment have sufficient feedstock to meet the requirements of the plant on an ongoing basis? • How sensitive is the operation to increases in transport cost? • Are there ways to minimise transport costs by compressing the biomass at harvest?
Water security of supply	• If irrigated, how secure is water supply given climate change and extended drought? • How secure is the water supply for processing?
Feedstock storage	• Can the feedstock be stockpiled and are there special storage considerations?
Impacts of growing, transporting, converting feedstock to fuel	• On-site and off-site impacts eg does growing or harvesting the feedstock have impacts on farm or forest sustainability, water supplies or biodiversity?
Feedstock harvest	• Are there established technologies for harvesting biomass feedstock efficiently and economically?
Co-products markets or disposal	• Will significant co-product streams arise in the biofuel production process? • Are markets available for them nearby? • Are there opportunities to co-locate with other facilities?
Processing inputs	• Is water available in suitable quantity and quality for the production facility? • Are electricity and/or alternative energy sources available for the production facility? • Is skilled labour available nearby? • Are necessary trades and services for technical servicing available nearby?
Transport systems	• Is there an existing transport capability to move the feedstock from farm/forest to factory and will the road systems and community withstand the increased traffic? • Similarly are there suitable systems in place to move the biofuels and co-products to markets?
Waste disposal.	• Are there waste streams from the factory that will cause environmental issues or prohibitive disposal costs?
Government policy	• Which Federal, state and local government, incentives and disincentives apply? • Are there significant obstacles present in relation to the regulatory environment or local community attitudes? • What are the risks of these policies changing?
Communities who may have an interest	• The project or industry will only succeed with a community 'license to operate'. • The consenting community includes proponents, investors, regulatory and planning authorities, impacted neighbours and other communities • If the business model is some type of community enterprise such as a co-operative - is there an adequate range of business skills in the group, as well as committed suppliers and purchasers?
Given the above factors is the undertaking likely to be viable from biophysical, economic and community viewpoints?	

at small concentrations (B5 or B10) and making sure that the blend meets the diesel specifications. This is likely to be less of a problem with higher quality oil such as canola.

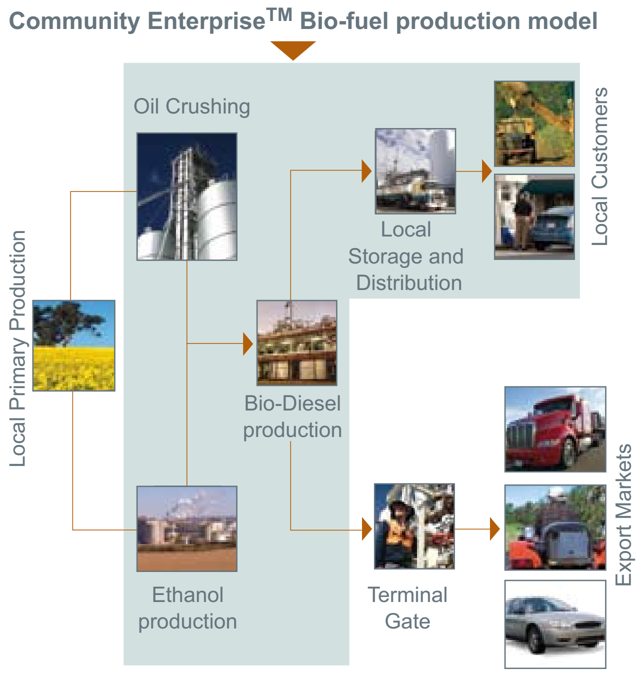
– Cost of the certificate required to receive the rebate that alternative fuel manufacture attracts. It is necessary to produce a certificate demonstrating that the fuel meets the Australian fuel quality standards in order to be eligible. The certificate costs $3 000 for each batch of fuel that is tested.

- An example of a business structure which looks promising in meeting these challenges is provided by the Bendigo Bank Community EnterpriseTM model [66]. As the first step in a five step process, the Bendigo Bank is trialling biodiesel viability. This step is aimed at getting local users to use biodiesel with confidence. Once users are accustomed to using biodiesel, it is more likely to have an assured market. The trial for biodiesel viability is taking place in two communities – Rupunyip/Minyip and Elmore/Lockington in Victoria. These communities are testing the business model for building local fuel storage and distribution capability. They have 75 customers using a B20 blend which meets the Australian diesel standard and therefore complies with the excise rebate scheme and engine manufactures warranty stipulations. They are delivering approximately 50 000–60 000 L of biodiesel blend per week. The enterprise opportunities include biodiesel production, local storage and distribution, and consumption elements of the biofuel value chain. The communities plan to get involved in the crushing of the oil seed at a local or regional level, thus retaining transport, storage costs etc (often up to $100/t of oil seed delivered to port) as well as participating in the sale and use of meal, for which they currently receive no value. This trial is being extended to two other rural communities and one metropolitan community.

5.3 Ethanol and bioproducts from sugar

- The sugar industry (closely aligned with regions) is ahead of other industries and regions in terms of quantifying their resource base, and diversifying into both energy (co-generation) and biofuel production. There are 26 processing mills located throughout the north eastern coast [24]. Sugar mills already use bagasse in co-generation — approximately 301.7 kW of installed renewable capacity and 10 % of Renewable Energy Certificates are from bagasse [105]. Ethanol from C-molasses is produced at two refineries (CSR at Sarina with capacity 32 ML/yr, and Heck Group at Rocky Point with capacity of 16 ML/yr), with a further (110 ML) capacity planned at a further two mills.

Figure 5-1 Bendigo Bank Community Enterprise™ model for biodiesel [66].



- If the relative value of either energy or other co-products were to increase, the current supply chain could be re-organised so as to optimise for the range of products rather than just sugar (with energy from the 'waste' streams) [67].

- Work is underway in the sugar industry to assess potential opportunities including improvements in efficiency of supply chain logistics eg [17, 18], adaptation to climate change eg [19-21], managing impacts on natural resources such as the Great Barrier Reef [22, 23] and diversifying the products from the industry to energy (co-generation), biofuel and biorefineries/bioproducts [24-27, 68].

5.4 New industries based on lignocellulosic biomass

- A 'first cut' regional analysis of biomass from grain crop residues [29] estimated a total of 30 Mt (about 9 ML ethanol) was identified in eight 'hotspot' areas. Three priority areas were identified as Moree (NSW), Griffith (NSW) and York/mid-north region of South Australia. This analysis showed that this could add up $2.5–12.5 million in additional profit to crop producers. No detailed assessment of carbon dynamics was undertaken. The input data from this study are not publicly available.
- There have been several studies in Australia over the last 15 or so years into developing new regional industries based on woody perennials, mosaic farming systems to:
  - address hydrological imbalance and salinity in mid-low rainfall (< 600mm) southern farming systems;
  - diversify farming systems and products;
  - improve rural and regional livelihoods.
- Several projects have aimed to identify and develop woody perennial species and commercially viable production systems and industries, with bioenergy and biofuels as two of the key product markets [12, 13, 15, 16, 42, 69-71] .

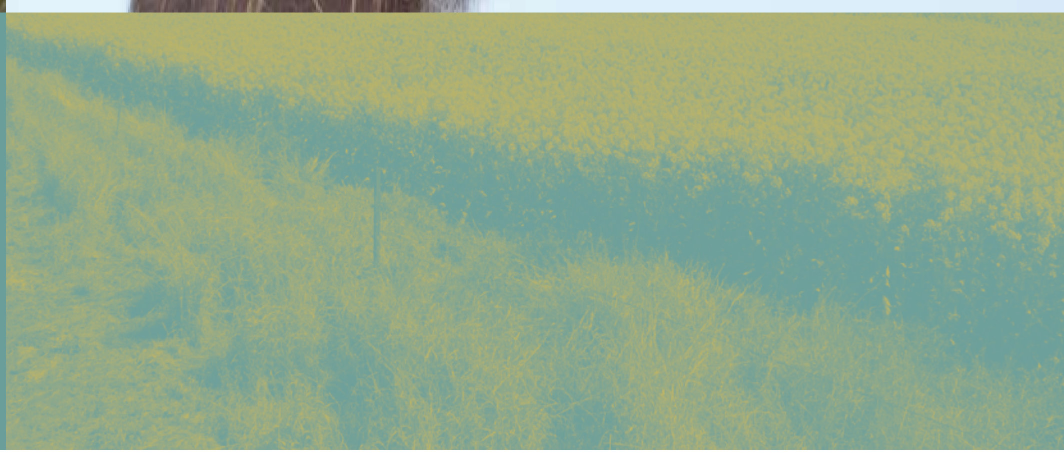
FloraSearch

WA Search, *AcaciaSearch* and *FloraSearch* build on the work on oil mallees to other native woody species which can be grown in agricultural land to address land degradation issues as well as profitability for farmers [14, 72]. *FloraSearch* developed an elegant six-step framework for the objective selection of the best species and product combinations to guide long term commercial development [16].

First, products and markets that could potentially use feedstock from newly developed woody crops were assessed, including: solid wood products; composite wood products; pulp and paper; carbonised wood (charcoal and activated carbon); energy products; electricity (direct combustion, co-firing with coal, gasification, pyrolysis, cogeneration, liquid fuels to power generators); liquid transport fuels (ethanol, methanol and pyrolytic bio-oil only); essential oils; tannins (tanning agents, water flocculants, anticorrosives and protective coatings, conditioning agent for drilling mud, biocides and wood preservatives, pharmaceuticals); gums and biopolymers; fodder; and plant secondary compounds (eg latex, terpenes, saponins).

Species were selected for further study based on databases of plant essential traits. They were sampled for life form and productivity. The promising species were taken to a more detailed level of product testing and suitability assessment. A Regional Industry Potential Analysis (RIPA) provided a simple analysis of the economic feasibility (including growth rates of representative species, transport distances and infrastructure), identifying the most promising regions to develop these new industries, and the economic returns to landholders in the region [15] .

6 Impacts on livestock industry



6.1 Impact of biofuels on feedgrain markets

- The target of 350 ML by 2010 could be met by the substitution of export grains into fuel ethanol production, without affecting domestic grain prices to a significant extent.
- ABARE [73], the Biofuels Taskforce [9] and the Centre for International Economics (CIE) [74] all concluded that significant increases in ethanol production would mean that the demand for grain as feedstock for ethanol could not be met by substitution from the export market, and that imports may be required.
- Importing grain for livestock feed raises the issue of biosecurity risks.
- Analysis for the current report (based on analysis of physical quantities rather than new economic models) shows:
  - If an 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 (see section 4.3 for assumptions of this scenario). Thus it is reasonable to expect that a sustained increase in demand for feedgrains would increase the vulnerability of all feedgrain users to the impact of drought.
  - Planned expansion of ethanol production capacity in Australia of 897 ML will require 2 770 kt of grain. As above, this requirement may struggle to be met by export substitution alone in drought years unless some of the 2 000–3 000 kt of feed-grade barley currently exported is included (and barley is not an ideal feedstock for biofuel).
- The CIE analysed four scenarios for the increase in ethanol production [74]. Their most extreme scenario, mandatory blending of ethanol at 10 % for petrol *combined with* 15 % for diesel (diesohol), is an unlikely one. This would be well over current export parity prices and prices paid by Australia's competitors, and does not appear to take any expansion of production as a response to this price signal into account. By their calculations, ethanol production would demand an additional 12.1 Mt of grain by 2010, relative to a potential pool of feedgrain of around 28 Mt. It was concluded that for this scenario, the average price of grain in Australia would permanently increase by over 25 %.
- The main shortcomings of all the analyses cited here [9, 73, 74] are that:
  - They ignore the likely impacts on Australia's grain industry of international developments in the trade of coarse grains. Rapid growth of ethanol production in the USA is likely to have a significant impact on the local price of grains, regardless of whether Australia develops a significant local ethanol industry.
  - Over the longer term 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.
- As second generation technologies become commercial, production of 2 000 ML of ethanol from lignocellulosic biomass would not compete directly for human food or livestock feed. It may, however, compete indirectly with the factors of production - land, water and labour resources required to produce food.
- Although grain supply might decrease, this could be partially offset in the livestock industry by use of biofuel co-products.

6.2 Biofuel co-products for livestock

Biofuel co-products important to Australia's livestock industries are:

Ethanol

- Fermentation of cereal starch for ethanol produces grain co-products (distillers grains);
- C-molasses is itself a co-product from sugar refining — and in converting to ethanol does not leave a co-product that is used for livestock.

Biodiesel

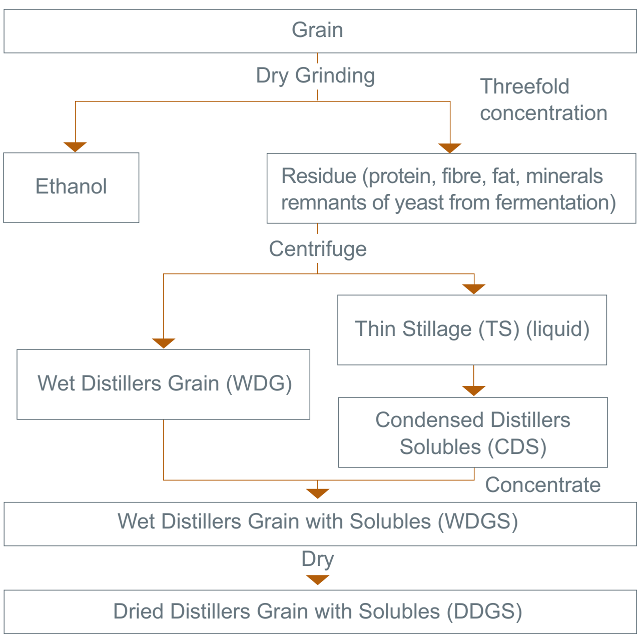
- The co-product fractions from oilseed crushing and processing for cooking oil or biodiesel is called meal — eg canola meal. This co-product is therefore not unique to biofuel production and does not change the market for livestock feed.

Distillers grains – ethanol co-products (Figure 6-1)

Approximately a third of the original grain (on a dry matter basis) is co-produced from fermentation of the starch to ethanol. The remaining components — protein, fibre, fat and minerals — are concentrated threefold in the residue together with remnants of the fermentation yeast.

- This residue is centrifuged to separate the liquid portion, Thin Stillage (TS), from the solids or Wet Distillers Grain (WDG).
- The Thin Stillage, concentrated to form Condensed Distillers Solubles (CDS) is then added back to Wet Distillers Grain.
- This can be used as a wet product, Wet Distillers Grains with Solubles (WDGS) or dried to form Dried Distillers Grain with Solubles (DDGS).

Figure 6-1 The process and co-products in first generation grain to ethanol conversion.



6.3 Quality, access and useability of ethanol co-products

6.3.1 Quality

- Dried Distillers Grain with Solubles has had problems with consistency and quality in the past. Variation occurs because Dried Distillers Grain with Solubles are produced from a process optimised for ethanol production. Variation in nutritional and physical properties is caused by variety of grain, type of fermentation process, the mix of Condensed Distillers Solubles with Wet Distillers Grain and drying temperatures.
- Dried Distillers Grain with Solubles produced from new ethanol plants in the USA has much improved quality with less variability. Development and application of new technologies (eg the Eluseive process) will further improve the quality and useability of Dried Distillers Grain with Solubles [75]— particularly for non-ruminants. Australian ethanol plants built around the latest technology should produce high quality co-products.
- Canola meal following the solvent extraction process to canola oil for biodiesel is consistent in quality with low levels of anti-nutritional factors of processing damage to components such as essential amino acids.

6.3.2 Useability

- Co-products from ethanol and biodiesel production have similar high levels of protein. Oilseed meals are used in pig and poultry and dairy cows diets.
- Wet Distillers Grain with Solubles or Dried Distillers Grain with Solubles in feedlot beef and dairy cattle has benefits [76, 77] including providing energy from digestible fibre and fat; supplying rumen by-pass protein; reducing ruminal acidosis; and when used to replace up to half of the grain in total mixed diets, outperforming grain in calculated Net Energy Gain, without affecting carcass or milk traits
- Dried Distillers Grain with Solubles can be added to the diet at rates of 20–40 % in cattle [78], 10–25 % in pigs [79], 9–15 % in poultry [80], 15–22.5 % in fish [81]

- Excretion of excess nitrogen from higher protein diets means that the animal waste must then be carefully managed [82].

6.3.3 Accessibility and the viability of transporting, storage and drying wet biofuel co-products.

- Wet stillage presents an acute disposal problem for the ethanol producer due to its high organic content, and must be either dried or moved.
- Wet Distillers Grains with Solubles can only be stored for 3–5 days at 22°C [83] and on a dry matter basis costs three times as much to transport as Dry Distillers Grains with Solubles. Accessing Wet Distillers Grains with Solubles requires close location of a feedlot or dairy to an ethanol plant, as well as trucking and storage facilities that meet Environmental Protection Authority (EPA) requirements.
- Wet Distillers Grains with Solubles has already undergone fermentation so it will not ensile without the addition of fermentable material. Adding mould inhibitors can increase the storage time to 21 days, and vacuum packing has been trialled for longer term storage [84, 85]. If the vacuum seal is broken there is a limited shelf-life.
- Drying the co-product uses 30–40 % of the total energy requirements of an ethanol plant [86]. But Dry Distillers Grains with Solubles can be readily transported, stored, added to pelleted feeds and is used in pigs, poultry and aquaculture as well as ruminants. This makes it more accessible to livestock industries and more marketable.

6.4 Opportunities for synergy

- There are some good opportunities for the intensive livestock producers to gain from biofuels production:
  - Availability of high-protein meal should moderate the price of livestock feed protein.
  - High protein meal can supplement ruminants grazing low-protein pastures for survival during drought, and also to improve breeding and other production traits. Dried Distillers Grains with Solubles will be ideal for this use as it is low in fermentable carbohydrates and consequently much safer than grain as a supplement.
- 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.
  - Use of higher protein feed will mean increase excretion of nitrogen, and management of animal waste is important. The addition of biogas production from cattle manure combined with excess wet co-products could further contribute to the energy efficiency of the ethanol plant or add to the cashflow of the venture.

7 Sustainability

What is sustainability?

The term sustainability has entered the mainstream, but it means different things to different people. There are many definitions of sustainability. The Brundtlandt Report stated the concept of sustainable development as

> "*Development that meets the needs of the present without compromising the ability of future generations to meet their own needs*" [87]

This report led to the United Nations Conference on Environment and Development (the Rio Earth Summit) in 1989. The Summit adopted Agenda 21 - a program of sustainable development at a global level. Ecologically Sustainable Development (ESD) is enshrined in legislation in Australia. ESD is defined in the National Strategy on Ecologically Sustainable Development [88] as

> "*…using, conserving and enhancing the community's resources so that ecological processes, on which life depends, are maintained, and the total quality of life, now and in the future, can be increased*".

7.1 Introduction

- In order to claim sustainability credentials, biofuels must be able to demonstrate improvements over conventional fuels across their full life cycles for a range of criteria including greenhouse gas emissions, air quality, land and water impacts, energy input:output ratios, and social outcomes [89].
- There are challenges in estimating the sustainable production of biomass — for current agriculture and forestry as well as an emerging industry such as biofuels.
- Climate change predictions in Australia show substantial change in seasonal and regional distribution of rainfall and temperature regimes over the next 50 years. Many of Australia's high value horticulture and dairy industries in the Murray Darling Basin are currently facing the prospect of severely reduced water allocations in 2007–08 due to prolonged drought and climate change. This has major implications for security of supply of human food and animal feed in Australia, as well as feedstocks for biofuels (especially those based on grains and oilseeds) — in dryland areas as well as irrigated areas.
- The sustainability issues depend partly on the ultimate size of the biofuels industry. If the biofuels industry
  - remains at the margins in Australia (ie 2–5 % of our total transport requirements), sustainability issues are similar to those facing our current agricultural systems. The economic sustainability risks would be largely carried by individual biofuel producers and investors, and those directly impacted by the enterprise.
  - becomes part of the main game (10–20 % of total transport) or part of the end game (> 20 % of our transport needs), the sustainability implications may change the profile of those faced by current agriculture and forestry — with positive or negative impacts depending on how the industry developed. For example if a large-scale industry developed in low rainfall areas based on native woody species producing reconstituted wood products as well as lignocellulosic ethanol, there could be very positive sustainability outcomes. On the other hand a large-scale industry (perhaps supported by inappropriate policy settings) based on high input agricultural systems could result in diverting water, human food and animal feed at a large scale, and have poor greenhouse gas outcomes due to high upstream energy inputs.
- Transition pathways to a large-scale sustainable industry need to be considered by three tiers of government, industry and society as well as by the producer or investor, because the risks and consequences are shared more broadly.

7.2 Management of sustainability

- The term sustainability has entered the mainstream, but it means different things to different people. There are many definitions of sustainability, as well as various approaches to measuring and monitoring it.
- Some methods for assessing and managing sustainability are relevant for national level reporting of trends (eg *Criteria for Sustainable Biomass Production* [90]). Others are useful to a specific sector - eg the *Oil Mallee Code of Conduct* [91], which is supported by ongoing research into the hydrology, nutrient

cycling, and biodiversity implications of oil mallee production. More intensive integrative approaches may be required for large scale, high impact/contentious projects, or at industry sector level.

- The *NSW Bioenergy Handbook* [52] outlined steps to developing a bioenergy industry in NSW, with the sustainability issues and conflicts in each part of the value chain clearly spelled out.
- The *Bioenergy Sustainability Guide - a Scoping Study* [89] embedded scientific or economic content (for example economic analysis, Life Cycle Analysis etc) within a *process* logic. It embraced
  – the notion of 'consenting communities'. The granting of a community 'licence to operate' takes a range of forms depending on the size, impact and sensitivity of any particular proposal. For example, a paddock-scale land use change may only require notification to a relevant government authority - or just avoiding complaints from neighbours! Farm or landscape land use changes require formal consents and approvals from the relevant authorities. Macro-scale land use changes may be initiated by government in pursuit of some new or existing policy objective.
  – a 'systems view' of bioenergy production, taking into account the land on which the biomass feedstock is growing, as well as the boundaries of where the impacts of the production system may be expressed. For example, the on-site boundary for a production system of sugar cane would comprise the area of land on which it grows, while the off-site boundary might include rivers, estuaries or offshore reefs which are impacted by sediment or other pollutants which run off the production site.
- 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. There are also processes in place for the short, medium and long term economic outlook of agriculture, forestry and energy at global scale, and in Australia at national and state scales.
- Providing static information does *not* on its own provide the basis for a sustainable industry. It needs to be balanced with understanding dynamic interactions into the future, potential transition pathways, and a broader dialogue in society about sustainability.
- There is increasing international focus on future trade of sustainably produced and ethically traded biomass (or products thereof such as biofuels) [92] [93]. The International Energy Agency (IEA) Bioenergy Task 40 *Sustainable International Bioenergy Trade: Securing Demand and Supply* focuses on developing these international opportunities.
- 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 % , most of which is in Malaysia and Indonesia - the world's largest producers of palm oil [94]. 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)[viii] is an international group to promote sustainability through a Code of Conduct for its members.
- 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.
- A path forward in ensuring the sustainability of the biofuels industry may include the following elements:
  – representation from different levels of government, governance authorities, industry, research and the broader community;
  – a national assessment of regional potential for sustainable biomass production (including the impacts of expanding production of lignocellulosic crops, and increasing the removal of agricultural and forest in-field residues);
  – investigation of 'closed loop' systems for vertically integrating biomass production, conversion to biofuels and bioproducts, and efficient waste stream management (eg for livestock industries);

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

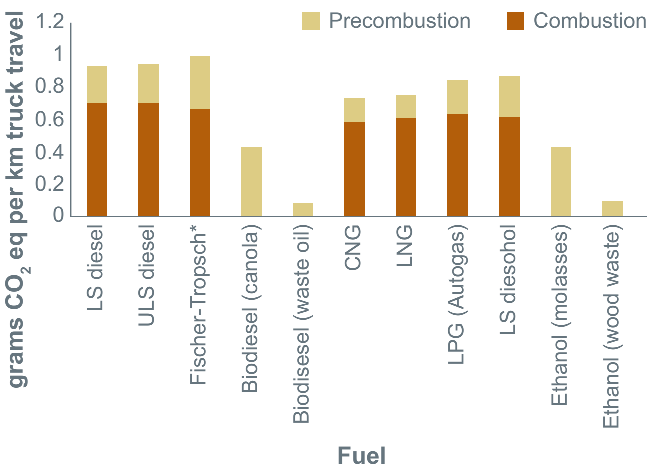
- analysis of sustainable transition pathways for biofuels in the context of a range of alternative transport futures, given a range of climate change, economic and policy scenarios;
- a systematic and scientifically defensible process to develop testable criteria (or other approach) to ensure sustainable development, which could be applied in legislation;
- develop track-and-trace certification mechanisms to 'sustainably produced' biomass;
- investigate policy mechanisms which steer the industry towards sustainable development;
- develop roadmaps for research and industry implementation which incorporate sustainability as a central tenet.

8 Comparisons of biodiesel and ethanol with reference standards

8.1 Comparison of ethanol and biodiesel with range of alternatives

- The potential role of first and second generation biofuels to our transport energy future can be assessed against a full range of alternative fuels (including fossil-based ones). Alternatives include Liquified Petroleum Gas (LPG — mainly propane), Liquified Natural Gas (LNG) and Compressed Natural Gas (CNG — mainly methane) and synthetic diesel from coal.
- 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 CNG or LPG [95] (Figure 8-1). The latest generation of ethanol refineries that use molecular sieve technology have lower greenhouse emissions, even when the fuel is mixed with petrol (in the case of ethanol) or diesel (in the case of biodiesel). CNG and LNG have lower emissions, and LPG - largely propane is slightly lower than low sulfur diesel. The Fischer Tropsch fuel refers to a synthetic diesel made from coal (Coal to Liquids or CTL fuel) – it emits more greenhouse gas than low sulfur diesel.

Figure 8-1 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.

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.

- There are tradeoffs between these options in terms of their contributions to climate, energy security, health and regional opportunities. For example, Coal to Liquids offers a high energy security because of Australia's coal supply, but higher greenhouse gas emissions than petrol or diesel. Conversely, biodiesel from waste oil has very low greenhouse gas emissions but there is a limited supply which cannot be increased.

8.2 Product quality and standards

- Biodiesel must meet the standards set under the Fuel Quality Standards Act (2000) administered by the Department of Environment and Water Resources (DEW). An Australian Ethanol Fuel Standard is being developed.
- It is difficult to produce a biodiesel that meets the Australian standard — especially if tallow is used as the feed stock.
- Biodiesel made from tallow or palm oil will solidify in cold weather. At present cold weather properties of biodiesel are not part of the Australian standard.
- The fuel standards and blends are currently being reviewed. Because of their difficulty in meeting the standards the biodiesel industry seeks liberalisation of the Australian biodiesel standard — particularly for farmers and regions who wish to be self-sufficient.
- To receive the rebate that alternative fuel manufacture attracts, a certificate must be obtained to show that the fuel meets the Australian fuel quality standards. Such a certificate costs $3 000 for each batch of fuel that is tested.

8.3 Warranty requirements

Ethanol

- Prior to regulation of a maximum 10 % ethanol blend, the Australian motor industry would not, in general, warrant vehicles operated on ethanol blends greater than 10 %.
- Ethanol can be mixed with petrol and used in spark ignition vehicles. In Australia, legislation now limits the maximum allowable ethanol in petrol to 10 % (E10).
- The Federal Chamber of Automotive Industries has published a list of vehicles that can use petrol containing E10 [ix]. As a general rule, modern cars can use E10, older vehicles should not. Because of the age of Australia's vehicle fleet, this means that about 60 % of vehicles can use E10.

Biodiesel

- Biodiesel can be used in compression ignition engines as a replacement for petroleum diesel fuel so that in terms of operability criteria any blend of biodiesel/petroleum diesel can be used.
- In general, engine and equipment manufacturers in the Australian market have taken a position, limiting biodiesel to B5. Manufacturers claim that higher blends raise significant issues involving engine performance, efficiency, emissions and warranties. While warranties generally cover materials and workmanship, and are not related to fuel per se (which is the responsibility of the fuel supplier), engine and vehicle manufacturers have taken the above position regarding biodiesel blends. Volvo permits only 4 % whereas Mitsubishi Australia and Mazda Australia both consider the use of any biodiesel to void the warranty. It is reported that biodiesel may be sold in Australia in blends as high as B26, while still meeting the current Petroleum Diesel Standard. As such, a situation may arise under current arrangements where fuel meeting the petroleum diesel standard becomes the subject of a dispute regarding compliance with a vehicle manufacturer's warranty requirements.
- Elsewhere in the world, where biodiesel may be supplied in blends up to B20, manufacturers have accepted blends beyond B5. Reasons for this approach to warranties in Australia are not clear; further research is required. It should also be noted that motor manufacturers in Australia largely do not cover warranty claims for fuel-related problems from LPG conversions.

[ix] www.fcai.com.au/ethanol

9 Infrastructure for biofuel production

9.1 Current and planned biofuel processing facilities in Australia

- The current processing capacity for ethanol in Australia in 2007 is 140 ML, with planned capacity of 1 155 ML. The current biodiesel capacity is 323 ML with a planned capacity of 1 122 ML (See Table 9-1 and Table 9-2).
- With the increasing prices of feedstocks, and the price sensitivity of biofuel production to feedstock price, some planned installations may not go ahead.

9.2 Potential issues in moving from first to second generation processing

- 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.

Table 9-1 Ethanol production capacity in Australia: current and proposed (from [9, 74, BP Australia]).

			Capacity	
Company	**Location**	**Feedstock(s)**	**2007 ML**	**Planned ML**
Queensland				
CSR Ethanol	Sarina	C-molasses	60	60
Heck Group	Rocky Point	C-molasses	16	16
Bundaberg Sugar	Bundaberg	C-molasses		10
Lemon Tree	Milmerran	Sorghum, wheat		67
Downs Fuel Farmers	Dalby	Sorghum, wheat		80
Austcane	Burdekin	Cane juice, molasses		100
Agri Energy	Lake Grace	All grains		90
New South Wales				
Manildra Group	Nowra	Waste starch	100	100
Primary Energy	Gunnedah	Sorghum		120
Agri Energy	Colleambally	All grains		90
Symgrain	Quirindi	Wheat		100
Victoria				
Agri Energy	Swan Hill	All grains		90
Symgrain	West Vic.	Wheat		100
Western Australia				
Primary Energy	Kwinana	Wheat		160
ETHANOL TOTAL			**148**	**1 155**

Table 9-2 Biodiesel production capacity in Australia: current and proposed (from [9, BP Australia and other company sources]).

Company	Location	Feedstock(s)	Capacity 2007 ML	Capacity Planned ML
Queensland				
Australian Biodiesel Group	Narangba	Various	160	160
Eco Tech Biodiesel	Narangba	Tallow	30	75
Evergreen Fuels	Mossman	Used cooking oils	1	1
New South Wales				
Australian Biodiesel Group	Berkeley V.	Various	40	45
Biodiesel Industries Aust.	Rutherford	UCO and other oils	12	20
Future Fuels	Moama		30	30
A J Bush	Sydney			60
Riverina Biofuels	Deniliquin			45
Biosel	Sydney			24
Natural Fuels Australia	Port Botany			150
Victoria				
Vilo Assets	Laverton	UCO, tallow	50	50
Axiom Energy	Geelong			150
Biodiesel Producers	Barnawartha			60
Western Australia				
Australian Renewable Fuels	Picton	Canola and Tallow		45
South Australia				
Australian Renewable Fuels	Largs Bay	Tallow		45
S.A. Farmers Federation	Gepps Cross			15
Northern Territory				
Natural Fuels Australia	Darwin	Palm oil		147
BIODIESEL TOTAL			**323**	**1 122**

- 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) [96].

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 [97]. 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.

9.2.1 Processing facilities

- Biofuel production facilities which use fermentation and distillation processes to create ethanol from starch and sugar (first generation) will be able use their infrastructure for some types of second generation process — namely fermentation or enzyme processing lignocellulosic material. Some modification — largely 'bolt-on' equipment — will be required to handle initial breaking down of the lignocellulose. There are other types of second generation processing such as gasification and pyrolysis, which require high temperature and pressure equipment, and are not compatible with first generation fermentation and distillation infrastructure.

9.2.2 Harvesting and transport

- First generation technologies relying on food crops or waste products generally have well established harvesting and transport infrastructure, with well understood economics in terms of the transport distances, amount of feedstock and the 'catchment' area required in order to supply a facility of specified size. In Australia, yields of some crops such as grains can be low and variable and hence transport distances to processing facilities relatively longer and more expensive. This difference will mean it will be more difficult to achieve the economies of scale sought via the large (> 200 ML) refineries such as those in Europe and the USA.
- For many new types of energy crops such as short rotation or coppicing crops, the harvesting machinery is not yet developed. It may be possible to modify existing harvesting techniques for collecting residues (eg for sugar trash) — transport distances for feedstocks can cost about 10 c/km per tonne, making distances of over 30 km uneconomic for small power stations (5–10 MW) in Australia [52]. This may pose a problem for agroforesty systems with a dispersed resource base which makes it more difficult to gain a critical mass within the economic transport radius from a processing facility. Systems which can compact the large volumes into high density briquettes or pellets in the field or forest may help to overcome this problem [52] and partly offset the cost of longer transport distance.
- The logistics and economics of harvesting and transport in the sugar industry are well understood. Transport distances much greater than 50 kms are difficult to justify from a financial perspective [67].

9.2.3 Blending and distribution

- Blending and distribution infrastructure depends as much on the tax and excise regime as it does on technical issues. Formerly the Australian Tax Office considered biodiesel excise exempt only as pure biodiesel — if any mineral diesel was in contact with biodiesel then it became subject to excise. This meant that any biodiesel users had to have new vehicles, new storage vessels, and new pumps to handle the biodiesel. This stance was then altered — B5 and E10 (provided that they meet the relevant diesel standard and petrol standard respectively) are now 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.

9.2.4 Opportunities for further installation

- Opportunities for further installation of biofuel facilities include:
  - Future changes in economics — such as through a carbon trading scheme (section 12.2), or through co-location with intensive livestock industries;
  - Research and development of second generation technologies for lignocellulosics to ethanol, as well as new bio-based products.
- There are no technical constraints to the establishment of further first generation biofuel operations. The major constraints are related to the security of supply of feedstock, and markets for the ethanol. The constraints in economic, policy and consumer demand domains are dealt with in sections 10, 11 and 12.

10 Policies affecting biofuels security

10.1 Subsidies to fossil fuel industry

- There are various estimates of subsidies to fossil fuel use in Australia, ranging from 2.2–10 billion dollars per year [98-100,101]. The estimates include elements of :
  - perverse subsidies ie those which increase GHG emissions and reduce economic efficiency;
  - subsidies to motorists — which would still apply if the motorists were running their vehicles on alternative fuels instead of fossil fuels.
- If estimates of subsidies directly associated with fossil fuel use in Australia are considered important to developing the biofuels industry, then these widely varying estimates require clarification in terms of the categories, reasons and beneficiaries across the fossil fuel value chain from producers through to consumers.

10.2 Australian biofuels policies and impacts

- The major biofuels policy at the national level is a 350 ML target by 2010. Based on production levels to date and the slow rollout of new stations that sell biofuels (since the oil majors are not convinced by the risk/reward ratio), there is a possibility that this target will not be met. Different states are developing their own approaches, which are in various stages of development.
- Assistance currently provided to producers includes:
  - production grant of 38.1 cents per litre (c/L), which fully offsets the excise paid on biofuels;
  - new facilities approved under the Biofuels Capital Grants Program also receive a capital grant 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.
- Domestic producers are eligible for the excise rebate from the Australian government. Ethanol imports are subject to both a general tariff of 5 % (zero if imports are from the US) and the full excise of mid-energy fuels of 38.1 c/L.
- Recent changes to the fuel taxation system have had a major impact on the biodiesel industry. The *Fuel Tax Act 2006* change means that the payment of a producer grant (under the *Energy Grants (Cleaner Fuels Scheme) Act 2004)* extinguishes the fuel tax liability — ie if the producer of the biodiesel has received a grant, the purchaser of biodiesel cannot claim a fuel tax credit. While the intent here was to avoid 'double dipping' (claims of an excise rebate in situations where no excise was gathered), the end result is that it penalises the biodiesel purchaser who could ordinarily claim a rebate on diesel, and impacts on the demand for biodiesel.

10.3 Comparison to overseas subsidies and policies

Drivers for the use of biofuels have differed greatly between countries, and between fuels (Table 10-1).

- Ethanol was initially regarded as a fuel extender. Then it was used as a replacement for MTBE. MTBE is an oxygenate which reduces air pollution of petrol in cities in America (but is not used in Australia). When MTBE contaminated groundwater in the USA, it was banned by the end of 2002 — with ethanol the replacement oxygenate. Oil companies then realised that ethanol was a good octane enhancer. It is now considered as an alternative fuel and major policy support in Brazil and USA is largely a response to the issue of energy security. Present law provides for a federal excise tax exemption of US 51 c/gallon (Australian 16.5 c/L) of ethanol blended into gasoline in the USA. In addition there are various State based incentives for ethanol production and use.
- Biodiesel - many countries moved to using Ultra Low Sulfur diesel (ULSD) because of the air pollution problems caused by sulphur in the fuel. When the sulphur was removed, however, many of the lubricant properties of the diesel were lost. Biodiesel has excellent lubricant properties, and biodiesel was introduced to a diesel blend as a lubricant enhancer. The further benefits of biodiesel were then demonstrated — especially in terms of lower particulate emissions and therefore reduced air pollution and better health outcomes. It is now considered as an alternative fuel rather than an extender. Major policy support in the European Union is based on reducing greenhouse gas emissions rather than as a response to energy security.

Table 10-1 History of key subsidies and other policy instruments in the international context.

Country	History of Key Subsidies and Other Policy Instruments
Brazil	• Proálcool policy (1970s) introduced to build passenger cars to run on ethanol. Led to building of a nationwide distribution network supplying ethanol in all service stations. • First ethanol-use mandate (1977) for a 4.5 % mixture of ethanol in petrol. Since then, the mix of ethanol in petrol is up to 25 %. By late 1980s, ethanol had a larger market share in the transportation sector than petrol. • 1975 to 2002, fuel ethanol use helped replace around 210 billion litres of petrol, saving the country around US$52 billion. • The Proálcool program left a long-term legacy of a dedicated ethanol-handling infrastructure, an ethanol-powered automotive fleet and continued production of both petrol-fuelled and ethanol-fuelled automobiles. Current legislation requires an ethanol content of 20–25 %, with flexibility to adjust levels within that band. • Young biodiesel industry is helped by a mandated 2 % mix by 2008, and 5 % by 2013.
Argentina	• Argentina has become the world's 17th-largest ethanol producer, and is considering mandating a 5 % mix of biodiesel with regular diesel (B5).
Venezuela	• Venezuela mandates ethanol blending in some parts of the country and may require a 10 % mix nationwide in the future.
Colombia	• Colombia has mandated 10 % ethanol mix in cities with populations over 500 000.
USA	• Energy Tax Act of 1978 introduced the first major Federal subsidy to ethanol, exemption from the 4 c/gallon (1.3 Australian c/L) motor fuel excise tax. Present law allows a partial federal excise tax exemption of 51 c/gallon for ethanol blended into gasoline. • Subsidies exist at many points in the supply chain – from production of feedstock crops to final consumers. The largest subsidies go to producers of feedstocks used to make biofuels, particularly corn (for ethanol) and soybeans (for biodiesel). Total subsidies provided for liquid biofuels currently fall somewhere between USA $5.1– $6.8 billion (ie A$6.4–$8.5 billion) for ethanol and US$0.4–$0.5 billion (ie A$0.5–$0.6 billion) for biodiesel. • Most subsidies are tied to output and output is increasing at double-digit growth rates, so the cost of these programs will continue to climb. • Oil refiners in California predominantly used methyl tertiary butyl ether (MTBE) to meet their oxygenation needs. MTBE has been detected in ground water and was therefore banned in gasoline by the end of 2002. Other states have followed, opening the way for ethanol to replace MTBE as oxygenate of first choice. • The USA government has announced the granting of US$385 million for the construction of six cellulosic ethanol pilot plants.
Canada	• Prospects for an ethanol industry improved substantially after the government in Ottawa pledged financial support: CAD$100 million (A$110 million) for the sector in the framework of its Kyoto commitments. E10 blends are expected to achieve a 35 % market penetration by 2010. At present, Ontario is the only sizeable fuel ethanol producing province in the country, but this could soon change.
European Union	• Fuel policies in the European Union (EU) are gradually shifting to be consistent with carbon trading. • European Commission's (EC) first directive aimed to achieve a 2 % share of renewables by the end of 2005 and a 5.75 % share by the end of 2010. • EC's second directive - biofuels such as ethanol and biodiesel are exempt from the tax on mineral oil products. • In January 2007, the EC proposed a radical energy and climate change package to cut emissions for the 21st Century – ie cut greenhouse gas emissions by at least 20 % by 2020 (largely through energy measures), and maintain the EU's position as a world leader in renewable energy with a binding target of 20 % of its overall energy mix to be sourced from renewable energy by 2020.

National and State policy approaches

Australian government

350 ML biofuels target by 2010 set by the 'Biofuels for Cleaner Transport' 2001 election policy — but this target was never mandated in legislative form. Assistance currently provided to producers:

- production grant of 38.1 c/L, which fully offsets the excise paid on biofuels;
- new facilities approved under the Biofuels Capital Grants Program also receive a capital grant 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.

Queensland

Queensland has been the most proactive state in promoting the biofuels industry. Two ethanol production facilities are operating already (CSR Sarina and Rocky Point), and another five ethanol production facilities are being planned. Queensland's Government fleet was the first to use E10 wherever possible. The state has developed an Ethanol Industry Blueprint as a precursor to a long term Ethanol Industry Action Plan. Announced in April 2005, this plan provides $7.3 million over two years for programs supporting Queensland's ethanol industry. Mackay Sugar, Bundaberg Sugar, CSR and Austcane have received assistance.

Queensland's Action Plan brings together several activities supported by the Government to develop Queensland's ethanol industry. The policy objectives include:

- lobbying the Commonwealth Government to introduce a national mandate for E10 fuel;
- promoting quality standards for ethanol fuels, and encouraging monitoring of standards under relevant State and Commonwealth Acts;
- lobbying the Commonwealth Government to retain domestic ethanol production grants indefinitely;
- assisting the provision of infrastructure for the production, distribution and export of ethanol through the provision of funds.

The major areas that the Queensland Government intends to focus on in order to promote the use of fuel ethanol are consumer confidence, supply capacity, the distribution network, value adding ethanol products, and market expansion.

Queensland is also developing an Industry Action Plan for biodiesel. It is similar to that for ethanol and biodiesel is being trialled in Government vehicles and other modes of transport. Another first for that state was the announcement in early August 2006 of a mandate for a minimum 5 % ethanol in regular unleaded petrol produced and wholesaled in Queensland from 31 December 2010.

New South Wales

New South Wales has announced that, it would introduce a E10 mandate in unleaded petrol produced and wholesaled in the state, on a phased-in basis with full implementation by 2011. An Ethanol Mandate Taskforce was established in August 2006 to examine a number of key issues related to the proposed mandate.

The New South Wales Government has also endorsed the use of E10 blends in their own government fleet, when that fuel is available. In addition, executive officers and public service staff who drive government-owned vehicles as part of their remuneration package are required to obtain E10 fuel "*where this is practicable, available and cost effective*."

Sydney Ferries are currently conducting a biodiesel trial that includes analysis of carbon dioxide, nitrogen oxide and PM emissions. The trial commenced in 2006, and will be expanded to other water craft following completion of initial studies. Initial studies have looked at using B20, with B80 and B100 to be assessed in future. The NSW Greenhouse Office provided a grant of $50 000 for the trial.

ACT

The Australian Capital Territory (ACT) has no biofuels policies of its own other than to generally follow what NSW is doing, because most of their fuel supplies are sourced from NSW. The ACT does not plan to mandate ethanol.

Victoria

Victoria has set a biofuels target of 5 % of the fuel market by 2010 (400 ML). It is expected that the target will be met, mostly by biodiesel. If it is not, the Victorian Government's recent Road Map and Action Plan for the industry stated that it may consider mandating a 5 % biofuel level.

All Government vehicles are supposed to use ethanol blended fuel whenever possible and trials are being conducted on the use of biodiesel in heavy vehicles. Also, a $5 million Biofuels Infrastructure Grant (BIG) program will be provided to assist infrastructure development.

South Australia

South Australia has no plans to mandate or set a target for biofuels use. In 2005, the South Australian Government announced a clean fuel initiative directed at reducing GHG emissions and fuel consumption by the public sector. Biofuels initiatives include the use of B5 in all metropolitan trains and diesel buses. This accounts for consumption of around 0.8 ML of neat biodiesel annually. In future, B20 may be introduced if this program proves successful.

Northern Territory

Although all fuel is imported into the Northern Territory, the NT Government encourages biofuels. Natural Fuels Australia and Charles Sturt University are working in cooperation with the NT Government to trial B20 in the Darwin bus fleet. Although not directed at transport activities, trials have also been conducted in the Northern Territory on the use of B100 for electricity generation in existing diesel generators.

Western Australia

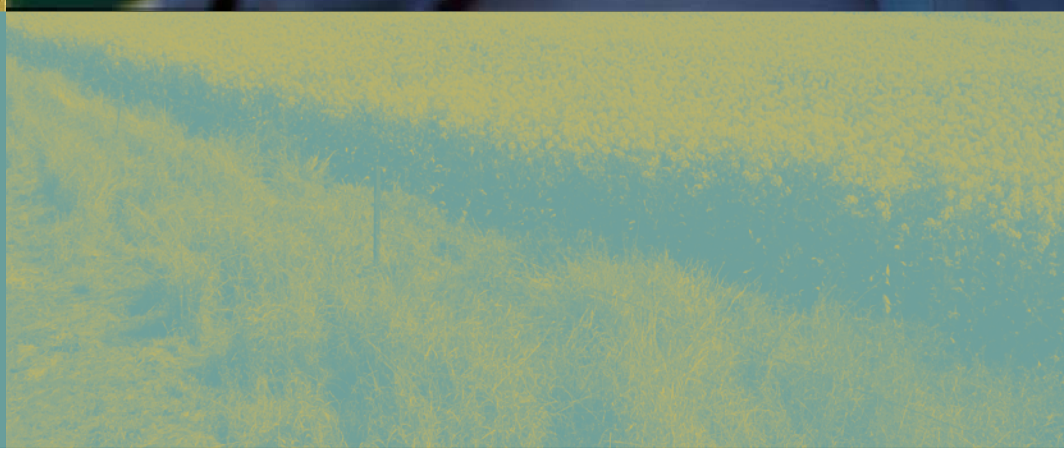
Western Australia has established a Biofuels Taskforce to examine the role of biofuels in that state. The Taskforce released its final report in May 2007. It will work with government and industry by providing recommendations and strategies on:

- reviewing and addressing opportunities and impediments to the development of a biofuels industry in Western Australia;
- increasing consumer acceptance and use of biofuels;
- using biofuels as cost-effective alternatives to petrol/diesel;
- maximizing WA's participation in providing biofuels to meet the national 350 ML fuel target;
- maximizing WA's opportunity to leverage funds from Commonwealth funding programs related to biofuels;
- provision of a consultation mechanism with industry and the Federal Government;
- promoting a whole of Government and industry approach to the use of biofuels.

Tasmania

Tasmania has a Parliamentary Inquiry into Alternative Fuels underway in early 2007. Tasmania's alternative fuel policy is currently based on Compressed Natural Gas in buses. The natural gas is supplied from Bass Strait through pipeline.

11 Options for expanding demand



11.1 Current barriers to demand

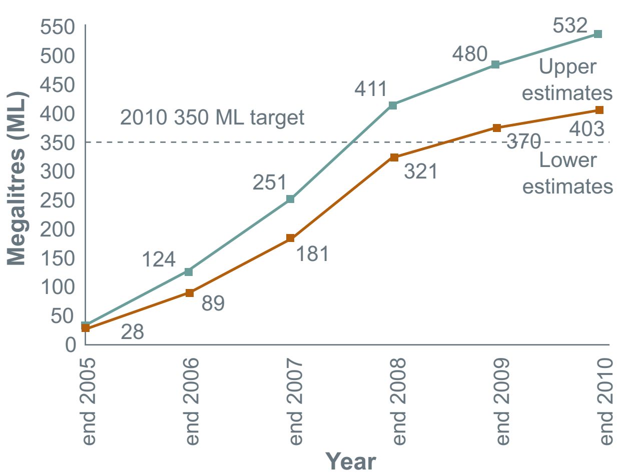
Total demand has two components:

- 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;
- Final demand — purchase by consumers.

11.1.1 Barriers to intermediate demand

- Industry projections quoted in the Prime Minister's Biofuels Action Plan [102] suggest that oil majors still expect to exceed the Government's biofuels target of 350 ML by 2010 (Figure 11-1).
- However only about 5 % of the 8 000 plus service stations across Australia are now selling ethanol or biodiesel blends, so there is a risk that the target will not be met.
- Ethanol and biodiesel blends are provided mostly by independent, small scale fuel providers (eg SAFF and Gull), since the oil majors are slowly increasing their involvement.
- Lack of availability of E10 and B5 in southern and western states remains one of the largest barriers stifling demand growth.

Figure 11-1 Aggregated industry projections up to 2010 [102].



11.1.2 Barriers to final demand

- Consumer confidence is the major barrier. Regional motorists are more comfortable with E10, and Queenslanders favour ethanol more than drivers from other states. Queensland government has introduced more initiatives to educate consumers and to promote ethanol.
- Motorists are concerned that ethanol will damage their engines. This concern is unfounded for modern cars running on E10 (see Chapter 8). A common belief is that E10 typically reduces fuel economy by about 3 %, because of its lower energy density. Therefore, motorists expect it to be 3–4 c/L cheaper.

11.1.3 Trade barriers

- Both the USA and the EU (expected to be Brazil's top purchaser of ethanol next year) impose tariffs on ethanol imports.
  - USA — 54 c/gallon (A$0.18/L) on direct ethanol imports plus a 2.5 % *ad valorum* (ie. according to value) tariff.
  - EU — €10.2 for every 100 L (A$0.17/L) for denatured alcohol, and a tariff of €19.2 per 100 L (A$0.24/L) for non-denatured alcohol.

Table 11-1 Some barriers affecting the demand for ethanol.

Demand barriers	States affected	Removal strategy
Lack of consumer confidence	All (Qld less so)	Wider information dissemination
Limited service station outlets	All (Qld and NSW less so)	Rollout incentives
Commercial risks for producers	All	Demand incentives
Unattractive relative price	All	Discounted prices
Lack of supply reliability	All	Supply monitoring

Table 11-2 Some barriers affecting the demand for biodiesel.

Demand barriers	States affected	Removal strategy
Limited service station outlets	All (NSW SA WA less so)	Rollout incentives
High cost of production	All	
Effect of *Fuel Tax Bill 2006*	All	
Commercial risk on entry	All	Demand incentives
Concern over some feedstocks	All	Standards testing

11.2 Strategies to stimulate demand

Strategies to stimulate demand include those recognised by the Biofuels Taskforce (2005) including:

- 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.

The following can be added to this list:

- Removal of demand barriers;
- Rollout incentives — investment incentives could be made available to companies to expand distribution networks — for example constructing retail outlets whose sales included, for example, 10 % ethanol and biodiesel blends;
- Price discounting:
  - if a biofuel is produced for less than the price of the standard fuel, pass on the savings to the consumers;
  - the introduction of controls on weekly fuel price movements;
  - price discounting of ethanol to compensate for differences in fuel efficiency.
- Mandating fuel blends — demand would be stimulated but the distortionary impacts on the economy and on related industry sectors could be wide-ranging and long-term. There are many complex issues involved in mandating biofuels and careful consideration of the goals and unintended consequences is required.
- Producing and/or mandating of flexi-fuel vehicles would address consumer confidence issues, and place Australia in a position to have greater ethanol use in the future.
- Tax, excise and import incentives:
  - Between July 2011 and July 2015, production grants for ethanol and biodiesel will incrementally reduce to about half the current excise rate.
  - Currently the production grant for biodiesel also applies to imports of biodiesel to Australia. Imported ethanol does not receive a production grant, although in 2011 imported ethanol will be treated equivalently to domestically produced ethanol.
  - The effect of this on the local production of ethanol is unclear. It is possible that Brazilian ethanol could be purchased at a lower price than Australian produced ethanol, so that the industry may experience increased competition from overseas producers when the import market is opened up in 2011.

12 Options for encouraging future capital investment

12.1 Effectiveness of present policy in encouraging sustainable capital investment and growth in supply

- 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 — particularly in the USA where there has been a massive increase in the production of ethanol — with consequent increases in the grain price, and impacts for the human and livestock food supplies.
- In contrast, Australia's policies have been cautious. At the present rate of growth in planned capacity, biofuel production is at risk of not reaching the 350 ML target by 2010 unless most of the oil majors adopt more ethanol as an octane enhancer. As well as the issues discussed in section 10.2, reductions in levels of excise relief from 2011 onwards and the uncertainty in the domestic industry about future directions, are likely to inhibit further capital investment.
- There are limits and security of supply risks to a biofuels industry based on domestic feedstocks and first generation technologies. These first generation technologies can serve as a small stepping stone towards a biofuels future based on second generation technologies.
- Given the potential for lignocellulosic ethanol to change the economics of the biofuels industry in the coming decade, policy interventions based on current industry technologies and feedstocks require careful consideration [9].

12.2 Targeted incentives and assistance programs

- 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.
- These incentives would require a technically defensible and transparent basis, and may favour biodiesel because the environmental benefits of first generation technologies and domestic feedstocks are more demonstrable. Ethanol from second generation lignocellulosic sources could target positive hydrological, biodiversity or regional benefits.
- An emissions trading scheme could promote the use of biofuels, if the sale of renewable fuels did not require the purchase of emissions allowances (see pullout box below). 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 [x].

12.3 Can the domestic industry supply sufficient biofuel to satisfy consumer demand or will imports be required

- Consumer demand is currently one of the barriers to biofuel expansion. At the moment, there is sufficient capacity to meet current levels of consumer demand for ethanol and biodiesel. If, however, community wide interest in climate change should rise rapidly, this would stimulate more rapid growth in consumer demand. The challenge facing Australia's biofuels industry today is to produce basic blends like B5 and E10 cheaply enough to attract interest from lukewarm oil majors and largely sceptical consumers in the southern and western states.

[x] http://www.pmc.gov.au/emissionstrading/

Emissions trading schemes

There are many different ways of designing emissions trading schemes, and these schemes are the subject of the Prime Ministerial Task Group on Emissions Trading. At present, the EU's Emission Trading Scheme is the largest multi-national, greenhouse gas emissions trading scheme in the world and is a main pillar of European Union climate policy. Under the scheme, each participating country has a National Allocation Plan specifying caps on greenhouse gas emissions for individual power plants and other large point sources. Each facility gets a maximum amount of emission allowances for a particular period (eg 2005–07). To comply, facilities can reduce their emissions or purchase allowances from facilities with an excess of allowances. Progressively tightening caps are foreseen for each new period, forcing overall reductions in emissions.

The second phase (2008–12) expands the scope significantly. All greenhouse gases (not just CO_2) will be included, aviation emissions may be added, and four non-EU members — Iceland, Liechtenstein, Norway and Switzerland — are expected to join the scheme. Aviation is important due to large, rapidly growing emissions of that sector. Ultimately, the European Commission wants the post-2012 scheme to include all greenhouse gases and all sectors, including aviation, maritime transport and forestry. For transport, the large number of individual users adds complexities, but it will be implemented either as a cap-and-trade system for fuel suppliers or a baseline-and-credit system for car manufacturers.

Extensions have been proposed to include tailpipe emissions of CO_2 from road vehicles in the EU scheme. Emissions allowances could be auctioned to fuel suppliers, and the revenue from auctions used to reduce fuel duty or for climate change mitigation measures or a combination of both. Biofuels would not require emissions allowances, since they are renewable, hence their supply would be promoted.

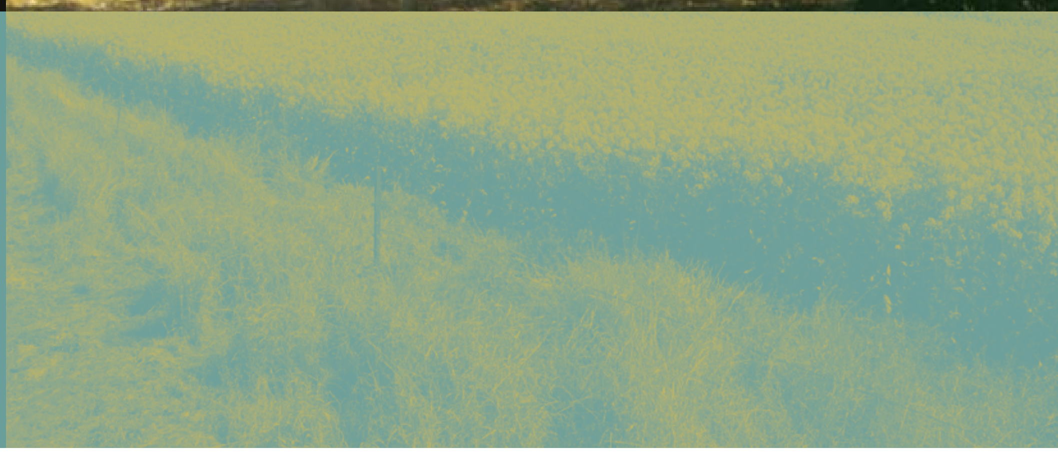
Effective emission reduction policies could encompass the following key features:

- slow down CO_2 and other carbon dioxide emissions where it is cost-effective to do so;
- involve some mechanism for compensating those who will be hurt;
- incorporate a high degree of consensus — domestically and internationally. It is unlikely that a rigid global regulatory regime for greenhouse policy could ever be implemented — few countries want to relinquish sovereignty over setting their own polices especially when the policies in question can have large economic effects;
- allow a core group of countries to continue to participate even if countries exit the system at certain times;
- able to adapt over time as new information about the climate and the ability to reduce emissions is revealed.

One approach that meets these requirements is the McKibbin Wilcoxen Blueprint [103]. The Blueprint is a hybrid system of annual and long-term emission permits. Annual permits focus on equating the costs and expected benefits of taking action. Long term permits focus on achieving targeted reductions in emissions, but only along a low cost pathway and without specifying in which year these reductions will be reached. Each participating country would take three concrete steps.

- They would issue a fixed quantity of long-term permits or property rights to emit CO_2 based on some target (possibly 1990 levels). The time horizon of these rights needs to be at least as long as the time horizon of energy investments (30–50 years). Some of these long-term permits can expire over time, so as to tighten the target.
- Countries would require producers of energy embodying carbon to hold an emission permit for every ton of carbon in their production.
- Countries would be allowed to issue annual emission permits of sufficient quantity to supplement the long-term permits in order to ensure that the price of annual permits do not rise above an internationally agreed price. Although the annual price is fixed the price of long-term permits will reflect the expected future price of annual permits. None of these permits would be traded internationally — the annual permits are the same price everywhere so no trade is necessary.

13 Conclusions



13.1 Benefits across the biofuels value chain

- 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 has the potential to significantly shift agriculture, forestry, environmental and fuel value chains — towards the emergence of a bio-based economy. Single Vision's *Propects for a viable grains based Australian biofuels industry* report[36] proposed a conceptual model of the potential benefits of the economic value chain, linked to those in an environmental value chain (Figure 13-1).
- Some of the likely benefits along these value chains have been quantified where possible, but it is clear that many of these are currently poorly understood. The transition pathways to realise the potential benefits of these value chains are also poorly understood. Development of a financially viable and ecologically sustainable industry will require a better understanding of these so that policy measures can be taken to achieve the desired outcomes, and manage potential unintended consequences such as impacts of human food and animal feed from rapid increase in ethanol production in the USA.

13.2 A broader set of strategies to address Australia's future transport needs

- This report focusses on the prospects for biofuels in Australia and the wider implications of their production and use. Biofuels are, however only a part of the solution to our future transport and energy needs. A range of responses 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). A range of potential strategies, and the drivers that they address, are given below (Table 13-1).
- In order 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.

Figure 13-1 Potential benefits from economic and environmental value chains for biofuels [36].

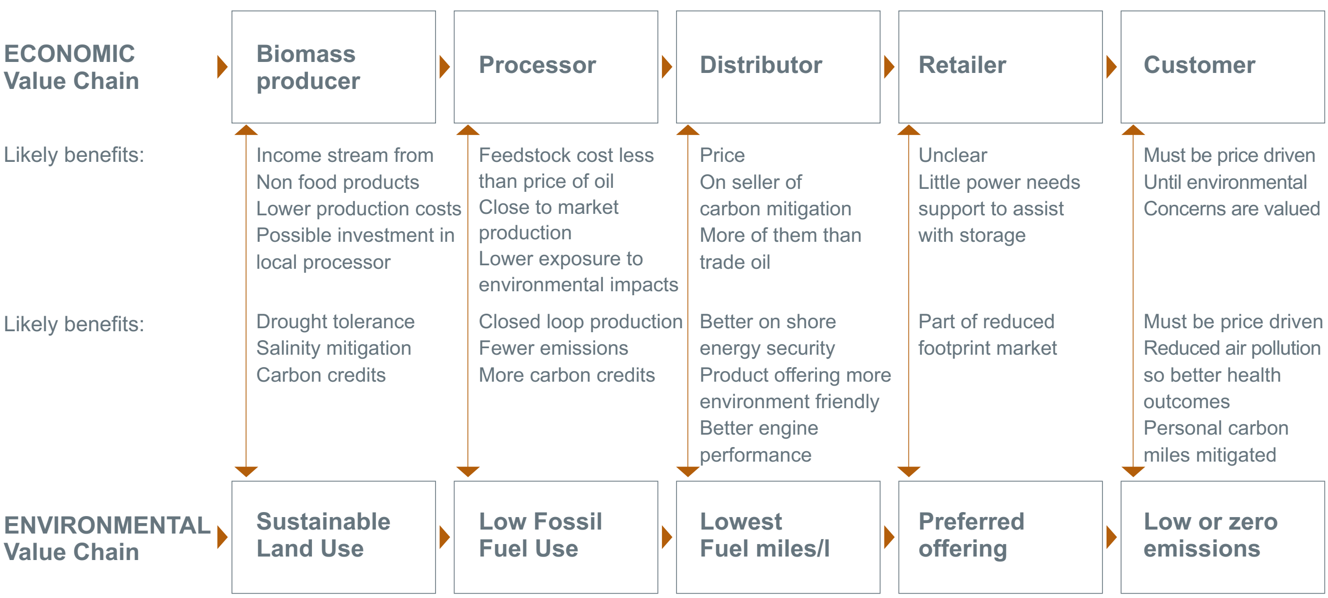
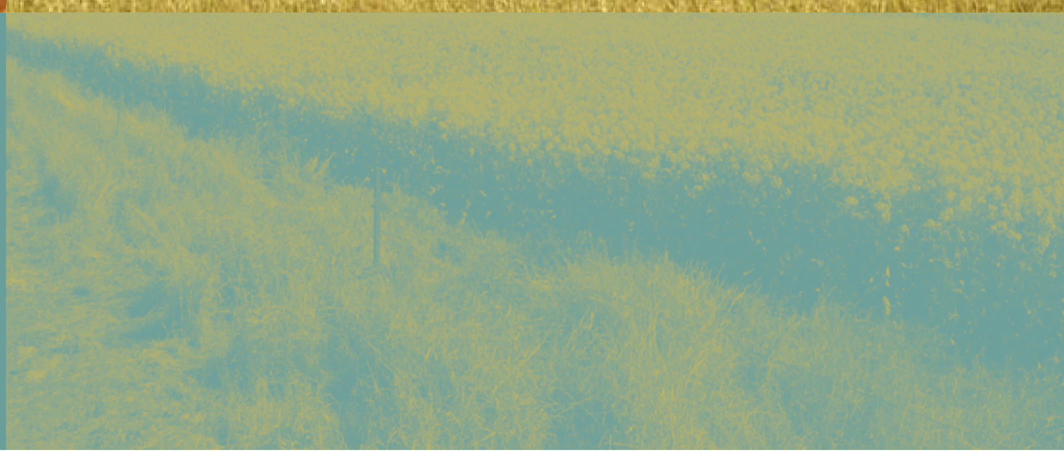


Table 13-1 Abroader set of strategies to address Australia's future transport needs.

Strategy	Examples	Driver addressed by strategy
Reduce overall demand	• Use less energy • Eco-efficient urban design • Improve energy efficiency and self-sufficiency of farming systems, rural communities and regions • Eco-efficient closed loop production systems which minimise waste • Efficient engine technologies eg hybrid electric, smaller engines • energy recovery from waste management	• Climate change, land and water • Energy security • Regional opportunities • Health
Use or sequester the target gases	• Target most potent GHGs eg methane. • Geo-sequester (bury) CO_2 at point sources eg power stations • Bio-sequesteration eg capture in biomass (reforestation; capture CO_2 at point sources and use for algal production of biodiesel; agrichar for long term stable capture of capture CO_2 and improvement in soil condition)	• Climate change, land and water • Energy security • Regional opportunities • Health
Expand and diversify use of fossil reserves	• New fossil fuel discoveries • More cost effective extraction and processing • Greater use of different types of gas (CNG, LPG) • New liquid fuel options — Gas to liquids (GTL), Coal to liquids (CTL)	• Energy security
Diversify sources of energy	• Renewable sources — including solar technologies, wind, tidal and bioenergy for electricity • 'Extend' fuel with biobased blends eg E10, B20 • Biomass to liquids (BTL) — use of lignocellulosics • Biogas	• Climate change, land and water • Energy security • Regional opportunities • Health
Diversify products	• Biobased replacements for petrochemical products • Biorefineries to optimise the use of a range of biomass sources in regional areas • Identification of high-value products and markets which may enable the profitable recovery of energy from biomaterial as a lower-order co-product	• Climate change • Regional opportunities • Health
And in the longer term …..	• Hydrogen from coal with carbon capture and storage • Hydrogen from nuclear or renewable electricity.	• Climate change • Energy security

14 References



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