To:
The Alternative Fuels Inquiry
The Joint standing Committee on Environment, Resources and Development.
State Government of Tasmania.

PROPOSAL

Development of a Wood Based Biofuels and Associated Products Industry in Tasmania

Mike Scott CEng
1st October 2007

Summary

Globally biofuels for transport and other applications are beginning to receive substantial interest and investment. This proposal references and distils findings from authoritative government, industrial and academic research to show that globally there is a high level of confidence that both technical and economic benchmarks have been met. Additionally these show that biofuels will provide an increasing proportion of the world's transport fuels mix with a future of strong returns for producing regions.

Tasmania with its maturing stock of hardwood plantation forests, an ideal source of feedstock, is uniquely placed to take advantage of this growing market.

In this proposal, recommendations are made for a 3 stage approach:

1. 2007-2009. Groundwork by government agencies and academic institutions to assess available technologies and select against measures particular to Tasmania.

2. 2009 onwards. Establishment of Tasmania as a technology leader and 'centre of excellence' for the development of a biofuels industry within the State and economic region. An increased involvement of private enterprise would be expected during this phase.

3. 2015 onwards. Consolidation of a biofuels industry based predominantly on plantation hardwood as a feedstock in Tasmania. This to satisfy 100% of technically achievable transport fuel demand within the state as well as exploiting potential export markets. Commercial scale plants would exploit biomass conversion technologies based on 'biorefinery' principles to develop a plurality of value streams such as power generation, bioplastics etc. With a legislative framework designed to encourage the development of low GHG, renewables industry it is expected that this phase would be driven by private investment.

The ability of Tasmania to benefit significantly from these opportunities is predicated on the need for open, 'free market' access to the plantation resource. This would enable the establishment of commercial scale facilities and ensure that all stakeholders in the forestry supply chain are able to maximise their returns.

1. Introduction

In recent years the replacement of transport fuels derived from crude oil has become a goal of many developed nations. The drivers can be summed up as:

- Strategic; the desire to reduce dependence on volatile parts of the world for energy supplies,
- Environmental; replacing crude oil energy products with renewable materials can substantially reduce Green House Gas (GHG) emissions and there is evidence that biofuels can reduce vehicle emissions of noxious pollutants,
- Economic; with the inexorable rise of crude oil prices as the world approaches 'peak oil' the costs of producing biofuels becomes increasingly competitive.

Tasmania is ideally placed to take advantage of the global revolution in biofuels. Following State and Federal government incentives over many years, Tasmania now has a maturing resource, in plantation hardwood, which will provide excellent feedstock for a biofuels industry. Harvesting output from these plantations will increase steadily over the coming decade, a timescale consistent with the staged growth of a biofuels industry. This proposal sets out the potential for a biofuels industry in Tasmania with recommendations as to how this can be achieved.

The text of this proposal is a distillation of many sources. Figures used are calculated from a variety of the referenced sources. As the provenance of the figures used is not always certain and the technologies involved are constantly being improved upon, all figures should be regarded as indicative. A thorough appraisal of the subject requires consultation of the referenced texts as a minimum.

2. Biofuels: Current Status

2.1. Preferred Fuels

To meet transportation needs in the short to medium term future, biofuels need to be as compatible as possible with current conventional powertrains; petrol and diesel engines. There are a plurality of fuels that can be derived from wood (ligno-cellulosic) feedstock however this proposal is restricted to the two most promising replacements:

- Ethanol. This is already used extensively in Brazil and the USA where there is extensive production of ethanol from short-rotation crops such as sugarcane and maize. Fermentation of ethanol from these high sugar content crops is relatively cheap and easy however the energy expended in growing the crops and the loss of agricultural output (food) means that this method is increasingly regarded as unsustainable. Cellulosic (woody) feedstocks are now seen as the best long term sustainable resource and commercial wood to ethanol plants are now in the process of being commissioned.
- Diesel. Replacements for diesel (biodiesels) have typically been made from easy to convert substances like used cooking oil and tallow. These have a limited supply so large scale manufacturers are looking to either farmed oil crops or

cellulosic feedstock. Commercial scale Biomass to Liquid (BTL) plants for wood to diesel are currently in construction in Europe.

2.2. Vehicle Fleet Adaptability

Biofuels are chemically different from the conventional crude oil derived fuels that they replace. For this reason there may be a need for new vehicles to be designed to handle these fuels and conversions be made available for older vehicles. Alternatively they can be mixed with conventional fuels without affecting vehicle operation.

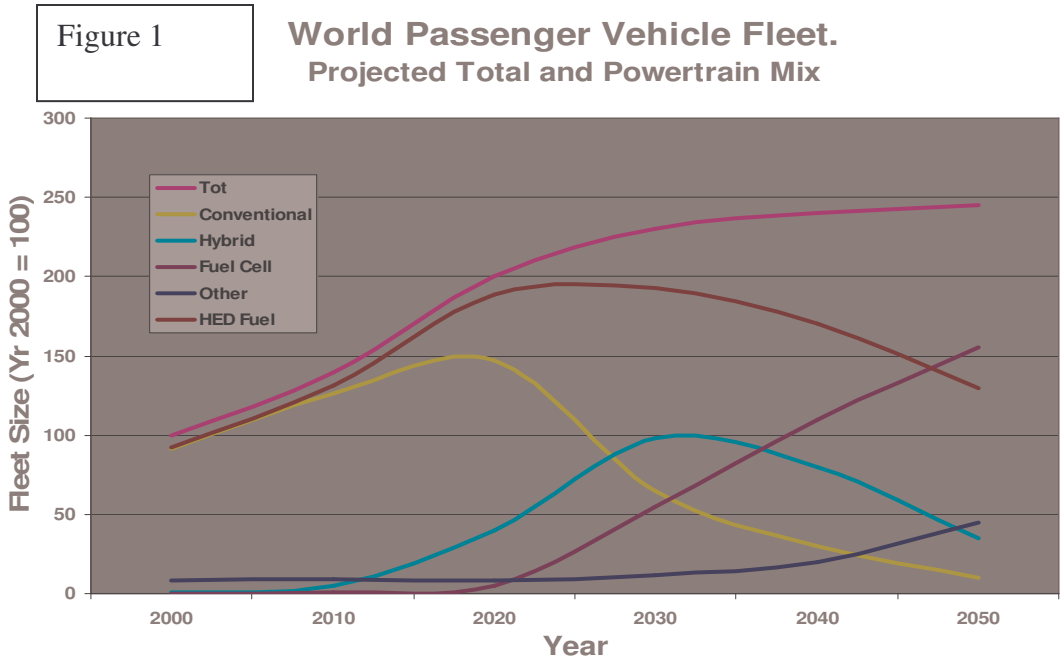
- Ethanol: Currently allowed in ULP (unleaded petrol) up to 5% (E5). Almost all vehicles built after 1986 can accept up to 10% (E10). With conversion (approximately $200 per vehicle) 85% (E85) is achievable. In Brazil and the USA Fully Flexible Vehicles (FFV) are available that can use 95+% (E95). Currently FFV's cost approximately $1600 extra to manufacture.
- Diesel: Typically biodiesels are blended with conventional diesel however most (BTL included) can be used as 100% replacements.

3. The Market Prospects

Before 2003 the outlook for biofuels in Australia was mixed and attracted little attention. Crude oil was relatively cheap, there was limited legislative support for a move away from fossil fuels. Also the automotive world was looking to fuel cells (FC) and the 'hydrogen economy' as the long term fix. Recognition of the potential has since grown dramatically with the surge in crude price, the acceptance of the need to curb GHG emissions and the substantial technical barriers that need to be overcome before hydrogen powered FC vehicles become a reality.

Figure 1 shows the long term view of how the mix of vehicle powertrains will change over the foreseeable future.

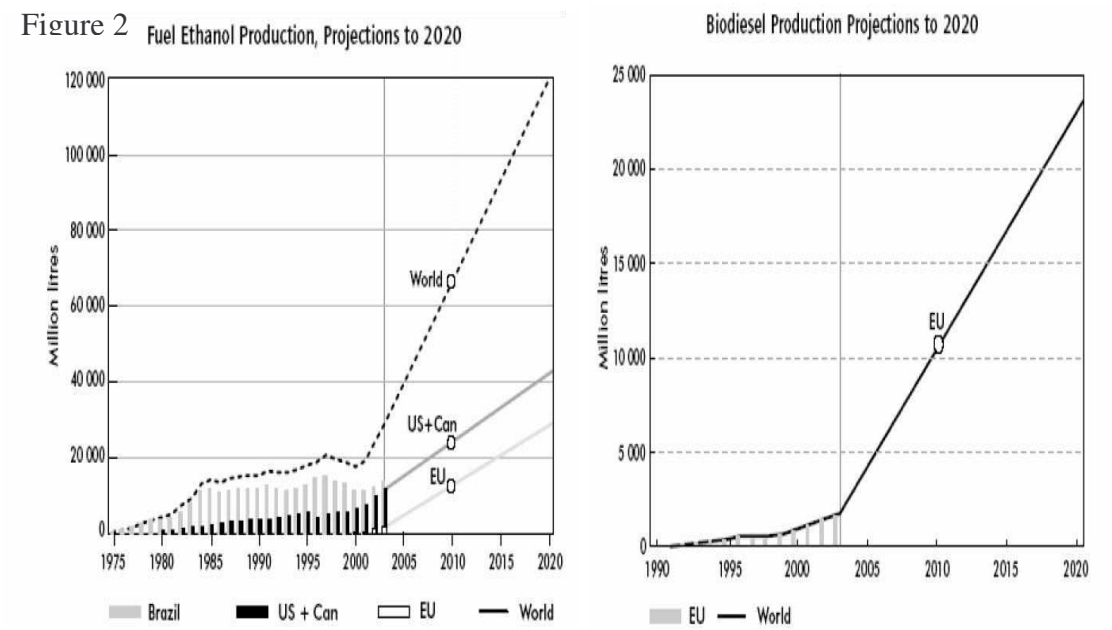
Figure 1



Although this shows the potential decline in conventional powertrains after 2020 the amount of vehicles requiring high energy density (HED) fuels such as petrol/ethanol and diesel will remain above 2000 levels for the foreseeable future. The evolving powertrain technologies such as hybrid vehicles and FC vehicles (with onboard generation of hydrogen from a HED fuel) will maintain this demand.

Combined with the environmental, strategic and economic drivers that now support biofuels the market growth prospects are extremely promising. Figure 2 shows the global production volumes predicted by the Australian Federal Government Biofuels Taskforce in 2005.

Figure 2

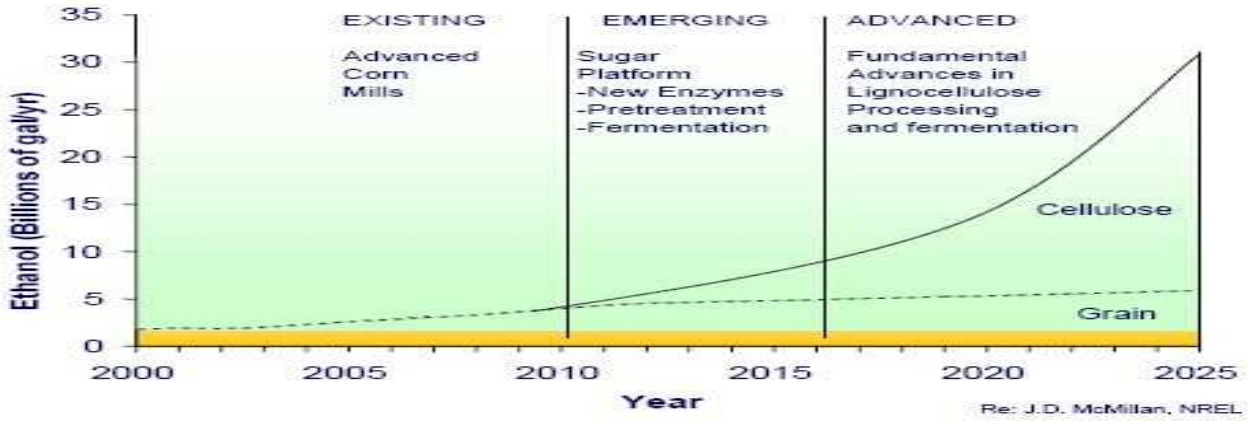


In the USA this dramatic rise in demand for ethanol is forecast to need a dramatic shift towards cellulosic feedstocks. This is foreseen in the 2005 Biofuels Taskforce report and is emphasised in the first conclusion:

> **Conclusion 1:** *The Taskforce notes the potential for lignocellulosic ethanol technology to impact materially on the economics of the ethanol industry in the coming decade. Policy interventions based on current industry technologies and feedstocks should be limited without further assessment of the impact of lignocellulosic technology.*

Figure 3 shows the predictions of the US Department of Energy (DoE) for the rise in fuel ethanol output and the technology steps required to bring it about, principally the expected 'Advances in Lignocellulose Processing'.

Figure 3 DOE Vision of Biofuel Growth



If the Australian market is to match the global predictions then biofuels will take a significant proportion of the domestic demand for transport fuels. Currently the total demand stands at an approximate annual requirement of (2004 figures):

- 20,000ML for automotive gasoline
- 15,000ML for automotive diesel

Tasmanian requirement, at around 2.1% of the national total equates to approximately:

- 420ML for automotive gasoline (340,000t)
- 320ML for automotive diesel (255,000t)

Growth in demand is expected to increase at 1-2% a year.

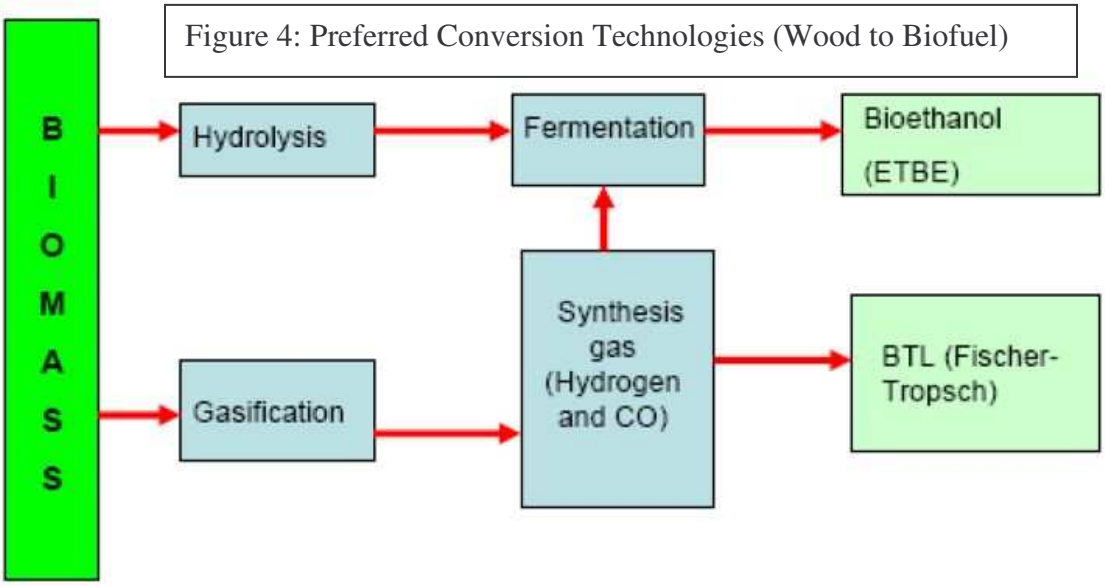
In 2003 a Federal Government Biofuels Target report suggested a target of 350ML annual production of biofuels in Australia by 2010. Although not formally adopted this target was used as the basis of the Biofuels Taskforce report in 2005. At the time of this report the output figures were only 23ML for ethanol and 4ML for biodiesel and there was little confidence the target would be met.

With the changing economic, environmental and technical outlook there is now renewed interest and impetus to meet expansionary targets.

4. Technology

There are many biofuels processes in use or in the process of development. For the purpose of this proposal the most promising methods for the conversion of wood to ethanol or biodiesel are considered. These are shown in figure 4.

Figure 4: Preferred Conversion Technologies (Wood to Biofuel)



Both of these methods are consistent with the 'biorefinery' concept in which a single feedstock, such as wood, is converted into a plurality of products (fuel, plastics, power etc).

5. Viability

For the 2005 Biofuels Taskforce report ABARE prepared a sensitivity study to demonstrate cost and price sensitivities at which both ethanol and biodiesel would become commercially viable. This concluded:

> **Conclusion 28**: *At a long-term exchange rate of US65c, the long-term world price of oil (West Texas Intermediate) would need to average US$42-47/bbl in 2004 dollars (depending on the feedstock used) for new ethanol producers to be viable post-2015 without assistance. With assistance, however, the required oil price is estimated to be US$25-30/bbl. Biodiesel producers would require an oil price of US$52-62/bbl without assistance for ethanol, or US$35-45/bbl with assistance provided by current policy settings.*

In the past two years WTI crude oil prices have surged to over US$80/bbl substantially exceeding the viability prices (without legislative assistance) set out in this conclusion.

The sensitivity studies are shown graphically in figures 5 and 6. These show:

- The threshold price at which the biofuel becomes commercially viable dependent on:
  - The price of crude
  - The availability of government assistance
  - The US$:AU$ exchange rate
- The upper and lower production costs for manufacture of the biofuel.
- Extrapolation to show the current WTI crude price.

Figure 5 **Sensitivity of ethanol threshold price to changes in oil price and exchange rate**

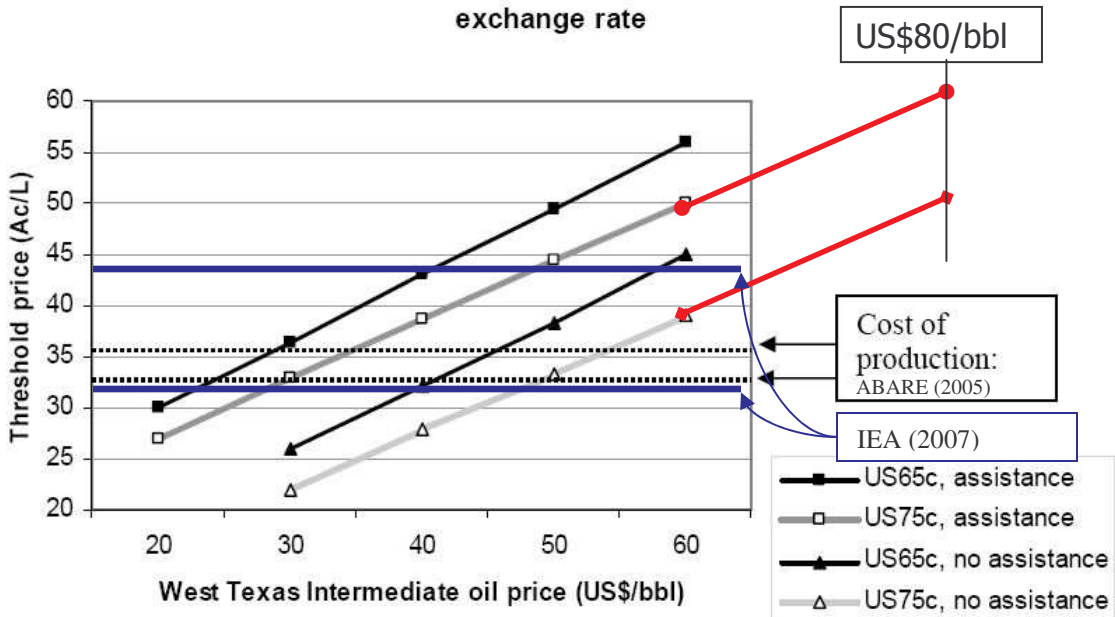
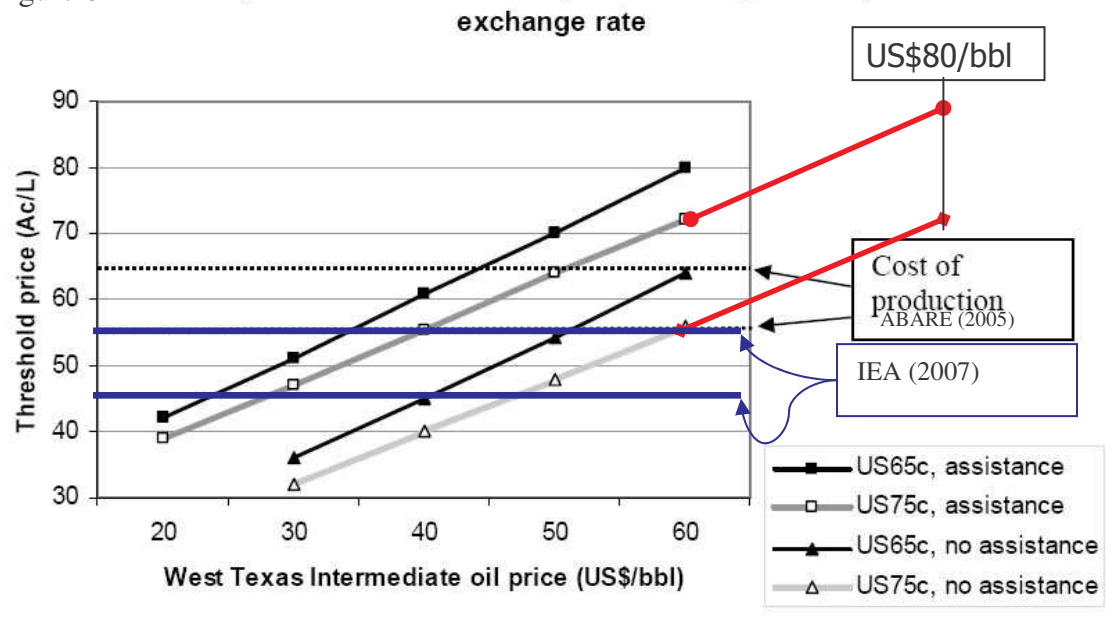


Figure 6 **Sensitivity of biodiesel threshold price to changes in oil price and exchange rate**



It should be noted that these studies were based on production from easily convertible feedstocks. Conversion costs for these are low but prices for the raw material are high:

- Ethanol from sorghum or molasses. (AU$50-150/t)
- Biodiesel from seed oil, used cooking oil or tallow. (AU$170-450/t)

Production costs for ligno-cellulosic processing are set out by the International Energy Authority in Table 1.

Table 1 IEA Estimated Production Costs for Wood Derived Biofuels (2007)

Concept	Energy efficiency (HHV) + energy inputs		Estimated production costs (€/GJ fuel)	
	Short-term	Long-term	Short-term	Long-term
Fischer-Tropsch liquids: via biomass gasification and subsequent syngas processing. Combined fuel and power production possible	45% (fuel only)	45% (fuel) 10% (power	12-17	7-9
Ethanol from wood: production takes place via hydrolysis techniques and subsequent fermentation and includes integrated electricity production of unprocessed components.	46% (fuel) 4% (power)	53% (fuel) 8% (power)	12-17	5-7

It should be noted that these figures are based on an energy content of 19GJ/t for ligno-cellulosic feedstock (consistent with softwood). It is also based on a feedstock cost of e2/GJ (approximately AU$60/t) which is based on European forestry prices. Capital costs for production facilities are costed at 10% annually for a 15yr project.

Using these figures, processing costs for wood to biofuels can be estimated as:

- Ethanol
  - Short Term: AU$0.75-1.05/LT
  - Long Term: AU$0.31-0.44/LT
- Biodiesel
  - Short Term: AU$0.75-1.05/LT
  - Long Term: AU$0.44-0.56/LT

(In this context 'short term' relates to pre-commercial pilot scale manufacture. 'Long term' indicates full scale commercial manufacture using mature, optimised technology).

To illustrate the impact of these costs the upper and lower limits for the long term processing costs are added to figures 5 and 6. These show that, even without legislative assistance, both types of biofuel will be commercially viable in the long term with crude oil prices exceeding US$60-65/bbl (WTI).

As Australian Federal policies (independent of which political party holds government) are set to significantly favour energy sources that have reduced GHG impact it can be expected that the threshold costs for these biofuels will be significantly lower, thereby increasing commercial viability and long term profitability.

When a 'cap and trade' or 'carbon tax' scheme is introduced in Australia biofuels will have a very significant advantage over crude oil derived petrol and diesel. Figure 7 shows graphically the difference in GHG emission levels between these fuels. This is based on wood derived biofuels and considers the full life-cycle GHG emissions (Well-to-Wheel). This shows GHG reductions for:

- Ethanol (45g/km) compared to petrol (165g/km) equivalent to a 73% reduction.
- BTL diesel (20g/km) compared to diesel (160g/km) equivalent to an 87% reduction.

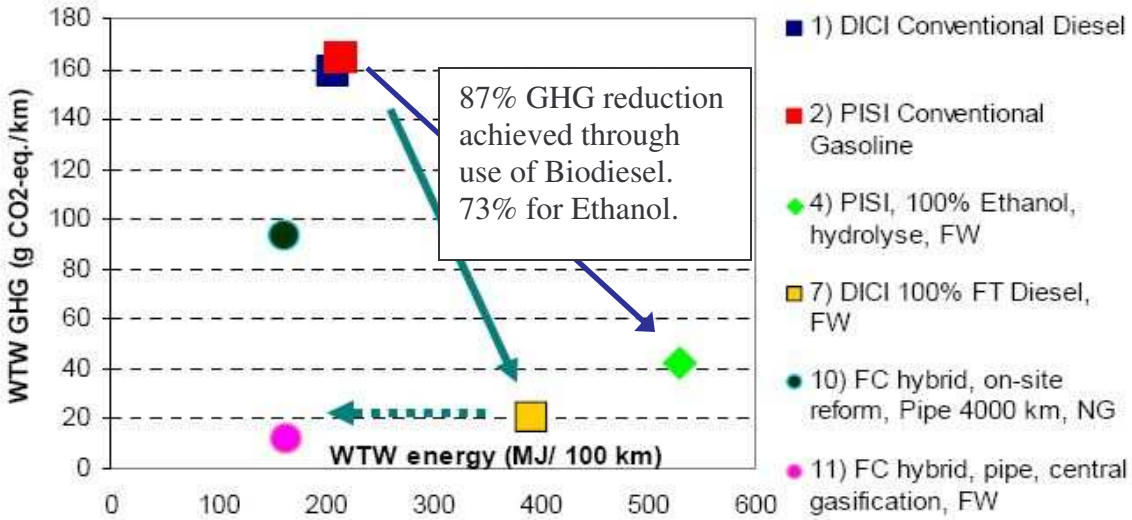


Figure . 7 Well To Wheel energy efficiency and $CO_{2\text{-eq}}$ emissions for some fuel chains

(Norwegian University of Science and Technology)

6. Summary of Background Information

The research behind the referenced documents and distilled above show very clearly that:

- Biofuels derived from wood are set to become a very significant portion of the global transport fuels mix.
- Technologies are proven at pilot scale and are currently being upgraded to commercial scales elsewhere in the world.
- Tasmania with its maturing plantation resource is ideally suited to become the pioneering State within Australia to adopt this technology.
- Economic, strategic and environmental drivers will ensure long term stability and profitability especially if a 'biorefinery' model is used with multiple product streams.

It is now clear that this industry is going to make a significant impact on global energy use in the coming century. Tasmania's best interests would be served by a legislature sympathetic to the development of domestic manufacturing capability. This would entail assistance in developing an optimised model for exploitation of the potential of wood based biofuels and ensuring fair and open 'free-market' access to Tasmanian plantation resource for the foreseeable future.

7. Proposed Development of a Biofuels Industry in Tasmania

In order to lay the best foundations for a biofuels industry in Tasmania it is proposed that a program consisting of three stages is adopted.

Stage 1: Education, Evaluation and Assimilation 2007-2009.

Groundwork by government agencies and academic institutions to:

- Identify representative of centres of expertise within public service, academia and private enterprise. To form a coordinating group from representatives.
- To assess available technologies and select against measures (technical, social and economic) particular to Tasmania. This would be well suited to a University research project.
- Gain an in depth knowledge of the biofuels industry and wood based biofuels in particular through study tours looking at global best practice.

Cost: Approximately AU$500,000/yr. 100% public funding.

Stage 2. Development within Tasmania of a Pioneering Centre of Excellence in Wood Based Biofuels. 2009 onwards.

Establishment of Tasmania as a technology leader for the development of a biofuels industry within the State and economic region.

- Investment in pilot processes with supporting research facilities and personnel:
  - Ethanol via hydrolysis and fermentation: 5-10ML/yr. AU$30-40M*.
  - BTL Diesel via gasification and Fischer Tropsche reaction: 15-20ML/yr. AU$40-50M**.
  - Ideally co-located as a 'biorefinery'.

  *Estimate based on Iogen (Canada) pilot plant.

  **Estimate based on Choren (Germany) 'Sundiesel' pilot plant.

Investment as above. Running costs approximately AU$3-5M/yr. Principle investment from government Renewable Energy Grants but substantially increased involvement and investment by private enterprise would be expected during this phase.

Stage 3 Development of a Commercial Scale Wood Based Biofuels Industry in Tasmania. 2015 onwards.

Consolidation of a biofuels industry based predominantly on plantation wood as a feedstock in Tasmania.

- Commercial scale biorefinery(s) producing (annually):
  - Ethanol: 375ML (300,000t) consuming approximately 1.15Mt*** of wood. Approximate refinery gate revenue AU$195M/yr.
  - BTL Diesel: 350ML (280,000t) consuming approximately 1.07Mt*** of wood. Approximate refinery gate revenue AU$256M/yr.
  - Other potential products to include: power generation (excess to on site needs), bioplastics etc.
- If the fuel produced was used to supply Tasmanian demand it would, at current retail prices, result in revenue within the state of $870M/yr.
- Figures are based on AU$1 = US$0.75. No government support or GHG tax / credit benefits are included.

  ***In Europe plantation harvesting for biofuels involves removal and use of the whole tree (trunk and trimmings) as all can be converted.

These quantities would satisfy 100% of technically achievable transport fuel demand within the state (assuming the adoption of the E85 ethanol mix standard). Exploiting potential export markets would necessitate scaling up limited only by feedstock availability. Commercial scale plants would exploit biomass conversion technologies based on 'biorefinery' principles enabling additional high value product streams.

Total investment cost is, at this stage, highly uncertain but would be expected in the region of AU$0.8 – 1.5bn. With a legislative framework designed to encourage the development of low GHG, renewables industry it is expected that this phase would be driven by private investment.

References

[ ] Description

General References

1 'The Prospects for Downstream Processing of Plantation Hardwood in Tasmania', M Scott, September 2007.

2 'Cleaning Up', Special Report on how business is tackling climate change, The Economist, June 2007

3 'Potential Contribution of Bioenergy to the World's Future Energy Demand', IEA Bioenergy, February 2007. (www.ieabioenergy.com)

4 'Production and/or Use of Biofuels in Victoria', CSIRO Submission 06-251, 2006

5 'Making Ethanol from Wood Chips', MIT Technology Review, 2006 (http://www.technologyreview.com)

6 'Wood for Alcohol Fuels Status of Technology and Cost/Benefit Analysis of Farm Forestry for Bioenergy', RIRDC Publication No 02/141, Joint Venture Agroforestry Program, Australia, 2002

7 'Sustainable Fuel for the Transportation Sector', Agrawal et al, Purdue University Indiana USA, 2007

8 'Biofuels form Lignocellulosic Material', Oyvind Vessia, Norwegian University of Science & Technology (NTNU), 20 December 2005.

9 'Who Needs Oil?', J Marshall, Lead Article, New Scientist Magazine, July 2007

10 'From Biomass to Biofuels', National Renewable Energy Laboratory, Office of Energy Efficiency & Renewable Energy, US Department of Energy. (www.nrel.gov)

11 'The Elusive Biorefinery', Jerry W Kram, Biomass Magazine, August 2007 Issue. (www.biomassmagazine.com)

References of Direct Significance to Tasmania

12 'Re: Draft Climate Change Strategy for Tasmania', C Woodfield, Tasmanian Conservation Trust, 29/01/2007. (http://www.tct.org.au/sub07jan29.pdf)

13 Report of the Biofuels Taskforce to the Prime Minister, Australian Government Biofuels Taskforce, August 2005
http://www.pmc.gov.au/biofuels