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Mathias Cormann
Chair
Senate Select Committee on Fuel and Energy
PO Box 6100
Parliament House
CANBERRA ACT 2600

Emailed (fuelenergy.sen@aph.gov.au)

Dear Senator Cormann

Submission into Inquiry into Fuel and Energy

The purpose of this Submission from Bioenergy Australia is to alert the Committee to the status and significant role bioenergy could make towards the provision of base-load power and towards transportation fuels in Australia, while assisting with domestic energy security, job creation, especially in rural areas, and providing various environmental benefits.

Bioenergy Australia is a nation-wide government-industry alliance of some 78 organisations, established to foster biomass as a source of sustainable energy and for value-added bio-products such as biofuels. Its broad objectives are to:

- Promote an awareness and understanding of the economic, social and environmental attributes of sustainable energy from biomass.
- Broaden the market for biomass by enhancing opportunities, and by helping to reduce financial, regulatory, fuel supply, technical and institutional barriers to enable widespread adoption of biomass energy.
- Facilitate the development and deployment of biomass energy business opportunities and projects.

Bioenergy Australia is also the vehicle for Australia's participation in the International Energy Agency's Bioenergy program, an international collaborative RD&D agreement involving some 23 countries plus the European Commission. The Bioenergy Australia Manager represents Australia on the Executive Committee of IEA Bioenergy, which covers the broad spectrum of bioenergy, including bioelectricity and biofuels. Bioenergy Australia acts as a forum for general and authoritative information dissemination on bioenergy, including drawing on international best practice experiences through its IEA Bioenergy participation.

Please note that this submission may not necessarily reflect the view of individual member organisations.

Biomass refers to organic matter, derived in recent times, directly or indirectly, from plants, as a result of the photosynthesis. It includes a wide variety of materials, from forestry and agricultural residues, to organic waste by-products from various industries, purpose grown energy crops, human sewage and animal manures, to woody weeds and municipal green waste. Bioenergy is the term used to describe energy and energy related products derived from biomass.

Bioenergy can be regarded as a form of solar energy, as photosynthesis combines atmospheric carbon dioxide with water in the presence of sunlight to form the biomass, while also producing oxygen.

The energy bound into the biomass can be recovered through the variety of bioenergy processes and technologies. During the energy recovery process, the carbon dioxide bound in the biomass is released to the atmosphere. Bioenergy is regarded as renewable, when the biomass resource consumed in the energy conversion process is replenished by the growth of an equivalent amount of biomass. Under the Kyoto Protocol bioenergy is regarded as carbon dioxide neutral.

Globally some 220 billion dry tonnes of biomass are produced through photosynthesis per year. The energy stored globally in biomass represents about 0.02% of solar energy incident on earth. This small portion of the absorbed energy is equivalent to approximately eight times the global anthropogenic primary energy consumption of around 400EJ/year. A study entitled, ‘Biomass in the Energy Cycle’ conducted for the former Energy Research and Development Corporation in1994 study identified some 54 million tonnes of broad acre agricultural residues that could be used for Bioenergy in Australia. This would equate to some 5,400 MW of bioenergy capacity. In addition there are many other sources of biomass, such as a major component of urban wastes, sawmill residues, plantation thinnings, sewage and animal manures.

According to the latest International Energy Agency’s data [1], renewable energy sources provide some 12.7% of the world’s total primary energy supply. Of this, some 9.9 percentage points are from renewable combustibles and waste (i.e. biomass). In the OECD countries, renewable combustibles and waste provide 55.7% of the total renewable energy supply.

Biomass can present itself in many forms, from relatively dry (e.g. rice husks) to very wet (sewage can contain 98 percent water). As such, appropriate technologies are required to convert the biomass to the desired end products. Converting the biomass can utilise a variety of paths and technologies. The primary conversion processes are via thermal, biochemical or mechanical/physical processing.

Figure 1 illustrates the range of energy processing paths for converting biomass to energy, chemical feedstocks and liquid biofuels. These are briefly explained below, coupled with providing examples of the commercial status of several bioenergy technologies.

Thermal (or thermo-chemical) energy conversion is generally applicable to drier biomass. The most familiar and commercially mature form of thermal energy conversion is combustion.

Combustion of biomass accounts for approximately 90 percent of the 52,000 MW of modern bioelectricity power plants world-wide, and is very similar to technology applied to solid fossil fuels such as brown coal. Excess air is applied for the combustion process to convert

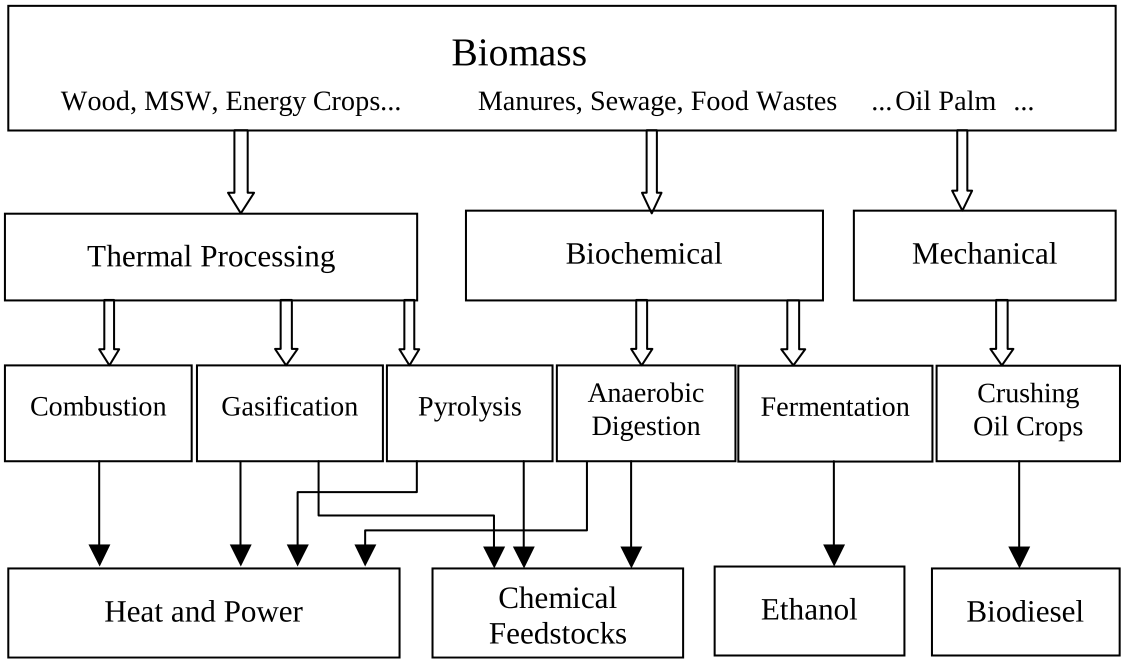


Figure 1: Bioenergy Conversion Routes

the biomass essentially to carbon dioxide and water vapour, liberating the stored energy in the biomass. Besides direct combustion, biomass can be co-combusted with coal in large utility boilers. Co-firing of biomass with coal is allowable under Australia's Mandatory Renewable Energy Target (MRET), if the biomass source itself complies with the relevant Regulation administered by the Office of the Renewable Energy Regulator. Combustion technologies are mature technologies and have some advantages in terms of a low technological risk and cost.

Examples of biomass combustion plants are the bagasse fired plants in the sugar industry, where for instance the Pioneer Mill in Queensland has 68MW of electrical generation. Other examples are the Rocky Point Sugar Mill cogeneration plant of 30 MW electrical capacity, and two 30MW plants recently commissioned at the Condong and Broadwater sugar mills on the NSW north coast. Co-firing has also been conducted at various Australian power stations, such as Liddell, Wallerawang, Muja power stations.

As an overseas example of a typical combustion bioenergy plant, Fig 2 shows an aerial photograph of the 36 MW Greyling Power Station in Michigan, USA. This plant operates on wood waste with steam conditions 510^{o}C and 8.8 MPa.

The Cuijk Fluidised Bed Combustor (FBC) power plant in the Netherlands near the German border is a prime example of this technology. This 25 MW_e wood-chip plant has a steam temperature of 525 °C and a pressure of 10 MPa. Figure 3 provides an aerial view of the Cuijk FBC plant. The two round buildings with conical roofs in the foreground provide covered fuel storage. Fuel is supplied by road and by barge. The plant uses dry cooling to condense the steam. As such, this plant uses minimal amounts of cooling water.

Figure 2 :   36.2 MW Grayling Power Station in USA   (photo NREL)

Figure 3: Aerial Photo of Cuijk 25 MW power plant (source Essent Energy)

One of the world's largest biomass boilers is at the Alholmens Kraft Power Plant on the west coast of Finland. The boiler has a capacity of 550 MW_{th} and an electrical capacity of 240 MW_e. This sophisticated plant incorporates reheating of the steam with superheater steam conditions being 545°C and 16.5 MPa, with reheat steam conditions being 545°C and 16.5 MPa. This power plant is in part supplied by slash bundle (tree harvesting logging waste) biomass railed to the power plant. Figure 4 provides an aerial view of the plant, with the 'slash' bundles at the bottom right of the photo.

(source: VTT)

Figure 4: Alholmens Kraft Bioenergy Plant in Finland

Figure 5 shows the turbine hall with the 240 MW steam turbo-generator.

(source: VTT)

Figure 5: Alholmens Kraft Turbine Hall Showing 240 MW Steam Turbo-Generator

A recent trend in some parts of the world is to use multifuel combustion energy plants, including use of biomass fuels. A prime example is the Avedore 2 Combined Heat and Power (CHP) plant located just outside of Copenhagen, Denmark. This power plant opened in mid 2002. It is has a multifuel capability, using both solid biofuels and natural gas. The biomass fuel consists of straw bales (200,000 tonnes per year) and wood pellets (300,000 tonnes per annum). The plant has an ultra super critical boiler with the steam conditions being 580-600°C and 300 bar (very similar to the Tarong North coal fired power station in Queensland). The overall plant efficiency is some 94% in combined heat and power mode. The pellets are manufactured at a nearby factory at Køge, mainly using imported logs and some are also imported, mainly from Sweden. The Køge pellet plant consists of 18 pellets presses. The main supplier of the CHP plant was Danish FLS Miljö. The output of the CHP plant is 570 MW_e and 570 MW_{th}. The Avedore 2 unit is shown below (rear and to left) in Figure 6 adjacent to Unit 1 which is coal fired. During the design phase, Unit 2 was converted from coal firing to mainly biomass and natural gas. Biomass at times provides some 70 percent of the fuel energy of this Avedore power plant.

(source: E2 Energi)

Figure 6: Avedore 2 Bioenergy Power Plant (taller unit)

Gasification uses a reduced amount of air or oxygen. In gasification combustible gases are liberated from the biomass, to produce a fuel or chemical feedstock. This gas is rich in carbon monoxide and hydrogen gases and can be used to fuel gas engines, gas turbines, or act as a chemical feedstock for the production of chemicals such as methanol or other synthetic fuels. The product gas is very similar to that produced from coal and reticulated around Australian cities before the advent of natural gas.

Biomass gasification is not as advanced as combustion technologies, but has been deployed to a limited extent in Australia. For instance Forestry Tasmania has had a small scale wood gasifier accredited by ORER fuelling a spark ignition engine. Overseas in the USA and Europe biomass gasification has reached commercial scale demonstration, with plants having operated in Burlington Vermont, USA, Gussing in Austria, Värnämo in Sweden. Biomass has also been co-gasified with coal at the flagship Buggenum gasifier in the Netherlands.

Biomass Integrated Gasification Combined Cycle (BIGCC) has been developed to maximise the energy conversion efficiency of biomass to electricity. In BIGCC gasified biomass powers a gas turbine, with the exhaust heat of the gas turbine raising steam to power a steam turbine. As such, electricity is provided by both the gas and steam turbines, resulting in overall higher thermal efficiency. In some instances heat is extracted from the BIGCC plant for district heating, raising the overall efficiency even further.

The world's first BIGCC demonstration plant was built in 1996 at Värnämo in Sweden by the Finnish engineering firm Ahlstrom and the Swedish utility Sydkraft. The plant used a pressurised version of Ahlstom's atmospheric pressure 'Pyroflow' circulating fluidised bed gasifier and supplied 6 MW of electricity and 9 MW of district heating. The air-blown gasifier operated at a temperature of 950-1000°C and 22 bar and incorporated a hot gas clean up system to remove tar and particulates. The gasifier was operated as a demonstration plant and clocked up some 8,500 hours gasifier operation and 3,600 hours BIGCC operation until the demonstration project was completed. Subsequently commercial considerations led to this plant being mothballed. This gasifier is now used for European Union research into producing liquid transportation fuels from gasified biomass. Figure 7 provides a schematic of the Värnämo BIGCC plant and Figure 8 provides an aerial photo of the plant.

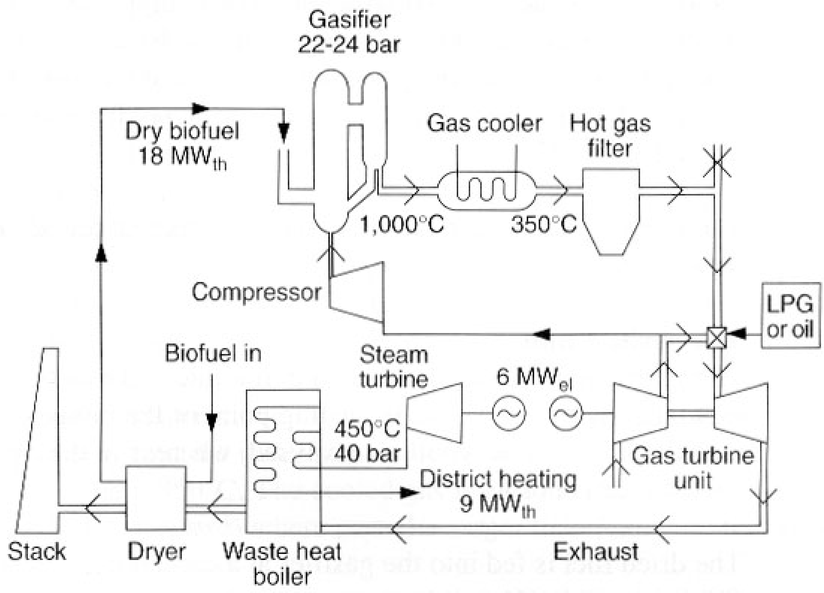


Figure 7 :   Värnämo Schematic   (sketch IEA)

Figure 8 :   Värnämo BIGCC plant, Sweden

Pyrolysis of biomass takes two forms, slow pyrolysis as traditionally applied to charcoal making, or fast pyrolysis (flash pyrolysis), which mainly produces a combustible liquid fuel which can substitute for diesel or act as a chemical feedstock. Fast pyrolysis can convert up to 75% of the mass of the dry biomass to bio-oil Pyrolysis occurs in the absence of oxygen under controlled conditions. Pyrolysis bio-oil is quite different to petroleum diesel, having a much higher specific gravity (1.2) and other physical and chemical properties. Bio-oil has approximately 60 percent the energy density of diesel on a volume for volume basis, and has been developed to the stage where commercial projects are beginning to emerge, after some 20 years of bio-oil development.

A leader in the pyrolysis bioenergy area has been Canadian company Dynamotive, who have built a 100 tonne/day biomass (input plant) in Ontario, Canada, where the bio-oil powers a 2.5 MW combustion turbine. Australian company, Renewable Oil Corporation has acquired a licence from Dynamotive and are developing projects in Australia to implement this technology.

Figure 9 shows the Dynamotive plant in Ontario, Canada, with the Orenda 2.5 MW combustion turbine in the foreground.

Figure 9: Dynamotive Plant in Canada (source: Dynamotive)

Biochemical conversion of biomass uses microbes to convert the biomass into energy related intermediate products such as methane or ethanol. A common example of biochemical conversion occurs in landfills, where anaerobic organisms convert garbage into a mixture of methane and carbon dioxide, in roughly equal proportions. Often this combustible gas is captured and used for producing electricity in gas engines or turbines driving alternators.

Australia has in excess of 170 MW of landfill gas power generation, which is a prime example of this technology. The largest plants are in excess of 10 MW per installation. EarthPower Technologies have also established a biodigester near Parramatta, NSW where they produce 3 MW of renewable electricity, plus a fertiliser co-product from the digestate.

Mechanical means can also be applied to oil seeds to produce a biomass oil. This oil, (or for instance animal fat), can be further converted to biodiesel through an esterification process involving methanol or ethanol and a catalyst such as potassium hydroxide. Verve Energy in WA have trialed biodiesel from tallow as the fuel in a combustion turbine at Kalgoorlie, WA and have had a tender out to source 1 million litres of such fuel for electricity production. In addition, a byproduct of biodiesel production is glycerine. This has been co-fired with coal at a NSW power station.

Some aspect of bioenergy that are worthy of note are:

- Bioenergy has an advantage over other forms of renewable energy such as wind and direct solar energy. As the energy bound into the biomass provides inherent energy storage, bioelectricity can be dispatched, providing firm capacity, unlike some other sources dispatched by nature. Additional energy storage is therefore not required for bioenergy. This allows excellent utilisation of the bioenergy plant's capacity. Many of the newer bioenergy plants have capacity factors in excess of 90 percent, on a par with coal fired units.
- Besides greenhouse gas abatement, a benefit of bioenergy that is of considerable interest in Australia is the combating of dryland salinity (e.g. in the Murray Darling Basin and in the WA wheatbelt). In Western Australia some 1.8 Mha of land is affected or is at high risk from dryland salinity. Without intervention this is expected to rise to 7.5 Mha by 2050, resulting in the loss of productive agricultural land. One way of addressing rising water tables and resulting dryland salinity, is through the planting of oil mallee eucalypts. Their deep roots act as water pumps, lowering water tables and mitigating the problem. To date some 30 million oil mallees have been planted for this primary purpose, and also for the provision of biomass for energy and other prospective value-added products. As such, tree crops can provide the dual function of providing landscape solutions in degraded landscapes as well as providing fuel for bioenergy. The Australian Conservation Foundation (ACF) produced a report 'Fuelling Landscape Repair' noting the merit of planting trees to rehabilitate land, and also providing an energy feedstock.

  Verve Energy (formerly Western Power Corporation), in conjunction with Enecon Pty Ltd and the Oil Mallee Company have completed trials of an Integrated Wood Processing plant at Narrogin, WA. This 1 MW demonstration pilot plant produced renewable bioelectricity, activated carbon and eucalyptus oil (as an industrial solvent). Verve is now seeking joint venture partners to further develop this technology, including for dispatchable electricity.
- There are employment opportunities from the ongoing requirement to source and provide fuel for the life of a bioenergy project (a 30 MW bioelectricity plant would require close to 300,000 tonnes of biomass per year). An assessment by IEA Bioenergy [2] indicates an employment level of some 180-500 person-years/TWh of fuel energy.
- Bioenergy has provided approximately 25% of surrendered Renewable Energy Certificates (RECs) under the MRET scheme.

Greenhouse Gas Balances of Bioenergy Systems

Life cycle analysis applies a methodical 'cradle-to-grave' assessment of a technology, within pre-defined system boundaries to assess the particular technology's use of resources for its manufacture, use and eventual decommissioning. This assessment is generally applied to inputs as well as outputs associated with the technology. Of particular interest for various energy technologies are the life cycle emissions of 'carbon dioxide equivalent' gases.

Table 1 shows the results from a UK Department of Trade and Industry study [3], partially based on an IEA study, comparing the life cycle emissions of carbon dioxide for various conventional and renewable energy technologies. On a life cycle basis, greenhouse gas emissions of bioenergy systems are project specific, but typically in the range 4-50 grams CO_2 equivalent/kWh. The high level for municipal solid waste incineration is largely a result of the high fossil fuel content of unsegregated wastes. By comparison, photovoltaic technology is reported at over 150 grams CO_2 equivalent/kWh.

Table 1: Life Cycle Carbon Dioxide Equivalent Emissions for various technologies (g/kWh) (adapted from [3]).

Technology	g/kWh CO_2
Brown Coal: Current Practice	1100-1300
Bituminous Coal: Best Practice	955
Gas: Combined cycle	446
Diesel: Embedded	772
Onshore wind	9
Hydro - existing large	32
Hydro – small-scale	5
Decentralised photovoltaic (PV)- retrofit	160
Decentralised PV – new houses	178
Decentralised PV – new commercial	154
Bioenergy Technologies	
Bioenergy – poultry litter - gasification	8
Bioenergy – poultry litter – steam cycle	10
Bioenergy – straw – steam cycle	13
Bioenergy –straw - pyrolysis	11
Bioenergy – energy crops - gasification	14
Bioenergy – Forestry residues – steam cycle	29
Bioenergy – Forestry residues - gasification	24
Bioenergy – animal slurry – anaerobic digestion	31
Landfill gas	49
Sewage gas	4

Industry Status

Table 2 lists operating renewable energy projects in Australia at 31 December 2005, while Table 3 lists the capacities of projects under construction [4]. As of 31 December 2005 there were a total of 96 bioenergy projects in Australia with a combined capacity of 646 MW. In addition 144 MW of bioenergy capacity was under construction, consisting of 86 MW bagasse, 34 MW landfill gas, 13 MW wood waste and 11 MW from other sources. It is believed that the Clean Energy Council (formerly the BCSE) has more up to date information on bioenergy and other renewable energy plants in a more up to date plant register.

Table 2: Operating Bioenergy Projects

Biomass Source	Number of Projects	Capacity (MW)
Bagasse	28	406.3
Paper Industry Wastes	3	76.5
Crop Wastes	1	1.5
Food Anaerobic Digestion	2	4,1
Landfill Gas	49	130.1
Municipal Solid Waste	1	1.4
Sewage Gas	10	17.9
Wood Waste	2	8.5
Total	96	646.2

Table 3: Bioenergy Plants Under Construction

Biomass Source	**Number of Projects**	**Capacity (MW)**
Bagasse/Wood	3	85.5
Energy Crops	2	1.1
Landfill Gas	8	33.8
Sewage Gas	2	10.8
Wood Waste	1	13.5
Total	16	144.7

The Committee should be aware that there are a number of bioenergy projects that have not as yet gone ahead for a variety of reasons, mainly due to the low and uncertain market for bioenergy and also difficulties and cost associated with fuel supply. Examples of these plants are three 40 MW scale plants in Western Australia, two similar scale plants in Tasmania, and a plant in the Green Triangle in eastern SA/western Victoria. A number of anaerobic digester plants have also been under consideration, and could possibly go ahead with added incentives, such as the mooted Renewable Energy Target and the Carbon Pollution Reduction Scheme (assuming an adequate price on carbon emissions).

The Committee's attention is also drawn to a major publication from the Federal Government's Rural Industries Research and Development Corporation entitled 'Biomass Energy Production in Australia – status, costs and opportunities for major technologies, which may provide the Committee with added information of the prospects for bioenergy in Australia.

Biofuels

The present generation of biofuels are largely based on ethanol and biodiesel, with Australia having a national target of 350 ML/a biofuels production by 2010. This national biofuels target for 2010 is approximately 1% of current petroleum fuels use in Australia, substantially less than many overseas targets.

New technologies for producing biofuels are being developed world wide, based on gasification of biomass and synthesis to form fuels such as methanol, DME (dimethyl ether) and hydrogen. The advantage of this route is that yields of biofuel would be approximately twice that of current biodiesel and ethanol production on a per hectare basis (Ref. VW presentation at SYNBIOS conference noted below), i.e. 3,100 litres diesel equivalent per hectare per annum. These processes for converting biomass to fuels are shown diagrammatically below.

Volkswagen in Germany is trialling a fuel called Sundiesel™, which is produced via the gasification of biomass, and synthesis to a synthetic diesel via Fischer Tropsch technology. This concept is not too dissimilar to the very large oil-from-coal industry, long established in South Africa, but importantly based on renewable biomass feedstocks. Similarly, Volvo in

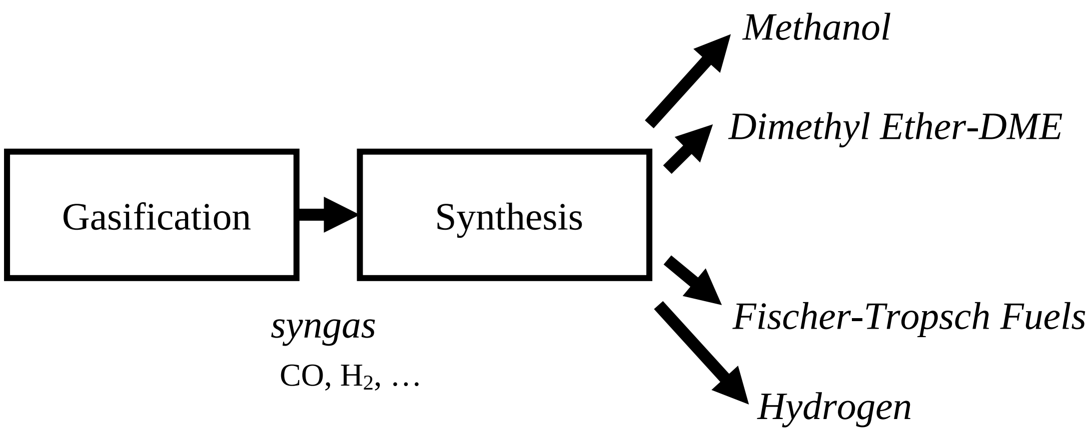


Figure 10: Thermochemical Biofuel Routes

Sweden is developing Dimethyl Ether (DME) as a transport fuel. DME is similarly derived from biomass gasification, having properties not too dissimilar to LPG. The photo below shows a Volvo DME truck being displayed at the May 2005 SYNBIOS conference.

(source: S Schuck)

Figure 11: Dimethyl Ether (DME) Truck on Display

Producing alcohol fuels from wood has been the subject of a Joint Venture Agroforestry study (*Wood for Alcohol Fuels – using farm forestry for bioenergy*), available from the Rural Industries Research and Development Corporation (www.rirdc.gov.au) as Project No. EPL-2A, Publication No. 03/018. This report examined the wide scale planting of mainly oil mallee eucalypts for salinity control, and using the coppiced biomass for methanol and ethanol production, either via the gasification route of via the hydrolysis of the biomass and fermentation of the cellulose and hemicellulose derived sugars.

The CSIRO (Barney Foran et al) produced several reports over a long period, examining future fuel scenarios. They concentrated on methanol and ethanol fuel futures. It is suggested, that the Committee re-examine these studies, to gauge the opportunities for large scale deployment of such technologies to meet our future fuel supplies.

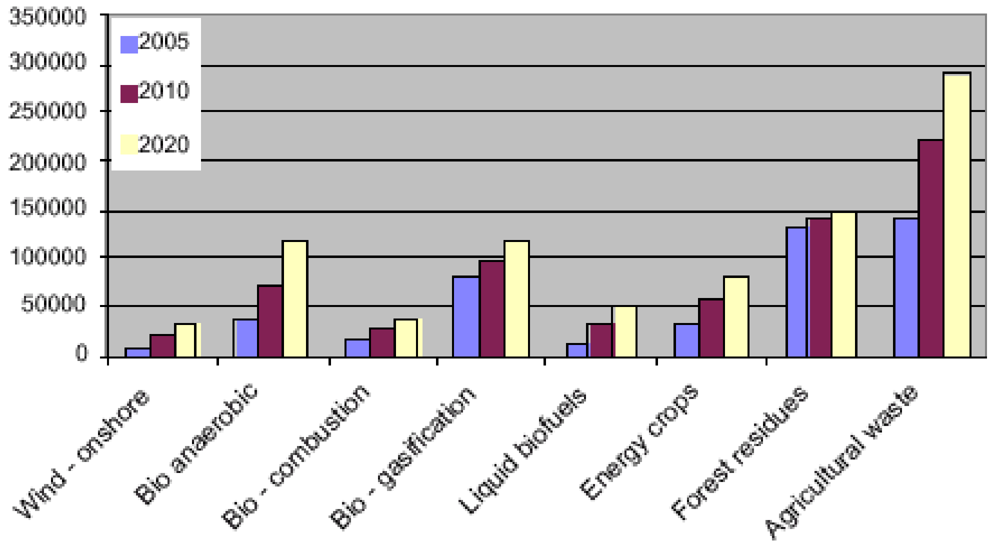
One emerging technology that could help address our fuel future is to cultivate high lipid content algae (a form of biomass), by possibly growing the algae in carbon dioxide rich environments (for instance supplied from the stack of a gas fired power station), and extracting the oil for a biodiesel feedstock. Several organisations have been developing this technology in Australia. RIRDC has also funded a study on growth parameters for a type of microalgae. SARDI in Adelaide is hosting a major algae research project for the production of fuel and other value added products. This is in part-funded via the NCRIS (National Collaborative Research Infrastructure Strategy) program, with this element being managed by AusBiotech. Another algae project is being conducted in Western Australia, under an Asia Pacific Partnership grant from the Federal Government. An advantage of algae is that it does not require arable land, and can use saline water to produce various types of biofuels. It is suggested that such innovative pathways for meeting future energy need be encouraged and supported.

Bioenergy Australia is the vehicle for Australia's participation in the International Energy Agency's Bioenergy Program (www.ieabioenergy.com). It is currently participating in five Tasks: Task 30 *Short Rotation Crops for Bioenergy Systems*, Task 34 *Biomass Pyrolysis*, Task 38 *Greenhouse Gas Balances of Biomass and Bioenergy Systems*, and Task 39 *Commercialising First and Second Generation Biofuels*, and Task 42 *Biorefineries: Coproduction of Fuels, Chemicals, Power and Materials from Biomass.* Such participation is exposing Members of Bioenergy Australia to the latest developments in liquid biofuels, and contributes to the development of alternatives to fossil fuels.

Energy crops could provide the feedstocks for substantial biofuel industries (noting the above developments). Such industries, besides contributing to our future fuel mix and energy security, would stimulate rural economies and provide permanent jobs through the production of the biomass and the supply logistics.

Job Creation

Bioenergy is known to have impressive economic multipliers, translating into employment



Projected employment in the EU for biomass technologies. Wind is included for comparison.
Source: EU Altener Report: Impact of RES on Employment, 2000.

Figure 12: Employment from Bioenergy Technologies

opportunities, especially in rural and regional areas. Figure 12 from a European Union study shows the impressive job creation potential of bioenergy.

Thank you for the opportunity of providing this submission. I would be most pleased to provide follow-up information and assistance to the Committee. This would hopefully lead to bioenergy opportunities contributing significant capacity to the generation mix and to future fuel supplies in Australia in the near future.

Yours Sincerely

Dr Stephen Schuck
Bioenergy Australia Manager

References:

[1] International Energy Agency, *Renewables Information*. IEA Statistics 2008. Paris, France, 2008.

[2] Danielsson, Bengt-Olaf. Employment Effects of Wood Fuel Harvesting, page 142 of IEA Bioenergy, *Forest Management for Bioenergy*, The Finnish Forest Research Institute, Vantaa, 1997.

[3] *New and Renewable Energy: Prospects in the UK for the 21st Century – Supporting Analysis*, page 202. UK Department of Trade and Industry, March 1999.

[4] Business Council for Sustainable Energy, *Renewable Energy Plant Register*, 31 December 2005. http://www.bcse.org.au/default.asp?id=172