Bioenergy Industry

Report
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Clean Energy Council

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Summary

This report was commissioned by the Clean Energy Council to provide its members with a status report on the Australian stationary bioenergy market, commentary on international markets for bioenergy, to indicate broadly the economics of bioenergy, and to give an indication of technology trends in this sector.

The Australian Bioenergy Market

The supply of bioenergy is largely shaped by specific biomass fuels, conversion technologies, cost of producing the energy, and the companies involved in deploying the technologies, while the demand element is shaped by energy needs, the regulatory framework for renewable energy and bioenergy, cost and availability of competing energy sources, customer preferences and the routes to the energy markets.

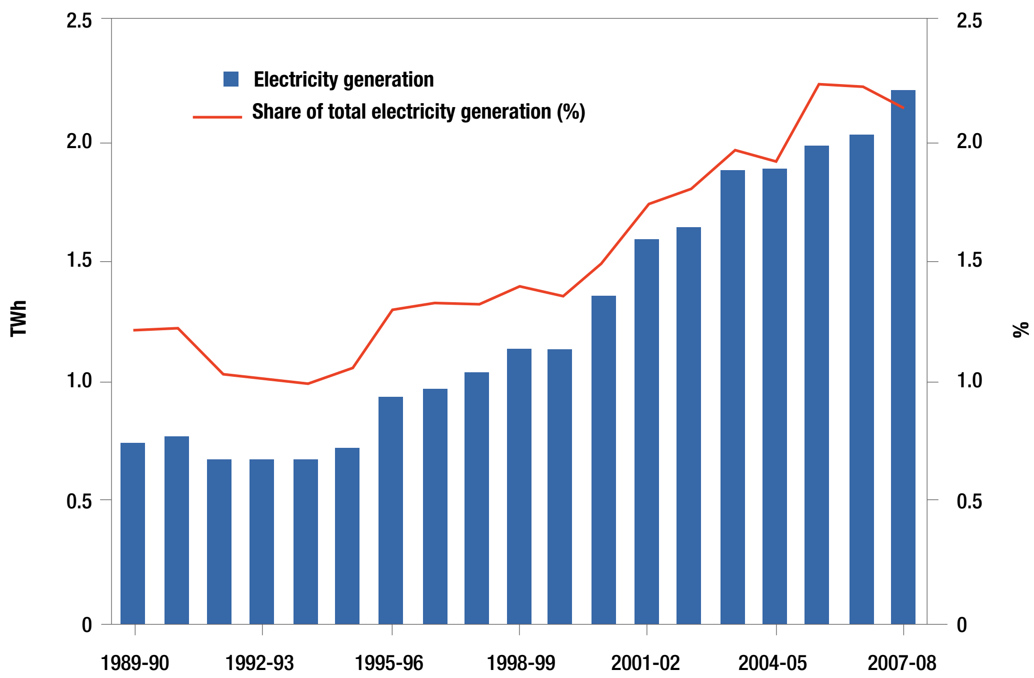
Bioenergy, unlike many other forms of renewable energy may be an adjunct to another process, such as: management of a waste stream; part of a landfill gas management plan; planting of oil mallee eucalyptus for the combination of land repair, shelter belts and as an energy crop; co-production of other value-added biobased products, in addition to energy. Bioenergy is often part of an integrated solution, of which energy is but one component. The sources of biomass are many and varied, requiring matching technologies to efficiently extract the energy. Bioenergy has a spectrum of technologies, from mature combustion and engine technologies, through to technologies such as gasification and pyrolysis which are not as well established in the market.

Like other forms of renewable energy, the market for bioenergy has largely been driven by the Mandatory Renewable Energy Target and its successor schemes, the RET (Renewable Energy Target) and the announced LRET (Large-scale RET) and SRES (small-scale renewable energy scheme) which is due to commence in 2011. The REC (Renewable Energy Certificate) price has been volatile and depressed for much of the past year. This has been largely due to the REC market having been flooded by solar photovoltaic and solar hot water RECs, which receive incentives not available to bioenergy. While spot REC prices have recovered to around $42 since the announcement of the separate LRET from the SRES, market confidence is unlikely to be instilled in the industry until more certainty is provided on the LRET and the small scale technologies still being generated are fully acquitted, and the broader market for RECs from the LRET picks up. An allied issue for the stationary bioenergy market has been the depressed wholesale price of electricity, which for a number of power industry reasons has been about a third lower than one year ago in the interconnected power system from South Australia to Queensland. The combination of low and volatile REC prices coupled to a low wholesale price for electricity, which is only projected to recover circa 2013, has provided a disincentive for new utility scale bioenergy projects. The report also notes that thermal energy from biomass is not supported by government incentives in Australia.

Market Penetration

In 2007-2008 biomass provided approximately 4 % of Australia's Total Primary Energy Supplies, providing 78% of Australia's renewable energy. Contributing to this is 4 million tonnes per year of fire wood used in Australia, mainly for domestic space and water heating. Bioenergy currently provides some 0.9 percent of Australia's electricity generation [1]. Bioenergy has contributed slightly less than one quarter of the new renewable electricity generated in Australia under the Mandatory Renewable Energy Target (MRET). Bioenergy generation under MRET (and now the RET) is primarily from bagasse-fired power plants at sugar mills and landfill gas.

Figure S.1: Australian Bioelectricity Production



Source: ABARE and [2]

Australia currently has 867MW of dedicated installed bioelectricity capacity, ignoring the contribution of biomass via co-firing with coal. Over half this capacity is from bagasse combustion in the sugar industry, with the second largest contributor being biogas, mainly landfill gas. The contributions to this capacity, by source and states is presented in Table S.1

Table S.1: Australian Bioelectricity Generation (MW), 2009

	Biogas	Bagasse	Wood Waste	Other bioenergy**	Total bioenergy
New South Wales*	73	81	42	3	199
Victoria	80	0	0	34	114
Queensland	19	377	15	4	415
South Australia	22	0	10	0	32
Western Australia	27	6	6	63	102
Tasmania	4	0	0	0	4
Northern Territory	1	0	0	0	1
Australia	226	464	73	104	867
Share of total renewable electricity capacity (%)	2.2	4.4	0.7	1.0	8.3

Source: Geoscience Australia 2009

*includes the ACT

** Unspecified biomass and biodiesel

Market Sectors

Sugar

A major form of bioenergy in Australia is cogeneration in Australia's 28 operating sugar mills. In 2006 bagasse produced approximately 1,200 GWh of electricity, exporting 600 GWh to the national electricity grid. Bagasse has a strong base for further expansion, being projected in the CEC Australian Bioenergy Roadmap [1] to reach an estimated 7,800 GWh per year by 2050.

Landfill Gas

Australia has been at the forefront of landfill gas development, with 70 landfill generation sites, mostly base load power producers having a combined capacity of approximately 170 MW. In 2009 the landfill gas sector generated and exported 950 GWh of electricity, making it the largest bioenergy contributor to the grid in Australia.

Biogas

Most of the larger sewage treatment plants incorporate digesters to capture biogas (up to 75 percent methane) to produce bioelectricity. The technology ranges from large covers over ponds to tank digesters.

Agricultural and Food Processing Wastes

The CEC Australian Bioenergy Roadmap [1] noted the tremendous potential for increased use of agricultural wastes in Australia, from an estimated 791 GWh per year in 2020 to 50,566 GWh in 2050.

Forestry Wastes

Bark, sawdust and other timber milling wastes have found applications for on-site thermal energy. Applications include log steaming at veneer mills and kiln drying of sawn timber. The thermal energy may be used for producing hot water, steam or if higher temperatures are required, thermal oil. The report identifies and tabulates 58 wood fuelled installations for thermal energy. The report also lists 15 bioelectricity installations using wood wastes (including two black liquor bioenergy plants).

Energy Pellets and Briquettes

The European market for bioenergy is creating a strong international demand for wood energy pellets. The current European market is 12 million tonnes per year of pellets, expected to grow to 30 million tonnes per year by 2020. This is now leading to export pellet mills being established in Australia, with the first 250,000 tonnes per year mill having been set up in Albany, Western Australia, with further mills under development.

Municipal Solid Waste and Refuse Derived Fuel

While there have been some development activities in this area, and some use of this fuel for co-firing, this sector is yet to implement any projects of scale in Australia.

Energy Crops

Oil mallee eucalyptus has been under development in Australia for over a decade, with a pilot plant based on this feedstock having been trialled at Narrogin, Western Australia. Delta Electricity has also launched a substantial trial involving ten farmers in the Central West of NSW to grow mallees for wood energy pellet manufacture and trial co-combustion with coal. Several other agricultural groups are also investigating agricultural energy crops.

Future Market for Bioenergy

The CEC Australian Bioenergy Roadmap [1] indicates that biomass currently provides approximately 0.9 percent of Australia’s electricity generation. The Roadmap also indicates that by 2020 the contribution from biomass for electricity generation could be 10,624 GWh per year or some six times the current generation. It further identifies the long-term potential for electricity from biomass in 2050 to be as much as 72,629 GWh per year, which is 40 times the current levels. An Australian Business Roundtable on Climate Change report (by the Allen Consulting Group) estimates that bioenergy could supply between 19.8 and 30.7% of Australian electricity needs by 2050 [3]. The Clean Energy Future for Australia study, funded by the former BCSE (now the Clean Energy Council) found that biomass could provide up to 29 percent of the generation mix by 2040 using known technologies and resources.

Market Participants

Bioenergy embraces a wide spectrum of industry participants, from fuel sourcing, supply logistics, energy conversion, equipment suppliers, those involved in the sale and distribution of the output energy, to bioenergy consultants and expert advisers. This spans a range of industries, including agriculture, forestry, food processing, cartage contractors, urban waste management, and also regulatory authorities. The report identifies several participants in the various industry sectors to provide a profile of market participants. This essentially elaborates on the Market Penetration section of the report, by giving further details on those in the market and their projects. Appendix A of the report lists the various power plants by industry sector category. The report notes other industry participants such as power companies, equipment suppliers, project developers and those providing support services to the industry.

Fuel Supply Aspects

Fuel supply for bioenergy is a key consideration, as over half the cost of the electricity produced can be related to the fuel cost. The fuel could be a waste stream with a low or even negative cost (if it has to be otherwise disposed of at a cost). At the other extreme the fuel could be from an energy crop, being relatively expensive, requiring inputs such as land, water, fertiliser, harvesting, pre-conditioning and long distance transport to a power plant. A bioenergy plant with an economic life of 20-25 years requires a constant and reliable supply of biomass, meeting a pre-determined specification. The biomass needs to be sustainably sourced, be free of contaminants, preferably have low moisture content, and have appropriate physical characteristics.

At the present time there is not a well developed biomass market in Australia with many competitors and established prices. Many potential suppliers of biomass are unfamiliar with the bioenergy industry. Several bioenergy project developers have spent substantial resources identifying and contracting biomass supplies for projects under development. As such, project specific resources and their cost are closely guarded.

Regulatory Framework for Biomass and Bioenergy

The Renewable Energy Target (RET) underpins the market for renewable electricity and bioelectricity in Australia. The RET has and is currently evolving from the former MRET to the Enhanced RET and now the Expanded RET.

On 26 February 2010 the Australian Government announced that the small scale technologies, predominantly solar hot water systems and solar photovoltaic systems, which have recently dominated the Renewable Energy Target market, will be split off into a Small-scale Renewable Energy Scheme (SRES), with a capped price of $40 per Renewable Energy Certificate. An amended 41,000 GWh per annum target by 2020 for utility scale renewables, designated LRET (Large-scale Renewable Energy Target) would be introduced from 1 January 2011. The main enabling legislation that is applicable for bioenergy is the **Renewable Energy (Electricity) Act** and the **Renewable Energy (Electricity) Regulation** as amended. The eligibility of biomass under the RET is tightly controlled, largely excluding the use of native forestry harvesting residues (due to overriding state regulations). The report notes how for instance NSW's **Protection of the Environment Operations Act** prohibits both in-forest harvesting residues and **"waste arising from activities (such as woodchipping or the manufacture of railway sleepers) carried out at the location from which the Australian native trees are harvested"** being used for electricity production at any appreciable scale (>200 kW).

Overseas Market Trends

Biomass, in its various forms meets approximately 10 percent to the world's approximate 500 EJ energy demand, as illustrated in Figure S.2.

The International Energy Agency [5] reports that in the OECD countries electricity generation from solid biomass grew from 93.1 TWh to 115.9 TWh between 1990 and 2006, yielding a 1.4% average annual growth. As the second largest renewable electricity source after hydropower, solid biomass accounted for 7.2% of renewable electricity in 2006. The USA accounted for 36.1 percent of electricity generated from solid biomass (41.8 TWh) where it makes up 10.6% of the country's renewable electricity production.

Renewable municipal waste represented 1.7% of renewable electricity generation in 2006 in OECD countries. The largest producer of electricity from renewable municipal waste was the United States, generating 36.1% of OECD production.

Globally, electricity from biogas grew from an estimated 3.59 TWh in 1990 to 24.54 TWh in 2006. A large proportion of the production took place in OECD Europe (63.1% in 2006). The largest producers in the European Union were Germany, followed by the UK.

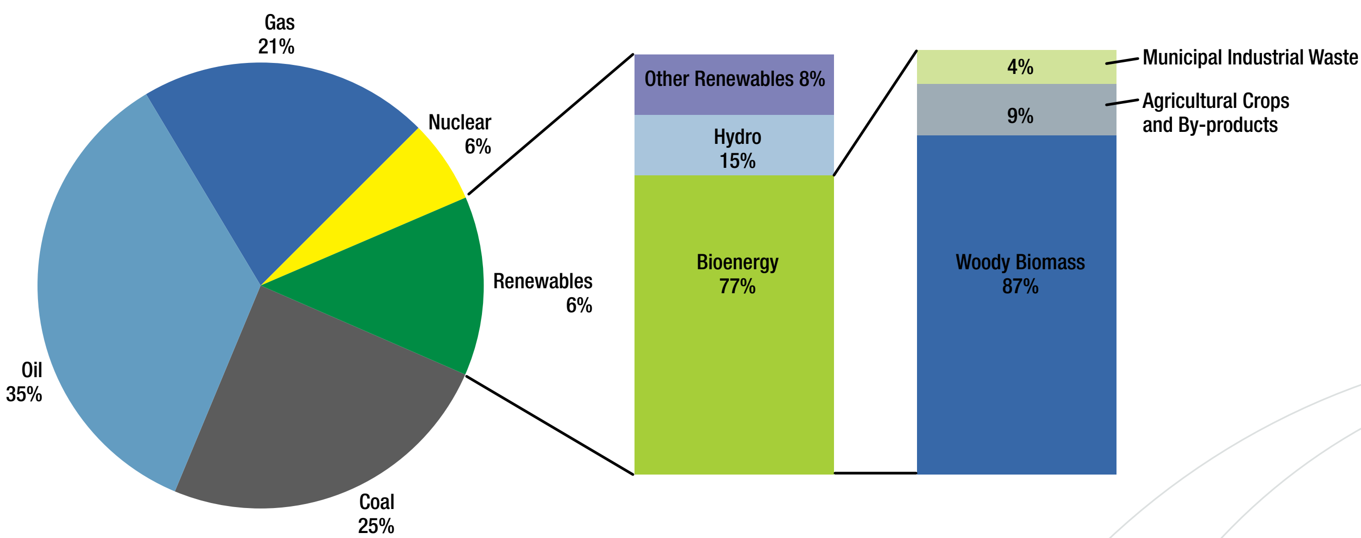
According to the IEA [5], within developed countries, Finland provides 20.1% of its Total Primary Energy Supplies from biomass (combustible renewables and waste), Sweden 17.5% and Denmark 11.9%. The equivalent figure for Australia is 4.9%, which includes space and water heating using firewood. In the EU, 55 TWh of electricity from biomass were produced in 2004 (roughly the annual consumption of Switzerland), mostly from wood residues and MSW. Finland is proportionately the leading producer with 12% of its power consumption produced from biomass and wastes.

China is in the midst of a fundamental shift in how it powers its rapidly expanding economy. By the end of 2009, the capacity of newly-built bioenergy facilities surpassed the government's 2010 target of 5.5GW. By 2020, China aims to expand this production to 30GW, which will require major investments in advanced foreign technologies.

In OECD countries the volume of biomass for residential heat is expected to grow by 40-90% to reach 3.2-4.3 EJ in 2030, mostly due to the growing market for modern boilers and stoves. The global use of biomass and waste in the industrial heat sector is expected to increase slowly, in line with increased energy demand, by between 1.9% and 2.2% annually to reach close to 13 EJ by 2030.

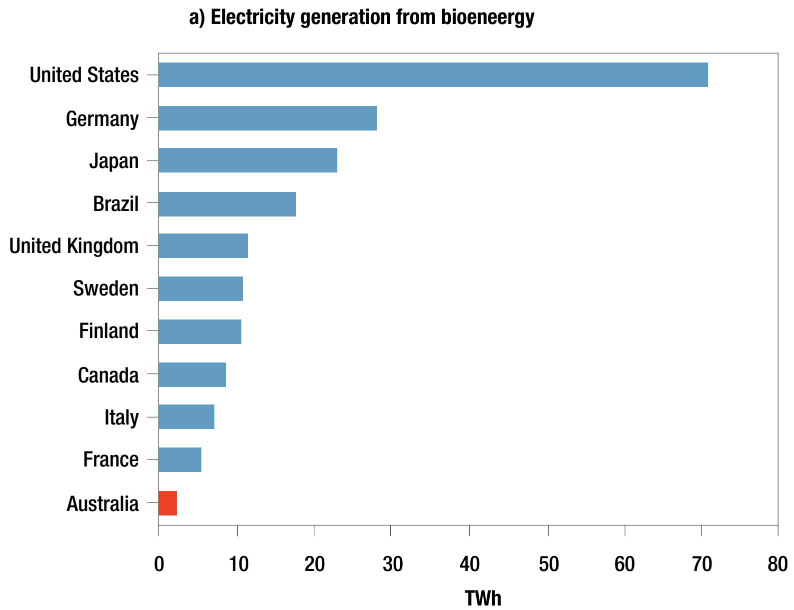
Figure S.3 [2] shows bioelectricity generation in various countries, both in absolute and relative terms, showing the relative position of Australia.

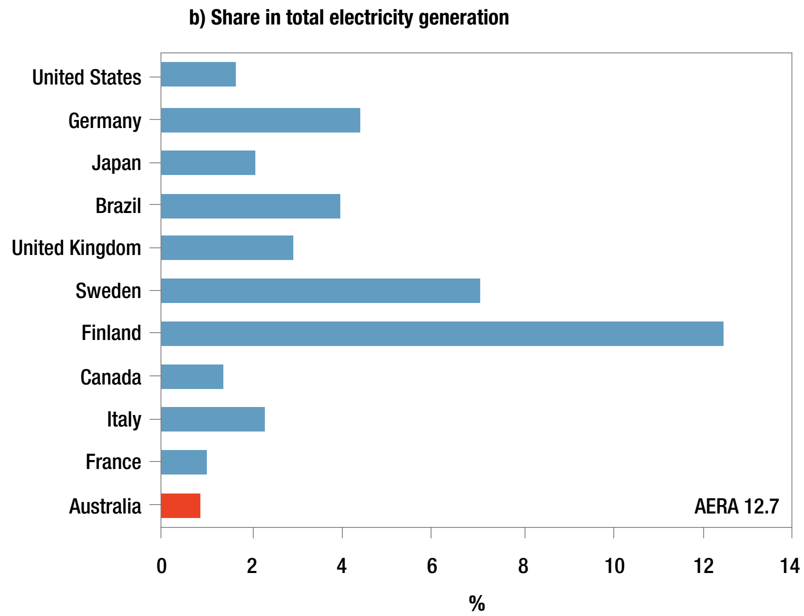
Figure S.2: Share of Bioenergy in Global Primary Energy Mix



Source: IEA Bioenergy [4]

Figure S.3: Bioelectricity Generation by Country





Source: Geoscience Australia [2]

The report gives several examples of flagship bioenergy projects – electricity, cogeneration and bioheat projects from Europe, including a 125 MW coal fired power plant in Belgium which has been converted to run exclusively on wood pellets.

Green Gas has become a relatively new product in the European market, with the German Government having a target of 10% of the gas being derived from biogas in the gas grid by 2030. That government has provided feed-in regulations since March 2008 which provide new incentives for on-farm biogas plants and waste treatment. The total number of farm-based biogas plants in Germany has increased from a few in the 1980s to approximately 4,800 with a combined electricity capacity of 1,600 MW at the present time. Energy from Waste plants are also relatively common in Japan and parts of Europe, where land tends to be expensive. For instance Denmark, Germany and the Netherlands collectively have 400 municipal waste-to-energy plants.

Regulatory Frameworks in Different Jurisdictions

Figure S.4 [4] provides an overview of policy instruments for the various stages applicable to bioenergy. It illustrates that policy instruments can be investment, production and environmental performance focussed. At the early market phase of invention and innovation, common policies and programs are focussed on R&D funding and investment subsidies for pilot and demonstration plants. As the technology transitions to the early market stage, policies are often geared towards soft loans and loan guarantees. Mechanisms at this stage include tax exemptions, price guarantees, feed-in tariffs and premium pricing for the output energy, government purchasing policies giving preference to renewable energy, and obligation and mandate schemes. At the mass market stage, policies have tended towards emission trading schemes and more demanding environmental standards.

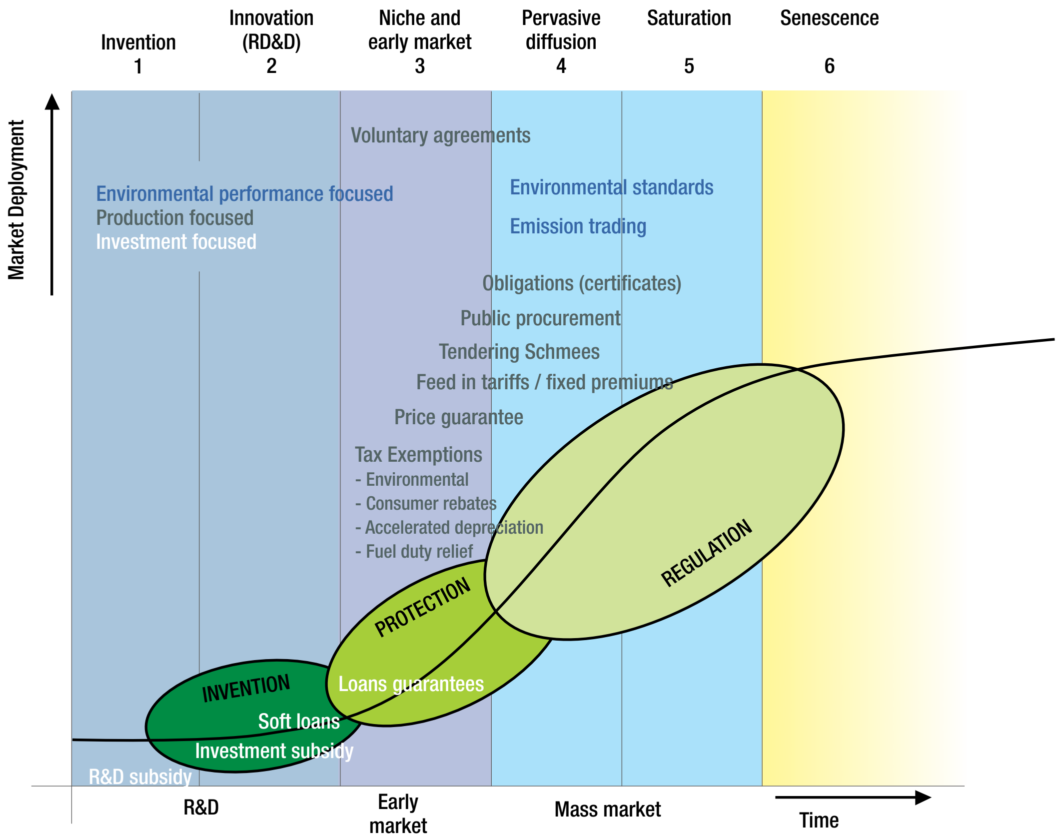
Mandates, similar to Australia's RET have been established in the UK, and 33 US States have Renewable Portfolio Standards (RPS), requiring a certain proportion of electricity be derived from renewable sources

Colorado provides an example of a US Renewable Portfolio Standard. The legislation in Colorado requires utilities to supply at least 12% of their retail electric sales from renewable sources from 2011 to 2014, 20% from 2015 to 2019, and 30% for 2020 and thereafter.

The US Biomass Crop Assistance Program (BCAP) is highlighted as an assistance program provided from the US Department of Agriculture. BCAP was established under the US 2008 Farm Bill and as of April 2010 the USDA has approved 4,605 agreements for the delivery of more than 4.18 million tons of biomass and paid eligible biomass owners US$165,274,695 in matching payments under BCAP's first phase.

Feed-in tariffs have become an effective stimulation measure in several overseas jurisdictions for bioenergy. The report gives some details of schemes in The Netherlands, Ontario Canada, Germany, China and Thailand. The report notes that feed-in tariffs exist within Australia, but exclude bioenergy at all scales.

Figure S.4: Overview of Policy Instruments



Source: IEA Bioenergy [4]

International Trade in Biomass

International trade in biomass, most notably fuel ethanol and wood pellets has increased dramatically over the past few years, especially within and to Europe to meet their greenhouse gas reduction targets. European use of pellets has grown from 6 million tonnes in 2007 to approximately 12 million tonnes in 2010 and is expected to grow to 30 million tonnes by 2020. The Western European demand for solid biomass is being met through trade, mainly from Eastern Europe and the former Soviet Union and also from Canada and the USA. Over half the woody biomass used for co-firing in Dutch power stations in 2008 was imported from North America. If all the energy plants planned for the UK materialise then the amount of imported wood products could dramatically increase to an annual total of 27 million tonnes per year. Australian companies have recognised the relatively high prices paid in Europe for wood pellets and coupled with the difficulties in launching large-scale bioenergy projects in Australia, are setting up wood pellet export mills. Plantation Energy Australia has set up a pellet factory near Albany, Western Australia and has announced plans for a succession of similar 250,000 tonnes per year pellet plants across Australia.

Economics of Bioenergy

Noting the diversity of bioenergy projects, a broad indication of the economics of bioenergy is presented via a modelling exercise with a discussion on the determinants of the economics. The scale of a bioenergy plant is crucial to its viability. Capital costs and operating costs for conventional combustion plants vary significantly with plant size. A large (40 MW) biomass power station may have a capital cost of $2.5 million per megawatt of installed capacity, while a biomass power plant of less than 1 MW may cost $8 million or more per MW. The modeling exercise for a 30 MW scale wood fired plant indicates a capital cost component of 3.40 c/kWh, a fuel component of 4.71 c/kWh, O&M of 1.50 c/kWh, giving a total levelised cost of electricity of 9.60 c/kWh. The sensitivity of the modeling assumptions can be readily made.

The economics of wood energy pellet production, selling into the European market which on occasions has commanded prices in excess of €200 per tonne shows that the dominant cost factors are the raw material closely followed by drying of the biomass.

Technology Trends

A range of new and emerging biomass and bioenergy technologies for the stationary energy market are in the areas of:

- Feedstocks
- Pre-processing and conditioning the biomass for transport and energy conversion
- Development of energy conversion technologies to provide a greater thermal conversion efficiency
- Smaller, modular systems for niche fuels and applications
- Co-production of bio-based products with energy
- Technologies to allow high co-firing levels and multi-fuel operation

The report notes that a future bio-based economy requires energy crops in addition to the use of residues. Torrefaction of biomass to manufacture a fuel with extremely low moisture content and a high calorific value (20-21 MJ/kg) is being developed, with the first commercial plant currently being constructed in Spain. Other technological trends are to increase the scale of plants to achieve better economics, and adoption of Circulating Fluid Bed Combustors to convert a wider range of fuels to energy. Gasification and pyrolysis, especially at a smaller, modular scale is also under development. Other new technological developments relate to the deployment of Organic Rankine Cycles, fuel cells and Stirling engines. Other technological developments are in the areas of small scale biogas, micro turbines, use of vegetable oil to fire gas turbines and large reciprocating engines, and co-firing biomass with coal. An extension of biomass co-firing (in several configurations) is the implementation of multi-fuel operation of energy plants, where biomass is a substantial contributor to the fuel mix.

Another trend is towards the implementation of biorefineries, where energy is coproduced with value-added bio-based products which may command a high price.

Issues Facing the Australia Bioenergy Industry and Forecasts for 2010

Some key issues facing the Australian bioenergy industry are:

- Poor recognition of bioenergy by policy makers and shapers. Bioenergy is a complex and in part controversial renewable energy source, not well recognised for its ability to provide reliable, sustainable, base load heat and power in Australia.
- LRET uncertainty remains. The legislation for the LRET is yet to be passed by Parliament, while deemed small scale RECs continue to accumulated. The REC price remains relatively low and volatile, and continues to provide uncertainty for the industry.
- Exclusion of bioheat from a mandatory renewable energy scheme. While solar hot water systems attract RECs, thermal energy from biomass does not.
- The depressed wholesale market for electricity on the eastern seaboard remains an adverse factor for power off-take contracts.
- The mooted CPRS has now been deferred for a further two years, with uncertainty that it may eventuate. As the RET is to transition into the CPRS, this adds further to market uncertainty.
- Lack of a feed-in tariff for bioenergy. While solar photovoltaics, micro-hydro and small wind technologies can access various state-based feed in tariffs, there is no such scheme for bioenergy in Australia.
- The landfill gas sector is adversely affected by the uncertainty of the carbon offset market and exclusion of current Greenhouse Friendly projects from the carbon market in the absence of the CPRS.
- Public acceptance. Combustion of biomass and municipal solid waste is likely to remain an issue for the industry. This especially relates to the use of native forest biomass. Air emissions, water use, land use competition, transport of biomass will be ongoing issues. The greenhouse gas benefits of bioenergy are generally not well understood by the public and community groups.
- Sustainability. A crucial issue for bioenergy is to prove that the ongoing requirement for fuels does not adversely affect the environment and society. Issues that will need to be managed are: ‘food vs. fuel’, land use, water and nutrient balances. Greenhouse gas balances will also remain under scrutiny.
- Fuel supplies over the long term. The economic life of a bioenergy plant can well exceed 25 years. The ongoing supply of compliant fuel needs to be secured.
- Asserting bioenergy as a centre stage renewable technology. Renewable energy technologies are often portrayed as being primary wind and solar. Renewables are often not deemed to be base load. Bioenergy in Australia needs to be vigorously promoted to key stake holders and gatekeepers, emphasising its status in Europe and North America and similar potential for Australia.

While the bioenergy industry has made steady progress over the past decade, uncertainty surrounding the RET and the setting up of the LRET, the delay in introducing an emission trading scheme, ongoing financial uncertainty associated with the Global Financial Crisis, depressed REC and wholesale electricity prices, and the excess of RECs still being produced from small-scale renewable energy sources under the RET, are all contributing to a wait-and-see attitude in the industry. It is suggested that once the REC surplus from the small-scale system are acquitted, financial conditions improve, and climate change mitigation and the pressing need for renewable energy returns, then the bioenergy industry will be well placed to contribute to renewable energy growth in Australia.

The CEC Roadmap predictions of 10,624 GWh bioenergy by 2020 and 72,629 GWh by 2050 may well be achievable.

1. Background and Introduction

This report was commissioned by the Clean Energy Council to provide its members with an overview of the stationary bioenergy market sector in Australia, how it compares with international markets for bioenergy, to indicate broadly the economics of bioenergy, and to give an indication of technology trends in this sector. The report scope also includes an overview of the biggest issues facing the Australian bioenergy industry and forecasts for 2010.

The Scope of Work for this report is:

- **Current state of the bioenergy market in Australia, including:**

  - Market penetration

  - Market participants

  - Fuel supply aspects

  - Regulatory framework for biomass and bioenergy

- **Overseas market trends**

  - Status of stationary bioenergy industry in selected international markets: Europe, USA, others

  - Regulatory frameworks in different jurisdictions (EU, USA)

  - Comment on international trade in biomass, e.g. wood pellets and how this is shaping overseas markets.

- **Economic analysis**

  - Cost analysis for technologies and their components (capital, fuels supply, operation and maintenance)

- **Technology trends**

  - Details of technologies under development and their future prospects (gasification, organic Rankine cycles, Stirling engines, small scale biogas, co-production).

The report is divided into four main sections, each covering the main bullet points above.

2. The Australian Bioenergy Market

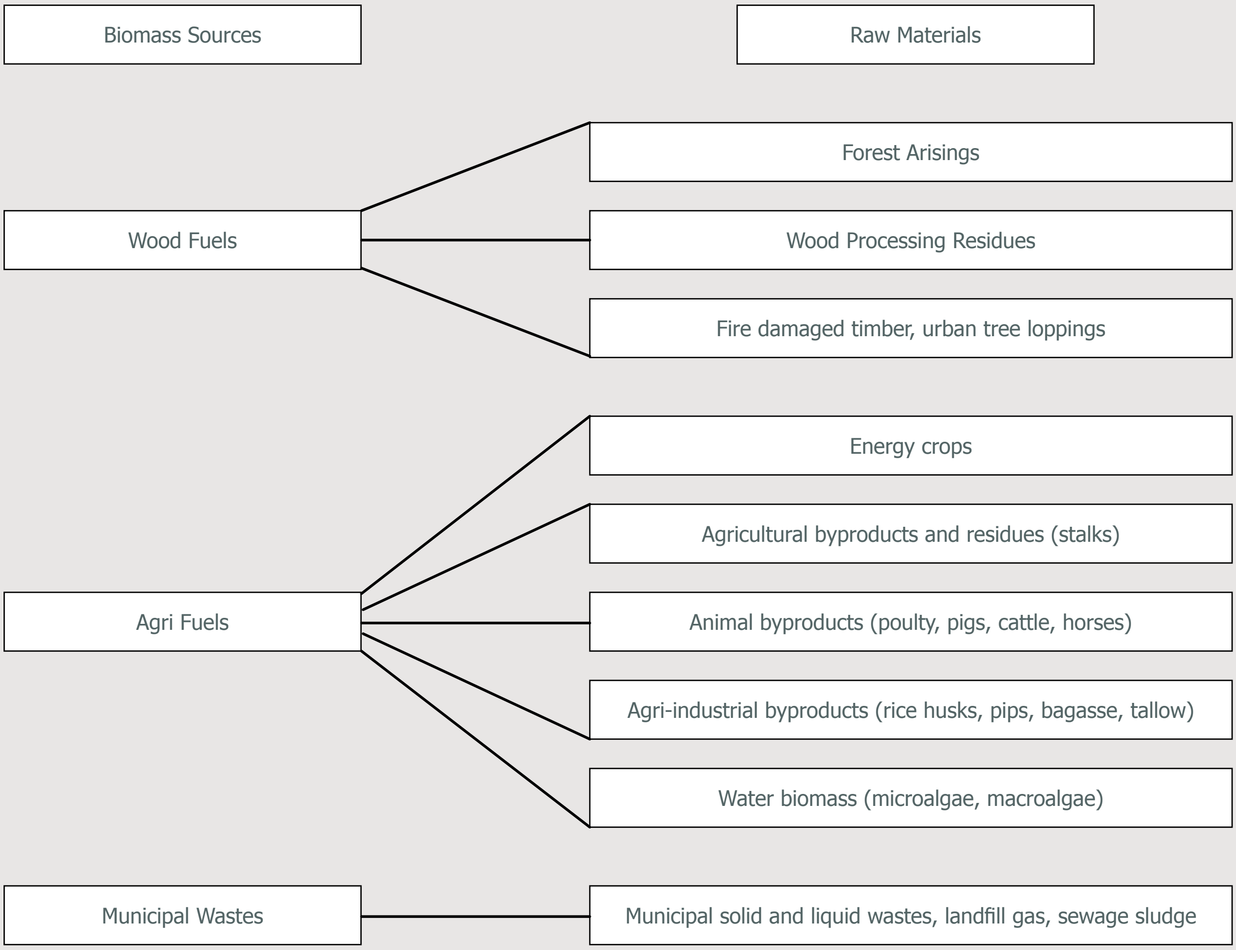
Two key elements underpin the bioenergy market; supply and demand. These elements are discussed to provide a picture of the Australian bioenergy market. The supply element is largely shaped by the specific biomass fuel, conversion technologies, cost of producing the energy, and companies involved in deploying the technologies, while the demand element is shaped by energy needs, the regulatory framework for renewable energy and bioenergy, cost and availability of competing energy sources, customer preferences and the routes to the energy markets. Aspects of these two elements are considered in turn.

2.1 Supply Aspects

Bioenergy, for the purposes of this report, refers to the production of sustainable, renewable heat and/or power from biomass. Biomass refers to products, wastes and residues of recent biological origin from agriculture, forestry, aquaculture, as well as the biogenic fraction of industrial and municipal wastes.

Bioenergy is a form of indirect solar energy, as the common element is the use of non-fossilised materials produced via photosynthesis, a process which involves binding atmospheric carbon dioxide into biomass via a process driven by sunlight. The inherent energy stored in biomass allows it to provide base load, dispatchable energy, unlike wind and direct solar energy. The main biomass sources stem from forestry, agriculture and municipal wastes. Biomass includes a wide variety of raw materials such as agricultural crop residues, by-products of timber harvesting and wood processing, manure, sewage sludge, the organic fraction of municipal solid waste, refuse derived fuels and purpose grown energy crops. This is illustrated in Figure 2.1.

Figure 2.1: Sources of Biomass



Biomass can take a variety of forms, presented in numerous settings. Biomass may have wide ranging physical and chemical properties. The biomass may present itself as a slurry, with a moisture content in excess of 95 percent moisture content (on a wet basis), or it may be relatively dry (for instance rice husks or wood pellets may have a moisture content below 10 percent). The varying properties of biomass require appropriate matching technologies to extract the inherent energy contained in the chemical bonds of the biomass.

Unlike several other forms of renewable energy, bioenergy is often part of an integrated response to managing a waste stream, addressing a local or regional environmental problem, or providing several value-added products. For instance bioenergy may use a waste stream that would otherwise require expenditure for its management. Examples are using sawdust produced at a sawmill, or using plantation silviculture thinnings (which would otherwise add to fuel loadings in the plantation) for energy; landfill gas extraction and use may be part of a gas management plan to destroy odours and a more potent greenhouse gas - methane; digestion of manure may be an alternative to spreading on the land (to reduce stable flies, pathogen spread and odour); or the use of sugar cane to co-produce sugar and electricity.

Unlike most forms of renewable energy, bioenergy requires ongoing supplies of fuel. The fuel supply aspect is highly dependent on the specifics of the biomass, the energy conversion technology, the scale of the operation, and on the project itself. Generally there would be a biomass supply cost curve, with on-site waste materials being the cheapest to source, and an increasing cost for similar fuel that may need to be transported to the power plant, with the most expensive fuels being those that require inputs, tending, harvesting, on site handling, transportation, such as purpose grown energy crops. In many instances the cost of the fuel component can account for over half the cost of product bioelectricity. The economics of bioenergy production are further covered in Section 4 below.

Conversion Technologies

Energy conversion technologies for processing the various forms of biomass may be broadly divided into processes that are thermochemicalor bio-chemical. Thermo-chemical processes are: combustion, gasification and pyrolysis, while bio-chemical processes utilise naturally occurring microorganisms to convert relatively wet biomass, such as found in landfills or covered lagoons, into a biogas rich in methane. Biogas can be used in spark ignition engines, gas turbines, and in future fuel cells. It can also be used at its production source as a boiler fuel, or purified further and injected into gas reticulation systems to provide 'green gas'.

Combustion is globally the dominant bioenergy conversion technology, accounting for approximately 90 percent of modern bioenergy plants worldwide. Combustion of solid biomass fuels is closely related to the combustion of solid fossil fuels, such as brown coal or bituminous coal. Many of the energy conversion plant components are very similar. Basically water is boiled to produce steam, the steam is superheated and expanded through a steam turbine or steam engine, which in turn powers a generator to produce the electricity. The predominant combustion technologies for biomass are grate, bubbling and circulating fluidised bed combustors.

Biogas, a mixture of mainly methane and carbon dioxide can also be combusted to produce energy. Combustion can be used for electricity only plants, or it can be used for the co-production of power and heat in a cogeneration power plant. Biomass is also used for co-firing with coal in power station boilers. This may be by direct co-firing (adding relatively small amounts of wood chips on coal conveyor belts), parallel co-firing (having a separate biomass energy plant, and integrating its output energy), or as implemented at Swanbank B Power Station in Queensland co-combusting biogas through modified, furnace wall mounted burners.

Pyrolysis of biomass takes two forms, slow pyrolysis as traditionally applied for 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. Pyrolysis occurs in the absence of oxygen under controlled conditions. Pyrolysis bio-oil has been used in Canada for electricity generation using a combustion turbine and also in slow speed diesel generator sets, using petroleum diesel for pilot ignition. Much research activity associated with pyrolysis of biomass is focussed on transportation fuels.

Landfill Gas and Biogas rely on microbes to digest relatively wet biomass to produce a gas mainly composed of methane and carbon dioxide. This combustible gas can be converted to electricity in combustion turbines, spark ignition engines, or used to dual fuel compression ignition engines. The gas may be used for thermal energy, or purified and injected into the gas distribution network, or as a transportation fuel. The largest landfills in Australia can support generation up to approximately 25 MW of electricity (the Woodlawn project in NSW's eventual capacity). Landfill gas production peaks shortly after a landfill site is closed, and decays exponentially over three or more decades. Generation capacity can be matched to gas production by using modular generation units. Biogas can be produced in covered ponds and lagoons, or in more highly engineered tank digesters.

2.2 Demand Aspects

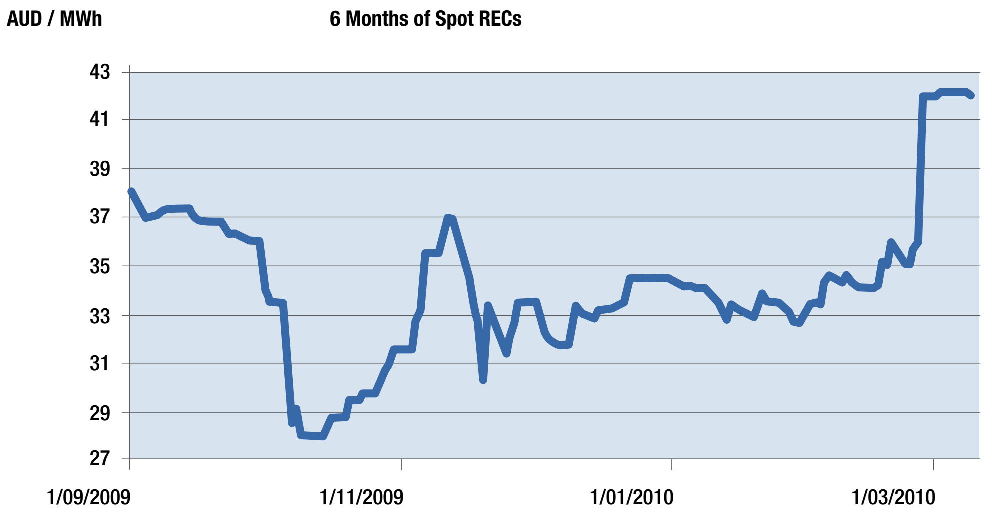
Bioelectricity

Market pull for bioelectricity has been mainly though the Australian Government's Mandatory Renewable Energy Target (MRET) and its successor schemes, the Expanded Renewable Energy Target (RET), and will from 1 January 2011 be supported by the Enhanced RET which will have a component - LRET (large-scale RET) specifically aimed at utility scale renewable electricity generation.

The LRET, announced on 26 February 2010 is to set a target of 41,000 GWh per year of large-scale renewable electricity by 2020, being held at that level until 2030. The LRET will be one of the main mechanisms for meeting the Australian Government's target of 20 percent of electricity being provided by renewable sources by 2020. The LRET increases the previous Mandatory Renewable Energy Target (MRET) by over four times, from 9,500 GWh/a by 2010 to 41,000 GWh/a by 2020. Further aspects of the RET/LRET and the planned transition into an emission trading scheme are covered in Section 2.6 - Regulatory Framework for Biomass and Bioenergy. the viability of bioelectricity is largely determined by the product electricity price available through Power Purchase Agreements (PPA). The price of bioelectricity has two main components; the price of the electricity and an overlay Renewable Energy Certificate (REC) price. Some bioenergy projects, notably those involving biogas, have a third component; a carbon credit price in the form of Greenhouse Friendly or New South Wales Greenhouse Abatement Certificates (NGACs).

The REC price has been volatile and depressed for much of the past year. This has been largely due to the REC market been flooded by solar photovoltaic and solar hot water RECs, which receive incentives not available to bioenergy and other utility scale renewable energy projects. Small scale technologies have been receiving deemed RECs upfront, with various other government incentives, such as an immediate five times solar multiplier for solar photovoltaics and in most states a feedin tariff, not available for bioenergy. The Australian Government has recently announced that these small scale technologies will be placed in the SRES (small-scale renewable energy scheme), which has caused the RET price to rebound in the past two months. Figure 2.2 shows the recent trend for spot market RECs. This topic is further covered under Section 2.6.

Figure 2.2: REC Spot Market Price of Past Six Months



Source: NextGen

Over the past year the wholesale price of electricity on the eastern seaboard (Queensland, NSW, South Australia and Victoria) has dropped by about one third, due to a number of electricity supply industry issue, most notably the ending of the drought in Queensland (removing constraints on cooling water for power stations) and newer capacity coming on line. Figure 2.3 shows the downward trajectory of Victorian electricity in c/kWh over the past year. This trend is similar in Queensland, South Australia and New South Wales. Industry predictions are that the wholesale price of 'black electricity' will remain depressed at around the current level for at least the next year, before rising to last year's levels circa 2013.

The Federal Government has introduced a lot of uncertainty into the carbon market by now further delaying its Carbon Pollution Reduction Scheme (CPRS) and by also creating a new voluntary standard that specifically excludes all Australian based bioenergy carbon offsets. The CPRS is delaying investments in clean energy projects including bioenergy. The exclusion of current Greenhouse Friendly projects from being able to continue to create Federally backed offsets, in the absence of a CPRS, puts at risk the viability of current bioenergy projects which rely on carbon offset revenue to be cost competitive with fossil fuels.

The combination of low and uncertain REC and electricity prices, coupled to the general uncertainty from the Global Financial Crisis has hampered the general development of bioenergy in Australia over the past year. When the LRET is fully functioning (post January 2011), and the small scale RECs pass through the RET, then market conditions are expected to be more conducive to bioenergy deployment in Australia.

Figure 2.3: Electricity Price Trajectory Over Past Year – Victoria

Source: http://d-cyphatrade.com.au

Other issues adversely affecting the bioenergy industry is the ongoing uncertainty surrounding the announced but not legislated LRET, connection rules and regulations, difficulty in securing a PPA in a relatively 'thin' retail electricity market, contractors not willing to undertake major projects (especially in the sugar industry) due to lack of competitive bidding for subcontracts, and concerns that once the economy picks up, competition for both labour and materials from the mining and minerals industries will drive up bioenergy project costs.

GreenPower has operated for over a decade in Australia as a voluntary market for some forms of renewable electricity. It is regarded as a 'dark green' offering provided by electricity retailers who invite customers to purchase renewable energy with pre-specified environmental credentials. This scheme precludes the use of native forest biomass and co-fired bioelectricity (irrespective of the environmental credentials of the biomass itself) using coal fired boilers, even when such bioelectricity generation complies with the RET scheme. Other forms of biomass are generally accepted under GreenPower. GreenPower is generally sourced via the surrender of Renewable Energy Certificates, but these need to be from energy sources accredited under GreenPower.

Bioheat

Thermal energy, including the heat component of cogeneration is not supported under any government programs such as the RET. This is in stark contrast to the support provided under the MRET/RET/ SRES (Small-scale Renewable Energy Scheme) for solar hot water systems. The UK is set to introduce a Bioheat program in 2011.

Several industries that require process heat for thermal oil, steam or hot water production have implemented projects using locally available biomass. Examples of the use of biomass for heat include:

- steam in sugar mills
- thermal oil in plywood factories
- steam for processing food
- kiln drying of lumber at saw mills
- steam at pulp and paper facilities.
- Firewood for domestic and commercial space and water heating.

2.3 Market Penetration

This section provides an overview of the penetration of bioenergy, with specific bioenergy power plant listings provided in Appendix A. Details of individual market participants is provided in Section 2.4

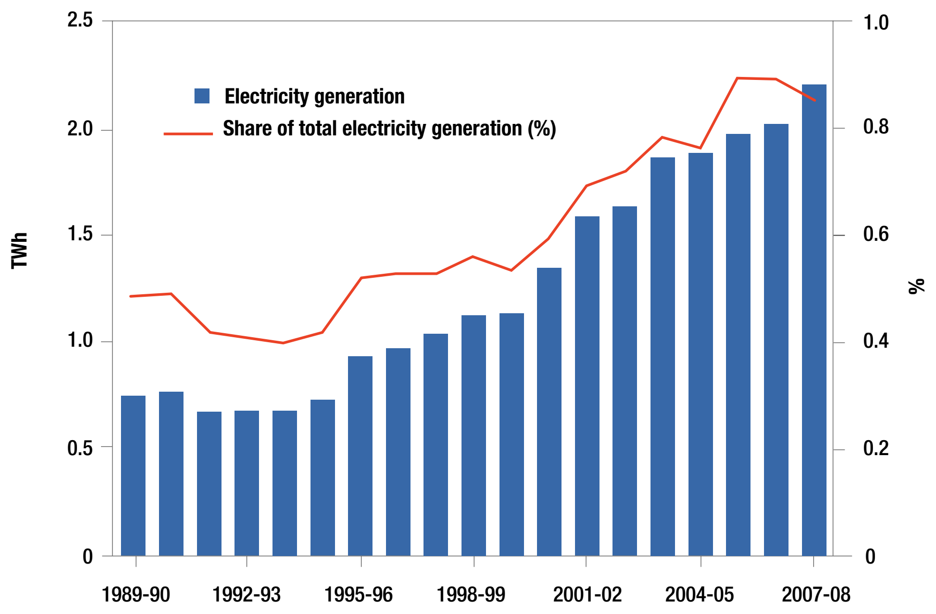
Various forms of biomass are used in the domestic, commercial and industrial sectors for thermal and electrical energy. In 2007-2008 biomass provided approximately 4 % of Australia's Total Primary Energy Supplies, providing 78% of Australia's renewable energy. Contributing to this is 4 million tonnes per year of fire wood used in Australia, mainly for domestic space and water heating. Various industries have used food and agricultural processing wastes for providing both thermal energy for hot water and steam. The forestry sector has used sawmill wastes for kiln drying of lumber. Various other industries, in close proximity to biomass resources have installed boilers to run their operations. For instance cement kilns, brick kilns and meat works are using biomass for fuel.

Australia has been a leader in the development of landfill gas for electricity production, with the earliest plants pre-dating the Mandatory Renewable Target by several years. The largest impetus for bioelectricity in Australia has been provided by the MRET and its successor scheme, the RET.

Bioenergy currently provides some 0.9 percent of Australia's electricity generation [1]. Bioenergy has contributed slightly less than one quarter of the new renewable electricity generated in Australia under the Mandatory Renewable Energy Target (MRET), which came into force in 2001. Bioenergy generation under MRET (and now the RET) is primarily from bagasse-fired power plants at sugar mills and landfill gas. Appendix A provides a listing of installations. Figure 2.4 shows the increase in bioelectricity production over the past two decades [2].

Australia currently has 867MW of dedicated installed bioelectricity capacity (this ignores the contribution of biomass via co-firing with coal). Over half this capacity is from bagasse combustion in the sugar industry, with the second largest contributor being biogas, mainly landfill gas. The contributions to this capacity, by source and states is presented in Table 2.1

Figure 2.4: Australian Bioelectricity Production



Source: ABARE and [2]

Table 2.1: Australian Bioelectricity Generation (MW), 2009

	Biogas	Bagasse	Wood Waste	Other bioenergy*	Total bioenergy
New South Wales*	73	81	42	3	199
Victoria	80	0	0	34	114
Queensland	19	377	15	4	415
South Australia	22	0	10	0	32
Western Australia	27	6	6	63	102
Tasmania	4	0	0	0	4
Northern Territory	1	0	0	0	1
Australia	**226**	**464**	**73**	**104**	**867**
Share of total renewable electricity capacity (%)	**2.2**	**4.4**	**0.7**	**1.0**	**8.3**

Source: Geoscience Australia 2009

*includes the ACT. **Unspecified biomass and biodiesel

Table 2.2: Recent Bioenergy Projects

Project	Company	State	Type	Start Up	Capacity (MW)
Tumut	Visy Paper	NSW	Wood waste	2001	17.0
Rocky Point	National Power and Babcock and Brown Joint Venture	QLD	Bagasse	2001	30.0
Stapylton	Green Pacific Energy	QLD	Wood waste	2003	5.0
South Cardup	Landfill Management Services Ltd	WA	Landfill methane	2005	3.3
Werribee (AGL) methane	AGL	VIC	Sewage	2005	7.8
Pioneer 2	CSR Sugar Mills	QLD	Bagasse	2005	63.0
Woodlawn Woodlawn	Bioreactor Energy Pty Ltd	NSW	Landfill methane	2006	25.6
Carrum Downs 1 & 2	Melbourne Water	VIC	Sewage methane	2007	17.0
Eastern Creek 2	LMS Generation Pty Ltd	NSW	Landfill methane	2008	8.8
Condong	Sunshine Electricity	NSW	Bagasse	2008	30.0
Broadwater	Sunshine Electricity	NSW	Bagasse	2008	30.0

Source: Geoscience Australia; ABARE [2]

Table 2.2 lists a number of recently commenced or commissioned bioelectricity projects (as at September 2009) [2].

Market Sectors

The nature of biomass and bioenergy is reflected in the segmentation of the Australian bioenergy industry. While many bioenergy plants accredited by the Office of the Renewable Energy Regulator are for more than one compliant fuel type, the host industry for the energy industry can be used for segmenting the industry in Australia as follows:

Figure 2.5: Condong Sugar Mill 30MW Power Plant

Source: S Schuck

Figure 2.5 shows the Condong Sugar Mill 30MW power plant in Northern New South Wales, one of the newer bioenergy projects in Australia. Appendix A (a) lists the bioenergy producing sugar mills and projects under construction.

Sugar

A major form of bioenergy in Australia is cogeneration in Australia's 28 operating sugar mills. These mills use mainly sugar cane bagasse (residue from crushed cane) as fuel, to power the mills and to provide process steam for their operations. Most of the sugar mill boilers were originally designed to efficiently dispose of surplus bagasse. In more recent times these power plants have been upgraded to maximise energy conversion, to additionally use other forms of biomass and to sell surplus electricity to the grid. In 2006 bagasse produced approximately 1,200 GWh of electricity, exporting 600 GWh to the national electricity grid. Bagasse has a strong base for further expansion, being projected in the CEC Australian Bioenergy Roadmap [1] to reach an estimated 7,800 GWh per year by 2050.

Landfill Gas

Australia has been at the forefront of landfill gas development, with 70 landfill generation sites, mostly base load power producers having a combined capacity of approximately 170 MW. Currently landfill gas is the largest exporter of bioelectricity. In 2009 the landfill gas industry generated and exported 950 GWh of electricity. A large proportion of this electricity was base load generation.

Most of the larger landfills in Australia incorporate landfill gas generation, generally using modular units of up to 1 MW each. A variant on the conventional landfill is the bioreactor cell. A bioreactor cell adjacent to the Swanbank B Power Station near Ipswich, Queensland provides landfill gas for co-firing with coal to produce electricity. The Woodlawn bioreactor landfill near Lake George, NSW uses the void from a former open cut mine. This will ultimately support up to 25 MW of installed capacity.

Appendix A (b) lists landfill gas bioenergy generation plants, together with their locality and capacities.

Biogas

Most of the larger sewage treatment plants incorporate digesters to capture biogas (up to 75 percent methane) emissions to produce bioelectricity. The technology ranges from large covers over open ponds to tank digesters. Tank digesters are generally heated using a portion of the biogas, to maintain the temperature at about 37 degrees Celsius. Spark ignition engines and gas turbines are most generally used for energy conversion to electricity.

Besides sewage, food waste and the putrescibles urban waste are converted using various processes and technologies. An 80,000 tonnes per annum food waste digester operates at Camellia, Sydney, while a plant based on the Israeli ArrowBio technology operates at Narellan, south-west Sydney and another plant based on ISAKA percolation technology operates at Eastern Creek, in Sydney's western suburbs.

Various agricultural and food processing digesters are also in operation using animal manure and rendering wastes. Examples are two digesters based on animal rendering wastes at AJ Bush and Sons, Bromelton, Queensland and another based on pig manure at Grantham, Queensland. Figures 2.6 and 2.7 show one of Melbourne Water's Carrum Downs biodigesters and the generation hall in south-east Melbourne.

Figure 2.6: Carrum Downs Digester

Source: S Schuck

Figure 2.7: Carrum Downs Generation Hall

Source: S Schuck

Agricultural and Food Processing Wastes

Various agricultural pursuits, including food processing can produce residues which can be used to produce energy. Knetic Energy has been developing a project to gasify peach pips to produce a combustible gas for powering an engine. Thermal energy from a gasifier has also used rice processing wastes to dehydrate fruit. AGL acquired a 1.5 MWe power plant from Ergon Energy at Suncoast Gold Macadamia, Gympie, Queensland that is fuelled using waste macadamia nut shells. Also at Gympie, Nestle has a 16 MWth biomass boiler for processing coffee beans.

The CEC Australian Bioenergy Roadmap [1] noted the tremendous potential for increased use of agricultural wastes in Australia, from an estimated 791 GWh per year in 2020 to 50,566 GWh in 2050.

Forestry Wastes

Bark, sawdust and other timber milling wastes have found applications for on-site thermal energy. Applications include log steaming at veneer mills and kiln drying of sawn timber. The thermal energy may be used for producing hot water, steam or if higher temperatures are required, thermal oil.

Many other industries also require steam or heat. This energy may be derived from timber wastes such as sawdust or chipped wood waste. An example of a cheese factory using wood waste is at Bega Cheese, Bega, NSW where two boilers provide the process heat for the factory. Figure 2.8 shows the exterior of the boiler house and fuel storage shed at Bega Cheese.

Figure 2.8: Bega Cheese Boiler House and Fuel Storage

Source: S Schuck

Table 2.3 lists several wood fuelled energy systems around Australia, provided by one industry participant, to give an indication of biomass use for industrial thermal energy.

Wood waste has also been widely used for co-firing with coal in several coal fired power station units, such as at Liddell, Walle-rawang, Vales Point, Muja Power Stations. This direct co-firing has been at relatively low levels (under 5 percent on an energy input basis), and only when market conditions have made this financially attractive. Processing wastes from pulp and paper manufacture have also been used for bioenergy. The Visy Tumut, NSW plant incorporates a 20 MW bubbling fluidised bed combustor and the PaperlinX Maryvale pulp and paper mill in the Latrobe Valley, Victoria combusts black liquor to produce 55 MW of electricity. 64% of Maryvale Mill's power supplies are produced on-site using wood waste and other bio-material.

Several wood waste based power plants are at an advanced stage of planning or are in the process of gaining development approval. The mooted Gunns pulp mill in Tasmania is slated to incorporate a 200 MW scale bioelectricity plant, a 40 MW plant in the Huon Valley Tasmania has been under development for several years, and a 44 MW power plant is at an advanced planning and development stage at Manjimup, WA. South East Fibre Exports, a wood chip mill at Eden, NSW is proposing to install a 5 MW scale bioelectricity plant to use under size and over size chipping wastes for energy.
A substantial proportion of these wastes are currently incinerated in a beehive burner for disposal.

Appendix A (d) lists several examples of bioenergy plants base on wood waste.

Table 2.3: Wood Fuelled Energy Systems

Client	Plant Location	Capacity MW	Product	Fuel
Visy Pulp & Paper	Melbourne, VIC	30	Water tube boiler	Sludge & Wood waste
ITC	Launceston, TAS	3	Water tube boiler	Dry Chip / Shavings
Nestlé	Gympie, QLD	16	Water tube boiler	Coffee waste / Wood waste
FEA	Georgetown, TAS	20	Water tube boiler	Wood waste
Hyne & Son	Tumbarumba, NSW	15	Thermal Oil	Heater Wood waste
Carter Holt Harvey	Oberon, NSW	12	Thermal Oil Heater/ Fibre drying	Wood waste (MDF waste and sawmill waste)
AKD Sawmill	Colac, VIC	15	Thermal Oil Heater	Wood waste
Hyne & Son	Tuan, QLD	12.5	Thermal Oil Heater	Wood waste
Starwood Australia	TAS	22	Water tube boiler	Biomass
Laminex	Gympie, Qld	24	Thermal Oil Heater	Wood waste

Source: RCR Energy Systems

Energy Pellets and Briquettes

Several countries, notably in Europe, have set fairly progressive renewable energy targets, requiring a substantial contribution from bioenergy. Figure 2.9 illustrates wood pellets – small cylinders of wood powder, approximately 6-8 mm in diameter. The combination of high European energy prices, the size of their stationary energy markets, and requirement for substantial amounts of biomass to contribute to renewable energy targets, require the importation of large quantities of biomass. One of the most convenient forms of biomass is wood energy pellets. The current European market for energy pellets is currently approximately 12 million tonnes per year, and is projected to grow to 30 million tonnes by 2020. Prices for bulk pellets in Western Europe have been as high as €200 per tonne.

The relatively low price for electricity, lack of incentives for bioheat in Australia, uncertainty surrounding the RET in recent times, and general difficulty is launching large scale bioenergy projects in Australia has provided an incentive for local companies to enter the international wood pellet market. Plantation Energy Australia has commissioned a 125,000 tonnes per annum wood pellet line at Albany, Western Australia, with a second line to shortly follow. They have announced plans for several other pellet plants, including at Millicent SA and Haywood, Victoria. A Queensland based company, Altus Energy has been in the process of launching a company to likewise pursue this international market.

Briquettes are a larger variation on pellets, often more tailored for thermal applications. One niche market is to substitute fire wood with reconstituted logs made from wood waste or lower grade timber. A product Hotrox has been on the Australia market for several years, mainly for domestic application. Briquettes can also be a suitable fuel for certain gasifiers, where larger chunks of biomass are required.

Figure 2.9: Wood Pellets

Energy Crops

An Integrated Wood Processing pilot plant, which generated 1 MW of electricity, has operated at Narrogin, Western Australia. This project co-produced eucalyptus oil (industrial solvent) and activated carbon (filtration medium). This project used oil mallee trees, planted mainly for dryland salinity control. In early 2010 a prototype mallee harvester was launched, to further develop oil mallees for energy and related products. On 9 March 2010 Delta Electricity launched a project which in part will see a relatively large scale planting of mallees, for conversion to wood pellets for a co-firing trial at Wallerawang Power Station. The success of this trial, coupled to an improvement in market conditions could see this energy crop project for stationary energy vastly expanded in the medium term.

MSW and RDF

Municipal Solid Waste (MSW) has been used to a limited extent for co-firing in Australia. Many countries such as Japan, The Netherlands, and Austria manage much of their urban waste via combustion and energy recovery plants. Allied to this is Refuse Derived Fuel (RDF), which provides a better environmental outcome than mass burn combustion of unsorted MSW. While there was a proposal several years ago to construct an Energy-from-Waste plant at Brighton, Tasmania, using Segher grate technology, such proposals are currently relatively uncommon. Benedict Enterprises has been granted development approval for a 5 MW scale plant based on municipal wood waste for its Chipping Norton site in suburban Sydney.

The Future Market for Bioenergy

While the CEC Australian Bioenergy Roadmap [1] indicates that biomass currently provides approximately 0.9 percent of Australia's electricity generation, the Roadmap also indicates that by 2020 the contribution from biomass for electricity generation could be 10,624 GWh per year or some six times the current generation. It further identifies the long-term potential for electricity from biomass in 2050 to be as much as 72,629 GWh/year, which is 40 times the current levels. Such a generation capacity would require constant industry growth at almost 10% per year for the next four decades.

As another indication of the significant potential for electricity from bioenergy, an Australian Business Roundtable on Climate Change report (by the Allen Consulting Group) estimates that bioenergy could supply between 19.8 and 30.7% of Australian electricity needs by 2050 [3].

The Clean Energy Future for Australia study, funded by the former BCSE (now the Clean Energy Council) found that biomass could provide up to 29 percent of the generation mix by 2040 using known technologies and resources.

2.4 Market Participants

Bioenergy embraces a wide spectrum of industry participants, from fuel sourcing, supply logistics, energy conversion, equipment suppliers, those involved in the sale and distribution of the output energy, to bioenergy consultants and expert advisers. This spans a range of industries, including agriculture, forestry, food processing, cartage contractors, urban waste management, and also regulatory authorities. This section is designed to give a broad indication of the category of market participants and is not meant to be a definitive directory. It is not possible to list every participant and potential participant in this emerging industry. Some select market participants are named below, to give an indication of the breadth and depth of bioenergy in Australia. This coverage is not meant to be comprehensive, and any omission from this list does not necessarily reflect on the credentials of organisation excluded from the discussion below.

Sugar Industry

Australia has some 28 sugar mills which incorporate boilers fuelled on bagasse. Production and harvesting the annual cane crop of approximately 35.5 million tonnes involves hundreds of sugar cane farmers as well as co-operatives and larger companies. The mills are variously privately, co-operatively or owned by public companies. Sugar industry organisations include Canegrowers and the Australian Sugar Milling Council. Delta Electricity and the NSW Sugar Milling Cooperative formed Sunshine Energy to manage the Condong and Broadwater 30 MW cogeneration power station projects in northern NSW. Other sugar industry participants in the bioenergy industry are CSR, Mackay Sugar and Bundaberg Sugar.

Appendix A (a) gives a listing of bagasse fuelled energy plants, providing further information on participation in the bioenergy industry.

Landfill Gas

This sector of the bioenergy industry requires the involvement of the organisations on whose landfills power plants are sited and the specialist companies responsible for gas extraction and energy conversion and distribution. Leaders in this field are Landfill Management Services (LMS), Energy Developments Limited (EDL), Landfill Gas and Power and AGL. Landfills are often controlled by Councils or large waste management organisations such as WSN Environmental Solutions, SITA or Veolia Environmental Services and their partners (e.g. JJ Richards and Sons Pty Ltd). Veolia is also involved in the Woodlawn 25 MW project near Lake George, NSW and the Ti Tree bioreactor landfill at Willow Park, near Ipswich, Queensland. In a collaboration between CS Energy, Thiess Services, Landfill Management Services, and New Hope Energy. landfill gas generated from Thiess Services' Swanbank Landfill is piped directly to a specifically modified boiler at the nearby Swanbank B Power Station to co-fire the biogas with coal to generate 5MW of baseload electricity.

Energy Developments' landfill gas projects include facilities in Victoria (Clayton, Springvale, Berwick, Brooklyn, Corio, Broadmeadows, Hampton Park and Werribee), South Australian (Wingfield, Pedler Creek, Highbury, Tea Tree Gully), the Australian Capital Territory (Mugga Lane, Belconnen), in New South Wales (Belrose, Lucas Heights, Jacks Gully, Eastern Creek, Whytes Gully) and Queensland (Fitzgibbon).

LMS also operates landfill gas power generation plants at Eastern Creek, Sydney, Smythesdale in Victoria, Wollert near Melbourne, Stotts Creek in northern New South Wales, Whitwood Road near Ipswich in Queensland, South Cardup in Perth, Tamala Park in Perth, Mowbray in northern Tasmania and Shoal Bay in the Northern Territory.

Appendix A (b) gives a listing of landfill gas projects, indicating market participation.

Biogas

Sewage treatment works are generally controlled by local and government authorities. Many of the larger sewage plants, such as Werribee and Currum Downs in Melbourne, Malabar, Cronulla and North Head in Sydney, Bolivar in Adelaide, Oxley Creek and Luggage Point in Brisbane, Woodman Point in Perth have sizeable biogas generation of electricity. Melbourne Water, owned by the Victorian State Government, manages Melbourne's water supply catchments and removes and treats most of the city's sewage. It operates the 1,700kW Carrum Downs 1 & 2 Power Stations that use sewage methane.

It also has a contract with AGL Pty Ltd to use the methane gas produced at its Werribee Sewerage Treatment Plant to generate electricity for the plant. Melbourne Water's Eastern Sewage Treatment Plant at Bangholme has also been upgraded to produce 30 GWh a year from methane.

EarthPower Technologies, a joint venture between Veolia and Transpacific Industries owns a food digester at Camellia, NSW and WSN Environmental Solutions has been involved in the Eastern Creek U3-3R waste processing and energy plant set up the GRL. WSN has also deployed ArrowBio digestion technology at an integrated waste processing plant of Jacks Gulley, in Sydney's south west. Several food processing plants also apply digestion to clean up their effluent streams while producing energy.

Quantum Bioenergy has been working with AJ Bush and Sons at Bromelton, Queensland, where two digesters have been set up. Figure 2.10 shows one of the AJ Bush and Sons' digesters.

Figure 2.11 shows a digester and generator set at Brisbane's Oxley Creek sewage treatment plant.

Figure 2.10: AJ Bush Digester at Rendering Plant

Source: S Schuck

Figure 2.11: Oxley Creek Digester and Generator Set

Source: S Schuck

Murray Goulbourn Co-operative, Leongatha, Victoria have recently completed the installation and commissioning of two biogas generators to convert biogas from their waste food and water treatment process, to 760 KW of electricity. Visy have an anaerobic digester at a waste paper processing plant on Gibson Island, Brisbane. Perth based Anaeco have launched a business based on a single tank aerobicanaerobic digestion system. A piggery at Grantham, Queensland uses an innovative floating cover to capture methane, currently only for flaring. Charles I.F.E. Pty Ltd operates the Berrybank Farm Piggery at Ballarat in Victoria, which is saving $435,000 per year using an innovative Total Waste Management System that includes an anaerobic digester. Products of this recycling system include 1,700 cubic metres of biogas per day that is used in a cogeneration plant to generate 2,900kW of electricity. PMP Bioenergy Pty Ltd, part of the PMP Group of Companies, specialises in harvesting biogas generated from organic waste. They have worked across many industries such as municipal sewerage, piggeries, rendering plants, abattoirs, tapioca plants and other food processing industries. Projects include Tapioca SPM 1 and 2 in Sumatra and the Westpork Piggery at Gin Gin in Western Australia. Diamond Energy is another renewable energy and low carbon generation company with expertise in the biogas sector. It currently operates a 1.1MW biogas plant at Tatura in northern Victoria that utilises sewage gas. 'Green gas' offerings, similar in concept to GreenPower for electricity is now available in the Australian market. For instance Origin Energy provides 'green gas' as a voluntary offering to its customers who are connected to standard gas.

Agricultural and Food Processing

Some agricultural and food processing industries have digesters or other energy plants on site to manage effluent streams and to use wastes for local energy use. Examples are at a brewery at Yattala, Queensland, a rice wastes gasifier in the Riverina and the above mentioned biogas plant at AJ Bush at Bromelton, Queensland. Nestle and Sun Coast Macadamia, both at Gympie, Queensland respectively using coffee and macadamia nut processing waste to produce bioenergy.

Pellets and Briquettes

For several years Pellet Heaters near Broadwater NSW has operated a relatively small wood pellet mill in support of their sales of wood pellet heaters. More recently Plantation Energy Australia Limited has established Australia's first large scale wood pellet mill at Albany, WA, with plans for several other mills across Australia, including at Millicent, SA and Haywood, Victoria. A Queensland base company, Altus Energy has also announced plans for a pellet mill. Global NRG, a company based off-shore has also announced plans to pelletise wheat straw in Western Australia, and to set up export pellet plants (including using nonbiomass sourcesl) and to cater for a future market. Delta Electricity has announced it will also be trialling pellets from various sources for co-firing at Wallerawang Power Station. SwarfTech, based at Eden, NSW is the supplier of equipment for briquette manufacture. Hotrox is another company involved in briquette manufacture and sale.

MSW and RDF

Only limited quantities of urban wood waste, such as demolition timber have been used for bioenergy in Australia. This has been in cement kilns, such as owned by Blue Circle Southern Cement. Limited co-firing using sorted MSW (municipal solid waste) has been undertaken by those involved in co-firing. As noted above, Global NRG has indicated plans to produce Refuse Derived Fuel for various markets. Benedict Enterprises has a facility at Chipping Norton in Sydney that recycles construction and demolition materials, commercial and industrial wastes, and residues from other recycling facilities. Plans for this site include the generation of over 5 MW of renewable energy powered by fuel derived from wood sorted from the waste stream.

Energy Crops

Most bioenergy in Australia utilises wastes and residues for fuel, with minimal reliance on purpose grown energy crops. However, as noted above, Delta Electricity has launched a project to plant several thousand oil mallee eucalypts in NSW and to use the biomass in a trial at Wallerawang Power Station. This trial involves some 10 farmers co-ordinated by agri-business Demand Farming. Others involved in promoting and developing oil mallees as an energy crops are the Oil Mallee Association, the Future Farm Industries Cooperative Research Centre, and BioSystems Engineering, a Toowoomba based company who have built a prototype mallee harvester for the Future Farm Industries CRC.

Power Companies

A number of coal fired power companies and enterprises have recognised the relatively low cost of producing Renewable Energy Certificates under the RET by co-firing biomass or biogas with coal in their boilers. While their core business remains based on fossil fuels such as coal, coal gas and natural gas, they have had some involvement in the bioenergy industry. Verve also conducted a trial run combusting liquid biofuels in a combustion turbine at Kalgoorlie, WA. Industry participants have included Delta Electricity, Macquarie Generation, CS Energy, Verve Energy and International Power.

Equipment Suppliers

Biomass fuel is often a waste or residue associated with agriculture, forestry, industrial processing, or urban waste management, and as such share in the use of existing infrastructure and plant and equipment, such as chippers, grinders, conveyors and trucks. Most of the companies that are involved in the supply of plant and equipment for biomass conversion are also involved in the supply of similar plant for use with fossil fuels, such as coal, LPG and natural gas. Several of the major plant and equipment suppliers are global companies with a presence in Australia. Often boilers would be fabricated in Australia, using licences and designs sourced from overseas (such as from Eckrohr Kessel of Germany), possibly requiring 'code conversion' to comply with Australian rules and regulations. Some of the larger plant and equipment suppliers are: AE&E Australia (boilers and allied plant), RCR Energy Systems (boilers and allied plant), Andritz (pellet mills and other wood handling systems), Maxitherm (boilers), Clyde Babcock Hitachi (boilers), Steam Systems (boilers), GE (Jenbacher gas engines), Catepillar (gas engines), MWM (Deutsch gas engines), Wartsila (gas engines). There are numerous wood pellet mill manufacturers, essentially overseas based companies, possibly with local sales and support offices. Australia does not produce steam turbines, and these would be supplied from overseas by companies such as Siemens and MAN.

There are also a few local manufacturers of small scale gasifiers who are developing technologies for the Australian market. Gasification Australia has been working with Fluidyne from New Zealand and Real Power Solutions and Corkys have both gone beyond the demonstration of their technologies. Figure 2.12 shows a RealPower Solutions gasifier under development near Canberra.

Project Developers

The market has seen the entry or a number of project developers, who co-ordinate and structure activities leading to bioenergy projects. An early entrant was Babcock and Brown who have worked with National Power on a number of projects that are yet to be constructed. The most advance project is a 44 MW wood fired plant at Manjimup, WA. A joint venture between Delta Electricity and the NSW Sugar Milling Cooperative has led to the construction of both the Condong and the Broadwater 30 MW cogeneration units at NSW sugar mills. Various industries have also developed on site bioheat projects (see listing of projects in Appendix B).

Figure 2.12: Real Power Solutions Gasifier

Source: S Schuck

Support Services

A large number of engineering, environmental and planning consultants are involved in the Australian bioenergy industry. They provide expert services covering biomass production, silviculture, agronomy, waste management, supply logistics, bulk material handling, occupational health and safety, fire protection, risk analysis, engineering design, economic assessment, finance and taxation, insurance, life cycle and greenhouse gas assessment, conducting studies for gaining development approvals, negotiating power off-take agreements, connection to the grid. Examples of service companies are: Aurecon, PB, Sinclair Knights Mertz and Worley Parsons. In addition, organisations and associations such as the Clean Energy Council and Bioenergy Australia support their members with lobbying, advocacy, and information to facilitate projects and businesses. The Clean Energy Council is the peak body representing Australia's clean energy and energy efficiency industries. Bioenergy Australia is the vehicle for Australia's participation in IEA Bioenergy, an international collaborative agreement on bioenergy, which provides networks and authoritative information on bioenergy to assist the Australian industry and other stakeholders.

2.5 Fuel Supply Aspects

Fuel supply for bioenergy is a key consideration. The fuel could be a waste stream with a low or even negative cost (if it has to be otherwise disposed of at a cost). At the other extreme the fuel could be from an energy crop, being relatively expensive, requiring inputs such as land, water, fertiliser, harvesting, pre-conditioning and long distance transport to a power plant. The fuel supply cost could be over half the cost of the product electricity. The economics of bioenergy are considered in Section 4.

A bioenergy plant with an economic life of 20-25 years requires a constant and reliable supply of biomass, meeting a pre-determined specification. The biomass needs to be sustainably sourced, be free of contaminants, preferably have low moisture content, and have appropriate physical characteristics.

At the present time there is not a well developed biomass market in Australia with many competitors and established prices. Many potential suppliers of biomass are unfamiliar with the bioenergy industry. Several bioenergy project developers have spent substantial resources identifying and contracting biomass supplies for projects under development. As such, project specific resources and their cost are closely guarded. Project proponents generally establish a cost-supply curve to identify varying amounts of biomass at different price points.

The combustion characteristics of biomass need to be carefully considered to match the fuel to the technology. High moisture content biomass, such as freshly chipped trees may need to be pre-dried, either through transpirational drying after harvest, or using waste heat from the conversion plant. Use of wet fuel has the dual disadvantages of transporting water which has zero calorific value and adds to the payload, and requiring a highly insulated furnace to cater for such wet fuel. Agricultural straw is often characterised by a high alkali metal and chlorine content, which is associated with corrosion and fouling of boiler tubes during combustion. The 'ash' content of fuel, and its thermal characteristics is also important, as this is associated with corrosion and fouling and also has zero calorific value and adds to the weight of fuel.

The legislation that underpins the Renewable Energy Target (RET) specifies the types of biomass that may be used for bioenergy to generate Renewable Energy Certificates. This topic is covered in detail in Section 2.6 below. Suffice to note is that there is a demanding process to ensure that biomass is from compliant sources, overseen by the Office of the Renewable Energy Regulator. Native forest trees cannot be used specifically as a fuel for bioenergy plants. The fuel must generally be a wood waste from another process, or thinnings from forestry operations, which adhere to the Renewable Energy (Electricity) Amendment Regulations.

2.6 Regulatory Framework for Biomass and Bioenergy

The Renewable Energy Target (RET) underpins the market for renewable electricity and bioelectricity in Australia. The RET has and is currently evolving from the former MRET to the Enhanced RET and now the Expanded RET.

Legislation to implement the expanded national RET scheme was passed by the Federal Parliament on 20 August 2009. A higher annual target under the expanded RET scheme has applied from 1 January 2010. The overall target is to reach 45,000GWh in 2020 and maintained at that level to 2030 when the RET scheme will end.

On 26 February 2010 the Australian Government announced that the small scale technologies, predominantly solar hot water systems and solar photovoltaic systems, which have recently dominated the Renewable Energy Target market, will be split off into a Small-scale Renewable Energy Scheme (SRES), with a capped price of $40 per Renewable Energy Certificate. An amended 41,000 GWh/a target by 2020 for utility scale renewables, designated LRET (Large-scale Renewable Energy Target) would be introduced from 1 January 2011. A discussion paper was issued for public comment on the enhanced RET, with a closing date for comments of 14 April 2010.

It is expected that renewable energy targets will no longer be required after 2030 as a mooted emission trading system matures to drive the deployment of renewable energy. Under the RET the shortfall penalty is set at $65 per megawatt-hour, maintained in nominal terms over the life of the scheme.

The main enabling legislation that is applicable for bioenergy is the Renewable Energy (Electricity) Act and the Renewable Energy (Electricity) Regulation as amended.

Section 17 of the Act prescribes eligible renewable energy sources, including several biomass resources. The biomass sources (using the numbering in the Act) are:

(i) energy crops;

(j) wood waste;

(k) agricultural waste;

(l) waste from processing of agricultural products;

(m) food waste;

(n) food processing waste;

(o) bagasse;

(p) black liquor;

(q) biomass-based components of municipal solid waste;

(r) landfill gas;

(s) sewage gas and biomass-based components of sewage;

(t) any other energy source prescribed by the regulations.

The eligibility of biomass is further covered by the Regulations to the Act. These essentially apply to forestry biomass. The applicable parts of the Regulations relating to bioenergy are presented in Appendix C.

The implications of the Federal Regulations are that native forest trees cannot be used specifically as a fuel for bioenergy plants. The fuel must generally be a wood waste from another process, or thinnings from forestry operations, which adhere to the Renewable Energy (Electricity) Amendment Regulations.

Any biomass used under the RET needs to comply with all State regulations. While coverage of each Australian jurisdiction is beyond the limited scope of this study, some aspects of NSW's regulatory framework gives some insight into the further requirements in that State.

NSW has regulations under the Protection of the Environment Operations Act that prohibit both in-forest harvesting residues and "waste arising from activities (such as woodchipping or the manufacture of railway sleepers) carried out at the location from which the Australian native trees are harvested" being used for electricity production at any appreciable scale. The Protection of the Environment Operations (General) Amendment (Burning of Bio-material) Regulation 2003 was gazetted on 10 January 2003 and requires that all stand alone power plants of more than 200kW capacity, which consume forest biomass, keep records regarding generation and fuels used and submit annual reports to the NSW Department of Environment, Climate Change and Water. The regulations state that "'Burning' includes the use of pyrolysis and gasification, which involve the heating of bio-material to produce combustible products, where such products are subsequently burnt for electricity generation."

Specific NSW Requirements for Non-Standard Fuels

In May 2005 the NSW Government's Department of Environment and Conservation (formerly the EPA and now part of the Department of Environment and Climate Change and Water) issued a "Guidance Note – Assessment of Non-Standard Fuels" to explain how it assesses non-standard fuels at facilities it regulates. This Guidance Note covers more potentially polluting forms of fuels that do not meet the definition of a Standard Fuel, such as painted timber and treated wood. This Guidance Note states Standard Fuels in NSW include "untreated timber residues, such as from forest operations or sawmilling" and "bagasse from sugar cane". The Guidance Note contains a list of criteria that DECCW uses to assess whether a waste proposed for use as a Non-Standard Fuel is for genuine energy recovery. One criterion is the chemical and physical homogeneity of the material. The NSW Government's main concerns are that bioenergy plants do no become de-facto incinerators for the disposal of waste through the atmosphere and that materials are used for their highest net resource value.

Landfill Gas Sector

Waste management policy and trends in Australia are of some concern to this sector of the bioenergy industry. Several jurisdictions would wish to scale down landfilling of waste on the basis of current landfill sites filling up and the need to transport waste longer distances (e.g. to Woodlawn from Sydney) and in an effort to increase recycling and reuse of materials otherwise destined for landfill. A long standing issue is ground water contamination from leachate. Landfill levies have been on the rise, to provide a price signal from state governments. The Victorian Government has also set up the Victorian Advanced Resource Recovery Initiative (VARRI) to progress alternative waste processing, with energy recovery options from several alternative technologies.

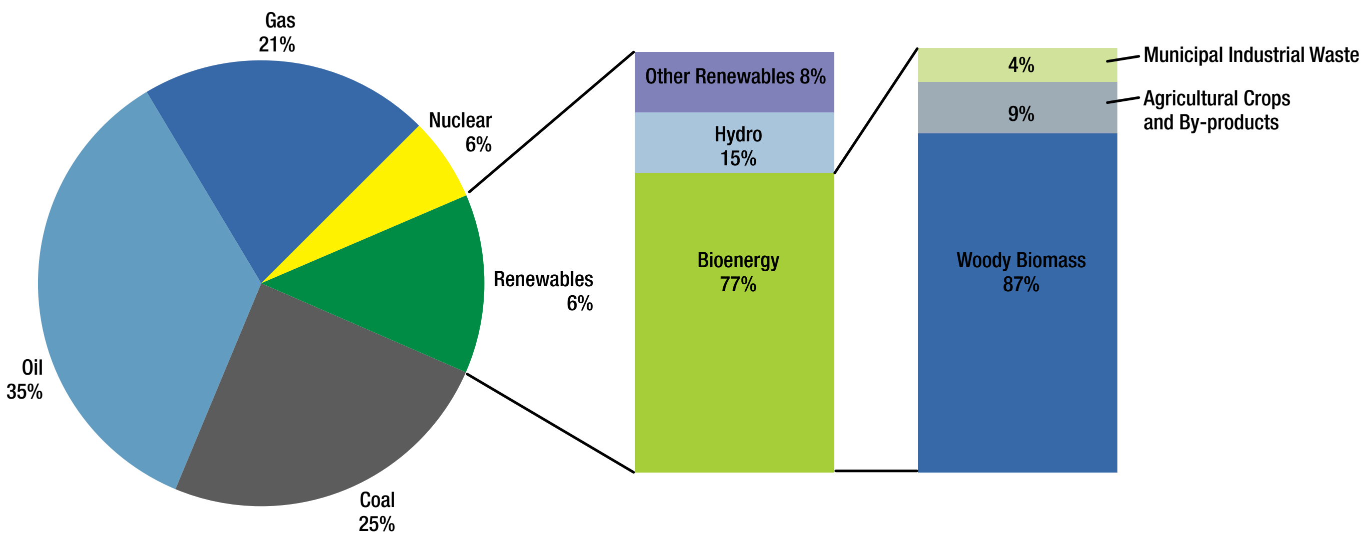
This sector is of the view that from a greenhouse perspective, well functioning landfills are just as environmentally friendly, if not more so than any other waste management technology for organic waste. Further, as both management of organic waste and as energy from waste technology, landfill comes at the lowest economic cost to the community. However, these benefits are largely ignored in legislated waste policies (such as increasing waste levies) that do not distinguish between the benefits of organics in well functioning, grid connected landfills, from inorganic waste that should be recycled. Given the high level of performance of landfill gas renewable electricity to the grid, if this issue is not resolved to the satisfaction of the landfill gas sector, it will greatly diminish the level of renewable energy coming from organic waste and will certainly limit further expansion.

The overall framework for bioenergy is a relatively complex, in that policy relating to agriculture, forestry, rural development, waste management, climate change, industry, water, transportation, biosecurity and energy can all come into play. State legislation relating to biomass takes precedent under the Federal RET legislation.

3. Overseas Market Trends

Biomass, in its various forms contributes approximately 10 percent to the world's approximate 500 EJ energy demand. Most bioenergy is fuelled by woody biomass, followed by agricultural crops and residues. This is illustrated in Figure 3.1.

Figure 3.1: Share of Bioenergy in Global Primary Energy Mix



Source: IEA Bioenergy [4]

A report by IEA Bioenergy [4] indicates that the technical potential of bioenergy could be as high as 1500 EJ/year by 2050, although sustainability constraints may reduce this to 200-500 EJ/year. Globally, modern bioelectricity has a current capacity of 52,000 MW, of the same order of magnitude as Australia's total coal fired power industry.

3.1 Status of Bioenergy in Selected International Markets

The International Energy Agency [5] reports that in the OECD countries electricity generation from solid biomass grew from 93.1 TWh to 115.9 TWh between 1990 and 2006, yielding a 1.4% average annual growth. As the second largest renewable electricity source after hydropower, solid biomass accounted for 7.2% of renewable electricity in 2006. The USA accounted for 36.1 percent of electricity generated from solid biomass (41.8 TWh) where it makes up 10.6% of the country's renewable electricity production. The second largest producer of electricity from solid biomass in the OECD is Japan (15.1 TWh), where it represents 13.9% of the country's renewable electricity supply. Other big producers are Finland (10.5 TWh), Canada (8.3 TWh) and Sweden (7.5 TWh).

Renewable municipal waste represented 1.7% of renewable electricity generation in 2006 in OECD countries. The largest producer of electricity from renewable municipal waste was the United States, generating 36.1% of OECD production.

Globally, electricity from biogas grew from an estimated 3.59 TWh in 1990 to 24.54 TWh in 2006. A large proportion of the production took place in OECD Europe (63.1% in 2006). The largest producers in the European Union were Germany, followed by the UK.

According to the IEA [5], within developed countries, Finland provides 20.1% of its Total Primary Energy Supplies from biomass (combustible renewables and waste), Sweden 17.5% and Denmark 11.9%. The equivalent figure for Australia is 4.9%, which includes space and water heating using firewood. In the EU, 55 TWh of electricity from biomass were produced in 2004 (roughly the annual consumption of Switzerland), mostly from wood residues and MSW. Finland is proportionately the leading producer with 12% of its power consumption produced from biomass and wastes.

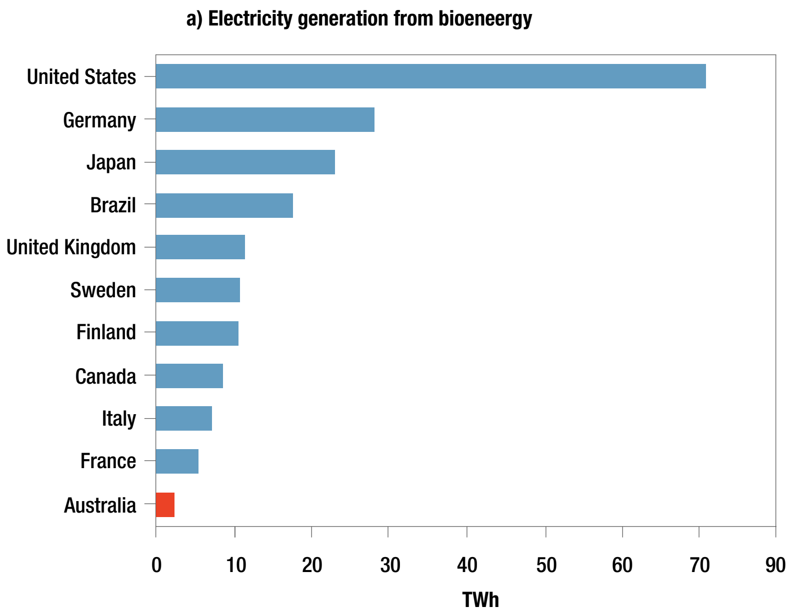
Global electricity production from biomass is projected to increase from its current 1.3% share (231 TWh/year) to 2.4-3.3% by 2030 (~800-1000 TWh/year) [4], corresponding to a 5-6% average annual growth rate. In absolute terms, the net increase would thus be about four times the current production. In spite of this rapid growth, this still represents a relatively small contribution from biomass compared with its technical potential.

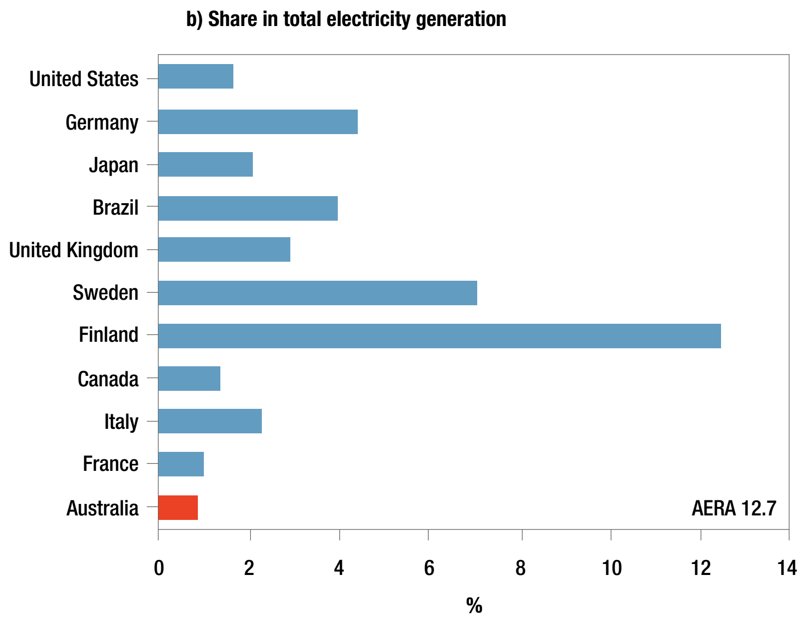
China is reputed to be the world's fastest growing market for both biopower and waste-to-energy technologies. With huge reserves of readily available waste feedstocks, China is in the midst of a fundamental shift in how it powers its rapidly expanding economy. By the end of 2009, the capacity of newly-built bioenergy facilities surpassed the government's 2010 target of 5.5GW. By 2020, China aims to expand this production to 30GW, which will require major investments in advanced foreign technologies.

Biomass heating is well developed in countries with good resource availability and where district heating systems are already in place e.g. northern Europe. Sweden is the leader with biomass contributing close to 50% of its large-scale heat production, followed by Austria (24%), Finland (17%), Denmark (14%) and Norway (10%). On average 5% of large-scale heat is provided by biomass in the USA and 7% in the IEA member countries [4].

In OECD countries the volume of biomass for residential heat is expected to grow by 40-90% to reach 3.2-4.3 EJ in 2030, mostly due to the growing market for modern boilers and stoves. The global use of biomass and waste in the industrial heat sector is expected to increase slowly, in line with increased energy demand, by between 1.9% and 2.2% annually to reach close to 13 EJ by 2030.

Figure 3.2: Bioelectricity Generation by Country





Source: Geoscience Australia [2]

Examples of Bioenergy in Europe

Finland has a vibrant bioenergy market with biomass providing 20% of its Total Primary Energy Supplies and biomass and wastes providing 12% of its power. Wisapower commissioned the world's largest black liquor (spent wood pulping liquor) boiler in 2004. This recovery boiler was supplied by Andritz, with the cogeneration power plant having an electrical output of 140 MWe and the process steam output being 600 MWth. Another example of a Finnish bioenergy project is the Alholmens Kraft cogeneration plant in Pietarsaari on the west coast of Finland. The CFBC boiler has a capacity of 550 MWth and an electrical capacity of 240 MWe. The Alholmens plant can use a variety of fuels, from 100% biomass to 100% coal. The plant was commissioned in 2001 at an investment cost of €170 million. Figure 3.3 is an aerial view of the energy plant with the biomass fuel yard in the foreground.

Large- scale industrial use of wood pellets occurs at the Electrabel Les Awirs Power Station in Belgium, where a 125 MW coal fired power station unit has been converted to be fuelled exclusively on wood pellets. In modifying the plant, its capacity has been derated to 80 MWe to cater for the altered fuel. The feedstock originates from all parts of the world, with wood pellets being delivered in a 'just in time' mode of operation by flat boats from the port of Antwerp and also by road. The plant consumes 350,000 tonnes of wood pellets annually, or approximately 1,000 tonnes per day. These pellets are reduced on site to wood dust where they fire the power plant. Figure 3.4 shows the pellet conveyor feeding into the Les Awirs Power Station.

As recently as April 2010 French global power utility GDF Suez signed a contract with engineering firm Foster Wheeler for the design and construction of a circulating fluidized-bed boiler for a proposed 190 MWe 100 percent biomass-fuelled power station near Polaniec, south-eastern Poland. The proponents believe this will be the world's largest biomass boiler fuelled exclusively by wood chips and biomass crops.

Figure 3.3: Alholmens Kraft Power Plant

Source: Alholmens Kraft

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Figure 3.4: Les Awirs Power Station in Belgium

Source: S Schuck

The facility will be located at the site of GDF Suez's 1,800 MW coal/biomass cofired-power station, Polaniec Power Station. The facility will require 222,000 tonnes of agri-fuels and 890,000 tonnes of woody biomass each year. The total project investment is €240 million. The power station is expected to be operational by the end of 2012. GDF Suez has more than 50 sites in the U.S., Europe and Brazil that annually consume more than 2 million tonnes of biomass for power generation.

The global use of wood pellets is currently estimated to be approximately 12 million tonnes per year, and is predicted to rise to 30 million tonnes by 2030. The main market for wood pellets is in western and northern Europe, spurred on by EU greenhouse gas reduction targets. Wood pellets are used in used in both the domestic and industrial sectors. Figure 3.5 shows a typical wood pellet district heating plant in Sweden, while Figure 3.6 shows a typical wood pellet boiler for domestic use.

Green Gas

A relatively new market offering is methane from biogas which is injected into gas distribution networks. As an example, UK company, Ecotricity has launched a tariff Green Gas to fund the construction of digesters which turn food leftovers and waste into methane. Under their new tariff, households will initially receive standard natural gas, but the firm will invest all profits into developing commercial plants which will inject methane from biogas into the grid. Ecotricity will supply a greater proportion of green gas in the mix as more people sign up and more plants are built.

The German Government has a target of 10% of the gas being derived from biogas in the gas grid by 2030. That government has provided feed-in regulations since March 2008 which provide new incentives for on-farm biogas plants and waste treatment. The total number of farm-based biogas plants in Germany has increased from a few in the 1980s to approximately 4,800 with a combined electricity capacity of 1,600 MW.

Figure 3.6: Typical Small Scale Wood Pellet Boiler

Source: S Schuck

Figure 3.5: Wood Pellet Fuelled Central Heating Plant in Sweden

Source: S Schuck

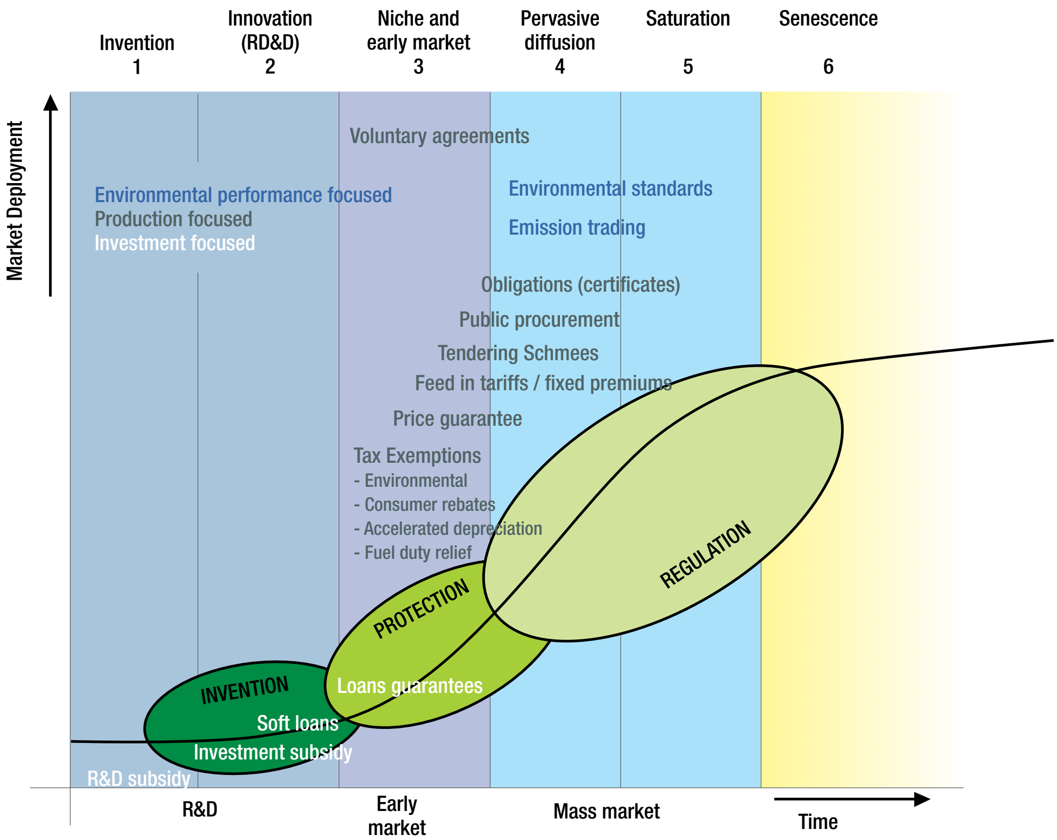
Waste-to-energy

Collectively, Denmark, Germany and the Netherlands have 400 municipal waste-to-energy plants. Denmark alone has 29 plants which serve 5.5 million people and 98 municipalities. Waste-to-energy plants are relatively expensive. Their capital costs are a significant barrier in all but the most expensive markets, in places where a high population density puts a large premium on available land for landfill.

3.2 Regulatory Frameworks in Different Jurisdictions

Noting that the regulatory framework can potentially cover all aspects of biomass and bioenergy, spanning agricultural and forestry policy, management of municipal solid and liquid wastes, land use, water, air emissions, industry, research and development, science, energy supply and energy markets, trade, climate change, transportation, and employment, this section focuses on examples of government policies and programs in some overseas jurisdictions covering aspects more specific to stimulating the bioenergy industry.

Figure 3.7: Overview of Policy Instruments



Source: IEA Bioenergy [4]

Various mechanisms have been set in the developed economies to stimulate greater deployment of renewable energy including bioenergy. Figure 3.7 [4] provides an overview of policy instruments for the various technology stages applicable to bioenergy.

Figure 3.7 illustrates that policy instruments can be investment, production and environmental performance focussed. At the early market phase of invention and innovation, common policies and programs are focussed on R&D funding and investment subsidies for pilot and demonstration plants. As the technology transitions to the early market stage, policies are often geared towards soft loans and loan guarantees. Mechanisms at this stage include tax exemptions, price guarantees, feed in tariffs and premium pricing for the output energy, government purchasing policies giving preference to renewable energy, and obligation and mandate schemes. At the mass market stage, policies have tended towards emission trading schemes and more demanding environmental standards.

Mandates, similar to Australia's RET have been established in the UK, and many US states have Renewable Portfolio Standards (RPS), requiring a certain proportion of electricity be derived from renewable sources. In some jurisdictions, feed-in tariffs that cater for several forms of bioenergy have been implemented. Feed-in tariffs provide guaranteed contract prices for a substantial period. Several schemes are indicated below.

Many jurisdictions have taken on targets to reduce greenhouse gas emissions and provide certain proportions of their energy from low emission sources, most notably renewable energy sources such as bioenergy. For instance the UK Government is committed to combating climate change by reducing greenhouse gas emissions by 80% of 1990 levels by 2050. In 2008, the UK Government signed up to European targets to produce 15% of all energy produced in the UK from renewable sources and their recent Renewable Energy Strategy proposed that 30% of that renewable energy would come from bioenergy. Some 33 US states have Renewable Portfolio Standards to similarly provide an increasing proportion of electricity from renewable sources.

Renewable Portfolio Standards (RPS) in the USA

Renewable Portfolio Standards require electric utilities and other retail electric providers to supply a particular minimum quantity of customer load with electricity from eligible renewable energy sources. This amount usually starts at a small percentage and increases over time. As of the end of 2008, Renewable Portfolio Standards had been created in 33 US states along with the District of Columbia. Regulations vary from state to state as there is no US federal policy. Four of the 33 states have voluntary rather than mandatory goals. Together these states account for more than 42% of US electricity sales. Each RPS is designed to take into account state-specific policy objectives, including economic growth, diversity of energy supply and environmental considerations.

Colorado provides an example of a RPS. Is has recently increased its renewable energy standard to require large utilities to obtain 30% of their power from renewable sources by 2020. In 2004, the state became the first in the United States to have a voter-approved renewable energy portfolio standard, when a referendum was approved calling for 10% renewable power by 2015. In 2007, state legislation increased the requirement to 20% renewable energy by 2020, a target that the new legislation has now increased to 30%. Bioenergy is one of the compliant forms of renewable energy under this RPS. The new law requires utilities to supply at least 12% of their retail electric sales from such sources from 2011 to 2014, 20% from 2015 to 2019, and 30% for 2020 and thereafter.

US Biomass Crop Assistance Program (BCAP)

Biomass supplies are crucial for the success of bioenergy. Recognising this, the United States has a legislated program, established in the 2008 Farm Bill, designed to stimulate new energy and economic developments in rural America by reducing financial risk for farmers, ranchers and foresters who invest in the establishment, production, harvest and delivery of biomass crops to displace fossil feedstocks used for biofuels and renewable energy. The BCAP has been developed to encourage farmers and forest landowners to help develop the biomass supply chain and accelerate energy independence, rural economic development and renewable sources of energy. The Program authorises the United States Department of Agriculture's (USDA) Farm Service Agency (FSA) to help those who own biomass by providing matching payments for the collection, harvest, storage and transportation of eligible biomass delivered to approved facilities. FSA service centres across the US have issuedpayments of up to US$45 per dry ton for eligible biomass deliveries. Through 2 April 2010, USDA has approved 4,605 agreements for the delivery of more than 4.18 million tons of biomass and paid eligible biomass owners US$165,274,695 in matching payments under BCAP's first phase. Charts showing BCAP Collection, Harvest, Storage & Transportation Component and Summary Reports are at www.fsa.usda.gov/bcap.

Feed-in Tariffs

As noted above, feed-in tariffs are a mechanisms for stimulating the uptake of renewables in overseas markets, including bioenergy. While Australia has several state-based feed-in tariff schemes, they are all small scale and do not apply to bioenergy. Three such international schemes are briefly covered below:

The Netherlands

The SDE (stimulering duurzame energie – stimulating sustainable energy) feed-in tariff scheme aims to stimulate the production of renewable electricity. The SDE is an important element of the Clean and Efficient, New Energy for the Climate program, to enable The Netherlands to reach its target of 20% of renewable energy by 2020.

In April 2009, a new round of SDE subsidies commenced. The government pays a subsidy for each MWh of renewable electricity. The SDE provides the investors in renewable energy long-term security. The scheme covers up to 1,000MW of renewable electricity, which corresponds to an investment of approximately €1.5 billion. The SDE compensates the difference between the cost of the regular energy and sustainable energy. This subsidy scheme will last for a period of fifteen years (for hydro, waste incineration, solar-PV and wind on land) or twelve years (for biomass, other green categories and gas). The scheme provides support for bioenergy in the categories in Table 3.1:

Table 3.1: SDE Feed-in Tariff Subsidies

Type of Biomass	Subsidies
Electricity generation using WWTP* / Landfill Gas	4.4 €ct per kWh
Green Gas production by WWTP / Landfill Gas	14.7 €ct per Nm^3
Green Gas production by co-fermentation of animal manure fermentation and vegetable waste	14.7 €ct per Nm^3
Burning of solid biomass, fermentation of vegetable waste and co-fermentation of manure	4.4 €ct per kWh
Waste incineration plant with an energy efficiency higher than 22%	9.2 €ct per kWh

*WWTP: waste water treatment plant
Source: SenterNovem, 2009

Ontario, Canada

The Canadian province of Ontario's feed-in tariff is North America's first comprehensive guaranteed pricing structure for renewable electricity production. It was brought into force in May 2009 by the Green Energy and Green Economy Act, 2009. It offers stable prices under long term contracts for renewable sources including biomass, biogas and landfill gas. The Ontario Power Authority is responsible for implementing the program. Aims of the program include phasing out coal-fired electricity generation by 2014, boosting economic activity to develop renewable energy technologies and to create new green industries and jobs.

The Ontario feed in tariff program provides 20 year contracts, provides a Consumer Price Index escalation, and has a peak performance factor of 1.35 for all peak demand hours and 0.90 for all off-peak hours. All forms of bioenergy also have an 'Aboriginal price adder' and 'community price adder'. The Ontario Power Authority owns all related products generated from projects, such as any environmental attributes or carbon credits. Table 3.2 lists the feed-in-tariff prices at the base date of 24 September 2009.

Table 3.2: Ontario Feed-in Tariff Tranches and Prices

Renewable Fuel	Size Tranches	Contract Price Ca c/kWh
Biomass	≤ 10 MW	13.8
Biomass	> 10 MW	13.0
Biogas on-farm	≤ 100 kW	19.5
Biogas on-farm	> 100 kW ≤ 250 kW	18.5
Biogas	≤ 500 kW	16.0
Biogas	> 500 kW ≤ 10 MW	14.7
Biogas	> 10 MW	10.4
Landfill gas	≤ 10 MW	13.1
Landfill gas	> 10 MW	12.2

Table 3.3: German Feed-in Tariffs

Size Tranches	Compensation (€ cents/kWh)
≤ 150 kW	11.67
> 150 kW ≤ 500 kW	9.18
> 500 kW ≤ 5 MW	8.25
> 5 MW ≤ 20 MW	7.79
Bonus Compensation for using:	
energy crops	4.0-7.0
manure	1.0-4.0
landscape preservation	2.0
innovative technology	1.0-2.0
combined heat and power	3.0
fewer emissions (clean air)	1.0

Germany

Germany has a feed-in tariff which provides bonus compensation for the use of energy crops, use of manure, landscape preservation, innovative technology and cogeneration. Table 3.3 shows the compensation available under the EEG (feed in tariff law).

Both China and Thailand have feed-in tariffs for bioenergy. In China, the feed-in tariff equates to 11.5 c/kWh and in Thailand the rate for <1MW is 10.5 c/kWh and for projects >1MW 9.9 c/kWh. Many jurisdictions around the world have incentives in place to stimulate the deployment of renewable energy and bioenergy. In several countries these measures have had a dramatic effect in increasing the scale of bioenergy. A good example is the huge growth of the German biogas industry.

3.3 International Trade in Biomass

International trade in biomass, most notably fuel ethanol and wood pellets has increased dramatically over the past few years. Other forms of biomass fuels traded are wood chips, round wood, palm oil, various agricultural residues, and waste wood. The trade in wood pellets has been largely driven by rapidly increasing demand in Western Europe for meeting greenhouse gas reduction targets and to a lesser extent diversifying sources of energy.

Pellets command a price premium (see Section 4) over other forms of biomass, such as logs and wood chips, mainly due to their higher energy density, low moisture content, and ease of handling, storage and use. Wood pellets are widely used in Europe for domestic heating and for industrial heat and power. European use of pellets has grown from 6 million tonnes in 2007 to approximately 12 million tonnes in 2010. The Western European demand for solid biomass is being met through trade, mainly from Eastern Europe and the former Soviet Union and also from Canada and the USA. Over half the woody biomass used for co-firing in Dutch power stations in 2008 was imported from north America. About 35% of all wood pellets produced in Europe (including eastern European countries) is traded across a border. Substantial quantities of Mountain Pine Beetle damaged timber in the western part of Canada and the USA are being converted to pellets, some in large pellet plants on the continent's eastern seaboard, and shipped to Europe.

A report from the British Confederation of Forest Industries (Confor) entitled 'Wood Fibre Availability and Demand in Britain 2007-2025', states that Britain will, for the first time, become reliant on imported wood chips and pellets as the demand for biomass will exceed domestic supply as early as 2012. If all the energy plants planned for the UK materialise then the amount of imported wood products could dramatically increase to an annual total of 27 million tonnes per year.

Australian companies have recognised the relatively high prices paid in Europe for wood pellets and coupled with the difficulties in launching large-scale bioenergy projects in Australia, are setting up wood pellet export mills. Plantation Energy Australia has set up a pellet factory near Albany, Western Australia and has announced plans for a succession of similar 250,000 tonnes per year pellet plants across Australia. Electabel, a Belgium power company has announced that it will be procuring some of its pellets from Plantation Energy Australia. Another Australian company, Altus Energy is planning a pellet mill in Queensland and other companies are also known to be exploring export of Australian biomass to Europe.

Examples of International Wood Pellet Trades

Recent trade media announcements regarding energy pellets have been:

- RWE Innogy has commenced construction of a 750,000 tonne per annum wood pellet plant, in Waycross in the southern region of the US state of Georgia. Once complete, the output from the plant will supply RWE power plants in Europe, for use both in dedicated biomass facilities and co-fired with coal. The total investment is €120 million. The company is also investing in the development of port facilities in Savannah through its subsidiary Georgia Biomass LLC. Construction in Waycross is expected to take around 15 months and the first pellets are due to be produced in the third quarter of 2011.
- Green Energy Resources announced it has signed a US$21 million pellet order with an Italian company. The order entails 12 monthly shipments of 10,000 tons commencing in February 2010. Green Energy Resources will supply pellets packaged in 18 kg bags to be distributed to retailers in Europe. Green Energy Resources works with US pellet manufacturers to move unused or built up inventories.

Issues surrounding biomass trade include sustainability issues, greenhouse gas balances, biosecurity, fire (dust explosions), and immature markets.

4. Economics of Bioenergy

Bioenergy, unlike direct solar energy and wind power, is highly specific to fuel type, scale, a variety of energy conversion technologies and the parameters of the project. Fuels and feedstocks differ widely in physical and chemical properties. The fuel may be landfill gas, an effluent stream having a water content of 98 percent, through to a very low moisture content fuel, such as rice husks.

A bioenergy technology or project may vary in scale from less than 10 kW to hundreds of megawatts, use a variety of energy conversion technologies, such as combustion, gasification, pyrolysis or a biodigester, and may use a low (or even negative) cost fuel presenting adjacent to the plant, or require the fuel to be harvested, pre-processed (pelletised or chipped), transported and stored on site. Biomass co-firing with coal largely uses existing infrastructure, while a greenfield plant incurs the full development cost of a new power plant. The project may be situated close to existing infrastructure and support services, or may be located in a remote setting.

The diversity of possible bioenergy projects results in costs specific to a particular project. Accordingly this section provides a broad indication of the economics of bioenergy and discusses many of the determinants of the economics.

The economics of bioenergy are largely determined by the capital cost of the plant, the ongoing requirement for fuel, and to a lesser extent the operational and maintenance expense.

The scale of a bioenergy plant is crucial to its viability. Capital costs and operating costs for conventional combustion plants vary significantly with plant size. A large (40 MW) biomass power station may have a capital cost of $2.5 million per megawatt of installed capacity. A biomass power plant of less than 1 MW may cost $8 million or more per MW. Thus the capital cost component on a per MW basis of a large plant may be less than one third of the small plant. Scale effects are discussed further in Section 5. Operating costs also favour larger plants on an energy produced basis.

The capital cost for methane generation and capture may be significant. Once the methane is captured and purified (if required), power generation is often based on relatively low cost spark ignition engines.

Modelling Bioenergy Cost of Production

Noting that the cost of bioelectricity is project specific, and dependent of numerous parameters, a model is presented to bring out several factors that set the capital and electricity production cost of a typical bioenergy plant. The example presented is for a 30 MW scale wood fired combustion power plant. This model can readily be adapted to cater for a range of technologies, scales and assumptions.

The model uses the following input parameters:

- Operating and Maintenance cost (c/kWh)
- Moisture content of fuel (% on wet basis)
- Calorific value of the dry fuel (MJ/kg)
- Capital cost of plant ($/kW)
- Real rate of return required (%)
- Life of project (years)
- Capacity Factor (ratio)
- Plant size (MW)
- Energy conversion efficiency (%).

The model calculates the operational heating value of the fuel, and uses the other plant parameters to calculate the total fuel requirement and the electricity cost. The cost of electricity production is broken down into capital, fuel and operating and maintenance costs, as well as providing the total annual cost of these components.

This example uses an assumed fuel price at the power station gate of $35 per tonne with an assumed moisture content of 45 percent, assumes an Operating and Maintenance cost of 1.5 c/kWh. A wood fuel with the typical calorific value of 19 MJ/kg, a capital cost of $2.7 million per MW of installed capacity (assuming a generic grate boiler), a real rate of return of 8 percent, an operating life of the plant of 25 years, a capacity factor of 0.85, and an energy conversion efficiency of 31 percent are all chosen for this modeling exercise. These are regarded as being realistic for a typical project.

The results of this modeling exercise is presented in Table 4.1 below. The example indicates a capital cost component of 3.40 c/kWh, a fuel component of 4.71 c/kWh, O&M (an assumption) of 1.50 c/kWh, giving a total levelised cost of energy of 9.60 c/kWh.

Table 4.1: Cost and Biomass Requirement Model – Indicative Example

Bioenergy Power Plant - Production Cost Model
30 MW Electricity Output

Assumptions:	Modelling inputs in bold						
Real rate of return:	**8**	percent					
Project life:	**25**	years					
Capital recovery factor:	0.0937						
Capital Cost of Plant:	**2,700**	$/kW installed					
Plant capacity factor:	**0.85**						
Plant size:	**30**	MW elec					
Overall plant efficiency:	**31**	percent					
Energy per 1 kW per year	7446	kWh/a	Energy from power plant:			223.4 GWh/a	
Capital							
Capital Cost per year:	$252.93	per kW/a					
Capital Component			3.40	c/kWh		$7.588	million/a
Total Capital Cost:	$81.0	million					
Fuel							
Wood cost	**35.00**	$/t	at moisture content		**45**	%	
Energy content dry	**19**	GJ/t	Energy content wet		8.6	GJ/t or MJ/kg	
Wood fuel cost	4.05 $/GJ					$10.516	million/a
Fuel component:			4.7	c/kWh			
O&M			**1.50**	**c/kWh**		$3.351	million/a
Total cost			9.60	c/kWh		$21.455	million/a
Fuel Consumption							
Energy output of plant:	804168.0	GJ/a					
Fuel Energy input:	2.6	PJ/a					
Fuel Use:	300.5	kt(wet)/a	or	165.3	kt(dry)/a		
	823.2	t(wet)/day		452.7	t(dry)/day		

Capital Cost Element

The capital cost and plant efficiency are design parameters and can to some extent be pre-specified. The specification of a higher steam temperature (e.g. 540 °C) would improve the steam cycle thermal efficiency. However, this would result in the need for more exotic boiler steel materials and water purity, raising the overall capital cost. However, the amount of energy produced from a given amount of wood fuel would also increase. This trade-off would need to be assessed at the feasibility study stage of a project. The model readily allows such sensitivities to be explored.

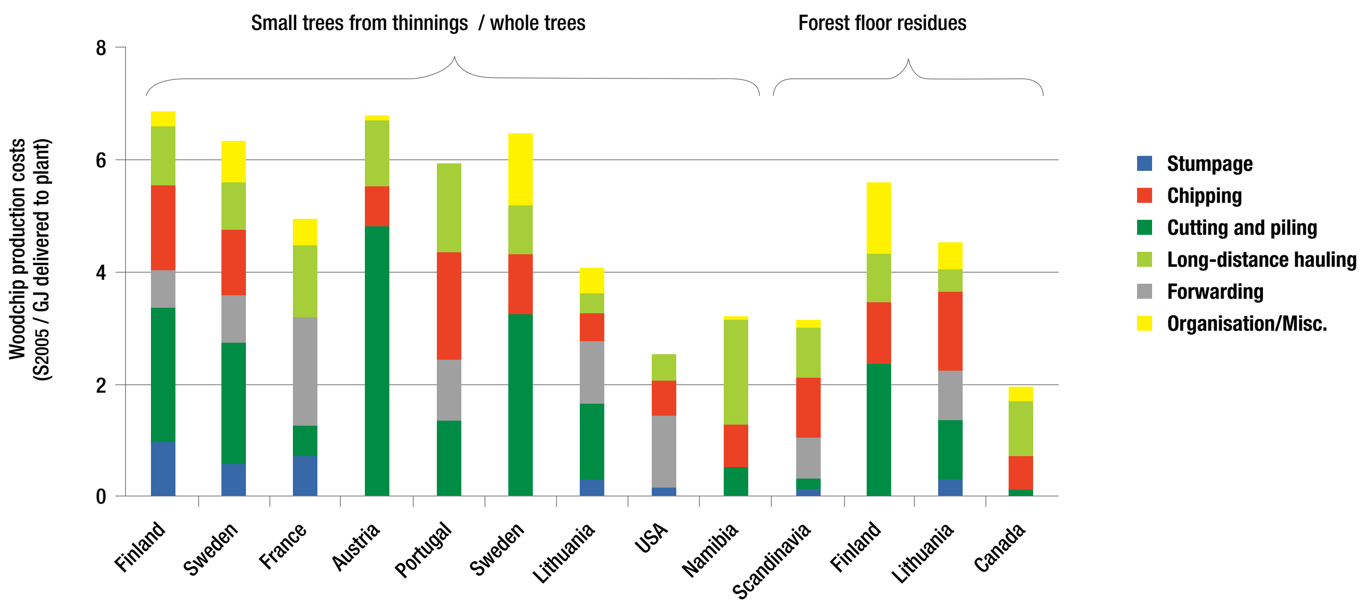
For the same size plant, a fluidised bed combustor would be somewhat more expensive than a grate type system. The EPC (Engineering, Procurement, Construction) cost includes the boiler island, turbine island, plant civil works, cooling water system, fuel handling (no grinding or processing), plant instrumentation and control systems, flue gas cleaning and ash handling plant etc. The estimates exclude any external water supply works, switchyard, new sewerage or storm water systems and other infrastructure costs.

Fuel Cost Element

The above model uses a relatively high cost fuel with an average cost of $35 per tonne (fresh weight), with an assumed moisture content of 45 percent on a wet basis. This equates to $4.05/GJ at the power plant which is in the mid-range of the values presented in Figure 4.1 [4].

If the fuel were an on-site waste, such as sawdust at a sawmill, the cost would be expected to be considerably cheaper. Again, the impact can be tested via the above model.

Figure 4.1: Typical Cost Structure for Wood Chips in Several Countries



Source: IEA Bioenergy [4]

Operation and Maintenance

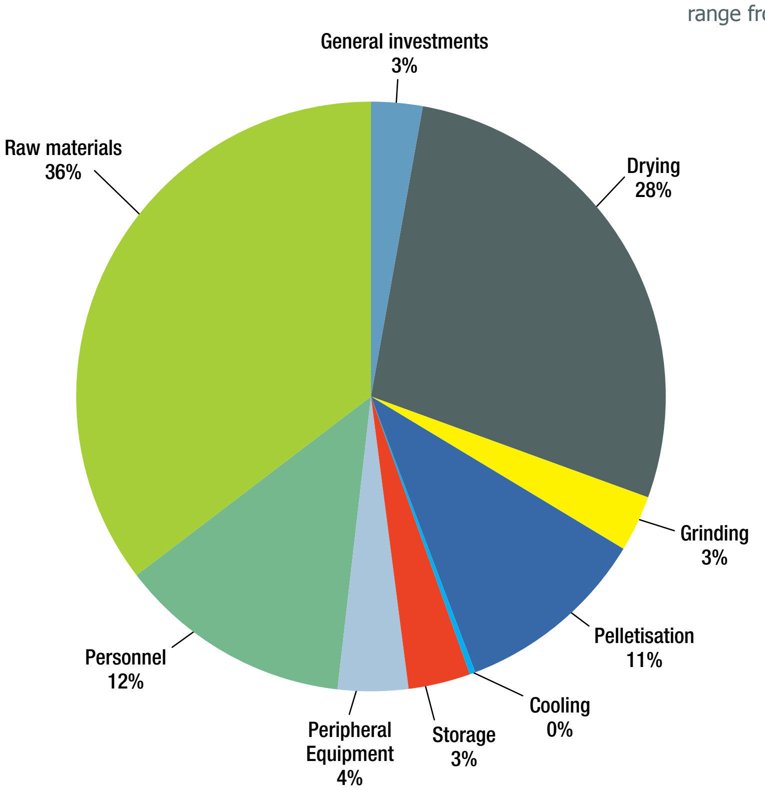
The cost of staff labour, lubricants, chemicals and other similar items are set at 1.5 c/kWh which is regarded as very conservative for a 30 MW scale wood waste fired power plant. In a study released by the Forest and Wood Products Australia [6], for a 10 MWe scale plant, the direct operating costs, including two full time staff, ash disposal, water make-up, water treatment, and maintenance were set at 1.5% of Capex, and was calculated at 1.69 c/kWhe. O&M costs can vary depending on synergistic opportunities at the power plant. For instance, staff could be shared with an adjacent sawmill if so located. Water availability and cost could dictate dry cooling with higher capital and O&M costs. However, ocean cooling, depending on siting could be a low cost option. O&M is not a dominant cost factor in the final cost of the electricity.

While the above analysis is of a general nature, applying to a typical solid biomass fired power plant, the model could be extended to landfill gas or biogas projects. Extraction of landfill gas involves the cost of a gas extraction well field, purifying the gas to remove moisture and other impurities, and generally combustion of the low calorific value gas in a spark ignition engine. The gas would generally be subject to a royalty, on the basis of gas used or energy produced. The project proponent generally assumes the fuel supply risk. Gas engines are relatively inexpensive and have good energy conversion efficiencies.

Economics of Pellet Production

Industrial scale energy pellet production is in its infancy in Australia, with only one large scale plant currently operating at Albany, Western Australia. Pellet production costs can vary somewhat, depending on a number of factors. The highest two cost elements are drying and the cost of the raw wood material. Overseas experience is that drying energy can exceed 200 kWh/tonne of pellets produced. Pellet production can be less expensive if the drying energy is supplied by a co-located biomass cogeneration power plant and using part of the heat output of the power plant for drying the pellet mill feed. Austrian experience is that the ex-factory production costs vary between approx. €79 and €101 per tonne on average for wet raw material and €52 and €81 per tonne for dry raw material. Swedish pellet production can be nearly half as much, as in that country it is common for pellet mills to be co-located with cogeneration plants (unlike Austria), the pellet mills tend to be much larger and as such energy cost for pellet production is less. Australian companies accessing European and other distant markets also need to cover transport and storage costs, which can be quite substantial. Coupled to this, pellet demand and hence prices, especially for domestic heating are weather dependent, and hence volatile. Figure 4.2 show a typical cost breakdown of pellet production using wet (55 percent moisture content) feed.

Figure 4.2: Typical Pellet Cost Breakdown Using Wet Raw Material



Bagged pellet prices are higher than bulk delivery, and typically range from €70 - €270 across Europe.

Energy Pellets

Energy pellets provide a convenient transformation of moist and low bulk density biomass fuels (such as wood chips) into a more convenient, easier to handle, preprocessed fuel with a very low moisture content (typically 8 percent) and a bulk and density of approximately 650 kg per cubic metre. This densification process has a number of advantages. The densification of the biomass has vastly expanded the economic distances that biomass can be transported for energy conversion, the pellets themselves have a high operational calorific value, the pellets can be milled allowing dust firing in power plants (such as practised in NSW and Queensland power stations), and co-firing using pellets can be at very high biomass percentages. A power station unit in Belgium has been converted from coal to being exclusively fired on wood pellets (Les Awirs plant near Liege, Belgium). Wood pellets are widely used for domestic space and water heating in several countries such as in Sweden, Austria and Canada. Pellets are also used for domestic district heating and for industrial use, predominantly in Europe, North America and more recently in Japan.

Wood pellets currently provide up to 70 percent of the fuel for the Avedore 2 unit in Denmark (590 MWe ultra-supercritical unit). European wood pellet use is currently approximately 12 million tonnes per annum, and is expected to reach 30 million tonnes by 2020.

Torrefaction

Torrefaction is an evolving biomass fuel pre-treatment process, similar to the roasting of coffee beans, that partially chars biomass, increasing its density and giving the biomass physical and chemical properties closely related to coal. This allows the biomass to be a fungible fuel, which can be handled using conventional coal power station equipment. Torrefied biomass is also not as liable to absorb ambient moisture. Torrefaction is viewed as an expensive option, which is still to be proven both technically and economically at an industrial scale. French engineering company Thermya is working to commercialise a fast continuous torrefaction technology. Their first commercial TORSPYD torrefaction plant is currently under construction in Northwest Spain, and should be operating at the end of 2010. Units developed by Thermya range from 100 to 5,000 kilograms per hour, and are designed to operate on the basis of 8,000 production hours annually. The fuel has a calorific value of 20-21 MJ/kg with a moisture content of a mere one percent.

Large Scale Bioenergy Plants

A power industry 'rule of thumb' is that for every doubling of a power plant's capacity, the specific capacity capital cost will reduce to approximately 85 percent. For instance, if a 40 MW thermal power plant costs $2.8 million per mega-watt of installed capacity, an 80 MW plant would cost $2.38 million per MW of installed capacity. This economy-of-scale for power plants has resulted in most Australian coal fired power station units being in excess of 500 MW. However, prior to the advent of large-scale international trade in solid biomass (logs, pellets and chips), and lack of market incentives, biomass power plants have generally been limited to relatively small units (up to 45 MW). The size has been largely set by the distance biomass can be economically transported to a power plant.

In recent years several large scale bioenergy projects have emerged. A number of 350 MWe scale bioelectricity plants have been announced for the UK, to be fuelled largely using imported biomass. These large plants operate at high steam temperatures and pressures, determinants setting the overall thermal conversion efficiency. This allows greater energy production for a given amount of fuel. This requires more exotic boiler steel and greater working fluid (water) purity, increasing the capital and operating cost (see Section 4).

Circulating Fluidised Bed Combustion (CFBC) technology has also been a contributor to the increase in scale of biomass boilers. Fluidised bed combustors can provide flexibility in the range of fuels combusted, allowing higher moisture content fuels to be used. A prime example of the application of CFBC technology is at the Alholmens Kraft pulp and paper mill in western Finland, where part of the fuel supply is 'slash bundles' conveyed to the plant by a dedicated biomass train. This 240 MWe unit can be fuelled on 100 percent biomass to 100 percent coal. Section 3 provides additional material on the Alholmens Kraft unit and also on a 190 MWe CFBC plant for Poland.

5. Technology Trends

There are a range of new and emerging biomass and bioenergy technologies for the stationary energy market. These cover the spectrum of:

- Feedstocks
- Pre-processing and conditioning the biomass for transport and energy conversion
- Development of energy conversion technologies to provide a greater thermal conversion efficiency
- Smaller, modular systems for niche fuels and applications
- Co-production of biobased products with energy
- Technologies to allow high co-firing levels and multifuel operation.

Selected technology trends are:

Energy Crops

It is generally recognised that the use of wastes and residues would only be able to provide a relatively small proportion of biomass fuels and feedstocks, in a future biobased economy scenario. Going beyond the use of byproducts from activities, such as sugar, cotton, rice, maize, wheat, nut production has sparked interest in energy crops for both that stationary and mobile bioenergy industries. In the northern hemisphere, there has been significant development of native willows, poplar, miscanthus, kenaf, Arundo donax as biomass energy crops.

In Australia oil mallee eucalyptus has been under development for over a decade as a feedstock for bioenergy and several other co-values and co-products such as dryland salinity mitigation, shelter belts for sheep and for the coproduction of eucalyptus oil as an industrial solvent and activated carbon for industrial filtration. Verve Energy has run an Integrated Wood Processing pilot plant at Narrogin, Western Australia producing 1 MWe, and on 9 March 2010 Delta Electricity announced the launch of a project at Forbes, NSW that will see extensive mallee plantings for a co-firing trial at Wallerawang Power Station, near Lithgow, NSW. An Australian group has been working towards exporting Arundo donax pellets to the UK for a co-firing trial at a UK power station.

There is considerable interest in developing microalgae as a source of biomass. While algae research and development is mainly to develop liquid fuels, the residual mash from oil extraction is seen as a potential feedstock for stationary energy via combustion, pyrolysis and fermentation.

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Energy pellets provide a convenient transformation of moist and low bulk density biomass fuels (such as wood chips) into a more convenient, easier to handle, preprocessed fuel with a very low moisture content (typically 8 percent) and a bulk and density of approximately 650 kg per cubic metre. This densification process has a number of advantages. The densification of the biomass has vastly expanded the economic distances that biomass can be transported for energy conversion, the pellets themselves have a high operational calorific value, the pellets can be milled allowing dust firing in power plants (such as practised in NSW and Queensland power stations), and co-firing using pellets can be at very high biomass percentages. A power station unit in Belgium has been converted from coal to being exclusively fired on wood pellets (Les Awirs plant near Liege, Belgium). Wood pellets are widely used for domestic space and water heating in several countries such as in Sweden, Austria and Canada. Pellets are also used for domestic district heating and for industrial use, predominantly in Europe, North America and more recently in Japan. Wood pellets currently provide up to 70 percent of the fuel for the Avedore 2 unit in Denmark (590 MWe ultra-supercritical unit). European wood pellet use is currently approximately 12 million tonnes per annum, and is expected to reach 30 million tonnes by 2020.

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Gasification and BIGCC

Gasification converts solid biomass into combustible gas which can be used in spark ignition engines, used for dual fuelling diesel generator sets, or at a larger scale in gas turbines. Small scale gasification of biomass opens up Remote Area Power Supply (RAPS) applications or the use of limited supplies of biomass which would otherwise be uneconomic to use. Figure 5.1 shows a small scale Ankur gasifier, sourced from India which has been used at a remote visitors' centre in Tasmania. In this configuration the producer gas is fed into the air intake of a diesel genset, shown in Figure 5.2. After starting on diesel, the fossil fuel proportion is reduced, allowing the genset to run on up to 80 percent gasified biomass. The use of small generator sets allows for modular systems and flexibility in meeting a load. Future developments will be directed towards broadening the fuel specification and automated and operation from a remote location. Gasification has an advantage in requiring no or minimal water for operation.

Figure 5.1: Ankur Gasifier at Tahune Visitor's Centre, Tasmania

Source: S Schuck

Figure 5.2 : Dual Fuelled Generator Set Coupled to Ankur Gasifier

Source: S Schuck

Figure 5.3: Värnamo BIGCC Plant, Sweden

Source: IEA Bioenergy

At a larger scale, gasification can be used for co-firing with fossil fuels. This has been implemented at the Amercentraal Power Station in The Netherlands.

An extension of biomass gasification is Biomass Integrated Gasification Combined Cycle (BIGCC). This concept 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 or process heat, raising the overall efficiency even further.

The world's first BIGCC demonstration plant was built in 1996 at Värnamo in Sweden by the Finnish engineering firm Ahlstrom and the Swedish utility Sydkraft in the mid 1990s. See Figure 5.3. 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 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. A similar BIGCC demonstration project near York, UK circa 2000 proved to be too expensive at the time, and was terminated. While BIGCC has been proved to be technically feasible, the performance gain is still regarded to come at an excessive price, with cheaper alternatives such as cogeneration being on offer. However, BIGCC is still regarded as a possible future technology for biomass.

Pyrolysis

Fast pyrolysis produces a bio-oil which can be used as a fuel in an industrial reciprocating engine or in a combustion turbine. While this technology is mainly aimed at upgrading the bio-oil for transportation applications, the use of biooil for power production has been demonstrated. Dynamotive has demonstrated biooil use for energy at two locations in Ontario, Canada. Australian company Renewable Oil Corporation has a relationship with Dynamotive and is understood to be advancing plans to implement an energy plant in Australia. Several other companies are also developing pyrolysis for the combined production of biochar, a soil amendment and renewable energy. Such a project has been mooted for the wheat belt in Western Australia.

Figure 5.4: ORC Unit at Oerlinghausen-D -600 kWe

Source: Turboden

Organic Rankine Cycles (ORC)

The Organic Rankine Cycle uses a high molecular weight organic fluid instead of water as the working fluid. The plants operate on a variety of heat sources, provided to the ORC via thermal oil. The heat sources can be from the combustion of biomass or waste heat. Turboden of Italy is the leader with this technology, having over 130 units in the range of 200 kWe to 2.5 MWe in operation, mainly in western Europe, operating on biomass. One plant at Admont, Austria has operated for over 50,000 hours at an availability of over 98%. ORCs are designed to operate efficiently at partial loads. The typical configuration is for cogeneration, but when optimised for electricity, it can attain an efficiency of over 24 percent. Figure 5.4 shows a typical ORC unit from Turboden. An ORC was identified as the preferred technology for a small bioenergy project using fired damaged timber in Victoria.

Fuel Cells

Fuel cells are electrochemical devices that convert a gaseous fuel directly into electricity. The fuel gas needs to be of exceptional purity to avoid damaging the fuel cell. Fuel cells have a relatively small footprint, and have low noise operation (unlike engines). Various demonstration projects have used purified biogas as a fuel. Ceramic Fuel Cells, an Australian company has been at the forefront of solid oxide fuel cell development. These are now being commercialised at a scale suitable for domestic or commercial premises, providing both heat and power, essentially from natural gas. Fuel cells are at the research, demonstration and early commercial stage of development. A future possibility is to combine fuel cell use with 'green gas'; biogas that is purified and injected into the gas distribution network. Fuel cells could also be configured for Integrated Biomass Gasification Fuel Cell operation (BIGFC).

Stirling Engines

These are external heat engines, with the input energy applied from outside the device. They have found application at small scale with concentrating solar dishes and small biomass combustion systems. The technology is complicated by the requirement to contain a small molecule gas (hydrogen or helium) working fluid. This technology is geared to niche and smaller scale applications, and could be used in combination with solar thermal energy to achieve 24 hour operation. Figure 5.5 shows a 70 kWe Stirling engine being developed by Bios Bioenergiesysteme GmbH of Graz, Austria.

Figure 5.5: Stirling Engine

Source: Bios Bioenergiesysteme GmbH

Small Scale Biogas

Low cost, small-scale community biogas plants are relatively common in countries such as Nepal, Vietnam and China for providing cooking and heating gas. There has been some interest in applying similar technology for niche applications in Australia such as at eco-tourism resorts, horse racing stables, and piggeries and beef feedlots. Growcom in Queensland has conducted a project with State funding to use banana packing shed wastes to produce biogas.

Micro Turbines

In the past decade several micro turbines in the range 30 – 120kW electrical output have reached the market, mainly aimed at the natural gas market. They operate at very high revolutions (90,000 rpm) and use electronics to produce 50 Hertz electricity. They have found application at landfill and biogas sites. It would take further development to allow micro turbines to run on producer gas (from gasification of biomass). The appeal of micro turbines is their very small size and not needing the cooling radiators that engines require.

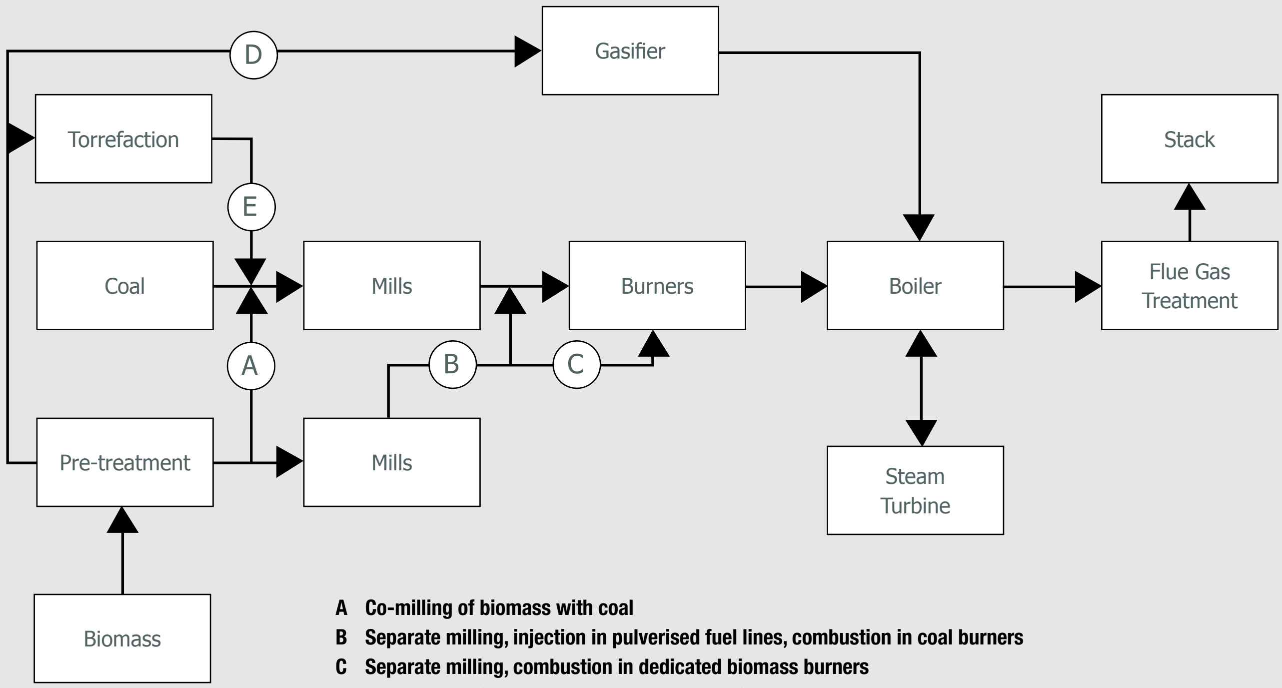
Vegetable Oil Fired Engines

A number of very large reciprocating engines are fuel on vegetable oil in Europe. Wärtsila has installed at least one such plant in Italy. Verve Energy in Western Australia has also conducted a trial of a combustion turbine at Kalgoorlie, WA on biodiesel. The long term economics of running stationary engines on vegetable oil is unlikely, as these feedstocks are more likely to be diverted for aviation and other transportation applications.

Co-firing and Multi-fuel Operation

Co-combustion or co-firing biomass with coal has been identified as a relatively low cost option for providing renewable energy using existing power station infrastructure. Co-firing trials and commercial operation is occurring at over 150 coal fired power stations worldwide. Figure 5.6 illustrates the several co-firing configurations that are possible.

Figure 5.6: Co-firing Configurations



A **Co-milling of biomass with coal**
B **Separate milling, injection in pulverised fuel lines, combustion in coal burners**
C **Separate milling, combustion in dedicated biomass burners**
D **Biomass gasification, syngas combusted in furnace**
E **Co-milling of torrefied biomass with coal**

Source: IEA Bioenergy

Route A is the simplest co-firing configurations, where biomass is introduced onto a coal conveyer and is co-milled with the coal. This is illustrated in Figure 5.7. Variation B uses separate biomass milling, but common burners, while C uses both separate milling and dedicated biomass burners. D uses a satellite gasifier to inject combustible gas into the furnace. This overcomes any co-milling and combustion property issues. E illustrates the use of torrefied biomass as a 'drop in' substitute of biomass for coal. The trend, especially in Europe is to adopt high co-firing percentages; in cases up to half the energy input can be from biomass.

Figure 5.7: Wood Waste on Coal Conveyor Belt at Wallerawang Power Station

Source: Delta Electricity)

Some fluidised bed combustors cater for a wide variety of fuels. This allows varying percentages of biomass to be co-combusted with coal and other waste fuels. Visy's Gibson Island, Brisbane fluidised bed combustor operates mainly on coal, with some paper processing wastes being used as a supplementary fuel. The 240 MWe Alholmens Kraft circulating fluidised bed combustor in Finland (see Section 3.1 above) can operate on 100 percent biomass to 100 percent coal. Another variation is multi-fuel operation, where a boiler may be fuelled by a combination of several fuels. An example of this technology is the Avedore 2 unit near Copenhagen, Denmark where wood pellets and straw bales contribute most of the input energy to this ultra-supercritical 590 MWe cogeneration power plant. This is of the same scale as Australia's largest coal fired power station units. At times wood pellets provide over 70 percent of the input energy to the main boiler. The milled wood pellets allow dust firing. On a yearly basis Avedore 2 consumes 150,000 tonnes of straw bales and 300,000 tonnes of wood pellets.

Figure 5.8 shows the Avedore 2 unit.

Figure 5.8: Avedore 2 Cogeneration Power Plant

Source: S Schuck

Figure 5.9: Wanze Biorefinery Boiler

Source: S Schuck

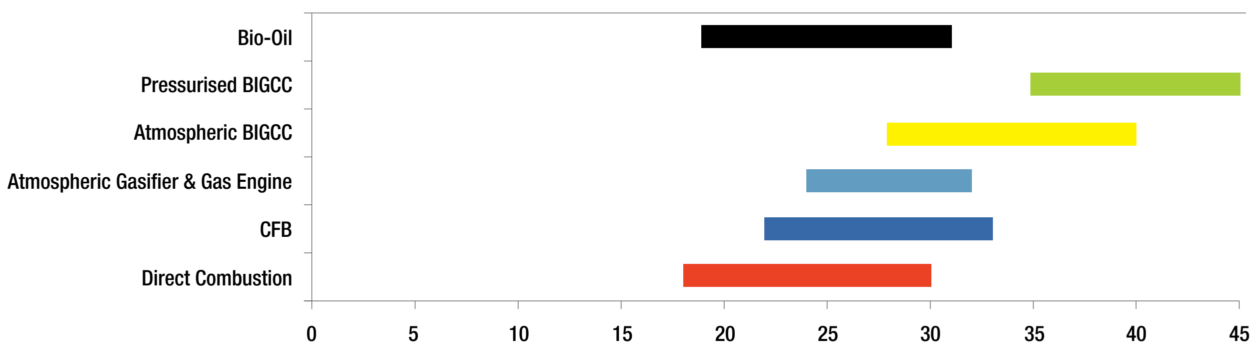
Biorefineries

The economics and flexibility of power production may be enhanced by using the biomass feedstock to additionally produce other biobased products. Often energy is not the main product. Examples of biorefineries are sugar mills where sugar is the main product and energy from bagasse is a major co-product. In Australia the Integrated Wood Processing plant at Narrogin in WA is an example of a biorefinery. In this demonstration plant, energy is produced in parallel with activated carbon and eucalyptus oil and the combined product revenues are estimated to be several times the revenue from energy alone. An example of a biorefinery in Belgium is the Wanze plant which co-produces ethanol, a liquid animal feed and 22 MW of electricity from wheat bran. The boiler is exclusively fired using wheat bran. The boiler is shown is Figure 5.9.

Efficiency Improvement

The net efficiency comparison of evolving thermal energy conversion technologies are shown in Figure 5.10. The diagram illustrates the very large potential for efficiency improvements over conventional technologies through Biomass Integrated Gasification Combined Cycle (BIGCC) plants. Bio-oil plants also show good performance in this efficiency comparison. Their potential also rests on lower fuel costs transportation and storage costs, with bio-oil having an energy density 60 percent that of diesel on a volumetric basis.

Figure 5.10: Net Efficiency (%) Comparison of Sub-40 MW Plant



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Appendix A: Bioelectricity Plants

(a) Bagasse

Plant Location	State	Fuel Category	Installed Capacity (MW)
Arriga (Tableland Mill)	QLD	Bagasse	7
Babinda	QLD	Bagasse	6
Bingera	QLD	Bagasse	5
Broadwater	NSW	Bagasse	8
Broadwater II	NSW	Bagasse	30
Condong	NSW	Bagasse	3
Condong II	NSW	Bagasse	30
Farleigh	QLD	Bagasse	13
Harwood	NSW	Bagasse	4.5
Inkerman	QLD	Bagasse	10
Invicta	QLD	Bagasse	50.5
Isis	QLD	Bagasse	11.5
Isis II	QLD	Bagasse	25.5

Plant Location	State	Fuel Category	Installed Capacity (MW)
Kalamia	QLD	Bagasse	9
Kununurra	WA	Bagasse	6
Macknade	QLD	Bagasse	8
Marian	QLD	Bagasse	18
Maryborough I	QLD	Bagasse	4.75
Millaquin	QLD	Bagasse	5
Mossman	QLD	Bagasse	11.85
Mulgrave	QLD	Bagasse	10.5
Pioneer II	QLD	Bagasse	68
Plane Creek	QLD	Bagasse	14
Proserpine	QLD	Bagasse	20
Racecourse	QLD	Bagasse	12.5
Racecourse II	QLD	Bagasse	90
Rocky Point	QLD	Bagasse	30
South Johnstone	QLD	Bagasse	19.3
Tully	QLD	Bagasse	21.4
Victoria	QLD	Bagasse	11.8

(b) Landfill Gas

Plant Location	State	Fuel Category	Installed Capacity (MW)
Woodlawn Bioreactor	NSW	Landfill Gas	6.36
Woodlawn Stages II-IV	NSW	Landfill Gas	19.08 (future)
Bathurst	NSW	Landfill Gas	0.5
Truganina II	VIC	Landfill Gas	1.1
Shenton Park	WA	Landfill Gas	1
Kincumber	NSW	Landfill Gas	1
Summerhill	NSW	Landfill Gas	2
Sleeman Aquatic Centre	QLD	Landfill Gas	0.7
Ti Tree	QLD	Landfill Gas	1
Ballarat (Smythesdale)	VIC	Landfill Gas	0.5
Belconnen	ACT	Landfill Gas	1
Mugga Lane	ACT	Landfill Gas	2.06
Mugga Lane II	ACT	Landfill Gas	1.3
Lucas Heights I	NSW	Landfill Gas	5.15
Belrose	NSW	Landfill Gas	1.03
Lucas Heights II	NSW	Landfill Gas	12.65
Jacks Gully	NSW	Landfill Gas	1.15
Shoalhaven/West Nowra	NSW	Landfill Gas	1
Eastern Creek	NSW	Landfill Gas	5.4
Grange Avenue	NSW	Landfill Gas	1.25
Jacks Gully II	NSW	Landfill Gas	1.35
Stotts Creek	NSW	Landfill Gas	0.37
Awaba	NSW	Landfill Gas	1.12
Shoal Bay	NT	Landfill Gas	1.1
Browns Plains	QLD	Landfill Gas	1.03
Swanbank B LFG	QLD	Landfill Gas	7
Molendinar	QLD	Landfill Gas	0.7
Stapylton	QLD	Landfill Gas	1

Plant Location	State	Fuel Category	Installed Capacity (MW)
Suntown	QLD	Landfill Gas	1
Reedy Creek	QLD	Landfill Gas	0.55
Browns Plains II	QLD	Landfill Gas	1.03
Roghan Road	QLD	Landfill Gas	1.96
Ipswich	QLD	Landfill Gas	1
Rochedale	QLD	Landfill Gas	3.3
Wingfield I	SA	Landfill Gas	4.1
Wingfield II	SA	Landfill Gas	4.1
Highbury	SA	Landfill Gas	1.03
Tea Tree Gully	SA	Landfill Gas	0.98
Pedler Creek	SA	Landfill Gas	2.93
Wingfield III	SA	Landfill Gas	7.8
McRobies Gully	TAS	Landfill Gas	1.06
Glenorchy	TAS	Landfill Gas	1.66
Remount	TAS	Landfill Gas	1.12
Wollert	VIC	Landfill Gas	1.1
Berwick	VIC	Landfill Gas	7.2
Corio	VIC	Landfill Gas	1
Broadmeadows	VIC	Landfill Gas	6.2
Clayton	VIC	Landfill Gas	1
Springvale	VIC	Landfill Gas	4.8
Epping	VIC	Landfill Gas	0.1
Brooklyn	VIC	Landfill Gas	2.2
Mornington	VIC	Landfill Gas	0.7
Brooklyn II	VIC	Landfill Gas	1
Wyndham	VIC	Landfill Gas	1
Truganina	VIC	Landfill Gas	1.1

Plant Location	State	Fuel Category	Installed Capacity (MW)
Hallam Rd/Hampton Park	VIC	Landfill Gas	1.1
Red Hill	WA	Landfill Gas	2.65
Brockway	WA	Landfill Gas	1
Kalamunda	WA	Landfill Gas	0.6
Canning Vale	WA	Landfill Gas	4
Kelvin Road, Gosnells	WA	Landfill Gas	1
Millar Road, Rockingham	WA	Landfill Gas	2.1
Tamala Park	WA	Landfill Gas	4.65
Atlas	WA	Landfill Gas	1
South Cardup	WA	Landfill Gas	3.3
Henderson	WA	Landfill Gas	2.13
Mandurah	WA	Landfill Gas	1.25

(c) Sewage Gas Power Plants

Plant Location	State	Fuel Category	Installed Capacity (MW)
North Head	NSW	Sewage Gas	1.4
Warriewood	NSW	Sewage Gas	0.25
Bondi	NSW	Sewage Gas	1.4
Glenfield	NSW	Sewage Gas	0.51
Liverpool	NSW	Sewage Gas	0.33
Wollongong	NSW	Sewage Gas	0.51
Shepparton	VIC	Sewage Gas	1.1
Malabar	NSW	Sewage Gas	3
Cronulla	NSW	Sewage Gas	0.47
Luggage Point	QLD	Sewage Gas	3.0
Townsville - Cleveland Bay & Mount St John	QLD	Sewage Gas	0.24
Oxley Creek	QLD	Sewage Gas	1.04
Elanora Waste Water Treatment Plant	QLD	Sewage Gas	0.23
Bolivar	SA	Sewage Gas	3.5
Glenelg	SA	Sewage Gas	1.95
Macquarie Point	TAS	Sewage Gas	0.14
Werribee	VIC	Sewage Gas	1.06
Werribee I	VIC	Sewage Gas	2.49
Werribee II	VIC	Sewage Gas	4.26
Tatura	VIC	Sewage Gas	1.1
Carrum Downs II	VIC	Sewage Gas	9.1
Woodman Point	WA	Sewage Gas	1.8

(d) Wood Waste Bioenergy Projects

Plant Location	State	Fuel Category	Installed Capacity (MW)
Grafton - Big River Timbers	NSW	Wood Waste	0.5
Tahune	TAS	Wood Waste	< 50KW
Stapylton	QLD	Wood Waste	5
Bayswater Power Station	NSW	Wood Waste	12
Gladstone Power Station	QLD	Wood Waste	10
Liddell Power Station	NSW	Wood Waste	12
Vales Point Power Station	NSW	Wood Waste	7.2
Wallerawang Power Station	NSW	Wood Waste	5.5
Muja Power Station	WA	Wood Waste	12
Mt. Piper Power Station	NSW	Wood Waste	1.2
Hazelwood Power Station	VIC	Wood Waste, MSW	1.8

(e) Bioenergy Projects – Black Liquor and Other Processing Wastes

Plant Location	State	Fuel Category	Installed Capacity (MW)
Tumut	NSW	Black Liquor	20
Maryvale	VIC	Black Liquor	54.5
Gympie	QLD	Crop Waste	1.5
Mt Cotton	QLD	Food And Agricultural Wet Waste	7.6
Camellia, Parramatta	NSW	Food And Agricultural Wet Waste (biogas)	3.9
Ballarat - Berrybank	VIC	Food And Agricultural Wet Waste (biogas)	0.23
Gibson Island, Brisbane	QLD	Paper processing wastes	2

Appendix B: Biomass Boilers – Thermal Applications

(a) Carter Holt Harvey timber processing plants using biomass to generate steam for heating applications

Sawmill	Size of boilers (MWth)
Morwell	6 + 7 + 6
Myrtleford	8 + 12
Yarram	3
Jubilee (Mt Gambier)	~20 + ~ 20
Highland Pine (Oberon)	20
Tumut	10 + 20
Lakeside (Mt Gambier)	10 + 4 + 4+ 4
Caboolture	8 + 10
Nangwarry	~2.5 + ~5

(b) Carter Holt Harvey panel board factories using wood waste (wood dust, large particle wood waste, and co-combustion with gas).

Facility	Fuel Source	Size (MWth)	Energy Product
Gympie	Dust/Fuel Oil	10	Hot gas
Tumut	Wood/Dust	20	Hot gas
Lakeside (Mt Gambier)	Wood	1.5	Hot Oil
	Dust	1.5	Hot Oil
	Dust/Gas	5	Hot gas
White Ave (Mt Gambier)	Wood	5	Hot water
	Dust/Fuel Oil	5	Hot gas
	Dust/Fuel Oil	8	Hot gas
Oberon STF	Dust/Gas	8	Hot gas
	Dust/Gas	4	Hot gas
Oberon MDF	Wood	13.5	Hot oil/gas
	Gas / Dust	~10	Hot gas

(c) Steam Systems Pty lists biomass boilers in operation in Australia with which they have been associated. These wood waste fuelled boilers span 24 years of installations.

Installation	Capacities (MWth)
Grafton Meat Co. Ramsey Foods Pty Ltd, NSW	1 x 4
Northern Meat Co-operative Casino, NSW	1 x 10
Gunns Timber Launceston, TAS.	1 x 4
Longford Meat Company Pty Ltd, TAS	2 x 8
Bega Butter Pty Ltd, NSW	1 x 4
Mc Cains Foods Smithton, TAS	2 x 6
Hobart Laundry TAS	1 x 3
Devonport Laundry, TAS	1 x 3
Gunns Launceston, TAS	1 x 10
Boral Timber Oberon NSW	2 x 6
Boral Timber Murwillumbah	1 x 6
Boral Timber Dungog NSW	1 x 6
Boral Timber Gloucester NSW	1 x 4
CHH Radius Pty Ltd	2 x 6
Hyne Timber Imbil, QLD	1 x 8
Ravenshoe, QLD	2 x 6
Monto, QLD	1 x 4
Britton Bros. Smithton, TAS	1 x 4
Wingham Beef Exports Macksville, NSW	1 x 7
Wingham Beef Exports Pty Ltd, NSW	1 x 4
French Pine Scottsdale, TAS	1 x 20
J Davey Plant Extraction	1 x 1
Austicks Pty Ltd Gladstone, QLD	1 x 4
J Notaros & Sons Pty Ltd, Grafton, NSW	1 x 4
Big River Timber Pty Ltd, Grafton, NSW	1 x 10
Reid Brothers Sawmillers, Yarra Junction, VIC	1 x 1
Forrest Timber Products	2 x 1
Coffs Harbour Hardwoods, NSW	1 x 1
J&A Brandsema Hydroponic Tomatoes, TAS	1 x 1.2

Appendix C: Excerpts from the Renewable Energy (Electricity) Regulation

6 Meaning of certain energy sources that are eligible renewable energy sources (Act s 17)

For subsections 17 (3) and (4) of the Act:

agricultural waste means the putrescible biomass wastes produced during agricultural operations, including livestock husbandry.

biomass-based components of municipal solid waste means the biomass-based components of wastes that are directly sourced from, or eligible to be disposed of in, landfill or a waste transfer station that is licensed by a State or Territory government body or by a local government authority, but does not include biomass-based components of wastes originating from:

(a) forestry or broadacre land clearing for agriculture, silviculture and horticulture operations; or

(b) fossil fuels.

black liquor means the mixture arising from the chemical wood pulping process.

hot dry rock includes hot fractured rock.

landfill gas means the gas produced by the breaking down of the organic part of municipal landfills.

sewage gas means gas produced by the decomposition of domestic and commercial wastes that are collected from sewerage systems and treated by sewage treatment plants.

waste from processing of agricultural products means the biomass waste produced from processing agricultural products.

7 Meaning of certain energy sources that are not eligible renewable energy sources (Act s 17)

For subsection 17 (3) of the Act:

fossil fuels means any of the following:

(a) coal, oil, natural gas or other petroleum-based products;

(b) products, by-products and wastes associated with, or produced from, extracting and processing coal, oil, natural gas or other petroleum-based products.

Examples
Condensate liquids, coal seam methane, coal mine methane.

waste products derived from fossil fuels means the components of waste streams that:

(a) are made using, as raw materials, any material that is a fossil fuel for the Act; and

(b) are products or by-products of manufacturing operations, including plastics, tyres, disposable nappies, synthetic carpets and synthetic textiles.

8 Meaning of wood waste

(1) For section 17 of the Act, wood waste means:

(a) biomass:

(i) produced from non-native environmental weed species; and

(ii) harvested for the control or eradication of the species, from a harvesting operation that is approved under relevant Commonwealth, State or Territory planning and approval processes; and

(b) a manufactured wood product or a by-product from a manufacturing process; and

(c) waste products from the construction of buildings or furniture, including timber off-cuts and timber from demolished buildings; and

(d) sawmill residue; and

(e) biomass from a native forest that meets all of the requirements in subregulation (2).

Examples for paragraph (b)
Packing case, pallet, recycled timber, engineered wood product (including one manufactured by binding wood strands, wood particles, wood fibres or wood veneers with adhesives to form a composite).

(2) Biomass from a native forest must be:

(a) harvested primarily for a purpose other than biomass for energy production; and

(b) either:

(i) a by-product or waste product of a harvesting operation, approved under relevant Commonwealth, State or Territory planning and approval processes, for which a high-value process is the primary purpose of the harvesting; or

(ii) a by-product (including thinnings and coppicing) of a harvesting operation that is carried out in accordance with ecologically sustainable forest management principles; and

(c) either:

(i) if it is from an area where a regional forest agreement is in force — produced in accordance with any ecologically sustainable forest management principles required by the agreement; or

(ii) if it is from an area where no regional forest agreement is in force — produced from harvesting that is carried out in accordance with ecologically sustainable forest management principles that the Minister is satisfied are consistent with those required by a regional forest agreement.

(3) For subparagraph (2) (b) (i), the primary purpose of a harvesting operation is taken to be a high-value process only if the total financial value of the products of the high value process is higher than the financial value of other products of the harvesting operation.

(4) In this regulation:
ecologically sustainable forest management principles means the following principles that meet the requirements of ecologically sustainable development for forests:

(a) maintenance of the ecological processes within forests, including the formation of soil, energy flows, and the carbon, nutrient and water cycles;

(b) maintenance of the biological diversity of forests;

(c) optimisation of the benefits to the community from all uses of forests within ecological constraints.

high-value process means the production of sawlogs, veneer, poles, piles, girders, wood for carpentry or craft uses, or oil products.

9 Energy crops (Act s 17)

(1) For section 17 of the Act, biomass from a plantation is not an energy crop unless all of the following apply to it:

(a) it must be a product of a harvesting operation (including thinnings and coppicing) approved under relevant Common wealth, State or Territory planning and approval processes;

(b) it must be biomass from a plantation that is managed in accordance with:

(i) a code of practice approved for a State under regulation 4B of the Export Control (Unprocessed Wood) Regulations; or

(ii) if a code of practice has not been approved for a State as required under subparagraph (i), Australian Standard AS 4708—2007 — The Australian Forestry Standard;

c) it must be taken from land that was not cleared of native vegetation after 31 December 1989 to establish the plantation.

(2) For section 17 of the Act, biomass from a native forest is not an energy crop.

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