Central Highlands Agribusiness Forum

Linnæus University

Recommendations for Bioenergy Technology Projects for the Ballarat Municipality

Central Highlands Agribusiness Forum

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Contents

Introduction

These recommendations are based on nine reports produced over a six month period by a final team of 10 people, with expertise in various aspects of management of, and energy from, biomass and municipal waste.
The work has been supervised by Professor Björn Zethræus at the Linnæus University in Sweden and constitutes fulfilment of the distance learning course “Bioenergy Technology and Bioenergy Business”, 7.5 ECTS.

The final group consists of

Karen Campisano –	Melbourne Water
Kelly Wickham –	Sustainability Victoria
Tony Mahoney –	Corangamite CMA board member
Andy Race –	Grampians Waste Management Group
Liz. Hamilton –	Department of Primary Industry
Andrew Lang –	SMARTimbers cooperative & CHAF
David Curry –	Otways Agroforestry Network
Barry Vaughan –	VicForests
Malory Weston –	Kilter Environmental Management
Simon Reid –	Ballarat Renewable Energy and Zero Emissions (BREAZE)

The course was auspiced by Central Highlands Agribusiness Forum (CHAF)

Summary

Within 80 km radius of Ballarat there are large amounts of four general types of biomass (including municipal wastes): agricultural dry residues, woody residues, municipal solid wastes and wet organic wastes. They are economically available in significant volumes, so they could potentially be used as sources of renewable energy using one or more mature bioenergy technologies. The energy forms would be as electricity, transport fuels, heat energy, and cooling.

Currently Ballarat sends hundreds of millions of dollars annually out of the regional economy to pay for importing gas, electricity and liquid transport fuels. About a third of energy 'spend' is from the domestic sector, about half from industry (including primary industries), and the balance from the commercial, institutional and retail sectors

At the same time, with the proposed growth plans for the coming four decades resulting in a population increase of over 50,000 residents, Ballarat needs many new permanent jobs (of the order of 10,000) and some distinctive development objectives and philosophies for the municipality that will begin to attract significant new industry and businesses.

As the reader will see (from Report Four and the appendices and base reports) it is possible using mature proven bioenergy technologies to produce a significant amount of our energy requirement regionally using regional biomass resources that are presently unutilised.

The most cost-competitive area to look at first is in production of heat energy. This currently represents almost 40% of the municipal energy demand, and so a significant fraction of 'energy money' exported.

Electricity represents only about 20% of energy requirement, though closer to 50% of present municipal emissions (and so potentially a high carbon tax impost on industries with high consumption). Paradoxically much of this electricity consumption is for production of heating and cooling in one form or another. Production of baseload electricity from biomass (and also municipal waste) is regular practice in many countries and the necessary plant is readily available, but achieving appropriate economies of scale is an issue regionally at current electricity pricing. This may change quite fast.

Transport fuels are all imported and total nearly 40% of energy consumed in the region. Production locally of renewable transport fuels cost-competitively is still probably five or ten years away but the region is well-placed for this and the most feasible technologies need to be understood and factored into municipal forward planning.

The recommendations in this Report Four include and encompass all these factors. The report contains proposals for a number of projects that will produce significant baseload low emission renewable energy, result in creation of many additional permanent jobs, and will help make Ballarat the leader in Australia in several bioenergy technologies - with the positive publicity and industry benefits that these will bring.

Summary of recommendations

Recommendation One

Establishment of a plant to anaerobically digest up to 60,000 m^3 of putrescible waste/year, for production of either upgraded biogas as bus or municipal fleet fuel, or to produce electricity and heat and possibly cooling. This may be sited at the CHW waste water treatment site, or in the Ballarat West Employment Zone (BWEZ), or with smaller plants at both sites.

Recommendation Two

Establishment of a 30 megawatt district heating plant within the BWEZ, fuelled by forestry residues and urban wood waste, to provide industrial heat (including steam).

Recommendation Three

Further feasibility work on establishment of a Biomass to Liquid Fuels plant within the BWEZ using straw-to-ethanol technology

Recommendations for smaller (possibly pilot or demonstration projects) with strong economic and environmental merit

- Installation of a chip or pellet-fuelled heating system of up to 1 megawatt heat output (1 MW-th) - possibly at the Ballarat Aquatic Centre or other municipal-owned year-round heat user
- Production of heat and electricity from 10,000 t annually of oat husks at oat milling plant within the municipality
- Installation of a bioreactor (in-ground accelerated anaerobic digestor) at the Smythesdale landfill site
- Small-scale production of wood pellets in a timber processing industry in city area for production of about 2,000 t/yr of pellets for domestic and commercial heating
- Production of pelleted Refuse Derived Fuel from sorted non-recyclable municipal waste (this RDF to be sold to industry as a high temperature furnace fuel, or as feedstock for production of synthetic transport fuel)
- Installation of a woody biomass gasifier for production of high temperature gas for kiln firing, to substitute for natural gas.

The information providing backup detail for the recommendations is to be found in Appendices One, Two Three and Four.

Appendix One

Summary of the information in group reports 1, 2 & 3 on Energy Services in the municipality, broken down into Transport, Industrial and Residential/Commercial. So it covers the requirement for energy as heat, electricity and transport fuels.

Appendix Two

Summary of the information in group reports 4, 5 & 6 on biomass availability: as woody biomass (including straw), putrescible biomass (organic wastes of over about 60% moisture content), and 'other' wastes - including municipal solid waste, agricultural plastic wastes and tyres. It covers the potential energy availability in these forms of unutilised wastes and residues, which often go to landfill or are freeburned or otherwise allowed to decompose with no energy capture from emitted greenhouse gases.

Appendix Three

Summary of the mature bioenergy technologies that may be most relevant to the municipality for converting the material covered in Appendix Two into the energy services covered in Appendix One.

Appendix Four

Summary of projections or forecasts of expanding need for energy services between 2011 and 2050 as the population of the municipality grows from about 100,000 to at least 150,000. Within this appendix are some suggested alternative pathways that may be considered if quality of life and reductions of municipal greenhouse gas emissions are seen as priorities.

These appendices make the material in each group of three reports available in a more condensed form. For those who want to access the information or the references in each report, these base reports are available from Central Highlands Agribusiness Forum.

Note: The reader can assume that figures in this and base reports are of the right order of magnitude, and any assumptions of costs, etc., are usually detailed. However, in formulating the nine base reports, we were too often forced to use poor and often conflicting data from supposedly authoritative sources.

<u>We recommend that any decision on these or other renewable energy projects would need to first assemble far more precise and accurate information.</u>
We also recommend that the Ballarat municipality makes it a priority to develop and maintain better base figures on energy use, population growth projections, traffic growth projections, and energy costs and emissions.

(Front page photo. Biomass-fuelled combined heat and power plant for Swedish city of 63,000, producing electricity and district heat and cooling)

Recommendation One

Anaerobic digestion of putrescible wastes to produce biogas for production of heat and electricity, or to be upgraded as a vehicle fuel

Background

Purescible waste is organic material of high moisture content that will readily decompose to release greenhouse gases including methane and carbon dioxide. Examples are sewage, food processing residues and household leafy green waste. The total volume produced in the municipality is of the order of 60,000 m^3 'wet' volume or about 60,000 'wet' tonnes.

The majority of this volume is as sewage waste and biosolids, saleyard and truck wash-down manure material, lake weed, green waste from private gardens and city parks, and food scraps and outdated supermarket foods. Much of this currently goes to municipal landfill, with the source organisations paying a significant and rising disposal fee.

Technical issues

The total of this combined volume of putrescible wastes is enough to warrant the installation of a state-of-the-art anaerobic digestor. These are common across Europe, where putrescible waste is no longer allowed to be disposed of into landfill, or manure from intensively-housed farm animals is no longer able to be spread on farm land.

Before entry to the digestor (also called the reactor) the material will be brought to a standard dry matter percentage (usually about 10%), chopped and churned to a soupy consistency, sometimes pasteurised to kill any pathogenic microorganisms, and then kept in a warm oxygen-free state in the reactor tank for 2-3 weeks (for a reactor running at 37^0 C. A system running at about 50^0 C will be significantly faster).

Methane given off is fully captured. It can be used after minor treatment to fuel a spark-ignition motor driving a generator and so produce electricity and heat, or it can be upgraded to near-pure methane to be used as a vehicle fuel or injected into the natural gas grid.

The volume of methane produced annually from annual throughput of 60,000 m^3 in an anaerobic digestor running at about 37^0 C should have the energy equivalent of about 2-2.5 million litres of petrol or diesel. Whether the product of the digestor is used to produce heat and electricity, or upgraded to be a vehicle fuel, is determined by which will be the more economically viable option.

The residue from a stirred digestor settles at the bottom of the tank and can be drawn off as new material is continually introduced at the top. The residue over a year is somewhat less than the feed-in volume, but the putrescible material is effectively converted and the residue is inoffensive in odour and can be spread as a high nutrient fertiliser. It is likely to have a sale value in this form. Alternately it can be dewatered and used as a fuel in a regional biomass-fired heating or combined heat and power plant.

Financial Issues

The capital cost of an anerobic digestor of this approximate capacity on a greenfield site is about $10-12 million. To install the optional upgrading processes may cost an additional $6-8 million.

By comparison a thermophyllic (50^0 C) anaerobic digestor built in 2010 at Kouvola (90,000 inhabitants) in southern Finland cost about $12 million including a pasteurising system and outdated packaged foods handling system, plus another $8-10 million for biogas upgrading system, gas motor and generator and all necessary installations for biomethane injection to the natural gas grid. This plant is on a greenfield site beside the city sewage farm. This digestor receives about 20,000 m^3 of material at about 20% MC, with capacity for some expansion. The feed material was about 9000 t (or m^3) of sewage sludge, and 7000 t of household residues and putrescibles from retail and industry. Extra material available locally includes field biomass (green crop) and lactose by-product from regional milk processing industry).

The value of the upgraded biomethane fuel at Ballarat is potentially up to $500,000 per year (going by 2011 LPG prices). It has identical characteristics to compressed natural gas (CNG). It has the attraction that it attracts no carbon tax and is likely to rise in value as alternate fossil gas fuels rise in price due to tax on CO_2 emissions.

Alternatively the sale value of the heat and electricity is up to $750,000/yr if all heat can be sold (at an assumed $50/MWh), and electricity is sold at a base wholesale value ($50/MWh). In practice the value of Renewable Energy Credits (RECs) needs to be added (so about 5000 MWh X (assumed) $35/REC = $175,000). Also it may be possible to run the plant's generator to take advantage of higher daytime wholesale electricity prices of $100-150/MWh. Assuming $100/MWh-e price, current gross income may be up to $1.7 million/yr for energy (heat and electricity) produced, plus value of RECs.

Income for heat and electricity from the anaerobic digester biogas is likely to increase steadily over the coming years as costs of fossil fuels rise and carbon taxes apply to energy from fossil sources.

A further aspect is that the plant will be able to charge a per-tonne or per-m^3 price for receival of most if not all of the putrescible waste; and even more so from 2014 when disposal of this material into landfill may be made illegal. It is the case in northern Europe that the income for similar plants may be 10% from energy produced and up to 90% from charges on waste receival (this is the case at Kouvola). An additional source of income may be from the annual sale of the digested residues for use as high nutrient fertiliser by farmers, including organic farmers.

A local example of cost-effective anaerobic digestion is by Charles I.F.E., which runs a feedlot of around 20,000 pigs near Ballarat. Charles I.F.E. has successfully run an anaerobic digestion system for over 20 years generating electricity, (1 GWh -e/yr) for both on and off-farm use, and with the heat energy produced (2-3 GWh-th/yr) used for warming the primary digester and other piggery needs. Key drivers for this project were originally addressing water pollution and odour issues. However, the owners estimate that they save around $125,000/yr (2004 figure) in energy costs and an additional $300,000 savings in reduced water and fertilizer costs on-farm. Charles I.F.E. is planning significant upgrades to capture and use more heat energy for use within the piggery, further reducing energy costs and potentially lifting productivity. They also state that their revenues from selling the bagged dewatered digester residue as organic garden composts and fertilisers are now a significant part of their enterprise income.

Economic benefit to the municipality

The benefits to the community include

- Reduced emissions of GHG and noxious odours from landfill
- Improved disposal of putrescible wastes
- Substitution of digestor residue for imported high nitrogen fertilisers
- Employment creation at digestor and in supply chains of 10-20 jobs
- Availability of zero-emission fuel, or heat and electricity

Anaerobic digestor at Hässleholm, Sweden, owned by a syndicate of six municipalities. Feedstock of food processing wastes and other ‘pure’ putrescible wastes. Output is upgraded bio-methane for municipal car, truck and bus fleets, and also for private cars.

Recommendation Two:

A chip-fuelled district heating plant of up to 30 MW-thermal capacity at the Ballarat West Employment Zone

Background

The most cost-competitive form of energy from biomass is usually as the production of heat. There are many industries that require large amounts of heat energy year-round, most of which in this municipality are relying on natural gas. Food production industries or industrial laundries are examples. However the costs of this energy source are rising fast and already heat energy from woody biomass fuels may be cheaper, and certainly will be so in the near future if current trends continue. Woody biomass fuel is available in the region in large volumes. It is currently little used in the instances of waste material from plantation harvest and from other farm timber (much of which is burned on site), or in the case of construction and demolition wood and urban waste wood, much of which goes to landfill.

Modern wood chip-fired furnaces can be highly efficient, with up to 90% of the energy in the fuel being able to be utilised provided there are several key factors in place. These include that

- the heat can be fully used within the plant or reticulated by underground insulated piping to industrial users or communities close-by (usually within a few kilometres)
- the amount of heat produced is matched to the demand, which ideally is relatively even 24 hours a day, 7 days a week
- any furnace runs at or near optimal rated output as much as possible over time

Technical issues

A chip-fuelled district heating plant of about 30 MW-th will require about 60-80,000 tonnes of chip a year. The range reflects the possible range of moisture content, as drier wood has a higher energy value and so less tonnage is needed for the same boiler heat output. It is common for a plant to run for about 11 months of the year and to shut-down annually for two weeks or more for maintenance, usually in mid-summer.

Ensuring that a plant runs at capacity may be done by use of one larger furnace and one smaller one, both fed from the same chip bunker, and both feeding heat output into a common heat distribution system. It is normal to have a back-up furnace, usually fired by natural gas or heating oil, able to be used over maintenance periods or in case of breakdown or forced shutdown.

Ensuring a steady supply of heat can also be helped by having a significant buffer store of heated water held in an insulated tank that can be drawn on in peak demand periods, and replenished by the boiler in lower demand periods (such as overnight).

Heat can be available to neighbouring industry at about 80-110 C (which is the system that utilises the buffer tank), or for higher temperature demand as steam under pressure at 200^0 C or more (depending on the amount of pressure the system is designed for). Steam is reticulated through a separate system of pipes and is normally significantly more expensive per unit of heat energy. At the neighbouring industry the heat energy is drawn off and measured at a heat exchanger, and the charge for total energy use by the industry is based on this measurement.

Financial issues

The appeal of heat energy supplied from a wood-fired boiler is that no carbon tax or CO_2 emission charge is going to apply, as this fuel is defined as carbon-neutral under the Kyoto Protocol.

The cost of 60,000 tonne of chip delivered at an assumed $90/tonne equals an annual fuel cost of $5.4 million. This figure includes cost of aggregating, chipping and transport. Costs of labour (3 shifts of 6 each) and overheads may be $2-2.5 million annually
The cost of the plant and the heat reticulation piping on a greenfield site may be $40-45 million.

Amount of heat energy produced over 11 months at 85% efficiency is about 153,000 MWh.

The pricing of heat energy is assumed to be at $50/megawatt hour for $80\text{-}110^0$ C, and about $100/MWh for $200\ ^{\mathbf{0}}$ C. If heat produced is as 76,000 MWh of each type gross income may be $11.4 million/year.

The pattern in other countries where significant use is made of district heating systems over many years is that the price of the fuel is relatively stable and the income from the heat energy rises on a faster trend line.

Economic benefit to municipality

The use of heat energy produced from wood waste has many broader economic benefits. These include –

- Utilisation of a previously valueless waste
- A market for thinnings from farm forestry including short rotation coppice windbreaks will provide added stimulus for planting
- Provides a market for senescent farm trees and industry wood waste
- Transporting chip and removing and spreading of ash creates extra jobs
- Spreading of ash returns nutrients to forest and plantation
- Municipal landfill volumes and GHG emissions will be significantly reduced
- Supply of low-emission heat will attract industries to the BWEZ
- Import of natural gas and LPG reduced, and money kept in the local economy
- Generation of at least 20 permanent new jobs at the plant
- Heat users will be paying less per unit of heat energy over time

Recommendation Three:

A straw-to-ethanol plant in the BWEZ.

Background

Within 150 km transport distance of Ballarat (and the BWEZ) farmers annually produce 200-400,000 tonnes of straw and canola stalk as a by-product of cereal and oilseed cropping. Presently in Canada, Denmark, China, Sweden, and several other countries, operators of large pilot plants are producing ethanol from this agricultural residue (while here the straw is usually burned in the paddock). While these pilot plants are of sizes up to 5-6 million litres a year output, commercial plants are in development in Canada and the USA to produce up to 70 million litres a year from up to 400,000 tonnes of crop residues a year.

Ballarat annually imports about 90 million litres of petrol annually at a cost of about $115 million (including excise). Australia is already using 10% ethanol in petrol, is in the process of introducing E85 blend, and the technology is now being widely used elsewhere for cars, as well as trucks and buses, to run on up to 100% ethanol.
In short, ethanol is a biofuel that is in national and international demand, Australia needs a lot more than our current supply volume, and one way to produce it is from straw.

Technical issues

Production of ethanol from straw requires two relatively simple stages, and one more technically complex stage.

Stage 1 (simple) – receive and handle the straw, test for moisture and remove any contaminants (mainly dirt or stones), hammer mill it and transport it to the start of the complex stage.

Stage 2 (complex) begin to break down the cellulose/lignin cellular structure of the straw by steam injection (200^0 C), remove the soluble lignin and C5 sugars, introduce enzyme for complete cellulose breakdown to C6 sugars, introduce yeast to ferment C6 sugars.

Stage 3 (simple) hold straw slurry until fermentation of C6 sugars complete, distil ethanol and purify to 99.5% fuel grade, add colour and emetics (to induce vomiting if drunk).

The heat requirement for processing 200,000 tonne of straw is about 200,000 MWh, requiring about 25 MW-th boiler output, potentially fuelled by about 55-60,000 t of dry woodchips (or lignin). The ethanol from C6 sugars is about 180 l per tonne of straw

The lignin is dried and pelleted and sold. It is about 280 kg per tonne of straw (or total about 56,000 t/yr. It has a potential value of $250-300/tonne as a biorefinery feedstock.
The C5 sugars are reduced to a molasses and sold, or can be fermented to produce 50% more ethanol (or an extra 90 l per tonne of straw), or be sold as a biorefinery feedstock.

Financial issues

Capital cost of plant on a greenfield site is up to $200 million (with possibility to attract some fraction of this as federal grant)

Running costs are straw, heat, enzyme and labour in that approximate order. Total costs need to be established but 200,000 t of straw at $60/tonne delivered will cost $12 million a year. Total annual operating costs are assumed to be no more about 2.5 times the cost of straw, or $30 million.

Gross sales of ethanol, lignin and C5 molasses may potentially total $60-80 million/yr, with price of ethanol expected to rise significantly with time. Costs of heat, straw and enzymes are expected to be relatively stable and flat compared to income from the three products.

Supply of straw is normally by contract to a number of main suppliers with prices negotiated forward up to five years, and with at least 1 year forward straw supply to be held under shelter.

Note: While these figures indicate the potential, it needs to be understood that production of cellulosic ethanol at commercial scale is not yet commonplace and we do not advise that Ballarat be a pioneer in this field. However the technology is proven, the economics are increasingly interesting, major plants in construction or advanced planning in USA, Italy, Canada, China and elsewhere should be in production within 3-5 years and it may be that the BWEZ is a prime site for such a plant within 5-10 years, with the potential of generally realising the benefits stated here.

Economic benefit to the municipality

A plant such as this would be an obvious ‘flagship’ for industry in the region, and label Ballarat as a bio-fuels innovator in Australia. Other benefits are -
Permanent jobs
Retention of money in the regional economy
Reduction of straw burning
Injection of extra money into farm sector
Attraction of allied industries
Attraction of professional businesses
Reduction of emissions from transport fuels
Stimulus of a biorefinery sector with commercial volumes of lignin and C5 sugars available as primary feedstocks
Biofuels production becomes the main purchaser of heat from the BWEZ district heating plant requiring up to 25 MW-th as steam at 200^0 C

Smaller projects and pilot or demonstration plants

Chip-fuelled heating plant up to 1 MW-th at year-round heat user in municipality.

Possible suitable site options are the Ballarat Aquatic centre or UB swimming pool, a sporting complex or the Queen Elizabeth medical complex. Use of wood chip fuel on this scale may already be cost-competitive with natural gas, or will be soon. This approach of converting to woodchip fuel for a system of this size is now accepted practice in the USA, New Zealand and across Europe.

All sections of such a system are available off-the-shelf, and efficiencies are very good at up to 90%. The ignition, ash removal and self monitoring and emergency shut-down are highly automated, and normally these chip-fuelled furnace systems only require a steady supply of a good quality wood chip, regular removal of ash in the hopper, and an annual checkover.

Cost for an Austrian system of about 840 kilowatts thermal output (fully installed and warranted) is assumed to be about $600,000. Where cost of conversion from a fossil fuelled system is assisted by some rebate (as in NZ and USA) the institution has usually found that the annual running cost is 30-50% less than with use of heating oil or LPG and payback times can be five years or less.

Oat husk to heat and electricity.

There are two oat milling facilities located within the study area at Beaufort and Smeaton. Dry oat husks are a cellulosic residue of this manufacturing process. From a combined production of 60 kt per year, an estimated 11,500 t/yr oat husk are produced at 12% moisture content. At present this large volume of low density residue has a significant handling and disposal cost, with associated GHG emissions and possible production of particulates.

Based on the estimated specification and costs for a 22,000 t/yr system elsewhere, the proposed project (11.5 kt/y) would annually produce around 5 MW-th in heat output mode alone, or with the inclusion of a steam driven generator about 1MW-e plus approx 3 MW of heat. For the combined heat and power option the estimated cost is approximately $4m. The heat from the process would replace use of significant gas-fired heating in the principal milling facility and in adjacent industry. The electricity would be sold into the grid at wholesale prices plus the value of the RECs. Potential revenue from sale of electricity would be $438,000 plus RECs value at $35/REC of $306,600, giving a potential gross income of about $745,000/yr.

Further analysis is needed on economics of electricity production at this small scale. Production may be more economically feasible with use of a reciprocating steam engine to drive the generator, or alternatively to use an organic rankin cycle module for converting excess heat (i.e., over summer) into electricity.

Installation of a bioreactor at the Smythesdale landfill.

A bioreactor inserts liquid carrying specific microorganisms into the sealed landfill, so speeding up the breakdown of organic matter and release of landfill gas (about 40% methane). The gas is extracted through a series of collection bores and pipes and used to fuel a gas motor driving a generator, which puts electricity into the grid (the heat is normally wasted).

It is important that the injected liquid is intercepted and recycled back to the distribution loop before it can escape through the bottom of the landfill possibly with unwanted dissolved contaminants (including heavy metals) and enter into the water table or aquifers. Normally a landfill that uses this sort of system is totally sealed including at the bottom. The attraction of installing such a system in a larger landfill such as at Smythesdale is that the organic matter the landfill contains is broken down within 10-20 years instead of over a period of up to 100 years.

A smaller pellet press in a regional timber processing industry

A pellet press of approximately 350-500 kg/hr output and using feedstock of dry pine sawdust and ground offcuts of pine truss or other kiln dried pine building product would provide up to 2000 tonnes a year of premium quality pellets for Ballarat municipality.

Capital cost of such a system would be in the order of $250,000-500,000. The cost of pelleting is up to $150-180/tonne of bagged pellets, and the retail value of bagged pellets in the municipality is assumed to be about $350/t. It is anticipated that there would be a growing demand for pellets in bulk for larger pellet-fuelled heating systems, and bulk pellets might sell for $280-300t. Labour already employed at the site would be able to monitor the pellet plant and do bagging-off (the system could be largely automated), building of pallet loads and general monitoring.

The benefit of a regional pellet press producing pellets from this waste wood stream is that by value-adding this waste stream that it would encourage the introduction of cost-effective pellet heaters in institutions and homes. This would result in reductions in GHG emissions from fossil sources of home or institutional space heating, but with none of the smoke normally associated with burning wood for heating.

Production of pelleted Refuse-Derived-Fuel

Dried sorted (non-recyclable) combustible waste can be dried and pelleted. In this form it is known as refuse-derived-fuel or RDF. Since it is often up to 60-70% biomass by dryweight this material may be able to be used as a fuel to provide lower emission energy.

For example, it can be used as a fuel in high temperature furnaces such as used in cement making. Other options for RDF include using it as a feedstock for production of synthetic fuels and other chemicals.

Up to 35,000 tonnes of municipal solid waste (MSW) is generated in Ballarat municipality annually. By 2014 this may not be able to be put in landfill, or at least may have to be trucked a significant distance. However the amount generated in the municipality is presently too little to warrant construction of a waste-to energy-plant. Transport of this amount of MSW to a high temperature industrial furnace or other specialist plant in a larger centre would be more economic if the material is dried and densified.

MSW can be assumed to have a moisture content of about 50%, and so the municipality could produce about 15-20,000 tonnes of RDF pellets annually. A key preliminary process before drying and pelleting is that hazardous materials, recyclables, non-combustibles, and materials that should be put in secure landfill, are all removed. Ideally this is done at the source of the contaminants and these materials never enter the MSW stream.

Gasification of woody biomass for high temperature furnaces

Industries in the municipality that use large volumes of natural gas to fire furnaces are finding that the costs of this are due to rise dramatically. This is due both to rises in the cost of gas, and also to the imminent cost of a carbon tax on CO_2 emissions from use of the gas.

There are options to reduce natural gas use by industry or larger institutions. Where temperatures needed are in the order of 80-100^0 C some or most of the gas use can be replaced by use of a hybrid solar hot water and biomass heating system.

However when the gas is used to produce temperature up to 1100^0 C one current option is to use a biomass gasifier. These reduce dry wood chip to a gas mainly consisting of hydrogen and carbon monoxide. The gas is flammable enough to substitute for natural gas.

The main issues are the availability of the necessary supply of woodchip to produce adequate gas supply, the cost of this supply, and the cost of gasifiers with ancillary systems. A gasifier producing about 1 megawatt of heat output 24 hours a day 7 days a week over 40 weeks of the year will require about 10,000 MWh of fuel energy, or about 2800 tonnes of 25% MC chip, costing up to $250,000 delivered.

Such a gasifier might cost about $800,000 plus some other ancillary system costs such as a chip bunker and feed systems. However it should annually save a natural gas bill of about $350,000, plus the carbon tax charges on this.