Castlemaine bioenergy project

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Castlemaine bioenergy project: independent review

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Executive Summary

The Mount Alexander Sustainability Group (MASG) group has proposed a bioenergy project, which is planned to produce 270,000 GJ of bioenergy for the Don Smallgoods company in Castlemaine. The planned facility comprises two waste treatment technologies to provide bioenergy, anaerobic digestion (AD) and pyrolysis, with inputs from clean organic waste streams.

The main aim of the project shall be to optimally treat food waste, while production of bioenergy is a secondary aim. Bioenergy is best useful in the short to medium term, during the global transition to renewable energy. In the medium term large-scale renewable energy plants and green hydrogen-fired power plants will provide zero carbon energy at highly competitive costs, limiting the value of small-scale bioenergy, while there will remain a major requirement to treat food waste.

It is recommended that the proposed anaerobic digestion system takes food wastes from major food companies in the region, including partners Don Smallgoods and potentially from other George Weston Foods' sites. Food waste may also be taken from restaurants and cafes, including grease trap waste. Feedstock may also include other local biological waste resources.

It is recommended that a biosolids drying system be selected for processing liquid biosolids from the anaerobic digester.

For environmental safety, the anaerobic digestor and bioenergy facility shall be built on a concrete pan with a perimeter bund around the anaerobic digestor and waste storage areas, to prevent any leaks of liquid waste leaving the site.

In contrast to food waste, it is recommended that green waste from Welshmans Reef Vineyard be preferentially composted, as a low cost and effective method. This could be done onsite, or with a commercial composting service.

A further option for treating wastewater from Don Smallgoods could be an artificial wetland located on the property. This might be useful if the volume of wastewater is excess to requirements for anaerobic digestion.

it is recommended to recycle the waste plastic from Don Smallgoods, according to the waste hierarchy. The waste plastic be first washed, to remove most food contamination. The waste plastic be sent to a commercial plastics recycler, while the waste water could be part of the feed for the anaerobic digestor.

Due to likely contamination of sewerage by PFAS and other hazardous compounds, it is recommended that (a) treated sewerage **not** be mixed with any other non-contaminated organic source, such as in anaerobic digestion with mixed sources, and (b) be separately treated by pyrolysis. For this purpose, it is suggested that Coliban Water ask to join the existing water company consortium for pyrolysis of biosolids.

As the potential pyrolysis facility would take prescribed industrial waste, and there would be significantly increased traffic of prescribed wastes through the town, this is not compatible with the green tourism profile of the town. For this and other issues, it is recommended that the pyrolysis component be removed from the bioenergy plan.

It is recommended that the Council assemble a development plan, in consultation with the community, in part to assess both the value and optimal location of the bioenergy facility. The development plan may usefully include precinct models.

For the bioenergy facility to be of optimal value to the community it is recommended that (a) that the Council set up a community retail energy business, to use the national GreenPower scheme, to buy electricity supply from the bioenergy facility, and potentially from other renewable energy sources on the grid; (b) the bioenergy facility to gain accreditation as a biomass electricity generator. Don Smallgoods, along with community members, will then be able to buy electricity from the bioenergy facility through the community retail energy business.

In this way the bioenergy facility is only required to be connected to the electricity grid to provide power, and so can be located in the waste resource precinct.

It is recommended that Don Smallgoods investigate the option for a PV solar system, in discussion with a selected number of commercial suppliers. The focus should be on meeting current power needs, and not the largest possible system, that some suppliers like to propose.

It is recommended the operating company for the bioenergy facility be of not-for-profit type, to avoid excessive management costs, with a preference for community ownership.

Further, diverse markets for treatment of food waste by the anaerobic digester facility be implemented, to minimise financial risk.

It should be recognised that such a large project will have a major impact on local traffic. It is then recommended that the Council create a traffic strategy report, and implement the requirements.

Lastly, it is recommended that the Council create and implement a local campaign to reduce food waste. The campaign may first focus on two sectors, food services and homes.

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Introduction

Food waste: a global and national issue

The food cycle has multi-stages and complex organizational structure, Figure 1. Due to the complexity of the process, rational food flow management represents a significant challenge. As a result of errors, the rise in the volume of goods available to purchase, and the extension of distribution and logistics channels, the scale of food loss and food waste (FLW) is increasing globally.

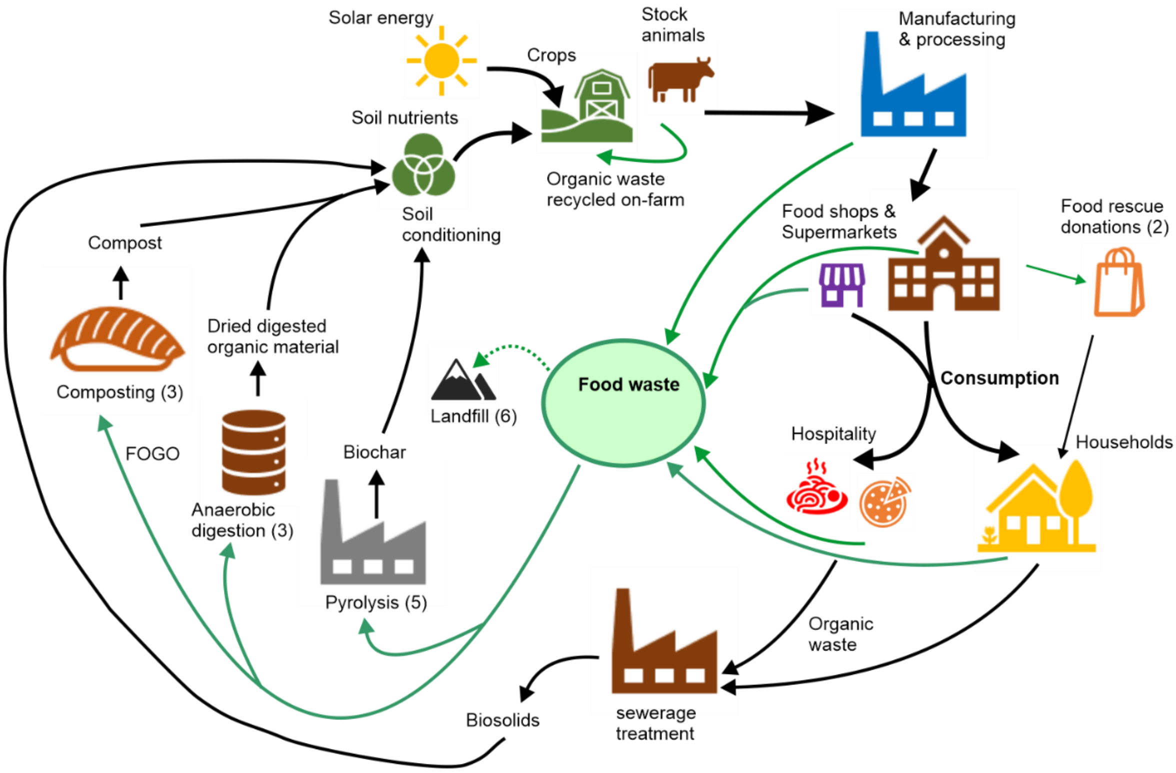

Figure 1 The food cycle, including food waste flows. FOGO, Food Organics and Garden Organics kerb-side collection by local councils. Numbers in brackets indicate level in food waste management hierarchy, Figure 2 and Table 2. The first aim is to reduce the transfer of food waste to landfill. Source, this report.

Roughly one-third of food produced for human consumption is lost or wasted globally, which amounts to about 1.3 billion tons per year. This inevitably also means that huge amounts of the resources used in food production are used in vain, and that the greenhouse gas emissions caused by production of food that gets lost or wasted are also emissions in vain (Gustavsson et al 2011).

Overall, on a per-capita basis, much more food is wasted in the industrialized world than in developing countries. We per capita food waste by consumers in Europe and North-America is estimated as 95-115 kg/year, while this figure in sub-Saharan Africa and South/Southeast Asia is only 6-11 kg/year (Gustavsson et al 2011).

Food waste is also a major problem in Australia (Commonwealth of Australia 2017):

- Food waste costs the economy around $20 billion each year.
- Each year we waste around 7.3 million tonnes of food, which equals about 300 kg per person or one in five bags of groceries.
- Food waste accounts for more than five percent of Australia's greenhouse gas emissions.

Food loss occurs at each stage in the food cycle, for a range of reasons, Table 1. For instance, at the agricultural production stage, losses may arise due to overproduction or grading because of quality standards. In food production and distribution, losses may result from unwanted components of raw ingredients and excess stock. At the stage of consumers, losses may occur due to consumer preferences or the preparation of oversized meals (Gorzeń-Mitka et al 2020).

Table 1 Where food waste occurs: main causes by stage

Stage	Causes of food waste
Agricultural production	• Product loss due to pests and diseases or weather • Excessive stock or stock damaged or discarded during production, packing or handling • Fall in market prices making it unprofitable to harvest • Inability to meet contracted produce specifications, such as quality or size • Changes in consumer tastes and preferences
Processing and manufacturing	• Product damaged during handling • Spoilage due to contamination or inadequate temperature control • Excessive trimming of vegetables for processed foods • Changes in production due to consumer demand • Equipment failure • Spillage on conveyor belts and transfer points • Inefficient inventory management • Damage to packaging resulting in food unfit for sale
Distribution	• Spoilage due to inadequate temperature control in transport and storage • Damage due to improper handling
Retail	• Poor stock management, including over ordering, improper stock rotation, storage and handling practices • Produce no longer meets quality standards • Last minute order changes that can leave suppliers with excess product • Limited access to facilities to recycle or repurpose food waste
Hospitality and food service	• Poor stock management, storage, and handling practices
Households	• Confusion over 'use-by' and 'best-before' date labelling • Over-purchasing of food that is then thrown away • Limited knowledge of how to safely repurpose or store food leftovers • Limited access to food waste collection systems

Source (Commonwealth of Australia 2017).

The main goal of the National Food Waste Strategy is to achieve a 50 percent reduction in food waste by 2030 (Commonwealth of Australia 2017).

It is recommended that the Council create and implement a local campaign to reduce food waste. The campaign may first focus on two sectors, food services and homes, with online information, including social media, and face-to-face events, when possible. Online information should include good local examples of reducing food waste. For instance, The Fig Café, has an operational plan, with limits for meal time, that allows supplying food to meet a specific demand, with minimal waste. So, get there on time before it all goes!

In manufacturing and processing food waste is largely unavoidable, particularly for meat products, principally due to bones, carcasses, and organs that are not commonly eaten. Technical malfunctions also play a role, including overproduction, inconsistency of manufacturing processes leading to misshapen products or product damage, packaging problems leading to food spoilage, and irregular sized products trimmed to fit or discarded entirely (Monier et al 2010).

To address manufacturing food waste, the Mount Alexander Sustainability Group (MASG) group has proposed a bioenergy project, which is planned to produce 270,000 GJ of bioenergy for the Don Smallgoods company in Castlemaine.

As an independent scientist, with knowledge of both waste treatment and energy systems, I was asked by a resident of Castlemaine to review the proposed bioenergy project. First, I list key information from published sources about the project (MAGS 2021a, b), then make a detailed analysis, based on a range of literature and government reports, to make a number of recommendations.

Mount Alexander Bioenergy (MAB) bioenergy project

The planned facility comprises two energy technologies, **anaerobic digestion** (AD) and **pyrolysis** from inputs from clean organic waste streams:

AD technology [~1 MW] - produces biogas CH_4 (methane) and CO_2 (carbon dioxide), CH_4 to produce heat and some electricity

Pyrolysis thermal technology [3 to 4 MWt] – pyrolysis and gasification to provide fuel (syngas), heat (water, steam) and biochar as bio-fertiliser

Anaerobic digestion

Converts liquefied wasted organics (Don Smallgoods' waste, other food, beverage, grease trap, wet garden organics) into biogas (methane) which will be used by Don Smallgoods as a substitute or natural gas.

- 20% of the feedstock will be sourced from Don Smallgoods
- The additional organics are being sourced externally to reduce organics to landfill
- The facility will upgrade Don Smallgoods wastewater and organic waste systems, reducing odour from existing management facilities.
- The nutrient-rich sludge (digestate) from the AD tanks can be converted into fertiliser by blending with biochar or being dried and used in the pyrolysis plant.

Pyrolysis

Uses a gasification/pyrolysis process that heats organics in a low/no oxygen chamber to produce biochar and a synthetic gas (syngas), consisting of CH_4 (methane) and H_2 (hydrogen).

- Feedstock
    - Feedstock streams - clean untreated wasted timber, saw dust, crop stubble, and other woody waste, some unrecyclable cardboard from Don Smallgoods, 'oversize' material from composting facilities, some incidental 'unrecyclable' (non-toxic) plastic wrap from Don Smallgoods.
    - 20% - 30% will be provided by Don Smallgoods.
    - Digestate from the Anaerobic Digester can be processed as a feedstock.
    - No mixed waste, no 'toxic waste' and no other plastics will be used.

    - The final mix of feedstock that can be received will depend on the technology selected and EPA requirements.
- Gas will be scrubbed/cleaned and then used as gas substitute by Don Smallgoods natural gas use.
- Biochar can be supplied to the agricultural / garden supplies market. Biochar can also be 'activated' with nutrients from AD digestate to make a valuable fertiliser.
- Emissions: water vapour and CO_2 will be the main components, also some CO will be produced.
- Total particulate emissions (mg/Nm^3) will be reduced from 190 mg to less than 5mg (per Billion mg) after scrubbing.

Traffic

- Currently there are about 30 movements per day of large trucks, and 60 movements of small vehicles. The expected additional number of truck movements by contracted parties is 3 to 5 per day: this means a net increase of 2 to 3 as there will be a reduction traffic from Don Smallgoods. That is, about 32 to 33 truck visits per day.

Commercial project supporters

- George Weston Foods Limited (brand owner of the Don Smallgoods and KR Castlemaine)
    - GWF is a wholly owned subsidiary of Associated British Foods plc, a diversified international food, ingredients and retail group.
- Welshmans Reef Vineyard (located west of Castlemaine on Maldon-Newstead Road)
- Coliban Water

Analysis

Food waste treatment and bioenergy

The main aim of the project shall be to optimally treat food waste, while production of bioenergy is a secondary aim. Bioenergy is best useful in the short to medium term, during the global transition to renewable energy, to help limit the need for energy provided by fossil fuels. In the medium term large-scale renewable energy plants and green hydrogen-fired power plants will provide zero carbon energy at highly competitive costs, limiting the value of small-scale bioenergy, while there will remain a major requirement to treat food waste.

Circular economy options

Key principles of the circular economy are that products and materials are circulated at their highest value at all times, and that conserving resources is a high priority, based on the waste management hierarchy, Figure 2. General ways to address food waste by level of waste hierarchy are summarised in Table 2.

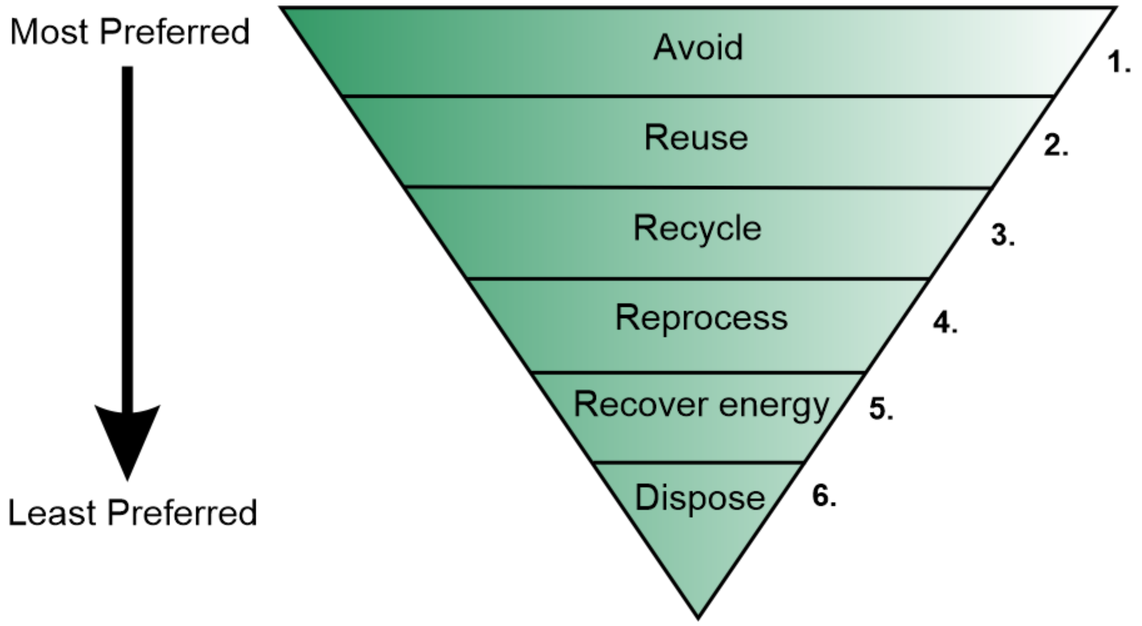

Figure 2 Food waste management hierarchy. Adapted from (Commonwealth of Australia 2017).

Table 2 Addressing food waste by waste hierarchy level

No.	Waste Hierarchy	Response
1	Avoid	• Education campaigns • Research and development to support more efficient production methods • Packaging initiatives to improve shelf life
2	Reuse	• Food rescue donations • Repurposing aesthetically imperfect food (e.g., packaged carrot sticks) • Repurposing without processing for animal feed
3	Recycle	• Composting (windrows and anaerobic digestion) • Soil conditioners • Worm farms • Biotechnology solutions for animal feed
4	Reprocess	• Conversion to pharmaceutical and nutraceuticals • Conversion to cosmetic products
5	Recover energy	• Incineration and anaerobic digestion for energy recovery
6	Dispose	• Incineration for non-energy recovery • Food waste sent to landfill • Food waste going to sewer

Source (Commonwealth of Australia 2017).

Options for circular economic depend on the type of waste. Don Smallgoods has three main types of waste, wastewater, containing organic food materials, waste pork materials, and polyethylene plastic wrap, contaminated with food (meat) materials.

As Don Smallgoods has imported pork meat, that waste pork material is assessed as a biosecurity issue, and so is required to be treated to kill any microbes or viruses that may possibly be a risk to pigs or other animals in Australia, if possibly present, prior to disposal. For this purpose, pyrolysis is an effective treatment process, to produce bio-clean biochar.

Composting option

While general food waste can be composted, there are limits to the composting option, as food waste is required to be mixed with green waste, to optimise the composting process. Food waste tends to have a high nitrogen content compared its carbon content, so optimally to be mixed with green waste, which has a low nitrogen content compared to its carbon content. The reported ideal ratio of Carbon to Nitrogen for thermophilic composting has been generally thought to be in the range of 25 to 40 (Haug 1993; Epstein 1997). The optimal moisture content for composting has also been thought to be around 50 percent (w/w) (Haug 1993; Epstein 1997). A more recent study indicates that the optimal ratio of Carbon to Nitrogen depends on the moisture content. In this study an optimal Carbon to Nitrogen ratio of 19.6 was associated with a range of moisture contents from 55 percent to 65 percent (Kumar et al 2010). Therefore, optimally composting food waste requires it to be mixed with a substantial amount of green waste. Further, the emerging option provided by councils of composting domestic food organics and garden organic (FOGO), for instance by the Surfcoast Shire (Surfcoast Shire 2021), is likely to limit the availability of composting substantial amount of waste food from commercial sources.

It is recommended that green waste from Welshmans Reef Vineyard be preferentially composted, as a low cost and effective method. This could be done onsite, or with a commercial composting service. This is preferable to pyrolysis, as composted materials have a higher value than biochar.

Food waste to energy by anaerobic digestion

Given the large amount of food waste produced by food manufacturing and processing, and potential lack of enough green waste to compost this type of waste, it is reasonable to view anaerobic digestion as an effective option to process food waste to digested organic material, along with producing biogas to provide bioenergy. That is, digested organic material has a significant economic value, as an organic fertiliser, with the associated advantage of bioenergy production.

A good example of converting food waste to energy by anaerobic digestion is the ReWaste facility of Yarra Valley Water. The output power is similar to that proposed for the Mount Alexander Bioenergy (MAB) bioenergy project. ReWaste can accept a range of organic wastes (ReWaste 2021), including:

- Fats, oils and grease (for example, grease trap waste)
- Food processing waste
- Cooked food waste from restaurants
- Dairy waste, for example, cheese whey
- Animal processing waste
- Dissolved Air Flotation (DAF) sludge
- De-packaged spoilt liquids
- Process upset wastes.

The process has 7 main steps:

1. Separately store solid and liquid organic waste [liquid waste stored in closed tanks)
2. Mix solid and liquid waste to make a slurry
3. Feed slurry to digestor
4. Collect biogas
5. Biogas burnt to make power: electricity to plant and grid
6. Waste heat to keep digester warm, at operating temperature
7. Transfer anaerobically digested sludge to the biosolids treatment process

The ReWaste takes in the equivalent of 33,000 tonnes of commercial food waste each year, around 140 tonnes per day. This diverts thousands of tonnes of waste away from landfill and can produce around 23,500 kilowatt hours of electricity per day (equivalent to a 0.981 MW system), the equivalent power demand of around 1,300 homes (Yarra Valley Water 2021).

It is reasonable to consider that truck load sizes may vary between about 5 tonnes to 15 tonnes, so at 140 tonnes per day, the number of truck visits may range from 9 to 28, with an average of 19 per day.

A particular advantage of the anaerobic digestion system is the closed system, so that odours are minimised.

It is recommended that the proposed anaerobic digestion system takes food wastes from major food companies in the region, including partners Don Smallgoods and potentially from other George Weston Foods' sites. Food waste may also be taken from restaurants and cafes, including grease trap waste. Feedstock may also include other local biological waste resources, Table 4.

Drying biosolids

The output from anaerobic digesters are liquid biosolids, which are essentially 94 to 97 percent water with relatively low amounts of solids (3 to 6 percent). It is often economical to reduce the volume of biosolids prior to transportation or storage. The amount of water in biosolids can first be reduced through mechanical processes such as draining, pressing, or centrifuging, resulting in a material composed of up to 30 percent dry solids. This material will be the consistency of damp soil (EPA USA 2000).

Dewatered biosolids do not require any specialized equipment and can be applied with conventional agricultural equipment, such as manure spreaders pulled by tractors (EPA USA 2000).

Biosolids can be further dried by applying heat. The drying system, in addition to the dryer itself, generally consists of materials handling and storage equipment, heat generation and transfer equipment, air movement and distribution equipment, emissions control equipment, and ancillary systems. Among drying systems there are different methods for heat transfer, including convection, conduction, and radiation heating (Water Environment Federation 2014).

Factors that affect capital costs for drying systems include the type of system selected, existing infrastructure, such as buildings and utilities, conveyance needs for moving dewatered solids to the process, and finished product storage requirements. The operating and maintenance (O&M) costs of thermal drying systems are also dependent on the type of system selected and the energy source. Systems that rely on combustion of fossil fuels will have significantly higher O&M costs than systems that recover heat from other processes or rely on solar radiation (Water Environment Federation 2014).

It is recommended that a biosolids drying system be selected for processing liquid biosolids from the anaerobic digester.

Wastewater treatment option

In addition to treating wastewater through anaerobic digestion, a further option for treating wastewater from Don Smallgoods could be an artificial wetland, located on the property. This is a relatively low-cost option, with a good environmental profile, and might be useful if the volume of wastewater is excess to requirements for anaerobic digestion. A key value of artificial wetlands is to remove nutrients, microbes and potential sources of odour from the effluent, which can then safely enter the stormwater system.

Plastic recycling

Plastic waste is effectively a fossil fuel (Friends of the Earth 2009), and should, therefore, not be incinerated or treated by pyrolysis. Therefore, it is recommended to recycle the waste plastic from Don Smallgoods, according to the waste hierarchy, Figure 1. The waste plastic be first washed, to remove most food contamination. The waste plastic be sent to a commercial plastics recycler, while the waste water could be part of the feed for the anaerobic digestor.

By corollary, types of plastics that cannot be reused or recycled, should not be used, and replaced by recyclable plastic types, or other recyclable materials. That is, a material that cannot be easily reused or recycled has no real value in the circular economy.

Sewerage sludge treatment

It has been commonly established that significant amounts of PFAS compounds, and other environmentally toxic organic chemicals, such as halogenated flame retardants, which have become widely present in regional areas as well as metropolitan areas around the world, including Australia, end up in sewerage treatment plants (Pan et al 2016; Eriksson et al 2017). In particular, due to phase separation, short-chain PFASs are preferentially found in the water effluent while long-chain PFASs are preferentially found in biosolids. While granular activated carbon (GAC) and reverse osmosis treatment systems have successfully removed key PFAS compounds, PFOA and PFOS, to non-detectable levels, for many years around the world (Carluccio 2019), the only solution for removing PFAS compounds from biosolids has proved to be pyrolysis (Bioforcetech Corporation 2019).

In Victoria, South East Water is helping to deliver a Biosolids to Biochar project in partnership with RMIT University, Intelligent Water Networks and Greater Western Water, utilising pyrolysis technology, and starting with a pilot test at Greater Western Water's Melton Recycled Water Plant (Harris 2021).

It is, therefore, recommended that (a) treated sewerage **not** be mixed with any other non-contaminated organic source, such as in anaerobic digestion with mixed sources, and (b) be separately treated by pyrolysis. For this purpose, it is suggested that Coliban Water ask to join the existing water company consortium for pyrolysis of biosolids, quoted above.

Pyrolysis

The production of energy by anaerobic digestion or pyrolysis is expected to provide zero net green house gas emissions, and therefore provide a saving in greenhouse gas emissions compared to energy provided by coal-fired power plants, through the national electricity grid.

However, any plastic treated by pyrolysis is equivalent to a fossil-fuel (Friends of the Earth 2009), and so potentially reduce the savings of greenhouse gas emissions. Further polyethylene plastic can be effectively recycled, starting with washing the plastic wash, where wash water can be treated with chlorine or other means to kill any animal microbes or viruses that might be present. Further during recycling the plastic is heated and dried, that would kill any living organisms that may be present (Rotajet Recycling 2021).

Apparently, wood chips are to be used as the biofuel to heat the pyrolysis system. Importantly, the pyrolysis process is conditionally carbon neutral. For the pyrolysis process, biochar may represent 25–30 percent of total plant products. Then, to ensure net zero green house gas emissions, a minimum of 41 percent of the biochar should be returned to the field, to ensure net zero green house gas emissions (Yang et al 2016). Also, if wood chips are treated by composting the compost products have more agricultural values than biochar. Therefore, the use of wood chips in the pyrolysis process should be minimised, simply to provide enough biofuel to process the waste meat or other prescribed organic wastes.

Further, as the energy provided by renewable energy sources continues to increase over time, as suppled through the national electricity grid, the savings of greenhouse gas emissions will be expected to fall to zero. According to planned closures of coal-fired power plants, emissions for these should fall by 50 percent by 2035, and 90 percent by 2048 (Rouch 2021). These are conservative dates, as coal-fired power plants are already becoming uneconomic, and so likely to close more rapidly in future. Therefore, bioenergy systems will become less competitive in future.

Products and emissions from pyrolysis

The components of gas products from wood pyrolysis are mainly H_2 (hydrogen), CO (carbon monoxide), CO_2 (carbon dioxide), CH_4 (methane), C_2H_4 (ethylene), C_2H_6 (ethane), C_3H_8 (propane) and water (Kinata et al 2013).

Products from a fluidised bed woodchip system vary according to temperature, Table 3. Therefore, if gas production is maximised, the biochar production is minimised. That is, there is a trade-off between producing gas for energy and producing biochar to ensure net zero green house gas emissions.

Table 3 Changes in proportions of products by process temperature

Temperature	Gas	Liquid†	Biochar
400	10	25	28
500	19	38	25
600	25	31	23
700	35	25	20

†, includes liquid oils and moisture. Source (Xiao et al 2006).

Also, importantly, the current plan indicates that Don Smallgoods will contribute about 20 to 30 percent of waste to the pyrolysis facility. While it is currently planned that that the pyrolysis facility will take only hard non-toxic organic material, when the business is created there will most likely be a push to take prescribed waste, due to increased profitability for this type of waste (Appendix A). That is, the market would need to be diversified and likely include a range of prescribed wastes, such as any organic material that has been contaminated with organic contaminants, like pesticides, herbicides, PCBs or PFASs. In this case there would be significantly increased traffic of prescribed wastes through the town, which is not compatible with the green tourism profile of the town.

Further there is a significant risk of locating the pyrolysis facility near to Don Smallgoods, to negatively impact on the clean food reputation of Don Smallgoods. Perception is important: it would appear not good to have a prescribed waste treatment facility adjacent to Don Smallgoods.

Also, as the pyrolysis facility will take in prescribed waste, it would be critical that it is well separated from the clean waste and clean products of the anaerobic digestor facility, to avoid contamination of the clean waste and clean products by prescribed wastes. Again, if these facilities are located close together, there may be a negative perception that all waste is contaminated.

For the collective reasons given above is recommended that the pyrolysis facility be removed from the bioenergy plan.

Site structure, location and precinct plan

Site structure and safety

For environmental safety, the anaerobic digestor and bioenergy facility shall be built on a concrete pan with a perimeter bund around the anaerobic digestor and waste storage areas, to prevent any leaks of liquid waste leaving the site, for environmental safety. The facility shall have its own gate entry.

Location

Such a location issue can be addressed by a council's development plan, discussed next.

Aspects of a development and precincts plan

A council's development plan shall be based on existing local advantages, in terms of current industry sectors and resources (Rouch 2020). This includes assessing future trends. This may include the food industry and associated recycling of waste resources, as key components of the global circular economy. This concept also relates to the green profile of the town.

Further, a key current feature of the food sector are small niche creative players, including unique cafes and restaurants that contribute to the wellbeing of the community and tourism.

Regional Development Association

Mount Alexander Shire is a southern member of the Loddon Mallee Regional Development Association. This aims to support economic growth by facilitating access to data and knowledge, and creates regional alliances, partnerships and networks to support public and private investment (Regional Development Victoria 2021).

The Loddon Mallee region is positioned to capitalise on energy, advanced manufacturing and intensified agriculture production. The committee is working with the region to drive and leverage investment for (Regional Development Victoria 2021):

- Improved Digital connectivity - including business-grade broadband to support the uptake of the Internet of Things to automate farming and food processing.
- Renewable energy projects - through the expansion of solar farms and emerging hydrogen industries.
- Agriculture, beverage and food production supply chain opportunities.
- The development of an international tourist brand to capitalise on Bendigo becoming a UNESCO Creative City of gastronomy and seeking World Heritage listing for the Central Victorian Goldfields and the Grampians region.
- Local TAFE and universities to align training with industry needs to address a lack of skilled labour in the region.

Renewable energy projects are planned to expand energy provided by solar farms and to support emerging hydrogen industries. In addition, bioenergy is part of the plan (Loddon Mallee New Energy Taskforce 2019).

Further, as the Greater Bendigo City is Australia’s first UNESCO Creative City of Gastronomy, to celebrate their region’s culture, creativity and sustainability, there is a potential link to the unique cafes and restaurants in Castlemaine that contribute to the wellbeing of the community and tourism of the local area. This suggests the potential for a gold fields food tourism trail, to link Castlemaine, Bendigo and other localities in the area that have good food services.

Community consultation

The creation of a development plan, should be done in consultation with the community. This would in part help to assess both the value and optimal location of the bioenergy facility.

Consultation, on community projects is optimally an ongoing process. A genuine consultation process ensures that a government has considered the real-world impact of proposed policy options. This is likely to lead to better outcomes and greater acceptance in the community, particularly among any stakeholders who may be adversely affected by the policy (Office of Best Practice Regulation 2016).

Governments must consider the scope of the proposed changes and consult widely to ensure that consultation captures the diversity of stakeholders affected by the changes. Relevant individuals and groups may include, the general public, businesses, consumers, unions, environmental groups and other interest groups. In this way, consultation can ensure that stakeholders can readily contribute to policy development (Office of Best Practice Regulation 2016).

Consultation with key stakeholders should be continuous and should start as early as possible. It is important that consultations begin early, when the policy objectives and different approaches are still under consideration. Involving stakeholders from the earliest possible stage in the policy development process will promote transparent and comprehensive participation. Consultation should continue through all stages of the development cycle, including when detailed design features are being finalised. This will help governments to identify and understand potential problems (Office of Best Practice Regulation 2016).

Also, timeframes for consultation should be realistic to allow stakeholders enough time to provide a considered response (Office of Best Practice Regulation 2016).

Further aspects

The population of Castlemaine is 6,757, at 2016 census, so there are limits to what can be done, in terms of supporting sectors that may compete for infrastructure, including land and roads. In contrast, Bendigo, a much larger town, has a population of 153,092, and has the existing infrastructure to potentially support all parts of the circular economy.

In turn, a precinct model would place the food and waste resource sectors in separate precincts, under the development plan, to support some further development of these two sectors. For instance, the centre area of the town might be identified as a food service/tourism precinct, and the area around Richards Road, Castlemaine, including Don Smallgoods, may be identified as a secondary food industry precinct, with the aim to preferentially attract other food companies to be located in this precinct. These may be small niche players or creative startup food businesses.

Conversely, the area around Sluicers Road, south west Castlemaine, where the Castlemaine Waste Facility is located, may be identified as a waste resources precinct. Then, new waste resource facilities, such as the proposed bioenergy facility, could preferentially be placed in this area. A further advantage of this area is the existing weigh bridge, which would also be essential for assessing the weight of food waste for the anaerobic digester.

Community retail energy business

While the tariff payments for sending electricity to the grid by the potential bioenergy facility would be low, an alternative approach is for the Council to set up a community retail energy business, to buy electricity supply from the bioenergy facility, and potentially from other renewable energy sources on the grid. This is done through the GreenPower scheme, which is a government-accredited scheme that lets individuals and businesses support renewable energy generation. When people buy a GreenPower product from an electricity retailer, they are paying for electricity produced by renewable power sources that meet a strict set of criteria for accreditation. GreenPower is quantified and traded through certificates. When people buy GreenPower from a retailer, the retailer registers the sale in their database. At the start of the next year, the retailer must buy certificates representing the same amount of electricity from an approved renewable energy generator. Called Large Scale Generation Certificates or LGCs, each one represents 1 MWh of renewable electricity. LGCs can only be 'created' by accredited wind, solar, hydro or biomass generators of more than 100 kW in size (Potter 2017). Then, the bioenergy facility to gain accreditation as a biomass electricity generator.

In this way the bioenergy facility is only required to be connected to the electricity grid to provide power, and so can be located in the waste resource precinct.

Also, an application for a retail energy licence may be made by any legal person including individuals, incorporated associations and corporations. Conversely, entities that are not a legal person (for example, an unincorporated joint venture) cannot apply for a licence (Essential Services Commission

2020). Also, if there is wider interest, the Council may consider asking other regional councils if there are interested in supporting the proposed community retail energy business.

In this way, the retail energy business could buy electricity from the bioenergy facility, when it is commissioned to send electricity to the grid, and then sell it to Don Smallgoods. In addition, there would be an opportunity for local citizens to buy green electricity from the retail energy business.

Renewable energy

In terms of energy savings and reducing greenhouse gas emissions, a PV solar system, located on the large roof of the Don Smallgoods company's main building, would optionally provide sufficient energy to run base operations during the day, at a highly competitive cost, while the anaerobic digestor could provide any additional power required during the day, as well as during the night. Any excess power could be sold to the national power grid.

It is recommended that Don Smallgoods investigate the option for a PV solar system, in discussion with a selected number of commercial suppliers. The focus should be on economically meeting current power needs, and not the largest possible system, that some suppliers like to propose. The commercial PV solar industry remains a mix of good and poor suppliers, like the domestic PV solar power industry, in Australia.

The underlying point being that the main aim of the project is to optimally treat food waste, while production of bioenergy is a secondary aim. PV solar energy will remain competitive in the long term, whereas bioenergy is best useful in the short to medium term, during the global transition to renewable energy.

Aspects of business plan

Business model

It is recommended the operating company be of not-for-profit type, to avoid excessive management costs, with a preference for community ownership. A community-ownership project is characterised by local stakeholders owning most of the project and voting rights and by control resting with a community-based organisation. Most of the project's socio-economic benefits are therefore distributed at the local community level (IRENA Coalition for Action, 2020).

The innovative aspect of community-ownership business models lies in the role of the community and its participants, which goes beyond renewable energy generation. Nowadays, community ownership models cover the entire energy value chain: they can provide localised generation for power, heat and energy-related services (for instance, storage, charging electric vehicles, energy trade with surrounding communities); enable efficient energy use; and provide flexibility to the entire power system (IRENA 2020).

Markets

Biological waste

Importantly, the current plan indicates that Don Smallgoods will contribute about 20 percent of food waste for the Anaerobic Digester. Further, it is important to increase the range of clients, to minimise financial risk. The market for the anaerobic digester may potentially include all food manufacturers and food services in the area, including supermarkets, restaurants and cafes.

Biological waste resources, in addition to food waste, in the local areas include digestible (level 5), compostable (level 3) and recyclable materials (level 3), Table 4: levels according to the waste management hierarchy. The four local governments listed under Mount Alexander Shire in Table 4 are located adjacent to Mount Alexander Shire, and so may be effectively available to provide biological waste for the proposed anaerobic digestor. The majority of biological waste is of straw and chaff, which is optimally composted. However, the total digestible wastes potentially provided by Mount Alexander Shire and adjacent local government areas amount to 54,300 tonnes, significantly more than the requirement for providing stock feed for the planned anaerobic digester facility, equivalent to 33,000 tonnes of commercial food waste.

Table 4 Top 3 biological waste resources, annually by Local Government Area

Local Government		Digestible (tonnes)	Compostable (tonnes)	Recyclable (tonnes)
Mount Alexander	Paper and cardboard			2,400
	C&I organics	1,800		
	C&D timber		400	
Greater Bendigo	Straw and chaff		71,475	
	Poultry litter	8,600		
	Pig manure / slurry	5,200		
Central Goldfields	Straw and chaff		38,000	
	Oilseed pods	7,700		
	Paper and cardboard			6,700
Macedon Ranges	Straw and chaff		7,000	
	Plantation bark		8,000	
	Sawmill wood chip		2,500	
Loddon	Straw and chaff		325,000	
	Pig effluent	8,000		
	Oilseed pods	23,000		
Total		**54,300**	**452,375**	**9,100**
Buloke	Straw and chaff		470,000	
	Pig effluent	1,500		
	Oilseed pods	12,000		
Gannawarra	Straw and chaff		426,000	
	Dairy effluent	24,000		
	Oilseed pods	15,000		
Swan Hill	Straw and chaff		30,000	
	Almond husks and shells		60,000	
	Grape marc	3,400		
Mildura	Straw and chaff		550,000	
	Almond husks and shells	80,000		
	Grape marc	16,000		
Campaspe	Straw and chaff		185,000	
	Dairy manure	46,000		
	Paper and cardboard			6,000
Total		**197,900**	**1,721,000**	**6,000**
Grand total		**252,200**	**2,173,375**	**15,100**

Source (Loddon Mallee New Energy Taskforce 2019).

Electricity
In the current plan the market for electricity supply is limited to one customer, Don Smallgoods, which may be a significant financial risk, for instance if Don Smallgoods subsequently decide to use an alternative source of power. This risk is reduced by the bioenergy system being certified for the GreenPower system, and linking it to the power grid, along with setting up a community retail energy business, to provide a number of customers, as discussed above in this report.

Pricing
The gate price should be set lower than the landfill levy. For 2021 to 2022, the rural Industrial waste levy is $93.19 per tonne (EPAV 2021a). If the gate price is set at 10 percent lower than the levy, then the gate price is then $83.87 per tonne.

Based on 33,000 tonnes of commercial food waste each year, as per the ReWaste facility, the total gate income then would be $2,767,710 per year.

For 2022-2023 the rural Industrial waste levy is $110.79 (EPAV 2021a), and 10 percent below that is $99.71. The total gate income would be $3,290,463 per year.

Truck wash onsite
Trucks are to washed after leaving waste, and before leaving the site, to maintain biological safety. Commercial rates for truck washing range from about $100 to $135.

Digested organic material
The unamended digested organic material is more like good compost than commercial organic fertilizers, which are amended with related materials. Digested organic material has wide values, for both fertilising and conditioning soil, include slow release of nitrogen soil nutrients. Commercially, compost is available by bag, for domestic customers, and by cubic metre for landscapers and horticultural applications. Example prices per bag and by cubic metre are shown in Table 5.

Table 5 Compost market price per bag and m^3

Compost	Price per bag†	Price per m^3
Bunnings	$9.29	NA
SA Composters (fine sieved)	$8.00	$63.00
SA Composters (Coarse)	$6.00	$42.00

†Prices for 25 L size bag.

Profitability
With the proposed capital cost of $20 million, it would be reasonable to gain at least $1.1 million profit per year, to return all of the investment by the 20th year, with an additional 10 percent financial return. Profitability will depend on operating costs and management costs, as well as prices. A detailed analysis of profitability is beyond the scope of this report.

Traffic management
It should be recognised that such a large project will have a major impact on local traffic, and therefore, require attention to creating a dedicated traffic management plan.

Planned location of bioenergy facility

Together the project and current Don Smallgoods may start with a total of 32 to 33 truck visits per day, a net increase of 2 to 3, to provide stockfeed for both an anaerobic digester and a pyrolysis facility. However, this number is expected to rise significantly as more clients are found. Experience with the ReWaste (anaerobic digester) facility indicates that on average about an additional 19 trucks per day may be expected (range 9 to 28).

It should be recognised that such a large project will have a major impact on local traffic. and therefore, require attention for the Council to create a dedicated traffic management plan to change the current truck route, given the likely future increase in truck traffic once the bioenergy facility has been commissioned. So, trucks will not need to enter the centre of town or associated high density pedestrian precincts.

The current route for trucks to Don Smallgoods follows both the east and south sides of the Castlemaine Botanical Gardens, Figure 3. While there is currently light traffic during the Covid-19 pandemic, this is reasonable. However, the south side of the Botanical Gardens, Walker Street, is a pedestrian precinct, including shops, hotel and medical centre and entry/exit roads for Castlemaine Hospital, a number of retirement homes, the Castlemaine Gardens Holiday Park and the public swimming pool. Pedestrian traffic varies between light and moderate busyness.

Also, major truck traffic on both the east and south sides of the Botanical Gardens will impact on the peace of people using the Gardens. Therefore, it is recommended that the Council plan to change the current truck route, given the likely future increase in truck traffic once the bioenergy facility has been commissioned.

It is suggested that trucks arriving from the north, east and south take the Harcourt exit of the Calder Freeway to enter Castlemaine along the Midlands Highway, from the north side. Due to the planned future increase in truck visits, it is suggested that they reduce travel by the Botanical Gardens and associated pedestrian and local traffic.

So, a potential better alternative route from the Midland Highway is to take Downes Road, turn right into Froomes Road, follow into Mary Street, then left into Richards Road, Figure 3. This is not perfect, as it goes by the north side of the Botanical Gardens, and over the single lane bridge. Further, there has been a local campaign to keep low traffic on Froomes Road, as a peaceful green area, and due to lack of community consultation on the Council's plan to widen the bridge (Hough 2019). Unfortunately, also, there is no effective entry of Richards Road from the Midland Highway from further north. In particular, Merrifield Road is highly unsuitable for truck traffic due to the creek ford, steepness and being unsealed.

From the west, for trucks travelling along the Pyrenees Highway, it is reasonable that they take the left turn into the Midland Highway, turn left into Parker Street, continue into Walker Street, and follow the curve right into Richards Road. Unfortunately, there is no main alternative, though this route goes through the pedestrian area in Walker Street.

Figure 3 Existing and alternative truck routes for Don Smallgoods and the planned bioenergy facility. Image, Google map.

Alternative location of bioenergy facility

According to the precinct model for a development plan, as discussed above, a better location for the bioenergy facility is by the current Castlemaine Waste Facility, Figure 4.

In this case it is suggested, again, that trucks arriving from the north, east and south take the Harcourt exit of the Calder Freeway to enter Castlemaine along the Midlands Highway, from the north side. Then, continue along the Midland Highway, turn right at the Pyrenees Highway, left into Langslow Street, and left into Sluicers Road, to reach the facility.

From the west, for trucks travelling along the Pyrenees Highway, it is suggested they take the right exit into Langslow Street, and left into Sluicers Road, to reach the facility.

In this way, there is no disruption to pedestrian areas or to the Botanical Gardens.

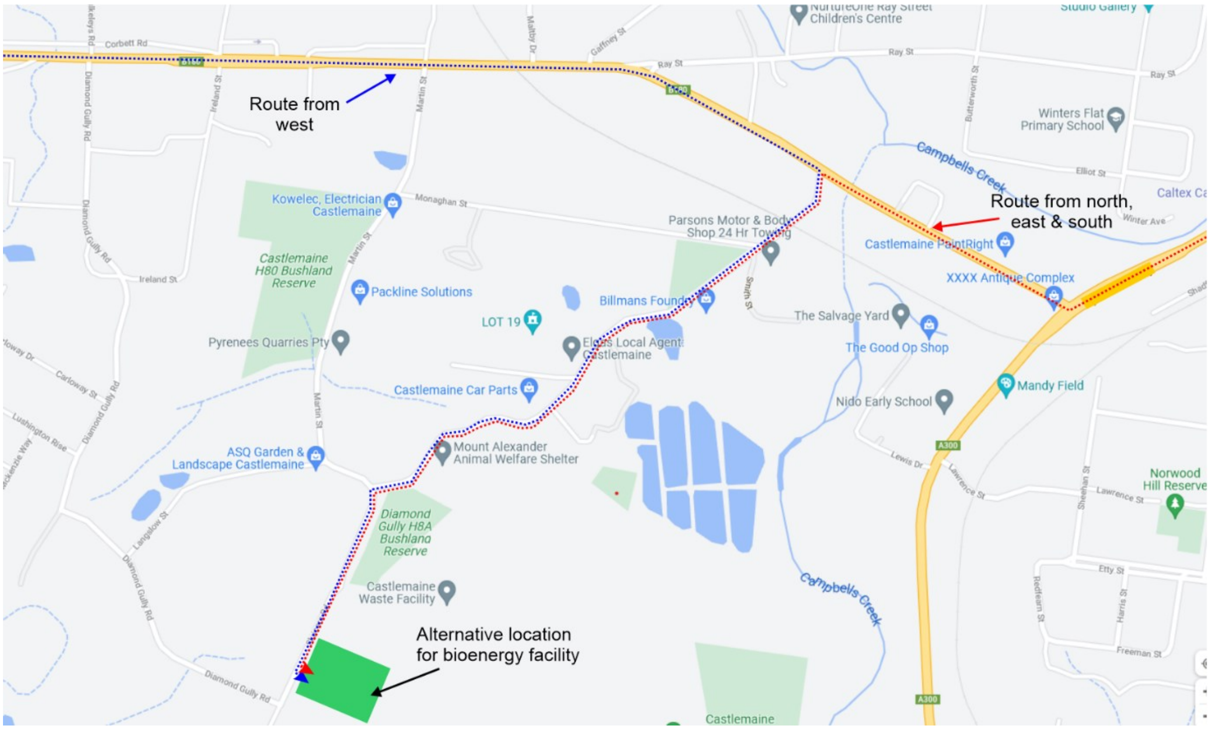

Figure 4 Suggested truck routes for the alternative location of the planned bioenergy facility. Image, Google map.

Conclusions and recommendations

The Mount Alexander Sustainability Group (MASG) group has proposed a bioenergy project, which is planned to produce 270,000 GJ of bioenergy for the Don Smallgoods company in Castlemaine. The planned facility comprises two waste treatment technologies to provide bioenergy, anaerobic digestion (AD) and Pyrolysis, with inputs from clean organic waste streams.

The main aim of the project shall be to optimally treat food waste, while production of bioenergy is a secondary aim. Bioenergy is best useful in the short to medium term, during the global transition to renewable energy. In the medium term large-scale renewable energy plants and green hydrogen-fired power plants will provide zero carbon energy at highly competitive costs, limiting the value of small-scale bioenergy, while there will remain a major requirement to treat food waste.

It is recommended that the proposed anaerobic digestion system takes food wastes from major food companies in the region, including partners Don Smallgoods and potentially from other George Weston Foods' sites. Food waste may also be taken from restaurants and cafes, including grease trap waste. Feedstock may also include other local biological waste resources.

It is recommended that a biosolids drying system be selected for processing liquid biosolids from the anaerobic digester.

For environmental safety, the anaerobic digestor and bioenergy facility shall be built on a concrete pan with a perimeter bund around the anaerobic digestor and waste storage areas, to prevent any leaks of liquid waste leaving the site.

In contrast to food waste, it is recommended that green waste from Welshmans Reef Vineyard be preferentially composted, as a low cost and effective method. This could be done onsite, or with a commercial composting service.

A further option for treating wastewater from Don Smallgoods could be an artificial wetland located on the property. This might be useful if the volume of wastewater is excess to requirements for anaerobic digestion.

it is recommended to recycle the waste plastic from Don Smallgoods, according to the waste hierarchy. The waste plastic be first washed, to remove most food contamination. The waste plastic be sent to a commercial plastics recycler, while the waste water could be part of the feed for the anaerobic digestor.

Due to likely contamination of sewerage by PFAS and other hazardous compounds, it is recommended that (a) treated sewerage **not** be mixed with any other non-contaminated organic source, such as in anaerobic digestion with mixed sources, and (b) be separately treated by pyrolysis. For this purpose, it is suggested that Coliban Water ask to join the existing water company consortium for pyrolysis of biosolids.

As the potential pyrolysis facility would take prescribed industrial waste, and there would be significantly increased traffic of prescribed wastes through the town, this is not compatible with the green tourism profile of the town. For this and other issues, it is recommended that the pyrolysis component be removed from the bioenergy plan.

It is recommended that the Council assemble a development plan, in consultation with the community, in part to assess both the value and optimal location of the bioenergy facility. The development plan may usefully include precinct models.

For the bioenergy facility to be of optimal value to the community it is recommended that (a) that the Council set up a community retail energy business, to use the national GreenPower scheme, to buy electricity supply from the bioenergy facility, and potentially from other renewable energy sources on the grid; (b) the bioenergy facility to gain accreditation as a biomass electricity generator. Don Smallgoods, along with community members, will then be able to buy electricity from the bioenergy facility through the community retail energy business.

In this way the bioenergy facility is only required to be connected to the electricity grid to provide power, and so can be located in the waste resource precinct.

It is recommended that Don Smallgoods investigate the option for a PV solar system, in discussion with a selected number of commercial suppliers. The focus should be on meeting current power needs, and not the largest possible system, that some suppliers like to propose.

It is recommended the operating company be of not-for-profit type, to avoid excessive management costs, with a preference for community ownership.

Further, diverse markets for treatment of food waste by the anaerobic digester facility be implemented, to minimise financial risk.

It should be recognised that such a large project will have a major impact on local traffic. It is then recommended that the Council create a traffic strategy report, and implement the requirements.

Lastly, it is recommended that the Council create and implement a local campaign to reduce food waste. The campaign may first focus on two sectors, food services and homes.

Acknowledgements

The proposed project would be located in Castlemaine, part of the land of the Dja Dja Wurrung traditional owners. The report was assembled on the traditional land of the Wurundjeri Woi Wurrung people.

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Appendix A Pyrolysis facility gate prices and biochar prices

To maximise income to provide return on investments for the planned pyrolysis facility it is likely that that the operating company will take in prescribed waste, as providing high profitability, due to higher gate prices than for normal waste.

Pyrolysis facility gate prices

The gate price for the pyrolysis facility should be set lower than the related landfill levy for the similar category. For prescribed waste the landfill levy can be significantly higher than for normal waste, Table A1. Therefore, the gate cost shall relate to the category of contamination.

Table A1 Landfill costs for prescribed wastes, 2021-2022

Priority waste received at a landfill premises	Amount ($/tonne)
Category A (highly hazardous)	Landfill is prohibited to receive waste. Levy does not apply
Category B† – includes wastes from manufacturing industries and contaminated soils.	257.76
Category C† – includes wastes that pose a low hazard from manufacturing industries and contaminated soils.	105.90
Category D† – industrial waste that is soil	105.90
Soil containing asbestos	30.96
Packaged waste asbestos	30.96

†, Category depends on the level of contamination by prescribed contaminants, see (EPAV 2021b). Table source (EPAV 2021a).

Digested organic material and biochar prices

The unamended digested organic material is more like good compost than commercial organic fertilizers, which are amended with related materials. The price per bag of biochar is substantially larger than for compost, Table A2, in part due to higher production costs for biochar. Nevertheless, digested organic material has wider values, for both fertilising and conditioning soil, include slow release of nitrogen soil nutrients. In contrast, the main value of biochar is simply as a soil conditioner.

Table 5 Compost and Biochar, market price per bag†

Compost	Price	Biochar	Price
Bunnings	$9.29	BosRural	$50
SA Composters (fine sieved)	$8.00	Green Man	$50
SA Composters (Coarse)	$6.00	Tripler Biochar	$91.25

†Prices for 25 L size bag.

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