Feasibility Study for Alternative Boiler Fuels

This is an MLA Donor Company funded project.

Meat & Livestock Australia acknowledges the matching funds provided by the Australian Government and contributions from the Australian Meat Processor Corporation to support the research and development detailed in this publication.

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Executive Summary

Australia’s A$17 billion red meat industry makes a significant contribution to the national economy and is one of the world’s largest and most efficient producers and exporters of red meat and livestock\(^1\).

Operating under tight profit margins and competitive market conditions, the red meat industry continuously seeks to improve efficiency and reduce costs to maintain its national and international standing.

The challenge of rising energy costs

Natural gas makes up more than 35% of the red meat processing industry’s total energy usage\(^2\). Increasing gas prices, forecast to nearly double over the next 2 - 3 years, are reducing profits by as much as 1%, which is highly significant in an industry where margins can be as low as 2 - 4%.

These costs are driving meat processors and other food manufacturing businesses to consider alternative fuels, including coal and fuels derived from waste products.

However, while coal-fired power is a lower cost option, the associated carbon emissions present a significant future risk as Australia moves to a lower carbon economy.

Ageing equipment and tighter environmental regulations are also driving the industry to consider low-emissions technologies such as waste-to-energy when replacing or upgrading equipment. Covering open anaerobic lagoons for example, not only provides better odour control but also creates an opportunity to capture and use biogas, which reduces carbon emissions, while displacing natural gas.

There are several examples of successful biomass and biogas projects in Australia. These projects have a number of characteristics in common:

- The alternative, available fuel is cheap (<$5/GJ)
- Waste is available from inside site operations or through the supply chain
- Supply is consistent and available for more than five years
- Conventional fuel is expensive (> $10/GJ)
- There is a need to replace or upgrade existing equipment (e.g. boiler) or infrastructure (e.g. wastewater treatment plant upgrade)
- Funding and/or financing support is available.

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Assessing the opportunities in alternative fuels and technologies for the meat industry

A study was undertaken in collaboration with an Australian meat processor to understand where both the barriers and opportunities lie in the take up of alternative fuel boiler technologies. This report outlines the findings of that study.

The study has three research milestones:

- **Milestone 1**: background research on alternative fuels in Australia and a review of waste to energy technologies
- **Milestone 2**: pre-feasibility studies of five sites and selected opportunities
- **Milestone 3**: a feasibility analysis for selected opportunities

**Milestone 1 – Background research**

There are three major forms of waste that can be used to generate energy: biogas, biomass and municipal solid waste.

**Biogas**

The research confirms that anaerobic digestion of onsite waste is the most common approach used by abattoirs and animal farms. Covered Anaerobic Lagoons (CAL) are the most economic option for generating biogas from wastewater as opposed to digester reactor tanks which are usually more expensive. There are also opportunities for increasing biogas production through the optimisation of CAL operation and efficient CAL design.

**Biomass**

Combustion of biomass such as woodchips or agricultural waste is a well-known waste-to-energy solution, but it is not widely used in the Australian red meat industry. The barriers to implementation include the high capital cost of equipment, lack of consistency in volume and quality, price (agricultural waste can often be in demand for uses such as cattle feed) and the remote location of sources of supply (thus increasing transport costs).

**Municipal solid waste (MSW)**

The use of municipal solid waste (MSW) is less attractive for food processing plants due to hygiene and environmental risks. The use of processed engineered fuels (PEF) such as wood pellets or refused derived fuels (RDF) is very limited and only applies in a few specific cases where existing fuel costs such as LPG are very high (e.g. above $20/GJ) or the are other drivers in place (e.g. diverting waste from landfill).

**Where do the potential opportunities lie?**

Tables 1 and 2 indicate the potential for using these waste fuel materials and technologies in the red meat processing industry.

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Table 1 – Types of waste and applicability in the red meat processing industry

<table>
<thead>
<tr>
<th>Type of waste</th>
<th>Availability</th>
<th>Supply cost</th>
<th>Competing uses</th>
<th>Potential for the meat industry</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biogas</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Biomass</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Municipal solid waste (MSW)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Table 2 – Type of waste to energy technologies and applicability in the red meat processing industry

<table>
<thead>
<tr>
<th>Technology</th>
<th>Feedstock tolerance</th>
<th>Development status</th>
<th>Scalability</th>
<th>Costs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anaerobic digestion – covered lagoons</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Anaerobic digestion – tanks</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Biomass boiler</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gasification</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pyrolysis</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

: Good opportunities  : Limited opportunities  : Very limited opportunities

### Milestone 2 – Pre-feasibility study

An extensive research program, which included meeting with various waste fuel suppliers near the five sites, revealed two opportunities. The facilities in South Australia (SA) and in South East Queensland (SEQ) were identified as attractive, potential sites for biomass boilers.

See Table 3 below for the analysis.

### Table 3 – Milestone 2 outcomes

<table>
<thead>
<tr>
<th>Site</th>
<th>Fuel type</th>
<th>Payback (biogas from WW)</th>
<th>Payback (biomass boiler)</th>
<th>Payback (co-digestion of solid waste)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Site one</td>
<td>Coal</td>
<td>14.7</td>
<td>9.1</td>
<td>16.1</td>
</tr>
<tr>
<td>Site two</td>
<td>Natural gas</td>
<td>Installed</td>
<td>2.4 – 2.8</td>
<td>9.2</td>
</tr>
<tr>
<td>Site three</td>
<td>Natural gas</td>
<td>Installed</td>
<td>3.3 – 5.6</td>
<td>7.6</td>
</tr>
<tr>
<td>Site four</td>
<td>Natural gas</td>
<td>Installed</td>
<td>3.9 – 5.4</td>
<td>12.2</td>
</tr>
<tr>
<td>Site five</td>
<td>Natural gas</td>
<td>20.6</td>
<td>3.0 – 3.5</td>
<td>13.4</td>
</tr>
</tbody>
</table>

: Good payback (<3yrs)  : Medium payback (3 – 6yrs)  : Poor payback (>6yrs)

**Assumptions and comments:**
- Includes $20/tonne for carbon price – claim under the Emissions Reduction Fund program
- Natural gas price forecast: low increase (conservative estimate)
- Installed projects have all included government funding support and rely on carbon emissions credits for part of the savings.

---

3 Payback varies according to price of biomass fuel and heating value
Milestone 3 – Feasibility study

The two opportunities identified at site five in SA and site two in SEQ were subject to a detailed business case analysis, which showed that both were worth pursuing.

Site two delivers a faster return with a payback of about three years; while site five yields a payback of between four to five years.

Understanding the barriers to take up

The study also identified significant barriers. The Australian biomass market is small compared to Europe or US and very fragmented. In addition technologies are high cost, scalability is poor, and there is a need for better integration with existing infrastructure. The study revealed that there are difficulties accessing waste fuel materials which include:

- Competing uses: limitations in terms of availability and price
- Use of external waste fuel supplies involves:
  - High transport costs associated with long distances (>100km)
  - Problems with quality control of the materials: properties not consistent, un-screened mixed waste (hazardous materials)
  - Relatively low volumes available from some sources
- Weather conditions (e.g. drought, floods, fires) which affects the availability of agricultural waste.

Recommended next steps

To develop a better understanding on the best way to address the barriers, the study recommends the following:

- **Review government support for alternative fuels projects.** Many of the anaerobic digestion and biomass projects reviewed during this research study received government funding. This type of funding is very limited at the moment. A review of government support at state and commonwealth levels for alternative fuel supply and projects is needed to determine if and how these projects can obtain government support.

- **Review biomass supply chains to determine the areas in Australia where biomass can be made available.** Several studies indicate that there are vast amounts of wood waste and agricultural biomass available in Australia. The biomass supply chain is underdeveloped and therefore this material is generally not available at a reasonable price for industry. A study focused on identifying the major sources of biomass in Australia, the processing requirements and the transport necessary to get this material to the end-user would help to define the most viable areas for biomass supply in Australia.

- **Conduct further research to identify best technology options in anaerobic digestion of solid waste.** All red meat processing plants have a substantial amount of solid waste which is generally sent to landfill or requires disposal at a cost. A detailed analysis of this waste, disposal methods and costs is required to determine the optimal waste processing methods such as anaerobic digestion.
• **Conduct further research to identify best technology options for biomass based fuels and boilers.** Gasifiers used for the conversion of biomass into synthesis gas can process a wide range of materials and the gases can be used to fire boilers. During this research study it was found that this technology has been successfully implemented in South America for many years. A demonstration project using a small gasifier and boiler could help establish this technology in Australia.

• **Conduct further research into the options for better integration of alternative fuel solutions with existing facilities.** An example of a fuel integration project is the use of a gasifier to produce synthesis gas integrated with a biogas supply to be fired in a gas fired boiler. This could form part of the demonstration project mentioned in gasifier project above. Other forms of alternative fuel integration include the use of biomass with coal and the use of biogas in coal fired boilers.
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1 Background

1.1 Bioenergy

Overview of bioenergy use in Australia

In Australia, the bioenergy sector currently generates approximately 2,400 GWh per annum. This equates to approximately 1% of total electricity generation, and 7.5% of total clean energy generation\(^4\). This is very low compared to the share bioenergy occupies in the energy mix of other countries as seen in Fig. 1.

However, there is potential to expand Australia’s bioenergy sector with increased utilisation of wood residue from plantations and forests, waste streams and other biomass sources.

![Fig. 1 - Share of total electricity generation, 2010\(^5\)](image)

Common sources of bioenergy in Australia are:

- sugar cane residues (also known as bagasse)
- wood waste
- landfill gas (methane)
- liquid biofuels (biodiesel)
- agricultural crop and livestock waste
- household garbage
- sewage gas
- black liquor (a by-product of the paper-making process)

In 2011–12, wood and bagasse represented 42% and 44% of bioenergy use, respectively\(^6\). Bagasse-fuelled electricity generation facilities represent over 50% of total bioenergy capacity, at 475 MW. A breakdown of electricity generation from bioenergy is shown in Fig. 2 below.

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Overview of energy use in red meat industry

The red meat industry uses a large amount of fuel and electricity. Energy is one of the main inputs and energy rising costs will continue to influence the usage of energy throughout the industry. The average industry split of energy by source is shown in Fig. 3 below.

![Red meat industry split of energy by source](image)

Energy sources and use varies between processing sites. Usage is influenced by factors such as the type of species processed, the throughput, the extent of rendering activity, the amount of refrigeration used, and the level of further processing.

Refrigeration and the production of steam and hot water dominate energy demand. Lesser amounts of energy are used for lighting, ventilation, motors, pumps and other equipment. A typical energy breakdown is shown in Fig. 4 below.

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7 AMPC, 2013. “Review of energy efficiency utilisation benchmarks & technologies for Australian red meat processing”
The opportunity to use alternative fuels

The use of alternative fuels in the red meat industry is limited mostly to the production of biogas using anaerobic digestion of meat processing plant wastewater streams. There are only a few examples of biomass combustion (woodchip boilers).

Biogas from anaerobic digestion is a well-established process gaining wide acceptance as an alternative fuel source for meat processing plants. Biogas generation systems are in use or planned for several meat processing plants in Australia, mostly using covered anaerobic lagoons (CALs) or ponds. The current status of biogas plants in Australian meat processing sites is shown in Fig. 5.

<table>
<thead>
<tr>
<th>Site</th>
<th>Technology</th>
<th>Commissioned</th>
<th>Biogas use</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. AMH Aberdeen</td>
<td>2 x CAL</td>
<td>1994</td>
<td>Flared</td>
</tr>
<tr>
<td>2. Throsby Singleton</td>
<td>1 x CAL</td>
<td>Late 90s</td>
<td>Unknown</td>
</tr>
<tr>
<td>3. A I Bush, Beaudesert</td>
<td>1 x 2 ML CAL, 1 x 2.5 ML CAL</td>
<td>2002</td>
<td>Cogeneration</td>
</tr>
<tr>
<td>4. Wagstaff, Cranbourne</td>
<td>1 x 2 ML CAL</td>
<td>Late 90s</td>
<td>Treated by biotfiter</td>
</tr>
<tr>
<td>5. Talent, Perth</td>
<td>2 x 4 ML CAL, 1 x 5 ML CAL</td>
<td>Late 90s</td>
<td>Treated by biotfiter</td>
</tr>
<tr>
<td>6. Carnes, Windsor</td>
<td>2 x CAL</td>
<td>Early-mid 2000s</td>
<td>Boiler \x94</td>
</tr>
<tr>
<td>7. JBS Aust., Longford</td>
<td>1 x CAL</td>
<td>Late 90s</td>
<td>Flared</td>
</tr>
<tr>
<td>8. BMP, Young</td>
<td>1 x 12 ML CAL</td>
<td>2007</td>
<td>Cogeneration</td>
</tr>
<tr>
<td>9. JBS King Island</td>
<td>1 x 3 ML CAL</td>
<td>2010</td>
<td>Flared</td>
</tr>
<tr>
<td>10. Tres Aust., Wagga</td>
<td>2 x 2 ML CALs</td>
<td>2010</td>
<td>Boiler \x94</td>
</tr>
<tr>
<td>11. Tres Aust., Tamworth</td>
<td>1 x CAL</td>
<td>2010</td>
<td>Boiler \x94</td>
</tr>
<tr>
<td>12. T &amp; T, Murray Bridge</td>
<td>2 x 1 ML CAL</td>
<td>2012</td>
<td>Boiler \x94</td>
</tr>
<tr>
<td>13. ORC, Bentery</td>
<td>1 x 3 ML CAL</td>
<td>2000s</td>
<td>Unknown</td>
</tr>
<tr>
<td>14. JBS Aust., Dimore</td>
<td>1 x 20 ML CAL</td>
<td>2013</td>
<td>Boiler \x94</td>
</tr>
<tr>
<td>15. Nippon Meat Packers</td>
<td>1 x 15.7 ML, Covered High Rate Anaerobic Lagoon</td>
<td>2014/15</td>
<td>Boiler \x94</td>
</tr>
</tbody>
</table>

Fig. 5 – Current status of biogas plants in the Australian red meat industry

---

8 AMPC, 2013. “Energy consumption guide for small to medium red meat processing facilities”
1.2 Meat processing market conditions

Meat processing is one of the largest sectors in Australia’s food processing industry, and like other food manufacturing businesses, the industry faces many cost pressures.

Long term trends show that industry profitability has been decreasing over time (Fig. 6), putting more pressure on businesses to reduce their operating costs.

Exports account for a significant proportion of beef production, with 74% of Australian beef exported in 2014\textsuperscript{11}. Profits are therefore also affected by foreign exchange rates. Recently, the industry was both assisted and challenged by the lower Australian dollar, which improved Australia’s trade position but also lead to higher costs for imported goods such as process equipment.

Cattle production, which is mainly influenced by weather conditions (rainfall) and market demand, also affects the efficiency of the processing plants. The process needs to remain efficient when running at lower plant loads but there is wide variation in performance across the industry.

Because of these factors, one of the key drivers for meat processors is to identify and achieve cost efficiencies, including reducing utility costs.

The cost of utilities typically accounts for around 5% of production costs\textsuperscript{12}. Fuel use (natural gas, coal and LPG) generally accounts for nearly 70% of a site total energy usage and 30% of energy costs (for plants with rendering)\textsuperscript{13}. In recent years, many red meat processing plants have moved from coal fired to natural gas fired boilers, when boilers were due for replacement and when natural gas supply became available to the plant. Natural gas use

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{fig6.png}
\caption{Long term profitability of average and Top 25% Northern beef businesses (1980 – 2012)\textsuperscript{10}}
\end{figure}


\textsuperscript{12} MLA, 2002. Eco-Efficiency Manual for Meat Processing

\textsuperscript{13} AMPC, 2013. “Energy consumption guide for small to medium red meat processing facilities”
represents over 35% of energy use in the red meat industry (Fig. 3). Therefore increases in natural gas prices have a significant impact on the bottom line of the business.

### 1.3 Rising gas prices

Natural gas prices are forecast to nearly double over the next 2 - 3 years (Fig. 7). A typical meat processing site is likely to see gas prices move from $5-8/GJ to $9-12+/GJ by 2016/17\(^{14}\). Gas price escalation will have a significant impact on the profitability of at least one-third of all processing plants, where gas makes a significant contribution to the energy used\(^{15}\).

The expected price escalation is a result of the integration of the east coast network and the exposure of the east coast to international market gas prices due to the construction of at least three LNG plants in Gladstone. The formation of the LNG industry on the east coast is based on coal seam methane extracted largely from Queensland fields. The suppliers have secured forward LNG contracts at global prices well above current domestic gas prices, and this will drive the local market price in the future.

The prospect of rising gas prices will influence the Australian meat industry to consider increasing the use of solid fuels, including coal (about $6/GJ delivered), and fuels derived from waste products (as low as $2 or less per GJ delivered). While coal provides a lower cost fuel alternative, the associated carbon emissions could result in a significant future risk as Australia moves to a lower carbon economy. Fuels from waste include (but are not limited to) biogas, biomass (agricultural waste), wood chips, site processing wastes, and processed municipal waste.

The study explored the range of alternative fuels, technologies and financing options for steam generation across five red meat processing facilities.

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\(^{14}\) Energetics, 2014  
\(^{15}\) MLA, 2007. Environmental Best Practice Guidelines for the Red Meat Processing Industry  
\(^{16}\) Energetics, 2014
In last few years, several biogas and biomass projects have been implemented as a result of environmental concerns and the availability of government funding\(^\text{17}\) to improve the economic attractiveness.

However, there have been some changes recently in the way project financing is offered for energy efficiency and renewable energy projects. Alternative financing options include Energy Services Agreement (ESA) (e.g. Build-Own-Operate (BOO) contracts) or corporate and energy efficiency loans (e.g. through the Clean Energy Finance Corporation and private banks), which can provide attractive terms depending on the nature of the project.

There are also government programs available such as the Victorian Regional Infrastructure Development Fund (RIDF) or the NSW Energy Savings Scheme (ESS), which is also looking to expand the scheme to include gas. The recently introduced Emissions Reduction Fund (ERF) also provides new incentives for carbon abatement projects, such as the capture and combustion of biogas from wastewater or displacement of fossil fuels.

### 2 Project Objectives

The key objective of this study is to define the full range of fuel options and technologies to deliver steam for the selected sites. A staged approach was adopted:

1. **Background research:**
   - A review of all research already undertaken on alternative fuels was conducted to determine current status of waste-to-energy development in Australia and particularly in the red meat processing sector.
   - The research includes investigating potential sources of waste fuel and a review of waste-to-energy technology options.

2. **Pre-feasibility studies at each site**
   - The range of alternative fuels, availability and cost is defined for each processing facility.
   - The site energy baseline is defined and a review of site steam demand is conducted to evaluate potential steam savings.
   - The pre-feasibility of supplying these energy requirements with a waste-to-energy solution using alternative fuels using estimated capital and operating costs.
   - A first cut ranking of options is conducted using a financial model which has been prepared for the project. Only those options which appeared economically viable proceeded to stage 3 (feasibility).

3. **Feasibility analysis**
   - Conduct a detail review of two selected options from stage 2, including more accurate assessment of capital and operating costs (from vendor quotes). Define the

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\(^{17}\) The Clean Technology Food and Foundries Investment Program (CTFFIP) is now closed. It provided grants to food manufacturers to support investments in energy-efficient capital equipment and low-emissions technologies, processes and products (business.gov.au)
economic and technical feasibility of using the fuel and calculate the return on investment.

- Consider the full range of issues relating to the use of the fuel (e.g., transport and fuel storage), and conduct a risk analysis (covering issues like reliability of supply).
- Consider alternative financing options to assist in implementing projects which are economically viable but may not otherwise meet the payback criteria typically required by the industry.

3 Methodology

3.1 Background research

3.1.1 Alternative fuel options in Australia

- Review all the research already undertaken on alternative fuels to ensure no duplication of effort.
- Conduct an overview of key alternative fuel sources in Australia suitable for steam-generation in the meat industry with a focus on those available at the target sites. Fuel types that are considered: onsite wastes; and external biomass, processed municipal wastes, biogas, and if commercially proven also pyrolysis/gasification.
- Overview of risks and constraints using these fuels (to be made more comprehensive and detailed in stage 2 when specific fuel options are being considered for the specific site(s)): technical, EPA regulations, reliability, quality and cost, variability of fuel supply, financial, carbon emissions and footprint.

3.1.2 Technology review

- Assess the capital and operating costs and implementation issues for the various types of boilers and steam generation systems required for each type of alternative fuel including: coal-fired, gas-fired and dual fuel boilers; fluidised bed and other boilers with greater fuel flexibility; solar thermal systems; review of technologies for handling and utilising these fuels – transport, materials handling, onsite storage (including space requirements) and boiler plan; and review of capital requirements and plant options for slag/ash removal, handling and disposal.

3.1.3 Economic tool development

- Create a financial model to allow what-if analysis and define the parameters impacting economic returns.
- Include options in the steam generation model to allow each type of alternative fuel and steam generation system to be assessed. The steam generation model equipment options include costs for steam generator equipment and installation, maintenance, chemicals and water use.
- Review the economics of potential solutions.
- Define where it is economical to generate power from these facilities using high pressure boiler and back-pressure steam turbine systems. Generally this will only be
economical for particularly high capacity and high utilisation plants with very low fuel cost.

3.2 Site pre-feasibility studies

The key initial issue is to determine the range of available alternative fuels, availability and cost, including seasonal variability. This is done to ensure there are sustainable options and to define whether the boiler will need to handle multiple fuels. Fuel availability and type of fuel determines the boiler design choice for the site.

Long-term site steam demands are defined (including potential for steam savings). The economic feasibility of meeting these heating requirements with boiler plant using the alternative fuels is reviewed, based on estimated capital and operating costs from stage 1. A first cut ranking of options is conducted using the financial model prepared in stage 1. Only those options which are economically viable proceed to stage 3.

3.2.1 Review existing steam generation systems

This work includes:

- Collecting boiler fuel use data and steam generation equipment details
- Review existing boiler performance and availability
- Review existing fuel supply arrangements
- Review fuel supply security plus delivery and storage issues
- Review steam demand profiles, define major end-uses and estimate their consumption, identify broad scope of opportunities for steam demand reduction, and define any expected changes in plant throughput or operations likely to impact steam demand, for the purpose of defining the optimal rate capacity for replacement plant.

3.2.2 Alternative fuel options for each site

This is the most critical stage in the research project. The key focus of the alternative fuel research at this stage is to discover those alternative fuels available internally and in the local geographic region of the meat processing plant.

Determine the viability of using these combustible wastes and cost of supply. This includes an assessment of the amount of fuel available, logistics and costs for collecting, transport and seasonal/long term supply reliability issues.

A detailed review of risks and constraints using these fuels is conducted. This work builds on the stage 1 review of alternative fuels and involves:

- Technical viability: Assessment of steam generation, fuel handling and storage equipment required and may require specific chemical analysis of alternative fuels where emissions may be an issue.
- EPA regulations: Including review of regulations and discussions with government authorities.
• Reliability, quality and cost (and variability) of fuel supply: Involving discussions with alternative fuel suppliers and site visits to inspect the fuel source, assess the factors that may impact costs and to test logics of fuel supply transport systems.

• Financial risks: Once technical feasibility of the alternative fuel supply has been determined, the business case model built in stage 1 will be used/enhance to define financial viability and risks.

• Carbon emissions: The research will include a first pass calculation of the carbon impact of burning each viable fuel source. It may be important in some cases to understand the supply chain to define whether the fuel source is environmentally sustainable and renewable.

3.2.3 Evaluation and opportunity selection

This works includes:

• Identify the equipment suppliers and develop a preliminary list of key equipment and services available in Australia for steam generation systems using alternative fuels.

• Conduct financial analyses for the various fuel and steam generation combinations using desktop research and equipment supplier indicative pricing where available.

• Allow sensitivity analysis for key variables such as:
  - Energy costs (fuel and electrical energy costs)
  - Steam generation efficiency
  - Equipment and installation costs (overseas content and local content)
  - Escalation of fuel prices
  - Cost of financing

3.3 Feasibility study

In this stage the best option(s) from stage 2 are reviewed in detail including more accurate analysis of capital and operating costs, and risk analysis around key issues relating to the use of the fuel.

Alternative financing options are considered to assist in implementing projects which are economically viable but may not otherwise meet the payback criteria typically required by the industry.

3.3.1 Supply options

Expand the preliminary risk analysis conducted in stage 2 to test key issues, uncertainties/risks which may either reduce the cost effectiveness of the solution or require further development.

This work includes further discussions with EPA to ensure that the planned solutions will meet with regulation requirements.

3.3.2 Capital and operating cost analysis

Based on the most feasible alternative fuels found in the stage 2 of this research, develop requests for tender for the steam generation, materials handling and other equipment for
each of the selected alternative fuels. This RFQ defines the alternative fuels to be used, EPA regulations to be considered, on-site materials handling, and the site specific issues.

Request equipment suppliers (identified during the previous stages of this research project) to provide proposals for the equipment and services required. Turnkey solutions are requested.

Evaluate the operating costs for each solution including maintenance services and operator labour. The cost analysis includes an assessment of the site storage, materials handling and waste disposal operations.

3.3.3 Review project finance options

The project explores ways to overcome the rapid payback requirement of most facilities across the red meat industry (typically one to three years). The financial modelling includes the key project financing options such as:

- In-house finance. Note that this is not likely to be attractive given the meat industry typically requires a rapid payback requirement as these projects are not likely to return funds within two years\(^\text{18}\)
- Finance via financial institutions. Commonwealth Bank and other banks have energy efficient project funding schemes. This type of financing can be designed with a repayment scheme to provide a neutral or even positive cash flow
- Government funding available including regional development, Emissions Reduction Fund, Renewable Energy Certificates (RECs)
- State programs, e.g. Sustainability Victoria Wood Waste program
- Build Own Operate and Transfer (BOOT)
- Steam supply contracts with 3rd party BOOM agreements (with take or pay contracts) which somewhat de-risk the project and remove the requirement for capital investment.

\(^{18}\) Several bioenergy projects were implemented with the aid of government grants such as the Clean Technology Investment Program (CTIP)
4 Results

4.1 Background research

4.1.1 Research approach

A large number of studies have been conducted to research the use of alternative fuels and waste to energy technologies in different industries across Australia. This study builds upon existing documentation and provides an extensive review of existing literature.

To avoid replication, a practical approach has been chosen for this study, where the principal aim is provide guidance on how to develop business cases for waste to energy projects based on the type of alternative fuel/waste materials available.

Drawing on information already developed in factsheets

Factsheets have been created to provide a summary of the current application status of a particular type of alternative fuel, and to discuss the key factors that need to be considered when developing a business case.

The factsheets contain several references to existing documentation to support information on waste properties, energy yields, technology costs and other aspects.

The intent is that the factsheets can be used in conjunction with an economic model tool (also developed as part of this study) to help users assess the viability of a project.

Analysis using a newly developed economic modelling tool

The economic model tool has two objectives:

1. Allow users to quickly assess the economic feasibility of a project using a limited number of data entries
2. Determine the financial feasibility of projects.

The diagram in Fig. 8 shows how the tool uses the outcomes of the research and pre-feasibility stages to evaluate the opportunities identified for each site in the detailed feasibility stage.
4.1.2 Factsheets

Each factsheet covers a different type of waste and discusses the applicability of each material as alternative fuel in the red meat processing industry. The following factsheets were developed:

- Biogas from anaerobic digestion of wastewater and solid waste
- Agricultural waste
- Wood waste
- Onsite solid waste
- Municipal solid waste
- Processed biofuels

All factsheets have the same structure and cover the following key factors:

- What is the opportunity for the red meat processing industry?
- Waste characteristics
- Integration with existing infrastructure
- Technology options
- Cost analysis
- Savings analysis
- Final business case
- Risks and constraints
- References

The factsheets have been attached in Appendix A and will be also published on the MLA website.

4.1.3 Main outcomes

The main research outcomes, as reported in the factsheets, are summarised in Tables 5 and 6 below. A more detailed discussion is shown in the following sections.
Table 4 – Types of waste and applicability in the red meat processing industry

<table>
<thead>
<tr>
<th>Type of waste</th>
<th>Availability</th>
<th>Supply cost</th>
<th>Competing uses</th>
<th>Potential for use in the meat industry</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Onsite (abattoir) wastewater</strong></td>
<td>Generally large volumes 8 - 13 ML/HSCW</td>
<td>None (internal source) but need to factor in cost for biogas recovery if system is not in place</td>
<td>Some plants used treated water for irrigation</td>
<td>Good source of COD and good biogas yield. Anaerobic ponds generally in place as part of WW treatment requirements</td>
</tr>
<tr>
<td><strong>Onsite (abattoir) solid waste</strong></td>
<td>Moderate to large volumes depending on the scale of operation</td>
<td>None (internal source) but need to factor in cost for material handling</td>
<td>Manure and paunch typically used as compost / fertiliser. Collected at no cost</td>
<td>Complexities associated with high moisture content and low heating value (direct combustion) or low biogas yields and high capital costs (anaerobic digestion)</td>
</tr>
<tr>
<td><strong>Wood waste</strong></td>
<td>Price of woodchips can vary from $50 to $90 per ton</td>
<td>Forestry waste: lower quality of (higher moisture content, larger particles), but cheaper prices ($30 - $7 per ton)</td>
<td>Woodchips: pulp and paper manufacturing, export markets, landscaping</td>
<td>Woodchips are a good fuel source for direct combustion applications</td>
</tr>
<tr>
<td></td>
<td>Sawmill woodwaste: price can be subject to other competing markets, but varies typically from $30 - $90 per ton. Distance to sawmills is a key factor due to transport costs</td>
<td>Sawmill woodwaste: no major competing markets for woody debris, stumps or fire damaged wood</td>
<td>Sawmill woodwaste: wood pellets, poultry litter, landscaping</td>
<td>Biomass or woodchips boilers are a mature, well proven technology, available at a reasonable cost</td>
</tr>
<tr>
<td></td>
<td>Manure: 4 – 13 kg/HSCW Paunch: 25 – 70 kg/HSCQ</td>
<td>Disposal savings may also be available</td>
<td></td>
<td>Applicability depends mostly on biomass fuel cost and available volumes</td>
</tr>
<tr>
<td><strong>Agricultural waste</strong></td>
<td>Waste from food processing (e.g. nut shells, rice husks, bagasse) is usually used internally as biomass fuel</td>
<td>Price can be subject to other competing markets</td>
<td>Farmers and food processors can sell their agricultural waste as stockfeed (e.g. almond shells) or use it as compost / fertiliser in their own plantations</td>
<td>Use of agricultural waste is limited due to lack of availability, i.e. waste fuel is already used by food processors as fuel source (bagasse, nut shells, grape marc, rice husks)</td>
</tr>
<tr>
<td></td>
<td>Production and waste varies according to export demand. Availability also depends on crop seasons and weather events</td>
<td>Cereal straw: $50 - $140/ton. Transport cost can be significant too, mostly due to the low bulk density associated with these materials</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Municipal solid waste</strong></td>
<td>Generally low volumes available, particularly in regional areas with low population density</td>
<td>Generally no cost associated with materials but need to factor in transport and screening costs (if required)</td>
<td>Green waste used for mulching</td>
<td>Segregated waste streams can be attractive if available in large volumes and there is consistent supply. Mixed waste is less attractive due to hygiene and environmental risks</td>
</tr>
<tr>
<td></td>
<td>Only a few waste streams are segregated, e.g. green waste</td>
<td></td>
<td>No other major competing uses</td>
<td></td>
</tr>
<tr>
<td><strong>Waste for processed engineered fuel</strong></td>
<td>Generally low volumes available. Different types of materials depending on the process, e.g. poppy seed oil, pyrethrum raffinate</td>
<td>Price depends on the quality of fuel, i.e. calorific value, moisture content</td>
<td>Major uses of tallow include soap making and biodiesel production</td>
<td>There is little potential for using processed biofuels in the meat industry due to lack of availability</td>
</tr>
<tr>
<td></td>
<td>Tallow oil by-product of rendering process, typically sold to external buyers</td>
<td>Wood torrefied pellets: $10 - $15/GJ</td>
<td>RDF pellets used by waste processors</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Wood torrefied pellets can be available in large volumes but most of it is exported overseas</td>
<td>Biodiesel: &gt;$40/GJ</td>
<td>Wood pellets sold to export markets</td>
<td></td>
</tr>
<tr>
<td></td>
<td>RDF pellets (e.g. cardboard) also available in some locations but most of it used internally by waste management businesses</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 5 – Type of waste to energy technologies and applicability in the red meat processing industry

<table>
<thead>
<tr>
<th>Technology</th>
<th>Feedstock tolerance</th>
<th>Development status</th>
<th>Scalability</th>
<th>Costs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anaerobic digestion – covered lagoons</td>
<td>Requires FOG(^1) removal to avoid crust formation. Temperature and pH conditions also important. Adding manure and paunch to the wastewater stream can be problematic (high nitrogen levels affecting BNR and solid accumulation in ponds)</td>
<td>Mature, well developed Several projects implemented in Australia Preferred option for meat processors</td>
<td>Suitable for small and large-scale applications</td>
<td>High capital cost Cost reduced if lagoon already in place.</td>
</tr>
<tr>
<td>Anaerobic digestion – plug flow, stirred tanks</td>
<td>Requires dilution if feedstock high in solid % Maceration also required to reduce particle size MSW not recommended if unscreened due to presence of non-biodegradable and hazardous material</td>
<td>Mature, well developed Large number of projects implemented in Europe and US Not many projects implemented in the Australian meat processing sector</td>
<td>Suitable for small and large-scale applications, but not many small applications found in Australia</td>
<td>Very high capital cost</td>
</tr>
<tr>
<td>Biomass boiler</td>
<td>Moving grate boilers are very robust and can handle moisture up to 50% and larger particle size Fluidised boilers can handle higher moisture content but particle size need to be small (&lt;50mm)</td>
<td>Mature, well developed Several projects implemented in Australia but none in the meat processing industry</td>
<td>Suitable for small and large-scale applications Capabilities range from 100kWth to over 100MWth</td>
<td>High capital cost for small-scale applications</td>
</tr>
<tr>
<td>Gasification</td>
<td>Can handle a wide range of different materials Starting to see more commercial applications being implemented</td>
<td>Suitable for small and large-scale applications Capabilities range from 100kWth to over 100MWth Some gasification technologies are still in early commercial stages, and not fully suitable for small applications yet</td>
<td>High capital cost for small-scale applications</td>
<td></td>
</tr>
<tr>
<td>Pyrolysis</td>
<td>Can handle a wide range of different materials Some pilot plants implemented in Australia. Technology is still in its early stages of commercial development</td>
<td></td>
<td>Pyrolysis is still in early commercial stages, therefore not suitable for small applications yet</td>
<td>Very high capital cost</td>
</tr>
</tbody>
</table>

4.1.3.1 Biogas

Biogas production from covered anaerobic lagoons (CALs) is the most common approach used in the Australian red meat industry, as well as other agricultural sectors (e.g. piggeries). Anaerobic lagoons are generally in place for wastewater treatment purposes and comply with EPA discharge regulations. In some cases, covers and flares also provide a solution to odour problems and fugitive methane emissions.

The use of covered anaerobic lagoons is the preferred technology option also because of lower capital costs compared to anaerobic digester tanks. However, they can be very

---

\(^1\) FOG: Fats, oils and grease
expensive where it is necessary build new lagoons (without government funding, CAL projects can have paybacks exceeding 6 years).

Anaerobic digestion in covered lagoons is a complex biochemical process, as there are several factors affecting the biogas yield (e.g. temperature, residence time or presence of inhibiting substances). Inefficiencies have been found in the process and the design of these systems, particularly around temperature management and low residence times. Therefore, opportunities exist for increasing biogas production through the optimisation of biogas yield. A number of studies have been conducted in this area and several case studies are available for biogas projects implemented in Australia (see biogas fact sheet in Appendix A).

Biodigester tanks (mixed tanks or plug flow reactors) are very expensive and there is only one example found in Australian beef abattoirs\(^20\). This technology works best when large amounts of waste are available, allowing economies of scale to apply. Depending on the mix of feedstocks, biogas yields are generally higher compared to CALs as there is a much better controlled environment (temperature, mixing). Biogas yields for waste such as manure are not very high, so co-digesting with other feedstocks such as food waste, fats, or red waste stream from the abattoir can increase biogas production. The solid content of feedstock is an important factor, as materials high in solid content require dilution to ensure adequate mixing and handling. These pre-treatment costs need to be factored in the evaluation.

Co-digestion of paunch and manure to produce biogas also reduces waste management costs. It is not recommended to add this waste into the wastewater treatment plant, as the high nitrogen content will affect the Biological Nutrient Removal (BNR) process that normally follows the anaerobic digestion ponds. The combined biogas yield resulting from the use of different substrates (co-digestion) can be difficult to estimate depending on feedstock properties. A number of studies have been conducted in this area to look at ways to increase biogas yields using different types of waste at different ratios. Anaerobic digestion models and calculators are also available and can be used to estimate biogas yields; some are quite

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\(^{20}\) Bindaree Beef in NSW will install a biodigester to produce biogas, an electricity generation facility using biogas as fuel, and a new more energy efficient rendering plant to replace the existing coal-fired plant and eliminate the use of coal. The project will cost $43m and will receive $17m in federal funding. ([http://www.cleanenergyfinancecorp.com.au/media/76497/cefc-pdf-factsheet-bindaree_lr.pdf](http://www.cleanenergyfinancecorp.com.au/media/76497/cefc-pdf-factsheet-bindaree_lr.pdf))

complex and are often used for academic purposes. Conducting a Bio-Methane Potential test (BMP) is an easier way to determine biogas potential and is relatively inexpensive. Using certain types of external waste, such as biosludge from sewage treatment plants, to increase feedstock volume and/or biogas yields (and therefore biogas production) can represent a risk in terms of hygiene and other environmental issues.

Funding is an important factor in the implementation of these projects due to the large capital expenditure required. Many anaerobic digestion projects developed for the red meat processing industry were implemented when the Clean Technology Investment Program (CTIP) offered grants that in some cases covered up to 50% of the total project cost. Other funding options such as the Victorian Regional Infrastructure Development Fund (RIDF), the NSW Energy Savings Scheme (ESS) or the recently introduced Emissions Reduction Fund (ERF) provide incentives for the development of bioenergy projects. Significant carbon credits can be achieved through the ERF due to avoided fugitive methane emissions from uncovered lagoons (apart from carbon savings available from displacement of natural gas). Other financing options include special loans for energy efficiency projects, Build-Own-Operate (BOO) contracts or Energy Performance Contracts (EPC), which are available through financing corporations such as Clean Energy Financing Corporation (CEFC). A good example of a government funded anaerobic digestion project is the waste to energy project implemented at site two (below Error! Reference source not found., in Table 6) which utilised the CTIP program funding.

**Table 6 – Site two CAL Project**

<table>
<thead>
<tr>
<th>Applicant</th>
<th>CTIP Grant Amount</th>
<th>Total Project Cost</th>
<th>Project Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Site two</td>
<td>$2,825,000</td>
<td>$6,061,750</td>
<td>Site two will install a 34 ML Covered Anaerobic Lagoon and receival basin to enable the capture of biogas for combustion on-site to offset natural gas consumption. The project is expected to reduce process-wide carbon emissions intensity at site two by 85% and will result in savings of $1.3 million in energy costs per year and savings of $380,000 in reduced carbon price liability per year.</td>
</tr>
</tbody>
</table>

The most common application of biogas in the red meat processing plants is co-firing in existing natural gas-fired boilers. Retrofitting a dual-gas burner is relatively low cost compared with a new boiler, and the business case is very favourable for sites that already have gas-fired boilers. Co-firing biogas in gas engines is also feasible but biogas cleaning is important due to risk of corrosion, as the engine internals can be more sensitive to the presence of moisture and hydrogen sulphide (H₂S). With boilers, H₂S concentration can be managed through the adjustment of co-firing ratios during the start-up or shut-down of boiler, in order to dilute biogas with natural gas when temperature in the stack gets closer to the acid dew point.

The price of natural gas is a key factor in the viability of biogas projects. Depending on the scope, biogas projects at sites with natural gas prices >$10/GJ are usually attractive. Forecasts show natural gas prices will increase in the next 2-4 years and prices have already gone up significantly in certain regions of NSW and Queensland. Prices in Victoria remain relatively low, thus opportunities for biogas projects are less attractive here. See detailed feasibility analysis.

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4.1.3.2 Wood waste

Sources of wood waste are difficult to locate. Most woodchips produced by wood processors are already used by the site (as fuel) or supplied to the pulp and paper industry. Little surplus is therefore available, and the price of woodchip is not always very attractive due to market demand for alternative uses. Forestry waste is more abundant in Victoria, south-east of SA and south of NSW. The quality of forestry waste fuel is lower than woodchips in terms of its heating value, as it generally contains higher moisture and larger particles (e.g. stumps), and is therefore available at cheaper prices. Availability of sawdust and other sawmill wood waste (e.g. shavings) can vary as some mills sell their waste to other customers (landscaping, chicken litter, wood pelletisers, or sold as biomass fuel). Small sawmills don’t generate large enough volumes to supply large woodchip boilers (e.g. >2MW) and the distance to mills is a key factor due to transport costs. Sites nominally located at distances greater than 100km are not a very attractive source.

Moisture content is important as it affects the calorific value of the fuel. Biomass boilers can handle wood waste with moisture content typically up to 50%. Determining the ash content and the ash melting point is an important aspect in the boiler design, particularly to avoid formation of slag ash. Boiler suppliers typically request proximate and ultimate fuel tests, as well as ash analysis (including fusion temperature) in order to start the design process.

In terms of environmental regulations, the Environmental Protection Agency (EPA) establishes emission limits for particulate matter (PM50), NOx, SOx, CO and other air pollutants in their Environment Protection Policies. These requirements need to be met in order for a site to obtain an EPA licence to run a biomass boiler and this is particularly important if the site is located near a residential area where stringent limits apply. Emissions control is therefore a key aspect in boiler design. For example, baghouses or electrostatic precipitators may be required to control particulate emissions.

Woodchip boilers are a mature and well-known technology but still relatively expensive and they are more labour-intensive than gas boilers (most modern gas fired units can be run unattended whereas a biomass boiler requires at least limited attendance). Biomass boilers also require more material handling equipment, fuel storage, and emissions control devices. Fig. 10 shows a diagram of a typical biomass boiler system. Several case studies of successful biomass boiler projects can be found in the wood processing industry and other agricultural sectors, but only a couple of biomass boiler examples have been found in the Australian red meat processing industry, a 6MW sawdust-fired boiler at the Nippon Meat Packers abattoir at Wingham (NSW) and a woodwaste boiler at the JBS Australia abattoir at Longford (Tasmania).
The business case for a biomass boiler can become more attractive when coal-fired boilers are already in place, as it can be possible to integrate biomass and coal firing with little change to the existing equipment (e.g. there will be some additional material handling equipment and environmental control).

Co-firing of wood waste with coal is also feasible but, according to some studies developed for the power generation sector, co-firing ratios need to remain low (up to 30%, using good quality wood). Co-firing with coal works best with biomass of certain characteristics i.e. low moisture content and small particle size.

Some combustion technologies are more robust than others and can handle variations in the quality of biomass. For example, fluidised bed boilers are able to burn materials with higher moisture content (e.g. up to 60%). This increased flexibility comes at premium cost.

4.1.3.3 Agricultural waste

Agricultural waste can have many different uses, which means prices (or cost) can vary significantly depending on the competing markets. For example, straw can be used as biomass fuel but can be also used for animal fodder. Also, for large producers of export products such as wheat, the quantities/mix of agricultural products and consequently waste available in the local market can be influenced by the demand in export markets. The use of agricultural waste for composting and reuse as fertiliser is another common practice which can reduce the availability for biomass fuels.

Supply of agricultural waste is affected by seasonality factors. For example, some crops are only available during a few months per year (e.g. harvest of almonds occurs between February and April) and this represents a challenge for a biomass buyer who is looking for a consistent supply throughout the year. Other factors that affect supply are extreme climate events such as floods, drought or fire.

Depending on their characteristics, some waste materials are more suitable for anaerobic digestion than other waste to energy technologies. For example, fruit and vegetable waste have a much higher biogas yield than straw, and are a good feedstock for an anaerobic

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digester. On the other hand, wastes with high calorific value and low moisture content such as nut shells or bagasse are more suitable for burning in biomass boilers.

As with wood waste, sources of supply are difficult to locate. A number of food processors use their agricultural waste as fuel in biomass boilers to supply their own energy needs. Major examples in Australia include bagasse (sugar mills), nut shells (macadamia nuts), grain husks (rice, oat) and grape marc.

Biomass boilers using agricultural waste may have better integration opportunities for meat processing plants with feedlots, as they already have facilities for handling cattle food (e.g. grains, straw, nut shells)

Depending on the type of waste, ash content and ash properties may result in higher handling and disposal costs than wood fired boilers. For example, ash from straw can cause agglomeration of fluidised material, affecting the efficiency of the combustion system or causing damage to equipment.

Pre-treatment is generally required to ensure the feedstock has the right characteristics according to the application. For anaerobic digestion for example, maceration and dilution is needed to ensure good mixing and reduce the risk of blockage or damage to digester equipment. For combustion, shredding and/or cutting may be required if the particle size is too large (Fig. 11). A pre-drying step may be also necessary if the moisture content is too high.

![Fig. 11 - Round bales fed into shredder on automatic conveyor to feed straw burner](image)

### 4.1.3.4 Municipal solid waste

There are currently no known examples of meat processing sites in Australia using municipal solid waste (MSW) to either supplement biological generation or standalone energy generation. Most applications are in the waste management industry where large mass combustors are used to incinerate or gasify waste to produce energy.

The major risks with using unscreened MSW in the red meat processing industry are associated with hygiene and other environmental aspects. In the case of anaerobic digestion from example, toxic substances such as heavy metals and other hazardous substances may end up in the digestate, which then can’t be used as a fertiliser. Combustion of timber from construction or demolition waste can be risky due to the presence of treated timber which may contain arsenic.

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Local councils segregate some waste streams such as green waste which reduces the risk of contamination, but volumes are generally low, particularly in regional areas with low population density. The quality of waste is often not consistent, therefore a robust technology such as gasification is recommended to process MSW.

Anaerobic digestion works well with food waste, but inorganics and other non-biodegradable material need to be screened out, which can be a costly pre-treatment process.

Gasification is a more robust technology as it is able to handle a wide range of waste materials, including inorganics. Syngas has a lower calorific value compared to biogas but can be supplied to gas-fired boiler and/or engines. The implementation cost is relatively high for small- to medium-size applications, as the technology is still in its early commercial deployment phase. At the moment, gasification has been successfully implemented for large-scale projects such as power generation in waste management facilities.

4.1.3.5 Onsite solid waste

Depending on the scale of operation, abattoirs can produce large amounts of solid waste such as paunch and manure; plus other waste such as biosolids from wastewater treatment lagoons, Dissolved Air Flotation (DAF) sludge, or waste carcases.

The common waste management practice used for paunch and manure is composting and disposal. Some farmers collect compost and use it as a fertiliser, but this is not a consistent practice and generally no revenue is generated from this activity (i.e. cost neutral activity)

Apart from energy offsets, the use of onsite solid waste to produce energy can bring extra benefits from a waste management point of view, particularly in the reduction of disposal costs as landfill levies continue to increase in many regions.

Paunch is normally dewatered and dried before disposal to reduce collection and disposal costs. The green liquid coming out of the dewatering process is rich in Chemical Oxygen Demand (COD) and is normally added to the wastewater stream to increase biogas production in the covered anaerobic lagoons. Some studies have looked at the use of paunch as alternative fuel for boilers, but preliminary results indicate only low co-firing ratios are feasible (<10%).

Paunch is a good feedstock for anaerobic digestion due to its high volatile solids (VS) content but it is normally not added into the wastewater treatment system due to its high nitrogen content which can affect the Biological Nutrient Removal (BNR) stage. The digestion of paunch in a separate biodigester system (e.g. mixed tank) may be a better option, provided there are large volumes of feedstock available to justify the high capital cost associated with digesters. Dewatered paunch has a solid content of about 30% and may require dilution prior to feeding it into a digester tank.

The anaerobic digestion of manure has similar issues as with paunch, i.e. it is not suitable for mixed digester tanks if not properly diluted, and the high nitrogen content can create problems in the BNR process if added directly to the wastewater stream. A more suitable digester option is a plug flow digester.
4.1.3.6 Processed biofuels

The use of processed biofuels or processed engineered fuels (PEF) is not very common and only a few large-scale applications are found in Australia. These include use of tallow and other oils to produce biodiesel, cardboard and paper from Municipal Solid Waste (MSW) or Commercial and Industrial (C&I) waste to produce MSW pellets, or wood waste (e.g. sawdust) to produce torrefied pellets.

There are very few examples of PEF being used in the meat processing sector in Australia. However, the Greenham meat processing plant in Smithton Tasmania is testing the use of processed pyrethrum raffinate\(^{25}\) supplied by Botanical Resources Australia (see Table 7).

Table 7 - Processed biofuel example (Pyrethrum Raffinate)\(^{26}\)

<table>
<thead>
<tr>
<th>Applicant</th>
<th>Total Project Cost</th>
<th>Project Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Greenham Tasmania Pty Ltd</td>
<td>$1,194,048</td>
<td>Greenham Tasmania modified their current boiler to enhance its efficiency and enable the co-combustion of a combination of pyrethrum briquettes and paunch waste biomass at its Smithton facility in Tasmania. The project is expected to reduce the site’s carbon emissions intensity by 62% and will result in energy cost savings of $243,000 p.a.</td>
</tr>
</tbody>
</table>

Densified waste fuels such as Refuse Derived Fuel (RDF) pellets, MSW pellets or woodwaste pellets have great fuel properties, particularly high calorific values (HHV>14MJ/kg) and low bulk density which makes it great for transport and handling. Because of these characteristics, these materials are typically sold at a premium price, particularly in export markets. For example, the spot price for wood pellets in Europe can range between $10 and $15/GJ. Therefore, availability and price are the two major limitations for using this type of PEF in the red meat industry.

Tallow oil, a by-product from the rendering process, also has a high energy value and has been used for some time by meat processors in remote locations to fire boilers in place of fuel oil. However, the use of tallow for the manufacturing of other goods, such as the production of biodiesel or more commonly for soap and pharmaceutical products, provides an opportunity for meat processors to sell tallow in domestic and international markets at a good price.

Biodiesel is not a financially feasible source of fuel for meat processing plants. The price for biodiesel is at least the same as conventional diesel at about $1.50/litre, or greater than $40/GJ, which is far higher than coal, natural gas and LPG.

\(^{25}\) Pyrethrum raffinate is a by-product from the pyrethrin extraction process. Pyrethrin is used in the production of natural pyrethrum insecticide and pyrethrum crops are grown mainly in north-west Tasmania. The raffinate is a viscous mixture of plant oils and waxes with high calorific value which can be used as fuel.

Plans for building new PEF plants have been reviewed in recent years and this could increase the availability of fuels in certain areas. For example, Global Renewables has received a $5m grant to build a new refuse-derived fuel facility in western Sydney²⁷.

### 4.2 Pre-feasibility studies

#### 4.2.1 Sources of supply

A draft inventory of alternative fuels potentially available in each region around the five plants has been developed. This includes volume and price information for different materials (where available), which were obtained by contacting local suppliers, councils and industry / government bodies. The outcomes of this research are summarised in Table 8 below.

Overall, the research shows that there is limited availability of externally sourced waste fuels due to five main factors:

1. Generated waste is used internally (e.g. bagasse in sugar mills, macadamia shells in nut processing plant)
2. Generated waste is sold to other businesses as biomass fuel (e.g. wood waste)
3. Generated waste is sold to other businesses for other purposes (e.g. agricultural waste used as feedstock for cattle; sawdust sold for chicken litter or for landscaping purposes)
4. Waste volumes are too low or supply is not consistent (e.g. green waste collected by councils)
5. Source of waste is located at a long distance (e.g. sawmills located >100km from site) and transport costs accounts for a significant proportion of the biomass cost.

#### Table 8 – Sources of waste fuel supply for the five sites

<table>
<thead>
<tr>
<th>Site</th>
<th>Site one</th>
<th>Site two</th>
<th>Site three</th>
<th>Site four</th>
<th>Site five</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biogas from wastewater</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Anaerobic lagoon not covered. Opportunity to cover existing anaerobic pond to generate biogas but volumes are too low to generate enough savings to recover investment.</td>
<td>Biogas captured from CAL and flared.</td>
<td>Biogas captured from CAL and co-fired in 6MW boiler. Opportunity to increase the biogas co-firing ratio by replacing the existing biogas blower with a larger unit.</td>
<td>Biogas captured from CALs and flared. Co-firing in new 15MW boiler planned for mid-2015</td>
<td>Anaerobic lagoon not covered. Opportunity to cover existing anaerobic pond to generate biogas but volumes will need to be assessed.</td>
<td></td>
</tr>
<tr>
<td>Wood waste</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sawdust and woodchips available from several local sawmills at significant volumes but all wood waste sold to a company in QLD and others. Other sawmills also available but located &gt;100km from site.</td>
<td>Approximately 2,500 tonnes p.a. of fibrous wood and wood briquettes available a manufacturing plant in South East Queensland ($15/ton, pick up price) Used to supply woodwaste to another customer but contract no</td>
<td>Some sawdust and woodwaste available from sawmills but already sold to chicken farmers and other customers. Price is too high ($35/ton or $12/GJ) for a biomass boiler project to be economically viable.</td>
<td>Sawdust and woodwaste available from sawmills but most of it sold to local customers. Other sawmills but located &gt;100km from site. For example, woodwaste available from NSW sawmills (290km away from site).</td>
<td>40,000 - 50,000 tonnes of pulp log and woodchips available from a producer located in SA ($70/ton delivered) Good opportunity</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Site</th>
<th>Site one</th>
<th>Site two</th>
<th>Site three</th>
<th>Site four</th>
<th>Site five</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>site.</td>
<td></td>
<td></td>
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</tr>
<tr>
<td></td>
<td>Can co-fire in new coal boiler if source becomes available in the future. Limited opportunities</td>
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</tr>
<tr>
<td></td>
<td>Volumes up to 5,000 tonnes p.a. ($6/m3 ($2/GJ) (pick up price)) Limited opportunities</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>Limited opportunities</td>
<td></td>
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<td></td>
</tr>
<tr>
<td></td>
<td>Limited opportunities</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Agricultural waste</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>Can co-fire in new coal boiler if source becomes available in the future. Limited opportunities</td>
<td></td>
<td></td>
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</tr>
<tr>
<td></td>
<td>Limited opportunities</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td></td>
<td>Limited opportunities</td>
<td></td>
<td></td>
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</tr>
<tr>
<td></td>
<td>Cotton gin waste: sold to local farmers (for farming mulch)</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>Macadamia shells: sources located &gt;100km from site. All large processors already make use of shell waste on-site.</td>
<td></td>
<td></td>
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</tr>
<tr>
<td></td>
<td>Large volumes but used internally by sugar mills and others.</td>
<td></td>
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<td></td>
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</tr>
<tr>
<td></td>
<td>Can co-fire in new coal boiler if source becomes available in the future. Limited opportunities</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Limited opportunities</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>Large amounts of poultry waste available from several chicken farms. Spent litter is used as fertiliser on farms.</td>
<td></td>
<td></td>
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</tr>
<tr>
<td></td>
<td>Can be used as fuel in a biomass boiler if pelleted</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>There may be future opportunities to use spent litter as a result of expansion plans in the poultry industry</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Some opportunities</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Large rice producer, currently selling rice husks as animal bedding and also producing pelletized animal feed products.</td>
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<td></td>
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<tr>
<td></td>
<td>Other sources of agricultural waste may be available which could be co-fired in a biomass boiler using wood waste (if economically feasible)</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td></td>
<td>Limited opportunities</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>Large almond producer, 60,000 to 70,000 tonnes of hull/shell per annum. Currently selling to a number of business but mainly for stock feed.</td>
<td></td>
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<td></td>
</tr>
<tr>
<td></td>
<td>Limited opportunities</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Onsite solid waste</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td></td>
<td>Pauch: 4,000 tonnes p.a. Currently composted and on-sold. Opportunity to co-fire with coal in new coal boiler if low moisture % and co-fired at low ratios.</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td></td>
<td>Manure: stock yard manure is cleared quarterly and used for composting; volumes are unknown at this point.</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td></td>
<td>Pauch: 4,000 to 5,000 tonnes p.a. (dewatered + disposed) Opportunity to co-fire with wood waste in a new biomass boiler or gasifier if low moisture % and co-fired at low ratios.</td>
<td></td>
<td></td>
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</tr>
<tr>
<td></td>
<td>Manure: volumes are unknown at this point</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Pauch: 2,500 tonnes p.a. (dewatered + disposed) Manure: composted + disposed; volumes are unknown at this point</td>
<td></td>
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<tr>
<td></td>
<td>Opportunity to digest in anaerobic plug flow digester but cost is too high.</td>
<td></td>
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</tr>
<tr>
<td></td>
<td>Pauch: 4,000 to 5,000 tonnes p.a. (dewatered + disposed) Manure: 1,000 tonnes p.a. ( composted + disposed)</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td></td>
<td>Opportunity to digest in anaerobic plug flow digester but cost is too high.</td>
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<tr>
<td></td>
<td>Pauch: 5,000 to 6,000 tonnes p.a. (current disposed by third party contractor) Opportunity to co-fire with wood waste in a new biomass boiler if low moisture % and co-fired at low ratios. Manure: volumes are unknown at this point</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Municipal Solid Waste</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>10,000m3 of green waste collected annually but 80% re-used by council and remainder given away to general public. No opportunities</td>
<td></td>
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<tr>
<td></td>
<td>30MW biomass generator near site takes all of the local councils green waste, bagasse waste from sugar production and a variety of other sources Limited opportunities</td>
<td></td>
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</tr>
<tr>
<td></td>
<td>Domestic and commercial green waste collections (approx. 14,000 tonnes p.a.) Waste Timber (pallets / crates / fabrication effluents) approx. 800 tonnes p.a. MSW approx. 45,000 tonnes p.a. (includes putrescibles) Could use green waste and some waste timber in a biomass boiler Some opportunities</td>
<td></td>
<td></td>
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</tr>
<tr>
<td></td>
<td>All green waste is chipped and either used as daily cover or for parks and gardens. No opportunities</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td></td>
<td>Local council: limited volumes of municipal waste due to low population density. Unlikely to provide a viable fuel source No opportunities</td>
<td></td>
<td></td>
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<tr>
<td>Processed Engineered Fuels</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>Altus renewables producing pelletized wood fuel in QLD at a processing plant (&gt;300km from site). Pellets sold to domestic and export markets. Price is too expensive ($160 - $200/ton) Limited opportunities</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Altus renewables pellets. Limited opportunities</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>No major sources available. No opportunities</td>
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<tr>
<td></td>
<td>No major sources available. No opportunities</td>
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<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>No major sources available. No opportunities</td>
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</tr>
</tbody>
</table>
4.2.2 Site visits

Site visits were conducted to collect information on existing equipment, as well as energy and process data to develop the energy baseline. Activities included:

- Collection of site energy use and cost data
- Collection of wastewater data
- Collection of site solid waste volumes (mainly paunch and manure) and disposal costs
- Collection of boiler fuel use data and steam generation equipment details
- Review of existing boiler performance and availability
- Review of existing wastewater treatment facilities and biogas recovery systems (where available)
- Review of existing fuel supply arrangements, including energy price forecasts
- Review of fuel supply security plus delivery and storage issues
- Review of steam demand profiles, define major end-uses and estimate their consumption
- Identification of the broad scope of opportunities for steam demand reduction
- Definition of any expected changes in plant throughput or operations likely to impact steam demand, for the purpose of defining the optimal rate capacity for replacement plant.

A summary of plant and fuel type for each site are provided in Table 9 below.

Table 9 – Summary of plant and fuel type

<table>
<thead>
<tr>
<th>Site</th>
<th>Site one</th>
<th>Site two</th>
<th>Site three</th>
<th>Site four</th>
<th>Site five</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boilers</td>
<td>10MW (coal)</td>
<td>2 x 10MW</td>
<td>10MW (nat gas)</td>
<td>10MW (nat gas)</td>
<td>2 x 3MW</td>
</tr>
<tr>
<td></td>
<td>2 x 3MW (LPG)</td>
<td>2 x 4MW</td>
<td>6MW (nat gas+biogas)</td>
<td>New 15MW (nat gas+biogas)</td>
<td>1 x 2MW</td>
</tr>
<tr>
<td></td>
<td>1 x 5MW (LPG)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Type</td>
<td>Coal, LPG</td>
<td>Natural gas</td>
<td>Natural gas, Biogas</td>
<td>Natural gas, Biogas (mid 2015)</td>
<td>Natural gas</td>
</tr>
<tr>
<td>fuels</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

4.2.3 Economic model tool

The energy baseline information for each site was used to complete the economic modelling tool, which also includes cost information and energy yields for different technologies.

There are three different tools/calculators for the following applications:

- Covered anaerobic lagoons
- Biomass boilers
- Co-digestion of paunch and manure in biodigester tanks

The tools assess the cost-effectiveness of implementing each solution by analysing:

- **Energy yields**: includes a biogas generation model and calorific values for different biomass fuels
• **Capital and operating costs**: selection of equipment according to existing infrastructure (e.g. burner retrofit for co-firing in existing boiler), cost multipliers used to allow cost calculation for small to large systems

• **Savings**: fuel offsets depending on site energy demand and availability of bioenergy; reduction of waste disposal costs; carbon emissions reduction.

The main inputs required for each calculator are:

• **Production data**: e.g. annual tonnes of Hot Standard Carcass Weight (HSCW), production days

• **Existing infrastructure**: e.g. number of boilers, wastewater treatment plant characteristics

• **Wastewater data** (for covered anaerobic lagoon tool): e.g. flow, COD

• **Onsite waste and external biomass** (for biomass boiler and co-digestion tool): volumes, cost of feedstock, disposal cost

• **Existing source of fuel**: e.g. type of fuel, consumption and energy prices

• **Funding**: amount of funding available

• **Carbon credits**: carbon price

The main outputs are:

• **Biogas produced** (covered anaerobic lagoon and co-digestion)

• **Carbon emissions reduction**

• **Total capital costs**

• **Total savings**: energy savings, carbon savings and other savings (e.g. waste disposal savings)

• **Discounted payback**

• **Net present value** (15yrs)

• **Internal rate of return**

• **Savings per head**

Each tool also has a sensitivity analysis section to look at the impact of key factors (energy price, biomass price, carbon price and funding) on project payback. Fig. 12 shows a snapshot of the tool.

The factsheets are to be used in conjunction with the tools, all of which will be available on the MLA website.
4.2.4 Economic analysis

The outcomes of the pre-feasibility stage are shown in Table 10 below. The opportunities to implement a biogas recovery system from CALs, biomass boilers, and a biodigester using onsite solid waste were assessed for each site using the economic model tool.

### Table 10 – Outcomes of pre-feasibility study

<table>
<thead>
<tr>
<th>Site</th>
<th>Fuel type</th>
<th>Payback (biogas from WW)</th>
<th>Payback (biomass boiler)</th>
<th>Payback (co-digestion of solid waste)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Site one</td>
<td>Coal</td>
<td>14.7</td>
<td>9.1</td>
<td>16.1</td>
</tr>
<tr>
<td>Site two</td>
<td>Natural gas</td>
<td>Installed</td>
<td>2.4 – 2.8</td>
<td>9.2</td>
</tr>
<tr>
<td>Site three</td>
<td>Natural gas</td>
<td>Installed</td>
<td>3.3 – 5.6</td>
<td>7.6</td>
</tr>
<tr>
<td>Site four</td>
<td>Natural gas</td>
<td>Installed</td>
<td>3.9 – 5.4</td>
<td>12.2</td>
</tr>
<tr>
<td>Site five</td>
<td>Natural gas</td>
<td>20.6</td>
<td>3.0 – 3.5</td>
<td>13.4</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Assumptions:</td>
<td>Includes $20/tonne for carbon price – claim under the Emissions Reduction Fund program</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Fig. 12 – Economic model tool (covered anaerobic lagoons)
The following assumptions were made for the evaluation:

- Low price increase scenario for natural gas price forecasts
- Escalation rate of 3% applied to other fuels
- No project funding, except for carbon credits created under the Emissions Reduction Fund
- Carbon price: $20 per carbon credit (tonne of CO$_2$e)
- Emissions reduction crediting period: seven years
- Project horizon: 15 years
- Project discount rate: 7%
- Cost estimates for CALs, biomass boilers and biodigesters were obtained from a range of different sources including bioenergy studies (e.g. MLA, AMPC, UK Carbon Trust), case studies and previous quotes from suppliers.

Biogas recovery at site one and site five is not cost-effective as both facilities currently operate at low fuel costs and relatively low biogas generation potential.

There were no major opportunities for implementing a biomass boiler at site one due to lack of biomass sources in the area. Co-firing of paunch waste and coal in the existing coal boiler is assumed to be limited to a maximum co-firing ratio of 10%, which does not provide enough savings to recover retrofit costs (boiler retrofits, paunch dewatering and handling equipment).

Sources of biomass at site four and site three, both located in NSW, haven’t been confirmed in terms of volume and cost. In order to create a reasonable scenario, an assumed sawdust price range of $6 - $9/GJ has been applied at site three, and woodchips at about $4 - $6/GJ at site four. The resulting paybacks indicate there may be good opportunities for biomass boilers if wood waste were available at lower prices. More research is required in these areas to confirm sources of supply, cost, volumes available, calorific value and transport cost.

Opportunities for co-digestion of paunch and manure in biodigester tanks are very limited due to the high capital cost of the system, low feedstock volumes and relatively low biogas yields associated with this type of waste.

The pre-feasibility analysis shows that the implementation of biomass boilers could be cost-effective at site two and site five. The business case at site two is benefited by high natural gas prices and very low biomass price (approx. $2/GJ). In the case of site five it is also favoured by the low cost estimated for woodchips (around $5/GJ), despite the fact that the supplier is located at about 100km from site.

### 4.3 Feasibility study

Based on the availability and cost of waste fuel and the cost-effectiveness of waste to energy solutions, the pre-feasibility stage confirmed two opportunities:
The business case for both sites is described in the following sections and a summary is shown in Table 11 below.

Table 11 – Outcomes of feasibility study

<table>
<thead>
<tr>
<th></th>
<th>Site two</th>
<th>Site five</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boiler</td>
<td>Biomass boiler</td>
<td>Woodchip boiler</td>
</tr>
<tr>
<td>Fuel supply</td>
<td>2,500 tonnes p.a. of wood briquettes</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Estimated price: $45/ton (delivered) or $2.4/GJ (HHV=19 GJ/ton)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Supply term: 5 years</td>
<td>10,000 tonnes p.a. of bark chips</td>
</tr>
<tr>
<td></td>
<td>Estimated price: $70/ton (delivered) or $5.3/GJ (HHV=13.3 GJ/ton)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Supply term: 5 years</td>
<td></td>
</tr>
<tr>
<td>Estimated project cost</td>
<td>$1.35m - $3m</td>
<td>$2m - $3.9m</td>
</tr>
<tr>
<td>Payback (yrs)</td>
<td>3.5 – 7.7 (based on different quotes)</td>
<td>4.8 – 9.3 (based on different quotes)</td>
</tr>
<tr>
<td>NPV (15yrs)</td>
<td>$2.7m - $4.2m (based on different quotes)</td>
<td>$2.2m - $4m (based on different quotes)</td>
</tr>
<tr>
<td>Carbon price ($/tCO2e) and total $ credit</td>
<td>$15 Carbon credits (ERF): $317K (7 years)</td>
<td>$15 Carbon credits (ERF): $604K (7 years)</td>
</tr>
<tr>
<td>Opportunity rating</td>
<td>⬤</td>
<td>⬤</td>
</tr>
</tbody>
</table>

4.3.1 Site two biomass boiler

4.3.1.1 Fuel supply

Up to 2,500 tonnes p.a. of wood waste briquettes are potentially available from a wood product manufacturer located within 100km’s of site two.

The briquettes (sample shown in Fig. 13) are made from wood fibre waste from the manufacturing process and consist of 60% hoop pine, 10% radiata pine and 30% hardwood (mixed species). Typically the waste stream is consistent in composition; therefore no significant variation in fuel properties is expected.

29 HHV: High Heating Value
Main fuel properties (as received) are:

- Calorific value (HHV): 18.9 MJ/kg
- Moisture content: 6.6%
- Ash content: 0.6%

Refer to the fuel test analysis available in Appendix B for more details.

Potential supply volumes were estimated at 2,000 - 2,500 tonnes p.a. and production dependant. The supply term could be up to five years at a pick-up price is $15/tonne. The processor would need to arrange transport. The estimated cost for transport was and additional $30/tonne based on a truck capacity of 12-13 tonnes per load.

With a HHV of 18.9 GJ/tonne and total price of $45/tonne, this is equivalent to $2.4/GJ.

### 4.3.1.2 Technology solutions

Quotes for biomass boiler systems were obtained from three different suppliers:

- Wood Energy Australia
- RCR Tomlinson
- Gasco

Proposal details are available in Appendix B and a summary of each solution is shown in Table 12 below.

#### Table 12 – Biomass boiler proposals for site two

<table>
<thead>
<tr>
<th>Boiler supplier</th>
<th>Wood Energy Australia</th>
<th>RCR Tomlinson</th>
<th>Gasco</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Boiler type</strong></td>
<td>Binder ‘TSRF’ model. Full length walking floor, capable of using higher ash fuels, and refractory walls for fuels with up to 35% MC</td>
<td>DES (Danish Energy Systems) biomass boiler. Inclined reciprocating combustion grate, hydraulic feeder</td>
<td>ERK fire-tube boiler. Combustion system either gasifier + torsional chamber OR furnace and fixed grate</td>
</tr>
<tr>
<td><strong>Scope</strong></td>
<td>Boiler, auger-fed combustion chamber, docking station, transfer auger, surge-bin, stoker auger, controls (PLC, moniter), ash handling, electro-static precipitator (ESP)</td>
<td>Boiler, combustion chamber, fans, moving floor fuel storage, dosing silo, transfer conveyor, hydraulic feeder, ash handling, multicyclone and bag filter, feedwater tank &amp; pumps, boiler economiser, O2 control, instrumentation &amp; valves, thermal</td>
<td>Boiler, combustion chamber, fans, 200m3 storage silo, transfer conveyor, hydraulic feeder, ash handling, cyclones and bag house filter, feedwater tank &amp; pumps, de-aerator, instrumentation &amp; valves, insulation (not installed), electrical</td>
</tr>
</tbody>
</table>
**Boiler supplier** | Wood Energy Australia | RCR Tomlinson | Gasco
--- | --- | --- |
| | insulation, electrical and control automation, installation, testing and commissioning, design, project management, documentation, freight | and control automation, installation, supervision of testing and commissioning, design, documentation, freight |

**Exclusions**
- Boiler house, fuel storage (walking floor system), civil works, pumps, piping, valves, steam meter, other boiler ancillaries (water treatment, de-aerator, blowdown vessels), electrical (power supply to boiler house)
- Boiler house, civil works, ancillaries piping (compressed air, instrumental air, condensate)
- Boiler house, civil works, compressed air, other boiler ancillaries (water treatment, blowdown vessels), installation of insulation

**Emissions limits**

<table>
<thead>
<tr>
<th>Pollutant</th>
<th>Concentration limit (mg/Nm³)</th>
<th>Reference conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Particulate: &lt;150 (mg/Nm³) without ESP; &lt;50 (mg/Nm³) with ESP</td>
<td>Particulate: &lt;50 (mg/Nm³) NOx: &lt;500 (mg/Nm³) (7% O2 dry basis) CO: &lt;250 (mg/Nm³) (7% O2)</td>
<td>Particulate: &lt;50 (mg/Nm³) NOx: &lt;300 (mg/Nm³) for gasifier; &lt;450 (mg/Nm³) for grate CO: &lt;240 (mg/Nm³) for gasifier; &lt;2,500 (mg/Nm³) for grate</td>
</tr>
</tbody>
</table>

| Budget installed cost | $1.35m | $3m<sup>30</sup> | $1.6m |
| Operating cost | Estimated at $30/kW/yr or 4.7% of total cost ($63K p.a.) | Estimated at $30/kW/yr or 2.1% of total cost ($63K p.a.) | Estimated at $30/kW/yr or 3.9% of total cost ($63K p.a.) |

### 4.3.1.3 EPA regulation

In the absence of guidelines in Queensland for emission sources, limits have been based on the New South Wales Protection of the Environment Operations (Clean Air) Regulation 2002. Site two is located near a residential area and therefore more stringent conditions apply.

Table 13 shows the maximum concentration limits expected for site two, in SEQ, based on EPA NSW license for a coal boiler (stringent local conditions).

**Table 13 – EPA concentration limits for site two**

<table>
<thead>
<tr>
<th>Pollutant</th>
<th>Concentration limit (mg/Nm³)</th>
<th>Reference conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Particulate matter</td>
<td>50</td>
<td>Dry basis, 7% oxygen correction</td>
</tr>
<tr>
<td>Nitrogen oxides (NOx)</td>
<td>300</td>
<td>Dry basis, 7% oxygen correction</td>
</tr>
<tr>
<td>Sulphuric acid and sulphur trioxide (SO3)</td>
<td>50</td>
<td>Dry basis, 7% oxygen correction</td>
</tr>
</tbody>
</table>

The boiler solutions proposed by the three suppliers are able to keep emissions within the concentration limits and meet the EPA requirements. A baghouse filter or an electro-static precipitator is required to meet the 50 (mg/Nm³) limit for particulate matter.

### 4.3.1.4 Final business case

A snapshot of the economic model is shown in Fig. 14.

<sup>30</sup> Budget pricing is for a more detailed scope of work, which includes boiler economiser, O2 control and installation of thermal insulation.
Based on the budget price provided by Wood Energy Australia ($1.35m), the project discounted payback is 3.5 years, with a Net Present Value of $4.2m. The payback increases to 7.7 years when the RCR Tomlinson quote ($3m) is used.

A sensitivity analysis has been conducted to analyse the impact of key factors:

- Price of natural gas
- Price of biomass
- Funding
- Carbon price

Three different scenarios were selected for each variable. The results are shown in Fig. 15 below.
The sensitivity analysis shows that the price of natural gas has a significant impact on the project payback.

The impact of funding is also significant and explains why several projects were implemented when government funding programs such as the Clean Technology Investment Program were available. Apart from ERF, no other financial assistance has been assumed for this project.

The price of biomass, though having a slightly lesser impact, can represent a higher risk due to its variability. Price can be affected by variations in competing markets, changes in transport costs or variations in availability (i.e. need to obtain biomass from other sources to maintain level of supply). Negotiating a long term supply contract with the supplier(s) is important to mitigate this risk. The transport cost makes up 66% of the fuel cost, alternative transport methods such as using other contractors, larger trucks or more energy efficient trucks should be considered when arranging the fuel supply contract.

The price of carbon has a minor effect due to the relatively low emissions reduction associated with this project. A conservative $15 per tonne of carbon has been assumed for this business case. Under the Emissions Reduction Fund (ERF) program, the carbon price is chosen by a participant who wants to register a carbon-saving project and submit a bid in an auction process to create carbon credits that will then be sold to the government at the chosen carbon price. The selected carbon price determines how competitive the bid is in the
auction, as the government compares it against a benchmark price to determine which projects will be selected. More details on the ERF program are available in section 5.3.2.1.

4.3.2 Site five biomass boiler

4.3.2.1 Fuel supply

Up to 13,000 tonnes p.a. of woodchips is available from a wood log/chip producer in SA, about 112km away from site five.

The woodchips are made from radiate pine with bark (bark chip), which is also used for particleboard manufacturing. The composition of chips is typically consistent but the calorific value can vary depending on weather conditions, which affects moisture content.

Main fuel properties (as received) are:

- Calorific value (HHV): 13.3 MJ/kg
- Moisture content: up to 50% depending on weather conditions
- Ash content: 1.4%

Refer to the fuel test analysis available in Appendix B for more details.

Supply volumes can range between 7,000 - 13,000 tonnes p.a. The supply term is up to five years and the delivered price was confirmed at $70/tonne. The supplier’s preference is to transport the chips to site in bins that can hold 25 - 30 tonnes or approximately 90m³.

With a HHV of 13.3 GJ/tonne and total price of $70/tonne this is equivalent to $5.3/GJ.

4.3.2.2 Technology solutions

As with the business case for site two, three quotes were obtained from the same boiler suppliers. A summary of the three proposals is shown in Table 14 below and proposal details are also available in Appendix B.

Table 14 – Biomass boiler proposals for site five

<table>
<thead>
<tr>
<th>Boiler supplier</th>
<th>Wood Energy Australia</th>
<th>RCR Tomlinson</th>
<th>Gasco</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Boiler type</strong></td>
<td>Visdamax Bio T-burner. Two chamber furnace of refractory-lined pile bed design, automatic fuel stoking screws. Can handle biomass fuel with high MC.</td>
<td>DES (Danish Energy Systems) biomass boiler. Inclined reciprocating combustion grate, hydraulic feeder.</td>
<td>ERK fire-tube boiler. Combustion system either gasifier + torsional chamber or furnace and fixed grate.</td>
</tr>
<tr>
<td><strong>Scope</strong></td>
<td>Boiler, boiler house, fuel reception &amp; storage (900m³), boiler ancillaries (feed pumps, fans), electrical and controls, ash handling, installation, freight</td>
<td>Boiler, combustion chamber, fans, moving floor fuel storage, dosing silo, transfer conveyor, hydraulic feeder, ash handling, multicyclone and bag filter, feedwater tank &amp; pumps, boiler economiser, O2 control, instrumentation &amp; valves, thermal insulation, electrical and control automation, installation, testing and commissioning, design, project management, documentation, freight</td>
<td>Boiler, combustion chamber, fans, 200m³ storage silo, transfer conveyor, hydraulic feeder, ash handling, cyclones and bag house filter, feedwater tank &amp; pumps, de-aerator, instrumentation &amp; valves, insulation (not installed), electrical and control automation, installation, supervision of testing and commissioning, design, documentation, freight</td>
</tr>
<tr>
<td><strong>Exclusions</strong></td>
<td>Bag house, civil works, water treatment</td>
<td>Boiler house, fuel storage, bag house, civil works, pumps, piping, valves, steam meter, other boiler ancillaries (water treatment, de-aerator, blowdown vessels), electrical (power supply to boiler house)</td>
<td>Boiler house, civil works, compressed air, other boiler ancillaries (water treatment, blowdown vessels), installation of insulation</td>
</tr>
</tbody>
</table>
### 4.3.2.3 EPA regulation

The SA EPA Environment Protection (Air Quality) Policy 1994 establishes the following maximum pollution levels (Table 15).

**Table 15 – EPA concentration limits for site five**

<table>
<thead>
<tr>
<th>Pollutant</th>
<th>Concentration limit (mg/Nm³)</th>
<th>Reference conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Particulate matter</td>
<td>250</td>
<td>Dry basis, 12% CO2 correction</td>
</tr>
<tr>
<td>Nitrogen oxides (NOx)</td>
<td>500</td>
<td>Dry basis, 7% oxygen correction</td>
</tr>
<tr>
<td>Sulphuric acid and sulphur trioxide (SO₃)</td>
<td>100</td>
<td>Dry basis, 7% oxygen correction</td>
</tr>
<tr>
<td>Carbon monoxide (CO)</td>
<td>1,000</td>
<td>Dry basis, 7% oxygen correction</td>
</tr>
</tbody>
</table>

Site five is located in SA in a non-residential area, therefore it is expected that these less stringent limits (compared to the site two) will apply.

As with site two, the boiler solutions proposed by the three suppliers are able to keep emissions within the concentration limits and meet the EPA requirements. Baghouse filters or electro-static precipitators may not be required to meet the 250 (mg/Nm³) limit for particulate matter, as the emissions from the boilers are below this limit.

### 4.3.2.4 Final business case

The final business case for the biomass boiler at site five is based on the quote provided by Gasco ($2m), the project discounted payback is 4.8 years, with a Net Present Value of $4m. The payback increases to 9.3 years when the RCR Tomlinson quote ($3.9m) is used.

As with the site two business case, a sensitivity analysis has been conducted to analyse the same key factors. The results are shown in Fig. 15 below.
The sensitivity analysis shows very similar results to the site two business case. The prices of natural gas and biomass, as well as the amount of funding available, have the largest impact on the project payback. However site five’s natural gas prices are based on present prices and a low escalation rate for future gas price. Should the price increase by 20% in the next year, this project payback reduces to 3.4 years. This rate of price escalation is entirely possible given the rates already experience by other meat processing facilities.

The price of carbon has a slightly larger effect compared to the site two business case due to the larger carbon savings associated with the project, i.e. a 4MW boiler has a greater natural gas offset compared to a 2MW boiler.
5 Discussion

5.1 Source of supply

The previous sections discussed the various factors affecting the availability and the cost of alternative fuels, as well as their applicability in the meat processing industry. As discussed in several studies such as the Australian Bioenergy Roadmap developed by the Clean Energy Council, the potential bioenergy resources in Australia are large but the market is fragmented and not fully developed, with the exception of a few biofuels such as bagasse.

As this study shows, identifying and determining whether an alternative fuel is suitable or not is a complex process. The following key factors need to be investigated when assessing sources and supply of alternative fuels.

- How much am I paying for energy on my site?
- What alternative fuels are available on my site?
- What alternative fuels are available near my site?
- Are external sources located within 100km from my site?
- Is the alternative fuel cheaper than the price of energy currently used?
- Are there any other benefits associated with the use of alternative fuels? (e.g. reduction of onsite waste and disposal cost)
- Is there a consistent, reliable, long term supply?
- Is the quality of the fuel consistent? Is there any pre-treatment required? (screening, cutting, drying, diluting, etc.) Are there any hazardous materials present in the fuel?
- How is the fuel going to be delivered? Do I need to organise my own transport for pick-up? What is the standard delivery volume and what is the frequency of delivery?
- What is the size of the fuel reception area required for delivered volumes?
- Do I need fuel storage on site? What is the minimum storage capacity?

There are other guidelines available that can assist in the identification and assessment of biofuels that are suitable for the meat industry. MLA and AMPC have developed several studies\(^\text{32,33}\) that look at the feasibility of using different waste materials such as paunch, as well as the applicability of a range of different waste to energy technologies.

The contribution of bioenergy to the energy supply in Australia is very low (approximately 3%) compared to Europe and the US (5 – 10%), and Asia (10 – 20%)\(^\text{34}\). In order to further develop the bioenergy market in Australia and increase the bioenergy share in Australia’s energy mix, more effort is required, particularly in the development of government policies, capacity-building in industrial and commercial sectors and technological development. The


Australian Bioenergy Roadmap\textsuperscript{35} provides good guidance and strategies to overcome the barriers that are currently affecting the growth of bioenergy.

## 5.2 Technology

With the exception of a few technologies such as anaerobic digestion and biomass boilers, many bioenergy conversion technologies are still in early development or commercial stages. The main limitations are in terms of cost and scalability, which makes implementation of small to medium-size applications very difficult. Fig. 17 shows the maturity status of different waste to energy technologies.

![Fig. 17 – Bioenergy technology maturity status\textsuperscript{36}](image)

Depending on the type of alternative fuel available, different technologies may be available, each one with different characteristics, outputs and costs. As with sources of alternative fuel, the technology selection process is complex and there are some key evaluation points that need to be considered when selecting a technology solution. Some of these are summarised below.

- What technology options are available for the selected alternative fuels?
- Is it available for small and medium-scale applications?
- How well developed is the technology? Is it proven and commercially available?
- Are there any suppliers in Australia? Is the technology manufactured and supplied from overseas?
- What is the capital and operating cost?
- What is the energy yield and the energy efficiency?
- How well does the technology integrate with my existing plant/equipment/process?


• What is the footprint requirement? Does my site have layout constraints?
• Apart from energy, what other outputs are associated with the technology? (e.g. digestate, ash)
• How flexible is the technology in terms of handling a range of different materials and/or variations in the quality of fuel?
• Is the technology capable of meeting environmental standards? (e.g. air emission limits)

MLA and AMPC have conducted studies looking at the applicability of different technologies such as covered anaerobic lagoons, direct combustion and other solutions, including pilot tests and trials conducted at different abattoirs. There are also other guidelines and factsheets developed by other organisations such as the UK Carbon Trust (e.g. Biomass Heating Guide\textsuperscript{37}), the US Department of Energy (Energy Efficiency & Renewable Energy\textsuperscript{38}) or the International Renewable Energy Agency (IRENA) (e.g. Biomass for Power Generation\textsuperscript{39}).

This study shows that there can be a significant difference in the costs of various technologies. This difference can be due not only to the level of maturity but also because many of these technologies are supplied from overseas. In this case, factors such as exchange rates have a significant impact on the technology/equipment cost. Equipment manufactured in Australia can also be expensive due to higher labour and material costs, compared to other countries such as the US or countries in Asia.

Other factors that affect the cost include the technology design and ancillary equipment. A premium is typically charged for high efficiency or high flexibility. For example, a biomass boiler with an efficiency of 85% or higher is likely to be more expensive than a boiler with standard efficiency of about 80%. Similarly, a boiler than can run only with a narrow range of biomass fuel types is likely to be cheaper than a more robust, flexible boiler such as a fluidised bed boiler. Other technology components such as environmental control devices (e.g. baghouses, electro-static precipitators), feedstock pre-treating equipment (e.g. shredding machines), fuel storage, or gas treatment (e.g. biogas cleaning) can also represent a large proportion of the total cost. An example of a capital cost-breakdown is shown in Fig. 18 below.


There are also some advantages and disadvantages between technologies. Most have to do with how well a technology can integrate with an existing process. For example, a site that has a gas-fired boiler would probably consider an anaerobic digestion process over a biomass boiler (assuming both technologies are suitable for a certain type of biomass) due to the option of co-firing biogas into the existing gas boiler, as opposed to having to purchase an entire new biomass boiler system. Ricardo-AEA developed a Waste to Energy Background Paper that compares the advantage and disadvantages of different technologies. There is a need to continue developing these technologies so that they can become more cost-effective and better integrated for industries such as the meat processing sector. Equipment cost, scalability and integration are three main areas where improvements can be made in the deployment of alternative fuel technologies.

5.3 Other key factors

5.3.1 Energy prices

As shown in the sensitivity analysis for site five and site two, the impact of energy prices on the economic viability of the project can be significant. Monitoring and forecasting energy prices is therefore important to assess when bioenergy opportunities may become available.

Having a good understanding of existing energy contracts is also important to see if there are any limitations to introducing alternative fuels or whether the use of them results in

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negative impacts on the existing contract. For example, offsetting natural gas through biogas recovery would not be a very attractive option if this reduces natural gas use to below the take-or-pay contract limit (where it is required to consume a minimum amount of gas per year, often as much 80% of the Annual Contract Quality (ACQ)).

Energy supply tariff analysis is required to understand the different components associated with an energy bill. The difference between the fixed and variable components of natural gas price for example is of particular importance, as the energy savings that result from natural gas displacement are associated with the variable component only. Generally the energy user still has to pay the same amount of fixed charges, regardless of the reduction in natural gas consumption.

Another area of energy price analysis requiring regular monitoring is the difference between the price for gas and electricity (what is sometimes referred to as the “Spark Gap”). This can indicate opportunities for power generation using cogeneration systems. For example, if a site pays a high variable price for electricity and relatively low natural gas rates (at least four times less than the electricity price), then the option of adding a cogeneration unit to a biogas recovery project may be economically attractive. However, the trends currently observed in the electricity and gas markets do not show an attractive outlook for cogeneration projects, i.e. increasing gas prices and steady, possibly falling electricity prices.

5.3.2 Funding and financing

As discussed in previous sections, the implementation cost of a waste to energy solution is generally very high. Access to funding or financing can significantly improve the economics of the project. A number of Australian meat processors received grants from the government’s Clean Technology Investment Program (CTIP) to implement bioenergy projects, most of them for biogas recovery systems. There are also other examples of successful bioenergy projects that received financing assistance, either through corporate loans, energy performance contracts (EPC) and other types of financial arrangements.

Some of the funding programs and financing options currently available are discussed in the sections below.

5.3.2.1 Government funding programs

Emissions Reduction Fund

The Emissions Reduction Fund (ERF) is a voluntary program that provides incentives for emissions reduction activities across the Australian economy. Up to $2.55 billion is initially available for participants that achieve carbon savings through the successful implementation of eligible carbon abatement projects.

Participants can nominate carbon abatement projects to create carbon credits (Australian carbon credit units or ACCUs), which they can then sell to the Government or to other businesses through a secondary market. Nominated projects need to be covered under an

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42 More details available on the Biogas Factsheet, available in Appendix A
approved emissions reduction method\textsuperscript{43} and registered with the Clean Energy Regulator. The Regulator holds auctions where participants are able to submit a bid ($/t\text{CO}_2\text{e}) for their registered projects. Successful bids that fall under the benchmark price (set by the Regulator) are selected and participants can sign a contract with the government for the abatement of a total volume of carbon emissions over the life of the project at the nominated bid price. After the project has been implemented, participants are required to report on the emissions reductions to generate carbon credits, i.e. credits are paid as carbon savings are realised. This is done through measurement and verification (M\&V) audits (conducted independently) of the projects implemented and submitting offset reports to the Clean Energy Regulator.

The ERF provides funding opportunities for the meat processing industry, mostly through the following abatement methods:

- **Wastewater Treatment**: treatment of industrial wastewater in an anaerobic digestion system to generate biogas
- **Industrial Fuel and Energy Efficiency**: reduction of carbon emissions achieved through fuel and energy efficiency measures such as boiler upgrades, optimisation of refrigeration systems, installation of efficient lighting and other efficiency improvement projects.

Organic solid waste such as manure, paunch or biosolids from wastewater treatment ponds are excluded from the Alternative Waste Treatment method, as there are other treatment options (such as composting) available as opposed to landfill disposal.

The aggregation of projects is recommended, as large emission reductions are required in order to register a project, i.e. a 2,000t \text{CO}_2\text{e}/yr emissions reduction threshold applies. Installing covers on open anaerobic lagoons for example, provides significant emissions reduction potential as there are two abatement methods that can apply: one is the reduction of fugitive emissions from open lagoons, and the other relates to the displacement of fossil fuels if biogas is captured and used in the process.

An example of the carbon savings that can be achieved from covering anaerobic lagoons is shown in Fig. 19. In this specific example, the amount of carbon savings achieved from reduced methane fugitive emissions (6,716 t\text{CO}_2\text{e/year}) is almost 4 times the amount of savings achieved from fossil fuel offset (1,704 t\text{CO}_2\text{e/yr}).

Fig. 19 – Example of carbon emissions reduction associated with covered anaerobic lagoon projects

Victorian Regional Infrastructure Development Fund (RIDF)

Regional Development Victoria, through their Infrastructure Branch, provides funding for capital works to enhance the economic and social development of regional communities.

The Regional Infrastructure Development Fund (RIDF) supports a diverse range of infrastructure projects including the development of energy and utilities infrastructure and industrial development. Implemented projects funded by RIDF include industrial water and energy reduction initiatives and renewable energy projects, including bioenergy.

For example, Australian Tartaric Products identified an opportunity to generate energy using spent grape marc and then secured a $1.8m grant from RIDF for its $7.5m biomass boiler (Fig. 20).
Applications for funding under RIDF are assessed against published eligibility guidelines, and must demonstrate an ability to meet a significant number of criteria. These criteria are:

- Economic outcomes, including employment, new investment, and access into new markets
- Socio-economic impacts
- Priority areas within a state and/or regional context
- Projects must be feasible and implementable
- Financial viability, leveraging additional funding from alternate sources
- Use of local content in accordance with the Government’s Victorian Industry Participation Policy

There are funding opportunities through the RIDF available for red meat processing plants located in Victorian regional areas that are looking at implementing plant upgrades, such as biomass boilers or biogas production/recovery from anaerobic digestion lagoons.

**NSW Energy Savings Scheme**

The Energy Savings Scheme (ESS) is a NSW-based voluntary program that provides financial incentives for organisations to invest in energy savings projects to reduce electricity consumption in New South Wales. Energy savings are achieved by installing, improving or

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replacing energy savings equipment. Energy Savings Certificates (ESCs) are created through an Accredited Certificate Provider (ACP) when electricity savings are realised and participants can then trade these certificates with electricity retailers.

The NSW Government has announced that the ESS will be enhanced and expanded to include natural gas starting in early 2016, which will support businesses to reduce gas consumption through the implementation of gas efficiency measures and alternative fuel projects.

5.3.2.2 Alternative financing options

The number and type of alternative financing options has developed significantly in recent years and a range of different financing solutions are now available for alternative fuel projects. The NSW Office of Environment and Heritage (OEH) has published an Energy Efficiency and Renewables Finance Guide\(^{45}\) that explains the different types of finance options available. These are summarised below:

- **Commercial loan**: a lender provides capital to a borrower, to be repaid by a certain date, typically at a predetermined interest rate that moves in line with changes in a reference lending rate. The customer makes regular repayments to the lender to cover interest costs. Capital repayments can be bundled with interest payments, or can occur at the end of the loan.
- **Energy efficient loan**: these loans are specifically designed for energy efficiency and renewable energy projects, so generally have lower interest rates and longer finance periods
- **Operating lease**: the equipment is owned by the financier and the customer obtains the sole right to use it. The customer pays regular lease payments to the financier and pays all maintenance costs. At the end of the lease, the customer has the option of returning the equipment, making an offer to buy it, or continuing to lease it.
- **Capital lease**: similar to the operating lease, except that at the end of the lease, equipment ownership transfers to the customer on payment of an agreed amount.
- **Environmental Upgrade Agreement (EUA)**: a loan for the environmental upgrade of a building which is repaid through a local council environmental upgrade charge.
- **Utility on-bill financing**: an energy retailer installs equipment, which is later repaid through a ‘repayment’ charge on energy bills. Once all payments are made, the title for the equipment transfers to the customer.
- **Energy Services Agreement (ESA)**: an ESA provider designs, constructs, owns and operates equipment. The customer pays fees to cover operation and maintenance costs, including energy costs, and to repay capital and implementation cost. The fees are indexed to CPI, labour rates, and to the price of energy. The customer can typically purchase equipment at the end of an ESA. End-to-end delivery of energy efficiency and renewable energy projects is provided. Finance can be arranged using any of the finance options above, or through the ESA provider.

The finance terms for each option, as well as the applicability for biomass/biogas projects in the red meat processing industry, are shown in Table 16 below.

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### Table 16 – Typical finance terms for external energy efficiency finance options\(^{46}\)

<table>
<thead>
<tr>
<th>Option</th>
<th>Finance period (years)</th>
<th>Finance amount</th>
<th>Soft cost</th>
<th>Drawdowns</th>
<th>Residual value/balloon payment</th>
<th>Indicative interest rate %</th>
<th>Applicability to alt fuel projects</th>
</tr>
</thead>
<tbody>
<tr>
<td>COMMERCIAL LOAN</td>
<td>Generally 1-5</td>
<td>$10,000+</td>
<td>Beyond 10% depends on risk</td>
<td>Balloon available</td>
<td>6.5</td>
<td><img src="" alt=" " /></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1-15 for BankMECU</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ENERGY EFFICIENT LOAN</td>
<td>3-7</td>
<td>$250,000+ if an existing CBA customer, otherwise $50,000+</td>
<td>Beyond 10% depends on risk</td>
<td>Balloon available</td>
<td>8.0</td>
<td><img src="" alt=" " /></td>
<td></td>
</tr>
<tr>
<td>OPERATING LEASE</td>
<td>1-5</td>
<td>FlexiGroup, Affleas</td>
<td>20%+</td>
<td>Possible for larger projects</td>
<td>Depends on customer and asset risk</td>
<td>7.5</td>
<td><img src="" alt=" " /></td>
</tr>
<tr>
<td>CAPITAL LEASE</td>
<td>1-15</td>
<td>$2,000+</td>
<td>20%+</td>
<td>Possible for larger projects</td>
<td>Depends on customer and asset risk</td>
<td>0-7.5</td>
<td><img src="" alt=" " /></td>
</tr>
<tr>
<td>ENVIRONMENTAL UPGRADE AGREEMENT</td>
<td>BankMECU: 1-20 NAB: 3-10</td>
<td>BankMECU: $10,000+ NAB: $250,000+</td>
<td>No limit</td>
<td>Possible for larger projects</td>
<td>None</td>
<td>7</td>
<td><img src="" alt=" " /></td>
</tr>
<tr>
<td>ON-BILL FINANCING</td>
<td>1-7</td>
<td>No specific limit</td>
<td>No limit</td>
<td>N/A</td>
<td>None</td>
<td>N/A</td>
<td><img src="" alt=" " /></td>
</tr>
<tr>
<td>ENERGY SERVICES AGREEMENT</td>
<td>5-40</td>
<td>Up to $200,000,000</td>
<td>No limit</td>
<td>N/A</td>
<td>Depends on project, generally 0%</td>
<td>N/A</td>
<td><img src="" alt=" " /></td>
</tr>
</tbody>
</table>

### 5.3.2.3 Financing Sources

**CEFC**

The Clean Energy Finance Corporation (CEFC)\(^{47}\) invests using a commercial approach to overcome market barriers and mobilise investment in renewable energy, energy efficiency and low emissions technologies.

As at 30 June 2014, the CEFC has contracted investments of over $900m in projects with a total value of over $3b. The CEFC invests for a positive return, with its more than 40 direct investments and 25 projects co-financed under aggregation programs expected to achieve an average financial yield of about 7 per cent.

These CEFC investments are expected to achieve abatement of 4.2m tonnes of CO\(_2\)e per annum with a positive net benefit to the taxpayer in the order of $2.40 per tonne CO\(_2\)e. They

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help to improve energy productivity for businesses across Australia, develop local industries and generate new employment opportunities.

The CEFC operates under the Clean Energy Finance Corporation Act 2012.

An example of the projects financed by CEFC includes an energy to waste project for the major Australian garden products supplier, Richgro which is harnessing ground-breaking waste-to-energy technology to meet all its power needs by recycling organic waste.\(^{48}\)

**Equipment Suppliers**

In some cases, particularly where new technology is to be used, equipment suppliers may provide financing for the energy efficiency or alternative fuel project.

Equipment suppliers may utilise grants and other government funding to introduce new technologies or innovations and this can be a great opportunity for businesses to implement energy efficiency and energy to waste projects at reduced costs. In order to progress these projects the equipment/technology provider will need a co-investment group and project site.

**AusIndustry**

The Department of Industry and Science’s Single Business Service helps businesses access industry information, grants and services. Advice is available online, through a contact centre and a face-to-face business facilitation network to link interested businesses with relevant programs and services. Practical support includes:

- tailored advice for businesses
- direct links to services provided in the Entrepreneurs’ Infrastructure Programme
- connections with other Australian Government programs or services such as the R&D Tax Incentive and the Industry Skills Fund.

Bioenergy projects can often have an innovation or unique aspect which may be suitable for grant assistance under the AusIndustry (business.gov.au) programs such as The Entrepreneurs’ Infrastructure Programme.\(^{49}\)

The program also provides guidance, as well as connections and grants to accelerate the commercialisation of intellectual property in the form of novel products, processes and services.

5.3.3 Risks

**5.3.3.1 Environmental risks**

As discussed in previous sections, the state Environmental Protection Authorities (EPA) set environmental standards, such as air emission limits, that need to be met in order to obtain an EPA licence to install and operate alternative fuel systems.

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Some EPAs adopt the requirements of the National Environment Protection Council (Ambient Air Quality) Measure (NEPM). This NEPM sets standards, goals, monitoring and reporting protocols for six common pollutants: carbon monoxide (CO), nitrogen dioxide (NO\textsubscript{2}), photochemical oxidants (as ozone), sulfur dioxide (SO\textsubscript{2}), lead and particles as PM10.

The pollutant concentration limits that apply to biomass boiler emissions at site five and site two are shown in Sections 4.3.1.3 and 4.3.2.3. Alternative fuel technologies such as biomass boilers need to include the necessary environmental control equipment to meet these requirements. Generally, the lower the emission limits, the higher the cost associated with emissions control equipment. For example, most biomass boilers would be able to comply with particulate emission limits of 200 mg/Nm\textsuperscript{3}, but for concentrations of 50 mg/Nm\textsuperscript{3} or lower, devices such as baghouse filters or electro-static precipitators are required.

The location of the site/project is an important factor as different standards may apply depending on different states and specific local conditions. More stringent limits typically apply for sites located near residential areas.

Once a licence is obtained a site must comply with the conditions of operation defined in their licence. Emissions or discharges that exceed set limits may require the development of an environment improvement program (EIP). Therefore, monitoring of emissions is important to detect deviations in time. EPA licences are typically granted for a period of 5 years, after which a renewal is required.

5.3.3.2 Fuel supply risks

Variation in fuel supply conditions, whether in the form of volume, quality and/or price, is a key risk in the development of alternative fuel projects. These variations can be caused by several factors including weather events (e.g. drought affecting agricultural production, rain affecting moisture content), changes in supplier’s operations (e.g. process changes affecting waste composition), or changes in market conditions (e.g. changes in demand affecting price and volume).

Some of these risks are more manageable than others. Negotiating a secure, long-term contract is a good way of mitigating some of these risks (e.g. lock in biofuel prices for 5 -10 years). However, good terms and conditions are not always easy to obtain, i.e. most suppliers would be reluctant to offer a contract that lasts more than five years. This can be an issue considering that these types of projects generally have paybacks of 5 years or more.

Where variations in quality and/or volumes occur (and which cannot be controlled), having a flexible system is important. A robust technology that can handle a variety of different feed stocks with different properties is one example of a flexible system. Monitoring the quality of the biofuel supplied is another way to manage this risk. For example, if significant variation in the fuel calorific value is expected, then conducting regular fuel tests is a good way to anticipate changes in the combustion process of a biomass boiler.

5.3.3.3 Other risks

Typically, waste to energy projects have some degree of complexity in their development, particularly in the technical aspects associated with various technologies. For example,
understanding the biochemical process and the different factors that affect the production of biogas in anaerobic digestion processes can be a challenging task.

This study shows that, in general, there is a lack of knowledge about waste to energy technologies in the industry. This can lead to lack of acceptance, unawareness of opportunities, poor design and/or inefficient operation of existing bioenergy systems. Covered anaerobic lagoons are good example of this issue. Although there are several CAL systems implemented in Australian abattoirs, significant differences in performance are observed. The causes of these inefficiencies are not always fully understood and a number of studies have been developed by AMPC, MLA and other groups to look at ways of improving the operation of CAL and increase biogas production.  

Having a good understanding on how these technologies perform and what are the key factors that need to be considered when assessing the business case of a bioenergy project, will reduce the risk of inefficient design, implementation and operation.

The Australian Bioenergy Roadmap and other studies recognised the need for more capacity building in alternative fuels and bioenergy conversion technologies. MLA, AMPC, and other industrial and government groups have developed numerous factsheets and guidelines around the use of alternative fuels and waste to energy technologies. Training courses, seminars and conferences are also organised on a regular basis. Funding is also available for R&D activities, such as technology research or pilot tests.

Other institutions such as Bioenergy Australia promote awareness and understanding of bioenergy. Australia is also participating in several IEA Bioenergy tasks, which comprise a number of international working groups whose objective is to facilitate the commercialisation and market deployment of environmentally sound, socially accepted, sustainable, and cost-competitive bioenergy technologies. The working groups address issues such as technology development, non-technical barriers, and regulatory and legislative issues.

Agencies such as the Australian Renewable Energy Agency (ARENA) are also helping to improve the competitiveness of renewable energy technologies, by funding and supporting technology R&D activities and the implementation of bioenergy projects.

6 Conclusions and recommendations

6.1 Status of bioenergy use in Australia

Research shows that there is a wide range of alternative fuels available in Australia but the market is generally fragmented and not fully developed, particularly in the case of agricultural waste where large amounts of bioenergy resources are currently underutilised.

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50 More details available on the Biogas Factsheet, available in Appendix A
52 Bioenergy Australia website, http://www.bioenergyaustralia.org
The cost and availability of agricultural and other wastes are also subject to other competing markets. Typical examples of this include use of bagasse in the sugar industry, wood chips (export markets and also used for pulp and paper industry), and other agricultural waste such as nut shells and grain husks also used as biomass fuel.

The best sources are onsite waste, and some external sources but usually within 100km from the site. If sources are scattered or distances too great, transport costs can have a significant impact on the price of bioenergy fuels.

Currently, the most common form of alternative fuels found in the Australian red meat processing industry is the use of biogas recovery from covered anaerobic lagoons. Only a couple of examples of biomass boiler projects have been found in abattoirs.

Waste-to-energy technologies are similarly not fully developed, nor fully understood or accepted. The technology involved is generally expensive and, with the exception of a few suppliers, often supplied from overseas.

On balance, currently the best opportunities are for niche applications, where a good source of bioenergy is available.

6.1.1 The take up of bioenergy internationally

Research shows that the status of bioenergy in other parts of the world can vary from region to region. For example, a recent report published by the International Renewable Energy Agency (IRENA) shows that the weighted average levelised cost for biomass-fired electricity generation in China and India is lower than Europe and North America (Fig. 21). The bioenergy market in Europe and the US is very large but the LCOE\(^{54}\) is higher because of the use of more sophisticated technology as a result of more stringent emissions control and higher feedstock prices. Many of the large projects implemented in US and Europe are using municipal solid waste as feedstock, therefore cost is often higher due to pre-treatment required to sort out mixed waste.

Biomass power plants in developing countries can have significantly lower investment costs due to lower feedstock costs, lower local labour costs and cheaper equipment allowed by less stringent environmental regulations.

\(^{54}\)LCOE: Levelised cost of electricity
6.2 A shift in Australia’s market conditions makes bioenergy more attractive

Historically, the main limiting factors for the implementation of bioenergy projects have been the low cost of coal and gas. With the forecasted increase in gas prices there is interest in considering alternative fuels.

The typical payback for these projects is between 4 – 10yrs (without funding assistance). Therefore, financing is an important element in the economic viability of bioenergy projects. Various funding programs have assisted the implementation of bioenergy projects in the past and although most of them are no longer available, there are still funding opportunities such as the Emissions Reduction Fund and other state based programs that can support the implementation of these projects. A range of financing options, specifically designed for energy efficiency and renewable energy projects, is also available.

6.3 Major factors in assessing alternative fuel projects

Overall, the current status of bioenergy in Australia and other countries shows that alternative fuel projects become attractive or successful when several contributing factors are in line:

- A cheap source of alternative fuel is available (e.g. <$5/GJ)
- There is a consistent and reliable supply, available for long term (5+yrs)
- A high price is paid for conventional fuel (e.g. >$10/GJ)
- There is a need to replace or upgrade an existing process or equipment and this provides an opportunity to look at more unconventional technologies. For example:

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55 IRENA, Renewable Power Generation Costs in 2014, 
Expansion projects required as a result of increased production (increased steam demand, increased wastewater flows)

- Upgrades due to tighter environmental regulations, e.g. upgrade anaerobic lagoons for better odour control

- Economic incentives are available.

6.4 Challenges to overcome to realise the potential of bioenergy in Australia

There are two major issues that need to be overcome:

- **Alternative fuels market**: the size of the Australian market is small compared to Europe or US but there are still large amounts of bioenergy resources that are currently underutilised. This is mainly due to the fragmented nature of the Australian market. Many successful bioenergy projects have resulted from niche market opportunities within forestry, food production, food processing, and other primary industry sectors where onsite waste is available.

- **Technology development**: although some technologies are mature and well proven, the cost of implementation is still very high, particularly for small- to medium-scale applications. Other technologies such as gasification and pyrolysis are still in early commercial or development stages. The scalability and the integration of technology with existing infrastructure need to improve.

6.5 Insights from the meat processor business cases

The feasibility study shows there are two biomass boiler opportunities for processor:

- Woodchip boiler at site five
- Woodwaste briquette boiler at site two

The business case is supported by:

- Availability of good quality fuel at low price
- Relatively high price paid for natural gas
- Ageing assets

**Site two:**

With a payback of 3.5 years this project looks close to being economically attractive and further steps are recommended to look at the following:

- Conduct a gasification trial to review if the option of co-firing syngas with natural gas (and biogas in the future) into the existing gas boiler is feasible. If successful, this would avoid the need to install a new boiler and just use the gasification chamber proposed by Gasco, therefore reducing capital costs.
- The size of the biomass system is limited by the amount of wood waste that is available. If other sources of biomass become available in the area there are opportunities to increase the size of the system, thus increasing the amount of gas offsets and savings. Further investigation is recommended to identify other potential suppliers.
Site five:

The project payback is 4.8 years for the best case scenario (quote from Gasco) which does not make it as economically attractive as the site two business case. The following factors affect the payback:

- The price of biomass ($5.3/GJ) is relatively high compared to the site two case ($2.4/GJ). This is affected by the higher moisture content (30% - 50%) which reduces the heating value of the fuel (13 GJ/tonne). The price may fall if better moisture control is achieved.
- The current natural gas price is low, yet future increases are expected that would improve project return.

6.6 Recommendations

To develop a better understanding on the best way to address the barriers, the study recommends the following:

- **Review government support** for alternative fuels projects. Many of the anaerobic digestion and biomass projects reviewed during this research study received government funding. This type of funding is very limited at the moment. A review government support at state and commonwealth levels for alternative fuel supply and projects is needed to determine if and how these projects can obtain government support.

- **Review biomass supply chains** to determine the areas in Australia where biomass can be made available, several studies indicate there are vast amounts of wood waste and agricultural biomass available in Australia. The biomass supply chain is underdeveloped and therefore this material is generally not available at reasonable price for industry. A study focused on identifying the major sources of biomass in Australia, the processing requirements and the transport necessary to get this material to the end-user would help to define the most viable areas for biomass supply in Australia.

- **Conduct further research to identify best technology options in anaerobic digestion of solid waste.** All red meat processing plants have a substantial amount of solid waste which is generally sent to landfill or requires disposal at a cost. A detailed analysis of this waste, disposal methods and costs is required to determine the optimal waste processing methods such as anaerobic digestion.

- **Conduct further research to identify best technology options for biomass based fuels and boilers.** Gasifiers used for the conversion of biomass into synthesis gas can process a wide range of materials and the gases can be used to fire boilers. During this research study it was found that this technology has been successfully implemented in South America for many years. A demonstration project using a small gasifier and boiler could help establish this technology in Australia.

- **Conduct further research into the options for better integration of alternative fuel solutions with existing facilities.** An example of a fuel integration project is the use of a gasifier to produce synthesis gas integrated with a biogas supply to be fired
in a gas fired boiler. This could form part of the demonstration project mentioned in gasifier project above. Other forms of alternative fuel integration include the use of biomass with coal and the use of biogas into coal fired boilers.
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8 Appendix

8.1 Appendix A – Factsheets

Biogas

MLA AFS Biogas fact sheet v1.1.docx

Woodwaste

MLA AFS Wood waste fact sheet v1.1.docx

Agricultural waste

MLA AFS Agricultural waste fact sheet v1.1.docx

Onsite solid waste

MLA AFS Onsite Solid Waste fact sheet v1.1.docx

Municipal solid waste

MLA AFS MSW waste fact sheet v1.1.docx

Processed biofuels

MLA AFS Processed Engineered Fuels fact sheet v1.1.docx
8.2 Appendix B – Biomass boiler proposals and fuel test analysis

Appendix B.pdf