GIPPSLAND
Smart Specialisation

# The Gippsland Bioenergy Project Development Framework

## Gippsland Smart Specialisation Bioenergy Innovation Group

Framework co-owned by Wellington Shire Council and Latrobe Valley Authority on behalf of the Gippsland region

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EnviroMicroBio

WELLINGTON SHIRE COUNCIL
*The Heart of Gippsland*

LATROBE VALLEY AUTHORITY

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# ABBREVIATIONS

| | |
|---|---|
| ACFE | Australian Community Further Education |
| AEMC | Australian Energy Market Commission |
| AEMO | Australian Energy Market Operator |
| AQF | Australian Qualifications Framework |
| ARENA | Australian Renewable Energy Agency |
| ASQA | Australian Skills and Quality Authority |
| ATAR | Australian Tertiary Admissions Rank |
| BOT | Build-operate-transfer |
| CHMP | Cultural Heritage Management Plan |
| CMA | Catchment Management Authority |
| DB | Design-build |
| DBFO | Design-build-finance-operate |
| DBO | Design-build-operate |
| DELWP | Department of Environment, Land, Water and Planning |
| DoT | Department of Transport |
| DoU | Declaration of use |
| EES | Environmental Effects Statement |
| EPA | Environment Protection Authority |
| EPC | Engineering, procurement, construction |
| FIDIC | International Federation of Consulting Engineers |
| GED | General environmental duty |
| PAHT | Preliminary Aboriginal Heritage Test |
| PFAS | Polyfluoroalkyl substances |
| ROI | Return on investment |
| RTO | Registered Training Organisation |
| TAFE | Technical and Further Education |
| TRL | Technology Readiness Levels |
| VET | Vocational education and training |
| VPP | Victoria Planning Provisions |
| VRQA | Victorian Registration and Qualifications authority |
| WTIF | Workforce Training Innovation Fund |

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# SUMMARY


Following the closure of the Hazelwood power station and scheduled closures of Yallourn and Loy Yang A and B, and the Victorian Forestry Transition Plan, a plan to cease native timber harvesting by 2030, the bioenergy and biomanufacturing sectors represent potential growth sectors for Gippsland. The Bioenergy Innovation Group (supported by the Gippsland Smart Specialisation Strategy (GS3)) identified the need for a Gippsland Bioenergy Project Development Framework (Framework) to assist in the development of future bioenergy projects.

The Smart Specialisation approach originated in Europe to economically support regions undergoing transition. This approach depends on identifying a region's strengths and competitive advantages and targeting funding towards those areas which are most likely to succeed.

The development of a successful biomass-to-energy project requires a methodical approach and the navigation of a series of stages. This process can appear complex and requires careful preparation and adherence to a number of planning and environmental regulations. Further, engagement of community and other stakeholders is vital to the success of any bioenergy project.

The Framework report will provide assistance to those who wish to initiate, develop or invest in a biomass-to-energy project. It offers a technical, financial and environmental reference for a range of biomass-to-energy projects. The Framework also describes issues related to the sale of steam/heat and electricity and grid access, as well as biomass availability, sustainability and the supply chain. It links the social, technical and planning aspects of bioenergy production.

The Framework uses a practical Project Development Pathway to start a preliminary assessment of the technical and financial feasibility of different biomass-to-energy options.

The target audiences are businesses and industries for which biomass is a by-product, including (but not limited to) the food and beverage industry, the wood processing industry, forestry and agriculture and community groups.

The Framework can help these enterprises identify whether their biomass waste can be used for the production of energy and/or for biomanufacturing. In cases where low land use or poor soil condition is the primary driver, the growth of biomass crops may be an option to produce bioenergy.

The overall objectives of this guide are to:

- improve technical literacy around biomass and bioenergy
- capture the regulatory requirements for bioenergy projects in Gippsland
- build competence among key stakeholders to ensure bioenergy projects are delivered efficiently and effectively
- provide knowledge of the technical and financial feasibility of the different biomass-to-energy technologies available to business and industry
- assist in the expansion of biomass-to-energy sector across Gippsland by providing a communication and education packages.

# INTRODUCTION

Bioenergy is a form of renewable energy generated when biomass feedstock is processed using certain technologies. Biomass fuels come from organic materials such as harvest residues, purpose-grown crops and organic waste from homes, businesses and farms.

## What are biomass and bioenergy?

This Framework defines biomass and bioenergy in simple terms:

### Biomass

Any organic matter (biological material) available on a renewable basis.

Includes feedstock derived from animals or plants, such as wood and agricultural crops, and organic waste from municipal and industrial sources.

### Bioenergy

Energy generated from the conversion of solid, liquid and gaseous products derived from biomass.

*Figure 1: Definitions of biomass and bioenergy.*

This framework is focused on bioenergy which is created by using biomass-to-energy technologies to produce electricity and steam/heat from the combustion of solid, liquid and gaseous biomass fuels in high-efficiency and low-emission conversion systems.

It can also include biogas, where organic matter (such as agricultural residues and animal and food industry wastes) is converted into biogas through anaerobic digestion. The raw biogas can be combusted to produce electricity and/or steam and heat, or it can be transformed into biomethane and used as a substitute for natural gas in internal combustion engines.

Bioenergy is a sustainable solution that can reduce greenhouse gas emissions, assuming the use of secondary and tertiary biomass to substitute for the use of fossil fuels. Agricultural and forest-based industries can generate a substantial amount of biomass residue and that waste can be used for energy production.

In addition to harnessing waste biomass, crops can also be specifically grown for the production of bioenergy and bioproducts. The various forms of biomass and their sources (as considered in this Framework) are shown in Figure 2.

## Where does the biomass come from?

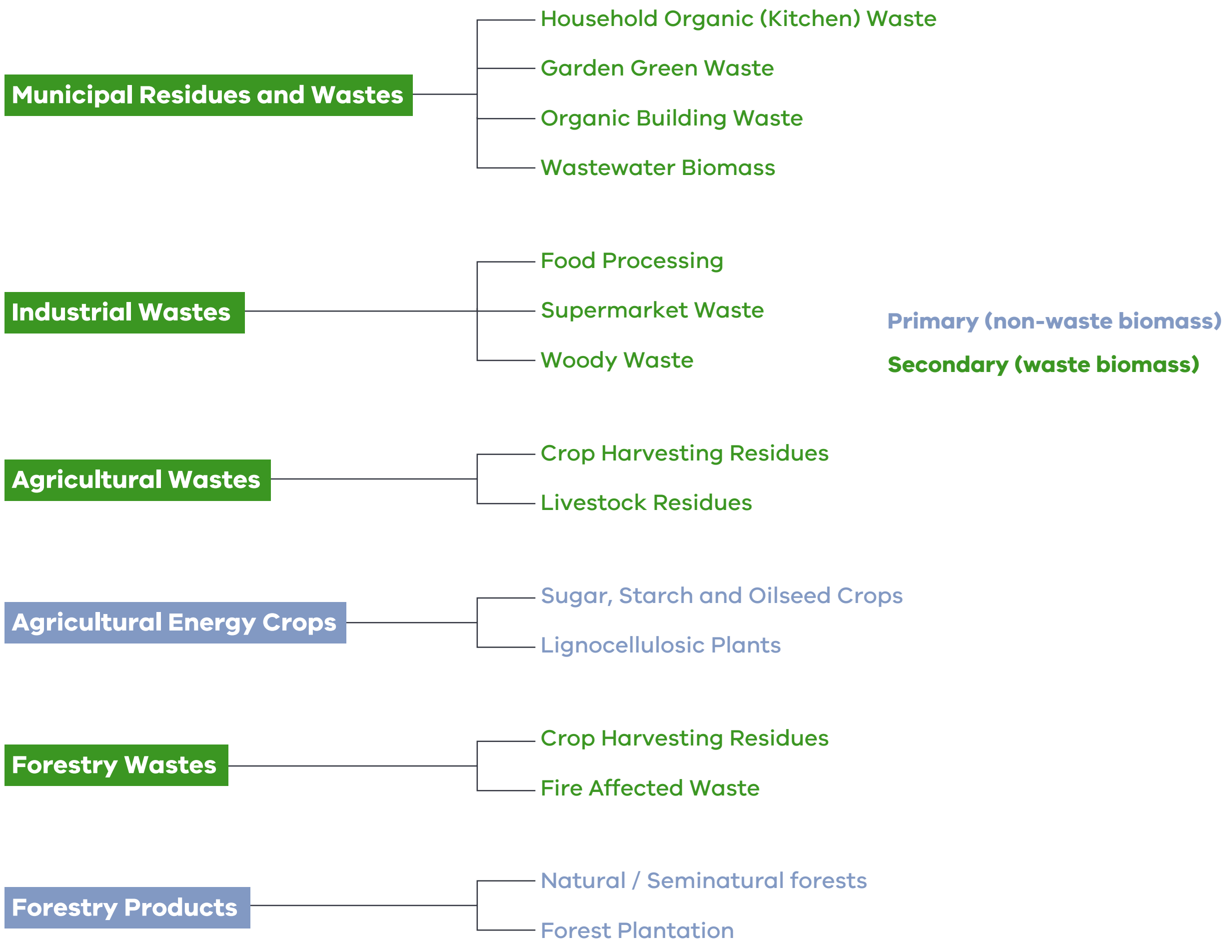



*Figure 2: Origins of primary and secondary biomass which may be used to produce bioenergy, highlighted by sector.*

# THE GIPPSLAND BIOENERGY DEVELOPMENT FRAMEWORK

Bioenergy and biomanufacturing have been identified as growth sectors through the GS3. This Framework is one of two areas of foundational work to support growth of these sectors and is designed to integrate the combined knowledge, interests and needs of stakeholders who were involved in, or impacted by, this sector's growth. The *Gippsland Biomass Audit and Opportunity Analysis* is the second foundational work undertaken through GS3 by Frontier Impact Group.

The deliverables for the Framework project consist of this report and three stand-alone support packs.

This report describes the necessary steps in the development of a successful biomass-to-energy project (bioenergy). It describes:

- biomass resources and how to secure biomass supply
- the relevant technologies, plant design, plant procurement, construction and operation
- Framework conditions, investment costs, financial and economic analyses and securing financing
- potential environmental and social considerations
- information relating to the procurement, construction and operation of bioenergy projects.

The main portion of the project (and thus this report) is the Project Development Pathway (Figure 4). The Pathway articulates the typical stages of project development, can help stakeholders identify the stage of their project and identify technical, regulatory and planning milestones. The Pathway enables more efficient planning, better understanding and a 'smoother' road for project development. A key part of this is to understand the requirements of stakeholders such as planners, regulators and economic development officers in the Gippsland councils and Victorian regulatory environment (Environment Protection Authority (EPA) Victoria, Department of Environment, Land, Water and Planning (DELWP), WorkSafe Victoria) and to capture these in one document.

The Pathway includes the *Bioenergy checklist* and *Bioenergy decision tree*. The checklist prompts the collection of basic background data. The checklist data then feeds into a decision tree that helps decide the bioenergy types that may be appropriate for particular feedstock availability, technology and siting.

The final part of the report is a *Skills and training analysis* which provides a description of the skills required to support the growing bioenergy sector. It locates sectors where such skills may already be available and where bioenergy-relevant training (tertiary and vocational) may be gained.

The three support packs (*What is Bioenergy?*, *Project Startup Guide* and *Social Risk Guide*) comprise a set of practical resources for stakeholders of bioenergy projects. These packs contain ready-to-populate bioenergy materials, a series of 'canvases' to help stakeholders shape their vision for a project and canvases to help evaluate social risk and encourage positive communication with the community. These packages are designed to be printed so that they can be completed as group activities. The use of these packages is prompted in the appropriate locations in the project Pathway.

More so than for other renewable energy solutions, each bioenergy project must be tailored both to the available biomass and a myriad of site-specific requirements. The resulting complexity adds to the time and cost of implementing a bioenergy solution but understanding the requirements can ultimately help ensure a successful bioenergy project.

# FRAMEWORK SCOPE AND BIOENERGY TECHNOLOGIES

The scope of this Framework is to provide a resource for project developers to progress their bioenergy project through a systematic process. It is particularly well-suited to those who are examining the development of small- to medium-scale biomass projects and projects seeking community ownership and benefit sharing. These circumstances have the potential to solve multiple problems for stakeholders (such as biomass disposal, nutrient management, odour control) and achieve economies of scale which make a project viable and share costs.

The main focus of this guide is on secondary and tertiary biomass types such as waste products from the food and beverage industry, the forestry and wood processing industry and agriculture. Growing of specific biomass crops is also an option to make bioenergy, but these projects are more capital-intensive as land and agricultural production need to be developed alongside investment in the conversion technology.

Anaerobic digestion and combustion are well suited to feedstocks which are combinations of wastes or substances which cannot be processed economically into higher value products. Anaerobic digestion is often the default bioenergy-producing treatment process for wet wastes (such as food processing organics and manures). Combustion is suited to mixed dry wastes. For the remaining four technologies the feedstocks generally have to be of a higher quality and purity. Figure 3 shows the four remaining technologies and the feedstock types which are commonly used with them.

This Framework focusses on six technologies with the highest technology readiness level:

- anaerobic digestion
- advanced combustion
- pyrolysis
- gasification
- transesterification
- fermentation.

There are other ways of producing energy from biomass but these six are proven technologies, are deployed in diverse locations globally and can be used on a commercial scale.

However, these technologies are not financially viable for all locations, feedstock types, equipment vendors or geopolitical/ regulatory situations. Furthermore, projects involving other technology types not listed above will involve greater financial risk, higher technical barriers and are likely to be more time consuming. It is also noted that projects which fit into this R&D category are not covered by this guide.

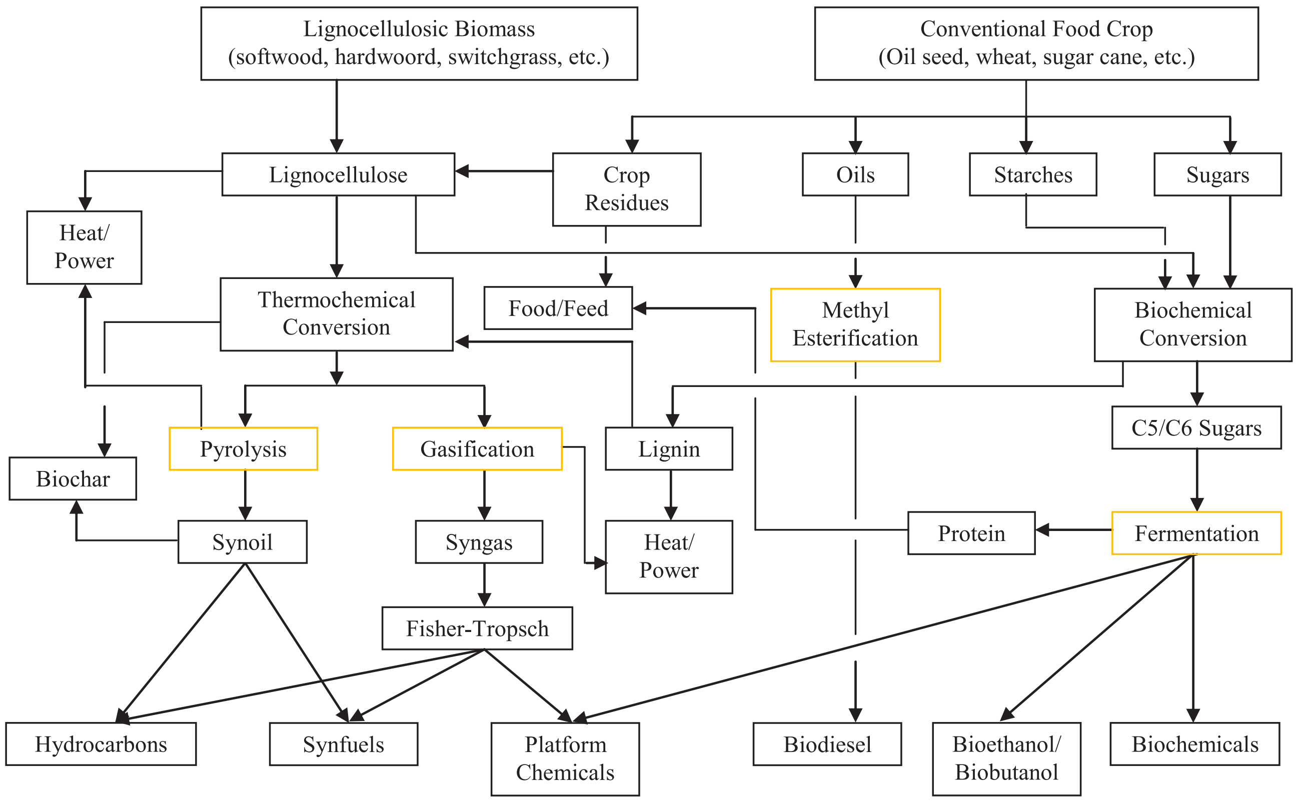



*Figure 3: The four liquid biofuel producing technologies in relation to the starting feedstocks and final products. Diagram taken from Liew, Hassim and Ng, 2014 but originally from Murphy et al., 2011. Yellow boxes are added in this report to highlight the four key technologies used to process higher quality and purity feedstocks.*

# Technology readiness level

Developed at NASA during the 1970s, Technology Readiness Levels (TRLs) are a method for estimating the maturity of technologies. The use of TRLs enables consistent, uniform discussions of technical maturity across different types of technology as determined during a Technology Readiness Assessment. This process examines program concepts, technology requirements and demonstrated technology capabilities and economically viable status. TRLs are based on a scale from 1 to 9 as shown in Table 1.

*Table 1: Technology Readiness Levels. Taken from https://demoplants.bioenergy2020.eu/explanations.html*

| Type | |
|---|---|
| *refers to technology readiness level (TRL)* | |
| TRL 1-3 Research | 1. basic principles observed<br>2. technology concept formulated<br>3. experimental proof of concept |
| TRL 4-5 Pilot | 4. technology validated in lab<br>5. technology validated in relevant environment (industrially relevant environment in the case of key enabling technologies)<br>In terms of biofuel facilities, this typically means<br>• facility, which does not operate continuously<br>• facility not embedded into an entire material logistic chain; only the feasibility of selected technological steps is demonstrated<br>• the product might not be marketed |
| TRL 6-7 Demonstration | 6. technology demonstrated in relevant environment (industrially relevant environment in the case of key enabling technologies)<br>7. system prototype demonstration in operational environment<br>In terms of biofuel facilities, this typically means<br>• facility demonstrating the capability of the technology for continuous production (operated mainly continuously)<br>• the facility is covering the entire production process or embedded into an entire material logistic chain<br>• the product is being marketed<br>• facility may not be operated under economical objectives |
| TRL 8 First-of-a-kind commercial demo | 8. system complete and qualified<br>In terms of biofuel facilities, this typically means<br>• facility operated under economical objectives<br>• the product is being marketed |
| TRL 9 Fully commercial | 9. Actual system proven in an operational and competitive environment |

The technologies included in this Framework are all confirmed as scoring a TRL of 9. It should be noted that this is for the technology itself and not necessarily for their use with any given feedstock, or for any specifically targeted output product. The TRL 9 rating shows that the system type is operational and proven to be economically viable. This does not necessarily mean that it is economically viable on the basis of bioenergy production alone.

Often such projects are made viable by a range of localised factors such as:

- the technology use results in significant reduction of landfill fees for disposal of wastes
- the technology use results in reduction of trucking costs for wastes
- the technology use in a given situation is able to provide a specific high-quality niche product for which a market has been secured
- plants in less developed countries generally have lower labour costs and therefore tasks such as manual pretreatment sorting are not prohibitive in cost
- the price of electricity/gas is higher in some regions or bioenergy does not attract tax excise
- the existence of carbon credits or a carbon price.

# Scale of bioenergy plants

This Framework categorises plant sizes, as biomass-to-energy projects are subject to different planning and approval requirements. Further, there are significant economies of scale associated with bioenergy projects. The projects are classified as:

- small (1–5 megawatt electrical (MWe))
- medium (5–10 MWe)
- large (10–40 MWe).

Projects with less than 1 MWe and those in the small category are unlikely to be economically viable if energy production is the only benefit factored into the cost. A project becomes more viable if additional benefits such as waste volume reduction, reduced chemical use, reduced transport costs, odour reduction, nutrient cycling and soil carbon building are factored into the project's cost-benefit analysis. Some of these costs (e.g. waste reduction and chemical use) are easily quantified, while others are less clear (e.g. soil health, odour management). There is a range of intangible benefits which may include community cohesion/pride and scientific or educational value.

## Determining the size of a plant

Once the amount of biomass residue has been identified and quantified the approximate plant size (expressed as electrical output for a steam-based power plant in full condensing mod) can be calculated:

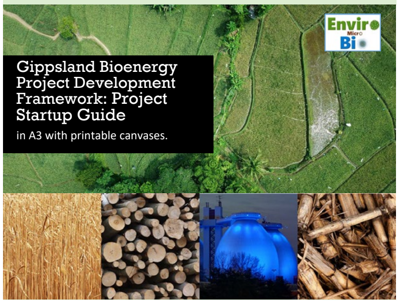
$$P = \frac{0.278 \times M \times H_u \times e}{T_o}$$

Where:
*P* = plant size (MWe)
*M* = mass flow of biomass (tonnes/year)
*Hu*= net heating value (MJ/kg)
$T_o$ = annual operating hours
*e* = plant efficiency (typically between 35 per cent and 40 per cent)

Varying across the technologies, there are significant economies of scale when comparing small and large bioenergy plants. This is important when carrying out financial and economic analyses as the marginal cost of producing one kilowatt hour decreases as the size of the bioenergy plant increases. Thus, subject to availability of sufficient volumes of biomass and demand for the produced energy, a larger plant will generally be more cost-efficient than a smaller plant.

# PROJECT DEVELOPMENT PATHWAY INCORPORATING CHECKLIST AND DECISION TREE

To guide you through the pre-feasibility portion of the process we have developed a **Project Start-up Guide**. This is an A3 printable package containing a series of exercises on 'canvases'.




As shown in Figure 4, the realisation of a bioenergy technology project can be analysed in four discreet phases. As each phase progresses, the level of detail and information required increases. At the conclusion of the first two phases it should be apparent whether the project is financially and technically feasible and should then move into implementation:

- **Phase 1: Pre-feasibility.** This analysis involves initial calculations using default data and assumptions. Only the most critical process units are considered for calculation and the operational regime (i.e. continuous or batch) is decided. Interaction with stakeholders and gauging community support also starts at this phase (engagement and input should continue regularly at all subsequent stages of development).
- **Phase 2: Feasibility.** The feasibility study uses more detailed information and process designs and considers all types of operation involved in processing. It also defines other operational details, such as feedstock and reagent suppliers and potential plant locations.
- **Phase 3: Design.** This phase involves final calculations and designs of equipment, building sites, equipment installation, internal configurations, modes of operation, stabilisation times, building permissions and environmental licences. This phase also includes an early exploration of the job/role training that may be required for the operators. At the conclusion of the design phase all the design, tendering and procurement documentation should be complete and engagement with the construction market can begin.
- **Phase 4: Build and operate.** Build and operate commences with the appointment of a preferred contractor through an appropriate procurement process and finalisation of the construction contract(s). Construction is the responsibility of a suitably qualified contractor and will include construction activities, site management, environmental management, health and safety management, community engagement and commissioning of the plant in line with expectations. After commissioning, the plant is handed over to the operator and the plant enters its warranty period as per any contractual agreements.

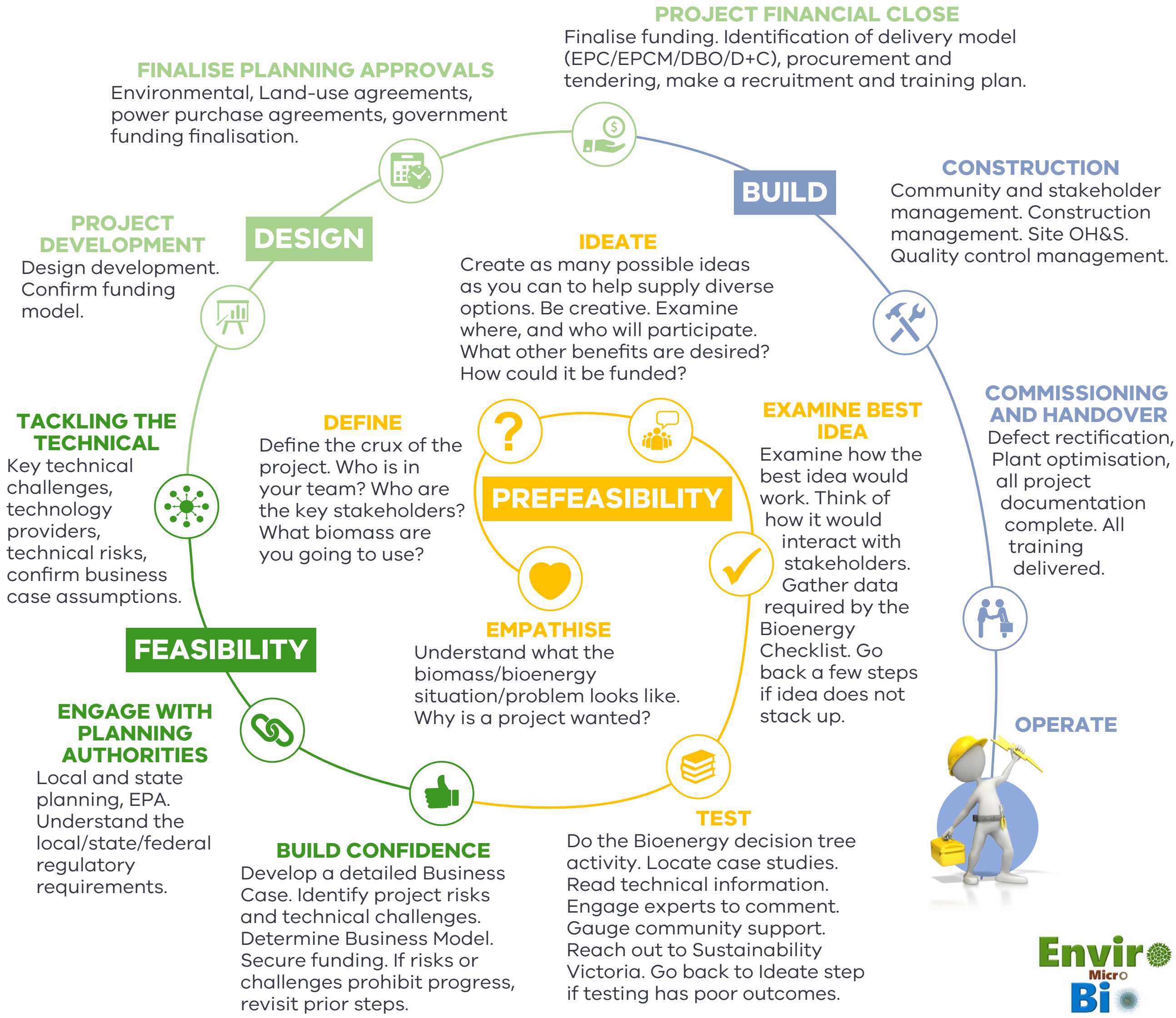



*Figure 4: The Pathway in graphical format. This report expands on each of these sections.*

# Design thinking

We have incorporated 'design thinking' into the initial stages of potential bioenergy project development. These activities ideally happen during the pre-feasibility phase of the project. This sort of thinking process is intended to supplement the more linear 'pathway' model which is detailed at length in this document. Its inclusion is deliberately intended to encourage creativity and iterative re-invention. No project ends up looking like the first idea and it should not be seen as failure to re-tread old ground and try out many different ideas.

Design thinking is both an ideology and a process, concerned with solving complex problems in a highly human-centred way. It focusses on humans first and foremost, seeking to understand people's needs and come up with effective solutions to meet those needs. It is based on the methods and processes of designers, but it evolved from a range of different fields, including architecture, engineering and business.

Design thinking can address the underlying causes of project failures, such as poor communication, rigid thinking, the propensity for tunnel vision and information silos. When done well, design thinking not only celebrates diversity, but actively seeks to bring diverse groups together and allows competing viewpoints to become opportunities. By emphasising the diversity of the design team involved in the process beyond the designers, the artefacts and the space they share, design thinking represents an effective and practical approach to managing stakeholder interactions in exploration of projects. Another key part of design thinking revolves around the idea that people's needs are at the heart of every successful endeavour.

Stakeholder engagement is important in any project. However, the human-centred co-design approach puts these stakeholders at the centre of the project rather than on the periphery. While this process may take longer at the pre-feasibility stage, it is likely to decrease social risk and facilitate greater community ownership in the longer term.

Government departments around Australia are now taking on design thinking as their driver for transformation strategy and exploring how to improve what they offer through an evolved dynamic, customer-focussed organisation model (Dam and Teo, 2020).

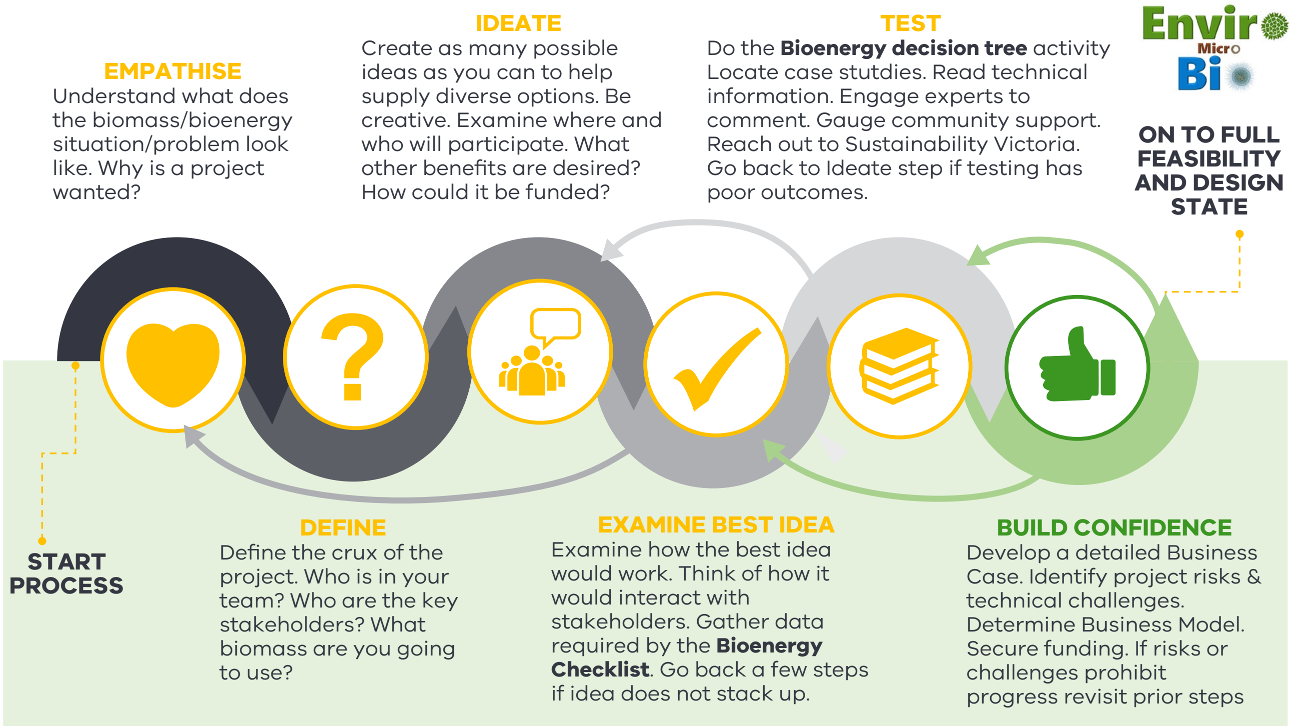


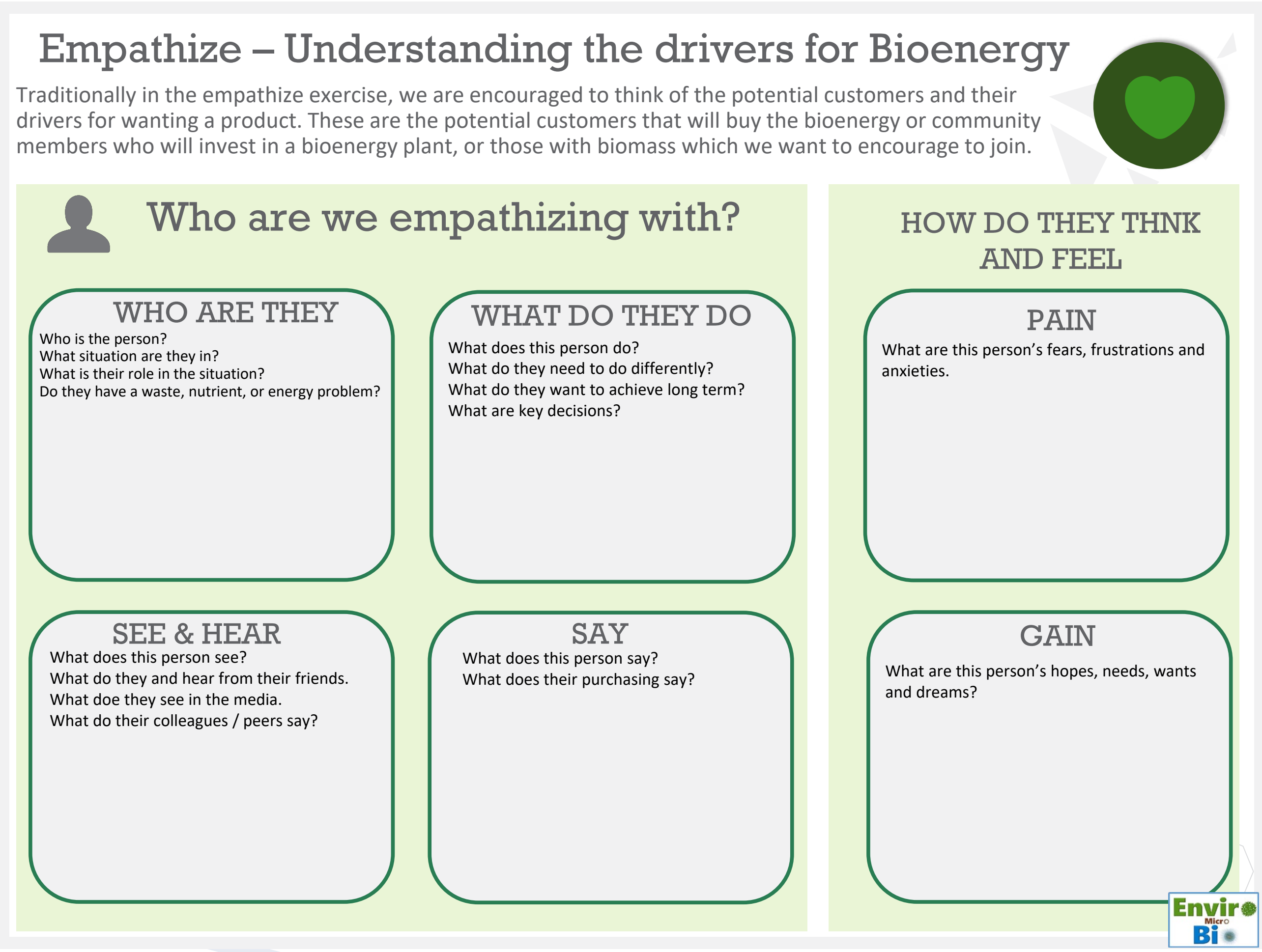

*Figure 5: Design thinking for bioenergy projects. Yellow indicates a prefeasibility, green indicates feasibility.*

# PHASE 1: PRE-FEASIBILITY

## Empathise

All bioenergy projects begin with a problem that needs solving or an idea of how things can be done better.

The issue may be demand for electricity, biogas, process steam or heat. It may be the desire to reuse available biomass residues from an organic waste from domestic, commercial or industrial premises, forestry activities or agricultural food production. Alternatively, the idea could be driven by local, state or national government policy to achieve greenhouse gas reductions or the development of a circular economy by replacing dependence on fossil fuels.




The *Project Start-up Guide* contains an exercise to ask questions to help understand the existing needs and who you may need to work with to complete your project. It allows you to empathise with those who may have needs in this area.

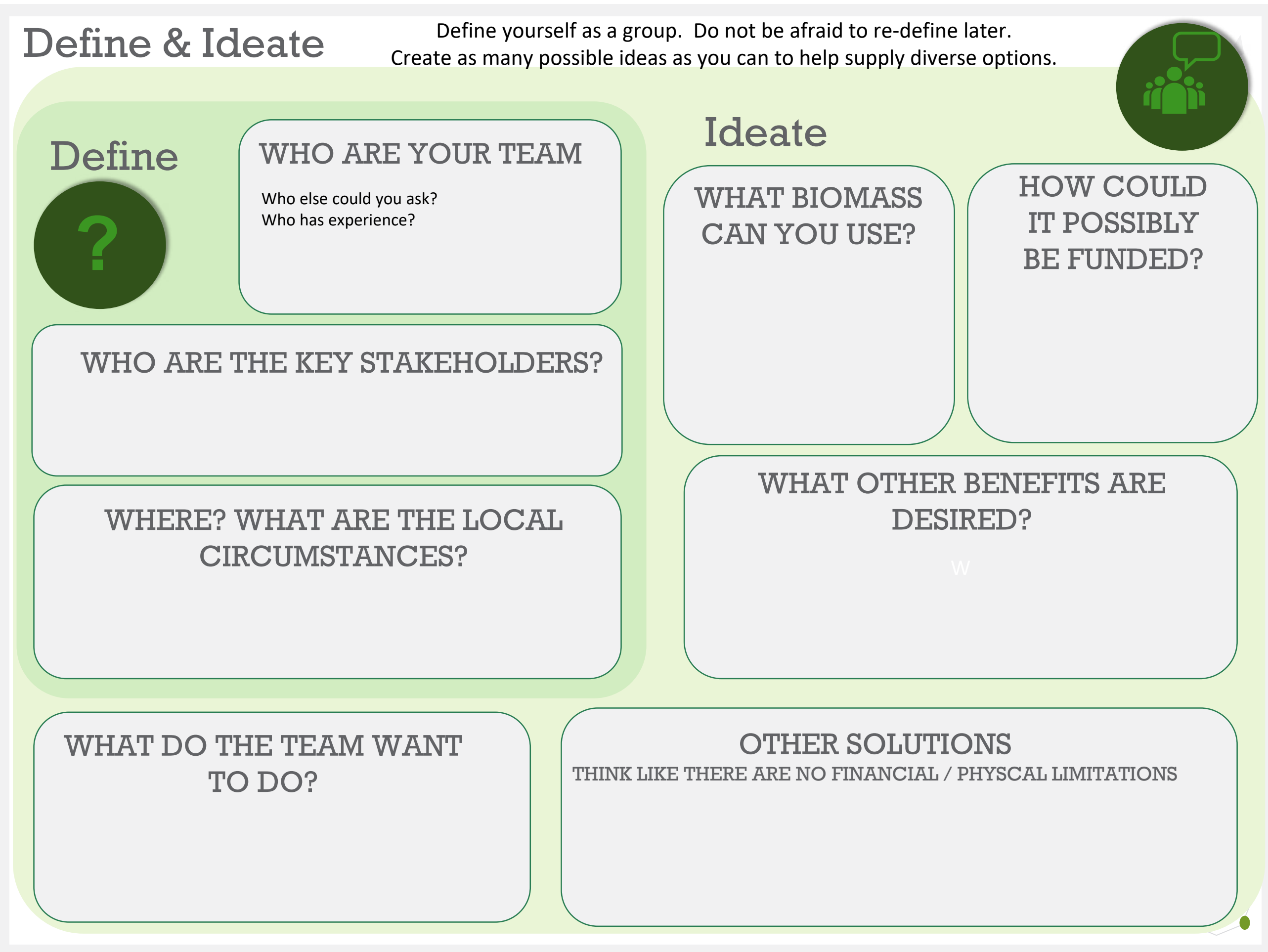
This includes:

- Who may want to purchase bioenergy?
- Who might want to purchase the biotechnology co products?
- Who has biomass in the local community?
- Who may want to invest in bioenergy?
- What other problems exist that may be solved by a bioenergy/biomass project?

## Define

During this stage of the project, you will need to define the crux of the project:

- Who is in your team and their expertise?
- What expertise gaps do you need to find or develop?
- Who are the key stakeholders?
- What biomass are you going to use?
- What are the local circumstances that allow/demand a project?



# Ideate

At this stage, create as many ideas as possible to help supply diverse options. Be creative. Examine where and who will participate. What other benefits are desired? How could it be funded?

The availability, amount and type of biomass will determine the types of technologies appropriate for the specific bioenergy project. Figure 6 shows a conceptual flow chart for biomass waste and biomass crops to bioenergy production.

## Generic Conversion of Biomass to Bioenergy

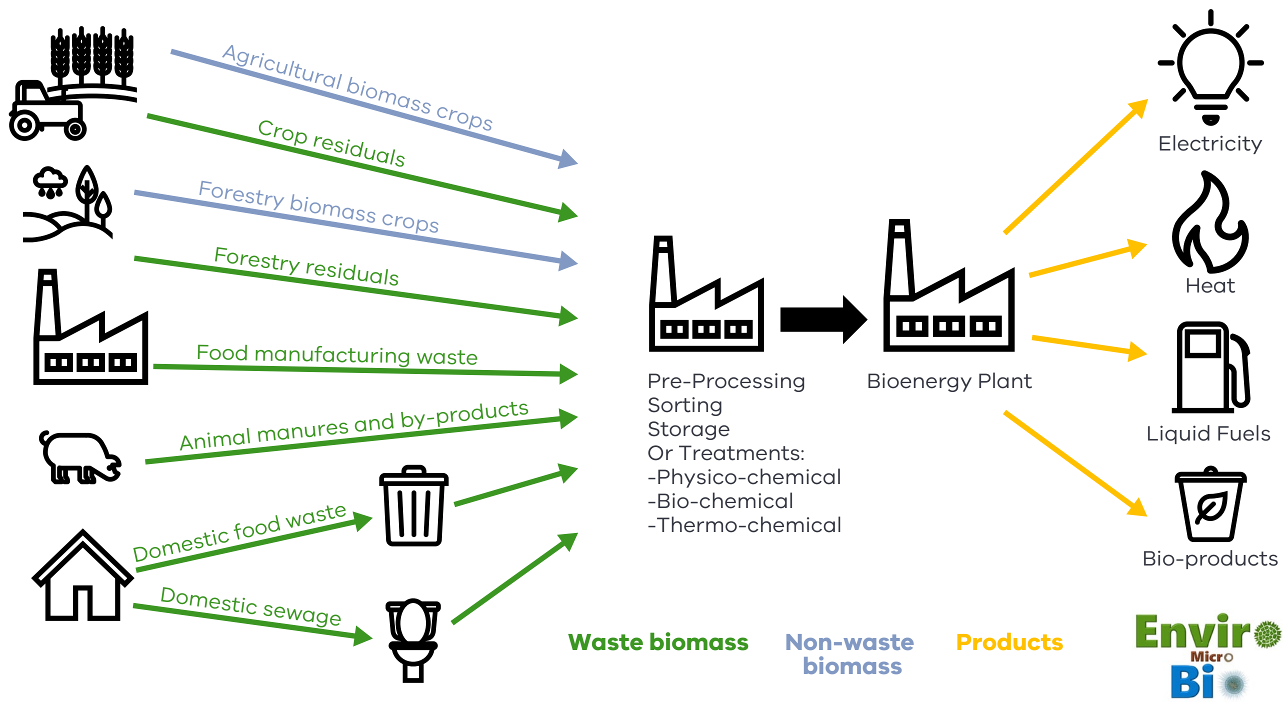



*Figure 6: Generic process of conversion of biomass to bioenergy.*

The initial idea will need incubation, socialisation and transformation into a preliminary technical concept and plant design, including:

- fuel (biomass) type and sourcing
- site location
- project size
- technology selection.

We have provided a *Start-up Guide* canvas to help you at this stage.

# Examining the best idea

Once you have narrowed down the options it is time to examine how the best idea would work. Incorporate data by using the *Bioenergy Checklist* (Figure 7) from the *Start-up Guide*. Engage with key stakeholders regarding your idea and use their feedback to help you model the way forward.

## Bioenergy Framework Checklist

This checklist is intended as a prompt for you to gather essential information about the biomass at your disposal and the potential site for your project. It is by no means an exhaustive list of required information, but it should help you to start thinking about the most important factors.

| Bioenergy Checklist | Answer |
|---|---|
| Do you intend to grow a biomass crop? If so which one suits your conditions? | |
| Is the main project driver to do with waste, nutrient, water or energy? | |
| How much organic material do you have? What is it on a dry weight basis? | |
| What are the waste or biomass material characteristics? | |
| Is the biomass liquid, wet or dry? What are handling implications of this? | |
| What is your moisture content? | |
| Is it readily combustible? | |
| Is it a continual supply, or seasonal in nature? If seasonal can you store it? What is the cost associated with this? | |
| Do the biomass properties change over the year? | |
| Where is your biomass compared to where you want to use it? What equipment is required to gather and handle it? | |
| Are there any potential OH&S issues with the biomass? (for example, sulfide production, flammability, biohazards) | |
| Is there potential contamination (metals, trace organics, asbestos, plastics / glass, Polyfluoroalkyl substances (PFAS))? | |
| Are there other sources of biomass in the area which may complement your biomass? | |
| What energy demands are there on your site? | |
| Is the network in your area capable of receiving generated electricity? | |
| Is your site located in a 'sensitive area' (environmental, cultural, social, historical, proximity)? | |

*Figure 7: The Bioenergy Framework Checklist.*

If your answers to the checklist indicate that there are issues with your idea, don't be worried about going back a few steps in the Pathway and rethinking. If the idea seems sound, you can expand on the themes in the checklist. There are many key questions to be answered during prefeasibility, especially concerning biomass, including those below.

## Biomass resources in Gippsland

Biomass resources are readily available in Victoria. Energy produced from biomass can reduce reliance on the existing electricity and gas grids, replace fossil fuels used by local industries and reduce greenhouse gas emissions.

The Australian Biomass for Bioenergy Assessment scheme, funded by the Australian Renewable Energy Agency (ARENA), has performed an assessment of biomass Australia wide. The results for Victoria are available at Gippsland ARENA data.

In this report Gippsland has been identified as having an estimated 793,720 tonnes of organic waste (2014–15). *The Gippsland Biomass Audit and Opportunity Analysis* (the sister project to this Framework by Frontier Impact Group) delivers more detail around biomass sources and potential sites for projects in Gippsland.

The region is already home to Opal, Australia's Maryvale Paper Mill (formerly Australian Paper) which is Victoria's largest generator of baseload renewable energy. In this system, black liquor (lignin dissolved in caustic) is burned to produce electricity and recover the chemicals for reuse.

## Biomass types and qualities

Biomass crops are grown for the purpose of creating bioenergy/bioproducts. In this case the crop/s must be carefully chosen and matched to the location and desired bioproduct. Information such as plant selection and their attributes, water and fertiliser requirements, salinity and temperature tolerance must be well defined, as well as its weed status. Chosen strains should be grown under trial situations to test and evaluate anticipated yields and harvest times.

Secondary/waste biomass sources include crop residuals after the bulk of a crop is harvested for food or fibre. In these cases, the by-products are used for energy production and can include materials such as straw, husks, shells, pruning waste etc. Similarly, for woody biomass the main crop is not used for energy generation (for example, wood is harvested for use as timber or paper production), while timber harvesting by-products can be used for energy generation. Other secondary sources are any organic by-products from animal production, such as slurry from pig farming or animal fats collected during abattoir operations.

To help understand your biomass resources consider:

- Are biomass resource records up to date?
- Are you planning to grow biomass crops?
- Are you using wood products and forestry residues as your biomass source?
- Do you have relevant characterisation information on your biomass and how it will impact the technology selection and energy potential?
- Are there any municipal and/or industrial organic waste streams available?

- Do you have characterisation information on locally available industrial, commercial and municipal wastes?
- Have you carried out a waste hierarchy review?
- What are the current land uses for arable, forest and pasture?
- What underutilised land is available?
- Can underutilised land be used for food production?
- Have you assessed if biomass cultivation is the most preferable use of the land?
- What are the current production levels and uses of local biomass resources?
- What is the current use of the biomass resources?
- Is there a biomass market or are costs stable?
- How will biomass and biofuel developments affect water resources, soil quality and carbon sequestration?

Once the biomass resources have been identified, it is important to determine their physical and chemical characteristics. This will help assess the energy output when applying different technologies and estimating the associated investment and other costs. The key characteristics which need to be understood are:

- moisture content
- biomass quantity
- frequency of biomass availability
- biomass form: chips, logs, bales, solid, liquid
- bulk density
- ash content
- approximate chemical composition (carbon, nitrogen, phosphorous)
- level of contamination (plastics, glass, metals, trace organics)
- calorific value (if combustion is anticipated)
- biochemical methane potential (if anaerobic digestion is anticipated).

To help understand biomass and bioenergy markets, consider:

- How does the cost of locally-produced bioenergy compare with current alternative local energy sources?
- What are the current market trends in the production of green energy?
- Could bioenergy affect the profitability of food crop and woodland production?
- Will this impact food security?
- Is there a bioenergy supply chain and how is it structured?
- Are there opportunities for potential synergies with existing commercial, municipal and industrial activities?
- Are you aware of the current regulatory framework affecting bioenergy projects?
- Are you planning on transporting biomass? If so, have you considered biosecurity issues?

## Test

At this point you should have a very detailed picture of your biomass and you probably have some ideas about the technology you may want to use to make bioenergy.

We have produced two *Bioenergy Decision Trees* (dry biomass decision tree (Figure 8) and wet biomass decision tree (Figure 9) to help guide developers, technology suppliers and biomass producers to the technologies which suit different circumstances. The decision trees identify key factors which influence the viability of a project and flag some risks.

## Technology options

The *Bioenergy Decision Tree* is designed to guide you to the most appropriate technology for your biomass type and volume, but it also asks about your preferred form of bioenergy. As discussed above, this guide focusses on the six technologies with the highest technology readiness level:

- anaerobic digestion
- advanced combustion
- pyrolysis
- gasification
- transesterification
- fermentation.

Please note that this does not automatically mean that these technologies are financially viable for any specific locations, feedstock types, equipment vendors or geopolitical/regulatory situations.

Furthermore, there are three other decision tree endpoints:

- The food security need is greater than bioenergy.
- There is an opportunity to integrate with other bioenergy project.
- You are attempting an R&D project.

### Food security is a greater need than bioenergy

The initial global wave of bioenergy largely generated bioethanol and biodiesel from food crops (corn, wheat, sugar beet and oil seeds). While this successfully introduced the idea of bioenergy, it competed directly with food production (Liew, Hassim and Ng, 2014). This 'food versus fuel' conflict created undesirable social, environmental and economic impacts. Subsequent generations of biofuel have moved away from direct competition, recognising that food production is more important to society than fuel production.

### Opportunity to integrate with other bioenergy projects

If you have arrived at this end point it means that you:

- do not have sufficient biomass to justify the required capital expense based on your feedstock alone
- may have enough biomass but your production of this biomass is temporary (for land remediation purposes)
- have sufficient biomass but it is not able to be stored economically to produce bioenergy over enough of the year to make the project viable.

### You are attempting an R&D project

While there are other ways of producing energy from biomass, if you choose a technology outside of these six technologies you will need to undertake a substantial degree of research and development to establish the technological and later financial viability. This will involve greater financial risk, higher technical barriers and is time consuming. Projects which fit in this R&D category are not covered by this guide and we suggest that you engage with a university or research consultancy.

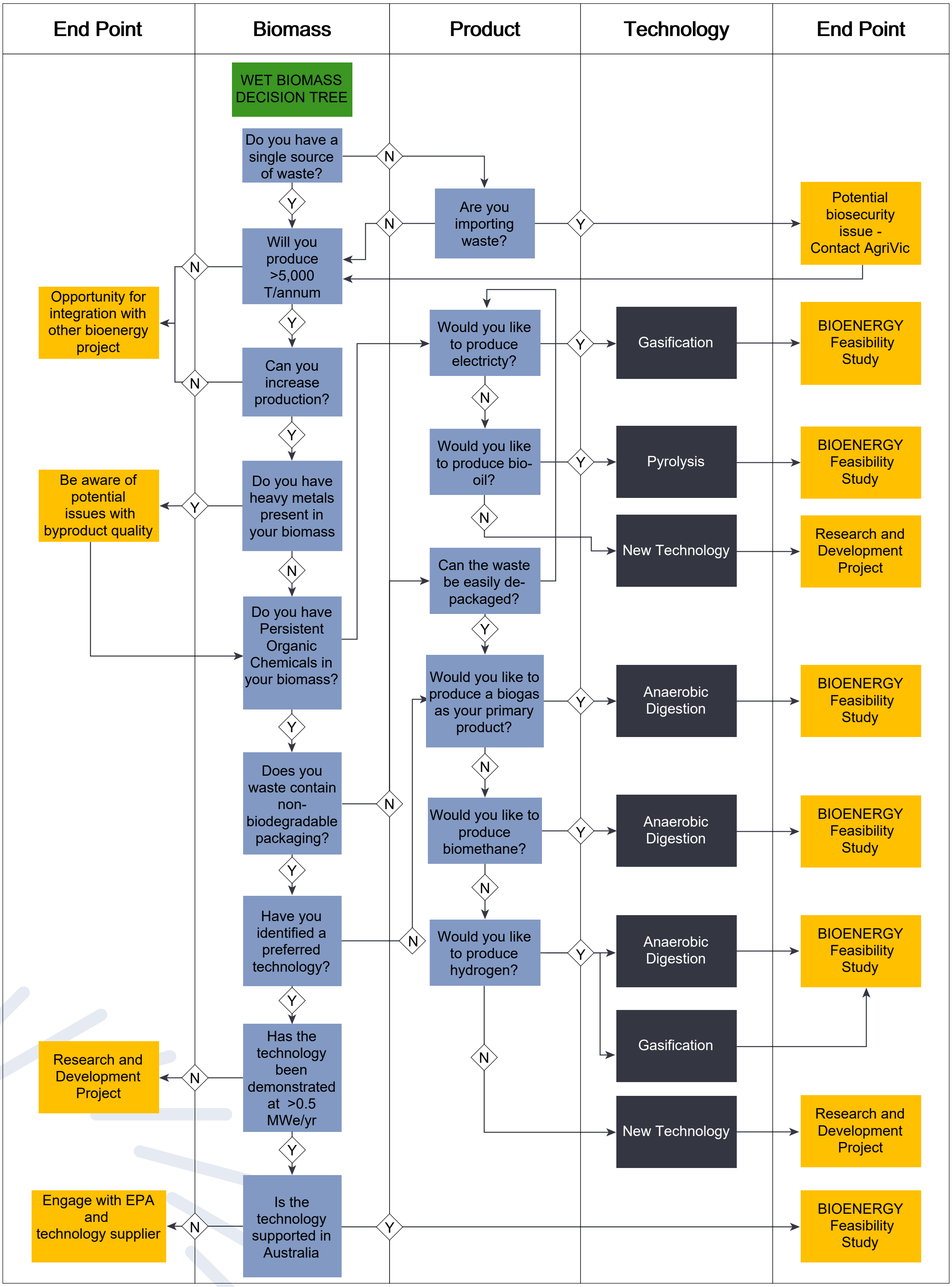



*Figure 8: Dry biomass technology decision tree.*

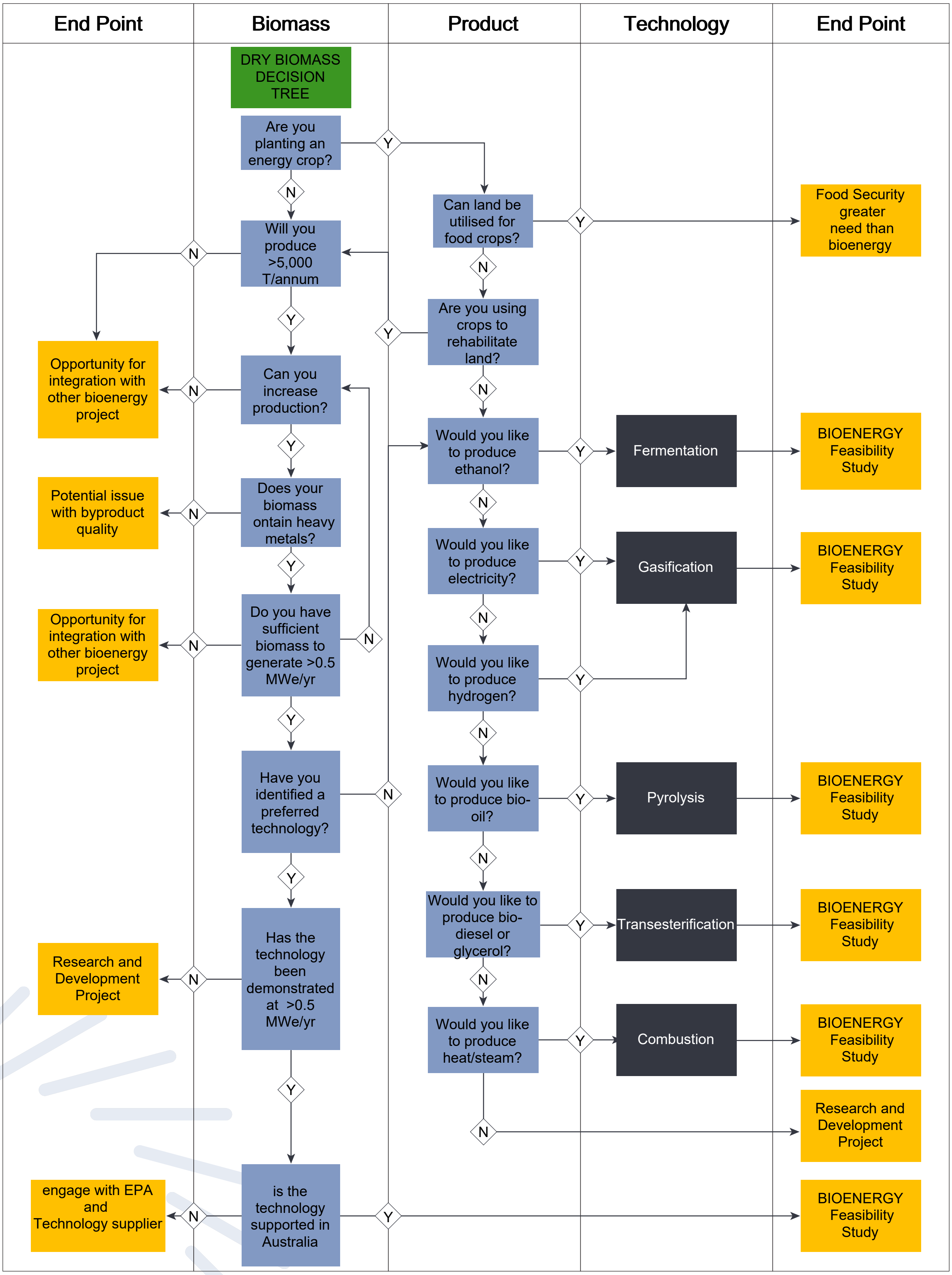



*Figure 9: Wet biomass technology decision tree.*

## The six technologies

Below is a brief overview of the feedstocks, products, benefits and drawbacks of each of the six technologies. This information is generic in nature and provided primarily to assist in use of the decision trees. This information does not replace the need for independent research and verification for each project.

Please note that terminology (particularly around liquid fuels: biodiesel, biofuel, renewable fuel, bioethanol) can refer to differing things. Combustion, gasification and pyrolysis are listed as three separate technologies, but there is often some overlap.

### Anaerobic digestion

Anaerobic digestion is a natural process in which microbes (bacteria and archaea) convert organic material to biogas (methane and carbon dioxide) in the absence of oxygen.

Biogas can be burnt to produce electricity, heat or steam. It can be converted into biomethane or hydrogen

A wide range of feedstocks can be used. Most commonly these are moist substances like sewage sludges, food waste, animal manures and industrial wastes.

A range of reactor styles and sizes can be used to suit the type and volume of feedstock.

Anaerobic digestion can have a range of benefits other than bioenergy production.

They reduce biomass volume, decrease chemical use and the digested biomass is called 'digestate' and can be cycled back to farms as a fertiliser.

*Figure 10: Summary of the characteristics of anaerobic digestion.*

Products: Biogas, digestate (treated biomass)

Reasons to choose anaerobic digestion technology:

- it is a good choice for wet feedstocks as no energy is expended to dry feedstocks before the process can begin
- it can deal with mixtures of feedstocks and variations in feedstock type (although the process works best when changes are introduced gradually)
- it does not need any energy inputs (although use of biogas for temperature control may be advisable in some cases)
- it can destroy weeds and pathogens in the feedstock
- it produces digestate which can be applied to land as fertiliser (thus it can help manage nutrients).

Anaerobic digestion complications and considerations:

- There is potential for odour related to handling of feedstocks and its management will require design effort and incur infrastructure costs.
- The degradation of organic feedstocks high in nitrogen will result in high ammonia levels in the digestate and its handling and/or distribution will require careful consideration.
- A hazardous zone will be created around the digestion unit and engineering. Procedural controls (and stringent adherence to them) will be necessary.
- The production of electricity requires a cogeneration engine which can be capital-intensive and expensive to maintain.
- Any non-biologically degradable materials (plastics, metals etc.) will be present in the final digestate. These will need to be separated or the digestate will be contaminated.

For export of the energy, an alternative to electricity is gas-to-grid. Biogas can be upgraded and turned into biomethane. Gas to grid projects can be complex since there are specific gas quality standards covering methane, carbon dioxide, hydrogen sulfide and moisture content as well as requirements for odourisation and gas grid injection. The process of turning biogas into biomethane involves the removal of contaminating compounds (water vapour, hydrogen sulfide, siloxanes, hydrocarbons, ammonia, oxygen, carbon monoxide and nitrogen) and the upgrading of the calorific value by separation of carbon dioxide from methane (Ryckebosch, Drouillon and Vervaeren, 2011).

Production of gas to put into the grid requires constant online monitoring of all these factors (and gas flow) to enable assurance and correct billing. The capital cost of the necessary equipment is in the order of hundreds of thousands of dollars and is maintenance-intensive.

A gas-to-grid project usually requires involves a gas energy infrastructure business that understands these complexities and has established relationships with gas grid operators. Although gas-to-grid is likely to become one main ways bioenergy is used in future, there is currently no mainstream or documented process. However, there are pilot scale projects underway in Australia.

### Advanced combustion

Highly controlled combustion processes operate in the presence of oxygen at a high temperature (800–1000° C).

Thus they efficiently convert solid/woody biomass into steam which can then produce electricity and heat.

A wide range of solid feedstocks can be used. Most commonly these include agricultural residues, forestry wastes, the organic fraction of domestic wastes, digestate from anaerobic digestion or specially made biomass pellets.

Combustion massively reduces the volume of most wastes, leaving only ash. This reduces landfill volumes.

Biomass combustion technologies can help reduce reliance on fossil fuels.

*Figure 11: Summary of the characteristics of advanced combustion.*

Products: Heat, steam, carbon dioxide and ash

Reasons to choose advanced combustion:

- Advanced combustion can be used to meet on-site heat or steam demand.
- Conversion of organic material to energy leaving only inorganics (reducing volume to landfill).
- Can be used with diverse feedstocks (although solids are preferred).
- If you have a requirement for carbon dioxide (e.g. protected cropping or industrial process).
- A wide variety of sizes of combustion unit is available, but needs to be sized correctly for your biomass supply.
- Combustion of non-renewable resources can be considered to supplement biological sources.

Advanced combustion complications and considerations:

- Depending on what you are burning, the ash may need to be disposed of in landfill due to contamination.
- Will produce carbon dioxide ($CO_2$), nitrous oxides (NOx) and sulfur oxides (SOx) as combustion involves reaction with oxygen, therefore this option is not as environmentally advantageous as some others.

## Pyrolysis

Pyrolysis is the heating of generally dry biomass in the absence of oxygen.

This process causes the biomass to decompose into a range of by-products which vary according to the temperature used and source of the feedstock (including biochar, wood vinegar and bio-oils).

A wide range of solid feedstocks can be used. Most commonly these include agricultural residues, forestry wastes, specially grown crops. Some crops can produce specific and valuable products when pyrolysed.

Biochar is a by-product which has a proven role in helping build soil carbon and can have a range of higher value uses.

Wood vinegar (condensate) has agricultural application.

Bio-oils can be further processed to bio-diesel.

*Figure 12: Summary of the characteristics of pyrolysis.*

Products: Biochar, bio-oils (can be made into biodiesel), wood vinegar

Reasons to choose pyrolysis:

- You wish to generate bioenergy even though exporting energy from your site is prohibitively difficult.
- You have identified a high-value biological oil/grade of biochar that can made from your feedstock.
- You have a large volume of relatively clean biomass which will produce dependable quantities and quality of products.
- You need biochar to build soil carbon and can use wood vinegar to assist in crop fertilisation.
- Pyrolysis plants come in many different types and sizes.

Pyrolysis complications and considerations:

- Pyrolysis products have an immature market in Australia and you may have difficulty selling your products.
- Pyrolysis is a technical process and minor variations (in feedstock, conditions or timing) may produce inconsistent products.
- For consistent product you require consistent feedstock with year-round availability (beware of seasonal property changes or effects of feedstock storage).
- Heavy metals present in your feedstocks will most likely concentrate in the biochar.

Pyrolysis can produce a range of bioproducts (biochar, wood vinegar, bio-oils) which may provide a source of income. However, the market for these products in Australia is very immature. We do not recommended relying on the sale of these products to support a business case unless you have a contract and are certain you can meet any quality requirements with your chosen technology. You should pilot your technology on your specific feedstocks, or at minimum run a lab-scale test to reduce the risk to your project. We also strongly recommend working backwards from a product which is in demand and determine if any technologies will make your biomass into that product. However it may not be amenable.

*Biochar*

Biochar is the solid which remains after pyrolysis. The properties of this depend greatly on the feedstock and the time and temperature of the pyrolysis process. Biochar is a good soil amendment to boost soil carbon. The structure of the biochar provides an environment for microbes to populate which also boosts soil health. Biochar can also be processed to make activated carbon for filtration of air and water and adsorption of pollutants.

*Bio-oils*

There is considerable variation in the terminology for various liquid fuels derived from biological/ renewable sources. Bio-oils (sometimes called biocrude) from pyrolysis can be converted into biodiesel or renewable fuels/oils. The properties of these vary based on feedstocks, the specific technology and conditions applied. Generally, the aim is to directly replace fossil fuel-based products and not require specialised equipment to use them.

These bio-oils may be sold 'as is' but will require purification and further processing to become useful end products. In their original state they can be highly corrosive and contaminated with water and biochar. Processing requires equipment, chemistry knowledge and skills. This may be viable on a small scale for some specific high-value products, but economically viable projects generally require large-scale production.

*Wood vinegar*

Wood vinegar is an acidic (pH 2.4-3.0) amber liquid condensate produced during pyrolysis. It can contain a wide range of organic acids and alcohols, the most common of which are acetic acid and methanol. The composition and properties of wood vinegar depend on feed source materials as well as the method (time/temperature) of the pyrolysis.

The claimed uses of this liquid are numerous but are mostly confined to agricultural use for partial replacement of fertiliser and insecticide, as well as a base source of acetic acid and methanol for industrial use.

## Gasification

Controlled $O_2$

Gasification is a highly controlled processes which operates at temperatures in excess of 700°C in the presence of controlled amounts of oxygen and or steam.

The process produces gas called syngas ($H_2$ and CO) and biochar (a solid product).

$H_2$

In the gasification process, the input biomass is not a fuel, but a feedstock for a high temperature chemical conversion to syngas and biochar.

Syngas may be burned directly in gas engines, or used to produce methanol or purified to hydrogen.

Gasification is more efficient than combustion at converting biomass to energy. The low oxygen conditions also mean that it is superior to combustion for the control of emissions such as SOx, NOx and dioxins.

*Figure 13: Summary of the characteristics of gasification.*

Gasification is the high temperature conversion of carbon-containing matter to syngas ($H_2$ and carbon monoxide (CO)) using limited amounts of oxygen and steam. The use of syngas directly is more efficient than direct combustion of the original fuel. There are numerous designs of gasifier depending on the desired feedstocks and outputs. Gasification can be used for 'waste to energy' processes and to produce energy from conventional fossil fuels. One of the steps of gasification is pyrolysis and thus drawing a definite line between pyrolysis and gasification technologies is difficult.

Products: syngas and biochar.

Reasons to choose gasification:

- You have very significant volumes of biomass.
- You have biomass which is contaminated by plastics/metals or organic pollutants.
- You want to produce hydrogen.
- You have heat, steam or electricity needs on-site.
- You want to produce ammonia and methanol or ethanol.

Gasification complications and considerations:

- Scrubbing of gases for specific uses is expensive for small scale systems.
- The history of small scale gasification from biomass overwhelmingly indicates difficulty achieving long-term economical operation (often due to reliability, maintenance and labour costs).
- Plants are designed to run optimally at certain volumes and generally cannot be operated at significantly lower volumes.

### Hydrogen

The development of a National Hydrogen Strategy has signalled hydrogen production as a high priority for development in Australia. This report highlights that the environmental credentials of hydrogen largely depend on the source of energy used in its production.

*Table 2: Emissions intensity of hydrogen production via various methods supplying the energy (COAG Energy Council Hydrogen Working Group, 2019).*

| Production technology | Emissions (kg $CO_{2-e}$/kg hydrogen) |
|---|---|
| Electrolysis – Australian grid electricity | 40.5 |
| Electrolysis – 100% renewable electricity | 0 |
| Coal gasification, no carbon capture and storage (CCS) | 12.7 – 16.8 |
| Coal gasification + CCS – best case | 0.71 |
| Steam methane reforming (SMR), no CCS | 8.5 |
| SMR + CCS – best case | 0.76 |

Hydrogen may be a highly desirable fuel of the future, but for it to have environmental credibility it must be created using renewable energy. The European experience indicates that a small volume can be blended with the natural gas grid without impacting current natural gas equipment. It can also be used to power vehicles (such as buses or farm machinery) which are equipped with specialised engines. It should be noted that there is currently no real market for hydrogen in Australia at this time.

### Fermentation

Fermentation is a biological process (involving yeasts) which produces ethanol from plant sugars, starches and cellulose.

A wide range of plant material (corn grain, sugar cane) can be used as feedstock for fermentation. Commonly plant material will have to undergo some sort of processing prior to fermentation to make these molecules available to yeast.

EtOH

Ethanol is an ideal biofuel as it can be an added to petrol and used in most current machinery without modification.

Newer biofuels try to use waste products or crops which can be grown on dryland without fertiliser.

*Figure 14: Summary of characteristics of fermentation.*

Products: bioethanol, spent fermentation mash.

Reasons to choose fermentation:

- You have land which is not suitable for food production (e.g. may be contaminated) but can produce cellulosic biomass.
- You have crop stubbles/agricultural wastes which can be fermented.
- You have a supply of food processing waste which is high in cellulose/starch/sugars.
- Bioethanol can directly replace or complement regular fuels and is already supplementing existing fuels at around 10 per cent concentration (E10) without great modifications of existing engines.

Fermentation complications and considerations:

- The fermentation of 'sugary' cellulosic based plant matter, which includes feedstocks such as sugarcane, corn, maize and wheat crops, waste straw, willow and trees, sawdust, reed canary grass, cord grasses, Jerusalem artichoke, miscanthus and sorghum plants. However, many of these may be replacing food production.
- Matching a crop to your land is a matter of balancing many factors such as sugar content, climate, soil and processing ease.
- The existence of Australian Government taxes and excise (from July 2020) may have a major impact on the financial viability of a bioethanol project.

Bioethanol can be manufactured in two ways: by reforming some of the products of gasification (see above) and via fermentation from starches and sugars in plant materials (the most common method).

Plant materials (fruits, grains, stems and leaves) are composed mainly of sugars, so in principle almost any plant can be a feedstock for ethanol manufacture. However, the ability to achieve economical fermentation depends entirely on the properties of the feedstock, how well it grows on the selected land and how difficult it is to access its sugars. The European Biomass Industry Association provides good information regarding bioethanol.

The food vs fuel debate tainted public perception of the first generation of bioethanol. However, progress has been made in developing suitable plants which grow in conditions and on lands not suitable for food production. Nevertheless, food crops (sugar cane, molasses, wheat and sugar beets) make up the bulk of the feedstock for bioethanol in the two countries with the largest uptake of bioethanol (USA and Brazil).

Much research and development is going into lignocellulosic bioethanol production. These feedstocks include short rotation biomass crops (such as willow, popular, miscanthus and eucalyptus), agricultural residues (straw and sugar cane bagasse), forest residues, woody waste and municipal solid wastes.

It should be stressed that this technology is yet to reach its potential as the relatively inaccessible molecular structure of these biomasses makes it more difficult to convert to sugars.

### Transesterification

Transesterification is the conversion of triglycerides to glycerin and biodiesel, using an alcohol. This is normally done in alkaline conditions using some heat.

A wide range of oil based feedstocks can be used. This includes waste cooking oil, animal fats, or vegetable oils. Oil based crops can be grown specifically for production of biodiesel as can algal mass.

After transesterification the crude biodiesel and glycerin need to be further refined to remove the methanol and purify the product

*Figure 15: Summary of characteristics of transesterification.*

Products: Biodiesel and glycerin

Reasons to choose transesterification:

- You have waste vegetable oils and fats.
- You have animal fats.
- You are able to grow oil-based crops on non-food producing land.
- You have need of on-farm use for transport fuel (specialised models of equipment are available for this fuel source).
- The process can work even at very small scales (it is a good lab demonstration for students).

Transesterification complications and considerations:

- Biodiesel produced by transesterification is often of low quality. Increasing quality requires pre-treatment of feedstocks (particularly removal of water) and/or post reaction purification.
- Biodiesel will be subject to Australian Government Taxes and Excise from 2030 which could significantly alter the economics of transesterification.
- Modified engines are required to run this fuel, but these engines are available.

The transesterification process requires fatty acids, alcohol and a catalyst (usually a strong base).

The end products of the transesterification process are raw biodiesel and raw glycerin. When using methanol as the alcohol, FAME (fatty acid methyl ester) biodiesel is produced. These raw products need to undergo a cleaning step. Purified glycerin can be used in the food and cosmetic and chemical industry and raw glycerin can be used as a substrate for anaerobic digestion.

Relevant standards/regulations defining the specification of biodiesel are European Committee for Standardization EN 14214, EN 590 and ASTM D 6751.

### Technology questions

Once you have decided on the technology, located case studies and read technical information you should have a broad picture of how it will transform your biomass. It is useful at this stage to engage technical experts for comment and start discussions with technology vendors as to whether your biomass fits with their technology.

You could ask a range of questions, including:

- Which bioenergy processing technologies are already deployed in Australia?
- Which vendors supply your specific technology?
- What are the available end-use options for the bioenergy produced?
- Are there opportunities to reuse waste products produced by the bioenergy process?

Once you have developed a level of confidence about your technology, it is time to socialise the idea and gauge the level of community support. It is also advisable to engage with Sustainability Victoria to understand what funding and assistance may be available to you.

## Examining your social risk

Once you are ready to move into the feasibility stage of your project, it is necessary to understand the social risk to your project. Work through the *Social Risk Guide* to ensure that you are aware of any factors which need to be managed.

### What is social risk?

Social risks to a project generally arise from the dissatisfaction and grievances of external community and stakeholders and more rarely from internal objections. These can arise from a failure to understand the differences in experiences, perceptions and cultures between the parties involved. They almost always arise in circumstances where there is little demonstrated benefit to those outside a project. These cases can also arise from a company's or project's desire to put profit before any other considerations, to the maximum extent allowable by law. In some cases, the legal ramifications may be factored into the cost of doing business.

Social risks to a community arise from the impact of a company's operations. These include community health, safety and environmental harms and can extend to social harms and impacts on visual amenity, restricted access to lands and impacts upon culturally significant locations.

Social risk can manifest as conflict, which may include:

- resistance to a project being located in that community
- active lobbying to prevent a project establishing, or stop a project operating where it already does
- interaction with politicians to apply pressure for a project to withdraw or stop
- legal action (for example, in a civil appeals tribunal).

Failure to manage social risk can have enormous economic costs, significantly damage the reputations of organisations involved and put investments at risk.

## Factors governing social risk

The factors linked with increased social risk to a bioenergy project are displayed in Figure 16. A large number of these risk factors can be identified at the pre-feasibility stage of a project and plans formulated to address them (see *Analysis of social risk* below). Community and stakeholder engagement should start as early as possible and continue regularly throughout all further stages of project development.

Genuine, concerted efforts to achieve positive social impact can reverse many of the factors that increase social risk. This often requires targeting a level of community education, ownership and connection. While this may increase costs (or slightly decrease profitability) the trade-off is a smoother project Pathway that benefits more stakeholders. It requires two-way communication to commence as early as possible to actively engage with influential community members to head off misinformation, poor perceptions, misconceptions and negative stakeholder activation.

| **PERCEPTION** | **MEANS** | **TRIGGER ISSUES** |
|---|---|---|
| Existing Information on company (social or conventional media) is negative.<br><br>Perception of local governments and NGOs is negative<br><br>Own media efforts are continually polluted by anti-project rhetoric, making perception change difficult. | Opposing parties have strong networks.<br><br>Opposing parties are highly mobilised on social media.<br><br>Opposing parties have good access to conventional media or political contacts | Previous attempts at similar projects have created negative air around the issue.<br><br>Historical circumstances of an area causes friction (eg history of coal based power production).<br><br>Project triggers underlying social or environmental issues, which increases resistance |
| **LOW CONNECTION** | **STAKEHOLDER ACTIVATION** | **POOR UNDERSTANDING** |
| Project has no local ownership<br><br>Project has low employment (eg fly-in fly- out workers)<br><br>Project procures equipment and construction workers from outside the area.<br><br>Project builds no mutually beneficial infrastructure | Prominent individuals become opposed (eg religious leaders, union leaders, environmental group leaders<br><br>Institutions such as NGOs, unions, citizens association take an official publicised opposing position.<br><br>Government or semi-government departments take an opposing view. | Locals do not understand the technologies being proposed.<br><br>The benefits of the technology are not communicated to the public or are only done so after negative publicity.<br><br>Attempts to explain the technology or project focus on the technical and are not 'received' by the public. |

*Figure 16: Factors which increase social risk.*

## Social risk vs social impact

Figure 17 shows the degrees to which investment can be extended to become social impact investment. A traditional approach to investment pitches risk against return, and the higher the risk involved, the higher the judged return must be in order to justify investment. Investment in the 'impact economy' offers a more community-centred approach which actively reduces social risk.

It remains to be seen how impact investment fits into a capitalist society, where public company boards have the responsibility to maximise profits for shareholders. However, there is clearly scope for the non-corporate/governmental sector to invest in the impact economy. Business structures such as cooperatives and social enterprises may be better suited to this section of the economy. Partnerships or cooperation between two privately owned companies with similarly holistic views may also enable positive impact.

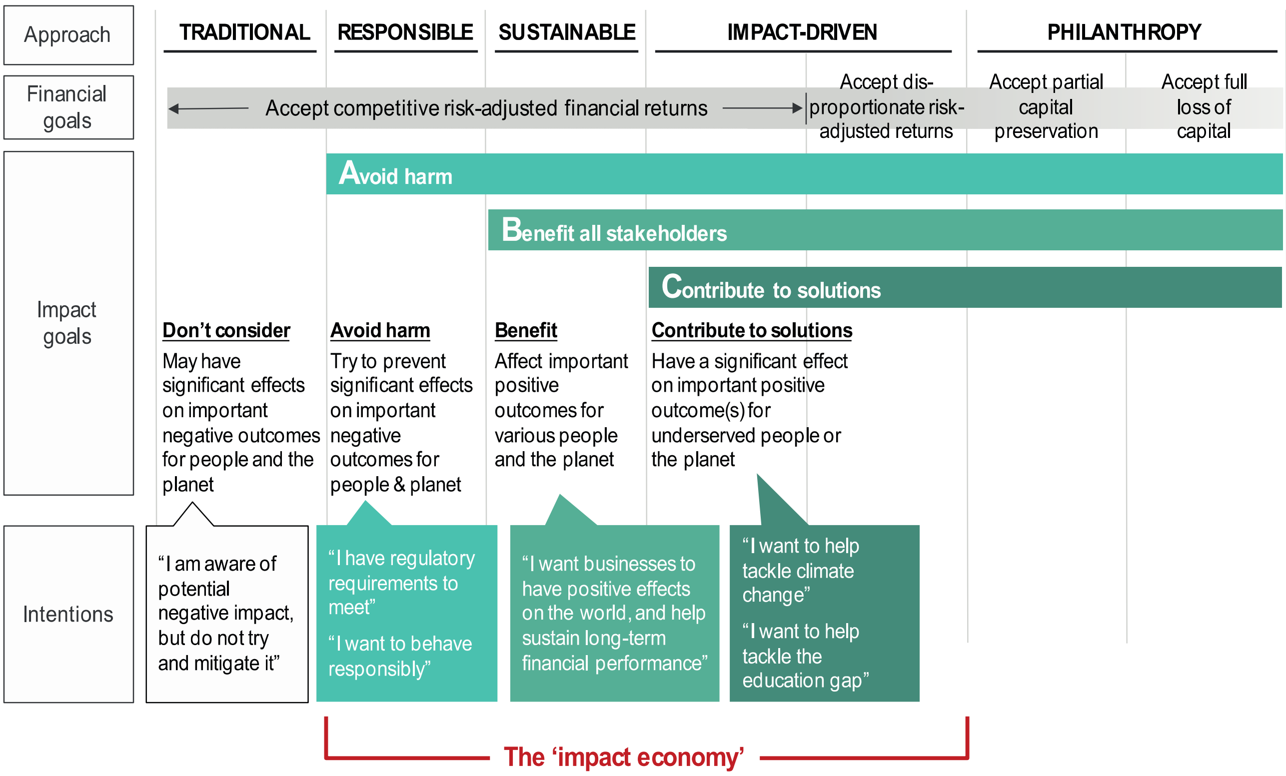



*Figure 17: Traditional investment approach versus responsible, sustainable and impact-driven investment. (Pasi, Misuraca and Maduro, 2018).*

## Analysis of social risk

An analysis of the social risk involved in the project should be performed early and often throughout all stages of a project. A helpful document in developing an understanding of social risk is the Victorian Government (DELWP) *Community Engagement and Benefit Sharing in Renewable Energy Development* (Lane and Hicks, 2017).

Their process recommends four steps:

- context narrative
- social impact site map
- social risk matrix
- stakeholder mapping spreadsheet.

To aid you through your projects journey we have developed a **Social Risk Guide**. This is an A3 printable package containing a series of exercises.


*Context narrative*

A context narrative involves constructing a 'story' of the local context. This includes an area's key attributes, values and features, local demographics, culture and history of the area. The aim is to become familiar with the local context to ensure alignment with the proposed development.

*Social impact site map*

Developing a **Social Risk Matrix** – A Social Risk Activity

The Social Risk Matrix should be used to register and rank all the possible risks. Please see the risk matrix in the Bioenergy framework to rate the various risks. Most attention should be given to mitigating the risk of those highest scoring risks.

| Potential Issue | Likelihood | Consequence | Risk Score | Mitigating Actions |
|---|---|---|---|---|
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |

A social impact site map is a map of the bioenergy project's location and its associated infrastructure in relation to the local community and residents. The purpose of the map is to physically locate features such as houses, valued landscapes, schools and areas of recreation. Impacts of increased traffic and truck movements should be considered in relation to these features.

*Social risk matrix*

Inclusion of a risk assessment for a wide range of factors (policy, economic, social, environmental) which may negatively impact a project is essential. The activities and matrix in the Social Risk Guide can assist in this process and use the risk = (likelihood x consequence) equation.

*Stakeholder mapping spreadsheet*

**Stakeholder Mapping Spreadsheet** – A social risk activity

The stakeholder mapping exercise should assess the appropriate level of engagement required with each stakeholder. These should be given a category from the following: Inform, Consult, Involve, Collaborate, Empower.

| Stakeholder Type | Name | Role in organisation | Contact Details | Interest in project | Ability to influence | Category of engagement |
|---|---|---|---|---|---|---|
| | | | | | | |
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| | | | | | | |

Stakeholder mapping is a process that identifies relevant stakeholders for a given project and records information about them in order to determine how best to engage with them. Stakeholders can be individuals, businesses, organisations and government/semi-government departments or simply be the adjacent landholder. In order to achieve this mapping, specific information needs to be gathered, including:

- local Traditional Owner representatives, organisations and elders
- local sustainability, climate action groups and academics in the environmental sciences
- environmental, conservation and outdoor recreation organisations, including bird watchers, photographers and walking groups
- local progress associations (Lions, Apex etc.) or chambers of commerce
- trade unions
- political stakeholders at all levels of government.

> Not all stakeholders need or want to be engaged in the same way or at the same time. In addition, not all stakeholders have the same level of interest in, or influence on, the project. The stakeholder mapping exercise should assess the appropriate level of engagement required with each stakeholder. These should be assigned a category from the following: inform, consult, involve, collaborate, empower. A stakeholder mapping spreadsheet is provided in the *Social Risk Guide*.

Social factors identified as being specific to bioenergy projects are listed in Table 3.

*Table 3: The social risk factors associated with bioenergy projects as identified by the DELWP publication Community Engagement and Benefit Sharing in Renewable Energy Development.*

| **Bioenergy** |
|---|
| Community understanding and perception of the technology |
| Sustainability (including growth, harvesting and transportation) of feedstock |
| Visual amenity of the generator facility |
| What removal of the resource may mean for other value chains in the local area and ecosystems |
| Competition of supply in the region and what this means for viability |
| Animal welfare (if animal waste is a feedstock) |
| Larger scale plants competing for feedstock and potentially increasing prices for other farmers |
| Transportation of the stock streams — nuisance and dust concerns |
| Odour concerns |

# Producing a Pre-feasibility Study Report

Before progressing to the feasibility stage of the project you should produce a report summarising all of the information you have gathered so far. It outlines the findings of your assessment, summarises conclusions and makes recommendations concerning the worth of progressing to the feasibility stage.

The report should include the following:

A typical Pre-feasibility Study Report includes:

- description and quantification of the biomass
- bioenergy end-use
- barriers for the project
- identification of strategic stakeholders
- identification of government funding opportunities
- identification of preferred technology and potential technology concepts
- calculation of expected energy output
- preliminary assessment of site(s) and preliminary site layout
- preliminary footprint and unit sizing
- potential to grid connections
- preliminary identification of environmental and social risks and issues
- preliminary assessment of capital costs
- preliminary assessment of operating and maintenance costs
- preliminary financial analysis
- preliminary risk assessment
- preliminary assessment of planning and environmental approvals required
- planning and project implementation, including tentative time schedule
- list of assumptions.

Depending on size and complexity, the costs and time associated with undertaking a pre-feasibility study can vary substantially. Planning and environmental authorities are not normally involved at this stage, so the study can usually be completed within six months. The associated costs also vary but typically range between $20,000 (for a small and less complicated project) and $100,000 (for a large and complicated project).

# PHASE 2: FEASIBILITY

If the outcomes of the pre-feasibility study are favourable, project development moves to feasibility. This study builds on previous work, uses more detailed information and process designs and considers all types of operations involved in processing. It is also important to define other operational details, such as feedstock and reagent suppliers and potential plant locations.

The purpose of the feasibility study is to provide sufficient detail for potential investors and stakeholders to support the development of the bioenergy project.

At this stage of your project there is an additional Bioenergy Project Self-Assessment Tool (developed by Bioenergy Australia) which may also assist in evaluating your project.

## Build confidence

The *Build confidence* stage involves developing a detailed business case that captures the reasoning for initiating the project. It includes the assessment of the viability of the project in technological, organisational, environmental, economic and financial terms, as well as financial and economic analyses. These provide a way for key stakeholders (such as investors, the local community and regulators) to compare different technical and financing solutions.

### Securing biomass supply

Ensuring a secure biomass supply is a precondition for a successful bioenergy project. Having a year-round, stable supply of biomass of sufficient quality is imperative and is dependent on the availability of the biomass and the stability of the supply chain. If you have not already done so, commence contractual negotiations to secure this supply.

When seeking investment for a bioenergy plant, the project initiator must ascertain that there is sufficient biomass available to keep the plant operational and therefore financially viable. This also requires an assessment of the minimum amounts of biomass needed for a bioenergy project to be technically feasible.

If the bioenergy plant depends on biomass sourced from agricultural or forestry production, the seasonal variation of the primary industry is a determining factor in its availability. It is necessary to map the seasonal variation for the most common crops in the local area that deliver biomass suitable for energy production. Some crops have more stable output year-round such as sugarcane and rice whereas wheat, sorghum and maize are strongly seasonal. This illustrates the importance of mapping agricultural crops and estimating the total available biomass and balancing the size of storage facilities and the bioenergy plant to guarantee year-round energy production.

A bioenergy plant may require supplementary biomass for several reasons:

- insufficient biomass availability
- insufficient biomass quality
- significant seasonal variation in the biomass stock.

If supplementary biomass is needed, then a mapping exercise of other available biomass residues in the region should be carried out and the costs associated with the transportation to the bioenergy facility incorporated into the financial analysis. If no supplementary biomass residues are available, this may affect the viability of the project.

After identifying an acceptable supply of biomass, a supply chain needs to be established. For biomass producers initiating their own bioenergy project, the need for supplementary biomass needs to be considered and an appropriate supply chain established.

This supply chain includes identification of the biomass producer, pricing, establishing supplier contracts and arranging transport and storage of the biomass. All information gathered at this stage will inform the business case and financial analysis of the bioenergy project.

The following will help ensure to secure a stable and reliable biomass supply chain.

Producers of the biomass:

- identify the biomass producer
- agree the price
- contractual arrangements for biomass supply must be negotiated covering time, cost and quality.

Transport:

- How will the biomass be collected?
- How will the biomass be transported?
- Who will be in charge of transport of the biomass?
- What related contractual arrangements are needed?

Storage:

- What are the requirements for on-site storage (volume, safety, dry storage etc.)?
- Is the biomass suitable for storage?
- How will storage affect the biomass?

When setting up the supply chain, the developer must ensure that the financial viability of the project is not put at risk. Ideally, the supply of biomass should be the best quality biomass at the lowest possible price within the physical and financial constraints of the project.

The contractual agreements must secure a long-term, stable supply of biomass at the best quality. The agreements of supply and transport should include incentives for the supplier to uphold their part of the agreement. The business case cannot be developed until there is a high degree of certainty around biomass supply.

## Developing a business case

Development of a business case involves both financial and economic analyses of the bioenergy project. It includes an assessment of the project's technological, organisational, environmental, economic and financial viability. The financial and economic analyses provide a way for key stakeholders (such as investor(s), the local community, regulator(s) and others in the decision-making process) to compare different technical and financing solutions. The financial and economic analyses should always include a comparison with a business-as-usual or do-nothing scenario.

The financial analysis should consider what can be directly measured and quantified within the boundaries of the project i.e. the capital, maintenance and operating costs, including:

- investor(s)
- market pricing and forecasting
- taxation, tariffs, subsidies and incentives.

The economic analysis considers society's perspective and includes externalities which can be quantified such as greenhouse gas emissions and the wider impact on local jobs and industry. The economic analysis should exclude taxes, tariffs, subsidies and incentives and therefore reflect the true cost of the project to society.


Further guidance on business case development and the economic assessment of projects in Victoria is available.

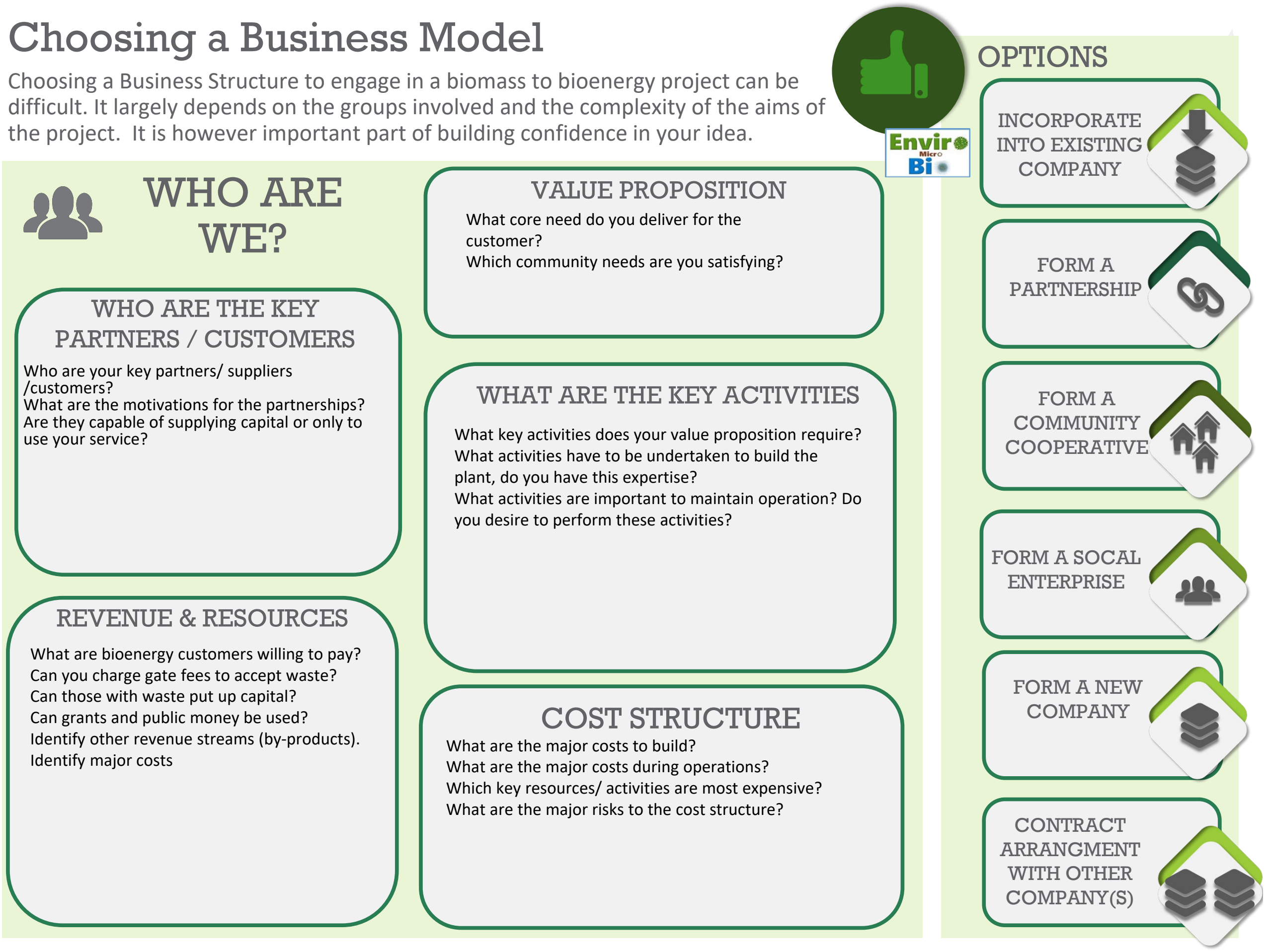
The business case should include the following:

- problem definition (the why)
- case for change (the benefits)
- options development (the possibilities)
- option assessment (the analysis, both economic and financial)
- project solution (the answer).

Typical risks relating to the financial viability of bioenergy projects include:

- insecure supply of biomass
- variable quality of biomass
- poor market access for bioenergy
- lack of, or limited, waste disposal options
- no access to finance at competitive terms
- need for collection, transport and pretreatment of biomass feedstock
- technology.

## Deciding on a business structure




The feasibility phase prompts you to examine how best to structure your business.

Consider:

- How will you earn income?
- Who is going to own the infrastructure?
- Who is going to run it?
- How will the major works be paid for?
- What is your relationship with the major vendors of the technology?

Answers to these questions will suggest a basic business structure. A canvas is supplied in the *Start-up Guide* and it can help you understand the business structure that may work best for your proposed bioenergy project.

## Workforce analysis

Depending on the skill sets already available in your team, you may have to engage others to assist with project management and business case development.

Design and engineering services are generally provided by an engineer/engineering firm, as well as the vendor of any major equipment that you use. For the vast majority of your project, generic process engineering skills should be sufficient, but some skills specific to bioenergy may be necessary and more difficult to find. Bioenergy is a relatively new sector in Australia, which means there is not a large body of experience, but some firms may have international access to engineers.

A similar situation exists with construction partners. Who will build the plant and do they have relevant skills and experience? Although engaging contractors and subcontractors is not required until much later in the project (see *Tendering* in *Project Financial Close*), understanding whether the skills are available locally is valuable.

Ensure your team includes people with:

- a high degree of financial literacy to help build the business case. This person should also be able to help with securing funding.
- a strong technical background to help you understand the technical risks to the project. This person should help manage your relationship with potential vendors and work with design engineers.
- strong ties to the local community who can act as a communications link.
- skills and experience in managing projects to lead the process.

At this point you are going to need to establish a local workforce to:

- design the bioenergy plant and achieve planning approval
- undertake the construction
- commission and operate the plant.

Bioenergy is a relatively new sector in Australia so design, engineering and construction experience is limited. You may need to engage with a training partner to identify and/or develop training specific programs, adapt those currently available or seek expertise from overseas.

# Engage with planning authorities

Developing a bioenergy project requires an understanding of relevant planning processes.

The Victorian planning approach is based on meeting the economic, social and environmental needs of the community and it is imperative that bioenergy developers understand the needs of their local community, project location and statewide policies and relevant government agencies.

*The Planning and Environment Act 1987* is the overarching legal Framework for the Victorian planning system and covers all municipalities within the state. Each of the municipalities is covered by a Planning Scheme that regulates the use, development and protection of the land.

Planning Schemes set out the:

- planning rules (state and local policies, zones, overlays and land use)
- vision for the municipality and community needs
- Municipal Planning Strategy.

All planning permit applications must be consistent with the Planning Scheme. All Planning Schemes have a standard structure drawn from the Victoria Planning Provisions (VPP) and specified in the Ministerial Direction on the Form and Content of Planning Schemes.

## Local Government planners

A first critical step is to determine who is responsible for planning decisions in the area of the proposed development (Local Planning information). Local councils are responsible for most planning decisions that affect their local government area. For example, they decide whether to grant a planning permit for a new use or development of land and appropriate permit conditions.

## State Government planners

The Victorian State Government provides a detailed guide to developers and individuals seeking guidance on Victoria's planning system. Planning covers a very broad range of issues but is essentially about the decisions that change the environment and affect everyday life.

Under Victoria's planning system, local councils and the State Government develop planning schemes to control land use and development. Planning schemes are also developed to ensure the protection and conservation of land in Victoria in the present and long-term interests of all Victorians. Planning schemes are developed in accordance with planning policies and strategies. They contain planning policies, zones, overlays and other provisions that affect how land can be used and developed.

Planning Victoria provides a useful overview and guide to the planning system and how to navigate the process (Planning in Victoria) and in particular the diagrammatic Planning on a Page. One relevant VPP document is 53.13 Renewable energy facility (other than wind energy facility) which calls for a site context analysis and a design response.

Before you choose a site, you should be aware of all the readily available information on that site, which can be found at the Victorian Government overlay service. This is a very informative tool for gaining information about proposed locations.

## EPA Victoria

In theory, renewable energy projects under 1 MW in size do not require engagement with EPA Victoria. However, these requirements are very heavily geared towards solar or wind installations. In practice a bioenergy project is always going to involve changing the land use, create emissions (solid, liquid or gas) and often involve changes to waste management practices. Therefore, all bioenergy projects will involve EPA Victoria.

As well as engaging early with local and state planning authorities, it is advisable to also engage with EPA Victoria. Their website will help determine if you require an EPA licence and/or works approval.

### EPA licence

An EPA licence allows a business to run certain activities at a licensed premise. You will need a licence for your project if your property is currently, or will become, a scheduled premise.

These are listed as:

- A: waste treatment, disposal and recycling
- B: primary industry and allied operations
- C: mining
- D: animal-derived by-products
- E: textiles
- F: wood and wood derivatives

- G: chemicals including petroleum
- H: non-metallic minerals
- I: metals and engineering
- J: printing
- K: utilities
- L: other.

In order to gain an EPA licence, you will first need a works approval. More information on the licence process can be found at EPA licence check. Figure 18 depicts the simplified processes involved in gaining local Council and EPA approvals.

As the size and complexity of a project increases, more detail will be required as part of the application process. The EPA offers a range of services and information on how to fill out applications, review applications and how to engage a consultant if required.

### Works approval

In Victoria:
*A works approval allows you to conduct works or make changes to your scheduled premises. For example, undertaking works including constructing a new plant or installing new plant equipment.*

A works approval allows a business to undertake works to:

- construct a building
- install new plant equipment
- change infrastructure
- change discharge or emission limits
- change work processes.

You may need a works approval if these works risk harming the environment. For example, if you install or change equipment at your premises that:

- create waste
- increases or changes the amount of discharge into the environment
- changes the way you treat or store waste.

More information about this can be found at EPA works approval.

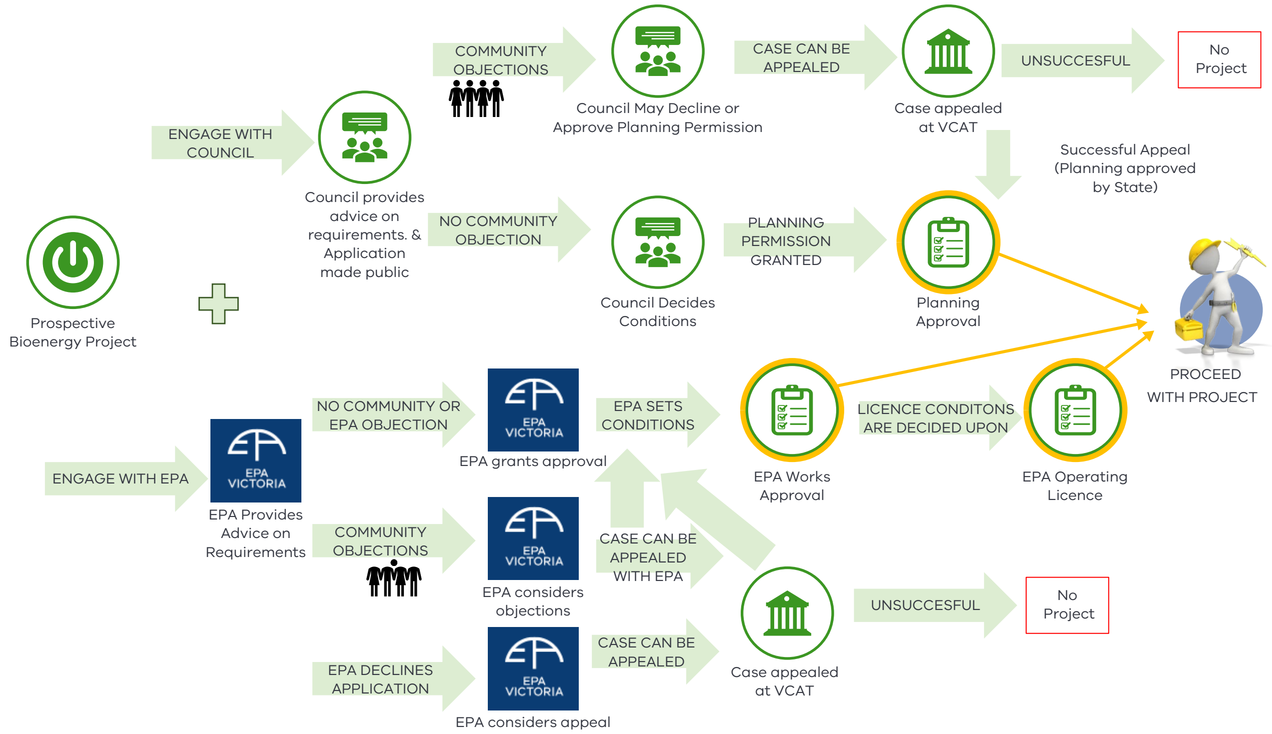



*Figure 18: Simplified diagram of the minimum local Council and EPA approvals processes. Before proceeding to the financial close of a project, you require a minimum of three approvals (shown in yellow circles): Council/state Planning Approval, EPA works approval and EPA operating licence.*

## General environmental duty

The general environmental duty (GED) is at the heart of environmental law reforms which will come into effect at the start of July 2021. The GED is a criminally enforceable requirement which states that "if you to conduct activities that pose a risk to human health and the environment, you must understand those risks. You must also take reasonably practicable steps to eliminate or minimise them."

The impact on agricultural activities is outlined out in EPA publication 1819: Agriculture - guide to preventing harm to people and the environment.

If you are accepting waste, you must be a lawful place under EPA licence, permit or registration. If the waste is considered 'priority' or hazardous there are additional responsibilities.

Under the GED If your business generates, transports or receives industrial (which includes agricultural) waste, you have duties to:

- take reasonable steps to identify and classify your waste
- take all reasonable steps to make sure your waste is taken to a lawful place.

## Declaration of use

One potential avenue for managing bioenergy feedstocks is via a 'Declaration of use' (DoU). This will commence on 1 July 2021 under the *Environment Protection Act 2017* and will support the safe reuse, storage and recovery of materials from low-risk waste only.

It will take the form of a short statement or checklist (usually only a couple of pages in length). The DoU will involve you completing a self-assessment that:

- describes your waste
- assesses its risks
- identifies legitimate uses for it.

This provides the end user with details about the quality and safety of your waste.

DoUs will be valid for up to 12 months, or until the form of your waste changes. You won't need a new DoU every time you receive the same kind of waste.

It is unclear when a DoU will be deemed insufficient and a registration will be required. The reasons for a DoU not being sufficient are currently given as:

- your activity requires an EPA permission
- your waste requires further processing or storage (new permissions apply)
- it is a high-risk or reportable priority waste
- you don't intend to reuse the waste.

## Other agencies you may be referred to

One of the best strategies to engage beyond your local Council is to host a multiagency meeting early in your project's development. This could include Council planners, EPA Victoria, DELWP and representatives from any other agencies from whom you may need approval. Such a process is likely to provide early clarity and smooth the passage of approvals process as much as possible.

If you have already engaged with the Council economic development team, they are may be able to help you connect with the necessary agencies.

### DELWP

In Victoria, environmental assessment of the potential environmental impacts or effects of a proposed development may be required under the *Environment Effects Act 1978*. The need for this will be made by statutory decision-makers (Ministers, local government and statutory authorities). Typically, direction to prepare an Environmental Effects Statement (EES) occurs under the direction of DELWP. More information can be found here.

An EES is released for public comment and a decision is made by Ministers, local government and statutory authorities. Some projects referred to DELWP for assessment under the Act can avoid preparing an EES by agreeing to additional conditions in lieu of the study.

A very significant project may also require assessment under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*. If an EES is completed in Victoria, some of this can be used in this process.

### Water agencies

Water obtained from surface/bore water is likely to be a key issue assessed by the DELWP process. In most cases, rights to use such water will be purchased from the current owners.

If your project might discharge water after exiting your site, or your project interacts with rivers, lakes or catchments you will need to engage with a Catchment Management Authority (CMA). In Gippsland these are East Gippsland CMA and West Gippsland CMA.

You will require a permit for works such as:

- dams
- bridges
- jetties
- crossings or culverts
- riverbank stabilisation
- removal of vegetation on riverbanks.

Where you wish to purchase raw or potable water from a water authority you must enter into a contractual arrangement with the relevant water authority for that water purchase. In Gippsland the relevant authorities are Gippsland Water, South Gippsland Water and East Gippsland Water.

You will also need to engage these water authorities to obtain a trade waste agreement if you wish to discharge wastewater to the sewer. If you cannot meet the specifications on the agreement you may have to pretreat the wastewater on site. Similarly, if you are not in a sewered area you may be required to treat wastewater on site. This can add substantially to the cost of a project.

### Energy and energy authorities

If export of electricity is key to your project's business case, then it is important to ensure that you are located near adequate electrical infrastructure.

If you are exporting substantial amounts of power you need to be less than 2 km from a zoned substation. You are likely to have to pay to upgrade powerlines between your site and a zoned substation (approximately $30 000 per 100 metres of 22 kvA line) and if you are unable to access a substation, you may be required to build one (approximately $15 million). This is prohibitive for most bioenergy projects.

The Australian Energy Regulator is the regulator of Australia's wholesale electricity and gas markets and is responsible for monitoring and enforcing national energy legislation. It is a useful resource for locating state regulators and other key stakeholders who may influence or directly affect bioenergy projects.

The Australian Energy Market Commission (AEMC) is the rule-maker for Australian electricity and gas markets. AEMC sets national standards, makes rules and the National Electricity and Gas Laws and Reform which covers:

- generator access and transmission pricing
- power system security
- integrated distributed energy resources
- digitalisation
- aligning financial incentives.

The Australian Energy Market Operator (AEMO, whose functions are described in the national energy laws), manages the electricity and gas systems and markets across Australia to ensure energy is secure, reliable and affordable. Spot pricing and demand are shown live on their website and updated every five minutes.

Generally, projects under 5 megawatts only require approval from AusNet (or another local owner of infrastructure). However, the Distributed Energy Resources program may be relevant for small scale bioenergy plants wishing to export excess energy generated to the electricity grid. It generally does not restrict energy exportation.

Any bioenergy project that seeks to participate in the National Energy Market must apply to become a market participant through AEMO. Projects over 5 megawatts are generally obliged to be registered unless they have grounds for exemption. It is important to understand that at this point the operation of the plant (daily operational schedule) is controlled by AEMO and not the plant owner. There is also a fee for registering as a market generator of $12,000 -$25,000. It is also important to note that it may take two to three years to finalise registration with AEMO.

If producing more than 1 megawatt of export power you are likely to be required to produce a network study, which will enable AusNet and/or AEMO to evaluate your effect on the electricity network. This exercise can cost several hundred thousand dollars and is much easier and quicker to do in areas with previous data and existing network studies.

### Gas

The production and export of either biomethane or hydrogen are alternatives to exporting electricity. Both of these options are technically viable and are becoming commonplace in Europe. However, there are minimal examples of green gas-to-grid or green hydrogen production in Australia at this time.

### Alternative energies

Due to the significant financial hurdles of exporting electricity, some consideration should be given to 'behind the meter' use of any electricity /gas generated. Alternative options involve the conversion of biomass to a different form of energy (see combustion, pyrolysis, gasification, fermentation, transesterification above). In these circumstances the exported energy product may be heat/steam which is not regulated in the same way as liquid biofuels or green hydrogen.

### Energy Safe Victoria

Energy Safe Victoria is the regulator responsible for electrical and gas safety in Victoria. This statutory authority audits the design, construction and maintenance of electricity and gas networks and installations and ensures that appliances meet safety and energy efficiency standards.

Areas of bioenergy instillations where gas (biogas, syngas) are produced, scrubbed or transported are assessed to determine their risk as a hazardous zone. Identification of an area as a hazardous zone requires specialised engineering, equipment and operational procedures.

Where industrial appliances (including energy generators) are used, they need to be assessed to see if they are considered to be hazardous. Gas installations and appliances operating at no more than 10 GJ/h or 200 kPa and not in an otherwise hazardous zone are deemed to be not hazardous. Anything larger will generally have some degree of hazardous zone regulation attached to it. Modifying equipment for on-site use to fit under these limits can result in significantly less complication and compliance cost.

For the construction and maintenance of equipment (such as cogeneration units) or work in hazardous zones using gas appliance, a Class B gasfitter licence is required. Organising a service contract/callout provision with the vendor of the equipment or other supplier of similar services is recommended.

For anaerobic digestions where gas generation cannot just be switched off, the consequences of a breakdown of gas using equipment (cogeneration) or production of off-specification gas should be considered. Instillation of a 'flare' for use in these situations is a must.

### WorkSafe Victoria

Although you do not need approvals as such from WorkSafe, it is wise to consult to consult them about both the construction, commissioning and operational phases of your project.

All procedures and equipment used on-site must comply with WorkSafe guidelines and laws. As any high-risk licences are controlled by WorkSafe, all businesses are required to have WorkSafe Insurance (based on a portion of the payroll).

Workplaces must also actively assess and manage risks on their site to meet legal requirements, including a system for recording workplace incidents and injuries. It is important to be familiar with the types of incidents which are mandatorily reported to WorkSafe.

Due to the relatively high-risk environment of construction activity, there are a large number of regulations and requirements imposed during this period. WorkSafe has dedicated pages to address these requirements. During this time, you should employ an experienced occupational health and safety and environmental policy manager to be responsible for these requirements.

The commissioning and operation of bioenergy plants is likely to warrant particular focus on areas such as:

- pressurised fluids and gases
- chemical hazards
- fire/explosion hazards
- biological hazards
- confined spaces.

### Country Fire Authority and Fire Rescue Victoria

The Country Fire Authority has produced a useful set of Guidelines for Renewable Energy Installations. In short, bioenergy facility operators are required to develop an emergency management plan consistent with the requirements of *Australian Standard 3745: Planning for emergencies in facilities*. This plan focusses on emergency prevention, preparedness and mitigation activities.

Some of these are relevant at the planning stage (physical infrastructure access, fire water mains, fire breaks, signage) and some are more relevant at the commissioning/operational stage (procedures and training). A Fire Management Plan forms part of the Emergency Management Plan.

### Agriculture Victoria

Agriculture Victoria regulates the movement of animals and plants within Victoria and interstate. Bioenergy projects may require the movement of plant materials or animal-derived products, so it is important to understand any potential restrictions on the movement of various types of plants. You can obtain a permit to move plant material (by first obtaining a Plant Health Certification). While there is a similar process for animals, there does not appear to be a recognised process for transfer of animal products.

With the exception of chicken litter and pig manure, the production of animal manures is generally diffuse and generally not economical to gather or transport. In the case of pig manure in particular, there are extreme odour issues associated with transport. Therefore, it is likely that chicken manure is the main animal-derived manure product which may be moved between sites. Currently, the requirement for movement is that the person (often a contractor) moving the product must keep track of where the manure is delivered to. There is no requirement for testing or paperwork/permits for movement.

Note that once the GED comes into effect in July 2021 there may be different rules governing the movement of plant and animal products. It is reasonable to expect that you will need to understand the risks of your activities and take reasonable practicable steps to eliminate or minimise them. Until the development of established case law around the duties implied by the GED, there is unlikely to be a prescriptive process which dictates what actions are required to meet environmental (and biosecurity) laws. However, the GED is likely to imply that initial and ongoing monitoring for biosecurity concerns is necessary.

### VicRoads (Victorian Department of Transport)

The Department of Transport (DoT) considers permit referrals to assess the impacts that proposed uses and development of land will have on the operation, assets and safety of the state transport network. More information about planning permits which require DoT approval is available. If your site will increase traffic in an area, or require road modification (roundabouts, traffic lights, turning lanes) then a DoT permit will be required.

Even if a permit is not required, all works in the road reserve (land adjacent to a road) are required be done safely. The preparation of a Traffic Management Plan is a legal requirement in this instance.

### Victorian Traditional Owners Corporations

There are two main Traditional Owner groups with ownership across the Gippsland region:

- The Gunaikurnai Land and Waters Aboriginal Corporation represents Traditional Owners from the Brataualung, Brayakaulung, Brabralung, Krauatungalung and Tatungalung family clans.
- The Bunurong Land Council Aboriginal Corporation represents the Bunurong people of the South-Eastern Kulin Nation.

You will need to establish if your site has cultural heritage sensitivity, firstly by searching the Aboriginal Cultural Heritage Register and Information System. The mapping of sites of significance in this tool may not be complete (but is continually reviewed) and you are advised to contact Aboriginal Victoria or your local Traditional Owner Corporation for absolute certainty. It is recommended that this search form part of a Preliminary Aboriginal Heritage Test (PAHT). A PAHT is a voluntary process which will help you fulfil your responsibilities under the *Aboriginal Heritage Act 2006* and establish if you need to undertake a Cultural Heritage Management Plan (CHMP). There is also an online tool which will help you understand if you need a CHMP.

The PAHT or self-assessment may direct you to engage a Heritage Adviser to conduct a survey that determines if you require a CHMP. A CHMP is required when a 'high impact activity' is planned in an area of 'cultural heritage sensitivity'. Ultimately if there is doubt, the Secretary to the Department of Premier and Cabinet certifies whether a CHMP is required for a proposed activity.

There are two main sets of relevant legislation: the *Traditional Owner Settlement Act 2010* and the *Aboriginal Heritage Act 2006*.

The *Aboriginal Heritage Act 2006* links the protection of Aboriginal cultural heritage in Victoria with planning and land development processes. This legislation requires a cultural heritage audit which is an assessment of the impact of an activity on Aboriginal cultural heritage.

The *Traditional Owner Settlement Act 2010* has three main parts:

- Land Agreement which formalises the handing back of parks and reserves of significance to the Traditional Owner group, to be jointly managed with the state.
- Land Use Activity Agreement which provides a simplified regime to guide consultation and negotiation with Traditional Owners for activities that have a substantial impact on Traditional Owner rights in public land within the agreement area.
- Natural Resource Agreement which provides for the access to, and sustainable use of, natural resources and Traditional Owner participation.

# Tackling the technical

During the feasibility stage it is valuable to run a laboratory or pilot scale process in order to understand and quantify a number of technical issues which can have a large impact on financial and technical viability. These typically include:

- advanced characterisation of the biomass to be used, including temporal variability
- likelihood and proportion of contaminating or off-specification biomass
- handling difficulties of biomass
- biomass degradation or odour/vermin issues with storage of biomass
- characterisation of by-products
- quantification of the energy produced.

Both the original biomass and any by-products or residues should be extensively tested to ensure that they are of the required quality, purity and do not contain higher than expected levels of contaminants. Investigation should include metals, trace organics, PFAS, as well as more basic carbon, nitrogen, phosphate, solids, moisture and volatile composition.

## Biomass sourcing implications

The technical aspects of biomass sourcing need to be considered at this stage and identification of any issues related to biomass sourcing is of utmost importance. If the biomass is a residue from production at the same site as the proposed facility, this includes not only biomass storage but also any pre-treatment at that site. However, if the bulk of the biomass (or supplementary biomass) comes from elsewhere, sourcing becomes an important issue that will influence the plant design.

Biomass that is brought to site must have places for unloading and storage; there may also be the requirement for equipment to move and store the biomass and its associated investment. Biomass from offsite will also have to be evaluated for quality, which will require investment either in technical capacity or engagement of appropriate consultancy.

## Biomass characteristics implications

Each form of biomass has specific characteristics and associated implications. Examples include:

- very wet biomass may require special drying or dewatering machinery prior to feeding into a bioprocess.
- biomass that has a relative low net heating value and low density requires large volumes.
- biomass with known levels of heavy metals (such as biosolids) requires a sufficient volume of other biomass to dilute it (if combustion is not the desired bioprocess).

Storage and preparation of the biomass can either be handled at the plant site, or at decentralised receiving stations for biomass collection, processing and storage. To some degree this will be determined by the characteristics of the waste, but may also be heavily tied to EPA transport rules around movement of 'waste' biomass.

An analysis of the benefits of decentralised processing versus centralised processing should form part of the financial analysis, in particular the environmental benefits of reducing the number of truck movements.

# PHASE 3: DESIGN

## Project development

A concept design provides a detailed technical description, plant layout, plant equipment list, civil design and geotechnical assessment. Sufficient detail will be needed in order to estimate the capital and operating costs with a sufficient degree of confidence to satisfy investors.

Designing a bioenergy plant is a complex process that requires considerable technical experience and knowledge. It requires the engagement of professional service providers who can take the project from concept to detailed design. The service provider and their subcontractors should be able to:

- demonstrate capability and understanding of the technology and technical aspects of the project (a proven track-record is preferable)
- carry out the detailed design of the bioenergy plant, including all aspects of engineering
- guide the project through the environmental planning and approvals processes
- demonstrate appropriate project management skills to ensure the project is delivered on time and within budget
- demonstrate appropriate quality assurance and quality control qualifications and are preferably ISO accredited
- have the capability to develop contractual and tender documentation for commercial pricing
- participate in the tender evaluation process
- have the capability to support the project through the construction phase
- have appropriate insurances.

The content of the concept design will vary but will typically include:

- definition of biomass characteristics, including testing to confirm calorific value or biochemical methane potential
- description of the preferred technology, including:
  - fuel handling
  - combustion system
  - boiler
  - ash handling and disposal
  - flue gas treatment technologies to meet applicable and relevant air emission standards
  - energy recovery system
- identification of suitable technology providers
- process flow diagram, including a mass and energy balance
- site layout and general arrangement of the site
- site access, security and road layout

- confirm grid connections with local energy companies
- assessment of potential plant location(s) following an evaluation of technical, environmental, geotechnical, economic aspect and community acceptability
- a secured sustainable long-term supply of biomass (volume, heating value/properties and price)
- financial and economic analysis including cost-benefit calculations, calculations of net present value and return on investment (ROI) and similar analyses
- overview of current relevant regulatory and policy frameworks
- assessment of potential additional sources of financing, sensitivity analyses and risk assessment important to financial partners
- assessment of potential risks to the financial viability of the project and associated mitigation measures
- environmental and social impact assessment, including identification of mitigation measures
- organisation studies of potential operations and maintenance service providers
- procurement plan and identification of potential equipment suppliers and construction contractors
- implementation plan including time, resourcing and financing schedule
- skills and gap analysis of local workforce
- community and stakeholder management plan.

## The Concept Design Report

A Concept Design Report outlines the findings of the feasibility study and includes the development of key design decisions to sufficient detail for a robust capital and operating cost estimate. The report should include the following:

- confirmation of financial viability
- key contracts
- supplementary biomass mapping if required
- robust projections of capital, operating and maintenance costs
- confirmed technical design detail
- geotechnical investigations
- conceptual operational hazards analysis
- operating plan
- key engineering drawings
- equipment and instrumentation list
- site layout
- interface report (grid connections, water/sewer, emissions connections, gas connections)
- utility services plan
- environmental approvals (including EPA licence conditions)
- risk register
- health and safety plan

- traffic management plan
- community engagement plan
- commissioning plan
- decommissioning plan.

It should also include financial models and the business case demonstrating the economic and financial viability of the bioenergy project to the satisfaction of investors and stakeholders. A capital, operating and maintenance cost estimate in line with estimating principles is also essential. Ideally the costs will be verified by an independent Quantity Surveyor or Professional Estimator with experience with similar types of projects.

At the end of the concept design the developer should be able to procure the services of a contractor(s) to carry out detailed design and construction of the project.

The project development phase will show whether cooperating with a host or nearby industrial complex is feasible. A bioenergy plant can, to some extent, be designed for monitoring and control of operation from a remote-control facility, such as at night and weekends.

## Finalise planning approvals

Investors normally seek to obtain approvals before reaching financial closure. Once financial closure is reached, detailed design and procurement can start unless the owner intends to proceed at their own risk.

The following elements are normally part of the planning and approval process:

- environmental permit based on the EES (prepared as per regulatory requirements)
- planning permissions (local, state and federal)
- land use
- business documentation and approval to operate
- import licences for equipment
- grid connection approval
- approval for wastewater discharge.

Depending on the environmental and social impacts, the associated costs and the planning and environmental authority involvement, a feasibility study can generally be completed in 12–18 months. The associated costs can vary substantially but typically range between $300,000 (for a small and relatively simple project) and $1,000,000 (for a large and complicated project).

# Project financial close

The technical complexity of a project can absorb much of the initial focus of the project developer, but difficulties of assuring the necessary financing can also be substantial. Before initiating the search for finance, the project developer should bear in mind:

- the process of acquiring finance can be time consuming
- the technical, contractual and permitting aspects of a bioenergy project all affect the opportunities for securing financing
- project lenders will carefully assess all aspects of the project, with specific attention to the risks involved.

Therefore, attention to detail, risk mitigation and anticipation of lender concerns are very important.

The key financing considerations of bioenergy projects that should be considered before approaching a potential source of finance include:

- a stable and sufficient supply of sufficient quality biomass is available within a reasonable distance
- the project is based on own-use of generated heat and power or has easy access to grid connection or a large local user
- the proposed technology is proven and suitable in the local circumstances
- capital costs and operation and management costs are estimated
- the project lifespan allows for recovery of the investment
- environmental and social considerations are identified and adequately mitigated.

There are many ways of securing financing for a biomass project. The most common ways are described below, along with a brief assessment:

- Own equity: must be able to ensure a reasonable ROI, but also consider the overall benefits to the owner (for example, the use of biomass from existing production).
- Bank loans: international commercial banks, local banks or multilateral financing institutions (for example, ARENA). Financing through commercial banks often entails high interest rates, whereas development banks may offer more favourable interest rates.
- Investment by technology supplier: as the technology supplier has an interest in seeing the project succeed, the technology supplier may be willing to offer loans at interest rates lower than the banks.
- Investment by biomass supplier: biomass suppliers could typically be cooperatives of farmers or biomass processing companies with significant biowaste. The chance of being able to sell their biowaste provides an incentive for suppliers to contribute to the success of the project. They could provide capital as investment or loans at reasonable rates.
- Build-operate-transfer: in a build-operate-transfer (BOT) framework, a third party (the BOT contractor) takes responsibility for financing, designing, building infrastructure and operating the plant for a fixed period.
- Private equity funds: capital for private equity is raised from retail and institutional investors and can be used to fund new technologies. The majority of private equity funds consist of institutional investors and accredited investors, who can commit large sums of money for long periods of time.

## Procurement and implementation

The procurement process can be structured in many ways and the size of the project will influence the approach. It is important to discuss and decide the procurement strategy in the early stages of the project, since this can influence some of the initial decisions. The procurement strategy is of significant interest to investors, as it identifies who is responsible for design and interface risks, the risks associated with final capital cost and the project delivery timeline.

Procurement and contracting of bioenergy plants may use a variety of models that reflect the scale of the project and the increasing transfer of risk and responsibility from the owner to the contractor(s). Some typical models include:

- traditional contracts, dividing the plant into several partial contracts with separate detailed designs. This requires a project manager to supervise and manage the contractor's performance.
- DB (design-build)/EPC (engineering, procurement, construction)/turnkey contract, with one contractor being responsible for design and construction of the entire plant. The plant owner is responsible for the operation and maintenance of the facility.
- DBO (design-build-operate)/BOT (build-operate-transfer) type contracts, where a third party operator (sometimes the main contractor) is engaged to operate and maintain the plant. The operator should be involved during the detailed design of the project.
- DBFO (design-build-finance-operate), where the contractor and a third party operator (sometimes the main contractor) takes full responsibility for the provision of a biomass-based power plant and is remunerated through the provision of heat and power.

Typically, bioenergy projects will use an EPC approach as this is the most prominent form of contracting agreement in the construction industry. The engineering and construction contractor is responsible for:

- detailed engineering design
- procurement all necessary equipment and materials
- construction and commissioning of the facility
- delivery of a functioning plant or asset which meets the client's performance requirements.

The DBO or DBFO approaches can be modified to negotiate an optional right to take over the operation and maintenance of the biomass plant after the initial two to four years of plant operation. This approach allows for the initial processing risk to be mitigated and for the owner to familiarise themselves with the plant and its operation and ensure it has adequate skilled resources to operate and maintain the plant to achieve maximum performance.

The decision on the type of contract will depend on the degree to which the bioenergy plant is integrated with the owner's existing facilities and on the owner's ability and willingness to transfer design decisions, operational control and project risks to the contractor.

It is of utmost importance to specify and agree upon the performance of the biomass plant. Sufficient time must be spent, and the necessary technical expertise engaged, to

Other considerations that will influence the type of contract are:

- the degree of owner involvement in the selection of subcontractors, technology supplier and detailed design
- ownership of the price and time risk
- the certainty of price
- certainty of project delivery time
- certainty of performance
- minimising the number of contractual interfaces.

define a sound contractual basis to cover plant performance risks. This should include general project warranties and process performance guarantees including energy generation and waste production, equipment reliability guarantees and plant availability guarantees.

## Form of contract

Choosing the right form of contract is an important decision and technical and legal advice should be sought as to which form of contract is best for your bioenergy project. The first form of contract to be considered should be standard forms of contract. In Australia there are a set of Australian Standard forms, and the most common standard forms of contract used in construction are:

- AS4300
- AS4000
- AS2124
- AS4902.

Alternative standard contract templates are available from sources such as the International Federation of Consulting Engineers (FIDIC). FIDIC standard forms are widely used for international procurement in the energy sector. FIDIC contracts are written in formal legal English and are drafted based on common law. They have been developed over decades and are well-respected among owners, contractors and investors. FIDIC forms are only used on relatively high-value projects (>$100 million) involving the private sector and process engineering projects, such as bioenergy plants.

> Useful references include *Standard Forms of Contract in the Australian Construction Industry* from the University of Melbourne School of Law and National Guidelines for Infrastructure Project Delivery.

## Tendering

The tendering procedure must comply with state and national laws covering construction contracts. Legal and transaction advisers can advise regarding the laws pertaining to the scale of the project and the best options to engage with the market. Alternatively, direct contracts with selected contractors may be used if the project is sufficiently small scale.

A public procurement approach offers the advantage of being able to interact with potential bidders during the procurement process. Conducting an initial market sounding prior to the tendering procedure is an excellent way to gain an understanding of the competition in the marketplace, potential bidders, available technologies and to gain feedback on various forms of contract. The market sounding may include the following questions:

- Which technology or technology supplier is the contractor offering?
- Is the contractor offering suitable alternatives that are proven for the biomass project?
- Does the contractor have experience with the biomass to be used?
- Does the contractor have experience and suitable reference plants in Australia?
- Does the contractor have a strong financial track record?
- Does the contractor offer a parent company guarantee?

- Does the contractor offer a process guarantee?
- Does the contractor possess the necessary technical capability in-house?
- Does the contractor have sufficient skilled labour for the construction and commissioning?
- Does the contractor and/or technology supplier have a local service capability?

If a public procurement process is used, we recommend that a prequalification stage is included and that only experienced, financially sound and capable contractors are selected for the formal tendering phase. The tender specification should be ready at the time of prequalification and the evaluation criteria clearly outlined in the tender documentation.

When applying a private (non-public) procurement system, it is possible to use a similar approach to the public procurement process by including a prequalification stage and tendering based on a detailed tender specification. To elicit best value, it is important that the tendering procedure be competitive and transparent.

In a private procurement system, bidders are invited by the developer to submit a bid, usually based on the tender specification. The bid can be as detailed as a public tender or a simpler performance-based specification can be used, stating the overall requirements of supply. Following an evaluation of the budgetary bids received, all details must be discussed with the preferred bidder and incorporated in the draft contract.

## Recruitment and training plan

At the end of the design period you will have a good idea of the important processes to produce bioenergy from your chosen feedstocks and your plants design should be largely fixed. You should therefore be able to identify the specific roles and skills that will be necessary to operate your plant and associated critical procedures.

Building on the relationships you established during your initial workforce analysis, you should explore how to ensure that your operators have the required skills. For most projects there will be roles that require officially recognised skills (such as electricians, gasfitters, high voltage operators). Tasks involving high-risk work (such as confined space entries and operation of forklifts and cranes,) must be carried out by staff with specific accreditation, as dictated by WorkSafe. There are other tasks where a Bachelor of Science degree qualification may be required (e.g. operating biological processes) but other roles might be filled by people who learn scientific skills on-the-job or via a suitable Technical and Further Education (TAFE) course.

A job skills/task analysis should be carried out to identify the types of roles for each major task on site. Both a recruitment plan and a training plan should be devised to decide when and who to hire, and when and what training should be delivered. The training plan will be based on an analysis of the skills, knowledge and attributes held by each of the individuals chosen for the roles. It is advisable that some operational staff be involved in the commissioning process so that they can learn directly from the vendors of the plant and from commissioning engineers.

# PHASE 4: BUILD AND OPERATE

## Construction

The division of responsibilities between the developer and the contractor during construction and commissioning is dependent on the type of contract in use. However, the basic tasks to be performed during the construction and commissioning phase are the same regardless if they are carried out by the developer or the contractor.

The construction of a bioenergy plant is a complex process that requires extensive knowledge and considerable experience in technical, environmental, project planning and construction management. Successful construction of a bioenergy plant requires the project to be managed in line with general construction project management best practice.

A biomass-to-energy plant includes a number of scope items outside of the plant itself, the following additional tasks need to be considered:

- temporary works
- site construction area
- fuel reception, yard and storage
- emission monitoring
- solid waste transport and storage
- make-up and cooling water
- sewer connection
- electricity and power distribution
- grid connection
- offices, stores and workshop
- communications infrastructure
- security.

A construction site management plan should be in place to plan and coordinate daily on-site activities during construction.

For smaller projects or for those with only one contractor, several roles may be carried by the same individual. The developer's construction site organisation should, at a minimum, include the following roles:

- construction site manager
- environment, health and safety manager
- quality manager
- site documentation and control.

The developer's construction site organisation should be independent of on-site contractors. In addition, the contractor will have their own construction site organisation in place and the two parties should work together.

The developer's company is usually engaged in other types of business (different from bioenergy plant construction and operation) and may not have qualified personnel for this type of task in the organisation. They should engage external experts independent of the contractor to ensure their interests are represented.

# Commissioning and project handover

## Commissioning

When all equipment has been installed, the project moves into the commissioning stage. During the commissioning stage, it is important that all equipment is tested in a logical and systematic way. A well-prepared commissioning plan ensures that commissioning is conducted in a systematic and safe way.

The commissioning phase aims to demonstrate that all installations are complete and comply with contractually-specified requirements, have completed electrical safety checks and are safe to operate.

The commissioning phase includes, at a minimum:

- program and timeline
- roles and responsibilities
- communication plan
- development of training materials
- classroom training (as per training plan written in late planning stage)
- plant training (as per training plan written in late planning stage)
- cold testing (including instrumentation and control system aspects)
- hot/wet testing
- functional test and trial operation
- performance test and availability analysis
- success criteria
- production of handover documentation.

During this period it is also common to construct a list of defects and a plan for who will fix them and pay for the work. If the plant is well-designed and quality control during construction was good, this list may be minor in nature. However, this is often not the case and resolution may require engagement of legal advice.

Operating staff are trained during the commissioning phase so they become familiar with the equipment, and ensure efficient and safe operation and maintenance.

As the operations team become skilled in operating the plant and learn its strengths and limitations, it is common for some process improvements and optimisations to be made during the late commissioning phase.

## Handover

Documents which need to be handed over include:

- commissioning report, showing compliance with all design and compliance specifications and detailing any defects that have been rectified
- As Build diagrams of plant
- operations manuals
- unit process control procedures
- evidence of training identified in the training plan (including Safety and Critical Compliance Operational Procedures)
- certificates of occupancy
- site emergency management plan
- maintenance schedules for equipment (often in order to maintain warranty)
- defined job descriptions and training and assessment manuals for each job.

# Operate

The profitable operating life of a biomass-to-energy plant depends on the biomass, operational profile and maintenance history. Major overhauls or rehabilitation of key systems and components may take place during the operating period.

Plant operation includes several tasks and responsibilities, such as:

- scheduling of power and heat production and fuel supply
- operating and monitoring all functions of the energy-producing plant and equipment
- operation of biomass reception and handling, including weight measuring and quality control
- operation and handling of systems for waste by-products
- supervision of plant operations
- planning and scheduling of necessary maintenance work.

During operations it is essential that operators have access to a comprehensive and well-structured system which contains the relevant documentation and operation and maintenance manuals. These are essential for reliable and efficient operation and maintenance. The tender specifications should define the structure, quality, timing and extent of the equipment suppliers' documentation. Documentation which operations staff should become familiar with should include:

- general description of plant and functional description of individual systems
- drawings of layout and diagrams with a clear tag number system for systems and components
- operation manuals for each system
- detailed descriptions of all major equipment and components with precise and understandable maintenance manuals
- performance data and technical guarantees with correction curves for variations in preconditions, such as ambient temperature
- copies of technical and literature data from equipment suppliers.

Clear instructions from plant management to operators and maintenance staff are essential for a safe working environment.

The operation of a bioenergy plant comprises of a series of daily, weekly, monthly and annual tasks to maintain its safe and optimal production. These tasks must be completed, monitored and reviewed on a regular basis. Detailed records of completed tasks ensure the plant operates effectively and that warranties and guarantees can be enforced.

# BIOENERGY SKILLS AND EDUCATION ANALYSIS

## How big could bioenergy be in Australia?

Australia's transition to low or no carbon power is largely dominated by solar and wind. These sources are now cheaper than investing in the fossil fuel equivalents for producing electricity. Because of this dominance, the role of biologically-produced energy is likely to be best captured by the production of transport fuels, the production of 'bioheat' and the production of green gas to supplement fossil sources of gas.

A recent submission to the Bioenergy Roadmap, Bioenergy Australia stated that bioenergy has the potential to attract at a minimum $3.5-$5 billion investment, mostly into Australia's regional economies (McKenzie, 2020). The relative potential size of the bioenergy market is demonstrated by two countries where bioenergy has a longer history. Bioenergy contributes upwards of 23 per cent of total primary energy supply in Denmark and 30 per cent in Brazil (McKenzie, 2020).

# What types of jobs are in the bioenergy economy?

*Table 4: Occupations identified in the bioenergy sector (International Labour Office, 2011).*

**Project development**

- Biochemists and microbiologists (H)
- Agricultural, biological, chemical and physical scientists (H)
- Chemical, biological, mechanical and electrical engineers (H)
- Material scientists in R&D (H)
- Software engineers (H)
- Manufacturing engineers (H)
- Manufacturing quality assurance specialists (H,M)
- Manufacturing technicians (H,M)
- Quality assurance specialists (H,M)
- Logistics professionals (H,M)
- Logistics operators (L)
- Equipment transporters (L)
- Procurement professionals (H,M)
- Marketing specialist (H,M)
- Sales personnel (H,M)
- Environmental and social NGO representatives (H,M)
- Public relations officer (H)
- Procurement professionals (H,M)

**Construction and instillation**

- Biochemists and microbiologists (H)
- Environmental engineers (H)
- Laboratory technicians and assistants (M)
- Chemical, biological, mechanical and electrical engineers (H)
- Project designers and managers (H)
- Software engineers (H)
- Construction professionals (H)
- General electricians, plumbers, roofers (M)
- General construction workers (L)
- Business developers (H)
- Commissioning engineer (electrical) (H)
- Transportation workers (L)

**Biomass production**

- Agricultural scientists (H)
- Biomass production managers (H,M)
- Plant breeders and foresters (H,M)
- Agricultural/forestry workers (L)
- Transportation workers (L)

**Supporting enablers**

- Policy-makers and government office workers (H,M)
- Trade association and professional society staff (H,M,L)
- Educators and trainers (H)
- Management (H,M,L)
- Administration (H,M,L)
- Publishers and science writers (H,M)
- Insurer representatives (H,M)
- IT professionals (H,M)

**Operations and maintenance**

- Biochemists and microbiologists (H)
- Laboratory technicians and assistants (M)
- Operations and maintenance specialists (M,L)

H = High skilled – Professional/managerial

M = Medium skilled – Technician/skilled crafts/supervisory

L = Low skilled – Semi-skilled and unskilled

The jobs listed in Table 4 were identified by the European Union's International Labour Office as being created by the bioenergy sector. Unlike coal and gas used to produce electricity, the bioenergy sector does not just produce energy. Due to many potential by-products and potential feedstocks, the effect of this is the development of an entire bioeconomy. This is one of the reasons that bioenergy is employment-intensive, with jobs being created all along the bioenergy value chain, from biomass production or procurement, to transport, conversion, distribution and marketing of biofuels and electricity (International Labour Office, 2011). It has been suggested that renewables create relatively more jobs than the fossil fuels they displace (Malamatenios, 2016).

# Bioenergy skills in existing sectors and existing educational and training

To some degree the occupations identified in the table above can be found in at least three sectors: electrical operations, the water and wastewater industry and agriculture. In addition, much of the education and training in the existing engineering and science degree programs and the skills gained by existing electrical and gas fitting trades is able to be transferred to the bioenergy sector. This is reflected in Figure 19.

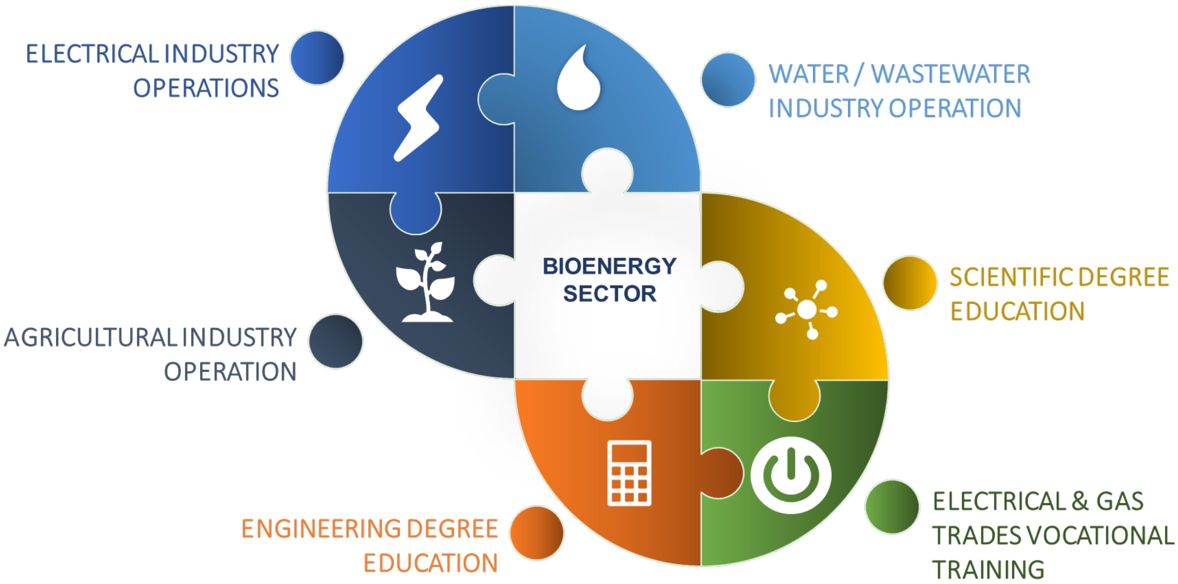



*Figure 19: Diagram of existing sectors and existing education and training which have skills transferrable to the bioenergy sector.*

The approach of solely employing workers who have originated in other industries leaves bioenergy vulnerable to movement of those workers back to their original (probably higher-paying) sectors. Given the agricultural and water/wastewater sectors will expand in coming decades to accommodate population growth, this only leaves the (non-renewable) energy sector as a potential net donor of workers to the bioenergy sector.

In the Latrobe Valley (where the bulk of the Victoria's fossil fuel-based energy is created) the closure of the Hazelwood power station and scheduled closure of Yallourn and Loy Yang A and B will provide many workers in need of a transition. A potential hurdle to a smooth transition may be the workers being accustomed to relatively high earnings.

# The Australian Qualifications Framework

The Australian Qualifications Framework (AQF) is the national policy which regulates qualifications in Australian education and training. It incorporates the qualifications from each education and training sector (higher education, vocational education and training (VET) and schools) into a single comprehensive Framework.

There are 10 assigned levels for education and training to supply knowledge and skills, as shown in Table 5 below. Universities typically deliver levels 6-10 and the training and educational sector providing levels 1-6. The university sector is simpler to explain with Australia having a number of public and private (full fee paying) universities to cater to the market in diplomas, degrees and postgraduate qualifications.

*Table 5: AQF levels showing skills and experience gained and the qualification type gained at each level.*

| Level | Level 1 | Level 2 | Level 3 | Level 4 | Level 5 |
|---|---|---|---|---|---|
| Summary | Graduates at this level will have knowledge andskills for initial work, community involvement and/or further learning | Graduates at this level will have knowledge andskills for work in a defined context and/ or further learning | Graduates at this level will have theoretical and practical knowledge andskills for work and/ or further learning | Graduates at this level will have theoretical and practical knowledge andskills for specialised and/or skilled work and/ or further learning | Graduates at this level will have specialised knowledge and skills for skilled/para-professional work and/or further learning |
| Qualification Type | Certificate I | Certificate II | Certificate III | Certificate IV | Diploma |
| **Level** | **Level 6** | **Level 7** | **Level 8** | **Level 9** | **Level 10** |
| Summary | Graduates at this level will have broad knowledge and skills for para-professional/ highly skilled work and/ or further learning | Graduates at this level will have broad and coherent knowledge and skills for professional work and/ or further learning | Graduates at this level will have advanced knowledge and skills for professional highly skilled work and/ or further learning | Graduates at this level will have specialised knowledge and skills for research, and/or professional practice and/ or further learning | Graduates at this level will have systematic and critical understanding of a complex field of learning and specialised research skills for the advancement of learning and/or for professional practice |
| Qualification Type | Advanced Diploma Associate Degree | Bachelor Degree | Bachelor Honours Degree<br>Graduate Certificate Graduate Diploma | Masters Degree | Doctoral Degree |

Table 5 shows the range of courses available in the Australian market and the institutions responsible for delivering them. This ranges from the pre-accredited, nationally accredited to the non-accredited space. In Australia a market is emerging for non-accredited courses known as short online open, medium online open and micro-credentialed.

Furthermore, the VET sector has seen a number of developments over the past decade, with regular changes to training packages and industry engagement. These changes have impacted the way educational products are delivered and seen delivery modes evolve.

The educational delivery model in Australia has moved from majority face-to-face delivery to a blended model that incorporates digital learning within a learning management system with a combination of face-to-face, on-the-job and at-home learning. This new blend allows learners to evolve with the changes that their industry is experiencing while also ensuring that they are 'industry ready'.

# Pre-accredited (ACFE) funded and non-Accredited courses

In the pre-accredited market, courses are funded by Australian Community Further Education (ACFE) which is a Victorian-based funding body that supports Learn Local-registered ACFE approved courses within metropolitan and regional Victoria. Learn Locals normally consist of approved not-for-profits, community centres and neighbourhood learning centres, that all apply to become an approved ACFE provider of pre-accredited education.

The structure of a pre-accredited course is similar to that within a nationally approved training package, but simplified for an individual course. The course is designed through the creation of the compliance document called an A frame, which is considered a scaled-down version of the structure of learning in the TAFE system.

Finally, non-accredited education can be delivered by anyone with the ability to sell themselves as trainers and can take the form of:

- micro-credentials
- short online open course (SOOC)
- massive online open course (MOOC)
- a learning course delivered through an online video platform
- educational workshops, supporting a group to learn new skills.

# Higher education: the tertiary sector

Higher education (also known as tertiary education) leads to the award of an academic degree. A university education often exposes students to new research and technology and encourages creative and independent thought. It is not always vocationally-based.

Each qualification (degree) is structured over a number of years. Typically, there are core subjects that must be included and elective subjects which are chosen by the student.

Entry to a degree may require specific Victorian Certificate of Education subjects, predefined levels of achievement in those subjects or a minimum Australian Tertiary Admissions Rank (ATAR) rank (or all of the above).

A student must pass each subject to gain points for that subject. Often first year units are prerequisites for units in second and subsequent years of learning. A degree is awarded when the appropriate number of points is achieved and the core subjects have been passed.

## Universities in Victoria

Universities outside the Gippsland region offer a wide range of engineering and scientific disciplines. Those most relevant to bioenergy are listed below.

### Melbourne University

Melbourne University run courses on-site at its Parkville campus:

- The Master of Energy Systems accepts students who have completed a degree in engineering, science, business, finance or economics and are looking to work in the energy sector. It has a renewable energy core unit which covers "the chemistry and technologies for biomass for heat and electricity and liquid biofuels" and renewable integration and policy, all of which are relevant to the development and operation of bioenergy plants.
- The Master of Environmental Engineering also provides a path into bioenergy. Students study one of three streams (waste management, energy or water resources).
- Two law courses (Graduate Diploma in Energy and Resources Law and the Master of Energy and Resources Law) develop knowledge in the industrial structure and legislative requirements of the changing energy industry, both in Australia and internationally.

### Deakin University

Deakin University offers several courses relevant to the bioenergy industry in person at its Geelong campus and online:

- The Bachelor of Electrical and Electronics Engineering (Honours) teaches sought-after skills in power generation, distribution and control and includes electives in renewable energy systems.
- The Master of Energy System Management and Master of Energy System Management (Professional) are designed to produce skilled senior engineers who can design, manage and maintain new distributed energy grid systems.

### RMIT

RMIT runs this course on-site at its Melbourne City and Bundoora campuses:

- The Master of Engineering (Sustainable Energy) is designed to enable students to work on sustainable energy projects at professional consulting and managing levels and sustainable energy-related projects in research institutes. There is a unit on Renewable and Solar Fuels which covers the fundamentals (biochemistry) and technical information on biomass and biofuel technologies including production and use in mobile and stationary power and thermal systems.

### Monash University

Monash University runs these courses at the Clayton campus:

- Master of Advanced Renewable and Sustainable Energy Engineering is a one-year program that teaches the operation, benefits and limitations surrounding each of the major renewable energy technologies in the emerging energy sector, with understanding around how such technologies modify existing electricity networks and the markets in which they operate.
- Master of Bioproduct Manufacturing Engineering looks at innovative ways to convert natural renewable biological resources, such as wood and crop waste, into a wide range of value-added chemicals, materials and energy. This includes a subject on biomass and biorefineries.

### Federation University

Federation University has a campuses in Gippsland (at Churchill) and Ballarat.

Many of the bioenergy-relevant engineering degrees (electronics, mining, mechanical, manufacturing) are only offered at the Ballarat Campus. The Churchill campus offers Civil and Mechatronics Engineering at an undergraduate level. There are a number of postgraduate engineering qualifications available.

Federation University also offers a wide range of degrees relevant to bioenergy, such as Bachelor of Science, Bachelor of Biotechnology and Bachelor of Environmental and Conservation Science.

# Vocational education and training (VET)

VET qualifications are provided by government institutions, called TAFE institutions, as well as private institutions. These courses tend to be skills-based and prepare learners for jobs that are based in manual or practical activities, traditionally non-academic and totally related to a specific trade, occupation or vocation.

Recognised courses are either nationally- or state-registered. The Australian Skills and Quality Authority (ASQA) registers training providers and accredits VET courses to meet nationally approved standards. Victorian state-based training is owned by the Victorian Registration and Qualifications authority (VRQA).

Some copyright over the course and materials is held by the Registered Training Organisation (RTO) which developed the training.

A qualification is made up of units of competency, including core and elective units that have an assumed number of hours required to achieve competency. Each unit has performance criteria against individual elements, and students must demonstrate:

- knowledge evidence
- performance evidence
- foundation skills.

Each student is assessed for each of these areas and will pass the unit if they demonstrate their competency. To complete an individual unit a student must enrol in a certificate or course and select compulsory and elective units. Generally, a student cannot complete a single unit without having completed the required prerequisites and enrolling in broader subjects.

However, a fee for service (generally to an industry client wanting tailored training for its workforce) may be available in many subject areas. This fee charged for service is arranged between the RTO and their client.

## Training development in renewable and bioenergy sectors

The renewable energy sector (mainly comprised of solar and wind to date) has sparked a national transformation. The sector will become a major employer over the coming decade, as fossil fuel-based sectors recede. As a result, the skills and experience required of workers in the sector will change and the VET sector will need to meet these new demands.

The renewable and bioenergy sector has depended upon traditional training qualifications, with minimal specialisation. This is now starting to shift to greater specialisation, so that specific skillsets can be provided to trainees and apprentices for future careers in bioenergy.

The specialisations required (among many) are related to:

- solar and wind product installation and integration with traditional electrical systems
- increased knowledge and understanding of the many renewable energy system types
- linking of plumbing and gasfitting skills to renewable gas systems
- understanding of biomass (basic biology and chemistry)
- understanding of pretreatment technologies
- understanding of separation technologies
- adaptation of traditional skills in welding and fabrication to bioenergy plants
- transfer of instrumentation and control system skills to bioenergy plants.

ASQA and VRQA oversee the training and educational sector and ask industry to annually review and validate the training in TAFEs and private RTOs. This normally allows for industry to provide critical feedback on changes, amendments and innovations.

The tertiary sector has already begun to respond to these changes, and now suitable VET development is starting to become available. For example, in response to demand from Gippsland Solar, TAFE Gippsland runs a dedicated solar panel installers course.

## TAFE Gippsland

### Biopathways (WTIF) project

Australian Paper received a Victorian State Government Workforce Training Innovation Fund (WTIF) grant to develop vocational training to help foster the biomanufacturing sector (of which bioenergy is one). The project (run jointly by TAFE Gippsland and Federation University) identified the need for certificate level III and IV level qualifications that align with the traineeship and apprenticeship model in Australia.

This resulted in the development of a Certificate III in Biomanufacturing and in specialised teaching facilities for the course. The course is run by TAFE Gippsland at their Yallourn/Newborough campus. This project also funded some research work with Federation University. This certificate level training fits the standardised approach for traineeship models while also allowing on-the-job training with local industries.

The central structure of the course revolves around three broad categories: separation, transformation and resource recovery (see Table 6). Each of these three core areas of learning involve topics that are relevant to those working in a bioenergy plant.

*Table 6: Structure of the scientific concepts around the Biopathways program (Biopathways Program, 2019).*

| Separation | Transformation | | Resource Recovery |
|---|---|---|---|
| | Biological | Chemical | |
| Sieving | Fermentation (anaerobic) | Synthesis | Anaerobic digestion |
| Flocculation | Aerobic biological reactions | Combustion/ Pyrolysis/Torrefaction | Water recycling |
| Centrifugation | Enzymatic digestion/ hydrolysis | Decomposition/ Rearrangement | Heat and steam recovery |
| Filtration (membrane) | Biotechnical approaches | Polymerisation | Chemical treatment |
| Distillation | | Transesterification | Aerobic biological treatment |
| Evaporation | | Gasification | Odour treatment |
| Extraction | | Hydrothermal liquefaction | Composting |
| Chromatography | | | Agricultural re-use |

All six of the technologies discussed as viable bioenergy processes in this Framework (anaerobic digestion, combustion, fermentation, pyrolysis, gasification and transesterification) are included in the Biopathways training package.

### Qualifications with relevance to the bioenergy industry

Ranging from Certificate III to Diploma, a wide range of qualifications are available that are directly relevant to the bioenergy industry (see Table 7).

*Table 7: Qualifications with relevance to the bioenergy industry. Many of these have units of competency directly related to renewable energy.*

| Certificate category and name | Victorian RTOs |
|---|---|
| Agriculture | |
| Diploma of Agriculture, Diploma of Agribusiness Management | Federation University, TAFE Gippsland and others |
| Engineering | |
| Diploma of Engineering Technology | Box Hill, Chisholm, VU, Wodonga TAFE, Melbourne Polytechnic |
| Advanced Diploma of Engineering Technology – Renewable Energy | Chisholm |
| Advanced Diploma of Engineering Technology – Electrical | RMIT, Swinbourne, Victoria University |

| Certificate category and name | Victorian RTOs |
|---|---|
| Process | |
| Certificate III in Process Manufacturing | Leadership Management Australia Pty Ltd |
| Certificate III in Process Plant Operations, Certificate IV in Process Plant Technology | Box Hill, Chisholm |
| Certificate IV in Process Plant Technology | Box Hill, Chisholm |
| Laboratory skills | |
| MSL30118 - Certificate III in Laboratory Skills (Release 1) | Bendigo, Box Hill, Homesglenn, Labtech Training + 2 |
| MSL60118 - Advanced Diploma of Laboratory Operations | Labtech Training Victoria Pty Ltd. |
| Water industry | |
| NWP20119 - Certificate II in Water Industry Operations (Release 1) | Chisholm, Water Training Australia |
| NWP30219 - Certificate III in Water Industry Operations (Release 1) | Chisholm, Water Training Australia |
| NWP40615 - Certificate IV in Water Industry Treatment | Water Training Australia Pty Ltd |
| WP50118 - Diploma of Water Industry Operations | No |
| Waste management | |
| TLI30419 - Certificate III in Waste Driving Operations | No |
| CPP30719 - Certificate III in Waste Management (Release 1) | No |
| CPP40919 - Certificate IV in Waste Management | No |
| Electrical | |
| Certificate II in Electrotechnology (Pre-vocational) | Box Hill, Chisholm, VU, Wodonga TAFE, Melbourne Polytechnic |
| Certificate III in Renewable Energy - ELV | No |
| UEE30920 - Certificate III in Electronics and Communications | Bendigo, Chisholm, TAFE Gippsland, Swinbourne |
| UEE40920 - Certificate IV in Industrial Electronics and Control (Release 1) | No |
| UEE40620 - Certificate IV in Electrotechnology - Systems Electrician | No |
| UEE43220 - Certificate IV in Industrial Automation and Control (Release 1) | Victoria University, Skills Lab Pty Ltd |
| UEE42620 - Certificate IV in Hazardous areas - Electrical (Release 1) | No |
| UEE42220 - Certificate IV in Instrumentation and Control (Release 1) | RMIT |

# Suggestions for future bioenergy education and training

## Tertiary education

Victoria's tertiary sector is well-placed to train engineers in renewable energy-related subjects. Currently the main focus is on renewables such as solar and wind, but the biomass/bioeconomy-based programs at Monash University indicate that bioenergy is starting to become more important.

However, true mastery of design in renewable and bioenergy systems comes with experience. Examining bioenergy technology uptake across Australia, we see:

- anaerobic systems are installed in 25 locations across Victoria, which provides a moderate amount of engineering and scientific experience
- gasification and combustion are currently applied to municipal solid waste (garbage) and sometimes coal, so there is an existing base of knowledge in that area
- fermentation is widely used to produce food and drinks.

Therefore pyrolysis and transesterification (as well as pretreatment technologies) are the technologies lacking experienced engineers and scientists in Australia. One method to increase the exchange of experience might be for scholarships (partly funded by government and engineering companies) to encourage junior engineers in Gippsland to take up a bioenergy placements in Europe.

## Vocational training

Gippsland is better placed than many other locations to commence training for the growing bioeconomy. However, more work remains to be done to link traditional trades and the agricultural sector to bioenergy.

Some training of electrical, plumbing and instrumentation trades could take place on-site at an anaerobic reactor, and associated educational materials provided to increase awareness of the bioenergy sector and its growing employment market.

The agricultural sector could also benefit from increased knowledge of bioenergy. We recommend the development of a more comprehensive package for those undertaking training in the agricultural trades at TAFE (and also offered as a stand-alone session). Aside from focusing on useful on-farm technologies, specific units could focus on the ways in which bioenergy projects may enhance nutrient management, soil health, water recycling, odour control and greenhouse gas emissions.

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