

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	Construction and instillation	Supporting enablers
<ul style="list-style-type: none"> 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) 	<ul style="list-style-type: none"> 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) 	<ul style="list-style-type: none"> 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)
	Biomass production	Operations and maintenance
	<ul style="list-style-type: none"> Agricultural scientists (H) Biomass production managers (H,M) Plant breeders and foresters (H,M) Agricultural/forestry workers (L) Transportation workers (L) 	<ul style="list-style-type: none"> Biochemists and microbiologists (H) Laboratory technicians and assistants (M) Operations and maintenance specialists (M,L)
		<p>H = High skilled – Professional/managerial</p> <p>M = Medium skilled – Technician/skilled crafts/supervisory</p> <p>L = Low skilled – Semi-skilled and unskilled</p>

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.

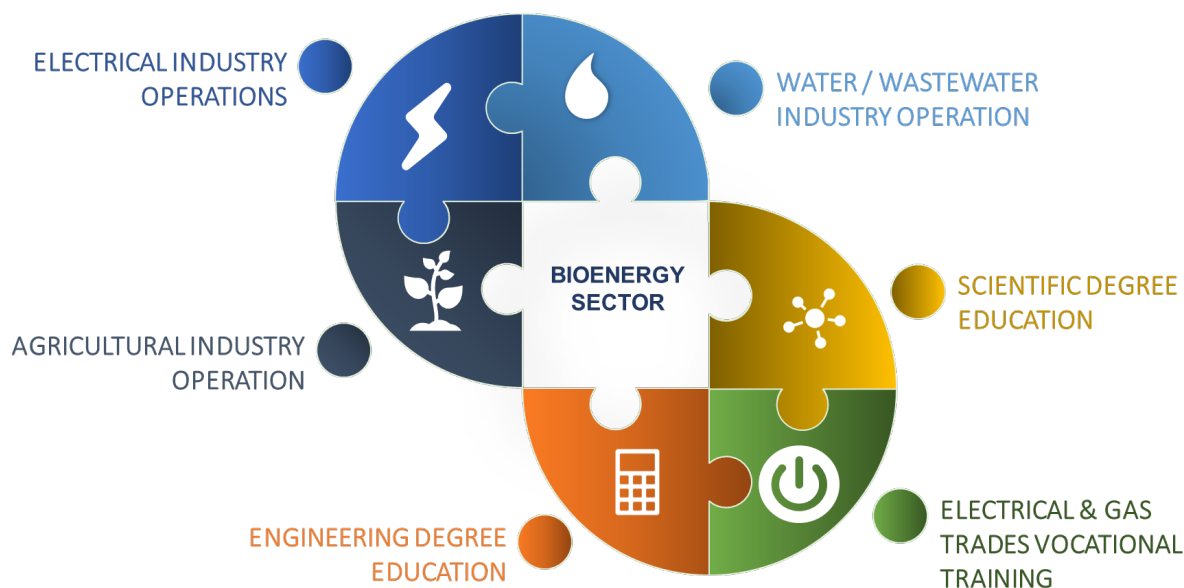


Figure 19: Diagram of existing sectors and existing education and training which have skills transferrable to the bioenergy sector.

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 and skills for initial work, community involvement and/or further learning	Graduates at this level will have knowledge and skills for work in a defined context and/or further learning	Graduates at this level will have theoretical and practical knowledge and skills for work and/or further learning	Graduates at this level will have theoretical and practical knowledge and skills 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 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.