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Australia's Bioenergy Roadmap

Appendix – Market Activity and Opportunities

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Prepared by ENEA Australia Pty Ltd and Deloitte Financial Advisory Pty Ltd for ARENA.

Australian Government
Australian Renewable Energy Agency

ARENA

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1. Key findings

Bioenergy is a major component of the global energy mix, currently providing 70 per cent of the world's renewable energy demand. Bioenergy is also the most widely used source of renewable energy:

- Bioenergy currently accounts for 47 per cent of Australia's current renewable energy production.
- Bioheat in Australia accounts for 15 per cent of Australia's heat generation. It is well established due to high uptake amongst waste-producing industries, including drying processes in the sugar, food, wood, and the pulp and paper industries.
- Bioelectricity accounts for 1.3 per cent of Australia's electricity generation. Bagasse is the leading bioelectricity resource used in Australia, followed by landfill gas. Although bioelectricity accounts for a small proportion of generation, the use of municipal and industrial waste for electricity production has accelerated in recent years.
- Transport biofuels account for just 0.4 per cent of Australia's transport fuel demand. This is well below Australia's biofuel production capacity, which is mainly located in New South Wales and Queensland, the only two states with biofuel mandates.
- As of 2021, there is currently one demonstration biogas upgrading plant in Australia for injecting biomethane, a renewable natural gas, into the gas grid. Most of Australia's biogas production is currently used to generate heat and electricity or is otherwise flared.

Bioenergy has the potential to play an even larger role in Australian markets. Significant opportunities exist, especially in hard-to-abate sectors. Market opportunities identified as part of this Roadmap are:

- Industrial renewable heat
- Dispatchable renewable electricity
- Renewable fuel for passenger vehicles
- Renewable fuel for long-haul transport (including marine shipping)
- Sustainable aviation fuels (SAF)
- Renewable gas grid injection

2. Appendix overview

This appendix:

- provides an overview of bioenergy production in global and Australian markets.
- identifies bioenergy market opportunities for Australia in heat, electricity, transport and gas uses.

3. Global and Australian market overview

Bioenergy is a major source of renewable energy, accounting for 70 per cent of global renewable energy production[1] [1].

Within this, more than half of global bioenergy production is 'modern' bioenergy as opposed to 'traditional', which accounts for the remaining share. Modern uses of bioenergy refer to the sustainable conversion of biomass and waste into value-added energy products at an industrial scale (see Table 1).

There are both traditional and modern bioenergy uses [2]:

- Traditional uses of bioenergy refer to the direct combustion of untreated solid biomass for cooking or heating purposes, principally in rural areas of developing countries. Although traditional uses represent 45 per cent of global bioenergy primary demand, they are declining.
- Modern uses of bioenergy refer to the sustainable conversion of biomass and waste into value-added energy products at an industrial scale. Modern uses are expected to increase in the future.

This Roadmap focuses on modern bioenergy uses.

Bioenergy is a major renewable energy source in Australia. In 2019-2020, Australia's bioenergy production represented approximately **47 per cent of Australia's renewable energy** production (including hydropower, wind and solar) [3]. However, bioenergy only accounted for around 3.3 per cent of Australia's total primary energy supply.

Image: MSM Milling's canola processing facility in Manildra, NSW.

[1] This is approximately 10 per cent (57 EJ) of global primary energy supply in 2018. Bioenergy is currently the fourth largest energy source after coal, oil and natural gas.

Table 1 – Global and Australian bioenergy production per market, 2018[2]

	Global 2018	Australia 2018
Modern bioenergy primary supply (PJ)	30,858	218
Average annual growth 2010-2018	+3.4%	+2%
Share of primary energy supply	5%	3.3%
Heat generation		
Heat generation from bioenergy (PJ)	14,300	194
Share of total heat generation	7%	15%
Average annual growth 2010-2018	+1%	+1%
Electricity generation		
Electricity generation from bioenergy (TWh)	546	3.5
Electricity generation from bioenergy (PJ)	1,966	12.6
Share of total electricity generation	2%	1%
Average annual growth 2010-2018	+7%	+3%
Transport		
Biofuels production (mtoe)	89	0.15
Biofuels production (PJ)	3,726	6.3
Share of total transport fuel consumption	3%	0.4%
Average annual growth 2010-2018	+6%	+2.3%
Gas		
Biomethane production (PJ)	125	0
Share of gas consumption	0.1%	0%
Average annual growth 2010-2018	+15%	0%

Source: IEA [1] [5], Commonwealth Government [4]

4. Heat

Overview

Heat is the largest end-use market for modern bioenergy. It accounts for approximately half of the global modern bioenergy consumption.

In 2018, bioheat – heat generated from modern bioenergy – amounted to more than seven per cent of global heat generation [1]. However, global bioheat production has displayed limited growth over the past decade[3] [5]. This limited growth has been witnessed in niche markets such as district heating, which are particularly developed in Europe.

In addition to solid biofuels, new developments increasingly involve other resources such as municipal waste, industrial waste and biogas [6].

In Australia, heat is also by far the largest end-use market for bioenergy.

In 2019-2020, heat generated from bioenergy amounted to 12 per cent of Australia's heat demand and approximately 90 per cent of the renewable heat demand [4].

Industrial heat production from bioenergy is particularly developed in Australia.

This includes steam production and drying processes in sugar, food, wood, and the pulp and paper industries.

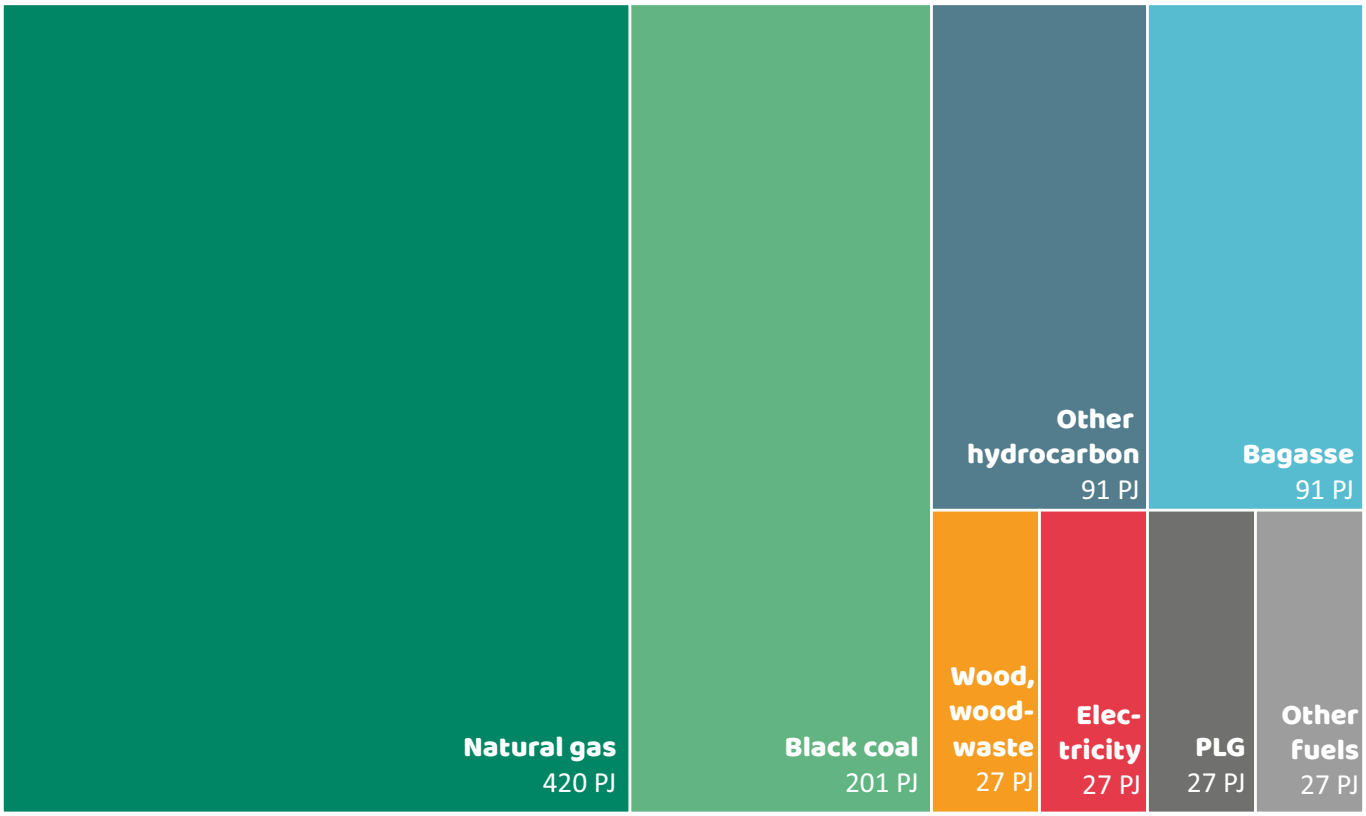
These industries rely on direct access to bioenergy feedstocks, mainly wastes from their own production processes. As an illustration, sugar mills produce heat from bagasse. Similarly, the pulp and paper and the wood industries produce heat from wood waste.

Bagasse is currently the main renewable heat source for industry, and the third industrial heat source after natural gas and coal (see Figure 1) [7].

2. Market-specific figures relate to final energy supply (that is in the form of heat, electricity, or heating value for gas and fuels). Total bioenergy figures relate to primary energy supply, prior to conversion into usable energy products. The sum of final energy supply is smaller than total primary energy supply, accounting for conversion losses.

3. Global bioheat production has increased from 13 EJ to 14 EJ between 2010 and 2018, which represents an average annual growth of 1 per cent over that period.

Figure 1 – Industrial heat energy sources (primary energy) in Australia, 2017



Source: ITP Thermal [7]

Market opportunities

Though already important, industrial bioheat production still has significant potential to grow in Australia [7].

In 2017, industrial heat generation amounted to 730 PJ in Australia[4]. According to a recent report for ARENA, approximately 165 PJ of this could be addressed by bioenergy in the next 20 years [7]. This would almost double Australia's demand for industrial bioheat.

Consistent with this, stakeholders identified industrial heating as one of the key market opportunities for Australia.

Sectors with the greatest heat opportunities include the food and cement industries.

They account for approximately 40 per cent of the short-term opportunities for industrial heat from bioenergy [7]. The food industry has direct access to inexpensive feedstocks, while the cement industry could benefit from the use of various bioenergy resources instead of coal.

By comparison, residential and district heating are not considered to be a significant market opportunity.

Residential heating requires lower temperatures than industrial heating, which can be more easily met with electrification – for example, through reverse-cycle air conditioners.

In addition, higher gas prices in the eastern states have already triggered a switch to electrification for natural gas consumers. Finally, district heating, which has driven recent growth in bioheat production in Europe, is not developed in Australia, and may not be such a good fit due to the warmer climate.

4. This represents more than 70 per cent of Australia's total heat consumption and corresponds to 910 PJ of primary energy supply, as shown in Figure 2-1.

5. Electricity

Overview

Electricity is the second largest end-use market for bioenergy globally.

It accounts for more than 25 per cent of the global consumption of bioenergy resources.

Bioelectricity is mainly generated from solid biofuels, followed by municipal and industrial waste and biogas[5]. In 2018, it contributed to two per cent of global electricity generation[6]. Bioenergy is thus the third largest renewable electricity source, after hydropower and wind and before solar energy [1].

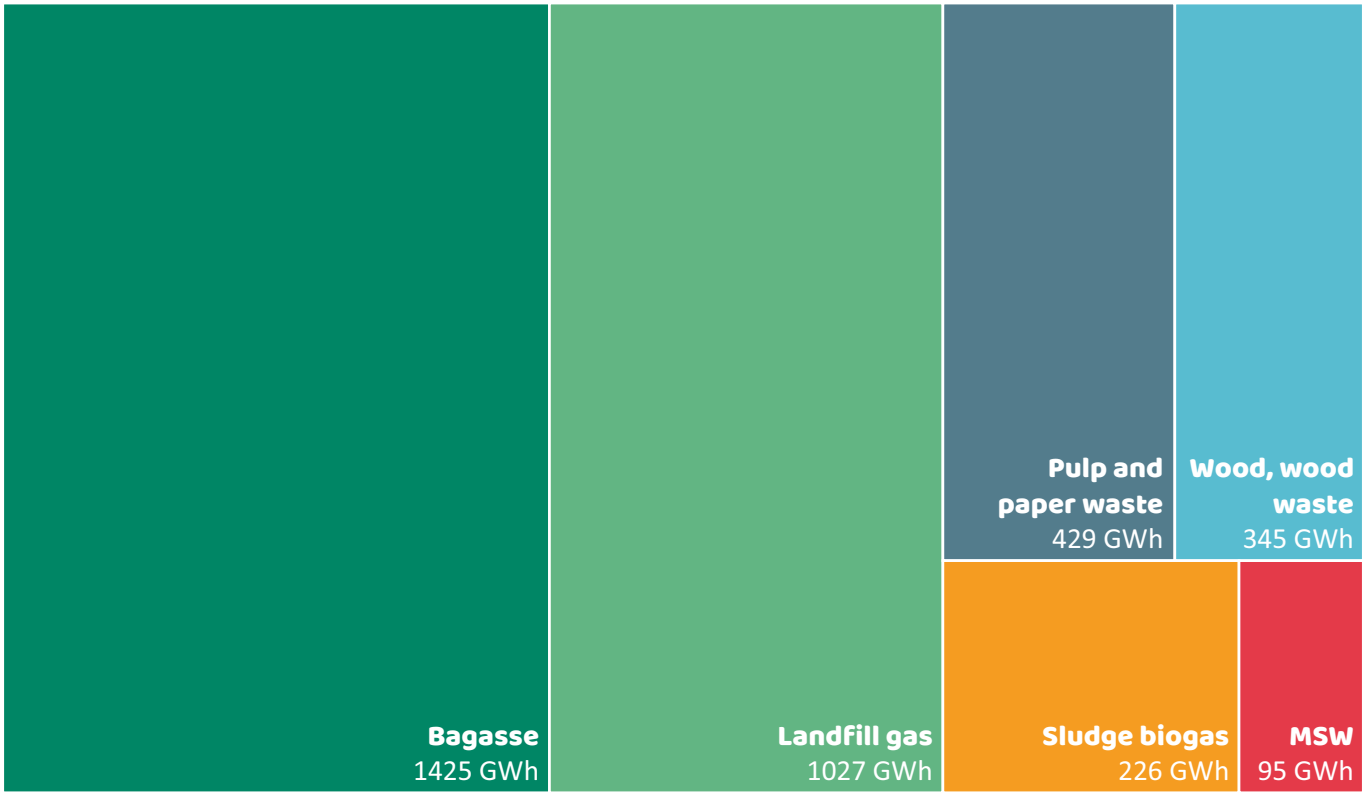
Electricity is also the second largest bioenergy market in Australia.

The bioelectricity market, however, is much less developed than the bioheat market. In 2020, 1.3 per cent of Australia's electricity generation was from bioenergy[7], well below hydro, wind and solar energy [4].

Bagasse is the leading bioelectricity resource used in Australia, followed by landfill gas (see Figure 2).

Queensland and New South Wales are leading Australia's bioelectricity production[8] [8].

Figure 2 – Australia's bioelectricity generation per type of feedstock, 2019-2020



Source: Commonwealth Government [4]

5. Respective shares of solid biofuels, municipal and industrial waste and biogas are 65, 19 and 14 per cent.

6. This is equivalent to 546 TWh of electricity generated from bioenergy.

7. This is equivalent to approximately 3.5 TWh of electricity generated from bioenergy.

8. New South Wales and Queensland respectively generated 1.2 TWh and 1.1 TWh of bioelectricity in 2019.

Market opportunities

Although bioenergy represents a small portion of Australia's electricity production, the sector is well placed to address Australia's increasing need for dispatchable and synchronous electricity generation.

The penetration of intermittent renewables is significantly increasing in Australia. Between 2017–2018 and 2040, the share of wind and solar energy in total electricity generation will at least double [9]. In addition, the majority of Australia's coal-fired power plants are likely to retire by 2040[9].

The Australian Energy Market Operator (AEMO) consequently forecasts that 6 to 19 GW of dispatchable generation will be needed in Australia's National Electricity Market (NEM) by 2040 [9]. Given that bioelectricity is inherently dispatchable, this context creates opportunities for bioenergy.

Bioelectricity can also seize upon niche opportunities in off-grid areas with direct access to bioenergy resources.

Stakeholders that participated in the consultation workshops as part of this Roadmap identified this end-use application as a main market opportunity of bioenergy.

Off-grid systems supply electricity to regional or remote areas that are not connected to the main electricity grid. They have, however, been historically powered by diesel generators, resulting in high electricity costs and significant greenhouse gas emissions.

As such, bioenergy can be particularly relevant to reduce emissions in off-grid systems, especially in areas with direct access to bioenergy resources.

Further supporting this potential, demand for off-grid electricity has increased over the past decades, notably due to the growth of the mining sector [10]. In addition, some electricity distribution businesses are considering off-gridding some of their remote, edge-of-network customers to manage their costs-to-serve and bolster grid resilience.

6. Transport

Overview

Transport is the third largest bioenergy market after heat and electricity, and transport biofuels account for approximately a quarter of the global modern bioenergy consumption.

In 2018, global transport biofuel production served three per cent of the global transport market[10].

First generation (1G) biofuels contribute to the vast majority of this production [6]. These include bioethanol first, followed by biodiesel[11], both of which are produced mainly from food crops such as sugarcane and corn for bioethanol or oil crops for biodiesel.

Advanced (2G+) biofuels based on non-food crops or wastes such as lignocellulosic biomass are emerging, with some pathways such as hydrotreated vegetable oil (HVO) already mature. Advanced biofuels currently account for approximately 10 per cent of the global biofuel production [6].

Although significant over the past decade, the growth of transport biofuel production has slowed down since 2010.

Between 2000 and 2010, double-digit global output growth was supported by the development of 1G biofuels. This was driven by substantial growth in the US and Brazilian markets resulting from strong policy direction and incentives.

After 2010, the growth of the biofuel market slowed with an average annual growth of six per cent. This was due to economic and structural challenges resulting from the Global Financial Crisis, as well as policy uncertainty in key markets [2] [11].

[9] At least 63 per cent of today coal-fired generation is expected to retire by 2040 according to AEMO [8].

[10] This is equivalent to 89 mtoe.

[11] Bioethanol and biodiesel respectively account for 62 and 26 per cent of the global biofuel production.

Different types of biofuels

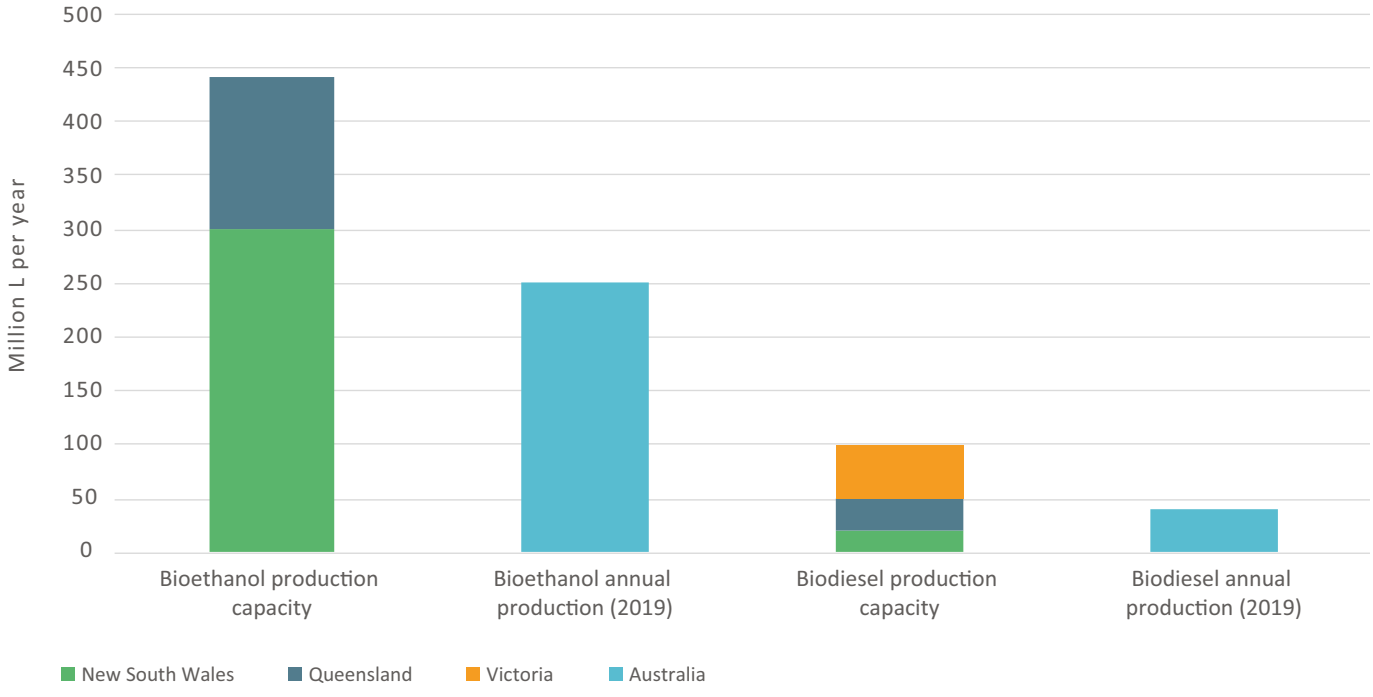
Different terms are used in the industry to name biofuels, depending on the fuel chemical composition and the type of resource uses. In this Roadmap, the following types of biofuels are differentiated:

- **Conventional or first generation (1G) biofuels:** These include bioethanol, biodiesel (sometimes referred to Fatty Acid Methyl Esters or FAME biodiesel) and renewable diesel produced from food crops. Bioethanol and biodiesel are most often blended into petrol and diesel respectively.
- **Advanced or second generation (2G+) biofuels:** These include advanced bioethanol (second generation or cellulosic bioethanol), advanced renewable diesel and compressed or liquefied biomethane (bioCNG/LNG). They are produced from non-food, waste and residue feedstocks. Some of them are 'drop-in' biofuels such as advanced renewable diesel. They have a chemical composition similar to conventional fossil fuels and can thus act as a direct subsitute for them.

Australia's biofuel consumption is low compared to other countries, and Australia's existing production capacity is underutilised.

In 2018–2019, Australia's transport biofuel consumption amounted to 0.4 per cent of transport fuel consumption [4], compared to a global average of three per cent. In 2018, Australia's annual installed biofuel production capacity was approximately double current production amounts[12] [12] (see Figure 3).

Figure 3 – Australia's operating commercial-scale plants and annual production, 2019



Source: ARENA [12], US Department of Agriculture [13]

In particular, Australia's biodiesel production significantly decreased after 2014 [14]. High feedstock prices, low crude oil prices and a limited and unsustained policy framework at state and national level led to a decline of the national biodiesel demand.

Consequently, biodiesel resource exports to international markets with incentives have significantly increased in recent years. This includes tallows exports to Singapore and the US and canola exports to Europe (see Appendix – Production Pathways) [14].

[12] Australia's biofuel consumption was 177 ktoe in 2018-2019 while the national production capacity was 345 ktoe.

Market opportunities

Market opportunities in the transport sector vary across the three market segments of road transportation fuels (petrol and diesel), aviation and marine fuels.

Market opportunities for biofuels are expected to be dominated by advanced biofuels in the aviation and diesel markets globally [12].

Diesel end-uses such as long-haul transport and aviation also have limited low emissions alternatives in the short to medium term, such as renewable electricity and hydrogen.

Conventional biofuels (1G bioethanol and 1G biodiesel) are expected to experience limited growth compared to advanced biofuels (2G bioethanol and renewable diesel) due to resource sustainability and availability considerations.

This is especially true for biodiesel, which is expected to phase out in the long term and be replaced with advanced renewable diesel.

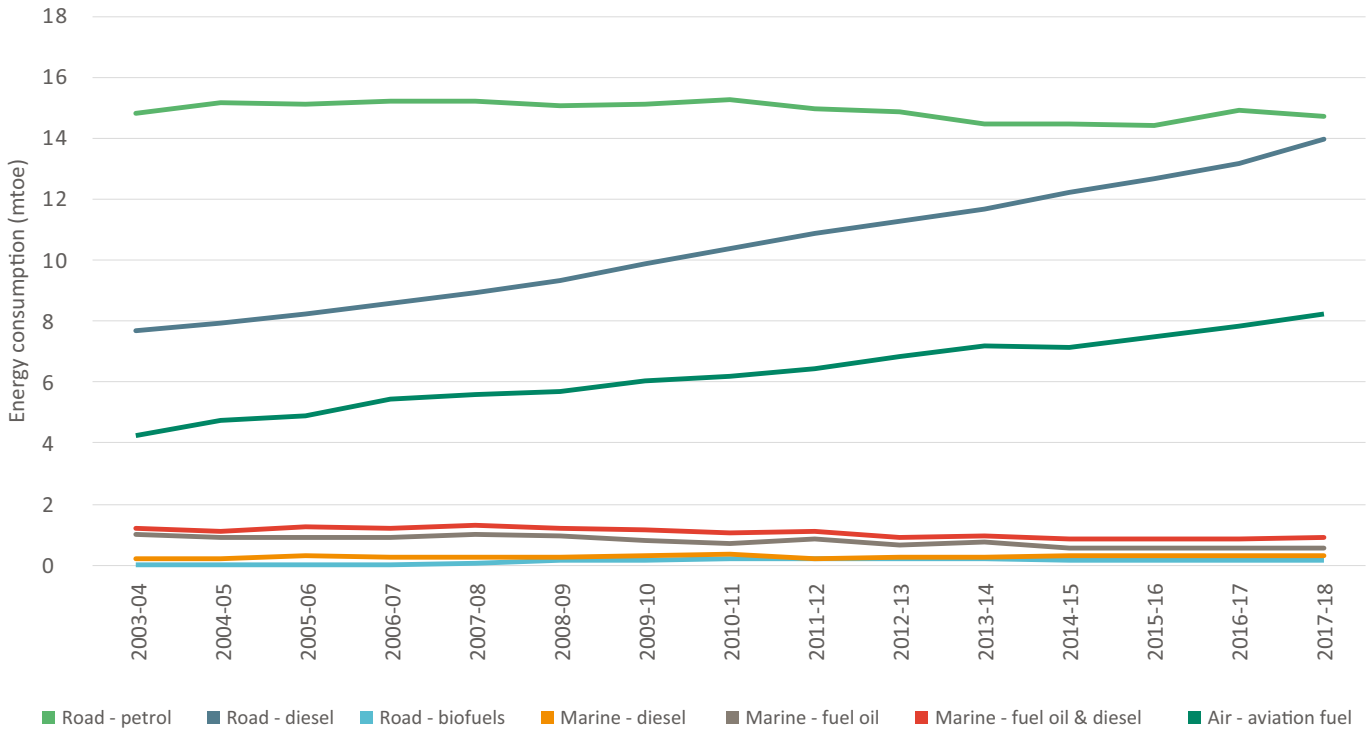
In line with international trends, Australia's road transport biofuel market could be driven by 'hard-to-abate' long-haul transport currently relying on diesel.

Diesel is the most used transport fuel in Australia and its consumption has displayed the fastest growth amongst conventional fuels in the past decades[13] [4] (see Figure 4). Among diesel's end-use market segments, road freight is likely to grow significantly in the near future, with an expected average annual growth rate of four per cent by 2030 [15].

Considering that there are few short-term low emissions alternatives for long-haul transport, this offers opportunities for higher penetrations of biofuels such as biodiesel and renewable diesel.

[13] Diesel consumption has grown at around 9 per cent per year since the early 2000s.

Figure 4 - Australian transport energy consumption by major fuel type



Source: Commonwealth Government [4]

Also, the aviation sector's growth in Australia – combined with the lack of low emissions alternatives in the short term – offers opportunities for biojet fuels to reduce emissions in this sector.

Aviation fuels are the third largest transport fuels in Australia[14] and demand for these fuels has significantly grown over the past decades [4] (see Figure 4). Despite the drop of usage in 2020 due to COVID-19, the aviation market is likely to grow significantly in the medium term, at an expected annual average growth rate of five per cent by 2030 [16].

Electrification or conversion to hydrogen (fuel cells or turbines) are not feasible in the short term or for larger aircrafts/long-haul flights [17].

In addition to opportunities in the aviation and long-haul transport markets, short-term opportunities exist for biofuels in passenger vehicles.

The consumption of petrol has been slightly declining since the early 2000s, as a result of the growing diesel vehicle fleet and energy efficiency [4]. However, petrol is still the most widely used fuel for passenger transport before diesel[15].

Most of Australia's petrol cars are estimated to be ethanol-compatible[16] [12]. By comparison, only 0.01 per cent of Australia's current vehicle fleet is fully electric. This creates opportunities in the short term for further penetration of bioethanol for passenger cars.

Though real, opportunities for biofuels in the marine sector are less significant than in other transport sectors.

Marine transport is less developed than road transport and aviation in Australia, with a slight decline in consumption over the past decade. The sector represented approximately three per cent of Australia's transport energy consumption [4].

Nonetheless, there are opportunities for marine biofuels as the incorporation of these biofuels could be comparatively easier due to less stringent fuel specifications. In addition, the marine industry is taking steps to reduce its emissions through the International Marine Organisation.

In addition to emissions reduction opportunities in the transport sector, increasing transport biofuel production and consumption in Australia would improve the country's liquid fuel security.

7. Gas

Overview

Biogas production is still marginal compared to other types of bioenergy and is focused on the production of heat and electricity[17].

In 2018, the global production of biogas covered less than one per cent of the global gas consumption. Biogas is primarily used for electricity and heat production[18] [18].

The production of biogas is currently driven by Europe, which accounts for about half of the global production. In terms of resources, biogas is currently mainly produced from the anaerobic digestion of animal manure, crops and municipal solid waste [18].

Biogas can also be upgraded into biomethane, a gas with a chemical composition very close to natural gas.

Biomethane can be injected into the natural gas grid and thus serve similar uses to natural gas. Approximately 10 per cent of the global biogas production is currently upgraded to biomethane.

Biomethane production has significantly increased over the past decade.

The production of biomethane increased at an average annual growth rate of 15 per cent between 2010 and 2018 (see Figure 5).

Whilst coming from a very low base, biomethane production has thus displayed the most significant growth of all bioenergy markets over the past decade [18].

[14] The annual aviation fuel consumption was more than 8 mtoe in 2018.

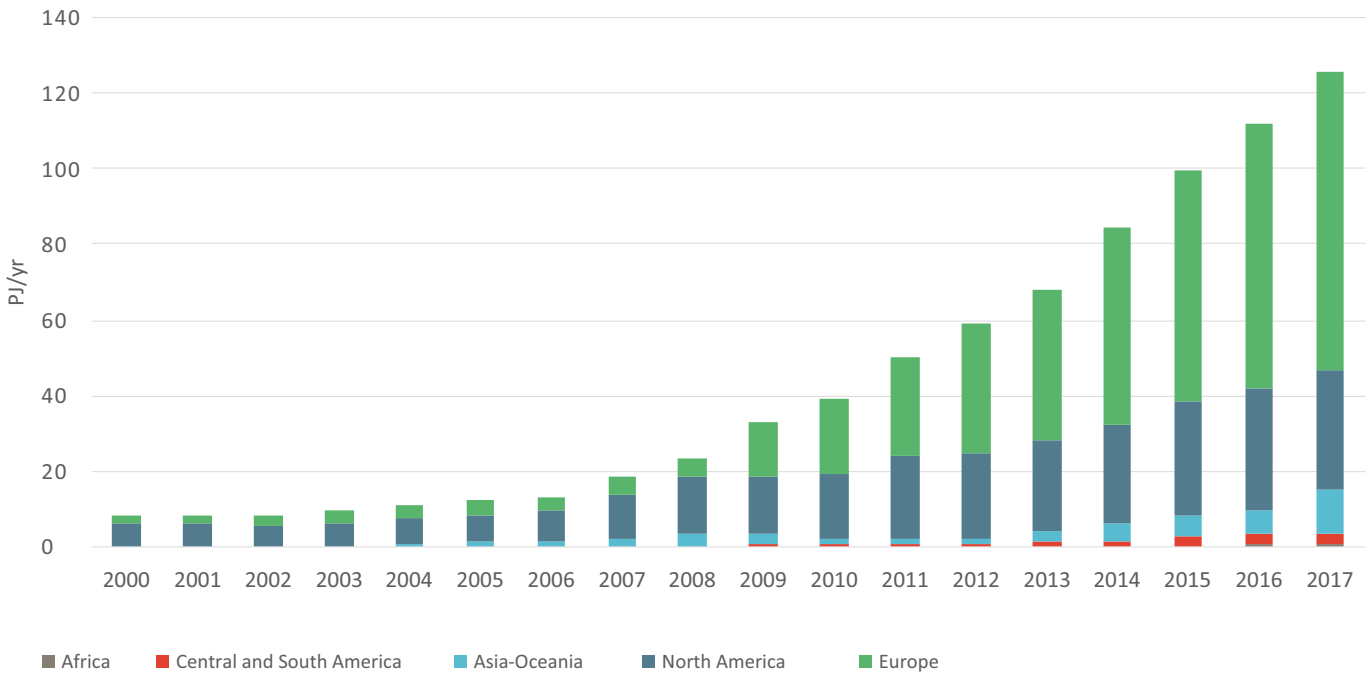
[15] The annual petrol consumption was 14.5 mtoe in 2018.

[16] As an illustration, more than 95 per cent cars in Queensland are estimated to be ethanol-compatible.

[17] The production of heat and electricity from biogas is covered in the heat and electricity sections.

[18] Electricity and heat production accounts for approximately 90 per cent of biogas uses.

Figure 5 – Global biomethane production by region



Source: IEA [18]

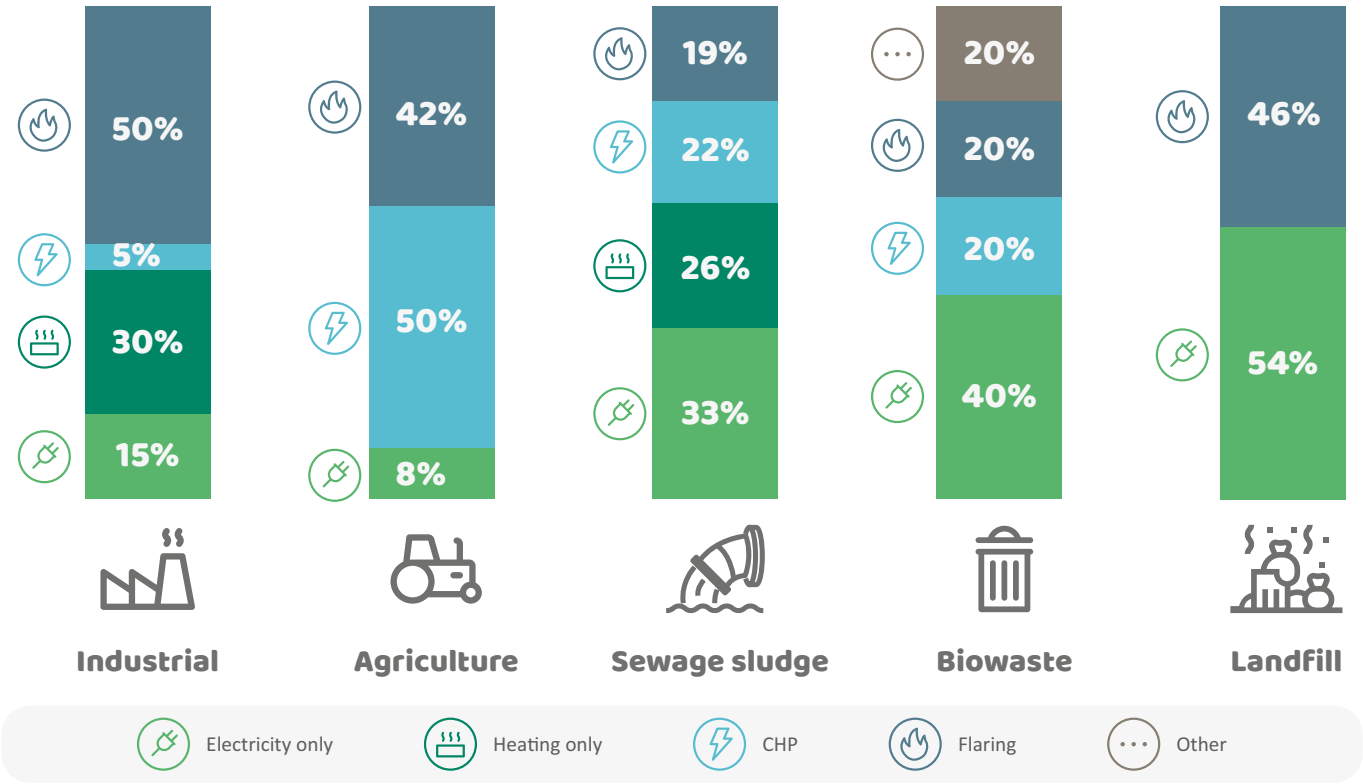
Most of the biogas production in Australia is currently used to generate heat and electricity or is being flared [19] (see Figure 6).

In 2017, there were 242 biogas plants in Australia, amounting to a biogas production of 23 PJ. Half of these plants were collecting landfill gas and 20 per cent were wastewater treatment plants.

No biogas upgrading plant is currently operating in Australia for biomethane injection into gas pipelines.

However, Australia's first biomethane grid injection project was announced in November 2020 [20]. The demonstration-scale project will upgrade biogas produced from the anaerobic digestion process at Sydney Water's Malabar wastewater treatment plant to biomethane for injection into Jemena's gas distribution network. It is expected to start injecting biomethane into the gas network in early 2022.

Figure 6 – Utilisation of biogas in Australia by feedstock source in 2017



Source: IEA [21]

Market opportunity

Biomethane grid injection could contribute to reducing emissions from Australia's gas consumption.

Industry stakeholders identified gas grid injection as a top priority for bioenergy in Australia. Noting that biogas upgrading pathways are developed in other regions such as Europe and the US, biomethane could support Australia in reducing emissions from gas uses in the short to medium term before hydrogen becomes more widespread.

It is also identified as one of the key pathways to reduce emissions from Australia's gas uses, along with hydrogen and CO_2 capture and storage [22].

Biomethane production costs are currently more attractive than other renewable gas pathways such as hydrogen. Furthermore, if injected into the natural gas grid, biomethane does not require significant upgrade of gas infrastructure or consumer appliances.

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7. Acknowledgment and disclaimer

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Enea is a strategy consultancy that maximises energy transition and climate change opportunities for public and private organisations globally. Enea works with diverse organisations: governments, energy companies, investors and financiers, commercial and industrial companies, technology firms and start-ups.

Enea provides independent analysis and tangible future-driven advice through strategy, innovation and modelling services. Its team is united by shared values and is positively focused on addressing climate change, sustainable development and energy access.

Through dedicated consulting services and pro bono support to NGOs and social entrepreneurs, Enea is also committed to improving energy access, especially in developing countries.

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Enea Consulting led the research on markets, resources, production pathways and public policy.

Deloitte led the demand and economic scenario modelling, the stakeholder consultation and research on community support and benefits.

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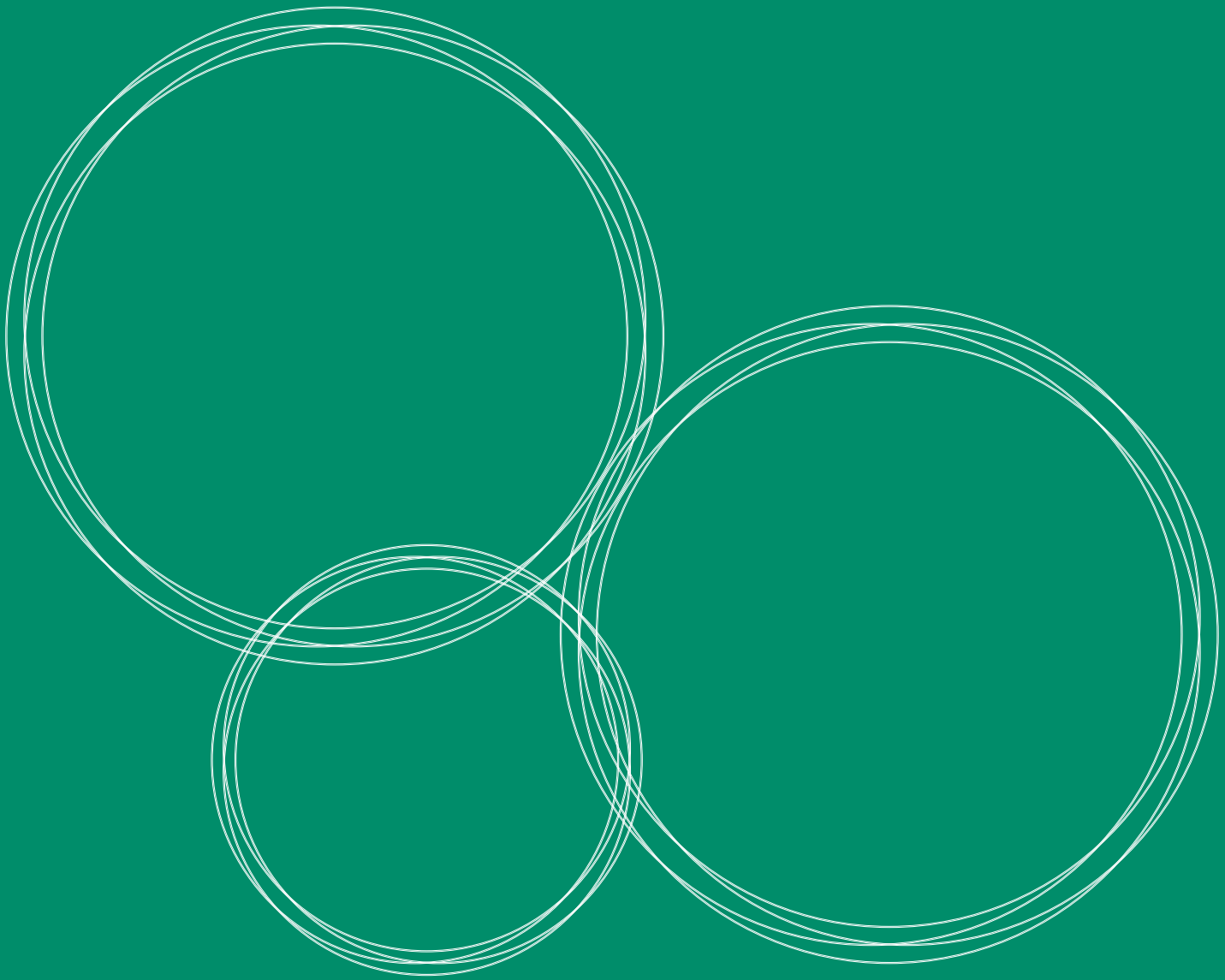

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