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Australia's Bioenergy Roadmap

November 2021

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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Executive summary

The Bioenergy Roadmap has been developed following extensive consultation to enhance the growth of Australia's bioenergy sector and identify bioenergy's role in Australia's future energy mix. It is designed to help inform future policy and investment decisions.

Australia's Bioenergy Roadmap (referred to as the Bioenergy Roadmap or this Roadmap) has been developed following extensive consultation to enhance the growth of Australia's bioenergy sector and identify bioenergy's role in Australia's future energy mix. It is designed to help inform future policy and investment decisions.

It sets out a vision for a sustainable bioenergy industry that delivers lower emissions, regional growth, energy resilience and waste management benefits for Australia.

Given the extent of bioenergy's potential, this Bioenergy Roadmap presents a framework from now until 2030 to:

- Showcase where bioenergy has a comparative advantage and where it can complement other low emissions alternative technologies
- Identify current barriers to the development of the bioenergy sector
- Provide findings for industry and government to drive commercial outcomes
- Highlight opportunities to inform and empower the broader community.

International experience shows that the key to growing a bioenergy industry involves strong partnerships across both the public and private sectors. This Roadmap helps identify opportunities for collaboration and outlines the steps that industry can take to build its capabilities and to develop innovative projects and business models.

Benefits for Australia

By the start of the next decade, Australia's bioenergy sector could contribute to around $10 billion in extra GDP per annum and 26,200 new jobs, reduce emissions by about 9 per cent, divert an extra 6 per cent of waste from landfill, and enhance fuel security.

The bioenergy sector offers regional development opportunities. Many of the bioenergy feedstocks come from agricultural activities, such as from sugarcane waste and the livestock industries. As a majority of these industries are regional, bioenergy investment will support long-term regional employment, provide additional revenue streams for farmers and ultimately national economic growth. See the regional bioenergy case studies section below for some recent and current bioenergy opportunities. As nations pursue efforts for a low carbon future, bioenergy also offers complementary low carbon solutions, especially in 'hard-to-abate' industrial and transport sectors.

Another benefit of the bioenergy sector is that it helps drive more effective waste management. Waste that cannot be avoided should be reused, recycled or recovered, with the lowest priority given to landfill disposal. Energy recovery from organic wastes and residues can provide an alternative waste treatment route. In some cases, these resources would have been left to decompose or be burned without energy recovery, contributing to greenhouse gas emissions.

In addition, bioenergy can support liquid fuel security. The dependence of Australia's transport sector on imported crude oil and refined petroleum products such as petrol, diesel and jet fuels has grown over the past two decades. More local biofuel production could help further diversify these fuel sources.

Bioenergy

Bioenergy is a form of renewable energy generated from the conversion of biomass into heat, electricity, biogas and liquid fuels. Biomass is organic matter derived from forestry, agriculture or waste streams available on a renewable basis. It can also include combustible components of municipal solid waste.

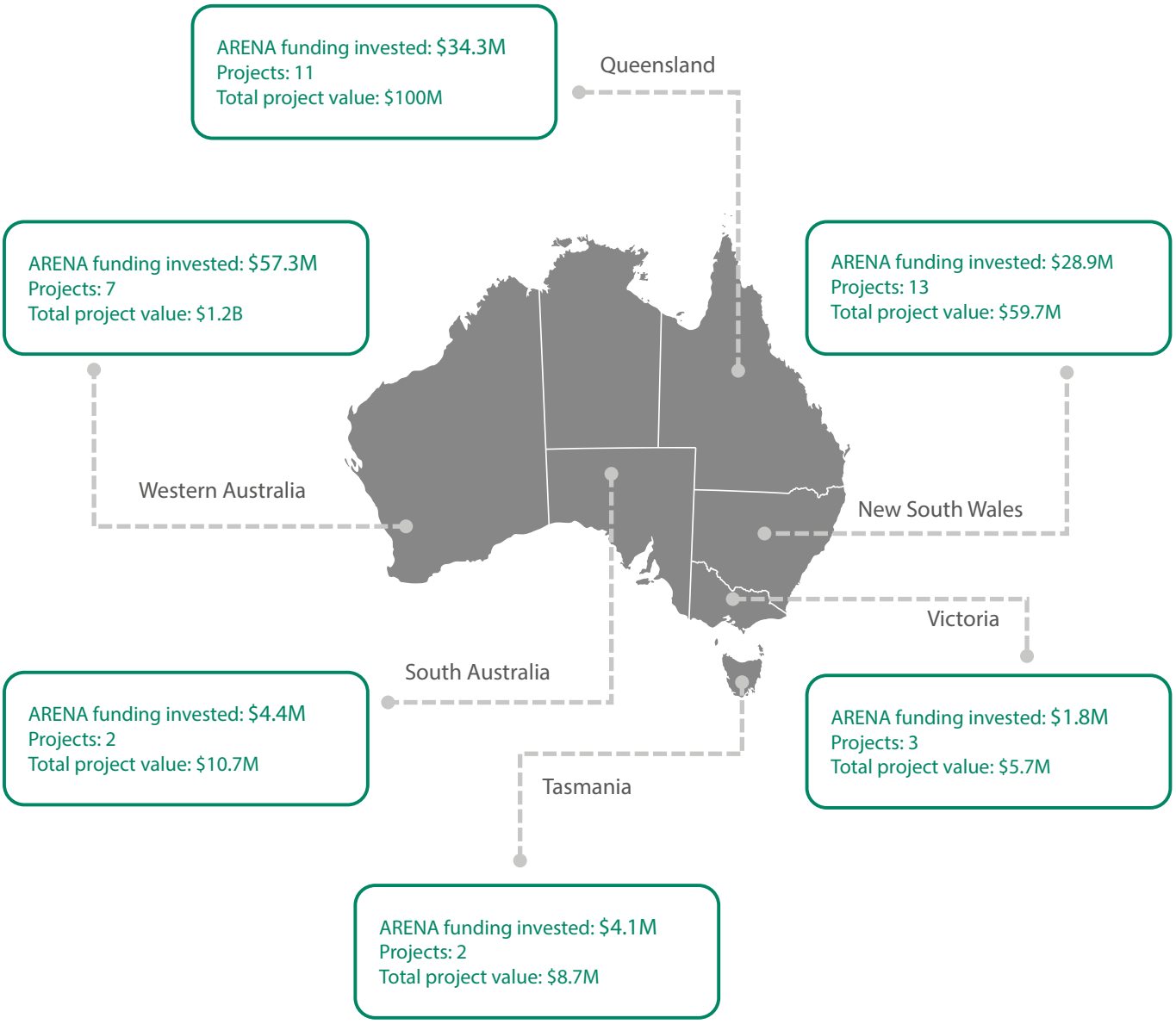
The bioenergy sector is a complex industry, comprising many different resources, technologies, products, coproducts, stakeholders and markets. Bioenergy accounts for 47 per cent of Australia's current renewable energy production and 3 per cent of total energy consumption. Modelling for this Bioenergy Roadmap shows that bioenergy has the potential to provide up to 20 per cent of Australia's total energy consumption by the 2050s. This demonstrates there is scope for expansion if commercial scale is able to be achieved and if production costs can be reduced.

1. Although biomass can be used to produce non-energy products, such as bioplastics or biochemicals, this Bioenergy Roadmap focuses on energy products.

ARENA's impact on Australian bioenergy projects

Between 2012 and 2020, ARENA committed total funding of $131 million to bioenergy related projects which have improved the competitiveness or increased supply of renewable energy in Australia. In total, ARENA has provided this funding to 38 bioenergy related projects with a total project value of $1.4 billion (see below).

TOTAL ARENA FUNDING FOR BIOENERGY RELATED PROJECTS BY STATE AND TERRITORY (AS AT 30 SEPTEMBER 2021)



Source: ARENA

Regional bioenergy case studies

Avertas Energy Waste to Energy Project

Location:
Kwinana, Western Australia

Employment: 800 construction jobs and 60 full-time operational jobs will be supported by this project

Project investment: $696 million ($23 million of ARENA funding)

Project commissioning:
Scheduled for the end of 2021

Plant: 36 MW thermal utility-scale Waste to Energy (WtE) facility. The project aims to process approximately 400,000 tonnes of waste per annum diverting approximately 25 per cent of Perth's post-recycling rubbish from landfill sites. The use of combustion grate technology is well established in Europe and North America, but this project is the first time this technology will be deployed in Australia. With more than 23 million tonnes of municipal solid waste produced annually in Australia, this project could help divert non-recyclable waste from landfill and recover energy in the process.

Avertas Energy Waste to Energy Project
Credit: Avertas Energy

MSM Milling Biomass Fuel Switch Project

Location:
Manildra, New South Wales

Employment: Helped to secure the long-term jobs of 70 employees

Project investment: $5.38 million ($2 million of ARENA funding)

Project commissioning:
October 2019

Plant: In 2019, MSM Milling commissioned a cornerstone project for the Australian food processing industry, making it the country's first low carbon canola oil producer. The biomass-fuelled boiler was funded by MSM Milling, in conjunction with a $2 million grant from ARENA, under the Advancing Renewables Program. The 5 MW biomass boiler utilises locally sourced renewable woodchips for electricity generation, displacing several smaller existing LPG boilers, to be used in milling and processing operations. This will save around 4,000 tCO_2-e per annum and over 80,000 tCO_2-e over the life of the project.

MSM Milling's canola processing facility in Manildra
Credit: MSM Milling

Australia's Bioenergy Roadmap

The Bioenergy Roadmap lays out a vision for a sustainable bioenergy industry that delivers lower emissions, regional growth, energy resilience and waste management benefits for Australia.

The Bioenergy Roadmap was developed in broad consultation and collaboration with industry, governments, researchers and the general public. This cross-sectoral approach, with multiple opportunities for stakeholder input, ensured varied stakeholder views were considered.

- **Submissions:** 147 submissions, both confidential and for public distribution, were received. Individuals and organisations representing a diverse range of interests were invited to respond to a public request seeking input on prompting questions on a range of bioenergy topics.
- **Consultation workshops:** Nine consultation workshops were held to receive more targeted feedback from specific stakeholder groups on certain topics. This included one consultation workshop open to the general public.
- **Direct interviews:** 40 direct interviews were undertaken with subject matter experts and stakeholders representing key interests in the bioenergy sector.

Given the extent of bioenergy's potential, this Roadmap outlines a collaborative framework to:

- Showcase where bioenergy has a comparative advantage and where it can complement other low emissions technologies
- Identify current barriers to the development of the bioenergy sector
- Provide findings for industry and government to drive commercial outcomes
- Highlight opportunities to inform and empower the broader community.

The modelling supporting the Bioenergy Roadmap explores potential future scenarios of the Australian bioenergy industry from 2021 to 2050 (see page 18 for modelling summary). For the purposes of the Bioenergy Roadmap below, figures relating to the bioenergy sector have been drawn from the 'Targeted Deployment' scenario.

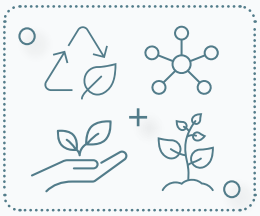
Within this framework, opportunities and actions are grouped in the following four themes.

Theme 1: Enabling market opportunities in hard-to-abate sectors

Renewable industrial heat, aviation and renewable gas grid injection. These opportunities currently have limited low emissions alternatives. Due to their different characteristics, each market opportunity requires a range of specific actions to enable their growth.

Theme 2: Enabling market opportunities where bioenergy can complement other low emissions alternatives

Road transport and electricity markets. Opportunities for consideration should focus on enabling this complementarity.



Theme 3: Developing our resources

Australia has a significant bioenergy resource potential. However, there is insufficient clarity and detail over the viability and sustainability of these resources. Additional work is suggested to enable the industry to understand and utilise all potential resources, known as feedstocks.

Theme 4: Building supportive ecosystems

An enduring and successful bioenergy industry will require concerted efforts beyond those relating to markets and feedstocks. It will be necessary to harness an ecosystem that links the diverse parts of the bioenergy industry to facilitate its growth.

Australia's Bioenergy Roadmap

Vision

A sustainable bioenergy industry that delivers lower emissions, regional growth, energy resilience and waste management benefits for Australia.

Guiding principles

1. **Commercial:** focus on hard-to-abate markets and bridging the economic viability gap
2. **Emissions reduction and climate change:** optimise the role of bioenergy alongside alternative low emissions technologies to safeguard Australia's resource potential
3. **Community:** maximise benefits for Australians, particularly for those in regional communities
4. **Collaboration:** industry, state and Commonwealth governments to all work collaboratively on potential action options to ensure greater activation of Australia's bioenergy industry and focus growth areas
5. **Co-investment:** private and public sectors to have clarity and certainty on where to target investments

Theme 1: Enabling market opportunities in hard-to-abate sectors

Three hard-to-abate priority market opportunities have been identified: renewable industrial heat generation, aviation and renewable gas grid injection. These opportunities currently have limited low carbon alternatives and, due to their different market characteristics, there are a range of specific actions to enable their growth. In line with modelling conducted under the 'Targeted Deployment' scenario and stakeholder consultation, progress in these sectors by the 2030s would see:

- Bioenergy providing up to **244 PJ per annum of renewable industrial heat**, with widespread commercial deployment. This represents approximately **33 per cent of the total industrial heat market**.[2]
- Early deployment of pre-commercial sustainable aviation fuel (SAF) production plants to establish a viable Australian-based industry, with production of up to **1,908 ML per annum of SAF** representing approximately **18 per cent of the aviation fuel market**.[3]
- Gas pipelines incorporating up to **105 PJ per annum of renewable gas**, utilised within the existing network and compatible with low emission hydrogen, accounting for **23 per cent of the total pipeline gas market**.[4]

Time frame	Possible action options for industry, state and Commonwealth governments
2021-24 / 2025-30	

THEME 1: ENABLING MARKET OPPORTUNITIES IN HARD-TO-ABATE SECTORS

Industrial renewable heat • Raise the profile of bioenergy solutions and successful project case studies • Educate industrial heat consumers about bioenergy solutions and benefits • Provide financial support for feasibility studies to encourage uptake and scale-up • Explore ways to overcome short project payback expectations	• Review market developments periodically to ascertain future priorities and efforts
Sustainable aviation fuels • Communicate the role and benefits of biojet fuels to the community • Coordinate public-private partnerships across all stakeholder groups to develop the market • Assess opportunities in foundation sub-markets such as the Royal Australian Air Force or regional routes • Encourage research, pilots and trials focusing on the demonstration of advanced biojet fuels from non-food resources at commercial scale	• Assess ways to bridge the economic viability gap such as lowering production costs for biojet fuel production in the long term
Renewable gas grid injection • Develop a certificate of origin scheme to complement the work underway on hydrogen • Clean Energy Regulator to finalise Emissions Reduction Fund methodologies underway recognising biomethane injection into gas networks • Pursue a uniform regulatory approach for digestate specifications and use • Continue to assess the appropriateness of the natural gas specifications for biomethane grid injection and implement amendments to the National Gas Law so it extends to renewable gas blending to provide more legal certainty for industry[6]	• Assess ways to bridge the economic viability gap such as lowering production costs for biomethane production from anaerobic digestion • Promote the ongoing development of case studies focusing on biomethane production from anaerobic digestion

2. Assumed cost of renewable industrial heat is AU$5.60/GJ in 2030.
3. Assumed cost of SAF is AU$1.40/L in 2030.
4. Assumed cost of biomethane is $9.80/GJ in 2030.
5. In December 2020, the Minister for Energy and Emissions Reduction announced biomethane as a priority for method development for the ERF, with the CER progressing this work.
6. On 20 August 2021, Energy Ministers agreed to amend the National Gas Law, National Energy Retail Law and subordinate instruments through an expedited process to bring hydrogen blends, biomethane and other renewable methane gas blends within the national energy regulatory framework [https://www.minister.industry.gov.au/ministers/taylor/media-releases/energy-national-cabinet-reform-committee-1].

Theme 2: Enabling market opportunities where bioenergy can complement other low emissions alternatives

In addition to the above priority market areas, there are other market opportunities where bioenergy can complement low emissions alternatives in the road transport and electricity markets. Opportunities for consideration should focus on enabling this complementarity. In line with modelling conducted under the 'Targeted Deployment' scenario and stakeholder consultation, progress in these sectors by the 2030s would see:

- **Up to 2,605 ML per annum of road transport biofuels** produced for local consumption, accounting for **7 per cent of the total road transport fuel market.**[7]
- Deployment of **14 TWh per annum of utility-scale and small-scale electricity generation**, demonstrating the value of dispatchability from bioenergy-derived electricity, which would make up **8 per cent of the total utility-scale and small-scale electricity generation market.**[8]

Time frame

2021-24 **2025-30**

Possible action options for industry, state and Commonwealth governments

THEME 2: ENABLING MARKET OPPORTUNITIES WHERE BIOENERGY CAN COMPLEMENT OTHER LOW EMISSIONS ALTERNATIVES

Road transport

- Educate the community about biofuels and their future potential
- Consider broader ways to harmonise the treatment of biofuels with conventional fuels where appropriate
- Encourage research, pilots and trials focusing on the demonstration of advanced biofuels from non-food resources at commercial scale, in combination with biojet fuels
- Consider the role of biofuels in aligning Australia's fuel quality standards to address aromatics levels[9]
- Review market developments periodically to ascertain future priorities and efforts

- Review market developments periodically to ascertain future priorities and efforts

Dispatchable renewable electricity

- Promote successful business cases optimising diverse revenue streams
- Increase visibility of bioenergy in schemes promoting dispatchable electricity generation

7. Assumed costs of road transport biofuels are $20.50/GJ (petrol) and $26.00/GJ (diesel) in 2030. This is equal to $0.70/L (petrol) and $1.00/L (diesel) in 2030.
8. Assumed costs of bioenergy-derived electricity are $66.30/MWh (on-grid) and $117.00/MWh (off-grid) in 2030.
9. As part of the 2021-22 Budget and part of the Australian Government's comprehensive fuel security package, the Australian Government announced that it would bring forward the industry-wide review of fuel quality standards from 2022 to 2021.

Loganholme Wastewater Treatment Plant
Credit: Logan City Council

Theme 3: Developing resources

Australia has a significant bioenergy resource potential. However, there is insufficient clarity and detail over the viability and sustainability of these resources. Additional work is suggested to enable the industry to understand and utilise all potential feedstocks. In line with modelling conducted under the 'Targeted Deployment' scenario and stakeholder consultation, progress in these sectors by the 2030s would see:

- Up to **559 PJ per annum generated from bioenergy in total**, reflecting greater utilisation of existing resources and potential for new sustainable resources.
- **Deployment of bioenergy within precincts** reflecting mature business models and complementary use alongside other low emissions energy technologies.

Time frame

2021-24 **2025-30**

Possible action options for industry, state and Commonwealth governments

THEME 3: DEVELOPING RESOURCES

Expanding the assessment of Australia's resource potential

- Expand the assessment of Australia's current and future, technical, economic and sustainable resource potential building on existing initiatives such as the Australian Biomass for Bioenergy Assessment (ABBA) Project[10]
- Conduct regular ongoing reviews of this assessment

Making the most of waste and residue resources

- Encourage separation of organics at source, enabling higher steps in the waste hierarchy
- Consider tailored options to support regional bioenergy projects targeting agricultural residues

- Promote options to create consistent and aligned waste policies and levies across the country
- Consider additional options to reduce organics and waste going to landfills

Developing a sustainability framework

- Develop a sustainability framework to ensure resources used for bioenergy in Australia are sustainably sourced, leveraging existing frameworks in the European Union and the United States

Identifying and building biohubs

- Consider biohub opportunities using the assessment of Australia's resource potential
- Streamline planning approval processes for biohubs

- Monitor the progress of biohubs and assess additional needs

10. The ARENA-funded ABBA Project collates data on the different types, volumes and locations of organic wastes and residues that may be used for bioenergy. It does not cover the technical, economic and sustainability assessments of these resources.

Theme 4: Building ecosystems

To ensure success, and in addition to effort focused on markets and feedstocks, it will be necessary to build an ecosystem that supports the sector's growth more broadly. In line with modelling conducted under the 'Targeted Deployment' scenario and stakeholder consultation, progress in these sectors by the 2030s would see:

- **Improved knowledge sharing** between key bioenergy stakeholders (such as industry groups, developers and offtakers) to promote awareness of available technology solutions and provide useful and consistent benchmarking of business models and pricing
- **Maturation of the local industry** with capability to develop and install fit-for-purpose technology using global best-practice standards
- **Commercial development of business models** that address the current and emerging needs of industry for both energy and products that can be derived from biomass
- **Clear and consistent communication** of the areas where bioenergy has a comparative advantage against other low emissions technologies to both end-users and the broader community.

Time frame

2021-24 **2025-30**

Possible action options for industry, state and Commonwealth governments

THEME 4: BUILDING ECOSYSTEMS

Facilitating the commercialisation of mature technologies that are new to Australia

- Develop industry guidelines and standards for new technologies to assist in producing reliable and repeatable results
- Promote feasibility studies with commerciality objectives
- Increase knowledge sharing of commercial, technical and financial learnings
- Explore public-private partnerships to advance the roll-out of mature technologies

Supporting project development

- Explore ways to streamline project development approval processes (e.g. regulatory or environmental approvals)

Furthering a bioeconomy perspective

- Assess the potential use of biomass resources beyond bioenergy and evaluate the benefits that could be delivered by pursuing bioeconomy opportunities

Raising public awareness of bioenergy

- Develop consistent community engagement guidelines across projects

Through the comprehensive analysis of future scenarios, a set of signposts has been developed to measure the success of industry development.

INDUSTRY ADVANCES QUICKLY	2025 to 2030	INDUSTRY ADVANCES SLOWLY
Increased uptake and breakthroughs are driving costs down so that bioenergy is increasingly competitive with incumbent and alternative solutions.	**Cost competitiveness**	Limited uptake and few breakthroughs are resulting in stagnation of bioenergy's costs whilst the costs of other solutions are falling.
Investment from the private sector is flowing into new projects and exceeds government investment.	**Investment**	The majority of projects that are reaching financial close have a significant proportion of government investment.
The industry has a thorough data-driven understanding of the feedstocks that are available for bioenergy production and there is growing consensus amongst industry stakeholders on the best use of those feedstocks.	**Resource potential**	The industry has a limited understanding of available feedstocks and there is little to no consensus on the optimal use of those feedstocks. This results in an industry that suffers from uncertainty amongst investors and low levels of community support.
Industry and government are working to ensure the sustainable use of feedstocks and rules/ frameworks have emerged or are, at least, scheduled.	**Feedstock sustainability**	Governance is not improved and there are risks that biomass production and use could in some circumstances be worse for the climate than using fossil fuels.
There is a steady rate of new installations, particularly in waste-generating industries such as the food industry which has access to feedstock onsite. The supply chain for such installations is maturing and bringing down the costs further.	**Renewable industrial heat**	Limited awareness of solutions amongst end-users and an immature supply chain results in few commercial deployments in the market.
Stakeholder collaboration and co-investment to support the development of commercial scale SAF production.	**Sustainable aviation fuels**	No clear actions committed to, or underway, by industry or government to catalyse SAF production in Australia.
Commercial-scale digestion facilities for injection into gas pipelines are in operation, under construction or announced.	**Renewable gas grid injection**	Traceability mechanisms are not developed. There are some commercial-scale facilities in development, but none are in operation.
Consumers' growing awareness of, and comfort with, low emissions road transport solutions is leading to increasing demands for bioenergy for liquid fuel vehicles.	**Road transport biofuels**	Consumer preferences for biofuels remain at current levels or decline due to market and/or policy settings.
The value of dispatchable technologies has been increasingly recognised, and several bioenergy projects are currently being developed.	**Renewable and dispatchable electricity**	No grid or off-grid bioenergy projects are under development.

Key insights

Bioenergy can complement other low emissions energies to reduce emissions. It can also enhance regional development, reduce reliance on imported liquid fuels and assist waste recovery initiatives.

Australia's bioenergy potential

Bioenergy provides over half of Australia's current renewable energy output. In 2019-20, bioenergy accounted for 47 per cent of Australia's current renewable energy production, and 3 per cent of Australia's total energy consumption[11]. However, its potential is significantly larger. The modelling undertaken for this Bioenergy Roadmap under the Targeted Deployment scenario shows that bioenergy could grow to 20 per cent of consumption by the 2050s.

11. Australian Government, *Australian Energy Update*, 2021.

THIS COULD TRANSLATE INTO MULTIPLE BENEFITS ACROSS FOUR MAIN AREAS.

Bioenergy's potential contribution	By the 2030s	By the 2050s
1. Economic benefits, including in regional areas Bioenergy could result in economic benefits for Australia, including national economic growth and job creation. Many resources are located in regional areas and harnessing them for bioenergy could support local economies by creating new income streams and jobs, with at least one in four additional jobs expected to be in regional areas.		
GDP Impact: additional annual GDP	$10 billion	$14 billion
Additional jobs	26,200	35,300
2. Emissions reductions Bioenergy supports the transition to lower emissions by providing a source of renewable electricity, heat, gas and transport fuels. It can also reduce emissions in 'hard-to-abate' industrial and transport sectors.		
Emissions abatement: per cent of 2019 national emissions	9%	12%
3. Liquid fuel security Producing biofuels can reduce reliance on imported oil and petroleum products and improve Australia's liquid fuel security.[12]		
Extra days of consumption cover above 2019 levels[13]	27 days	63 days
4. Waste recovery Using wastes and residues as feedstock can reduce the amount of waste sent to landfill by creating value for what would otherwise be end-of-life products.		
Extra share of landfill waste diverted compared to 2019 levels	6%	7%

12. Most but not all biofuels rely on blending with traditional fossil fuels in order to be used in existing engines.

13. This represents an extra 4,513 ML (2030) of biofuel per annum and is based on daily consumption of diesel, petrol and aviation fuel of 167 ML/day (2018-2019 Australian Petroleum Statistics). Consumption cover days are not comparable to days used in the methodology for the International Energy Agency 90-day stockholding obligation.

This potential is underpinned by some of bioenergy's key characteristics.

- Globally, bioenergy production benefits from relatively mature technologies which have been demonstrated (both technically and commercially) across the majority of markets (except aviation). Additionally, new technologies are under development to make better use of organic wastes and residues and overcome resource constraints.

- Bioenergy can be more easily integrated into existing energy systems compared to other low emissions technologies such as hydrogen or intermittent renewables. This is due to bioenergy's similar characteristics to fossil technologies, which have been the historical standard used to build these systems. As an illustration, liquid biofuels could be blended into petroleum-derived fuels or act as a direct substitute without upgrading existing refuelling infrastructure or engines.

Realising this opportunity will require careful consideration of other factors.

- Bioenergy is a complex industry, involving many different resources, technologies, coproducts, products, stakeholders and markets. As an illustration of this complexity, more than one hundred bioenergy production pathways were identified through the development of this Roadmap.

- In addition, even though bioenergy can be cost-competitive in some markets, long term production cost reductions are limited due to the dispersed nature of bioenergy resources as well as mature technologies in all markets except aviation. Feedstock collection and transport costs may be reduced through supply chain improvements. These cost reductions, however, will not be enough to make all bioenergy production pathways cost-competitive.

- Overseas experience shows that consistent, sustainable policy support with industry partnerships is integral to establishing and growing a bioenergy industry. Policy by itself, however, is insufficient.

  Industry should build its capabilities, develop innovative projects and business models and clearly articulate where bioenergy has a comparative advantage against other low emissions alternatives. These integrated efforts have proven to be successful in other jurisdictions and are expected to foster equivalent benefits in Australia.

- Community awareness of bioenergy is limited. Community perceptions of bioenergy need to be respectfully acknowledged and people should be empowered with more information about the sector.

  Diverse stakeholders identified social acceptance as a poignant consideration for the expansion of Australia's bioenergy sector. This has the potential to significantly impact both the social licence for projects and the cost competitiveness of bioenergy.

Bioenergy market opportunities

Although significant, Australia's bioenergy potential varies across the different markets. In particular, this potential is anticipated to be highest in hard-to-abate sectors. Four scenarios have been developed to test a range of possible futures, ranging from least to most optimistic about bioenergy uptake. Industry Stagnation represents a loss of government and community support while Business As Usual represents a continuation of current levels of support. Broad Use comprises increased government and community support coupled with strong technology cost reductions, and Targeted Deployment consists of concerted effort by industry and government on end-use markets that are hard to abate.

Australia's bioenergy potential varies across markets. This potential could be the highest in hard-to-abate sectors.

BIOENERGY DEMAND BY MARKET BETWEEN 2020 AND 2050

Hard-to-abate sectors

Hard-to-abate sectors include renewable industrial heat generation, aviation and renewable gas grid injection.

In these sectors, limited low emissions alternatives exist in the short to medium term. The modelling for this Roadmap shows that industry and government efforts focusing on these three markets could expand bioenergy's share in these hard-to-abate sectors.

Renewable industrial heat generation benefits from technologies that are mature and in use throughout the world. It is well established in Australia and can still grow. However, low visibility and non-economic barriers impede its development in Australia.

Key insights

- Bioenergy pathways for industrial renewable heat generation are both technically mature and cost-effective compared to incumbent fuels and other renewable energy sources. In addition, unlike other renewable sources, bioenergy can address most industrial heat requirements, such as different steam grades. This offers low emissions opportunities where there are limited low emissions alternatives.
- Also, Australia already has an established market for industrial renewable heat generation, primarily from solid biomass (mainly bagasse and wood waste) and biogas. This is demonstrated by an existing significant market share, where bioenergy accounts for around 15 per cent of overall industrial heat demand. With access to a variety of feedstocks, there is scope to grow this market opportunity. The modelling conducted as part of this Roadmap suggests that by the 2050s bioenergy could account for as much as 33 per cent of the overall industrial heat demand.
- Industries that generate organic waste as a by-product, such as the food and wood processing industries, could viably integrate bioenergy within existing operations. This is because their production processes generate feedstocks, thus providing direct access to them. In addition, processes used by the cement industry could accommodate a variety of bioenergy feedstocks.
- However, many industrial heat users have a low appetite for investing in renewable industrial heat technologies, despite these technologies being cost-competitive with other alternatives. Stakeholders identified that heat generation is not part of their core business. It is considered an energy efficiency measure, with expectations that investments should result in short payback periods of three to five years.
- Furthermore, there has been limited attention paid to reducing emissions in industrial heat in Australia to date. The focus and incentive mechanisms have largely been on reducing emissions in the electricity sector.

Biojet fuels are one of the few options to reduce emissions in aviation in the short to medium term and can benefit from increasing maturity and growing industry momentum. However, their higher costs compared to conventional jet fuels are a barrier to increased uptake, and their costs are expected to remain higher in the medium to long term.

Key insights

- Renewable hydrogen and electrification could contribute to reducing emissions in aviation, but these solutions are still at an early development stage. By contrast, biojet fuels are relatively more mature, with a growing number of pathways certified to industry standards, demonstration flights and fuel off-take agreements both in Australia and overseas. Momentum is growing globally, with the recent announcements of biojet fuels blending mandates, such as in Norway, and the Sustainable Aviation Buyers Alliance.
- Market development is hampered by the current significantly higher costs of biojet fuels compared to conventional jet fuels, and higher costs are expected to continue over the medium term.
- Even though technology maturity is improving, advanced biofuel production technologies leveraging non-food resources still need to be proven at commercial scale. This will be key to overcoming potential resource limitations.
- As a result, biojet fuels are expected to experience limited uptake under the Business As Usual (BAU) scenario, contributing to around 12 per cent of Australia's jet fuel consumption in 2050. With increased targeted focus, this market share could grow to up to 45 per cent by the 2050s.
- It is noted that production methods can produce multiple road transport biofuels as well as biojet fuels. Therefore, the growth of biojet fuels has linkages with the growth of the wider transport fuels market.

Biomethane grid injection is one of the few options along with hydrogen to reduce emissions from Australia's gas consumption. It benefits from the global availability of mature technologies and growing momentum from both industry and government. Compared to hydrogen, biomethane grid injection thus presents a short to medium term opportunity to reduce emissions from Australia's gas consumption before hydrogen becomes more widespread. However, market development is hampered by higher costs compared to natural gas and inconsistencies in policy and regulation.

Key insights

- Pipeline gas is a hard-to-abate sector, with biomethane being one of the few low emissions options along with low emissions hydrogen. Unlike hydrogen, however, biomethane has a chemical composition very close to natural gas. This means it can be injected directly into the gas grid without requiring upgrades of the gas infrastructure or consumer appliances.
- Biomethane benefits from mature technologies developed overseas. Also, it is less expensive than renewable hydrogen in the short to medium term. In the short term, biomethane production from landfill gas offers a low-cost opportunity to ignite the market, being close to cost-competitive with natural gas already.[14] In the longer-term, although more expensive than natural gas, biomethane from anaerobic digestion could leverage Australia's access to a variety of feedstocks to expand volumes.
- Despite being a mature pathway overseas, all biogas produced in Australia is either flared or used for heat and electricity generation. There is currently no biogas upgrading plant operating in Australia for biomethane production, although the first demonstration-scale project has recently been announced.[15]
- The lack of commercial upgrading facilities can be attributed to the absence of sufficient mechanisms for the full value of injection into the gas grid to be monetised. For example, uncertainty around digestate management regulation prevents biogas project developers from maximising its use. However, the development of ERF (Emission Reduction Fund) methods for biomethane has been announced by the Government in December 2020 and is being led by the Clean Energy Regulator. Method scoping, planning and co-design processes have been completed. Consultations on draft methodologies opened in early November 2021.[16] This will ultimately allow biomethane from waste and agricultural methods to reduce emissions and receive Australian carbon credit units.
- Under the BAU scenario, biomethane grid injection experiences limited uptake, contributing to around 9 per cent of Australia's gas consumption in 2050. With increased targeted support, this share could grow to up to 33 per cent by the 2050s.
- On 20 August 2021, Energy Ministers agreed to make reforms to the National Gas Law, National Energy Retail Law and subordinate instruments to bring hydrogen blends, biomethane and other renewable gases within their scope. These reforms will provide more legal certainty for industry.

14. Modelled cost of biomethane is $12.20 (2021) and $9.80/GJ (2030), compared to forecast cost of gas of $8.60 (2021) and $11.50/GJ (2030).
15. ARENA, Malabar Biomethane Injection Project, 2020, https://arena.gov.au/projects/malabar-biomethane-injection-project/.
16. CER, Method development tracker – Biomethane, 2021, http://www.cleanenergyregulator.gov.au/ERF/Pages/Method%20development%20tracker/Biomethane.aspx.

Malabar Wastewater Treatment Plant
Credit: Sydney Water

Other markets

In other markets, bioenergy can complement low emissions alternatives. These include the road transport and electricity markets. These are each outlined below.

Road transport biofuels can complement other low emissions alternatives such as hydrogen and electric vehicles in the short term. Market development has been hampered to date by the higher costs of advanced biofuels compared to conventional fuels.

Key insights

- Road transport biofuels can complement other low emissions alternatives such as hydrogen and electric vehicles, which are currently experiencing a gradual uptake. In particular, there are opportunities for biofuels to displace diesel in long-haul transport where there are limited low emissions alternatives.
- Liquid biofuels can use existing refuelling infrastructure and conventional vehicle fleets, which is particularly beneficial for reducing emissions in road transport in the short term. Some biofuels, such as 1G bioethanol and HVO renewable diesel, are close to being cost-competitive with conventional fuels.
- Biofuels from food crops will face resource constraints, while advanced biofuels that are able to overcome this limitation are more expensive. Advanced biofuels are not fully commercial and demonstrated at scale yet, despite significant research and demonstration efforts in Australia and overseas.
- Inconsistent policy support in Australia across jurisdictions and time, coupled with community and industry issues, have affected the uptake of biofuels. Only Queensland and New South Wales have biofuel blending mandates, with limited success in meeting targets so far. In response, the New South Wales Government passed the Biofuels Amendment Act in 2016. This legislation restricts exemptions available to liable parties, increases accessibility of biofuels and targets greater compliance.
- However, persisting industry challenges including difficulty forming supply contracts, high feedstock costs, low market maturity and consumer acceptance continue to limit the effectiveness of mandates. These challenges were also identified in the Queensland Government's review of its mandates in 2019 and were reflected in the outcomes of this Roadmap's stakeholder consultation.
- Overall, this has resulted in limited uptake to date, with biofuels only accounting for 0.4 per cent of Australia's fuel consumption in 2019-2020. The modelling for this Bioenergy Roadmap outlines that this share could grow to 5 and 10 per cent of the petrol and diesel markets respectively by the 2050s if assisted by technological progress and commercial support (Targeted Deployment scenario).
- In the 2021-22 Budget, the Australian Government secured commitments from the major refineries to continue operating until at least 2027 through the Fuel Security Services Payment and support for major refinery infrastructure upgrades to deliver ultra-low sulfur petrol. The Australian Government is also bringing forward the industry-wide review of the petrol and diesel standard to 2021 (originally scheduled for 2022). The aim of this review is to identify a pathway towards Euro 6-equivalent fuel standards. Bioethanol represents a potential solution for high octane, low aromatics fuel.[17]

17. This review aims to create a Euro-6 equivalent petrol and diesel standard that considers the Australian context. The Australian Government willl consider a range of options, including bioethanol, as a potential substitute for aromatics in petrol as part of the industry-wide review of the petrol and diesel standards, which will take into account supply-chain wide considerations.

Bioelectricity generation can complement and support the increasing penetration of variable renewable energy. It can address Australia's need for dispatchable and synchronous electricity generation in both grid-connected and off-grid areas with renewable sources.

Recognition of specific contributions of bioelectricity generation, such as system strength and inertia, could help its efficient integration into a lower emission electricity system.

Reforms to value essential system services are being progressed through the Post-2025 National Electrcity Market package, as agreed by Energy Ministers.

Key insights

- The growing penetration of renewable energy such as wind and solar combined with the progressive reduction in baseload fossil generation brings new challenges to the electricity system. Such challenges include additional firming requirements for intermittent renewable energy. This could be provided by a mix of technologies of which bioelectricity is one option (along with gas, pumped hydro, and long duration batteries). Bioelectricity generation can contribute to both system strength and inertia by being synchronous and dispatchable. The Australian Energy Market Operator estimates we will need up to 19 GW of on-demand, dispatchable power by 2040 to support the increasing amont of intermittment renewables in the system.
- In off-grid areas, bioelectricity generation, particularly from biogas and solid biomass, also offers a low emission, dispatchable and low-cost alternative to diesel generation. Electricity from biogas and solid biomass have a cost of $149.00/MWh and $138.00/MWh respectively, compared to $143.00/MWh for diesel power generation. Further, in the Australian Government's Regional and Remote Communities Reliability Fund, three of the 37 projects to date involve bioenergy.
- Bioelectricity generation is mature and has similar costs to other low emissions, dispatchable alternatives such as wind and solar combined with battery storage. However, such storage may only be able to provide dispatchable capacity for short durations of a few hours. Also, bioenergy can be used for co-firing within existing power stations, or power stations can be upgraded to exclusively use bioenergy resources.
- To date, there has been limited penetration of bioelectricity generation, which accounts for just 1.3 per cent of Australia's total electricity generation. The modelling for this Roadmap shows that this share could grow to 9 per cent of grid and 11 per cent of off-grid electricity generation by the 2050s under the Targeted Deployment Scenario.[18]

18. Assumed cost of off-grid bioenergy electricity is $94.10/MWh in 2050, compared to $188.00/MWh for diesel power generation in 2050.

East Rockingham Waste to Energy Project
Credit: East Rockingham Waste to Energy

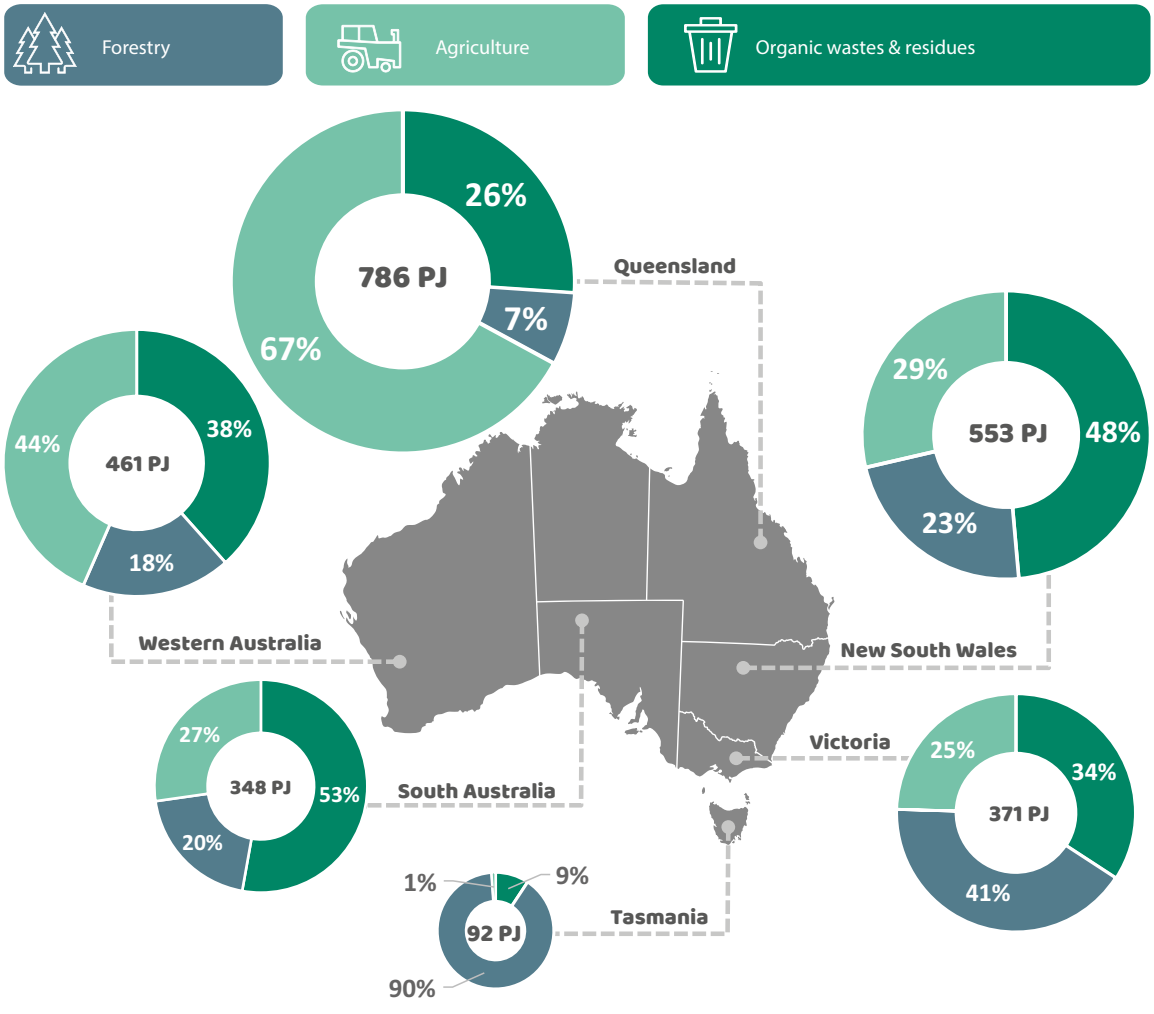
Bioenergy resources

Central to the realisation of Australia's bioenergy potential is the efficient and sustainable use of its vast resources.

Australia's theoretical bioenergy resource potential is significant. It is estimated to be over 2,600 PJ per year. If this potential was economically feasible, it would represent more than 40 per cent of Australia's current primary energy supply and more than 10 times its current bioenergy production.

- Organic wastes and residues are the largest resource opportunity, for developing the industry in the short term, representing 37 per cent of Australia's current potential. They are less expensive to produce as they have less competing uses than primary resources such as agricultural and forestry resources and pose fewer social licence obstacles.
- Agricultural resources can complement the wastes and residues opportunity. While they have the largest potential (41 per cent of Australia's resource potential), agricultural resources are more expensive to produce than wastes and have competing uses other than for bioenergy. However, there is potential to improve the sustainable and value-add utilisation of these resources.
- Some of Australia's agricultural resources, such as canola and tallow, are currently exported to overseas markets with robust resource sustainability frameworks in place. Also, other agricultural resources are already used for bioenergy production in Australia, such as sorghum or sugar cane, and have scope to be more intensively used for bioenergy.
- The forestry sector accounts for 22 per cent of total resource potential, largely composed of plantation forests, most of which are certified sustainable forestry residues and wood processing wastes. Given the low community support for harvesting native forests, this resource is not a feasible component of the growth of Australia's bioenergy industry.

BREAKDOWN OF AUSTRALIA'S THEORETICAL RESOURCE POTENTIAL (PJ PER ANNUM)



Source: Enea, Deloitte based on ABBA project information and ABARES production data

There is a significant difference between theoretical resource potential, representing all the feedstock that is available, and the resources that are technically, commercially and sustainably accessible.

- The difference stems from the practicalities of collection and transport of low energy density, distributed supplies, resource quality, competing uses of resources and other supply chain costs. Also, while reasonably robust data is available to estimate the current theoretical resource potential, limited information is available to assess its current and future, technical, commercial and sustainable accessibility.
- For the modelling in this Roadmap, the Business As Usual scenario assumed on average only 45 per cent of the theoretical potential could be accessed. This was based on consultations with experts and learnings from other countries.

The growth of bioenergy is therefore constrained across all markets by accessibility considerations. Even when bioenergy is cost-competitive, or has strong policy settings, the modelling for this Roadmap shows that resources cannot be accessed in sufficient quantities to meet all of the potential demand.

There is potential to expand Australia's accessible bioenergy resources.

- There are opportunities to maximise the potential of waste and residue resources. In some countries, initiatives such as waste levies harmonisation and selective bans at landfills have proven effective in enabling better waste utilisation including for instance waste to energy (WtE) projects.
- California, Germany and Sweden have either banned organics to landfill or have targets to reduce the amount of organic waste sent to landfill. At the national level, Australia is progressing towards similar outcomes through its National Waste Strategy.
- Australia's agricultural and forestry resource potential could be further expanded through strategies that minimise competition for land from other uses. These strategies include increasing crop yields (tonnes per hectare), integrating energy crops with other crops on agricultural land (intercropping), and using marginal lands for energy cropping.

Expanding this potential will require careful consideration of the environmental sustainability of each bioenergy resource.

- While bioenergy can significantly reduce greenhouse gas emissions across all end-use markets compared to fossil fuels, its emissions reduction potential heavily depends on the sustainability of resources used to produce bioenergy.
- Bioenergy can have the greatest emissions reduction potential in hard-to-abate sectors, such as aviation, and by leveraging waste and residue resources, thereby avoiding methane emissions from waste decomposition. However, land use change associated with the use of primary agricultural and forestry resources for bioenergy can also lead to increased emissions.
- In line with this, many countries studied in this Roadmap have developed sustainability frameworks and associated mechanisms. In these countries, sustainably sourced biomass can be enabled through eligibility criteria, sub-targets or additional incentives to complement other policies. Guarantees of origin certificate schemes enable retailers and consumers to trace the sustainability of the bioenergy that they have purchased and provide complementary revenues to energy producers.
- Community concerns identified as part of this Roadmap include sustainability considerations, especially related to forestry and agricultural resources. These revolve around the productive use of Australia's native forests, the removal of agricultural residues essential for soil fertility and carbon sequestration, and the 'food versus fuel' debate.
- Also, any expansion of Australia's resource potential should consider climate impacts. These climate impacts and weather events may affect sectors that are dependent on natural resources, including agriculture and forestry.

Conclusion

Achieving significant emissions reductions by 2050 will require advances in low emissions technologies and innovation, combined with widespread adoption of best practices by industry and targeted co-investment from the private and public sectors.

Australia's Bioenergy Roadmap provides a framework to assess where bioenergy could play a greater role in Australia's future energy mix. It identifies the bioenergy subsectors with a comparative advantage, such as in hard-to-abate sectors, and proposes potential actions to overcome the barriers currently halting progress. Accordingly, this Bioenergy Roadmap shows how bioenergy can help reduce emissions across the economy, which will be considered by the Government including through the ongoing Low Emissions Technology Statement process.

As well as addressing low emissions energy technologies, this Bioenergy Roadmap sets out the benefits of developing a strong bioenergy industry in Australia. With the potential to create around $10 billion in extra GDP and 26,200 new jobs by the 2030s, as well as divert an extra 6 per cent of waste from landfill and enhance fuel security, the economic benefits of developing key sectors of the bioenergy industry are clear. The benefits for the community, as well as regional areas of Australia, are also clear. The Bioenergy Roadmap provides the framework to inform future policy and investment decisions across all levels of government and industry. It has the strategic aim of identifying where Australia's comparative advantages in bioenergy could develop into an industry that is economically competitive with established technologies, while reducing emissions, to unlock new opportunities across the country.

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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.

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

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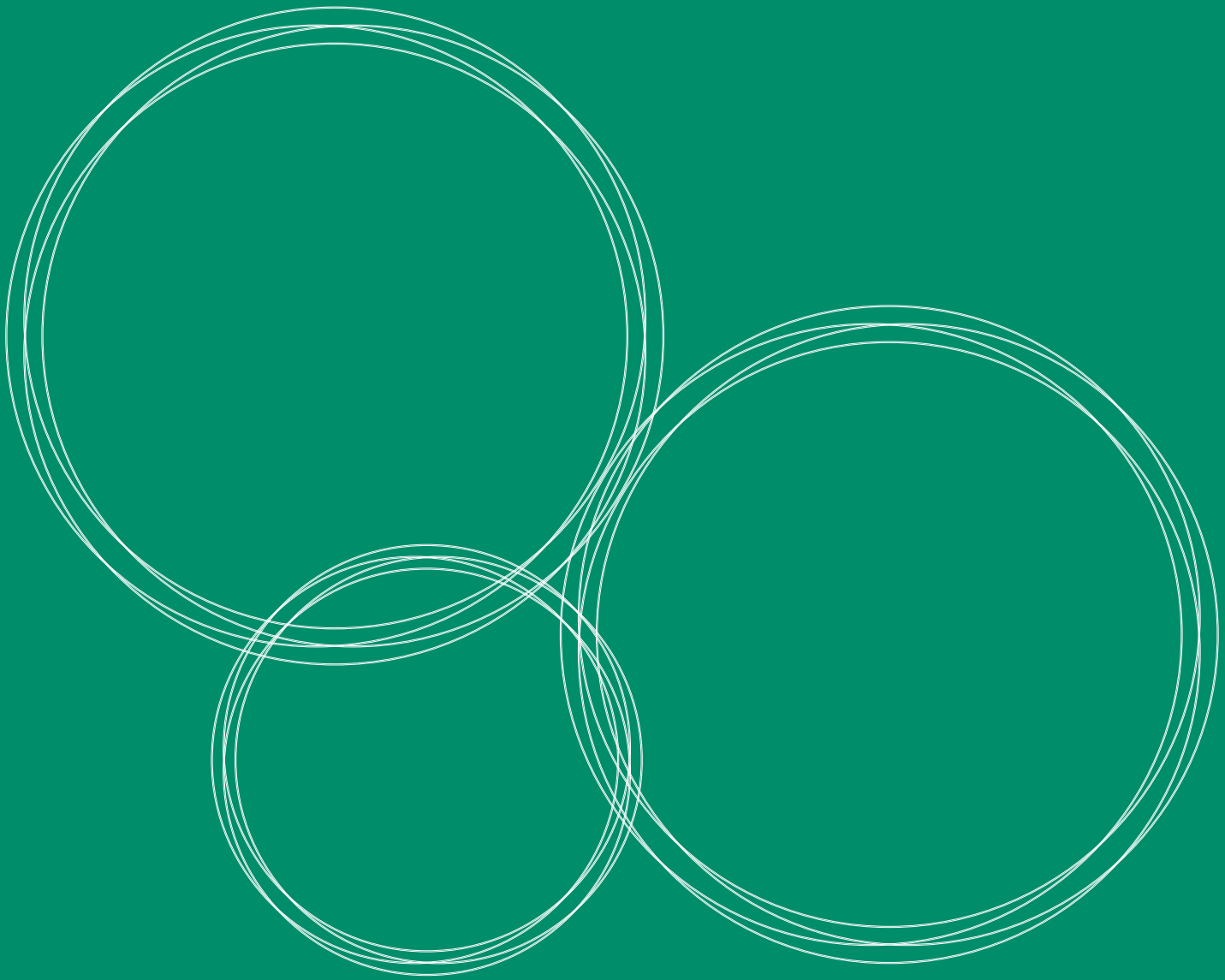

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