Sustainability Victoria – Government measures and interventions for biogas

November 2021

EXECUTIVE SUMMARY

Context and objectives

In February 2020, the Victorian Government announced the $10 million waste to energy support package as part of the *Recycling Victoria: A new economy* 10-year action plan to reform Victoria's waste and recycling system. Amongst other targets, this action plan aims to halve the volume of organic waste going to landfill by 2030. In line with this target, anaerobic digestion is considered a priority for investment in waste to energy infrastructure by the Victorian Government (this will be informed by the proposed Waste to Energy Framework, which is currently under development).

In light of this funding announcement as well as the pending closure of the W2E Infrastructure Fund, Sustainability Victoria has engaged Enea Consulting to complete a project that evaluates the two rounds of funding and investigates the landscape for future investment in anaerobic digestion in Victoria. This project (titled *W2E Infrastructure Fund Evaluation and Sector Development*) comprises three main phases, each with its own objective:

1. **W2E Infrastructure Fund evaluation:** Evaluate how the W2E Infrastructure Fund was delivered by measuring performance against program objectives
2. **Estimate of Victoria's biogas potential:** Analyse and expand the Australian Biomass for Bioenergy Assessment (ABBA) project biomass data and provide an estimate of Victoria's (anaerobic digestion) biogas potential
3. **Government measures and interventions:** Investigate global measures and intervention strategies that facilitate anaerobic digestion infrastructure development and provide recommendations for Victoria.

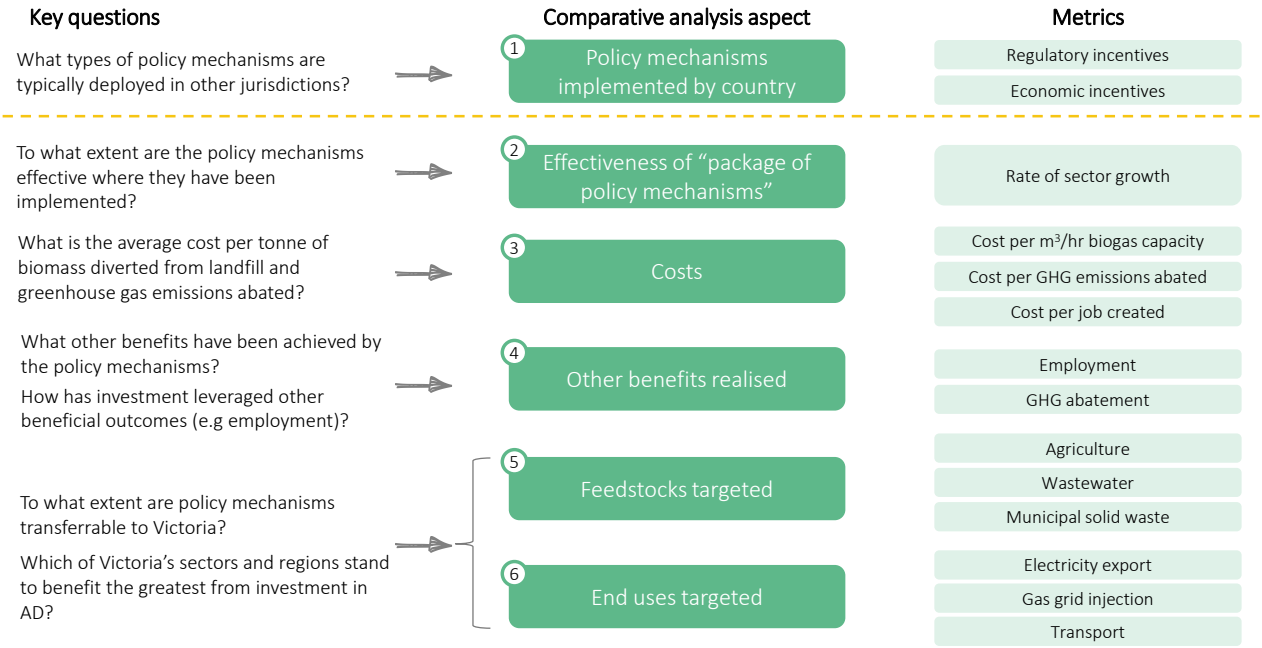
This global biogas policy benchmarking report encompasses the third phase of the project. The findings of this report provide insights on the success of different biogas policies from key jurisdictions. These learnings have then been distilled into recommendations for Sustainability Victoria and the Victorian Government to support the growth of infrastructure for anaerobic digestion.

Method and data sources

A longlist of potential jurisdictions to investigate was created from a comprehensive review and categorisation of global biogas policy mechanisms (see Appendix 1). This longlist was then prioritised and allowed the selection of the jurisdictions which could provide the most relevant learnings and insight for Victoria. The five jurisdictions selected were: Italy, Germany, Canada, California and France. Each jurisdiction's package of policy mechanisms used to support their biogas sector was investigated and compared against each other using the analysis framework in Figure 1.

Aspects of the comparative analysis included benchmarking the effectiveness of the biogas policies implemented in growing a jurisdiction's biogas sector and cost efficiency of the benefits gained. The targeting of specific feedstocks and end uses was also investigated. The metrics used for each of these aspects are provided in Figure 1.

Figure 1– Analysis framework for policy benchmark.



Key findings

Generous electricity Feed in Tariffs (FiTs) were the dominant support mechanisms used to fuel the initial growth of all five jurisdictions' biogas sectors

These biogas electricity FiTs were first implemented between 2000 and 2009 alongside other renewable alternatives such as wind and solar. These initial FiTs ranged from 110 – 450 AUD/MWh$_e$, depending on feedstock and jurisdiction. This led to CAGRs of up to 74% in Italy, which had the highest FiT.

Italy, France, Canada and California focus on biomethane end uses while Germany continues to target CHP

France is using FiTs to encourage biomethane grid injection and will be launching a biomethane certificate scheme in 2022 which can be used in the liquified natural gas (LNG) market, while Italy's biomethane certificates targets transport as an end use. Canada and California have mandates for biomethane consumption and California increased grant support for grid injection after reducing their electricity FiT support. On the other hand, Germany continues to incentivise electricity from both biogas and biomethane with the goal of providing grid firming capacity.

Focus is shifting from electricity FiTs to other types of mechanisms such as capital grants, mandates, certificates, or more 'market exposed' mechanisms depending on the jurisdiction

All five jurisdictions have either reduced support from electricity FiTs, by up to 65%, or removed them in the past decade (2016 for Canada and 2014 for large projects in Germany). California and Canada are supporting biogas mainly through grants and mandates, while France and Italy are using biomethane FiTs and certificates respectively. Germany's mature biogas sector is moving to market exposed mechanisms such as auctions for biogas electricity and only keeping FiTs support for smaller plants.

All jurisdictions target agricultural waste through extra incentives

In all explored jurisdictions, agricultural waste receives, or received, one of the highest FiT bonuses (up to 33% higher than base FiT). Canada and California also have targeted grants and loans programs specifically for farmers, such as California's Dairy Digestor R&D Program which specifically focuses on dairy manure.

Jurisdictions which previously had extra incentives for energy crops, such as Germany and Italy, have since removed these bonuses. Key drivers include minimisation of food competition and greater emission reduction potential achieved from using agricultural waste compared to other feedstocks such as energy crops.

FiTs and, to a lesser extent, certificates were the most effective policies in driving biogas sector growth

Biogas production growth rates correlated strongly with FiT incentives in the five jurisdictions. The end of or reduction in FiTs resulted in slowed growth in all jurisdictions (up to 17% reduction in growth rate). Meanwhile, Germany adjusted its FiT rates based on progress towards its biogas production targets, with higher FiTs to increase growth and lower FiTs to slow growth. Italy achieved a biogas upgrading capacity CAGR of 36% from 2014-2020 by introducing biomethane certificates[1] (98 AUD/MWh_{th}). This is linked to an 8% biofuel mandate targeting transport as an end use.

France's biomethane FiT (145 AUD/MWh_{th}) has been most effective in growing biogas upgrading capacity among the five jurisdiction and achieved a 66% CAGR in capacity from 2014-2020. Approximately 80% of this capacity comes from agricultural feedstock.

Although effective, FiTs were more expensive compared to grants

While FiTs have been most effective in growing biogas production capacity (in France, Germany and Italy, they are not the most cost efficient compared to other mechanisms such as capital grants, loans and biomethane procurement or consumption mandates (in California and Canada). Policy packages dominated by FiT support cost 115k – 169k AUD/(m^3/hr)[1] whereas biogas capacity growth driven by mainly grants cost 16k – 30k AUD/(m^3/hr).[1] In 2020, France set up a progressive reduction of its FiTs (by 2% per annum) to encourage the development of a cost-competitive biogas industry.

Grants tend to be cheaper as they are a one-off cost to cover capital costs as opposed to annual costs from a 10-20 year contract for FiTs covering both capital and operating costs. Additionally, projects supported by only grants are the ones able to sustain an operating profit without long-term support. Although these projects are more cost efficient to support, there are less of them, which leads to lower effectiveness in growing the sector. Conversely, although FiTs are more expensive, they can make more projects viable that otherwise would not have an operating profit without assistance.

This was demonstrated in Canada and California which experienced relatively low growth rates (5-7% CAGR between 2011 and 2019) whereas FiT driven jurisdictions such as Italy and France achieved higher growth rates (8-11% CAGR between 2011 and 2019).

Recommendations for Victoria

Targeted feedstocks and end uses

Considering Victoria's agricultural potential and Australia's focus on renewable natural gas, Victoria could target agricultural waste as a feedstock and biomethane as an end use.

Regardless of selected policy mechanisms, Victoria would benefit from focusing on using agricultural waste as this makes up the majority of Victoria's biogas potential. The other jurisdictions are also targeting agricultural waste, and similar to California, Victoria could efficiently maximise its Greenhouse gas (GHG) abatement through targeting high emission feedstock such as manure.

[1] The cost efficiency was calculated from dividing the cost of the key biogas support policies (e.g., FiTs, certificates, grants and loans, carbon pricing) over 2011-2019 by the biogas production capacity gained during this period. Note that cash flows (e.g., for FiTs) were not discounted.

Electricity production from biogas competes against low-cost renewable electricity alternatives such as wind or solar. Despite being able to provide capacity firming for the electricity system, most of explored jurisdictions now use biogas to offset hard-to-abate end uses such natural gas uses, including industrial heating and transport.

Clear digestate guidelines and standards could be implemented.

All jurisdictions have legislation in place covering the minimum treatment and storage of digestate. Additionally, standards on digestate (such as maximum heavy metal concentrations, pathogen concentrations and physical contaminants) help facilitate digestate markets by ensuring digestate is safe for end users.

Short to medium term action

If Victoria aims to achieve rapid growth, it could consider implementing a biomethane FiT to kick-start the biogas sector.

All reviewed jurisdictions started their biogas growth with a FiT. This allowed the development of a biogas ecosystem (such as suppliers, developers, skills and knowledge). Ambitious long-term growth of the sector can be linked to an attractive FiT, as demonstrated in France, Italy and Germany.

In the medium term, a biomethane certificate scheme linked to a mandate could be considered

A biomethane certificate scheme allows biomethane producers to adjust to a more market exposed business model compared to a fixed FiT. A biomethane certificate system will also create a market for buyers wishing to offset their natural gas use. For example, France will be implementing a biomethane certificate scheme in 2022, in conjunction with a progressive lowering of its biomethane FiT.

Linking a certificate scheme to a mandated target for biomethane consumption will further bolster support for biogas and increase demand for biomethane certificate. The introduction of a biomethane consumption mandate quantifies the goal to be achieved and is a strong signal to industry. It has been successful in growing the Italian biogas sector (after a FiT).

Longer term policy mechanisms

Victoria could use grants with FiTs at the beginning of biogas sector's growth and as a potential replacement for FiTs in the longer term

While grants can be useful during the project development phase and reduces the upfront capital requirements, none of the jurisdictions reviewed used only grants to start their biogas sector's growth. However, combining a FiT with grants led to Ontario becoming the leading province in Canada in terms of biogas production. In the long term, transitioning away from FiTs to grants has shown to be more cost efficient in California and Canada, albeit with lower biogas sector growth rates. The transition can involve progressive reduction of the FiTs, (such as on an annual basis as implemented in France), which fosters the cost competitiveness of the biogas industry.

To reduce the cost of supporting the biogas sector, Victoria could move towards market exposed mechanisms in the long term

While financial support is required at early stages, once the biogas sector has professionalised, policies can transition to more market exposed mechanisms, such as auctions (e.g., Germany). This transition should be conditioned to the maturity of the biogas sector. The purpose is to ensure that the sector continues to grow, while government support is reduced.

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1 CONTEXT, SCOPE AND OBJECTIVES

1.1 Background

In 2015, Sustainability Victoria's *Infrastructure Gap Analysis* found that government collaboration with the waste and resource recovery industry, waste generators and water authorities was required to support food waste recovery and reduce Victoria's greenhouse gas emissions. In response, the $2.3 million AUD Waste to Energy (W2E) Infrastructure Fund was introduced in July 2016. Since 2016, Sustainability Victoria has delivered two rounds of funding (the second under Sustainability Victoria's Bioenergy Infrastructure Fund, which reallocated over $700k AUD of W2E Infrastructure Fund budget following the withdrawal of a project).

In 2020, the development of a $10 million AUD waste to energy support package was announced as part of the *Recycling Victoria: A new economy* 10-year action plan to reform Victoria's waste and recycling system. This action plan intends to reduce the amount of waste sent to landfill and contribute to the Victorian Government's target of net zero emissions by 2050 by reducing emissions in the waste sector.

More specifically, *Recycling Victoria: A new economy* aims to reduce the volume of organic waste going to landfill by 50 per cent and provide household Food Organics Garden Organics collection services by 2030. The Victorian Government has highlighted that biological waste to energy treatments such as anaerobic digestion (to generate biogas) will be critical to achieving greater recovery of organic wastes.

Thus, anaerobic digestion is considered a priority for investment in waste to energy infrastructure by the Victorian Government. With the greater understanding of the quantity and distribution of organic residues in Victoria, coupled with the focus on waste to energy with recent funding and waste policies, there is now a need to understand what policies can be used to unlock the biogas potential in Victoria.

1.2 Project objectives and scope

Pending the closure of the W2E Infrastructure Fund and in light of the most recent funding announcements, Sustainability Victoria has sought an overview of anaerobic digestion within the waste to energy sector. To inform the development of the new $10 million package, Sustainability Victoria has engaged Enea Consulting to evaluate the W2E Infrastructure Fund and investigate the landscape for future investment.

The project comprises three main phases, each with its own objectives (see Table 1-1). This report encompasses Phase 3 of the project.

Table 1-1 – Summary of project phases and objectives

#	Phase	Objective
1	W2E Infrastructure Fund evaluation (completed)	Evaluate how the W2E Infrastructure Fund was delivered by measuring performance against program objectives
2	Estimate of Victoria's biogas potential (completed)	Analyse and expand the Australian Biomass for Bioenergy Assessment (ABBA) project biomass data and provide an estimate of Victoria's biogas potential

#	Phase	Objective
3	Government measures and interventions for biogas (this report)	Investigate global measures and intervention strategies that facilitate anaerobic digestion infrastructure and provide recommendations for Victoria

1.3 Objectives of this report

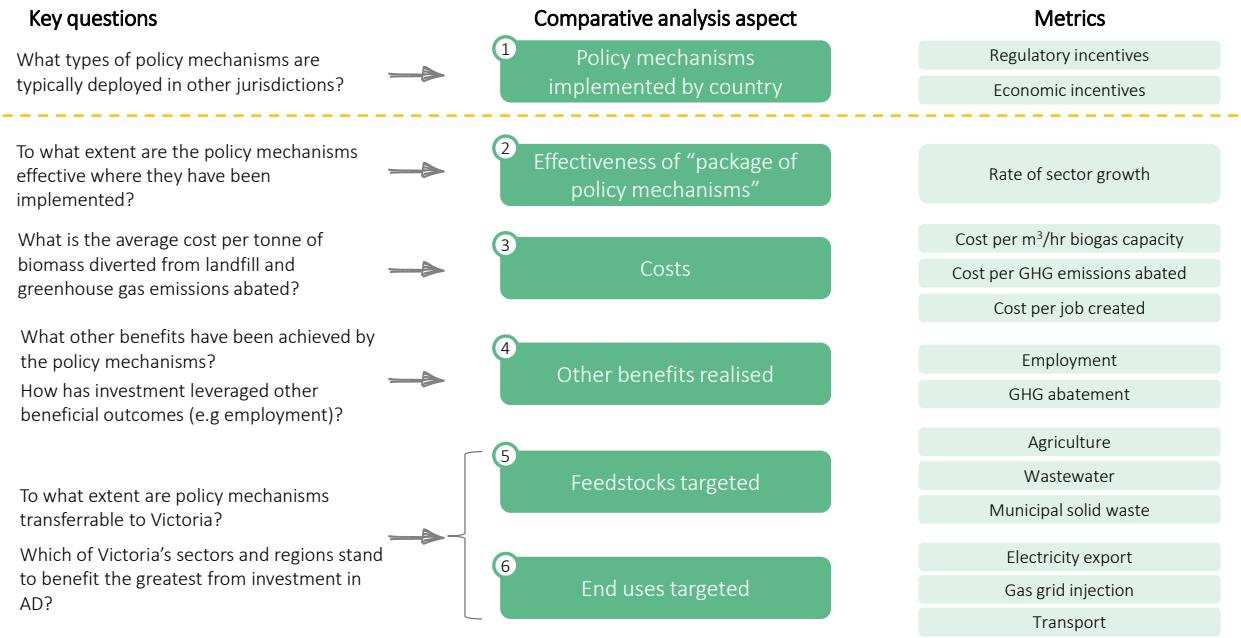
The objective of the third phase of the project was to provide an overview of the global biogas policy landscape in order to inform Sustainability Victoria which biogas policies would be most successful in Victoria. To achieve this, the investigation included:

- Benchmarking the success of different biogas policies across different jurisdictions through a literature review and stakeholder consultation
- Recommend policies with the most potential for unlocking Victoria's biogas potential based on the policies proven to grow biogas sectors globally and the policy relevance to Victoria

2 METHODOLOGY

This chapter outlines the methodology used to carry out the biogas policy benchmark. Five jurisdictions were selected to understand the effectiveness and efficiency of the development of their biogas sectors. The package of policy mechanisms used to support their biogas sector were investigated and compared using the framework in Figure 2-1. Recommendations for Victoria to develop its own biogas sector were made based upon the effectiveness and efficiency of the different policy packages, as well as their relevance to Victoria.

Figure 2-1 – Overall methodology for policy benchmark and selection of recommended biogas policies.



2.1 Jurisdiction selection

A longlist of potential jurisdictions to investigate was created from a comprehensive review and categorisation of global biogas policy mechanisms. This longlist was then prioritised during a workshop with Sustainability Victoria which allowed the selection of the jurisdictions which could provide the most relevant learnings and insight for Victoria. The rationale for the jurisdictions selected for the shortlist in this investigation is shown in Table 2-2.

Global biogas production amounted to more than 385 PWh in 2018 [1] with Europe being the leading region accounting for approximately 55% of this amount. France, Italy and Germany have three of the most developed biogas sectors within Europe. Approximately 50% of all European biogas plants are in Germany [2] [3], while France and Italy were selected for their focus on biomethane. California and Canada were investigated because of similar political systems to Victoria within Australia.

Table 2-1 – Rationale for shortlisted countries / jurisdictions

Country / Jurisdiction	Rationale
California	➢ Leadership position within USA. ➢ Like Victoria, California operates as a state within a federal system.
Canada	➢ Similar geographic characteristics (such as distances and population density) to Australia. ➢ Province system similar to Australian states/territories.
France	➢ Biomethane focus with rapid growth in biomethane capacity recently. ➢ Agricultural focus with 78% of biomethane plants owned by farmers. ➢ One of the leading European countries in terms of biogas production.
Germany	➢ European leader in biogas production (accounts for over 50% of biogas plants in Europe). ➢ Mature biogas industry which will give long term insights for Victoria.
Italy	➢ Biomethane focus with rapid growth in biomethane capacity. ➢ Focus on using biogas to abate the transport sector. ➢ One of the leading European countries in terms of biogas production.

2.2 Effectiveness of package of policy mechanisms

2.2.1 Sector growth

The primary metrics to assess the effectiveness of a jurisdiction's biogas policy package were related to the increase in biogas electricity, in biomethane upgrading and in combined capacity. In particular, three metrics were used to compare biogas production capacity across jurisdictions:

- Absolute growth (Nm^3 raw biogas/hr)
- Compounded annual growth rate (CAGR %)
- Relative to 2011 figures (%)

2.2.2 Jobs and GHG abatement

Some of the benefits of biogas sector development include increasing employment and GHG abatement. Both metrics were used to assess the effectiveness of the jurisdiction's biogas policy packages.

Employment from biogas sector growth was calculated by applying a conversion factor of 900 jobs per TWh [3] of thermal biogas energy which was an average recorded across biogas plants in Europe and representative of the global biogas sector. It must be noted that the job creation factor in Australia will be affected by local factors such as the average biogas plant size, the types of feedstocks and end-uses. This accounts for both direct and indirect jobs created from biogas plant construction and operation. It includes the activities around the production, collection, storage and transport of biomass as well as biogas production (construction and operation).

GHG abatement in each jurisdiction was calculated by taking into account[2]:

- Grid electricity offset through biogas electricity production
- Natural gas offset through biomethane upgrading

Jurisdiction specific emission factors were applied to determine the carbon intensity of the fossil fuel offset from biogas electricity and biomethane use. The GHG abatement of biogas took into account the jurisdiction specific feedstock mix (e.g., lower for jurisdiction with energy crops and higher for jurisdictions focussing on manure). The final GHG abatement factors can be found in Appendix 2. GHG abatement was calculated based on a 20-year operating lifetime of biogas plants built in the 2011-2019 period.

2.3 Efficiency of package of policy mechanisms

2.3.1 Total costs

The method and key assumptions for the cost estimate of policies are summarised in Table 2-2. The costs of certain policies, such as organic landfill bans, were not included in the total cost of the policy packages due to lack of publicly available data. The total cost of a jurisdictions policy package was calculated by summing the individual policy costs (if that jurisdiction used that policy) as calculated in Table 2-2.

Depending on the policy type, costs are attributed to different stakeholders. While all grants and loans are support comes from government, in some countries, the cost of FiTs are sometimes passed onto the consumers' energy bill (e.g., Germany). Certificates schemes (such as in Italy) are passed onto industry as companies are required to purchase a minimum amount of certificates to offset their energy use, or are fined.

Table 2-2 – Methods and key assumptions for determining costs of different policy types.[3]

Policy type	Methods and key assumptions
Grants & loans	▶ Data on annual biogas grants and loans were gathered from fund reports where available. ▶ Where spending for each year was unavailable, total biogas grants and loans amounts were split equally across the years of fund operation. ▶ Where funds were broader than biogas plants in scope (e.g. bioenergy or agricultural technology funds), split of biogas funding was estimated from input from stakeholder interviews (see Appendix 3) and/or from scope of fund.
Feed-in-tariff (FiT)	▶ FiT rates for different years were obtained from literature with a weighted average FiT calculated based on the feedstock composition of that jurisdiction and the bonuses applicable to those feedstocks. ▶ Total cost of FiT was calculated across the total time period of the FiT contract offered for biogas plants built during the corresponding FiT scheme.
Certificates	▶ Market prices of certificates were obtained from literature for different years where available. Where data was missing for some years, averages values

[2] The incorporation of GHG abatement through using digestate to offset synthetic GHG intensive fertilisers would further increase GHG abatement.

[3] The weighted average cost of capital was also not considered in the total cost calculation, which would have the effect of discounting future cash flows.

Policy type	Methods and key assumptions
	➢ Because current certificate schemes have no official deadline, the total cost of certificates was assumed using current market prices for the next 15 years.
Carbon credits / pricing	➢ Prices of carbon credits were obtained from literature for different years. ➢ The biogas capacity of plants eligible for carbon credits were used to calculate the value of carbon credits. ➢ European Union Emission Trading scheme was excluded from Italy, France and Germany cost calculations (does not currently cover biogas). ➢ France's and Canada's national carbon taxes were included in cost calculations. ➢ Californian carbon credits were included in cost calculations.

2.3.2 Cost efficiency metrics

Cost efficiency was assessed to benchmark the input of economic resources for biogas sector development achieved. To assess the cost efficiency of the biogas capacity gained, jobs created and GHG abated, the following cost efficiency metrics were calculated:

- Cost per biogas capacity gained was calculated by dividing the total cost of a jurisdictions biogas policy package by the biogas capacity gained from 2011-2019
- Cost per job created was calculated by dividing the total cost of a jurisdictions biogas policy package by the jobs created from biogas plants built from 2011-2019
- Cost per GHG abatement was calculated by dividing the total cost of a jurisdictions biogas policy package by the GHG abated during the operational lifetime (assumed 20 years) of biogas plants built from 2011-2019

2.4 Feedstocks and end uses targeted

Feedstocks and end uses are assessed to understand the relevance of the policies to Victoria's context. The most abundant feedstocks in Victoria are agricultural residues (Phase 2 report: *Estimate of Victoria's biogas potential*) while biomethane is the most relevant end use due to the renewable gas focus in Australia (feedback from workshop with Sustainability Victoria). To assess the targeting of feedstocks and end uses of different jurisdictions, the following factors were considered:

- Presence of funds targeting specific feedstocks or end uses of biogas
- Different FiT rates or bonuses for certain feedstocks or end uses of biogas
- Presence of mandates for different end uses (e.g. biomethane or RNG)
- Presence of certificates or other incentives targeting specific feedstocks or end uses

3 GLOBAL BIOGAS POLICY INSIGHTS

This chapter provides insights into the biogas sector development of France, Italy, Canada, California and Germany. These jurisdictions are first examined individually (Section 3.1) followed by a comparative analysis (Section 3.2) to benchmark the effectiveness and efficiency of their biogas sector development.

3.1 Deep dive on selected jurisdiction's biogas policies

This section provides an individual overview of each of the jurisdictions with:

- highlights from the jurisdiction's biogas sector including feedstock mix, key drivers and a policy timeline
- analysis of the sector development and policy support figures dedicated to growing the jurisdiction's biogas sector

3.1.1 California

California's biogas mix was driven by landfill and wastewater in 2019, and forecasted to be fuelled mainly by agricultural residues by 2030

A summary of the California's biogas feedstock mix and production, both in 2019 and forecasted for 2030, is provided in Figure 3-1. A key driver is the state law requirement to capture biogas from large scale wastewater treatment plants [4, 5]. In 2010, there were already 117 wastewater treatment plants producing biogas [6], and as can be seen by Figure 3-1, about half of California's 2019 biogas production capacity came from wastewater. With grants programs funding biogas plants in the agricultural sector, California's biogas mix is forecasted to be produced mainly by agricultural residues (>75%).

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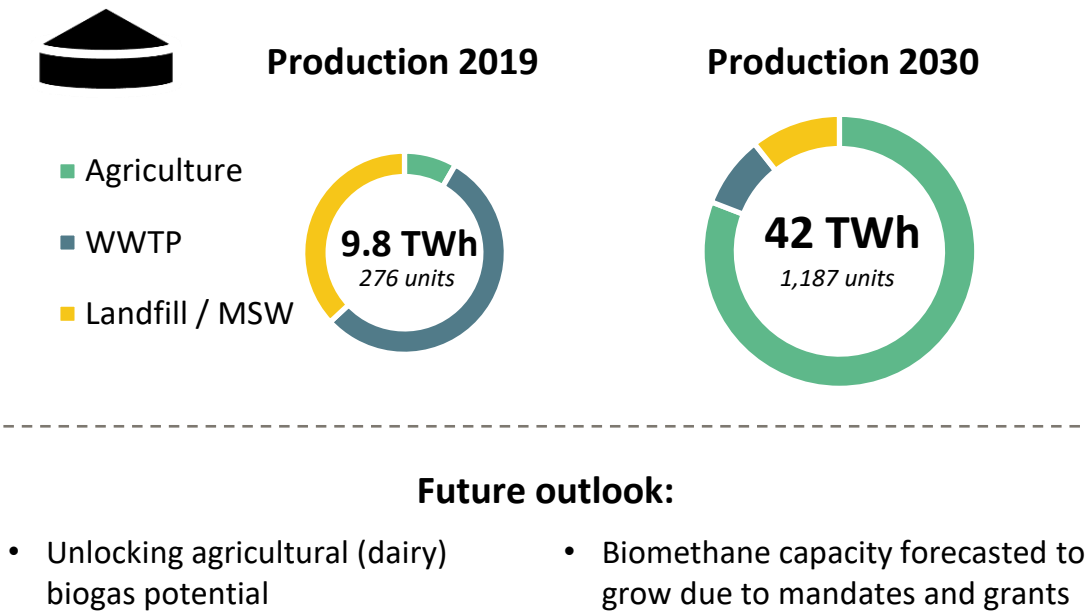
Figure 3-1 – Summary of California's biogas feedstock composition and production in 2019 and 2030 ([7] [8]). [4]

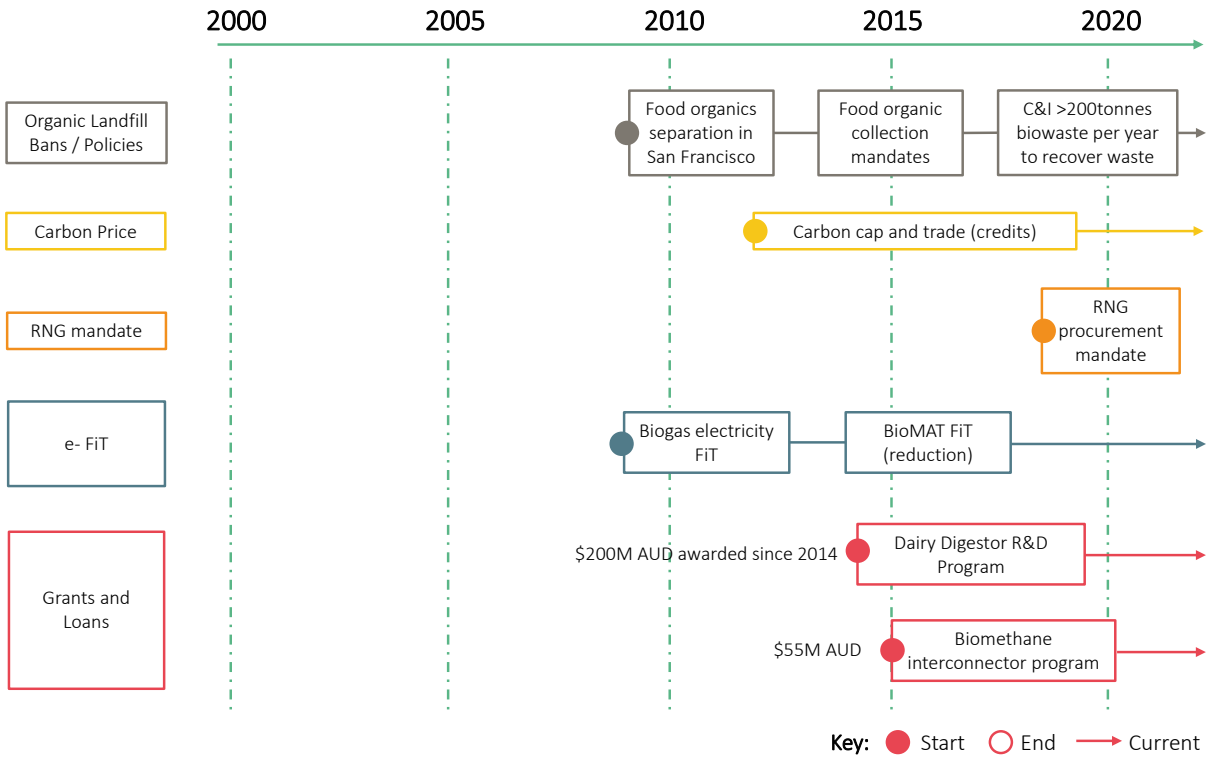


California is leading the US in terms of biogas production with state level grants programs and mandates

California is the largest biogas producer in the USA with 301 biogas plants in 2021 [9]. An overview of the biogas policy timeline in California is provided in Figure 3-2. The development of the biogas industry in California has been driven by high energy costs and the willingness to increase renewable energy production to reduce emissions. Most of California's biogas growth is attributed to its first electricity FiT, which was reduced in 2015, and led to stagnated growth after. Methane reduction and biomethane procurement mandates have driven growth in biomethane since then.

[4] Production and potential figures represent California only (not USA).

Figure 3-2 - Timeline of key policies affecting California's biogas sector.



In 2005, the Renewable Fuel Standard (RFS) was introduced federally and required a minimum volume of renewable fuel (including biogas) to be included in the total transportation fuel sold. The RFS was extended in 2007. In 2011, California enacted legislation aiming to reduce landfill disposal of organic waste by 75% by 2025 from the 2014 level. This encouraged the development of bioenergy as it created a demand for alternative waste treatment solutions.

In 2015, California announced ambitious energy targets (renewable energy to make up 50% of utilities' total procurement by 2030) under the Renewable Portfolio Standards (RPS). The RPS also introduced certificates as electricity suppliers were required to demonstrate compliance with the energy targets. In 2016, regulations and targets for methane emission reduction and for the reduction of organic waste disposal were also established. These policy mechanisms boosted the biogas/biomethane industry.

In 2017, California adopted a Low Carbon Fuel Standard (LCFS) [10], which inspired Oregon to enact similar legislature in 2019 and led multiple states, including Washington State to consider similar standards. The LCFS allow for the generation of certificates for low emission fuels, which can be purchased to balance out deficits collected due to the production of higher emission fuels. California has been developing new bills to extend funding programs. The state also established biomethane mandates for private, investor-owned gas utilities requiring the procurement of renewable gas annually for injection into the gas grid, through long-term offtake agreements. Lastly, California also has legislation around the storage, transport and processing of digestate. This includes standards around heavy metal concentration, pathogen concentration and physical contaminants [12].

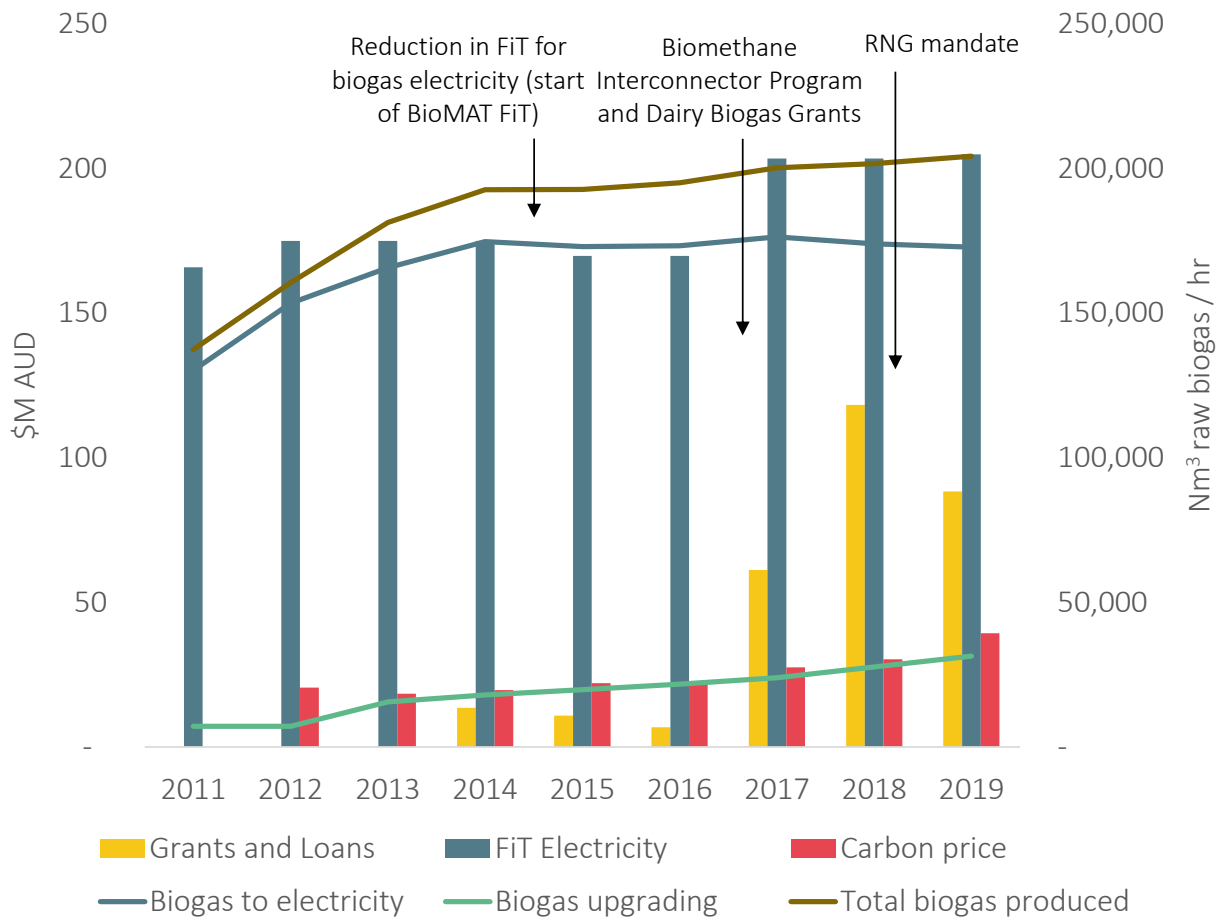
California biogas electricity growth stagnated after 2014, while recent biomethane growth was achieved with procurement mandates, grants and loans

California's lowered FiT for electricity led to a stagnation in biogas electricity growth after 2014. However, biomethane production has continued to grow since then, driven by procurement mandates, grants and loans instead of a biomethane FiT (Figure 3-3). Examples of targeted grant programs include the:

- Dairy Digestor R&D Program which has funded over $260M AUD to build over 118 diary digestors since 2015 [11]
- 'Biomethane Interconnector Program' with a fund value of $55M AUD and covers ~50% of the connection costs to grid for biomethane project [12]

Despite no biomethane FiT, biomethane capacity has grown at a CAGR of 18% since 2011 driven mainly by the Low Carbon Fuel Standard, grants and loans.

Figure 3-3 - California's biogas sector growth from 2011-2019 and policy support ([13], [14]).



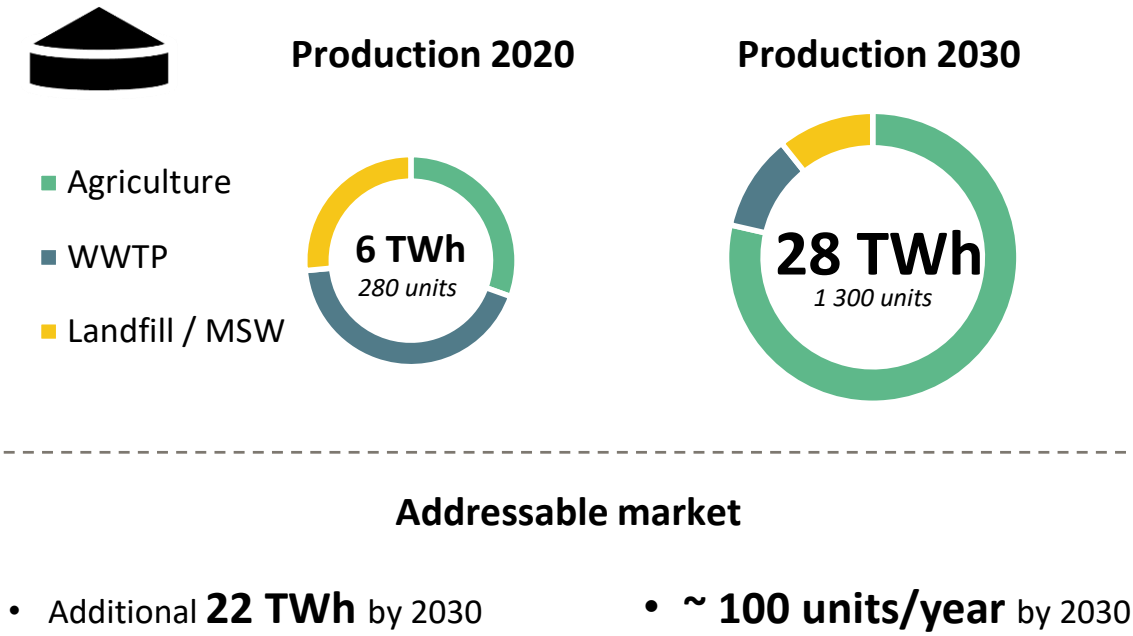
A total of $1.9B AUD has been dedicated to California's biogas sector from 2011 to 2019 with the cost of the new installed biogas capacity amounting to $16k AUD / ($Nm^3$ raw biogas/hr). Overall, the biogas sector grew at a CAGR of 5% during this period (Figure 3-3). 1,877 new jobs created from developing the biogas sector from 2011-2020 and 13.5 million tonnes CO_2 e will be abated from biogas production capacity developed during this period.

3.1.2 Canada

Canada's biogas mix was evenly distributed between agriculture, wastewater and landfill / MSW in 2019 and forecasted to be fuelled mainly by agricultural residues by 2030

A summary of the Canada's biogas feedstock mix and production, both in 2020 and forecasted for 2030, is provided in Figure 3-4. In the past, incentives for biogas such as FiTs and grants have not specifically targeted certain feedstocks, resulting in an equal distribution of biogas feedstocks in 2019. With grants programs now focussing on funding biogas plants in the agricultural sector, Canada's biogas mix is forecasted to be produced mainly by agricultural residues (>75%).

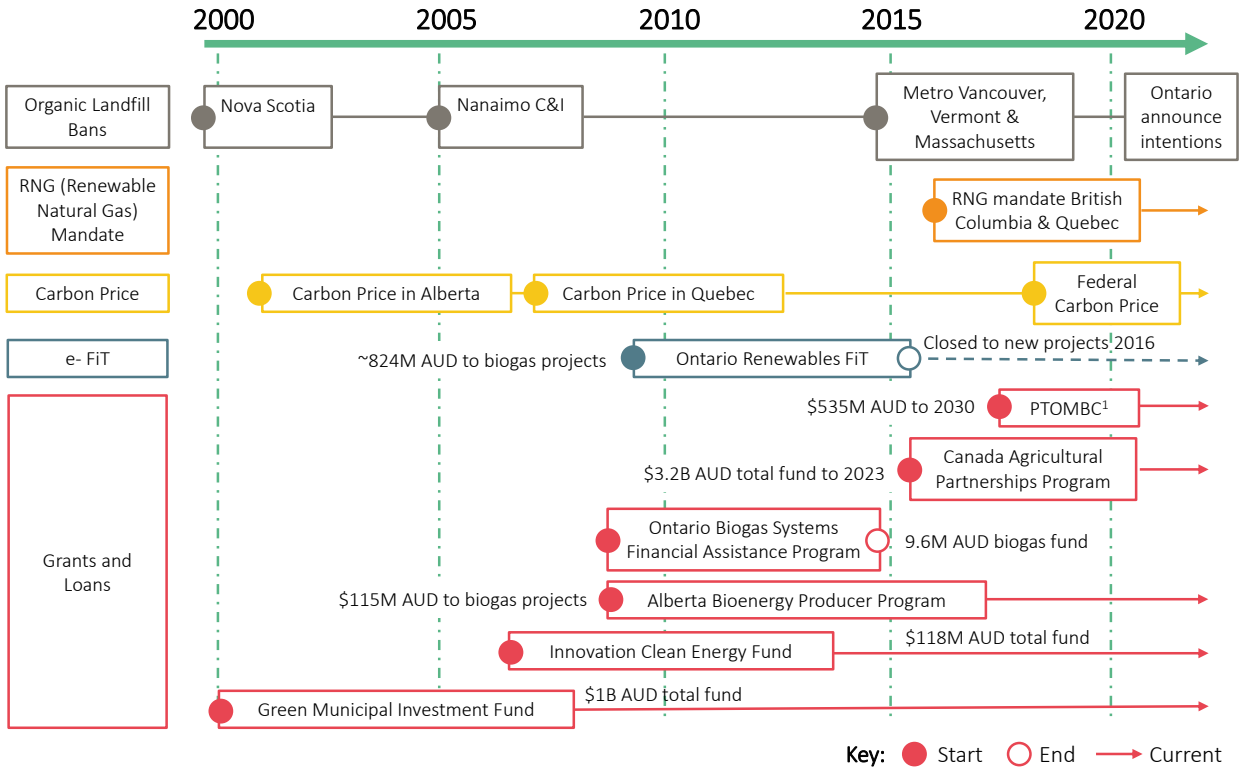
Figure 3-4 – Summary of Canada's biogas feedstock composition and production in 2020 and 2030 (Sources: [7]).



Biogas consumption in Canada is now driven by policies supporting organic waste management and decarbonisation of gas uses

In Canada, interest in biogas production has been driven by climate change mitigation measures, such as carbon pricing (first implemented in 2001) and renewable fuel mandates (first implemented in 2016), as well as restrictions on the landfilling of organic matter (first implemented in 1999). An overview of the biogas policy timeline in Canada is provided in Figure 3-5.

Figure 3-5 - Timeline of key policies affecting Canada's biogas sector.[5]



Canada has implemented a range of policy packages including biogas infrastructure grants and loans (since 2000), biogas electricity FiT (since 2009) and a federal carbon subsidy on biogas (since 2018). Since 2009, Ontario launched its electricity FiT program to support the development of biogas and other renewable energy projects. The FiT, in conjunction with a biogas grants and loan program, were effective in the development of biogas plants. As a result, over 50% of Canadian biogas plants are located in the Ontario province.

Since the end of the FiT program in 2016, there is a greater focus on the Renewable Natural Gas (RNG) market. RNG blending mandates were introduced in 2018 for British Columbia (15% by 2030) and in 2019 for Quebec (5% by 2025). These provinces are expected to drive biogas growth in Canada moving forward [15].

Some funding programs exist to support anaerobic digestion projects, on a regional, provincial and federal level [5]. Most of these funds are not specifically dedicated to biogas but to climate change, agriculture and/or waste management. There is a focus on agricultural feedstocks for biogas production with grants programs, such as the $3.2B AUD Canada Agricultural Partnerships Program.

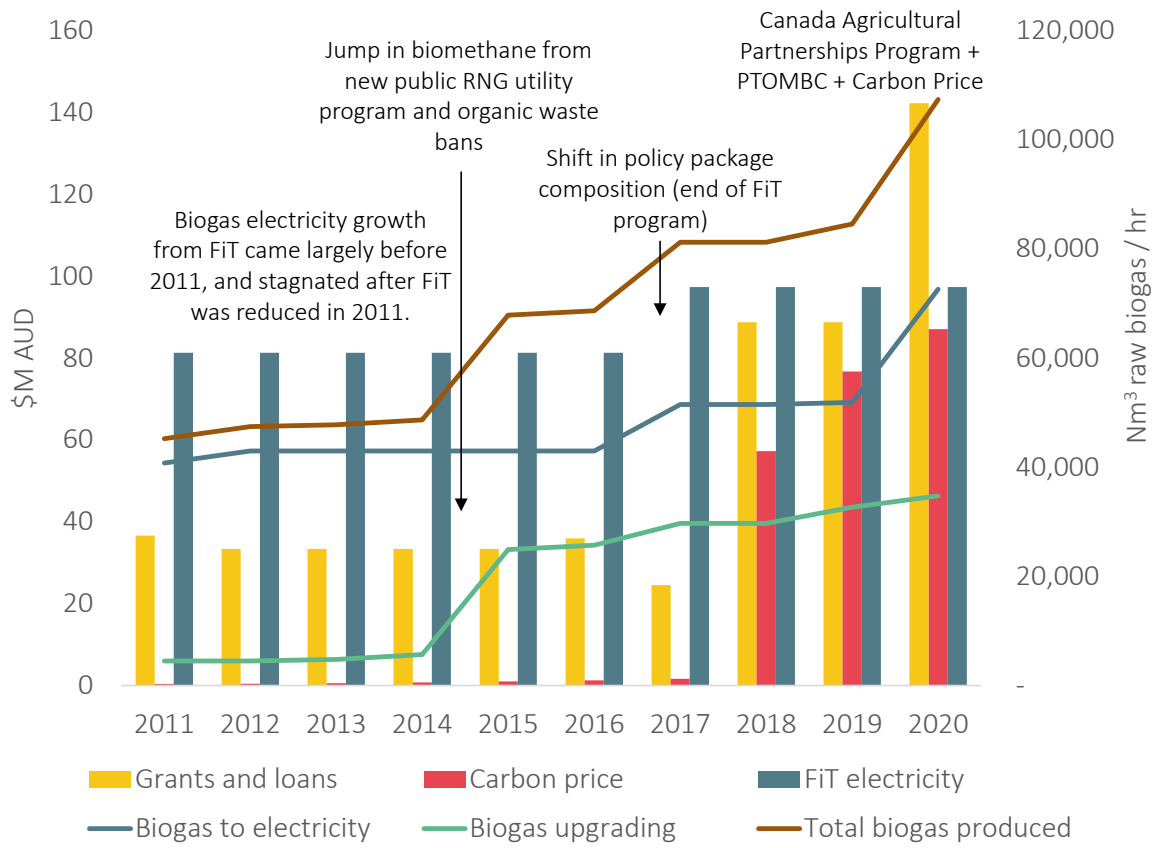
Lastly, Canada also has legislation around the storage, transport and processing of digestate. This includes standards around heavy metal concentration, pathogen concentration and physical contaminants. There are also guidelines around applying digestate to land and integrating digestate into a farm's nutrient management strategy [18].

[5] PTOMBC: Program for Processing Organic Matter using Biomethanisation and Composting.

Canada managed to maintain similar growth rates before 2017 (driven by electricity FiT) and after 2017 (driven by grants)

The CAGR under the first policy package (2011-2017) was 10.2% while the CAGR of the second policy (2017-2020) was 9.8%. This demonstrates Canada's ability to maintain similar growth rates after transitioning away from a FiT dependant biogas sector. Meanwhile, biomethane capacity grew from 10% to 32% of Canada's biogas supply over the past decade and is expected to grow further in Canada due to the RNG mandates in British Columbia and Quebec.

Figure 3-6 - Canada's biogas sector growth from 2011-2020 and policy support ([13], [14]).



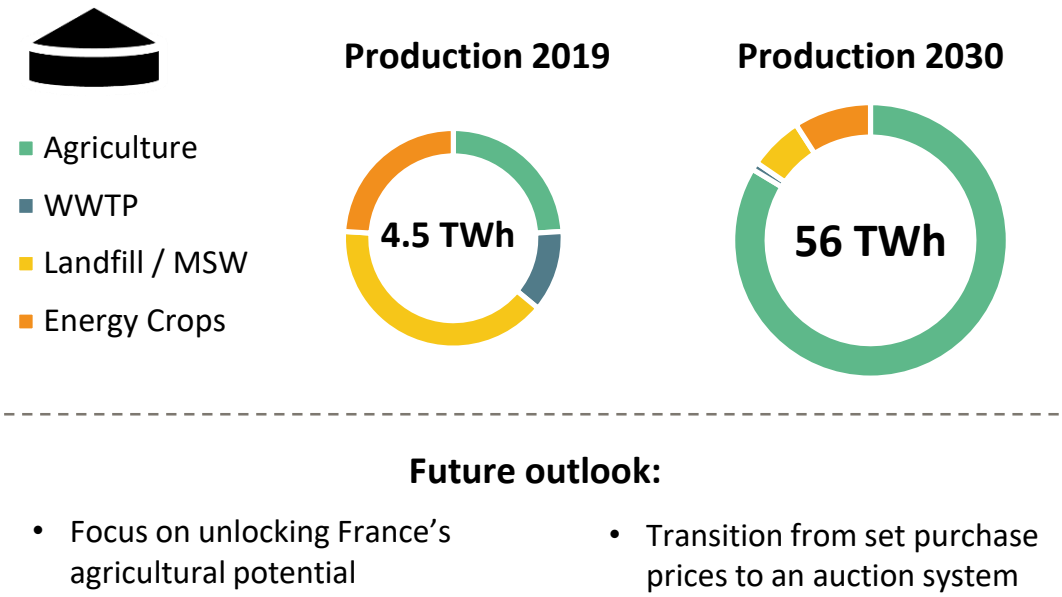
A total of $1.4B AUD has been dedicated to Canada's biogas sector from 2011-2019 with the cost of the new biogas capacity being $30k AUD / ($Nm^3$ raw biogas/hr) (see Figure 3-6). Overall, the biogas sector grew at a CAGR of 10.1% during this period. 1,433 new jobs created from developing the biogas sector from 2011-2019 and 10.7 million tonnes CO2-e will be abated from biogas production capacity developed during this period.

3.1.3 France

France's biogas sector was fuelled mainly by landfill / MSW waste in 2019, but forecasted to be fuelled mainly by agricultural residues by 2030

A summary of the France's biogas feedstock mix and production, both in 2019 and forecasted for 2030, is provided in Figure 3-7. Landfill made up a large portion of France's 2019 biogas production due to the legal requirement for landfills to capture methane emissions. Intermediate crops for energy purposes are also key driver for the biogas industry in France which is why agricultural residues were the second highest feedstock in 2019. Recent growth in biogas has been driven by agricultural biomethane production with over 75% of all biomethane plants owned by small farmers. By 2030, approximately 80% of France's biogas sector is forecasted to be fuelled by agricultural residues.

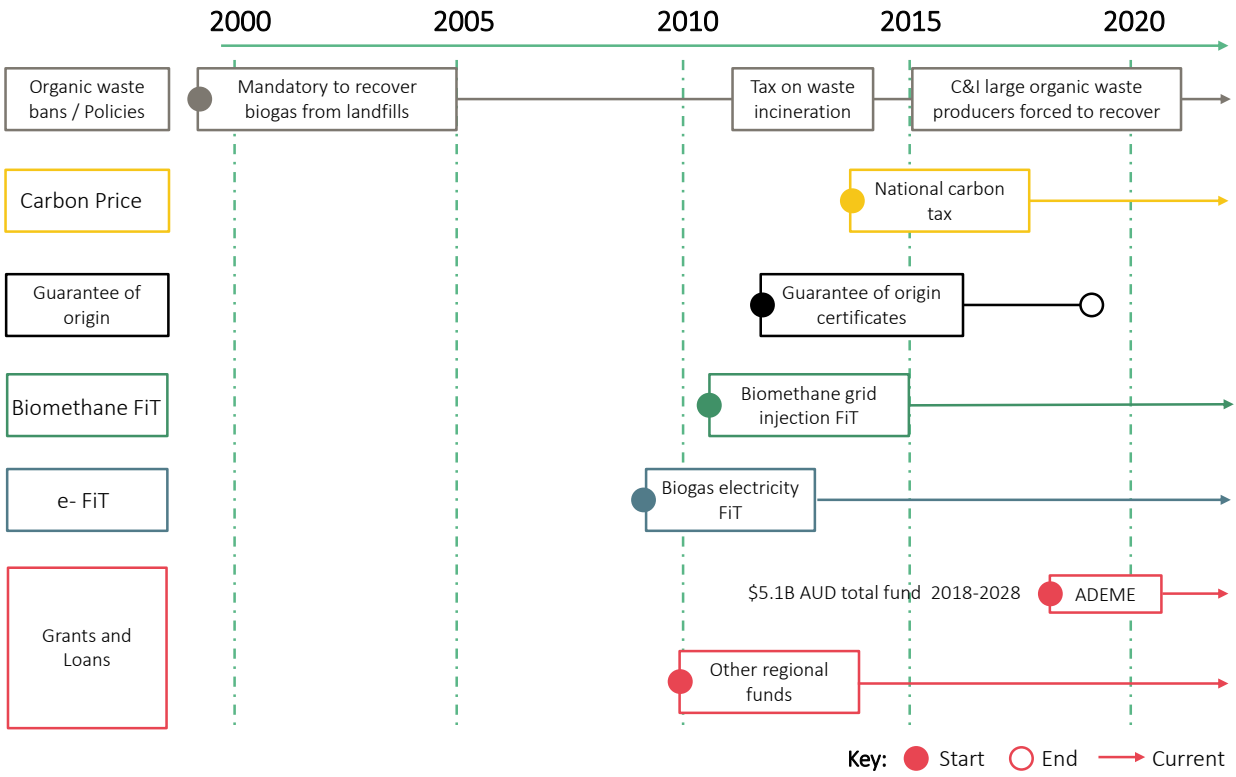
Figure 3-7 – Summary of France's biogas feedstock composition and production in 2019 and 2030 (Sources: [7]).



France's policy support to biogas has shifted from electricity to biomethane production in the past decade

In 2009, the French government introduced FiTs for electricity export to grid and in 2011 FiTs for biomethane injection into the gas grid. A Guarantees of Origin scheme was launched in 2012 to ensure the traceability of biomethane and provide complimentary revenues to producers. An overview of the biogas policy timeline in France is provided in Figure 3-8.

Figure 3-8 – Timeline of key policies affecting France's biogas sector.



While landfill biogas plants dominate France's biogas sector, the use of agricultural residues as feedstocks has been experiencing stronger growth recently. A bonus for the use of manure and other agricultural feedstocks was announced in 2016 to target the use of biogas in the agricultural sector and provide additional revenue to farmers. In 2017, restrictions on energy crops used for feedstock in biogas production were implemented in the form of a 15% cap. Digestate is formally recognized as a fertilizer for agricultural use.

Additional support to the development of the biogas industry in France included:

- the setting of national targets for the development of biogas plants and on the consumption of renewable gas
- investment support in the form of capital grants and soft loans from the National Energy Agency (ADEME), regional councils, and the European Union (FEDER)
- a national carbon tax implemented in 2014 which acts as an indirect subsidy to biogas plants by making carbon substitutes more expensive

Currently, 88% of biogas is used for CHP and less than 12% upgraded to biomethane. However, biomethane is expected to further increase due to national targets and the FiT which were first implemented in 2011. In addition, in 2022, France will launch a biomethane certificate scheme that can also be used in the LNG market.

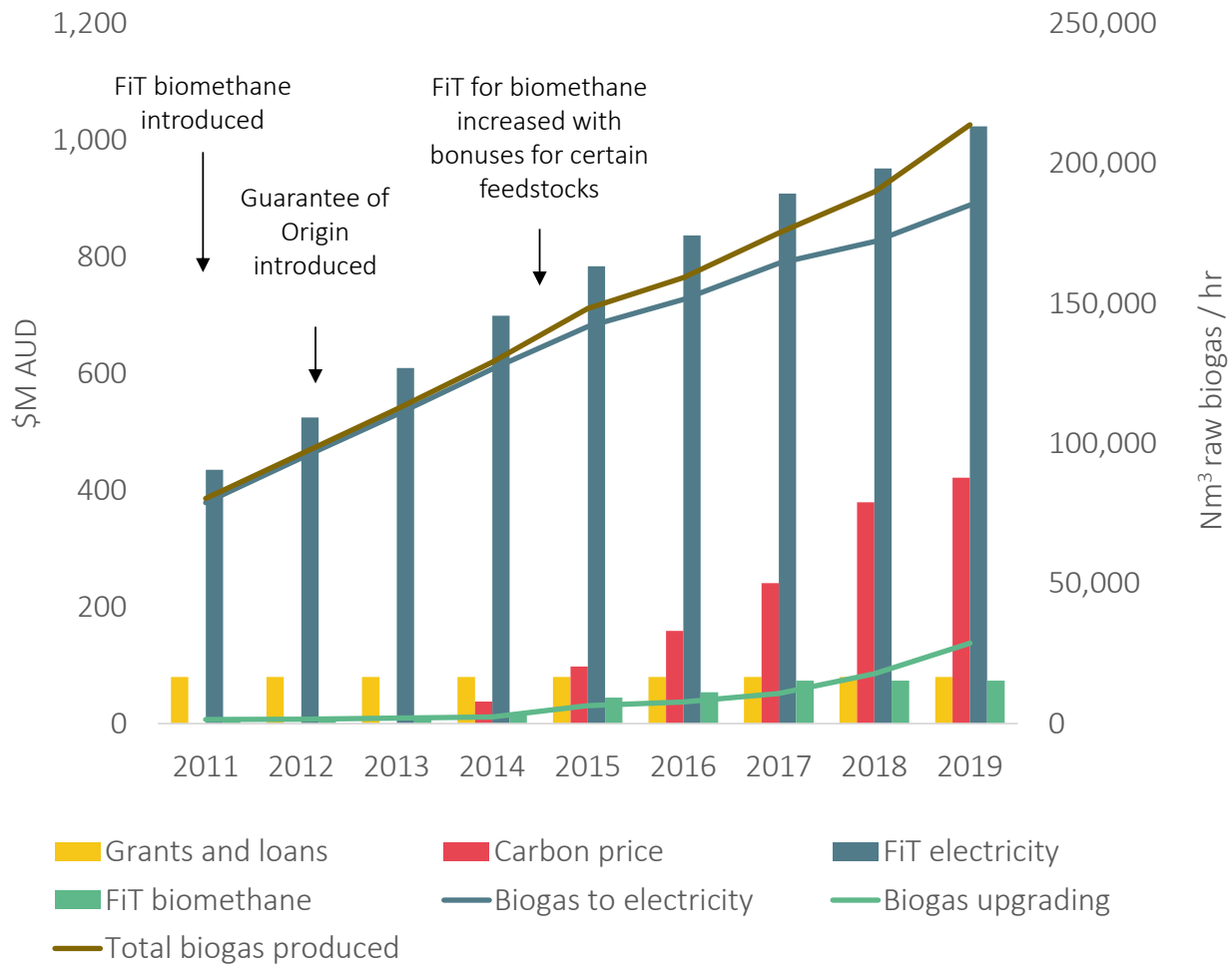
Lastly, France also has legislation around the storage, transport and processing of digestate and is part of the 'EU Quality Assurance Scheme for Compost and Digestate'. This includes standards around heavy metal concentration, pathogen concentration and physical contaminants [19].

France's biogas sector has grown steadily driven mainly by the electricity FiT and more recently by the biomethane FiT

Over 90% of total growth attributed to biogas electricity production which was driven by France's electricity FiT. The most recent trend if the shift in focus from biogas electricity production to biomethane upgrading as a result of the biomethane FiT being more profitable for project developers compared to the biogas electricity FiT. Although the FiT for biomethane was announced in 2011, the sector only began rapidly growing after 2014,

as this represented the project development period for the first biomethane projects in France. It must be noted that, to encourage the development of a cost-competitive biogas industry, France has set up a progressive reduction of its FiT (by 2% per annum).

Figure 3-9 – France's biogas sector growth from 2011-2019 and policy support ([13], [14]).



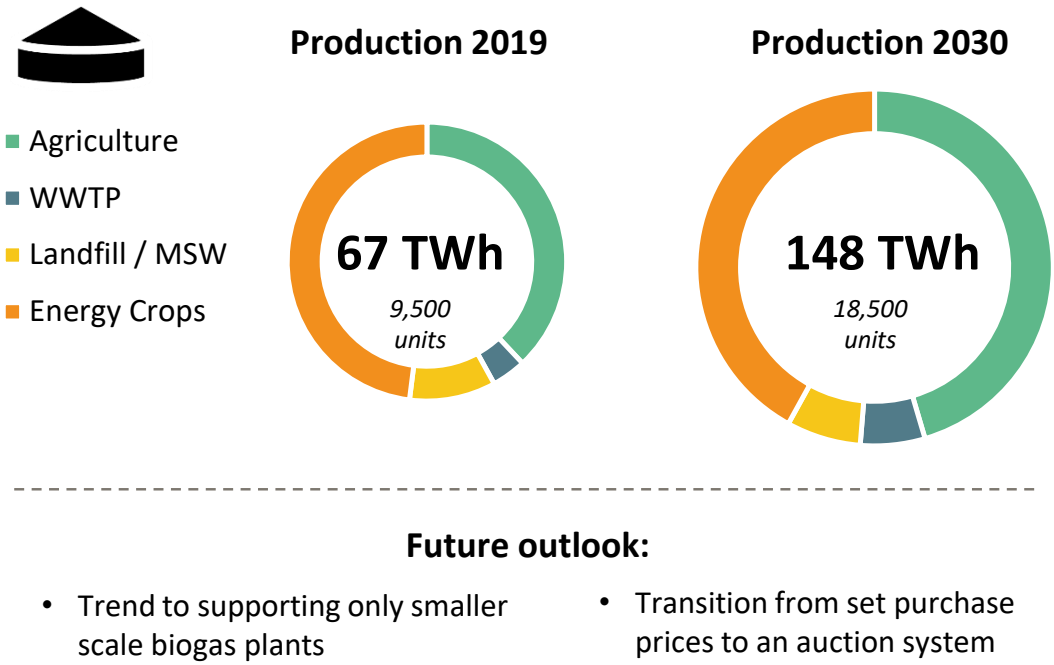
Since 2014, the biomethane capacity in France has grown at a CAGR of 66% in response to the FiT. A total of $7.8B AUD has been dedicated to France's biogas sector from 2011-2019 with the cost of the new biogas capacity being $115k AUD / ($Nm^3$ raw biogas/hr) (Figure 3-9). Overall, the biogas sector grew at a CAGR of 11% during this period. 2,466 new jobs created from developing the biogas sector from 2011-2019 and 32.8 million tonnes CO_2 e will be abated from biogas production capacity developed during this period.

3.1.4 Germany

Energy crops fuelled the majority of German biogas plants in 2019, with agricultural residues to become the dominant feedstock by 2030

A summary of the Germany's biogas feedstock mix and production, both in 2019 and forecasted for 2030, is provided in Figure 3-10. While new FiT contracts don't incentivise energy crops for biogas production anymore, almost half the biogas plants in Germany used energy crops in 2019 due to the previously high bonuses for using this as a feedstock for biogas production. Agricultural residues are expected to be the most widely used feedstock by 2030 due to the higher FiT incentives for their use in biogas production.

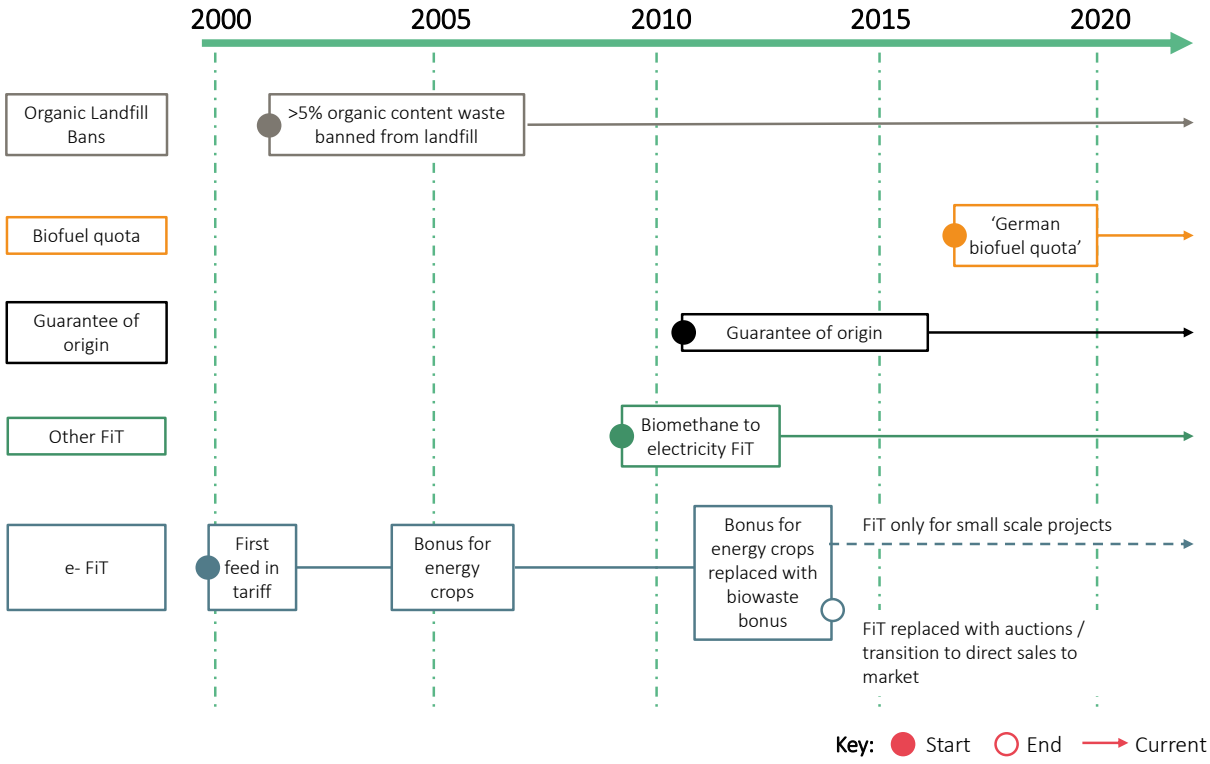
Figure 3-10 – Summary of Germany's biogas feedstock composition and production in 2019 and 2030 (Sources: [7]).



Germany has supported most of its biogas sector growth through electricity FiTs

Germany has approximately half the total biogas plants in Europe with approximately 9,500 operating today. Germany's historic 'biogas boom' was driven by an attractive FiT in 2004 with bonuses for the use of energy crops. The German government considered the FiTs alone to be sufficient for viable economic operation of biogas plants. The FiTs would be tweaked with bonuses to target certain feedstocks (e.g., MSW and manure replaced the energy crop bonus in 2012. FiT amount adjusted up and down in response to desired development rate. An overview of the biogas policy timeline in Germany is provided in Figure 3-11.

Figure 3-11 - Timeline of key policies affecting Germany's biogas sector.



In 2011, Germany announced its plan to remove nuclear energy from its generation mix. More recently, Germany has set ambitious renewable energy targets of 40-45% by 2025, 55-60% by 2035, and 80% by 2050.

The Renewable Energy Sources Act (EEG) (2000, amendments in 2004, 2009, 2012, 2014, and 2017) leads the transition of the German energy sector. Under the EEG 2000, electricity FiTs were introduced, and in 2002, landfilling waste with an organic content matter of more than 5% was prohibited. Between 2004 and 2012, a specific bonus within the FiT scheme existed for the use of energy crops. It was then replaced by a bonus for the use of organic waste residues, with the highest bonus being from agricultural residues. From 2009 to 2014, a biogas upgrading bonus within the FiTs was available and boosted biomethane injection in the gas grid. After 2014, investments in biogas upgrading slowed down significantly.

In 2014, the FiTs started being gradually replaced by direct sales on the electricity market, with contract-for-difference in place to facilitate transition. Then, the EEG 2017 introduced an auction model to encourage competition (and subsequently cost reduction) and replace FiTs. Additionally, between 2011 and 2019, several guarantees of origin and certificates have been introduced to ensure traceability of biogas and biomethane.

The 2014 and 2017 amendments to the EEG, the replacement of several FiTs schemes, the introduction of the auction scheme, and the restrictions implemented on energy crops has caused biogas growth to slow compared to the "biogas boom" which occurred from 2000-2014.

There is a shift towards biogas plants operating flexibly today to provide grid stability and targeted incentives are expected to be implemented soon.

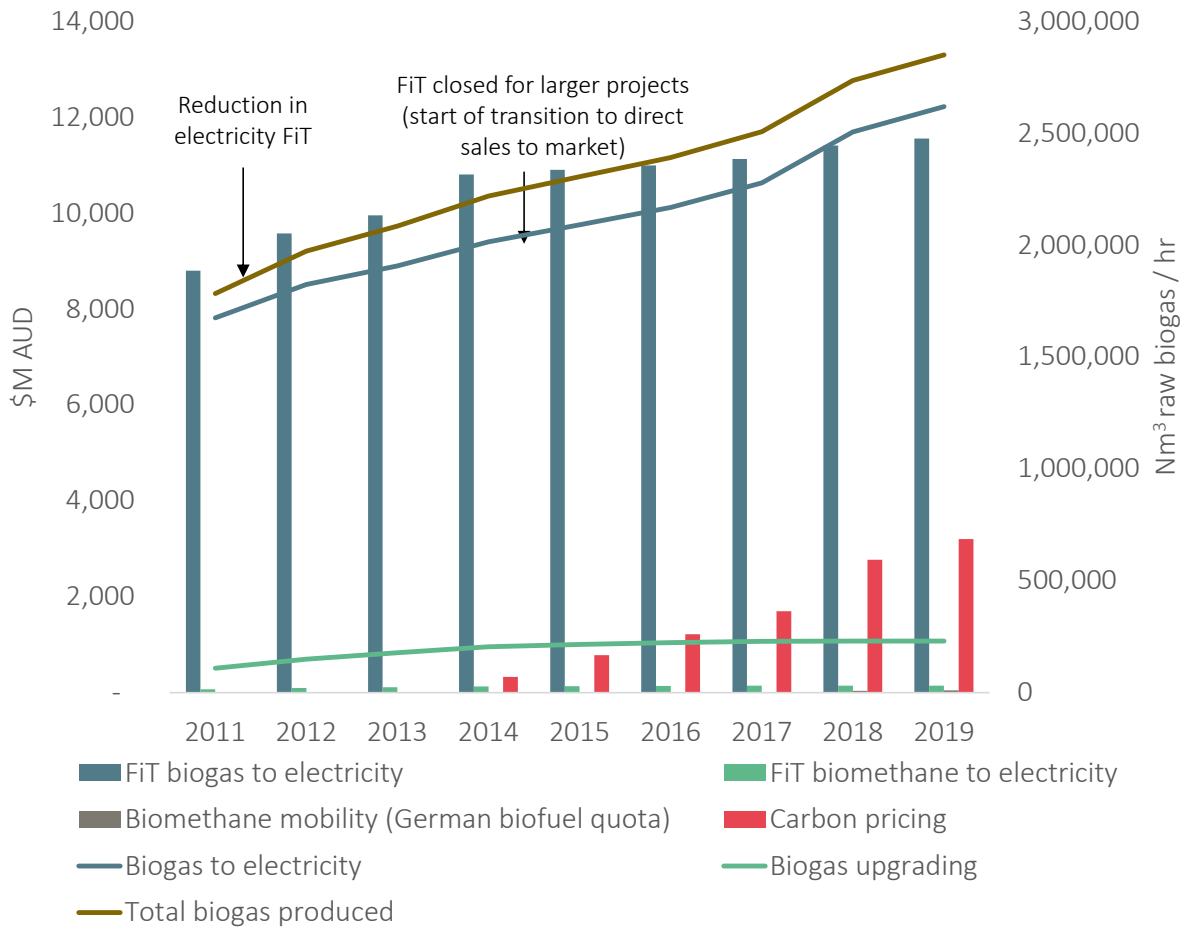
Lastly, Germany also has legislation around the storage, transport and processing of digestate and is part of the 'EU Quality Assurance Scheme for Compost and Digestate'. This includes standards around heavy metal concentration, pathogen concentration and physical contaminants [19].

Germany's biogas to electricity capacity continued to grow as it transitioned from FiTs to direct sales to market

Germany's biogas sector growth was mainly driven by its electricity FiT. The majority of Germany's biogas growth occurred between 2004-2012 where there were more attractive FiTs including bonuses for using energy crops. Despite the drop-in FiT support for larger projects in 2014, 90% of new projects since then have been smaller biogas projects (<100kW) mainly from the agricultural sector that use the FiT. The remaining capacity are larger projects that operate without FiT support either on an auction-based system or through direct sales to the electricity market, as Germany begins its transition away from a FiT reliant industry to more market exposed mechanisms.

Germany supports biomethane indirectly, through a tariff for converting biomethane into electricity via CHP (grid stability and closer to heat users) and a quota for vehicle fuels. Over 90% of biomethane is used for CHP generation, as agricultural producers of biogas tend to not require large amounts of heat. The incentive aims to separate the generation of biogas and its consumption to industrial heat users in industrial areas instead. Despite this, biomethane capacity growth has stagnated since 2014 under these policies.

Figure 3-12 – Germany's biogas sector growth from 2011-2019 and policy support ([13], [14]).



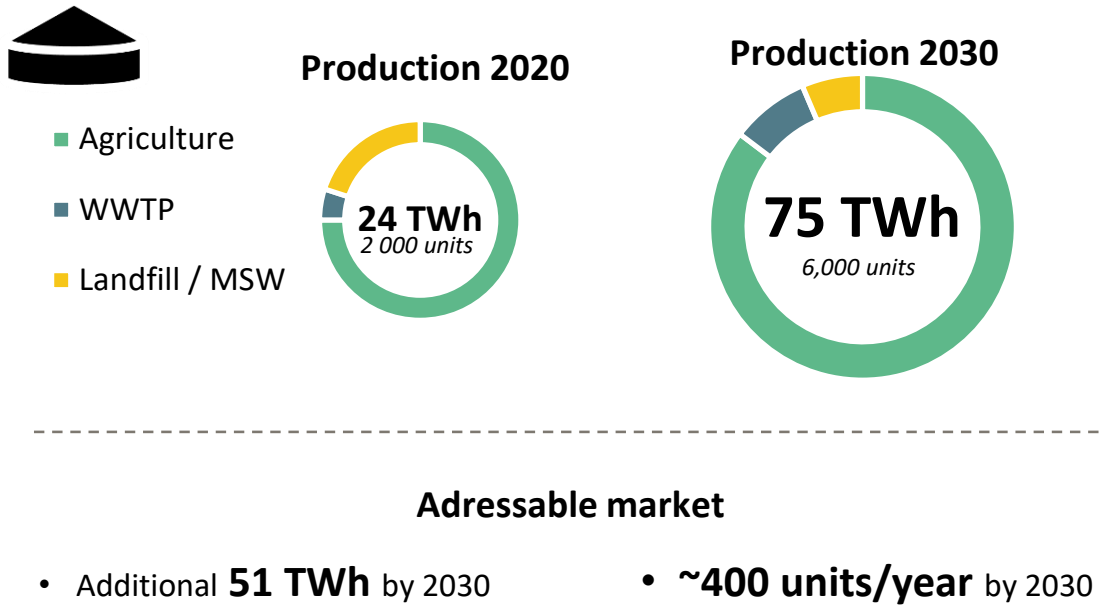
A total of $108B AUD has been dedicated to Germany's biogas sector from 2011-2019 with the cost of the new biogas capacity being $85k AUD / ($Nm^3$ raw biogas/hr) (Figure 3-12). Overall, the biogas sector grew at a CAGR of 5% during this period. 23,607 new jobs created from developing the biogas sector from 2011-2020 and 303 million tonnes CO_2 e will be abated from biogas production capacity developed during this period.

3.1.5 Italy

Italy's biogas production was largely driven by agricultural residues in 2019 and this is forecasted to continue to 2030

A summary of the Italy's biogas feedstock mix and production, both in 2019 and forecasted for 2030, is provided in Figure 3-13. Agricultural residues have been targeted through the use of higher electricity FiT rates in Italy.

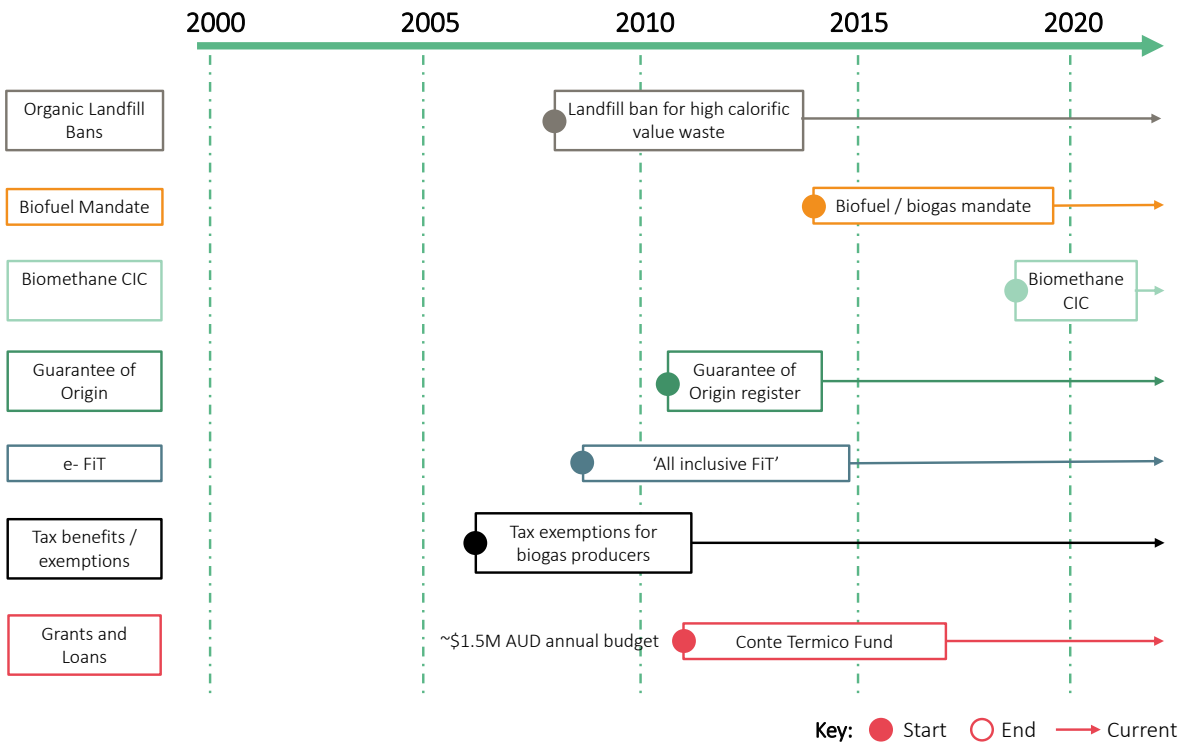
Figure 3-13 - Summary of Italy's biogas feedstock composition and production in 2020 and 2030 (Sources: [7]).



The Italian biogas market is currently driven by the use of biomethane for the transport sector

An overview of the biogas policy timeline in Italy is provided in Figure 3-14.

Figure 3-14 – Timeline of key policies affecting Italy's biogas sector.



In 2008, the "all inclusive" FiTs were granted to biogas plants with an electric nameplate power in the range 1-1000kW. As a result, the majority of Italy's biogas plants were built in the period of 2008-2012 during a highly attractive FiT for renewable electricity (450 AUD / MWh_e), after which the FiT was reduced by 40%. The 2012 FER Decree also changed the conditions of the FiTs with rates dependant on the kind of feedstock used. This resulted in a reduction in the number of new plants in 2013.

Since 2012, capital grants for renewable energy (including biogas) under the Heating and Cooling Support Scheme (Conto Termico) were established. The Conto Termico was revised and extended in 2016 and has had an average annual budget of $1.5M AUD since its inception.

Italy now issues certificates (CIC) for biomethane grid injection targeting mobility. These certificates are linked to the national biofuel mandate. The recent support for biomethane for mobility since 2017 has driven significant growth (~35% CAGR in biogas upgrading capacity from 2018-2020).

Additional support to the development of the biogas industry in Italy included:

- tax exemptions being granted to biogas generators in 2007
- guarantees of Origin (GO) implemented in 2011, under the European Union EECS scheme
- a land fill bans on high calorific value organic waste since 2007

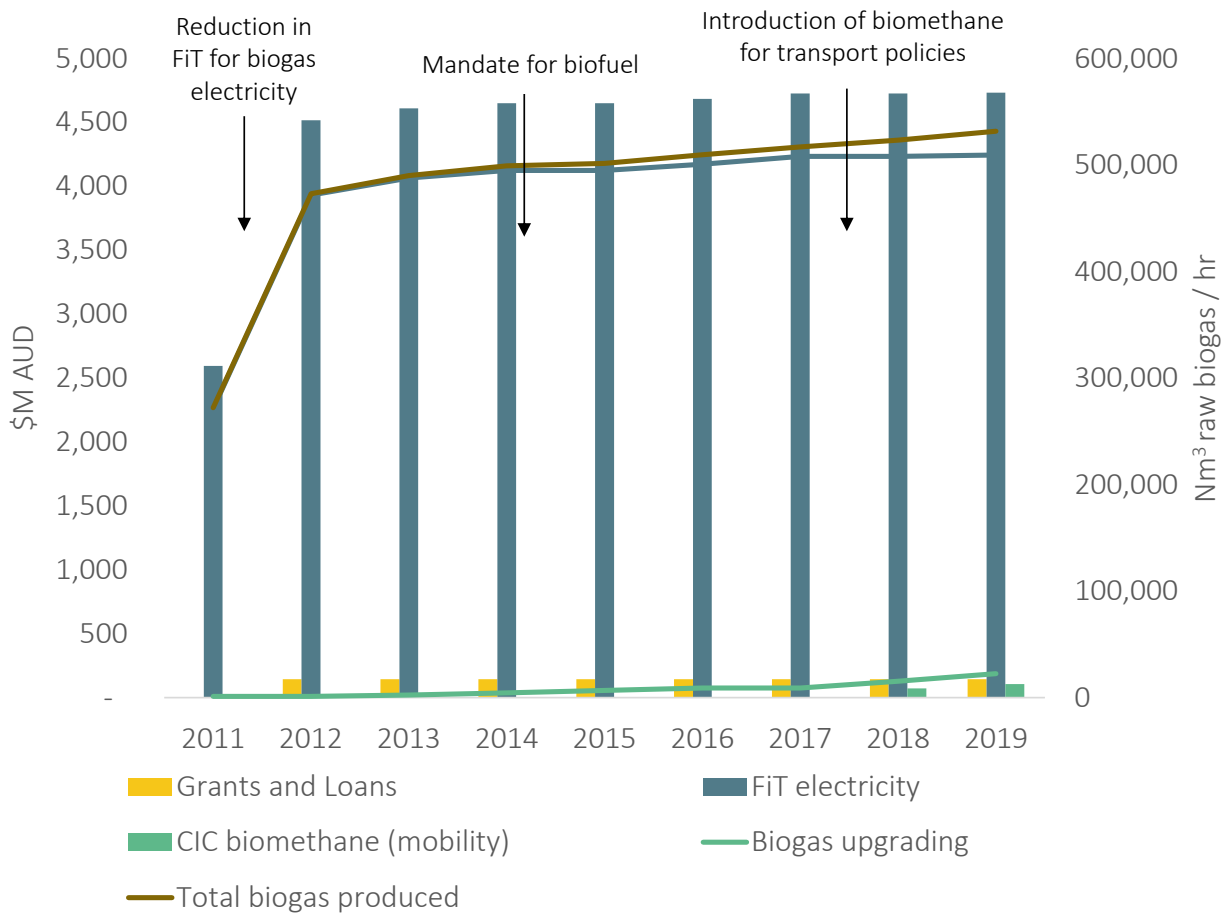
Lastly, Italy also has legislation around the storage, transport and processing of digestate and is part of the 'EU Quality Assurance Scheme for Compost and Digestate'. This includes standards around heavy metal concentration, pathogen concentration and physical contaminants [19].

Italy aggressively supported biogas electricity until 2012 and has since switched to focusing on biomethane for transport

An overview of the growth of Italy's biogas sector is provided in Figure 3-15 highlighting the key figures and changes in policy support amount and type. A total of $41B AUD has been dedicated to Italy's biogas sector from 2011-2019 with the cost of the new biogas capacity being $169k AUD / ($Nm^3$ raw biogas/hr). Overall, the biogas sector grew at a CAGR of 8% during this period with the majority of growth occurring in 2011-2012 before a reduction in electricity FiT rate. Over 83% of total growth is attributed to biogas electricity production.

Recent biogas production growth has come from biomethane. Biomethane capacity has increased 180% from 2018 to 2021, since the implementation of a biomethane certificate system targeting the transport sector. The certificate system is linked to an 8% biofuel mandate with certificates worth ~ 98 AUD/MWh_{th}. Despite being the fastest growing segment of the biogas sector recently, biomethane only represents 4% of total biogas production capacity in Italy.

Figure 3-15 – Italy's biogas sector growth from 2011-2019 and policy support (Sources: [13], [14]).



5,554 new jobs created from developing the biogas sector from 2011-2019 and 102.7 million tonnes CO2 e will be abated from biogas production capacity developed during this period.

3.2 Global biogas policy comparison

The aim of this section is to benchmark the different jurisdictions' biogas policies based on the metrics outlined in Section 2. A summary of the results of the benchmark are shown in Table 3-1 with further analysis of each aspect of the analysis framework in following sub sections.

From comparative analysis it was found that the most effective biogas development was driven by FiTs (such as in Germany, Italy and France) but this growth was more expensive. Meanwhile, the most cost-efficient growth was driven by grants and loans (such as in California and Canada), however this resulted limited effectiveness in growing biogas capacity. Germany had the highest job creation and GHG abatement which was driven by the largest absolute size of biogas capacity added from 2011 to 2019. California had the most efficient GHG abatement through targeting dairy manure as a feedstock. All five jurisdictions had legislation on the treatment and storage of digestate including safety standards (such as maximum heavy metal, pathogen or physical contaminant concentrations).

Table 3-1 – Summary table of comparative analysis results.[6]

	Canada	Italy	Germany	France	California
Policy package	Previously electricity FiT. Currently grants, loans, carbon credits and mandates	Previously electricity FiT Currently biomethane certificates for transport.	Previously electricity FiT. Currently transitioning to free market auctions for electricity.	Electricity and biomethane FiTs. Currently focused on biomethane FiT.	Previously electricity FiT. Currently grants, loans, carbon credits and mandates.
Growth achieved (CAGR)	7% total 3% electricity 25% upgrading	8% total 7% electricity 40% upgrading	5% total 5% electricity 9% upgrading	11% total 10% electricity 39% upgrading	5% total 3% electricity 18% upgrading
Growth achieved (absolute)	39,299 (m3/hr)	259,540 (m3/hr)	1,065,507 (m3/hr)	133,554 (m3/hr)	66,842 (m3/hr)
Cost efficiency	$30k / (m3/hr)	$169k / (m3/hr)	$49k / (m3/hr)	$115k / (m3/hr)	$16k / (m3/hr)
Jobs created	1,433	5,554	23,607	2,466	1,877
GHG abated	11 $MTCO_2$-e	109 $MTCO_2$-e	303 $MTCO_2$-e	33 $MTCO_2$-e	14 $MTCO_2$-e
Feedstock targeted with extra incentives / support					
Main end use currently targeted					

Key: CHP, Ag. waste, MSW, Wastewater, C&I, Grid injection, Transport

[6] See Appendix 4 for full legend.

3.2.1 Effectiveness of jurisdictions' biogas policies

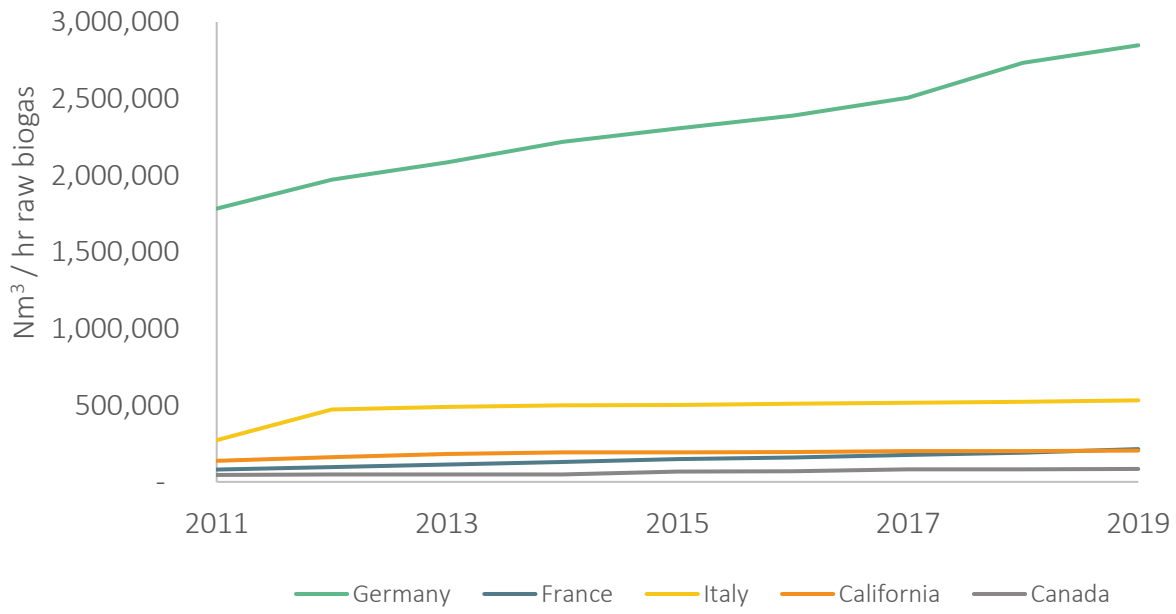
3.2.1.1 Biogas sector growth

Germany's mature biogas industry continues to grow and is 5-50 times larger than the other jurisdictions' biogas sectors

Germany's mature biogas industry is 5-50 times larger than the other jurisdictions' biogas sectors. Germany's absolute growth in biogas capacity was greater than any other jurisdiction, driven mainly by its electricity FiT (Figure 3-16). The German biogas sector continues to grow showing its ability to sustain itself after maturing with government support despite lowering FiT support in 2014.

Italy has the second biggest biogas sector (5 times smaller than Germany), and its growth was also driven by a strong electricity FiT but stagnated after the reduction of the FiT amount in 2012. From the period of 2011 to 2019, the only change in rankings between the five jurisdictions was that France's biogas production capacity overtook that of California's. Meanwhile, Canada had the smallest biogas capacity which is partially due to this jurisdiction having the smallest population and abundance of other renewables (such as hydropower).

Figure 3-16 - Biogas production absolute capacity growth 2011 – 2019 (Sources: [13], [14]).

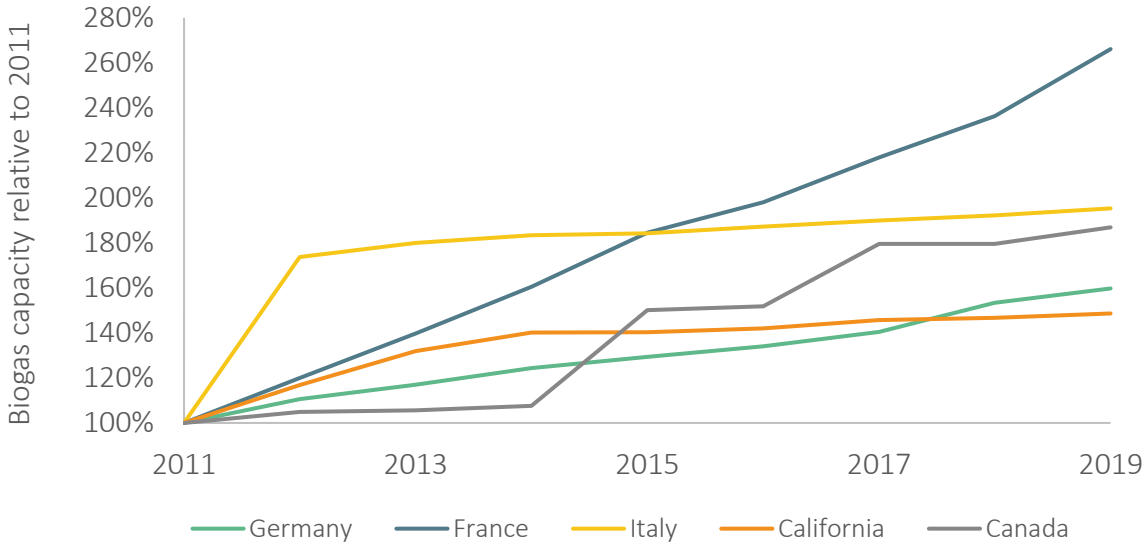


France had the most effective policy package of all jurisdictions for driving the overall biogas relative growth

France had the most effective policy package as it grew the most relative to its 2011 capacity which was driven by an electricity FiT and by its biomethane FiT (Figure 3-17). Meanwhile, Italy's and California's stagnated biogas capacity growth corresponds to the reduction of their previously high electricity FiT.

Canada's intermittent growth correlates with the several different policy milestones such as the launch of a public utility RNG program, RNG mandates, electricity FiT deadline date and increased grants and loans support for agricultural biogas plants.

Figure 3-17 - Biogas production capacity relative to 2011 (Sources: [13], [14]).

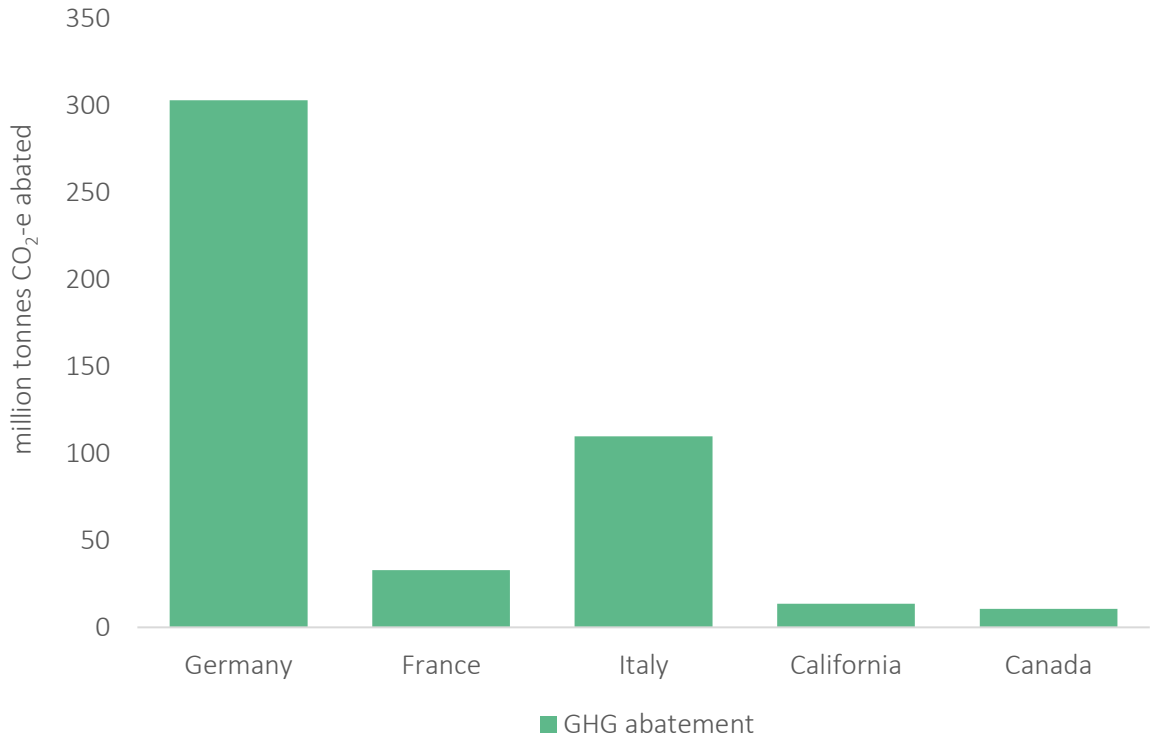


3.2.1.2 GHG abatement

Germany abated the most carbon which was driven by the absolute size of its biogas capacity growth

GHG abatement is an important metric for any jurisdictions attempting to meet their climate related goals. While jurisdiction specific factors, such as electricity grid emission factors, affect the amount of GHG abated, the results of total GHG abated (Figure 3-18) follow the same ranking as absolute biogas capacity achieved (Table 3-1). Germany had the highest GHG abatement due to having the largest amount of new biogas capacity. California and Canada had the smallest absolute GHG abatement due to the smaller size of their biogas sectors.

Figure 3-18 – Absolute GHG abatement from biogas capacity added 2011-2019 (Sources: [13], [14], [16], [17], [18], [19], [20]).

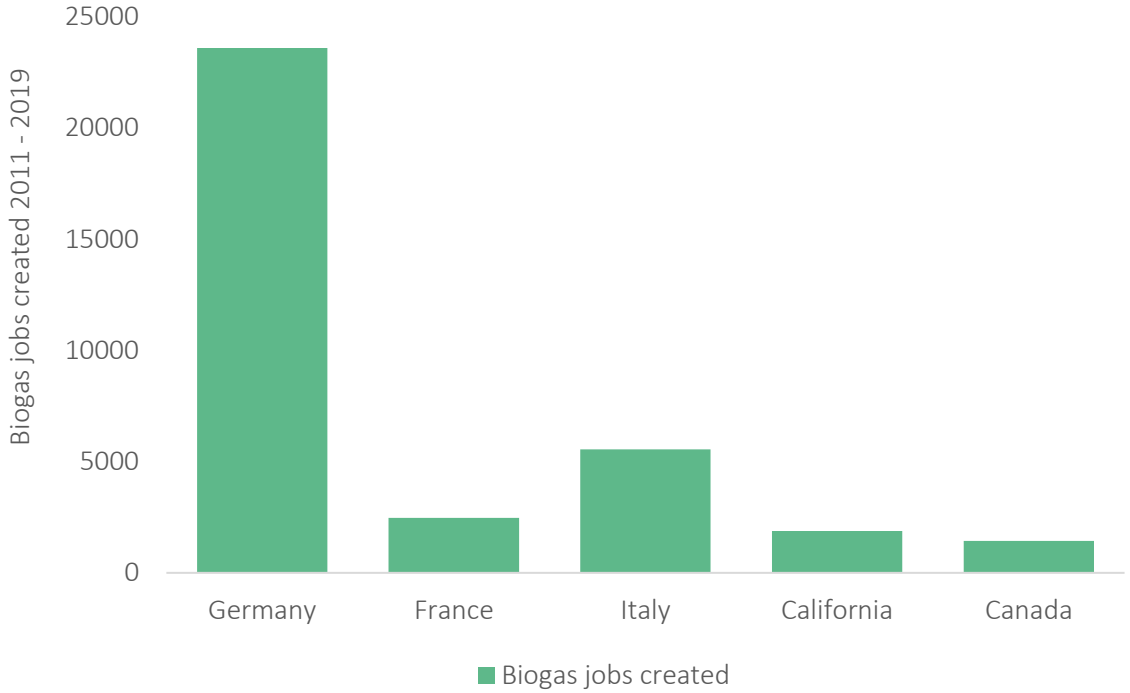


3.2.1.3 Job creation

Germany created the most jobs due to the size of its growth

Job creation is an important economic metric related to creating opportunities for local citizens and residents. Similar to GHG abatement, the results of total biogas jobs created abated (Figure 3-19) follow the same ranking as absolute biogas capacity achieved (Table 3-1). Germany created the most jobs due to it building the highest amount of new biogas capacity between 2011 – 2019 with currently ~47,000 biogas jobs (as of 2021) in total across the country [21]. California and Canada had the smallest absolute job creation due to the smaller size of their biogas sectors.

Figure 3-19 – Absolute job creation from biogas capacity added 2011-2019 (Sources: [3], [13], [14]).



3.2.2 Cost efficiency of jurisdictions' biogas policies

3.2.2.1 Biogas sector growth

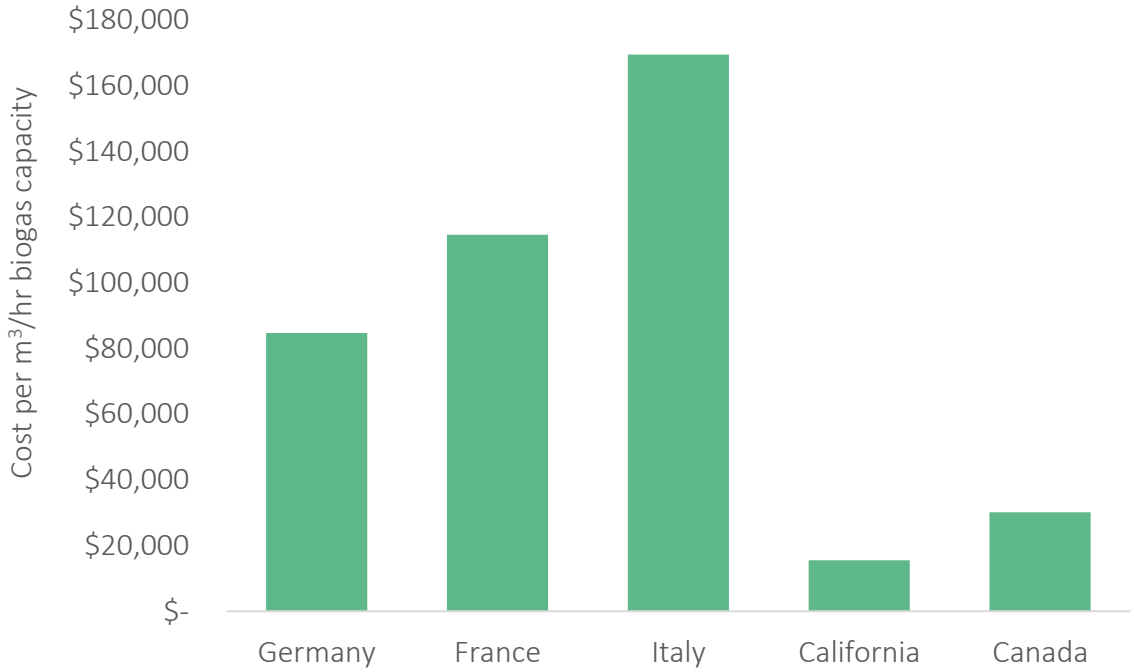
While attractive FiTs led to the most growth, they were the least cost-efficient policy across the five jurisdictions

The cost efficiency of biogas capacity was calculated (see Section 2.3 for methodology) to assess how much economic support the achieved biogas capacity required. This metric allows us to compare which jurisdictions grew their biogas sectors with the minimum input.

Italy, France and Germany had the least cost efficiency biogas growth (Figure 3-20). The majority these jurisdiction' cost comes from funding the electricity FiT for a period of 15-20 years (>85% for all 3 countries). Italy has had the most aggressive feed in tariff (450 AUD/MWh_e) during the 2011-2019 period while France and Germany were ~230 -280 AUD/MWh_e. While these countries had high CAGRs (or in Germany's case, absolute growth), they had the most expensive biogas capacity growth.

Despite being less effective in growing the sector, both California and Canada were the most cost efficient with newly added biogas capacity, which was driven mainly by capital grants and loans. California and Canada's electricity FiT were / are much lower compared to the other jurisdictions at 135 - 147 AUD/MWh_e. Instead, these jurisdictions targeted agriculture and biomethane injection with grants and loans instead.

Figure 3-20 - Cost efficiency of biogas capacity growth 2011-2019 (Sources: [13], [14]).



3.2.2.2 GHG abatement

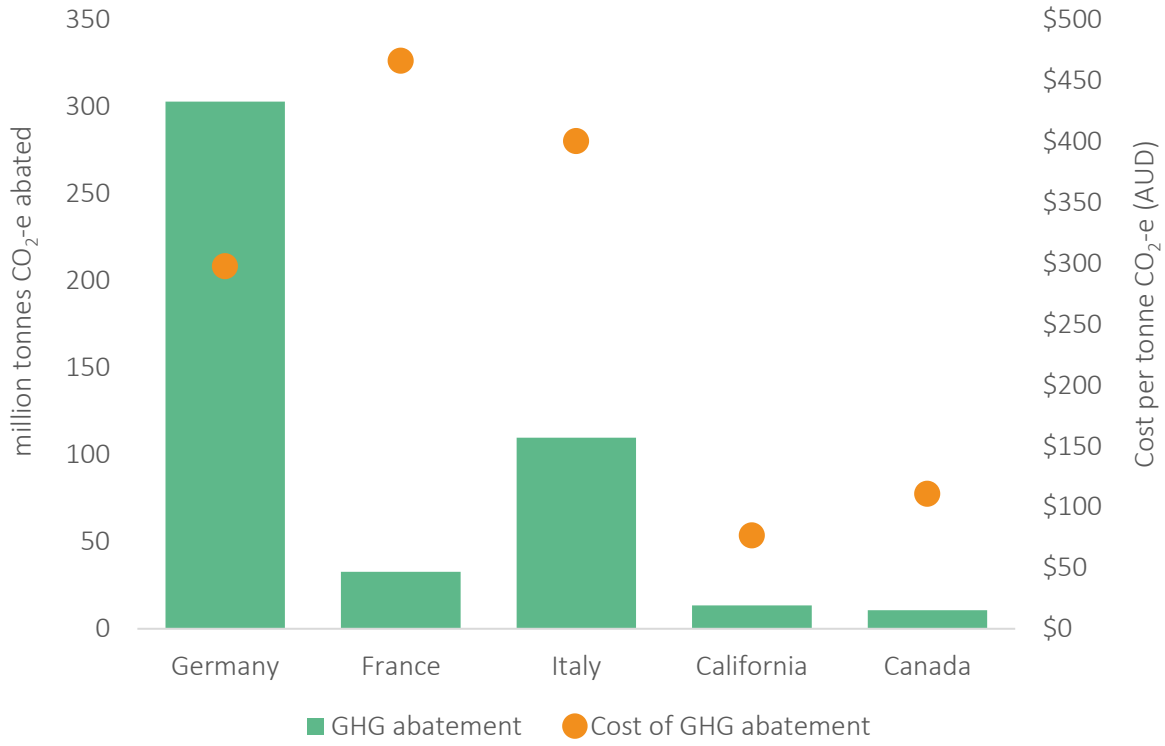
California's least expensive GHG abatement was driven by an efficient biogas capacity growth and by targeting high emission feedstock

In the context of the energy transition, finding cost efficient ways to abate GHG is important. The most cost efficient GHG abatement strategies for biogas production have been determined through comparing this metric between the jurisdictions.

California had the most cost efficient GHG abatement which was achieved through targeting high GHG dairy manure feedstock with a grants and loan program (the 'Dairy Digestor R&D Program') (Figure 3-21). Depending on the exact agricultural practice employed, dairy manure can result in high GHG emissions, especially if heaped causing methane emissions. Despite being the most cost efficient for GHG abatement, California was second last in terms of GHG abated in absolute quantity due to the small absolute growth in biogas capacity compared to other jurisdictions.

France's GHG abatement is more expensive than other jurisdictions due to its fairly low grid emission factor (>70% of France's electricity comes from nuclear energy). Additionally, the expensive FiTs used to drive this growth resulted in an expensive cost efficiency of biogas capacity gained (as discussed shown in Figure 3-20). Italy's expensive GHG abatement was driven mainly by its high FiT amount.

Figure 3-21 – Efficiency of GHG abatement of biogas capacity added 2011 -2019 (Sources: [13], [14]).



3.2.2.3 Job creation

California had the most cost-efficient job creation

The cost efficiency of biogas jobs created was obtained from taking the total policy cost and dividing it by the jobs created from biogas plants built in the 2011-2019 period (see Section 2.3 for methodology). The results of this calculation are shown for the five jurisdictions in Figure 3-22.

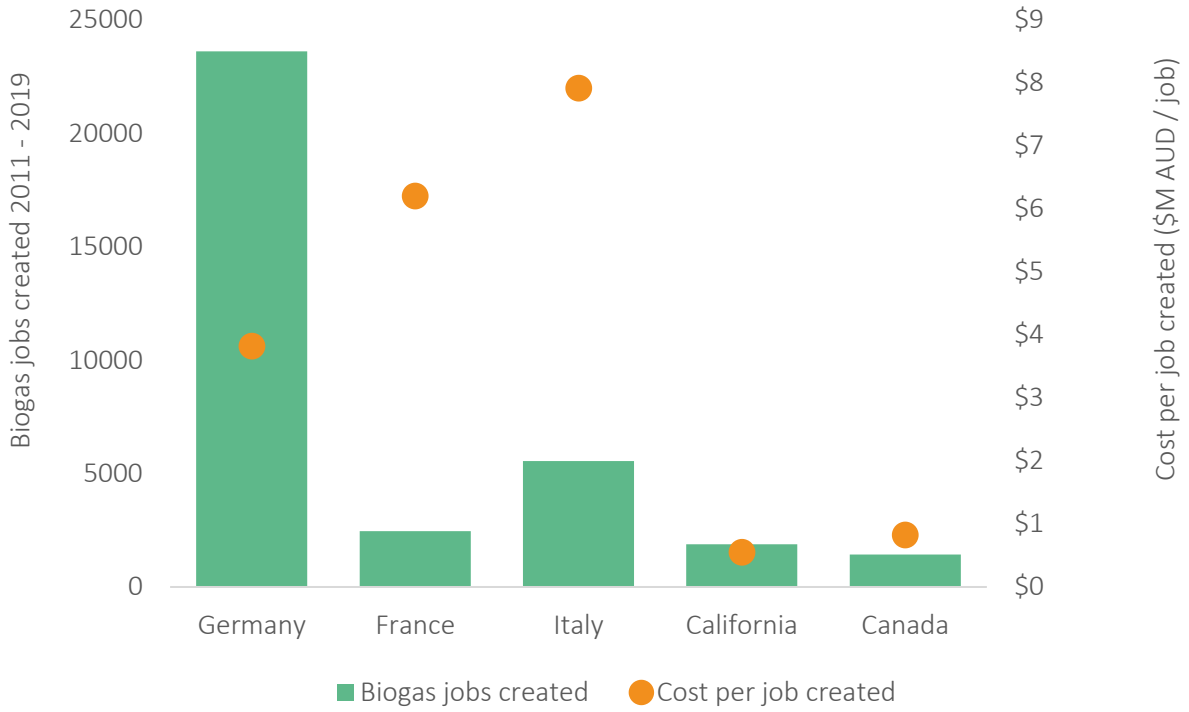
California and Canada were the most cost efficient in creating biogas jobs at $550-880k AUD/job but were the least effective in the amount of jobs created. Italy and France were the least cost efficient per job at $6.2-7.9M AUD/job created due to the expensive FiTs used to incentivise new biogas plants.[7]

For reference, a recent policy package by the Australian Government[8] aimed at creating jobs came at a cost of ~$300k AUD per job. While the figures for biogas job creation were more expensive and ranged from $0.55 – 7.9M AUD/job, these costs also cover the capital of constructing biogas plants.

[7] Cash flows are not discounted.

[8] A $74.6B AUD government spending with the aim of creating >250,000 jobs was announced in May 2021.

Figure 3-22 – Efficiency of job creation from biogas capacity added 2011 – 2019 (Sources: [3], [13], [14]).



3.2.3 Targeting of end uses and feedstocks

Agricultural feedstocks are being targeted by all jurisdictions through different policy mechanisms

Targeting agricultural feedstocks brings a range of benefits, including the potential for high GHG abatement from using manure, and increasing regional employment. Similar to Victoria, the majority of each jurisdiction's biogas potential is related to agricultural feedstocks. Agricultural residues are forecasted to account for the majority of biogas potential in all five jurisdictions (accounting for ~45-85% of biogas production) by 2030.

Agricultural feedstocks are being targeted with grants and loans for farmers and higher FiT / certificate bonuses for agricultural residues:

- California and Canada targeted the agricultural sector with specific grants & loans programs for farmers. Approximately 50-80% of grant funding in the 2011-2019 period was allocated to agricultural biogas projects. For example, California's Dairy Digestor R&D Program is a dedicated grants and loans program funding dairy manure biogas plants with the added benefit of increasing GHG abatement.
- France and Germany targeted the agricultural sector with higher FiT for smaller scale plants and FiT bonuses for agricultural waste (for example, France's FiT from agricultural residues is 30% higher than the base rate aimed to support small farmers).
- Italy placed certain restrictions on which feedstocks are eligible for biomethane certificates with agricultural residues being a preferred feedstock.

Policy mechanisms are mostly targeting biomethane end uses for grid injection and transport

With alternatives sources of renewable electricity available from sources such as solar and wind, most jurisdictions are focussing biogas towards hard to abate sectors such as natural gas grid usage and transport. Biomethane grid injection has been targeted with a FiT in France and has resulted in an exponential growth in biomethane plants since 2014 (81% CAGR). Meanwhile, California's and Canada's grants, loans and mandates have led to a lower but more cost-efficient growth in biomethane capacity. California's $55M AUD 'Biomethane

Interconnector Program' is an example of a grants program targeting biomethane through covering 50% of the connection costs to the gas grid.

Both Germany's and Italy's end use policies are less relevant to Victoria as they don't target grid injection:

- Due to the phase out of coal-fire-power plants, there is a need for dispatchable electricity production. As a result, Germany continues to target electricity from both biogas and biomethane with FiTs for grid firming capacity – however a grid stability incentive is expected to be released in the future. There are no direct incentives for biomethane grid injection currently.
- Italy is targeting biomethane for transport use with a NGV fleet size of over 1.13 million while Australia NGV fleet size is only a few thousand.

4 BIOGAS POLICY RECOMMENDATIONS

This section provides recommendations to Sustainability Victoria based on policies found to be most effective and cost efficient in growing the biogas sector in the jurisdictions explored. In addition to this, the relevance of policies to Victoria's context were also considered based on feedstocks and end uses targeted. These recommendations are intended to assist Victoria unlock the biogas potential as outlined in the separate report *"Estimate of Victoria's biogas potential"*.

4.1 Targeted feedstocks and end uses

Considering Victoria's agricultural potential and Australia's focus on renewable natural gas, Victoria could target agricultural waste as a feedstock and biomethane as an end use

Regardless of the policy mechanism chosen to build the biogas sector, Victoria should focus on using agricultural waste as this makes up the majority of Victoria's biogas potential. This could be achieved with higher FiT rates for using agricultural residues such as manure, or targeted grants for agricultural biogas plants. By growing the biogas production capacity in the agricultural sector:

- Victorian farmers will have access to new revenue streams
- Regional employment will be increased with the operation of biogas plants
- Low contamination risk in digestate from agricultural feedstocks
- End users of digestate are likely to be located near agricultural biogas plants

In addition to this, Victoria can efficiently maximise its GHG abatement through targeting high emission agricultural feedstock such as manure or the straw and chaff that is currently being burnt off (without energy recovery) in certain regions of Victoria throughout the year.

If Victoria aims to achieve rapid growth, it could consider implementing a biomethane FiT to kick-start the biogas sector, as this has proven effective in other jurisdictions. In the medium term, a biomethane certificate scheme linked to a mandate could be considered to transition to a more market exposed system.

While biogas electricity production was a previous focus across all five jurisdictions during their sector development, most jurisdictions have since shifted to biomethane. Electricity production from biogas now competes against low-cost renewable electricity alternatives such as wind or solar. Despite being able to provide capacity firming for the electricity system, most of explored jurisdictions use biogas to offset hard-to-abate end uses such natural gas uses including industrial heating and transport

Victoria also has access to solar and wind for renewable electricity and does not have an existing large natural gas vehicle fleet. Thus, its biogas potential could instead be directed towards natural gas uses instead, unless significant grid firming capacity is required.

Clear digestate guidelines and standards could also be implemented to reduce emissions, ensure minimum digestate quality for end users and help grow the digestate market.

All jurisdictions have legislation in place regulating the minimum treatment and storage of digestate. This helps reduce methane emissions from digestate and ensure it is safe to use for land application. Safety standards on digestate (such as maximum heavy metal concentrations, pathogen concentrations and physical contaminants) also help facilitate digestate markets by ensuring minimum quality for end users.

4.2 Short to medium term action

If Victoria aims to achieve rapid growth, then it could consider implementing a biomethane FiT to kick-start the biogas sector, as this has proven effective in other jurisdictions.

All the reviewed jurisdictions started their biogas growth with a FiT. This supported the establishment of their biogas ecosystems (such as suppliers, developers, skills and knowledge) by offsetting the higher initial capital and operating costs during the early phase of an industry. FiTs also made projects easier to finance as revenue prices for biogas projects would be fixed as opposed to being exposed to market mechanisms. Lastly, FiTs provide long term visibility to project developers that the biogas industry is supported by the government. Ambitious longer-term growth of the sector can be linked to a longer term attractive FiT, as demonstrated in France, Italy and Germany.

If Victoria aims to transition to a more market exposed system in the medium term, a biomethane certificate scheme linked to a mandate could be considered, as this has proven effective in other jurisdictions

The introduction of a quantified biomethane consumption target to be achieved and is a strong signal to industry. It has been successful in growing the Italian biogas sector and was linked to a certificate system. France will also be implementing a biomethane certificate scheme in 2022 in conjunction with a progressive reduction of its FiT. Victoria could potentially use a certificate system linked to a mandate as a transition step towards a market exposed biogas sector. However, it should be noted that certificates alone have not been proven as a way to kick start the biogas industry in any of the jurisdictions investigated, as Italy only implemented the system after its FiT.

4.3 Longer term policy mechanisms

Victoria could use grants with FiTs at the beginning of biogas sector's growth and as a potential replacement for FiTs in the longer term

It is important to note that none of the jurisdictions reviewed used only grants to start their biogas sector's growth. Grants can be used in addition to FiTs at the beginning of a biogas sector's growth to provide additional support for upfront costs that FiTs alone would not provide. This would accelerate the development of the biogas sector in the early stages of the industry as seen by Ontario which resulted in its biogas leadership position among the provinces in Canada. Similar to FiTs, grants can be targeted to specific feedstocks and end uses such as agriculture and biomethane. Lastly, grants can be also used to encourage the use of projects with onsite usage (or behind the meter) use of biogas which would otherwise be unsupported in a FiT only scheme.

Alternatively, transitioning away from FiTs to grants in the longer term has been shown to be more cost efficient in California and Canada. Grants alone, with no FiT or other support, will only be of use to projects that can generate an operating profit without additional support. If grants are implemented in the longer term, after the biogas ecosystem has matured, then grants will be more cost efficient in the long term only projects that are able to operate at a profit unsupported will be eligible.

To reduce the cost of supporting the biogas sector, Victoria could move towards market exposed mechanisms in the long term

While financial support is required at early stages, once the biogas sector has professionalised, policies can transition to more market exposed mechanisms, such as auctions (e.g., Germany). This transition should be conditioned to the maturity of the biogas sector. The purpose is to ensure that the sector continues to grow, while government support is reduced.

BIBLIOGRAPHY

[1] IEA, "Biogas production by region and by feedstock type, 2018," 2018. [Online]. Available: https://www.iea.org/data-and-statistics/charts/biogas-production-by-region-and-by-feedstock-type-2018.

[2] German Biogas Association, "Biogas market data in Germany," 2021.

[3] Navigant, "Gas for Climate - Job creation by scaling up renewable gas in Europe," 2019.

[4] C. B. A. CBA, Interviewee, *California biogas sector development interview.* [Interview]. 2021.

[5] Canadian Biogas Association, "Funding & Incentives," 2021. [Online]. Available: https://biogasassociation.ca/resources/funding_and_incentives. [Accessed 2021].

[6] P. E. International, "Biogas from sewage plants helping to meet California's environmental mandates," 2010. [Online]. Available: https://www.powerengineeringint.com/decentralized-energy/on-site-renewables/biogas-from-sewage/. [Accessed October 2021].

[7] Enea Consulting, "The potential of anaerobic digestion," French Energy Agency, 2019.

[8] American Biogas Council, "Biogas State Profile: California," 2019. [Online]. Available: https://americanbiogascouncil.org/wp-content/uploads/2019/05/ABCBiogasStateProfile_CA.pdf. [Accessed 2019].

[9] American Biogas Council, "California Biogas State Profile," 2020.

[10] American Biogas Council, "101 For Low Carbon Fuel Standard," 2019.

[11] DDRDP, "Report of Funded Projects," Dairy Digestor R&D Program, 2021.

[12] SoCalGas, "Biomethane Monetary Incentive Program," 2020. [Online]. Available: https://www.socalgas.com/clean-energy/renewable-gas/biomethane-monetary-incentive-program. [Accessed October 2021].

[13] IRENA, "Renewable Capacity Statistics," International Renewable Energy Agency, 2021.

[14] International Energy Agency, "Biomethane Plant List," 2019. [Online]. Available: http://task37.ieabioenergy.com/plant-list.html. [Accessed 2019].

[15] BioCycle, "RNG Trends In Canada," 2017. [Online]. Available: https://www.biocycle.net/rng-trends-canada/#:~:text=Moreover%2C%20gasification%20of%20forest%20and,%243.25%20for%20conventional%20natural%20gas.. [Accessed 2017].

[16] Carbon Footprint, "Carbon Footprint Country Specific Electricity Grid Greenhouse Gas Emission Factors," 2020.

[17] Enea Consulting, "Australia's Bioenergy Roadmap," 2021.

[18] US Energy Information Administration, "How much carbon dioxide is produced per kilowatthour of U.S. electricity generation?," 2020. [Online]. Available: https://www.eia.gov/tools/faqs/faq.php?id=74&t=11. [Accessed 2020].

[19] British Columbia: Ministry of Environment and Climate Change Strategy, "2020 B.C. Best Practices Methodology For Quantifying Greenhouse Gas Emissions," [Online]. Available: https://www2.gov.bc.ca/assets/gov/environment/climate-change/cng/methodology/2020-pso-methodology.pdf.

[20] Umwelt Bundesamt, "Emission Factors for Fossil Fuels in Germany," 2017. [Online]. Available: https://iea.blob.core.windows.net/assets/imports/events/243/13_Germany_K.Juhrich.pdf. [Accessed 2017].

[21] Germany Biogas Association, «State of the German Biogas Association,» 2021.

[22] European Biogas Association, "EBA Statistical Report," 2020.

APPENDIX 1 – BIOGAS POLICY LONGLIST

Policy category	Policy subcategory	Policy mechanism
Economic Support	Carbon credits, taxes, emissions trading	Carbon credits, taxes, emissions trading scheme
Economic Support	Contracts-for-difference	Contracts-for-difference for low-carbon electricity generation
Economic Support	Energy auction schemes	Auction scheme for renewable energy
Economic Support	Feed-in-tariff (biomethane)	FiT + bonus for biogas upgrading
Economic Support	Feed-in-tariff (biomethane)	FiT for biomethane grid injection
Economic Support	Feed-in-tariff (electricity)	Feed-in-tariff for electricity generation
Economic Support	Feed-in-tariff (electricity)	Feed-in-tariff for electricity grid export
Economic Support	Feed-in-tariff (electricity)	FiT + bonus for agricultural waste and/or manure
Economic Support	Feed-in-tariff (electricity)	FiT + bonus for biowaste
Economic Support	Feed-in-tariff (electricity)	FiT + bonus for energy crops
Economic Support	Grants and loans	Capital grants and loans for renewable energy or energy projects
Economic Support	Grants and loans	Capital grants for infrastructure (e.g., W2E infra)
Economic Support	Grants and loans	Government funding to support earlier stages of projects, recoupable if project proceeds
Economic Support	Grants and loans	Grants for innovation or R&D (granted to renewable energy projects)
Economic Support	Grants and loans	Grants for resource recovery or waste treatment
Economic Support	Tax treatment	Tax credit for investment in renewable energy
Economic Support	Tax treatment	Tax credit for renewable energy production
Economic Support	Tax treatment	Tax exemption for renewable energy production
Economic Support	Tax treatment	Tax exemption for renewable energy quota
Economic Support	Tax treatment	Tax incentive for assets used for renewable energy production
Economic Support	Tax treatment	Tax incentive for R&D
Economic Support	Underwriting risk	Government support in underwriting feedstock supply risk

Policy category	Policy subcategory	Policy mechanism
Economic Support	Waste levies	Landfill tax
Economic Support	Waste levies	Waste levies
Regulatory Support	Guarantee of origin	Guarantees of Origin scheme
Regulatory Support	Project related regulations	Regulation on biogas production (including regulation on feedstock and residue)
Regulatory Support	Project related regulations	Regulatory clarity on digestate
Regulatory Support	Project related regulations	Reviewing waste receival laws to allow unclassified trucks to transport waste
Regulatory Support	Project related regulations	Simplified approval process
Regulatory Support	Renewable energy target/mandate	Renewable Electricity Certificates
Regulatory Support	Renewable energy target/mandate	Renewable Energy mandate
Regulatory Support	Renewable energy target/mandate	Renewable Energy targets
Regulatory Support	Renewable gas target/mandate	Biofuel blending mandate
Regulatory Support	Renewable gas target/mandate	Biomethane procurement mandate
Regulatory Support	Renewable gas target/mandate	Low Carbon/Clean Fuel Standards
Regulatory Support	Waste policies	Ban on waste export
Regulatory Support	Waste policies	Landfilling ban for recoverable waste
Regulatory Support	Waste policies	Landfilling bans for organic waste
Regulatory Support	Waste policies	Circular economy policy, impacting waste management
Regulatory Support	Waste policies	Waste avoidance and/or resource recovery policies (beneficial to bioenergy production)
Strategic Support	Environmental policies	Renewable energy and/or Climate Change policies
Strategic Support	Strategies and roadmaps	Bioenergy/bioeconomy strategy or roadmap

APPENDIX 2 – GHG ABATEMENT

Emissions factors for grid electricity and biogas electricity production in each jurisdiction are provided in the table below.

Biogas electricity emission factors

Jurisdiction	Electricity grid emission factors (gCO_2 / kWh_e)	Biogas electricity emission factor (gCO_2 / kWh_e)	Net abatement (gCO_2 / kWh)
California	191 [16]	-750 [17]	941
Canada	130 [16]	-500 [17]	630
France	39 [16]	-600 [17]	639
Germany	379 [16]	-250 [17]	629
Italy	338 [16]	-600 [17]	938

Emission factors for natural gas / diesel and biomethane production in each jurisdiction are provided in the table below.

Biomethane emission factors

Jurisdiction	Natural gas / diesel emission factors[9] (gCO_2 / kWh)	Biogas electricity emission factor (gCO_2 / kWh)	Net abatement (gCO_2 / kWh)
California	184 [18]	-200 [17]	384
Canada	180 [19]	-200 [17]	380
France	200 [17]	-200 [17]	400
Germany	202 [20]	-200 [17]	402
Italy	444 [17]	-200 [17]	644

[9] Natural gas emissions factors were used for California, Canada, France and Germany for biomethane grid injection, while a diesel emission factor was used in Italy due to the targeting of the transport sector.

APPENDIX 3 – STAKEHOLDERS INTERVIEWS

Jurisdiction	Organisation
Australia	(Previously) Sustainability Victoria
Canada	Canadian Government
France	Gas distribution company
France	Organic waste industry player
Germany	Germany Biogas Association
Europe	European Biogas Association
Italy	Waste management industry player
California	California Bioenergy Association

APPENDIX 4 – KEY TO COMPARATIVE ANALYSIS RESULTS

The following is a key to the colour coding used in the comparative analysis results (Table 3-1) in Section 3.2.

Aspect	Red	Orange	Green
Total growth achieved (CAGR from 2011 - 2019	<6%	6-10%	>10%
Electricity growth achieved (CAGR from 2011 - 2019	<5%	5-9%	>9%
Upgrading growth achieved (CAGR from 2011 - 2019	<10%	10-30%	>30%
Growth achieved (absolute)	<100,000 (m3/hr)	100,000-1,000,000 (m3/hr)	>1,000,000 (m3/hr)
Cost efficiency (2011 – 2019)	>120k AUD/(m3/hr)	80-120k AUD/(m3/hr)	<80k AUD/(m3/hr)
Jobs created (2011 – 2019)	<5,000	5,000-20,000	>20,000
GHG abated (2011 – 2019 new plants)	<20 MTCO2-e	20-100 MTCO2-e	>100 MTCO2-e

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