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BIO-METHANE SUPPORT POLICY IN FRANCE

Study

On behalf of:

Federal Ministry for the Environment, Nature Conservation and Nuclear Safety

European Climate Initiative EUKI

of the Federal Republic of Germany

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1 Summary

This study looks at French climate and agricultural policy, in particular **'Le plan Énergie Methanisation Autonomie Azote** (EMAA)' (the energy methanisation autonomy nitrogen plan), and assesses its transferability to the German context. Together with a package of supporting policies, EMAA provides a supportive framework for the development of agricultural methanisation in France, being the production of biogas and bio-methane from agricultural and other wastes. The policies enable investment subsidies for research and equipment, as well as guaranteed prices for their bioenergy products, achieving emissions reductions directly in the agricultural sector and across a range of sub-sectors, including transport, waste, electricity and heat.

The main strength of the French approach is that their policies are embedded in France's agricultural development policy framework, especially the agro-ecologic project. This puts the renewable energy and climate objectives into a tangible socio-economic perspective, relating them directly to rural jobs, increasing productivity and competitiveness, and the growth of a modern 'green' sector. Typical issues related to energy crops are explicitly avoided through stringent regulated limits on feedstocks, while the French government exerts a high level of control over the development trajectory of the sector.

Germany is more advanced than France in its use of methanisation in the agricultural sector, albeit with a strong dependence on energy crops. Manure and other agricultural residue is already broadly utilised as a bioenergy feedstock in Germany, although there seems to be significant potential to expand.

The main potential for policy transfer to Germany lies in the comprehensive framing of the French policies within broader sustainability goals related to nutrient optimisation, rural development and agricultural reforms. Energy policy in Germany tends to be distanced from discussions about sustainable agriculture, so that a comprehensive (re-)framing in line with the French approach could help to overcome political barriers and unlock the future abatement potential of agricultural methanisation in Germany.

Differences in the energy and climate profiles of the two countries mean that the energy aspect of the French approach is less transferable to Germany than the mitigation of agricultural emissions from manure management. In Germany, bioenergy policy has been shaped by the context of the Energiewende, and the substitution of fossil and nuclear energy with renewables. However, France's low-carbon power sector makes using bio-methane for electricity ineffective as a decarbonisation strategy, where it has rather been pursued as a waste management and agricultural development strategy. Still, increasing the methanisation of livestock manure, together with other waste and residual streams, provides an effective pathway towards reducing agricultural greenhouse gas emissions both in France and Germany.

2 Introduction to the instrument

The group of policy measures examined in this study together foster agricultural methanisation, which is the use of agricultural waste to produce bioenergy. They consist of two plans and two supporting incentive schemes:

- Le plan Énergie Methanisation Autonomie Azote (EMAA)
  - the energy methanisation autonomy nitrogen plan
- Plan pour la compétitivité et l'adaptation des exploitations agricoles 2014–2020 (PCAE)
  - the plan for competitiveness and adaptation of agriculture 2014–2020
- Feed-in-premium for biogas to electricity and heat
- Feed-in tariff for bio-methane injection into the gas grid

These measures provide a support framework and strategic guidance for development of agricultural methanisation. They enable investment subsidies for research and equipment, as well as guaranteed prices for their bioenergy products. The measures achieve emissions reductions directly in the agricultural sector as well as across a range of sub-sectors, including transport, waste, electricity and heat.

There are two sides to the EMAA approach. First, the methanisation of agricultural waste is a proven strategy to reduce methane (CH_4) emissions from livestock manure while still allowing nutrients to be recovered and used as fertiliser. Second, methanisation effectively captures methane emissions from livestock manure (and other organic feedstocks) to produce biogas and eventually bio-methane, which can then be used as a renewable energy source to substitute fossil fuels on the farm and across the economy (see Appendix A. for an overview of agricultural methanisation).

The measures examined in this study are rooted in overarching strategies for the sustainable development of the French agricultural sector, as well as renewable energy strategies. While their effect on the climate is considered important, it is only one objective of the policy measures, which also aim to foster regional energy independence, rural economic growth and jobs, agricultural productivity and competitiveness, and a range of other objectives related to France's agro-ecological transition. They are also embedded in France's national climate and energy policy strategy, which **supports and frames the group of measures as key policies to engage the agricultural sector in** greenhouse gas (GHG) **emission reductions, and to help meet** a range of climate change mitigation and renewable energy targets outlined in the **French National Low-Carbon Strategy (SNBC) of 2016.**

The main focus of this analysis is the **EMAA plan** (MEDDE & MAAF, 2013), which is a **cross-ministerial strategy by the Ministry for Agriculture and Food** (Ministère de l'Agriculture et de l'Alimentation et de la Forêt) **and the Ministry for an Ecological and Inclusive Transition** (Ministère de la Transition Écologique et Solidaire – MTES, until 2016 the Ministry of Ecology, Sustainable Development and Energy – MEDDE).

3 National context

3.1 National climate policy

The foundation of current French national climate and energy policy is the Law on Energy Transition for Green Growth (La loi relative à la Transition Énergétique pour la Croissance Verte - LTECV).[1] It was implemented in 2015 and sets national climate targets to cut GHG emissions by 75% by 2050, and to meet France's commitments to the European Union (EU) of a 40% reduction by 2030 below 1990 levels. It also sets a range of renewable energy targets to 2030: increasing the share of renewables to 40% in electricity generation, 38% in production of final heat consumption, 15% of final fuel consumption, and 10% of gas consumption by 2030. Fossil fuel consumption and overall energy consumption should be reduced by 30% and 50%, respectively, below 2012 levels (MEEM, 2016).

In order to implement the long-term targets of the LTECV in a transparent and deliberate manner that provides investors with certainty, the law required two strategic plans to be developed – the Multiannual Energy Programme 2014–2020 (Programmation Pluriannuelle de l'Énergie 2014–2020, PPE) and the national low-carbon strategy (Stratégie Nationale bas Carbone, SNBC). Approved in 2016, the PPE defines the priorities for action to achieve the energy targets of the LTECV. It sets ambitious medium-term targets for the energy use of biogas and bio-methane for 2018 and 2023, including targets for electricity and heat generation as well as for the injection of bio-methane into the gas grid. Total installed power capacity should reach 137 MW in 2018 and 237–300 MW in 2023; heat production should reach 300 kilotonnes of oil equivalents (ktoe) in 2018 and 700–900 ktoe in 2023; and the production of injected io-methane should reach 1.7 TWh in 2018 and 8 TWh in 2023. It also sets a specific target for transport – the development of bio-natural gas for vehicles (NGV), which is to account for up to 20% of NGV consumption in 2023 (MTES, 2016). The renewable energy targets underline the expansion of biogas and bio-methane, and provide a further mandate for the use of regulations, subsidies and incentive schemes for their development.

The SNBC sets carbon budgets that reflect the targets outlined in the LTECV and outlines cross-sector and sector-specific policies to achieve them. Strategies for the agricultural sector include using biomass over fossil fuels, storing carbon in soils, and reducing direct emissions of nitrous oxide (N_2O) and CH_4. Agricultural methanisation takes a key position in France's climate and energy strategies in the agricultural sector and across several energy sub-sectors. The SNBC reiterates the aims of the EMAA plan with particular regard to the optimisation of the use of inputs and efforts toward achieving autonomy with local resources, as well as enhancing the energy performance of the agricultural sector and the significant development of agricultural methanisation. Importantly, it sets a guideline target for 40% of usable excrement to be methanised (MEDDE, 2016).

[1] The current French national climate and energy policy outlined here was implemented in 2015–2016. This development took place several years after the measures analysed in this study were first introduced (e.g. the EMAA plan was published in 2013 and the feed-in-tariff for bio-methane injection began in 2011). However, national climate policies fully support the existing measures for agricultural methanisation and biogas utilisation, framing them within a comprehensive climate change mitigation and energy strategy.

3.2 Sector context

France's emissions profile is unique and largely influenced by the heavy use of nuclear energy. As of 2015, 92.3% of the electricity sector in France is composed of non-emitting sources and is dominated by nuclear energy (76.3%), while coal plays a very small role (1.6%). The electricity sector's low emissions are compensated by the average performance of the transport and heating sectors. Yet, France has the lowest CO_2 emissions per capita and the third-lowest emission intensity of GDP in the OECD (Mathieu, 2016). Agriculture is the second largest emitting sector in France after transport and is responsible for around 19% of the national GHG emissions (including energy use and land-use changes) (MTES, 2017). The SNBC sets a reference target to reduce agricultural emissions by 12% by the third carbon budget (2023–2028), and twofold by 2050 compared with 1990.

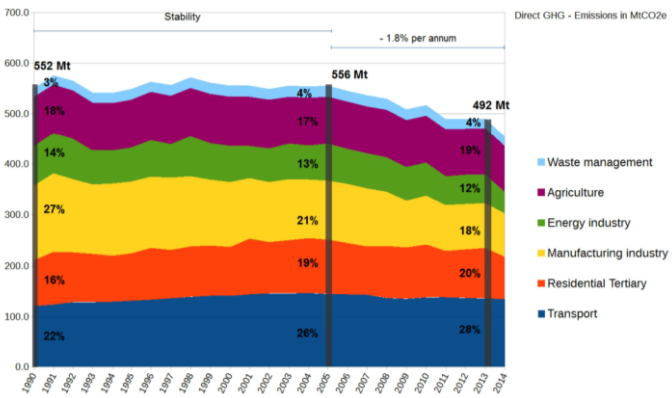

Figure 1: Evolution of GHG emissions for France between 1990 and 2013 (MTES, 2017)

Although it has lost market share in recent years, France remains one of the world's leading producers and exporters of agricultural products, and Europe's largest cattle farmer with 19.4 million cows in 2015. Furthermore, there is high regard in France for the cultural importance of its agricultural and food products as well as its history of collective action and workers' rights. Recently, the sector has undergone profound changes in response to internal and external factors: shifts in consumer preferences, globalisation, commercialisation, and the industry's increasing impact on ecology and the environment (Momagri, 2018).

In 2015, GHG emissions from France's agricultural sector represented 90.7 million tonnes CO_2e ($MtCO_2e$) (including emissions from energy use in agriculture, ca. 12 $MtCO_2e$). These were mainly due to the cropping and livestock activities of about 450,000 farms. Despite the ongoing rural exodus, emissions from the sector have been relatively stable, dropping around 4.4% between 1990 and 2015 mainly due to reduced animals, nitrogen fertiliser and energy consumption. Agriculture differs from other sectors in that the majority of GHG emissions are not related to energy use. In 2015, emissions from agricultural soils accounted for 39.2% of emissions from the sector, followed by emissions from enteric fermentation (38.1%), energy consumption (13.4%) and animal manure (8.9%). CH_4 emissions (from enteric fermentation and animal manure) and N_2O emissions (emissions from agricultural soils due to fertiliser use) are predominant, accounting for 45.1% and 40.2% respectively (MTES, 2017). Sectoral emissions, excluding those from energy use, are detailed in Table 1.

Table 1: Major GHG emissions from agricultural activities in France in 2015 (MTES, 2017)

Sector	CH_4 (tCO_2e)	N_2O (tCO_2e)	Total (tCO_2e), excluding emissions from energy use
Agriculture	40 929	35 437	78 373
Enteric fermentation	34 580		34 580
Manure management	6 219	1 858	8 078
Agricultural soils		33 563	33 564

4 General description of the policy instrument

4.1 History

The support mechanisms for bioenergy in France developed more slowly than in other European countries. France is certainly not a pioneer in this sector; Germany and Italy are still the leading countries, however with a historical focus on energy crops and biogas to electricity and heat generation. In France, agricultural methanisation policy has been fragmented, stemming from different political objectives related to environment and resource management, renewable energy policy, and agricultural reform.

Feed-in tariffs for biogas to electricity, heat and co-generation were already implemented in France in 2001, before being reformed and strengthened under the Energy Law (Code de l'Energie) in 2005. The projects established were mostly to recover energy from the waste sector, with large-scale projects for landfill gas recovery, industrial waste and sewage processing. The development of the national environment programme 'Grenelle de l'Environment' (2007–2009), based on an extensive public consultation, set a broad policy framework. It established measures such as the 'Waste Fund', financed from the General Tax on Polluting Activities (TGAP), which made methanisation projects for waste management eligible to receive subsidies. France is now considered a technical leader in certain waste methanisation operations, particularly for waste water and sewage.

To align national renewable energy strategy with the EU Renewable Energy Directive (RED)[2], France established the first Multiannual Energy Programme (Programmation pluriannuelle de l'énergie) in 2009 and submitted a National Renewable Energy Action Plan in 2010. The national plan laid the ground for the establishment of a feed-in-tariff for bio-methane injected into natural gas grid, similar to that for electricity. The 'eight decrees and orders' enabling public support for the bio-methane injection sector were then enacted in November 2011.

Alongside the EU reforms related to the 'greening' of the Common Agricultural Policy (CAP), the French government launched the 'Plan Performance Énergétique des Entreprises Agricoles' (energy performance plan for agricultural enterprises, PPEEA) in 2009. The plan engaged regional and state authorities to pursue productivity and efficiency improvements in agriculture and established a framework of financial mechanisms drawing on European, national and sub-national rural development funding. One of the priority areas of the plan is the fostering of renewable energies in agricultural processes, in particular agricultural methanisation. In 2014, the plan was then succeeded by the 'Plan pour la compétitivité et l'adaptation des exploitations agricoles 2014–2020' (PCAE), which provides a consolidated strategic framework for financing the energy development of the agricultural sector.

Drawing together the different environmental, economic and social objectives for the agricultural sector, the French government announced the overarching strategy for the development of ecologically-based, sustainable agriculture in France in 2012, known as 'Le projet agro-écologique pour la France' (the agro-ecological project of France). This was accompanied by a range of action plans, including the EMAA plan, which is considered one of the founding pillars of the agro-ecological project.

[2] 2009/28/EC on the Promotion of Electricity Produced from Renewable Energy Sources.

4.2 Legal basis

The legal basis for the multiple instruments allows for the legal production and sale of biogas and bio-methane; enables public investments in the agricultural methanisation sector; and sets the regulatory framework for energy providers and consumers.

Table 2: Legal basis for policy measures promoting agricultural biogas and bio-methane in France

Policy measures	Legal basis	Notes
Framework for biogas and bio-methane as renewable energy	**Legal basis for biogas production** Article 19 of the Grenelle 1 Law: (2009) Article L446 of the Energy Code Decrees of 29 October 2009 and 26 July 2010 Decrees of 28 April 2010 and 26 July 2010	• Provides a category (no. 2781) for non-hazardous waste methanisation activity; • Provides a category (no. 2910C) for co-generation plants consuming biogas; • Establishes the basis for tax revenues to be collected and used for public investment in the sector, e.g. via the TGAP.
	Regulation of the energy market Law of 10 February 2000	Creates the Commission of Regulation of Energy (CRE), which controls compliance with the energy market regulations.
	Use of energy crops Decree No. 2016-929 of July 7 2016	Limits the maximum rate of incorporation of food crops or energy crops grown as main crops in biogas plants to 15%.
Feed-in-tariffs and premiums for biogas to electricity and heat	Code de l'Energie' (Energy Code) Articles L. 314-1 and L.446-2 Order of 16 April 2002 Orders of 10 July 2006, 19 May 2011, 30 July 2013 and 30 October 2015 Act on Energy Transition for Green Growth-17 August 2015 Art. 1, Décret du 28 mai 2016 Art. 1, Arrêté du 13 décembre 2016 biogaz Art. 3, Décret n° 2016-1442	• Sets the terms for guaranteed purchasing of electricity and heat generated from biogas; • Sets the terms for purchasing electricity generated by installations exploiting biogas; • Sets the progressive replacement of feed-in tariffs with the 'compensation mechanism' of feed-in premiums; • Defines eligibility of small methanisation plants; • Foresees annual bidding procedures (tenders) for the development of methanisation projects.
Feed-in-tariffs for bio-methane injection and guarantee of origin	Grenelle 2 act adopted on 12 July 2010 Decree no. 2011-1594, 1595, 1596 and 1597 of November 21, 2011 Four Ministerial Orders of November 23, 2011	Establishes two mechanisms: a regulated and guaranteed feed-in tariff for 15 years; and a guarantee of origin system, which ensures bio-methane for consumers can be traced.

Policy measures	Legal basis	Notes
Financial subsidies for agricultural methanisation	Plan pour la compétitivité et l'adaptation des exploitations agricoles 2014-2020 (PCAE) 04/2014 Title I of Book V of the Environment Code Law on the Energy Transition for Green Growth (LTECV) of 17 August 2015	Provide the legal basis for public funding of sectoral projects such as start-up investments and research and development.

4.3 Functioning

The EMAA plan defines the specific strategy for the development of methanisation in the French agricultural sector and the ensuing recovery and management of nutrients. It provides targeted investment subsidies for new projects and lays out the approach to fostering the development pathway of the emerging sector.

The EMAA plan was launched in 2013 to complement the PCAE (and its predecessor, the PPEEA) from 2014 onward. The PCAE sets the broader strategic framework for improving the energy efficiency and performance of the agricultural sector and establishes a range of funding mechanisms for rural development projects.

In addition to the investment subsidies of the PCAE and EMAA plans, the development of France's agricultural methanisation industry is supported by two schemes for guaranteed purchase rates (feed-in-tariffs), one for biogas to power and another for biogas to bio-methane, which provide stable long-term returns on electricity and heat produced from biogas, as well as for bio-methane injected into the natural gas network.

The overall aim of the EMAA plan is to foster an agro-ecologic shift away from existing practices, whereby manure is collected and stored for several months before being spread directly on fields. This practice puts pressure on the nitrogen cycle in some areas, while leaving others to purchase synthetic fertilisers. Furthermore, under standard practices the manure naturally decomposes, releasing unused methane to the atmosphere where it acts as a powerful GHG.

The approach outlined in the EMAA plan has two complementary aspects, linked by the process of methanisation. The first 'nitrogen' aspect relates to the cycling of nutrients from waste products to energy feedstocks to valuable agricultural inputs. The second 'energy' aspect relates to the capture of methane from these waste products for the production of biogas and bio-methane.

The establishment and growth of the French methanisation sector is the central objective, with a target **of installing 1000 methanisation units on farms by 2020**, as compared to 90 at the end of 2012. By reaching this target, it aims to make agricultural methanisation an additional income source for farmers through the economic use of bioenergy and digestates (the nutrient-rich material left over after methanisation). Specific objectives include:

- Fostering the agricultural use of digestates both locally and in areas further away from the manure production site, and develop value-added fertiliser products from the digestate that can substitute synthetic mineral fertilisers;

- Funding the installation of individual and multi-partner collective methanisation plants rooted in the rural territories[3];
- Building a French domestic methanisation technology and equipment industry.

In order to meet these objectives, the EMAA plan outlines a range of tools and approaches that encompass sectoral structuring, engagement with actors, fostering research and development, and granting direct subsidies for methanisation equipment:

Sectoral structuring

- Support work towards standards, certification and marketing of digestate products;
- Simplify administrative procedures and make them accessible to developers;

Engagement with actors

- Promote the emergence of collective projects through the framework of engaging 'economic and environmental interest groups' (Groupements d'intérêt économique et environnemental, GIEE);

Research and development

- Launch calls for projects to fund new and innovative technologies and approaches for nitrogen management and methanisation;
- Foster scientific research and innovative research and development both by commissioning research and working with government, academic and private actors to frame research needs;

Investment subsidies

- Use the Waste Fund to subsidise the demonstration and implementation of agricultural methanisation technologies;
- Direct research and development efforts towards innovation and industry development by including agricultural methanisation in calls for projects under the 'Investments for the Future Programme' (PIA);
- Support investment financing through the leverage effect of the financial instruments of BPI-Finance (the French public investment bank - Banque publique d'investissement) –, including investment credit guarantees and other finance instruments.

In order to fund these activities and subsidies, the EMAA plan identifies the Waste Fund[4] and the 'Investments for the Future Programme', which are both administered by the French Environment and Energy Management Agency (ADEME)[5]. Further funding, including for BPI-Finance, is facilitated by the PCAE. This funding originates

[3] The plan favours autonomous local and collective approaches using a majority of waste feedstocks. Units are typically either on-farm methanisers (one or two farms) sourcing around 90% of their feedstocks from agricultural waste, or larger-scale collective methanisers (multiple farms together with local authorities and agri-businesses) incorporating a variety of feedstocks (such as municipal waste) with around 30% from agricultural waste.

[4] The Waste Fund is financed from the TGAP applied to waste.

[5] ADEME provide investment subsidies for methanisation projects incorporating the use of biogas, either for cogeneration or for purification and injection of bio-methane into the natural gas network or bio-NGV. Consequently, 547 projects have benefited from investment support between 2007 and 2015, representing EUR 192.3 million in ADEME aid (ADEME, 2017)

from the French Ministry of Agriculture, the European Agricultural Fund for Rural Development (EAFRD) (see section **Error! Reference source not found.**), and to a lesser extent the regional authorities and water agencies. Total subsidies for single projects are limited by EU regulations. [6]

4.3.1 Feed-in tariffs for biogas to electricity and heat

From 2011 to 2016, the period most relevant to the measures of this study, feed-in tariffs for electricity produced from biogas were in place in France. The feed-in-tariff, fixed for a period of 20 years, was available for biogas power plants using vegetable and animal agricultural waste among other feedstocks. Biogas electricity and combined heat and power (CHP) plants were eligible for a basic reference tariff of EUR cents 11.9–13.4/kWh depending on their production capacity and favouring smaller installations. An efficiency bonus of up to EUR cents 4.0/kWh was available,[7] as well as a bonus for the use of agricultural waste feedstock of EUR cents 1.5–2.6/kWh, with smaller installations (below 500 kW) being favoured. The maximum rate available (for small, highly efficient plants using agricultural waste) was therefore EUR cents 20.0/kWh (RES Legal, 2017).

In 2016, the LTECV, in line with European regulations,[8] set out ongoing reforms for the existing support schemes, so that the feed-in tariffs for electricity from biogas are to be replaced with feed-in-premiums as a 'compensation mechanism'. This new system grants a premium tariff to renewable electricity producers on top of the sale price they get on the electricity market. However, the feed-in-premium only applies to larger biogas plants of more than 500 kW capacity. As of October 2017, the tariff order regulating conditions for biogas plants eligible for the premium tariff was still pending.

Plants smaller than 500 kW are still eligible for the simpler feed-in tariff, with new rates set by the LTECV in 2016 and comprising a basic tariff (sliding scale depending on plant capacity), with a bonus for using a share of at least 60% of livestock manure. The smallest plants (under 80 kW) are eligible for EUR cents 17.5/kWh, with the rate sliding to EUR cents 15.0/kWh for 500 kW plants. The bonus for livestock manure is EUR cents 5.0/kWh, meaning that the maximum rate available is EUR cents 22.5/kWh.

Furthermore, in order for the government to be able to regulate the growth in capacity, feed-in-premiums for biogas plants over 500 kW will only be granted through tenders. The PPE outlines annual bidding procedures for the development of methanisation projects for a total capacity of 10 MW per year until 2019. Descriptions of the legal framework for the tariffs and tables outlining their rates are published by the Commission for Energy Regulation (Commission de régulation de L'énergie, 2018).

Electricity end-consumers in France bear the costs arising from the suppliers' obligation to pay the feed-in-tariff via a Public Service Obligation (PSO) (Contribution au Service Public de l'Electricité). The PSO surcharge, determined by the energy regulatory commission, is added to the grid use charges or electricity prices, and the funds are then managed by the public financial institution 'Caisse des Dépôts'.

[6] The total subsidy amount must not exceed 45% for large companies, 55% for medium-sized companies, and 65% for small companies. Limits are defined in the General Block Exemption Regulations (GBER) 'Aid for investment in the promotion of energy from renewable energy' (Art. 23).

[7] To receive the bonus, a plant must achieve overall efficiency of at least 40% and at least 70% for the maximum.

[8] European State Aid Guidelines require that renewable energy be progressively exposed to market competition.

4.3.2 Feed-in tariffs for bio-methane injection into the gas grid

A feed-in-tariff for injection of bio-methane into the gas network was established in 2011 (Government of France, 2011). Producers of bio-methane are guaranteed to sell their product to a natural gas supplier at a fixed rate for a period of 15 years. The tariff depends on the size of the methanisation facility and the type of organic matter that is used as a feedstock. The rates are thereby made up of a basic reference tariff and a feedstock premium. In the case of collective facilities that use diverse feedstocks, the premium is calculated from the share of each feedstock.

Tariff rates are shown in Figure 2. The basic tariff is between EUR cents 4.5–9.5/kWh for landfill activities and EUR cents 6.4–9.5/kWh for other feedstocks. The premium for urban municipal waste is EUR cents 5.0/kWh. The maximum premium for sewage waste is EUR cents 3.9/kWh. The premium for agricultural agri-food industry waste is between 2.0–3.0/kWh, depending on the size of the facility. The maximum rate for an agricultural waste methanisation plant is therefore EUR cents 12.5/kWh.[9]

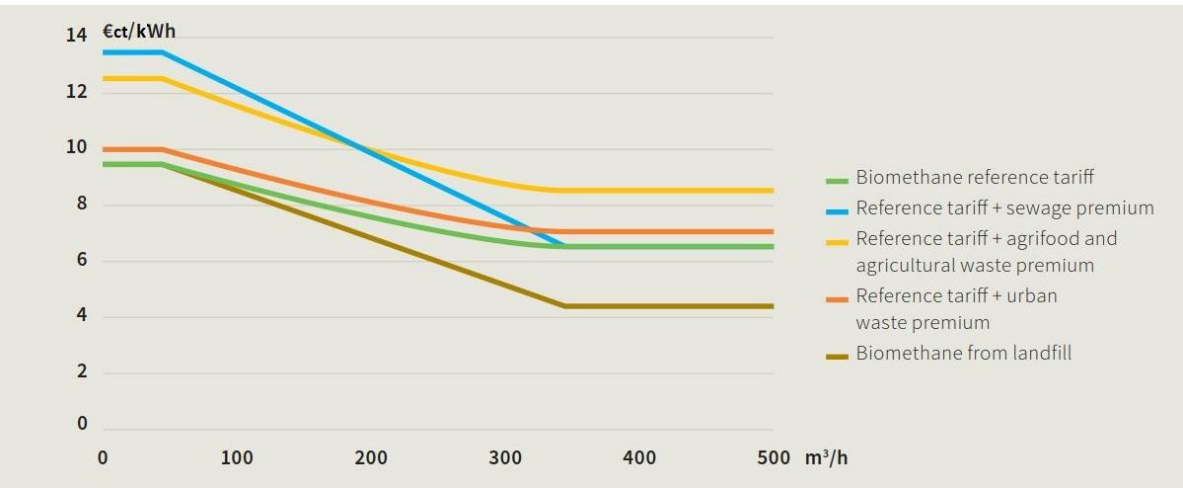

Figure 2: Bio-methane feed-in-tariff (as of December 2016), according to the type of feedstock and the installation's maximum production capacity of bio-methane (GRDF, GRTgaz, SER, SPEGNN, & TIGF, 2016)

According to analysis, the cost of production (without subsidies) ranges from EUR cents 9.3–7.8/kWh depending on the scale of the facility (from autonomous agricultural units up to regional collective facilities) (ENEA, 2017).

The costs of the feed-in-tariff for bio-methane are borne by gas and other energy consumers via state taxes: the Domestic Consumption Tax on Natural Gas (TICGN) paid by French gas consumers, and the Domestic Consumption Tax on Energy Products (TICPE), which is levied for the most part on petroleum products. Revenues are allocated to a compensation mechanism earmarked for the 'Energy Transition' and managed by the Caisse des Dépôts.

[9] Bio-methane, like natural gas, is typically measured in cubic meters of volume. The capacity of plants supplying bio-methane are therefore listed in Nm^3/h (normalised cubic meters per hour). For the sake of calculating the feed-in-tariff rates, gas volume is converted to kW/h representing the energy contained in the gas at a given pressure. Conversion factors are applied in the legal documents of the bio-methane feed-in-tariff regulations (Government of France, 2011)

Designed to work alongside the bio-methane feed-in-tariff, a 'guarantee of origin' (GO) system has been established to certify whether the gas has been produced from renewable sources. For each MWh of bio-methane injected into the network, a GO is created. The system ensures that the bio-methane injected into natural gas networks can be traced and enables suppliers to sell certified 'green gas' across the national grid.

4.4 Interlinkages with other policy instruments

The instruments outlined above function as an effective policy package with no counteracting effects. The EU Emission Trading System (ETS) plays very little role in the policy functioning, except that it puts a price on some fossil energy, thereby making biogas and bio-methane substituted in the electricity sector slightly more competitive. However, at the European level, these national policy instruments are supported by two relevant EU frameworks, RED and CAP.

In response to growing concerns about the sustainability impacts of bioenergy feedstocks, in particular the lifecycle GHG emissions from food and energy crops, the EU defined a set of sustainability criteria as part of the RED 2009/28/EC RED (European Commission, 2009). Compliance with the criteria is needed for biofuels and bio-liquids to be eligible for government support.[10]

Biofuels must meet minimum GHG savings across their lifecycle, and not be sourced from areas that are rich in biodiversity or have high carbon stocks. Rules were further introduced in 2015 to limit indirect land-use change impacts (European Commission, 2018). From 2009 onwards, the GHG savings criteria were set at a minimum of 35% GHG emission reduction compared to substituted fossil fuel. This increased to 50% from the beginning of 2017 and 60% for new installations from 2018.[11]

The French approach has been very conservative with regard to the use of energy and food crops for methanisation. The restriction on the use of energy crops to just 15% of the feedstock of a methanisation unit[12] goes beyond what is required by the RED[13], and emphasises the focus on utilising waste for bioenergy, to maximise the GHG savings of their operations; maintain support for the agri-food sector; and avoid concerns about land-use change.

The process of 'greening' the CAP, leading to the 2014–2020 CAP reforms, allowed for the consideration of climate change in national agricultural policy (MEDDE, 2016). In particular, the strengthening of sustainability objectives in rural development policy (the 'second pillar' of the CAP) opened the way for rural authorities to access EU structural funds for energy and climate change objectives (European Commission, 2016). The PCAE plan aligns French agricultural development policy with the green CAP reform, and enables the European Agricultural Fund for Rural Development (EAFRD) to engage in the development of agricultural methanisation in rural France.

[10] The sustainability criteria for biomass used for electricity and heat are however non-binding recommendations.

[11] The RED lists standard values for the calculation of GHG savings from typical biomass feedstocks and process in RED Article 19(1).

[12] Decree No. 2016-929 of 7 July 2016 sets maximum supply thresholds on feedstocks for methanisation facilities. Non-hazardous waste installations are only permitted to use food crops or energy crops up to a maximum 15% of the total gross tonnage of feedstock per year.

[13] A study of lifecycle emissions from a range of feedstocks, mixed in variable proportions, indicates that under best practice energy crops can achieve 60–70% GHG savings when they are combined with waste feedstocks in a ratio of up to 30% of the total (ADEME, 2011).

The two aspects of the policy measures aim to reduce emissions both stemming directly from the agricultural sector and indirectly from a range of energy sectors depending on how and which fossil fuels are substituted. In so far as the biogas or bio-methane is used to substitute fossil fuels for electricity generation (often in CHP applications) or district heating, the mitigation effect falls under the EU ETS, while emissions from agriculture, transport and residential heating (from the gas grid) fall under the EU Effort Sharing Decision (ESD):

- ESD: manure management, on-farm fuel substitution for process heating, downstream substitution of bio-methane for transport fuels and residential gas supply;
- ETS: downstream production of heat and electricity directly from biogas in electricity and CHP for district heating, downstream use of bio-methane for electricity and CHP in district heating, and upstream substitution of energy in the fertiliser industry.

Whether an increased share of biogas in electricity generation/district heating can affect EU emissions thus depends on assumptions about the EU ETS as discussed in section 2.3 of the Policy Paper.

5 Impacts of the policy instrument

5.1 Effectiveness

An assessment of the emissions abatement effect and cost effectiveness of France's methanisation policies was submitted to the European Commission in 2017 as part of the obligations to report on national policies and measure for climate change mitigation (MEEM, 2017).[14] The effectiveness of the policies are measured by their effect on emissions, with regard to the aims and targets given in the EMAA plan, specifically the target of installing 1,000 methanisation units on farms by 2020.

According to the assessment the policy measures, including the PCAE, EMAA and the two feed-in-tariffs, made it possible to launch the dynamic development of agricultural methanisation in France: The number of methanisers went from 11 in 2008 to 90 at the end of 2012, then to 267 at the end of 2015. The assessment calculates emission reductions from the installed units up to 2015, and then projects these to 2035, assuming 85 new installations each year.

The assessment finds that an average methanisation unit of the size, type and feedstock profile promoted by these policies, achieves GHG emission reductions of about 2.0 ktCO_2e/year, through the management (via methanisation) of agricultural livestock manure and the substitution of fossil natural gas:

- The avoided GHG emissions per agricultural methanisation unit resulting from the storage and treatment of livestock manure are estimated at 1.7 kt CO_2e/year (ca. 80%).
- The avoided GHG emissions per agricultural methanisation unit resulting from the substitution of natural gas by bio-methane amount to 0.3 kt CO_2e/year (ca. 20%).

Table 3: Estimated emission reductions from France's agricultural methanisation policies (MEEM, 2017)

	Number of installations	Emissions reductions (ktCO_2e)
	Ex-post	
2012	90	180
2013	133	276
2014	185	370
2015	267	534
	Ex-ante	
2020	692	1384
2025	1117	2234
2030	1542	3084

[14] Pursuant to Article 13.1 of Regulation No 525/2013

	Number of installations	Emissions reductions ($ktCO_2e$)
2035	1967	3934

This assessment estimates that in 2015, 267 methanisation units were responsible for emission reductions of 0.53 $MtCO_2e$, of which about 80% resulted from the management of manure and 20% from fossil energy substitution. In 2035, assuming continued growth of the sector, around 2000 methanisation units would then result in the reduction of 3.15 $MtCO_2e$/year from manure management alone. This is equivalent to around half of France's emissions from manure management (6.2 $MtCO_2e$ in 2015) or around 4% of France's agricultural sector emissions at the time. Considering projected sectoral growth to 2035, this estimate is also roughly compatible with the guideline target outlined in the SNBC of 40% of usable excrement to be methanised.

The results were obtained using the following assumptions:

- In the absence of these measures, agricultural methanisation would not have developed in France. This is based on the fact that establishing and operating a methanisation plant needs significant investment and profitability is largely based on subsidies and feed-in tariffs.
- The average generation capacity of an agricultural methanisation unit is 300 kW, which operates for 8,000 hours/year. The average ratio of livestock manure to other feedstocks is one third (33.3%).
- Manure management standard practice (business-as-usual without methanisation) would result in an equivalent amount of methane emissions released to the atmosphere as is produced by the methanisation process. This assumption overestimates the abatement effect, as the methodology does not take into account the methanisation conversion factor (MCF) of standard manure management practice.[15]
- The net reduction of GHG emissions from the substitution of fossil natural gas with bio-methane is 188 gCO_2e/kWh[16] (GRDF, 2015).
- Emission reductions from digestate use substituting synthetic fertiliser, as well as the emission reductions from the methanisation of feedstocks other than manure (e.g. agri-food industry waste otherwise put to landfill) are not included in the assessment, potentially underestimating the overall abatement effect.

However, the methodology of this assessment is simplified and appears potentially flawed on two accounts:

[15] Under standard manure management practices, conditions for anaerobic digestion can be favourable, but not ideal, meaning that only a part of the potential methane is emitted. Methane emissions from manure management depend on factors such as storage practices, storage period and average temperature. Default MCFs provided by the Intergovernmental Panel on Climate Change (IPCC) for temperate countries range from 2% for solid manure storage to 78% for lagoon manure systems, with liquid slurry systems common in France ranging from 17–27% (IPCC, 2006 - Chapter 10, Table 10.17). If one was to include a 27% MCF in the equation, the abatement effect would approximately be reduced to 0.46 kt CO_2e/unit/year for manure management and a total of 0.76 $ktCO_2e$/unit/year (38% of the estimated 2.0 $ktCO_2e$/unit/year). Even allowing for some underestimations related to other 'waste' feedstocks, the actual abatement effect of the policy is likely less than half of that estimated.

[16] This value corresponds to the difference between the emission factor in the lifecycle analysis of the combustion of natural gas (which amounts to 243 gCO_2e/kWh PCI) and the emission factor in lifecycle analysis of bio-methane (which amounts to 55 gCO_2e/kWh).

- The abatement effect of changing from standard livestock manure management practices to methanisation is overestimated — the actual overall abatement effect is likely less than half of that estimated. However, a positive GHG balance is still expected.
- Regarding the projected growth of the methanisation sector, it is assumed to be a linear 85 units per year, which is still not enough to meet the EMAA target of 1000 units by 2020. However, uptake could be even slower; in 2016, 52 new units were installed (MTES, 2017).

Evaluating the abatement effect of these policies in more detail is beyond the scope of this study; however, this should be a priority when considering the cost efficiency of such a policy in the German context.

Overall emission reductions would also be affected by the sector in which the fossil energy is substituted. The current main use in France is for electricity and heat generation, which at least partly fall under the EU ETS. In this case, energy emissions would not necessarily be further reduced as they would fall under the cap of the ETS. Bio-methane use for transport and residential heat is also supported by these measures, and would not be subject to this effect. In any case, according to the assessment, the majority of emission reductions occur through the management of manure and therefore fall under the agricultural sector.

5.2 Cost efficiency

The assessment referred to above also made estimates of the cost effectiveness of the approach in reducing emissions (MEEM, 2017). The costs of agricultural methanisation consist of investment costs and operating costs. These fall both on the farmer and on the public, via investment subsidies and guaranteed purchase price mechanisms. The benefits come not only from the sale and use of biogas and bio-methane, but also from the use of the digestate. Generally, who bears the costs (farmer or state) depends on the level of investment support as well as the difference between market value and guaranteed price. The sector is characterised by a great disparity in investment costs between facilities depending on the scale, the feedstocks used, and the type of technology applied.

The assessment provides the following cost ranges per tCO_2 abated through agricultural methanisation, assuming an average operating lifetime of a plant of 25 years and using the typical investment costs for the establishment of different sized facilities (see Table 4.) These costs include only the investment costs and do not take into account operating costs, or profits from the sale of electricity and bio-methane, heat recovery and digestate use/sale.

Table 4: Cost-effectiveness of France's agri-methanisation policies to reduce GHG emissions (EUR/tCO_2e) (MEEM, 2017)

Installation capacity	35 kW	170 kW	500 kW
Cost per tCO_2e avoided	EUR 56–82/tCO_2e	EUR 46–53/tCO_2e	EUR 30–39/tCO_2e

As a purely climate change mitigation instrument, agricultural methanisation may not seem particularly cost effective, considering the current potential abatement opportunities under the EU ETS at EUR 15/tCO_2e or less. However, cost effectiveness clearly increases with scale, and there is potential for costs to come down as the

sector matures. Taking into account the full range of costs and benefits would also potentially improve the estimation of cost effectiveness. However, as the methodology potentially overestimates the level of abatement achieved, this may also make it more costly than here given. Considering the general technical and political difficulty of reducing emissions in the agricultural sector, and in particular emissions from livestock, this approach represents a concrete measure for reducing those emissions already available with current technologies.

5.3 Co-benefits and side-effects

Although the policy package discussed here effectively reduces GHG emissions, this is not its only objective. The measures are primarily designed to be a sustainable development solution for the agricultural sector, so that emissions reductions are complementary to a range of environmental, economic and social outcomes. The potential co-benefits of the approach, beyond GHG emission reductions, are outlined below:

- Increasing the share of domestic renewable energy in the energy mix, achieving a greater degree of energy independence in the regions and nationally;
- Reducing the dependence of French agriculture on mineral fertilisers, both locally and nationally;
- Reducing the volumes of waste sent to landfills or otherwise managed;
- Positioning French agriculture on a good footing with regard to the ecological transition, thereby enhancing the overall performance of the sector and making it more appealing;
- Minimising the risk of land-use conflicts and impacts surrounding food production, energy, biodiversity etc.;
- Creating value, skills and jobs, particularly for communities in rural areas.

An evaluation of most of these effects is not yet available, and outside the scope of this study. However, the potential co-benefits of the French approach are outlined in a recent report (ADEME, 2017), which also provides a breakdown of the number and type of jobs that have been created in the emerging sector. Based on a survey of 370 biogas facilities in 2013, there were 1,700 jobs in the sector, with around one third directly at the facilities and two thirds in associated activities such as research, design, consultancy, construction and maintenance. The jobs are mainly qualified and non-relocatable: 90% of on-site workers had vocational training and 70% in associated activities had four or more years of higher education. The report also indicates the number of jobs that can be expected, depending on the size and type of facility developed, as a ratio of full-time employment (FTE) to MW of installed capacity (MWe). These are shown in Table 5.

Table 5: Ratio of jobs created per MW of installed capacity and type of methanisation unit installed in France (FTE/MWe). Source (ADEME, 2017)

Agricultural/industrial 250 kWe	7.1 FTE/MW	4.8 FTE/MW
Agricultural/territorial 700 kWe	14.9 FTE/MW	6.7 FTE/MW
Industrial 1 MWe	3.8 FTE/MW	1.4 FTE/MW

Water treatment 1 MWe	14.0 FTE/MW	2.1 FTE/MW
Household waste 1 MWe	49.7 FTE/MW	17.9 FTE/MW

5.4 Success factors and challenges

One of the strengths of the measures is that they are embedded in France's agricultural development policy framework, especially the agro-ecologic project. This puts the renewable energy and climate objectives into a tangible socio-economic perspective, relating them directly to rural jobs, increasing productivity and competitiveness, and the growth of a modern 'green' sector. It favours smaller-scale collective approaches at the territorial level, and engages with local economic and environmental groups. This approach is likely to build stable long-term support among both investors and key stakeholders in provincial France.

The policies are designed to ensure that the bioenergy industry in France remains 'virtuous' by strongly encouraging the use of waste and avoiding the extensive use of energy crops. This is notable in the bonus structure of the feed-in-tariffs, the EMAA plan, and specific regulations. The focus on livestock waste boosts the emission reduction potential of the policies. It also frames them as driving agricultural resource efficiency rather than renewable energy, thereby avoiding food-for-fuel concerns. However, limiting energy crop use will likely slow the rate of sectoral expansion, meaning targets may be more difficult to meet. And even if such crops make up a small portion of feedstocks, growth of the industry will still drive their overall expansion.

The policies are nested in France's climate and energy strategy, which is integrated across sectors and has clear targets and guidelines. Considering France already has low-carbon electricity, the emphasis on bio-methane injection and bio-NGV in the country is consistent with multiple objectives, and is a laudable strategy for reducing emissions in the transport and residential heat sectors. This was stressed in the recent conclusions of the 'Methanisation Working Group' of the Ministry for Ecology that found bio-methane injection for transport should be favoured over its use in the electricity sector (MTES, 2018).

A final success factor is that the government maintains a degree of control over the development trajectory of the sector: it sets the strategy and the criteria for investment support, the research and development agenda, the stakeholder engagement process, and more practically it controls the tender process for establishing new installations, particularly the larger capacity units.

There are technical challenges that need to be overcome to allow the sector to develop in a way that is innovative, creates added value, and lowers costs of production over time. Areas with potential are microbiological research, technical equipment and the development of marketable fertiliser products from digestate (ADEME, 2017). Such challenges can also be considered opportunities.

If the policy instruments are successful, then the overall cost of the feed-in-tariffs is likely to rise quickly in line with the number of new installations and stay around for a long time (15–20 years guaranteed purchase rates). This poses two main challenges: First, there is the challenge of maintaining the correct level of the tariff schemes over time to balance stability for investors with incentives to be competitive and ensure that costs eventually fall in line with sectoral innovation. Second, as it is the public paying the extra costs, communicating the benefits of the policy will be important to maintain their backing. Steady increases in the carbon price in those sectors where biogas substitutes fossil fuels will make biogas and bio-methane relatively more competitive and closer

to market parity. The EU ETS currently imparts a carbon price on some of these sectors, such as electricity and central heating. To maximise this effect, however, carbon pricing would also need to be expanded in the non-ETS sectors, in particular transport and residential heating, which is also part of the country's broader climate strategy.

6 Transferability

6.1 General comparability of the context

In Germany, bioenergy policy has been shaped by the context of the 'Energiewende', the desired phase-out of nuclear and fossil energy and its substitution with renewable energy sources. Thus, unlike in France where bioenergy has been primarily pursued as a waste management and agricultural policy (see chapter **Error! Reference source not found.**), the energy policy context has been dominant in the German context.

With the Renewable Energy Law (Erneuerbare Energien Gesetz, EEG) of 2000, replacing the prior established Power Injection Law (Stromeinspeisungsgesetz) of 1991, using biomass to generate electricity became heavily subsidised, with initial feed-in tariffs for energy from renewable energy crops of 8.70 – 10.23 EUR cent/kWh and a 'Nawaro' bonus for electricity from re-growing resources. This set the sectoral development trajectory in Germany and stoked the food-to-fuel debate across Europe.

Germany initially set strong incentives to prioritise biomass use for electricity generation, with laws focused on its use in the transport and heating sectors in 2006 (Erneuerbare-Energien-Wärmegesetz) and 2008 (Biokraftstoffquotengesetz), respectively. This focus in Germany on using biomass for power is also present for bio-methane, with over 90% of the identifiable bio-methane being used for cogeneration in CHP, 3.5% solely for heat supply, and about 4% in the transport sector (Fachverband Biogas, 2017). Importantly, CHP — while also covering heat — falls under the EU ETS, reducing the impact that bio-methane currently plays in reducing Germany's ESD sector emissions.[17]

A related difference that affects comparability and explains some of the difference is the stark difference in the carbon intensity of electricity supply. France's low-carbon power sector makes using bio-methane for electricity ineffective as a decarbonisation strategy while Germany's high carbon intensity combined with a high share of intermittent renewables profiting from a dispatchable counterpart makes the use for electricity generation relatively far more attractive.

The agricultural sector is identified as the primary source of methane emissions in Germany (53%), with emission reductions thus far having been achieved through the reduction of animal populations in former Eastern Germany after reunification (UBA, 2018a). In France, the slow but steady decline in agricultural emissions since 1990 has also mainly been the result of structural changes resulting in fewer livestock.

Germany is already on the way towards an expanded use of livestock manure for bioenergy, and in this respect is much further advanced than France. According to a recent study, in 2016, manure made up 41% of total biogas production feedstocks in Germany when measured by mass, yet only 12% when measured by energy content (Daniel-Gromke et al., 2018). The total use of manure is estimated at 51 Mt, or around 25% of Germany's total manure production from livestock (see Table 6). Based on figures cited in this study, this is equal to about 22 PJ

[17] Indirectly, insofar as bio-methane supply increases the share of CHP, there is the possibility that heat from these plants substitutes distributed fossil heating in the ESD sector.

of energy (both electricity and heat) that was gained from manure in 2016[18]. Energy crops were still the dominant feedstock in 2016, accounting for around 51% of the mass and 78% of the energy content (ibid, 2018).

Not all manure collected can be economically used. However, while a substantial amount of German livestock manure is already being methanised, there still seems to be significant potential for expansion. For example, while around 17–20% of manure is currently used in Germany,[19] the French climate policy sets a target of 40%; the structural similarities between the French and German agricultural sectors indicate that this target would also be viable here. The potential for expansion can also be inferred from a study of the bioenergy potential of German livestock manure that projects a total of 69 PJ/year of bioenergy could be gained from manure feedstocks in 2020 (Seyfert, Bunzel, & Thrän, 2011). When compared to the estimated 22 PJ in 2016 (32% of the potential), this further indicates that there is still significant potential for biogas and emission reductions.

While the main development in German manure-to-biogas plants took place between 2004 and 2012, i.e. during the boom in German biogas development, the use of manure has more recently been emphasised via changes in the EEG in 2012 and 2014[20]. These changes reformed the tariff structure away from energy crops and introduced a new special tariff for small (<75 kW) biogas plants using at least 90% manure as feedstock. The number of such small plants has grown since 2014 to around 560 and small plants represent the main growth in biogas capacity since 2012 (Daniel-Gromke et al., 2018). However, the overall increase in bioenergy capacity in this period is relatively low. The emphasis on small, decentralised plants reflects the logistical challenges of transporting manure across the country. However, there is also extensive use of manure in other larger biogas plants, mixed primarily with energy crops, at a share of 80% or less of manure, with the number of agricultural-based methanisation plants using at least 30% manure estimated at between 5100–6200 (out of an estimated 8200).

Both the progress and the potential of Germany's manure-to-biogas operations can also be seen in Germany's National Inventory Report to the UNFCCC (UBA, 2018b). In 2016, GHG emissions from manure management (CH_4, N_2O and Ammonia, N_3) totalled around 10 MtCO2e, with CH_4 emissions contributing around 6 MtCO2e or 60%. The methanisation of manure is calculated to already have a significant abatement effect, with around 1 MtCO2e additional emissions avoided. This abatement effect grew steadily between 2005 and 2013, but then levelled off,[21] reflecting the overall growth in biogas plants over that period, as well as the relatively slower growth in the sector since the reform of the EEG.

[18] This represents 12.4% of the total energy generated from biogas and biomethane in 2016 (6.16 TWh out of a total of 49.67 TWh, comprised of 32.37 TWh of electricity and 17.3 TWh of heat energy).

[19] Germany's National Inventory Report gives a weighted average of 17% of (stored) manure being digested in methanisation plants in 2016 (UBA, 2018b, see Table 238, pg. 457). However, in Germany's Seventh National Communication to the UNFCCC, a target of 30% manure utilisation is indicated by 2025, with the EEG as the driving policy (BMUB, 2017, see section 4.3.10.3).

[20] Articles § 27b EEG 2012 and § 46 EEG 2014

[21] See UBA 2017, page 483, section 5.3.2.2.3, table 274

Table 6: Key indicators to assess comparability of the bio-methane context in Germany and France

	Germany	France	Comparability
General			
Primary context of bioenergy development	Renewable energy policy	Agricultural (mitigation) policy	**Not comparable**, different foci and dominant framing.
Features of the agricultural sector			
Livestock manure production (per capita), in 1000t per annum (Foged et al., 2012)	202,013 (2.4 t/capita)	263,264 (3.9 t/capita)	**Roughly comparable**, higher availability in France
Features of the energy system			
Share of intermittent sources in the power mix (increasing the value of dispatchable bio-electricity)	18	6	**Not comparable**, already much higher value in Germany for balancing of intermittent energy sources, will likely become higher.
Carbon intensity of the electricity supply	485	66	**Not comparable**, French electricity about seven times lower-carbon than Germany
Main sources of heating fuel (DIW Berlin and EEFA, 2016) (IEA, 2017)	Electricity (19.3%) Natural gas (39.9%); Oil/Petroleum (19.4%);	Electricity (34.4%); Natural Gas (28.9%); Oil/Petroleum (16.6%)	**Roughly comparable**, French heating supply is lower carbon but still large abatement potentials from replacing natural gas

6.2 Properties of the instrument

As discussed under Sections 4.1-4.3, the instrument consists of several components: feed-in tariffs for CHP and for bio-methane injection into the natural gas grid, as well as investment subsidies that incentivise the energetic usage of agricultural residues and the purification to methane across different decision contexts.

Many of these policy instruments exist in similar form in Germany and it would be possible to reform the German system in a way to more closely mirror the French context, i.e. (a) relying more strongly on bio-methane from agricultural waste rather than energy crops, and (b) more strongly incentivising injection into the natural gas network and reducing incentives for using bio-methane to generate electricity.

However, in the French context, the instruments are nested within the context of the agro-ecological transition, which frames the policies within agricultural reforms. While such a shift towards sustainable agriculture is also taking place in parts of Germany, there does not seem to be the same integration of the energy transition and local sustainability goals.

Biogas in Germany generally enjoys significantly less public support than solar and wind. For example, a representative survey from 2016 found only 56% of people living close to a biogas plant evaluating biogas as 'good' or 'very good', with 69% and 90% for onshore wind and solar, respectively. As such, the perception of biogas was much closer to that of conventional fossil gas, 40% (16-point differential), than to the most popular renewable option (solar, 36-point differential) (Agentur für Erneuerbare Energien, 2016).

More broadly, given concerns about environmental impacts, the time-scale of true carbon neutrality, and the potential competition with food production, public debates about bioenergy tend to be significantly more controversial than those surrounding wind and solar, where the negative effects are more abstract (intermittency, cost) or concentrated in locations outside Germany (material intensity, production conditions, waste streams).

For bio-methane from livestock manure and other waste, many legitimate concerns with other forms of biomass are not applicable. Yet it is not clear whether public debate features this degree of nuance and whether there could be significantly more support for bio-methane from these sources than from energy crops. The multiple co-benefits of this approach mean there is potential to build support from a range of stakeholders who would not typically engage in climate and energy concerns, such as rural populations, livestock farmers and district waste management agencies

From an energy-decarbonisation perspective, bio-methane from agricultural residue is not essential, as even the maximum potential it can achieve will only satisfy a relatively small part of estimated German demand for zero-carbon gas (Agora Energiewende, 2018). This makes it unlikely that strongly climate-oriented groups will prioritise bio-methane over advocacy for other techno-economic pathways with higher overall potential (such as power-to-gas technology). It also points to the ultimately stronger arguments for bio-methane likely resting with reducing agricultural emissions and short-term energy emission reductions rather than a long-run deep decarbonisation perspective.

In terms of likely policy windows, the unfolding discussion about Germany's 2020 climate targets opens a window of opportunity to discuss approaches that have received less attention in the past, such as an increased focused on methanisation of agricultural residues. With sector-specific targets of the German Climate Action Plan (Klimaschutzplan), the monitoring of agricultural emissions and reactions to deviations from a trajectory

consistent with sector-specific 2030 goals provides another opportunity for the strengthening of bio-methane policy. In its current short description of agricultural policies to achieve emission reductions (BMUB, 2016), the limited abatement potential in agriculture is stressed, with measures described focusing on N_2O and goals for lowering fertiliser utilisation, leaving the energetic use of agricultural residues undiscussed.

Another policy window will likely arise as both domestic and European level regulations drive the transition away from first-generation biofuels. With the RED limits on food and energy crops for bioenergy, current sustainability criteria and feedstock limits mainly apply to the production of biofuels. However, it can be expected that these will, in practice, put increasing stringency on the production of other forms of bioenergy, and eventually require biogas producers to reduce their dependence on energy crops. The substitution of energy crops with waste and manure feedstocks will therefore be required in Germany to avoid a drop in bioenergy capacity, both due to the reduction in viable feedstocks and as feed-in tariffs for first-generation producers eventually expire.

6.3 Potential impacts

In terms of impacts of a similar policy in Germany it can be differentiated between impacts on agricultural emissions and other impacts in the agricultural sector, as well as impacts on Germany's energy supply. It is important to consider that while there is more variation in the potential energetic use the primary mitigation effect of the instrument stems from the reduction of agricultural emissions.

Given that the fundamentals of animal agriculture are comparable in France and Germany and are heavily influenced by the EU's CAP, it is likely that bio-methane policy would have comparable impacts on reducing agricultural emissions in both countries. However, the feasibility of implementation in Germany would depend on the availability and distribution both of potential feedstocks and existing methanisation facilities. The positive effects on agricultural livelihoods and rural development should also be comparable in Germany and France.

Germany is among the largest natural gas importers in the world and natural gas is a highly useful fuel in the context of the German Energiewende (reducing coal, flexibly dispatchable and storable form of energy (Agora Energiewende, 2018)), i.e. the economic and environmental value of bio-methane as a low-carbon renewable natural gas is high. At the same time, bio-methane from agricultural residue would by far not be sufficient to meet Germany's natural gas demand, thereby only marginally increasing energy security.

Whether and by how much the increase of bio-methane reduces emissions in ESD sectors beyond agriculture, depends on (a) whether it is used for electricity, CHP or district heating (under the EU ETS) or distributed heating and transport (under the ESD) and (b) whether, if under the ESD, it substitutes synthetic gas from power-to-gas, fossil natural gas or even coal or oil. In France, it is estimated to save 188 gCO_2e/kWh based on assumptions that fossil natural gas is substituted (GRDF, 2015); effects are more than doubled when replacing lignite rather than natural gas so that the effect could be about 280 gCO_2e/kWh.[22] This would be under the EU ETS and the value of the reductions depend on whether one perceives the EU ETS cap as fully fixed (see section 2.3 of the Policy Paper).

Beyond methane emissions and the production of bioenergy, the French approach has the potential to promote broader resource optimisation, which may also have a mitigating effect on emissions. Particularly the concerted

[22] This is an indicative figure as giving a precise calculation is out of scope of the study as it concerns electricity substitution in the EU ETS.

effort to develop and market nutrient-rich digestate materials has the potential to reduce the production of synthetic fertilisers, thereby reducing energy related emissions from the fertiliser industry. The nutrient optimisation approach also has implications for broader nitrate policy, with potential impacts on GHG emissions of N_2O and N_3. However, the effects are unclear and will depend on other local technical and policy interactions, related, e.g., to fertiliser application techniques and regional environmental policy.

6.4 Conclusion

French bio-methane-policy, a combination of measures aimed at incentivising the capturing of agricultural waste (manure) and using it energetically through methanisation, has two climate-relevant components: 1) reducing agricultural emissions, and 2) replacing fossil fuels. Of the two, the agricultural emission reductions are generally more significant than avoided energy emissions by replacing fossil combustion. This is especially true in the French context given its low-carbon energy supply, however it also holds in the German context.

The agricultural sectors of France and Germany are sufficiently similar to expect a similar emission reduction effect from increased methanisation of manure in Germany. Germany is more advanced than France in its use of methanisation in the agricultural sector, albeit with a strong dependence on energy crops. Manure and other agricultural residue is already well utilised in Germany, although there seems to be significant potential to expand its use, especially with a primary focus on agricultural emission reductions from manure management. The existence of similar technical knowledge and policy measures in Germany could provide a starting point for transferring selected aspects of the French approach to the German context.

While not the cheapest mitigation option, French bio-methane policy provides an effective example of reducing sector-specific agricultural emissions, in a sector usually considered hard-to-decarbonise. The main advantage of the French approach, and thereby potential for transferability to Germany, lies in the comprehensive framing of the policies within broader sustainability goals related to nutrient optimisation, rural development and agricultural reforms.

Several barriers to transferability exist. In the German context, the upscaling and utilisation of bioenergy has generally occurred within the context of the Energiewende, prioritising energetic use over emission reductions. As such, Germany's biogas sector and accompanying policy is largely focused on utilising energy crops and livestock manure for power generation, whereas French policy is much more strongly focused on waste reduction and agricultural development. In addition, Germany's utilisation of bio-methane, in particular, is strongly focused on CHP (in EU ETS sectors) rather than injection into the natural gas grid for distributed heating or transport applications (in ESD sectors).

There are significant differences in the power sector of the two countries that help explain the differences in political economy and policy focus to date. One is focused on low-carbon baseload sources (e.g. nuclear and hydro) and the other on a mix of high carbon sources combined with intermittent low-carbon sources (e.g. coal, wind and solar). The policies so far make sense within the context of each country. However, there may be opportunities to expand the role of bio-methane within the German context, and therefore lessons may be learned from the French approach.

Regardless of the variation in preferred energetic usage patterns, increasing the methanisation of livestock manure, together with other waste and residual streams, provides an effective pathway towards reducing agricultural emissions as part of the ESD sector.

7 References

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