Agricultural biogas in France

KEY CHARACTERISTICS

GEOGRAPHIC SCOPE

POLICIES TARGETING

- Improve energy efficiency of farms
- Support production of renewable energy
- Support the market for biogas

KEY RESULTS

Between 2010 and 2015 the number of biogas plants increased from 32 to 267

By 2015, total avoided emissions from use of agricultural biogas of 534 $ktCO_2eq$

KEY PERFORMANCE METRICS

	NUMBER OF BIOGAS PLANTS	EMISSIONS AVOIDED ($KTCO_2EQ$)*
2010	32	64
2011	47	94
2012	90	180
2013	138	276
2014	185	370
2015	267	534

*Avoided emission by storage and treatment of agricultural livestock manure and by substitution of fossil energies (directly related to the exploitation of the installation).

SUCCESS FACTORS

- Comprehensively framed within broader sustainability goals related to nutrient optimisation, rural development and agricultural reforms
- Integrated policy framework with feed-in tariffs still available for small scale plants
- Multiple benefits to the farmer - sale of electricity and biomethane; recovery and utilisation of heat; utilisation of the digestate as a replacement for fertiliser
- Use of agricultural rest streams (e.g. reuse/recycling of by-products from production)

IMPLEMENTATION & REPLICATION PROCESS

Develop at national level an integrated set of policies to encourage agricultural biogas production

Implement at regional level, with fine tuning

Needs significant adaptation to local situation, if considering replication

Agricultural biogas promotion in France

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This case study is part of a series of six studies which show good practice examples for reducing greenhouse gas emissions in the sectors covered under the Effort Sharing Legislation. It has been developed under a contract for the European Commission, DG Climate Action.

A combination of four policy measures in France produces a package to stimulate the production of renewable energy by farmers. This is through production of biogas and ensures the purchase of the renewable energy generated.

Central to the scheme is anaerobic digestion, a technology for the degradation of agricultural biomass (especially manure, see figure below) and (external) organic matter. This allows production of biogas that can be valorised as renewable energy.

1 Overview of the Case Study

1.1 Description of Case Study

The production of biogas through anaerobic digestion (AD) of manure and other agricultural feedstocks such as energy crops or crop residues is one route to renewable energy. Anaerobic digestion takes these inputs and, in the absence of oxygen, creates methane (CH_4) and a digestate as a solid output. The primary route used to generate GHG savings is through capturing the methane and then combusting it in an associated engine for the production of electricity and low-level heat, both of which can be utilised. The digestate can be utilised as a fertiliser replacement, offering further GHG savings (N_2O and CO_2) related to fertilizer production. Alternatively, the biogas can be processed into biomethane and inserted into a gas grid to replace natural gas. This latter option is becoming increasingly popular.

The European Biogas Association (EBA) highlights the following benefits of AD (2011):

- It is the only fully established technology for a renewable energy source that can produce heat, steam, electricity and vehicle fuel
- Biogas can be produced from a great number of organic substrates
- If the substrate is properly selected, the digestate serves as an excellent fertiliser and soil improver of high quality, replacing mineral fertiliser.

In France there are four national level measures to promote the national biogas market. The European Environment Agency (EEA) identified these four policies and grouped them together into one scheme described as “Support Measures for Agricultural Biogas (SMAB)” in their literature (EEA database EEA#110, France). The combination of these four measures, described collectively as SMAB from here on, is the focus of this case study. It is important to realise that ‘SMAB’ does not actually exist as such in France, it is the grouping described by the EEA. The EEA# relates to the measure in the EEA database. The four separate measures are:

- Purchase rates for renewable electricity and high efficiency co-generation (PRC); EEA#2
- Purchase rates for bio methane injected into gas networks (PRI); EEA#4
- Farm competitiveness and adaptation plan (PCAE); EEA#73
- Energy Plan Biogas from Nitrogen (EMAA); EEA#74.

The development of AD biogas plants in France started later than in frontrunner countries such as Denmark and Germany. The number of agricultural biogas plants in France increased from 32 in 2010 to 90 at the end of 2012, and then to 267 at the end of 2015 (Rapport 2017 de la France en application de l'article 13.1 du règlement 525/2013).

The four individual policies that comprise the SMAB are described here individually:

Purchase rates for renewable electricity and high efficiency co-generation (PRC) and **Purchase rates for biomethane injected into gas networks (PRI)** have the aim of increasing renewable energy production in France.

The purchase rates for biomethane have further supplementary objectives. These are to enhance CH_4 collection and use, and improve animal waste management systems to optimise overall emission reductions. Central to these two measures is the obligation for public networks to purchase all energy supplied to the network at agreed prices, i.e. an economic incentive for the producer. The purchase rates are generally established by one of two mechanisms: Fixed Feed-in tariffs offer payments independent from the market price. Feed-in premiums on the other hand depend on the market, offering a constant or sliding scale payment above the market price.

Feed-in tariffs for biogas to electricity and heat, together with co-generation, were implemented in France in 2001. In 2016 the policies were updated through the introduction of the Law on Energy Transition for Green Growth (LTECV) to comply with EU regulations. Currently the financial support arrangements are split into three levels, depending on the size of the plant, with the level of support being greatest for the smallest installations (Annex 1, Arrêté du 13 décembre 2016 biogaz)[1]:

- Biogas plants with a capacity of less than 80 kW: feed-in tariff of 17.5 EUR ct per kWh
- Biogas plants with a capacity of less than 500 kW: feed-in tariff of 15 per EUR ct kWh
- Biogas plants with a capacity of over 500kW: open tendering for the selling price with feed-in premiums.

For biomass plants with a generating capacity above 500 kW, the feed-in tariffs were replaced by feed-in premiums as part of the updates in 2016. The values for biogas plants between 80 kW and 500 kW are calculated by linear interpolation. An additional bonus of 5 EUR ct per kWh is provided for biogas plants using at least 60% livestock manure as their input. The feed-in tariffs for biomethane injection were established in 2011 (Vidalic, 2019).Producers can sell biomethane between 6.4 and 12.5 EUR ct per kWh for AD depending on the maximum production capacity and the type of waste recovered. Waste premiums promote the recovery of waste from agriculture (including intermediate crops intended for energy) and agrifood industries (Bastide, 2015).

From 1 January 2018 the feed-in tariff decreased quarterly by 0.5%. The duration of feed-in tariff payment for biogas energy generation is set at 15 years for small plants, and 20 years for larger plants (art.10, Arrêté du 13 décembre 2016 biogaz).

A new system known as "dual recovery" has just been set up. This allows biogas producers to simultaneously recover their production in the form of electricity and biomethane injected into natural gas networks, by granting them the double benefit of the existing tariff support systems for the production of electricity from biogas and for the production of injected biomethane[2].

Farm competitiveness and adaptation plan (PCAE) has been in operation from 2014 (Ministère de l'Agriculture et de l'Alimentation, 2020). PCAE covers a broad farm investment support plan and deals with a range of issues on farm competitiveness and adaptation. It does not directly aim at climate change or greenhouse gas emissions other than through energy use efficiency improvements. The plan covers within its topics ammonia (NH_3) emission reduction, enhancing the fertilizer value of the manure through cover of manure pits, and reducing the need for additional mineral fertilizer application. The measure provides economic incentives with an average subsidy of 38% on investments as well as various fiscal aids (Allaire and Dupraz, 2017).

PCAE also covers investments for agroecology for the development of legume crops and fodder autonomy ("vegetable protein plan"), integrated into "the agro-ecological project". This project encourages innovation and the transition to new production systems, through considering several aspects (economic, environmental, and social) by promoting research, training and communication on agro-ecology.

Energy Plan Biogas from Nitrogen (EMAA) was launched in March 2013 (and entered into effect in 2014) to complement PCAE (République Française, 2013) . Its aims are to: optimise the purchase price for

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[1] For more information see:
https://www.legifrance.gouv.fr/affichTexteArticle.do?idArticle=JORFARTI000033585286&cidTexte=JORFTEXT000033585226&categorieLien=id
[2] Romain Cresson, personal statement

electricity produced from biogas; simplify administrative procedures for the development of anaerobic digestion projects; and to provide better support for project promoters and efforts to structure the sector.

The intention is to decrease losses of nitrogen to the environment. It is expected that the digestate from AD plants can partly replace the use of artificial fertilizer on arable land. The effect will be a net reduction of the total GHG emissions because of more efficient energy use in the production of nitrogen. If focussed only on nitrate and ammonia (NH_3), the indirect emissions of N_2O may decrease yet the direct emissions of N_2O may not be changed.

The four national level policies of the SMAB measures are implemented at the regional level. Two of the policies (PCAE and EMAA) are broad schemes, not only focussing on climate adaptation and mitigation but also on farm competitiveness and rural development. Details of the arrangements are set by the regional authorities. Individual farmers or farmer groups can voluntarily opt for the support measures in the Rural Development Plans (RDPs). The assigned annual budget of 200 million EUR for the period 2014-2020 was increased up to 350 million EUR (with 150 million EUR from a livestock support plan) in September 2015.

As a basket of measures is offered to farmers from which they can choose, the share allocated to support AD biogas production is not clear beforehand. The two further SMAB policy measures (PRC and PRI) support the biogas technology more directly through mandatory purchase prices. These regulations not only apply to the agricultural sector but also to biogas production from landfill, sewage and other non-agricultural sources.

1.2 Primary objectives of the scheme

The objectives of the French "Support Measures for Agricultural Biogas (SMAB)" are wide, with each measure having been described in detail above. Overall, the SMAB has implications for the rural economy, waste disposal, renewable energy, and security of energy supply.

Aims of the measures that are of interest here, in summary, are to:

- Improve the overall energy efficiency of farms and farm buildings;
- Support the reduction of CH_4, NH3 and N_2O emissions from manure, through improved waste management systems and through the collection and utilisation of CH_4;
- Support a direct application of digestate from manure, and reduction in use of fertiliser, to crop land;
- Support the production of renewable energy and the market for biogas through stimulating small AD installations by providing incentives for their creation, construction and confirmed prices for production of the energy generated;
- Support French farmers in accessing EU funding (CAP) for food production in environmentally safe and sustainable ways.

Although the SMAB measures address GHG emission reductions in the agricultural and energy sectors mostly indirectly, they can have a significant effect on such emissions.

1.3 Eligibility criteria and target groups

The SMAB applies to individual farmers or farmer groups who are willing to voluntarily invest in biogas plants. To comply with EU regulations, support through the mechanism of fixed feed-in tariffs is limited to smaller scale biogas plants. In France biogas production is eligible for feed-in tariffs with the following restrictions (Vidalic, 2019:

- The plant shall produce biogas through the (AD) of non-hazardous waste and raw vegetable matter (such as manure from farms)
- The installation shall be in continental metropolitan France (i.e. not the overseas parts)
- The installed capacity of the plant shall be less than 500 kW.

Larger plants are supported through the mechanism of feed-in premiums and through tenders for the definition of the premium tariff level. This applies not only to producers from the agricultural sector, but also to other suppliers of biogas. AD with co-fermentation of energy crops is specifically discouraged, by providing a bonus to plants with at least 60% manure input (Banja et al, 2019) and by putting a cap of 15% on the amount of energy crops allowed (Renewable gas. French panorama 2017).

1.4 Key actors involved in the delivery of the scheme

The key actors in the scheme are the individual farmers, farming cooperatives investing in biogas production and the purchasers of biogas. Furthermore, regional development agencies, as the administrators of these schemes, are heavily involved in the day to day running of the scheme. In addition, regional electricity networks benefit from the output of the systems into the local electricity supply, increasing the network level of renewable energy and potentially enhancing security of supply.

1.5 Interaction of schemes with instruments

As explained above the SMAB itself comprises several government policy programmes, government plans and strategies interacting with each other.

The SMAB policy measures interact with several national policy instruments in France such as the Agro-ecological project, the Economic and Environmental Interest Groups for agricultural holdings (GIEE), and the LTECV and the Ambition Bio Plan 2017. These policies seek an integrated approach for the great challenges of the agricultural sector in applying and enhancing agroecological principles. In their action plans they also make reference to the SMAB policy measures.

Tax benefits are also available. Generation of heat through renewable energy plants is promoted through several energy subsidies and tax regulation mechanisms as well as through a loan with zero percent interest.

1.6 Previous experiences and background to the case study

France's climate policy was initially spurred by France's entry into the United Nations Framework Convention on Climate Change in 1992 and its subsequent ratification of the Kyoto Protocol in 1998. Since then, there have been several iterations of climate law, culminating in the Energy Transition Act (The Energy Transition for Green Growth Act in France (*Loi relative à la transition énergétique pour la croissance verte – LTECV*, Hölscher et al., 2018).

One of the main benefits of the LTECV is that it consolidates the quite scattered energy and climate policy governance into an integrated framework for the energy transition (Hölscher et al., 2018; IEA, 2017). Prior to the adoption of the LTECV, the French governance framework was characterised by a multitude of overlapping and complex regulations, pursuing different objectives over various timeframes (Hölscher et al., 2018). The measures to support purchase rates PRC and PRI are addressed by LTECV and its precursors, and now specifically provide guaranteed purchase prices for electricity produced from biogas and biomethane injected into the natural gas network.

Specifically for the agricultural sector, PCAE and EMAA were developed from the Energy Performance Plan (PPEEA, République Française, 2009). This was launched in February 2009 by the Ministry of Agriculture, with the objectives of: improving the overall energy efficiency of farms; and supporting the production of renewable energy and financing equipment such as biogas plants. It was replaced in 2014 by the plan for the competitiveness and adaptation of farms (PCAE, Ministère de l'Agriculture et de l'Alimentation, 2020). The "nitrogen biomethane anaerobic energy" (EMAA) plan was launched in March 2013 to complement these measures. It provides for optimization of the purchase price for electricity produced from biogas, simplification of administrative procedures for the development of anaerobic digestion projects, better support for project promoters and efforts to structure the sector.

2 Implementation

2.1 Drivers and key actors for setting up the scheme

The SMAB policy measures were set up in conjunction with various levels of French government over several years to comply with renewable energy, effort sharing and LULUCF legislation.

Table 1 shows the four different measures contained in the scheme, the status of implementation, start and finish dates and the responsible authority.

Table 1: Implementation characteristics of the measurements

Measure abbreviation	Measure Title	Status	Start	Finish	Responsible for implementing the policy
PRC	Purchase rates for renewable electricity and high efficiency co-generation	Implemented	2001	Not set	Ministère en charge de l'énergie (National Ministry of Energy)
PRI	Purchase rates for bio methane injected into gas networks	Implemented	2011	Not set	Ministère en charge de l'énergie (National Ministry of Energy)
PCAE	Farm competitiveness and adaptation plan (PCAE)	Implemented	2014	2020	Conseils régionaux (Regional councils)
EMAA	Energy Plan Biogas from Nitrogen (EMAA)	Implemented	2013	Not set	Ministère de l'Agriculture (Ministry of Agriculture)

The four policy measures that combine to make the SMAB were developed from 2001 and modified and extended in 2013 and 2014.

The PRC support measure followed 3 years after French ratification of the Kyoto protocol in 1998. It took another decade to implement the other support measures mentioned.

2.2 Lessons to be learned from the scheme development and initial stages of implementation

France was an early adopter of AD technology in the 19th century (Marchaim, 1992). Modern commercial applications of AD technology were developed primarily in Denmark and Germany after the energy crisis of the 1970s (Lybaek et al., 2017). At the beginning of the 21st century AD technology was strong particularly in Germany (Theuerl et al., 2019) where more than 8,000 biogas plants were in operation by 2012, thanks to favourable subsidy schemes at that time. After 2012 when parts of the support scheme were heavily criticised (especially the co-digestion of energy crops) the subsidies became less attractive and the number of biogas plants in Germany stabilized at around 9,500 by the end of 2018.

However, the success of AD in Germany was also controversial due to medium to high mitigation costs compared to other renewable sources and the food versus fuel debate (Theuerl et al., 2019). Potential methane leakage from AD plants is also disadvantageous for the GHG balance when energy crops or residues (which normally do not decompose/degrade into methane) are used as a feedstock (Clemens et al., 2012; Liebetrau et al., 2017). The French scheme tries to avoid these disadvantages by using other types of renewable sources as feedstock for the co-digestion, especially intermediate crops. Intermediate crops are grown between two main crops to prevent leakage of nutrients and to preserve preferable soil conditions. As such they do not compete with food crops like dedicated energy crops tend to do.

The SMAB strategy is intended to support farmers in taking sustainability measures and in maintaining a vital rural area. From this perspective it is important to consider these integrated measures with the vitality of agriculture and liveability of the countryside.

A key observation is that feed-in tariffs are preferred by farmers over feed-in premiums because those offer a long lasting high level of support coupled to a low level of risk. This factor is very important as most farmers are quite risk-averse (Burrel, 2010). This means that fixed purchase rates for a long period are necessary to persuade farmers to invest in small scale biogas plants.

A lesson learned here is the need for a more flexible electricity market. An important change during SMAB development was introduced by the Act on Energy Transition in favour of a more flexible electricity market in France, in accordance with EU regulation. Renewable energy producers are no longer obliged to sell their electricity exclusively to the national electricity suppliers. The regulation extends the management of the purchase obligation of electricity to operators other than EDF or local distribution companies (Art. L314-6-1, Code de l'Énergie). The first supplier to have obtained an accreditation in October 2016 was Enercoop, a cooperative supplier providing energy from 100% renewable sources. However, this accreditation, which entered into force on 1 January 2017, is limited to 75 purchase contracts for a maximum installed capacity of 100 MW.

2.3 Adjustments made during the scheme

As mentioned above, adjustments have been made during the existence of the SMAB policy measures. Some of these respond to the needs of the policies, while others are in response to changing legislation at the EU level. Although the EU is in favour of feed-in premiums instead of (fixed) feed-in tariffs, the current support framework in France still provides for small installations or non-mature technologies to benefit from feed-in tariffs. Changes include:

- A maximum scale of installation (500 kW) eligible for funding;
- The feed-in tariffs have been adjusted throughout the scheme;
- A more flexible electricity market in France - renewable energy producers are no longer obliged to sell their electricity exclusively to the national electricity suppliers;
- The amendments to the Renewable Energy Directive (RED) in terms of addressing indirect land use changes for energy crops and biofuels and limiting the amount of food crops used as renewable energy sources has implications for this scheme[3].

[3] For more information, see: RED, RES directive 2009/28/EC and RES recast, RED II, (Directive 2018/2001)

3 Assessment

The EU policy on energy promotes new and renewable forms of energy because the market does not provide optimal levels of renewables in the absence of public intervention[4]. In 2009 the EU introduced the RED with its original target of 20% of energy from renewable sources by 2020. In 2016 the target was raised to 32% by 2030 through RED II. This 32% target is part of the 2030 climate & energy framework which also targets a 40% cut in GHG emissions (from the 1990 level) and at least 32.5% improvement in energy efficiency. GHG emissions are addressed by the EU ETS (emission trading system) for large scale energy users and by the Effort Sharing Regulation (ESR), which has a target of a 30% cut of GHG emissions by 2030 compared to 2005 at the EU level for most non-ETS sectors (transport, buildings, agriculture and waste).

Biogas plants operating in the agricultural sector (see Figure 1) contribute in a number of ways to these targets – through avoided emissions from manure, through replacement of fossil fuels with renewable biogas for electricity heat and potentially upgrading the biogas into biomethane for the transport sector.

3.1 Successes

The complex and interlinked nature of the French SMAB policy measures means that it is challenging to evaluate every aspect of the policy aims, and whether they have been fulfilled.

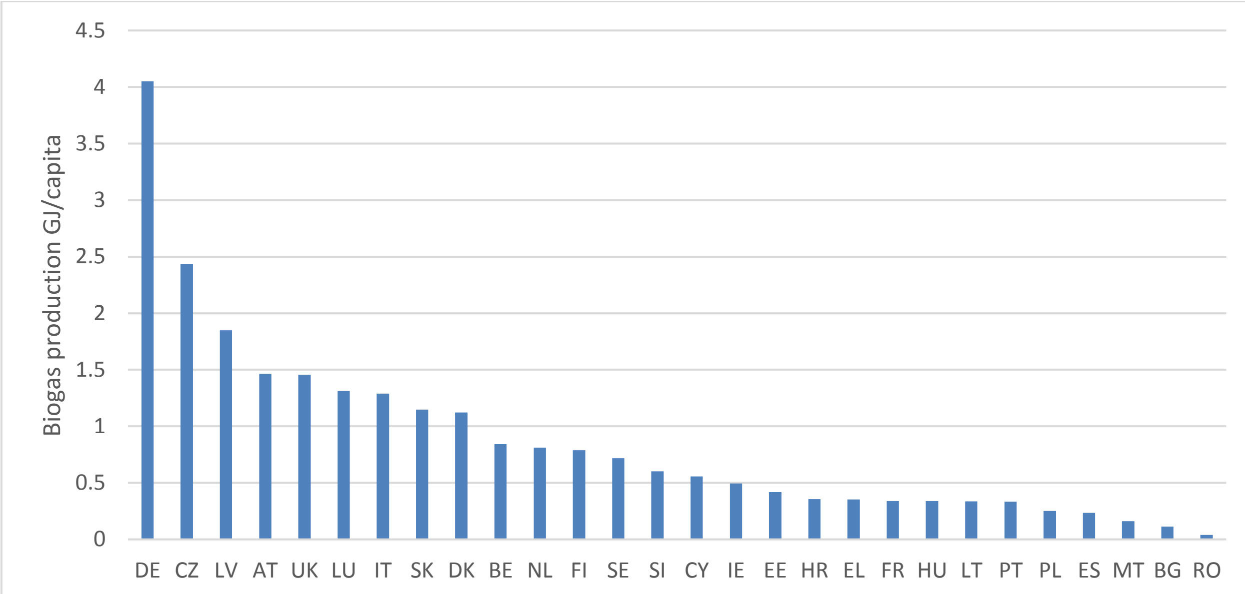
At a policy level a review of the French SMAB policy measures was conducted by Ecofys (and compared to the German situation, Eden, 2018). The conclusion was that, at a policy level, the French approach was very successful. This was highlighted as being due to the way the approach was embedded in France's agricultural development policy framework, and especially through the link to the agro-ecologic project. These connections were described as putting "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 was also noted that the scheme had successfully addressed challenges such as the use of energy crops through regulating limits on input feedstocks. Hence, the policy is well framed with wider sustainability goals, rural development and maintenance, agricultural reforms and nutrient optimisation. The question remains however of the extent to which the policy measures are actually contributing to the original RED target of 20% by 2020? This question will be addressed in the next sections.

3.1.1 How successful was the scheme?

Consideration of the actual levels of utilisation of the policy measures reveals that France still has a way to go. In 2015, the share of biogas in natural gas use within France was 1.5%, which is far below the EU average (Scarlat et al., 2018). The French a biogas production amounted to 0,34 GJ per head of population in 2015, and consequently was ranked 20th of the EU Member States (calculated from Scarlat et al., 2018, table 1 and Eurostat data on population per country).

[4] For more information, see SWD(2013) 439 final. Commission staff working document. European Commission guidance for the design of renewables support schemes.

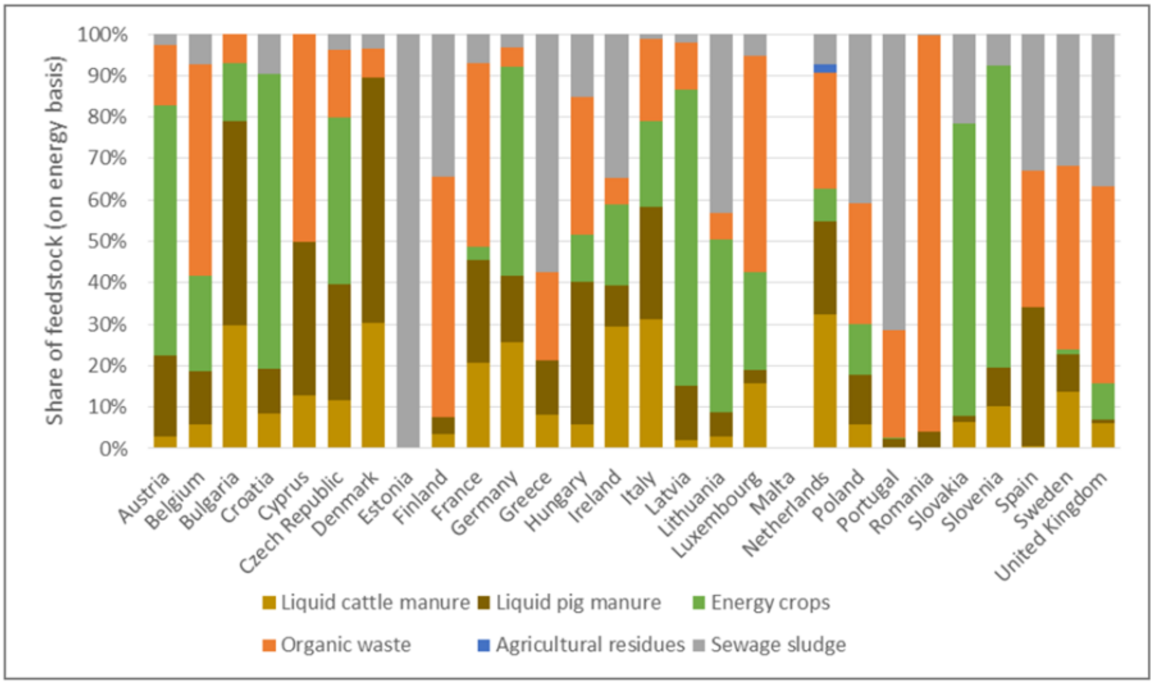
Figure 1: Total biogas production per capita, in European countries in 2015



Source: Calculation from Scarlat et al., 2018 table 1 and Eurostat data

Figure 1 shows the biogas production per capita per MS. This demonstrates that Germany was the frontrunner with the highest biogas production per head of population - 4.1 GJ/ capita, followed by the Czech Republic (2.4 GJ/ capita) and Latvia (1.8 GJ/ capita). From this perspective, France was behind most EU Member States in 2015. Furthermore figure 2 illustrates that more than half of the feedstock in France stemmed from organic waste and sewage sludge, rather than from the agricultural policies under consideration here. Hence, on a per capita basis France was in 20th place, with 0,34 GJ/ capita.

Figure 2: Share of feedstock use for biogas (on energy basis) in 2014, estimates



Source: Kampman et al., 2017

Figure 2 displays the share of different feedstocks across Member States in 2014. Energy crops (mainly maize) provided about half of the biogas production in the EU (318 PJ), followed by landfill (114 PJ), organic waste (including municipal waste) (86 PJ), sewage sludge (57 PJ) and manure (46 PJ) (Kampman et al, 2017).

The figure shows the 'feedstock profiles' of the European countries. In Austria, Croatia, Germany, Latvia, Slovakia and Slovenia energy crops made up more than 50% of the feedstock used. Cyprus, Denmark, Estonia, Finland, France, Greece, Portugal, Romania, Spain and Sweden all had a very low share of energy crops (<5%, often 0%). Favourable supportive European and national legal frameworks contributed directly to the increase in energy crop digester applications in Germany and also in Austria (Braun et al., 2009). As discussed here the French measures are specifically designed to discourage the use of energy crops. An overview of biogas support policies in the EU between 2005 and 2017 is presented in Banja et al, 2019 (figures 1, 3 to 7). By the end of 2017 almost 700 different measures (economic, financial, regulatory, administrative, support) for the deployment of bioenergy were in place in the EU. Annex 1 zooms in on the main support schemes for the promotion of biogas in the EU electricity sector after 2014 including agriculture and all other supply sectors. This does not comprise the renewable energy sources for heating and transport sectors.

Countries with a high share of (liquid) manure (>40%) were: Bulgaria, Cyprus, Czech Republic, Denmark, France, Germany, Hungary, Ireland, Italy and the Netherlands. There is evidence that manure-based pathways always have lower environmental impacts and higher GHG savings than energy crop-based pathways (Agostini et al., 2015). Manure digestion is the most efficient way to reduce GHG emissions in the agricultural sector, although there are trade-offs with other local environmental impacts. Biogas production from crops may be regarded as an option to facilitate the deployment of manure digestion, although not providing environmental benefits per se.

In terms of budget spending the PCAE was successful. A first overview of investment aids presented by Allaire and Dupraz (2017) showed a level of commitment that meets expectations with 8 890 farms in 2015 investing €86,000 on average and receiving an average support of 38% or €32,000 for their investments. This generated a total public expenditure of €288 million that year. The amount invested in AD was not reported.

The target according to the EMAA was to reach 1 000 farm biogas plants by 2020. Table 2 reveals that this target is probably not going to be reached, although the number of plants increased from 138 when EMAA was implemented to probably around 700 in 2020, or roughly 70% of the original target[5].

3.1.2 Measures of Success

The number of agricultural biogas plants and the emissions avoided that resulted from PCAE, EMAA and predecessor policy plans are reported by the French government[6]. The information available does not include the capacity of the plants, the amount of energy produced, or information on the measures leading to this success. Table 2 is taken from the report and shows both the number of biogas plants and the emissions avoided within the agricultural sector, ex post (actual numbers) for the period 2010-2015 and ex ante (projections) for the period 2020-2035. For the ex-ante period it is assumed in this report that the dynamic shown from 2010 until 2015 will be sustained with 85 new plants on an annual basis until 2035.

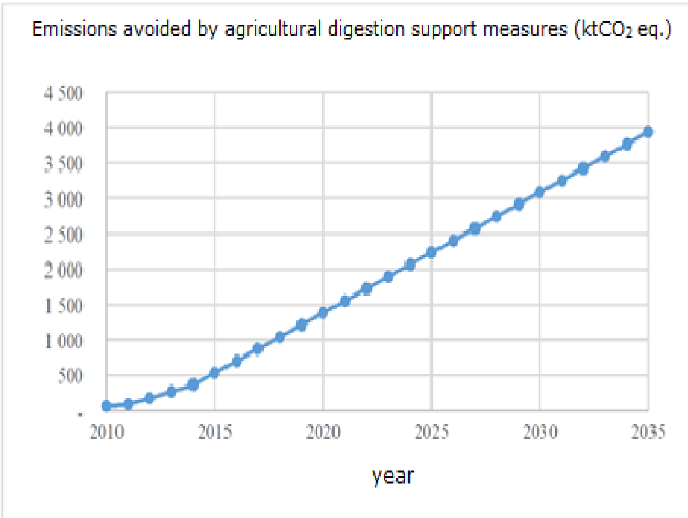
Table 2 Development number of agricultural biogas plants in France and avoided GHG emissions

	Total number of AD plants	Total Avoided Emissions(ktCO2eq)
(ex post)		
2010	32	64
2011	47	94
2012	90	180
2013	138	276
2014	185	370
2015	267	534
(ex ante)		
2020	692	1 384
2025	1 117	2 234
2030	1 542	3 084
2035	1 967	3 934

Source: French government[17]

[5] A recent update from ADEME shows 532 there are farm level units in France as of January 2020 as well as 76 central units also involving collective agricultural projects, i.e. a total of 608 units. Most of these (487) apply co-generation of electricity and heat with a total installed capacity of 138.7 Mwe, 52 farm level and 24 central units inject bio-methane into the grid (with a total capacity of 11933 Nm3/h) and the rest uses only the heat or is not specified. For more information, see (https://www.seametha.ademe.fr/) Chiffres clés du parc d'unités de méthanisation en France au 1er janvier 2020.
[6] For more information see Rapport 2017 de la France en application de l'article 13.1 du règlement 525/2013 relatif à un mécanisme pour la surveillance et la déclaration des émissions de gaz à effet de serre (http://cdr.eionet.europa.eu/fr/eu/mmr/art04-13-14_lcds_pams_projections/pams/envwm_t7a/Rapport_2017_France_MMR_article_13.pdf)

Figure 3: Avoided GHG emissions due to AD plants and the generation capacity



Source: French government

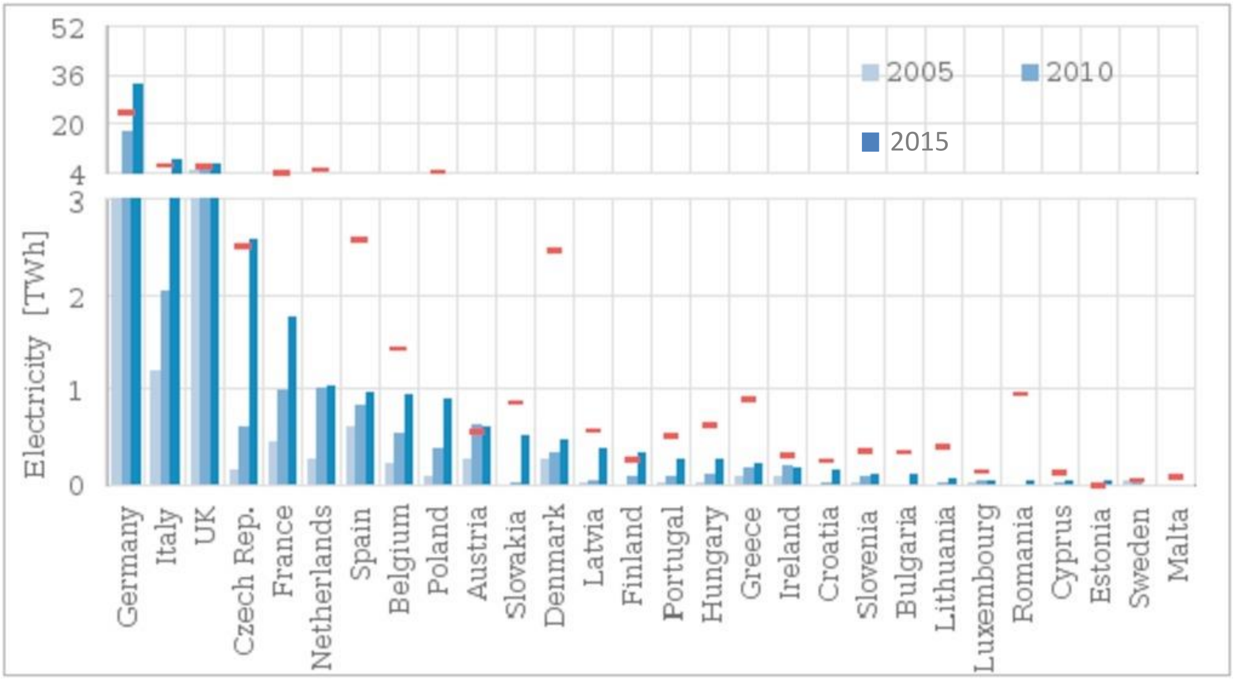
The emissions avoided from the nationally installed AD infrastructure described can be estimated per plant. An average biogas plant, with a capacity of 300 kW and 8 000 hours / year operating time, is considered to be capable of reducing greenhouse gas emissions by about 2.0 kt CO2e / year, through storage and treatment of agricultural livestock manure and by substitution of natural gas by biogas. The avoided GHG emissions from the production of fertilizer substituted by digestate are not taken into account in Figure 3, neither are emissions avoided by the AD of inputs other than livestock effluents (waste of agro-food industries, etc.) which would have been landfilled in the absence of AD plants.

Pellerin et al. (2013) provided detailed mitigation factors for different system set-ups of AD including direct and indirect effects on the global warming potential (GWP). The effects differ per type of feedstock and amount of manure involved in the mixture. The factors are useful to account for those externalities in future scenarios.

From the economic point of view, AD provides an additional activity for farmers with a stable complementary income from the supply of electricity and biomethane, together with utilisation of heat, and a reduction of dependence on mineral fertilizers. AD can also help to reduce the odour nuisance associated with the storage and spreading of livestock effluents. For regions, the use of AD provides a benefit in energy autonomy and the creation of local recycling and recovery of organic waste.

Comparing France to other EU member states, France was fifth in the EU in terms of total biogas electricity generation, and showed a stable increase in the number of AD plants between 2005 and 2015 (Scarlat et al., 2018). Comparable member states like Netherlands and Spain show a lower growth rate for this period.

Figure 4: Progress made and targets for 2020 for biogas electricity production in the EU Member States

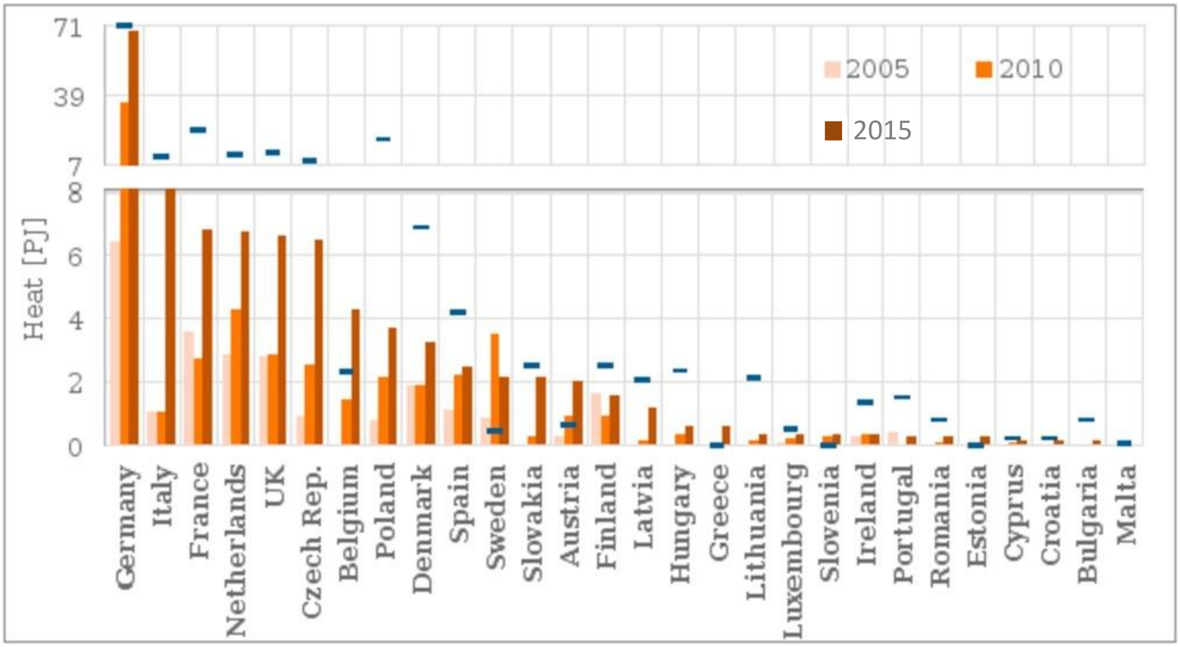


Source: Scarlat et al.(2018)

When we combine the expected growth in number of plants from Table 2 with the distance to target in Figure 4, France is expected to achieve the national RED 2020 target of 4 TWh. Assuming the ex-ante modelling is correct, in France there will be a growth in the number of plants by a factor of 2.6 (from 2015 to 2020 in Table 2). This implies that the generation level of 1.8 TWh in 2015 will reach 4.7 TWh in 2020 assuming a constant average capacity of the plants.

For biogas heat, France is also one of the leading Member States. Based on the expected growth given in Figure 5, in 2020 a level of 18PJ will be reached, which is close to the its national target.

Figure 5: Progress made and targets for 2020 for the use of biogas heat in Member States



Source: Scarlat et al.(2018)

Consideration of the production of biomethane in France is hampered by a lack of data. It is assumed that this is because of the current low production in France. Nevertheless, France has a high ambition for biomethane production in forthcoming decades. The Renewable Gas French Panorama, 2017states that the ambition for 2030 is to reach a share of 30% renewable gas in networks, which is 90 TWh (324 PJ) renewable gas, including 70 TWh of biomethane. This means a huge transformation to focus future AD installed capacity on the production of biogas and its transformation into biomethane for injection into the gas grid. This contrasts with the approach used to date, which focuses on utilising the biogas for production of electricity. According to a French platform for future developments on energy, the Comité de prospective de la CRE (2019), much depends on the development of the area that will be dedicated to growing intermediate crops for energy purposes. These crops are considered to be an important feedstock to boost methane production and these have only recently started to be implemented in regular French agricultural practice. The use of intermediate crops also avoids the disadvantages associated with traditional energy crops as explained in Section 2.2.

In conclusion, if the number of plants grows as expected in the period 2015-2020, the targets for biogas electricity and biogas heat for 2020 are expected to be met through the French SMAB policy measures. Hence it is successful overall. The next step is to ensure that the ambitious targets for 2030 can be met, and the analysis in 3.1.1 indicates that there could be significant un-utilised capacity within French agriculture.

3.1.3 Key factors that ensured success

The French policy is comprehensively framed within broader sustainability goals related to nutrient optimisation, rural development and agricultural reforms. A key factor seems to be the integrated policy framework with feed-in tariffs still available for small scale plants, and with it the recognition that feed-in tariffs are still the preferred financial support mechanism for the biogas producers (farmers).

It is expected that further cost reductions will occur as this technology continues to be adopted. Biomethane has a huge potential as one of the best solutions in the transport sector considering how costly many of the alternatives are. These factors are likely to help drive continued adoption of this technology.

A key aspect that the French SMAB scheme addresses is to create an environment where the financial benefits of developing an on-farm AD system are available to the farmers. Without this support it is unlikely many such systems would be built. The costs of AD for the farmer, within the French context, consist of investment costs (excluding public subsidies possibly received for investment) and operating costs. The benefits they derive come from the sale of electricity and biomethane, the recovery and utilisation of heat and the utilisation of the digestate as a replacement for fertiliser.

Anaerobic digestion is characterised by a great disparity in investment costs and operating costs from one facility to another. This depends on the size of the installation, the waste used, the territorial constraints and the chosen method of valuation. ADEME (2011) provided investment cost ranges depending on the size of the facility. By applying the calculation for avoided emissions and assuming a 25-year life of AD installations, cost ranges per tonne of CO_2 avoided can be obtained. The assumption of a 25-year period is noteworthy because the minimum period of the feed-in tariffs is 20 years.

Table 3: Investment cost and costs per tCO_2eq avoided by installation capacity

	Installation 35 kW	Installation 170 kW	Installation 500 kW
Investment	**0.3 to 0.5M€**	**1.3 to 1.5 M€**	**2.5 to 3.2 M€**
Cost per tCO_2eq avoided	**52-86 €/tCO2eq**	**46-53 €/tCO2eq**	**30-39 €/tCO2eq**

Source : Le guide de la méthanisation à la ferme, ADEME, 2011.

These costs include only the investment costs for the farmer and do not take into account any public support received for investment, operating costs, or profits from the sale of electricity and biomethane. As the ADEME (2011) study is 10 years old, it is expected that the CO_2 abatement cost will show a decline over time with technological progression (IEA, 2020) and is lower today.

Costs for public authorities consist of investment support costs. Renewable electricity purchase tariffs are financed by consumers via a tax on electricity. The contribution to the Public Electricity Service (CSPE: Contribution au service public de l'électricité) is calculated based on the electricity consumption in MWh.

3.1.4 Support measures that contribute to the success of the scheme

Overall, it is not very clear how and to what extent the various measures within the SMAB policy measures contributed to the development of the number of biogas plants and the associated GHG reductions illustrated in Table 2. The Ecofys study mentioned earlier suggests that it is precisely this integrated strategy approach – where it would be very difficult to reconstruct the individual elements contributing to success - that made the policy successful.

3.1.5 Cohesive interactions with other schemes and instruments

The scheme covers measures to ensure purchase of renewable energy and biomethane (on the demand side) and to stimulate the production of renewable energy by farmers (on the supply side). The measures therefore have a positive effect on renewable energy via production and use of biogas to replace fossil-based fuels. There is also a positive relation from the perspective of reducing waste and increasing recycling.

3.2 Assessment - Limitations

3.2.1 Aspects for Improvement

The broad scope of the SMAB policy measures and the complexity of the plans, each interacting at different governance levels, **can be simplified**. The complexity limits the possibilities for policy evaluation. This is for instance noted by Allaire and Dupraz (2017) in their evaluation of the PCAE. The complexity of the French energy policies is also mentioned in the study “The energy transition for green growth act in France (Hölscher et al., 2018): “This extensive scope together with very detailed provisions for implementation at different levels and with different timeframes makes this a highly complex piece of legislation. It is the basis for dozens of strategies, action plans, policy programmes and regulations, all of which interact with each other and involve different actors.”

The information available to assess how successful the scheme has been in terms of avoiding GHG emissions is the generated energy output from the systems operating within the SMAB. It would be welcome to be able to assess the French SMAB policy in terms of total avoided emissions, but this evidence was not identified.

The policy shifts from the advantageous feed-in tariffs to less-preferred (from the producer perspective) feed-in premiums. In addition, the decrease in guaranteed tariff level and abolition of substrate bonuses for energy crops or for biogas upgrading have led to stagnation in the level of European AD sites. Recent evaluations show that the **existence, stability and reliability of the framework and support schemes (still) are an important condition for renewable energy production** (Kampman et al. 2017).

3.2.2 External factors that may affect schemes success

One of the risks of biogas plants is methane leakage. It is not guaranteed that such leakages are accounted for in key performance indicators regarding GHG reductions.

There is a challenge across several countries in terms of the current legislation regarding the agricultural use of digestate as a fertilizer (Kampman et al., 2017). “In France, the legal framework for biogas plants is sufficiently developed to enable their deployment. However, the current legislation regarding the agricultural use of digestate as a fertilizer is not enough elaborated. Regulatory changes shall be made in the near future to clarify the legal value of digestate, and to recognise it as a valuable fertilizer instead of as a waste. This work is crucial to ensure that the whole process of AD is valued for its full potential (Kampman et al., 2017, page 123)”

Kampman et al. (2017) also identify a barrier that is highly relevant for the future in the lack of support schemes for direct liquefaction or compression of biomethane. As direct injection into the gas grid generates feed-in tariff support, most producers prefer their biomethane to be injected into the grid rather than further utilized, either for transport or for advanced biochemicals.

A logistical challenge for the increased production of biomethane is the location of the AD plant relative to the gas grid - many might be located too far from the injection site. The severity of the problem depends on the spatial distribution and scale of farms and therefore differs by region. Transporting biomethane by trucks over short distances may be an option for certain sites, but this is an aspect that should be fed into future development plans for injection facilities.

3.2.3 Negative interactions with other schemes or instruments

The scheme interacts with a multitude of other schemes and instruments such as the common agricultural policy, the Agro-ecological project, the Economic and Environmental Interest Groups for agricultural holdings (GIEE), and the LTECV and the Ambition Bio Plan 2017. The extent to which these interactions affect the functioning of the SMAB either positively or negatively is not known.

3.3 Assessment - Future Potentials

3.3.1 Scalability

Based on the ex-ante evaluation with future projections (see 3.1.2) for France a linear progress of capacity/ avoided emission is expected until 2035. Despite the expected continuous growth of the biogas and biomethane industry, some obstacles remain. The study "the Advent of the 3rd Gas Revolution" (Atlante, 2018) mentions, for example:

- High production and processing costs;
- Irregular and seasonal demand;
- The compartmentalised distribution network;
- Administrative procedures that are sometimes long and complex.

However, there are possible solutions for these problems, such as the use of new technologies and the implementation of regulatory changes. The actors involved from farming industry to (local) government are designated to mitigate these obstacles to optimise development.

3.3.2 Replicability

The French SMAB scheme demonstrates that **a highly interconnected set of measures, implemented at regional level is possible**. Direct replication of the scheme in other jurisdictions is probably not that easy as the measures are tailored to the French situation, including the infrastructure of the gas network. However, the measures are relevant to any area with significant agricultural outputs both for the production of renewable electricity and heat, and the production of biomethane. The policies themselves would need to be adapted for the particular set of regional circumstances.

France is not one of the leading countries in terms of the technical development of this technology. This also demonstrates that **the technology can be installed without being a front runner country**.

It is suggested that, with proper support mechanisms in place, the agricultural sector and AD can contribute to climate and sustainable energy goals simultaneously, i.e. reduction of agricultural GHG emissions, delivery of more renewable energy and producing more energy efficiently. An integrated approach is needed addressing all market and government failures with respect to the public goods involved (climate issues, environmental pressure, food security, social aspects, biodiversity, etc.). Agricultural businesses face several hurdles when they want to scale-up biogas production facilities and cannot compete with large scale industrial plants on energy prices alone. The higher level of support for small scale agricultural facilities can be justified by a higher contribution to public good. It is recognised that **agricultural support mechanisms need a lot of fine-tuning at a regional level**.

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Annex Support for biogas in the EU electricity sector after 2014

This annex summarises the main support schemes for the promotion of biogas in the EU electricity sector after 2014 and presents an overview of payment mechanisms used (Table 1) and the number of incentives per supply sector including others than agriculture (Table 2). Source, adapted from: Banja, M. et al. 2019. Support for biogas in the EU electricity sector – A comparative analysis. Biomass and Bioenergy 128 (2019) 105313.

As reported in the EU countries National Renewable Energy Action Plans (NREAPs) and the respective 4 sets of Progress Reports, the current main support schemes used to promote the deployment of biogas for electricity are feed-in tariff (FIT), feed-in premium (FIPc: constant FIP; FIPs: sliding FIP), Quotas combined with Tradable Green Certificates (TGC) systems, Contracts for Difference (CfD) and Tenders.

Table 1. Support schemes and incentives for biogas electricity in the EU after 2014.

	FIT	FIPc	FIPs	TGC	CfD	Tender
Austria	X					
Belgium				X		
Bulgaria	X					
Croatia	X		X			X
Cyprus	X					
Czech Republic	X	X				
Denmark		X				
Estonia		X				
Finland		X				
France	X	X				X
Germany	X	X	X			X
Greece	X	X				
Hungary	X	X				X
Ireland	X					
Italy	X	X				X
Latvia	X					
Lithuania			X			X
Luxembourg	X	X				
Malta						
Netherlands		X				
Poland	X	X				

	FIT	FIPc	FIPs	TGC	CfD	Tender
Portugal	X					
Romania				X		
Slovakia	X					
Slovenia	X		X			X
Spain						
Sweden				X		
(UK)	X				X	X

Source: NREAPs and Biennial Progress Reports (2010 & 2011 & 2013 & 2015 & 2017) https://ec.europa.eu/energy/en/topics/renewable-energy, Accessed Dec 2018

Table 2. Current number of incentives in EU countries to support biogas in the electricity sector.

	Total # Incentives	Biogas	Landfill gas	Anaerobic Digestion	Manure	Sewage gas	Waste	Biomethane
Austria	10	7				1		2
Belgium								
Bulgaria								
Croatia								
Cyprus								
Czech Republic	18	9						
Denmark	10	4						
Estonia	1	1						
Finland	2	2						
France	4	2			2			
Germany	21		6		3	6	6	
Greece	14	1	7					
Hungary	7	7						
Ireland	5	1	1	3				
Italy	5	5						
Latvia								
Lithuania	7	3		4				
Luxembourg	4	4						
Malta								
Netherlands	18	6						
Poland	14	3	3			3		
Portugal	5	1	2				2	
Romania	3	1					2	
Slovakia	8	1		4				1

	Total # Incentives	Biogas	Landfill gas	Anaerobic Digestion	Manure	Sewage gas	Waste	Biomethane
Slovenia								
Spain								
Sweden	3	3						
(UK)	13	6	2	3		2		

Table 2 (continued)

	Gasification	Other biomass	Landfill & sewage gas	Anaerobic fermentation	Agriculture	Conversion	Co-firing	Fermentation
Austria								
Belgium								
Bulgaria								
Croatia								
Cyprus								
Czech Republic			5	4				
Denmark	3						3	
Estonia								
Finland								
France								
Germany								
Greece		6						
Hungary								
Ireland								
Italy								
Latvia								

	Gasification	Other biomass	Landfill & sewage gas	Anaerobic fermentation	Agriculture	Conversion	Co-firing	Fermentation
Lithuania								
Luxembourg								
Malta								
Netherlands	3							9
Poland					5			
Portugal								
Romania								
Slovakia			1			1		
Slovenia								
Spain								
Sweden								
(UK)								

Source: RES-Legal http://www.res-legal.eu/ (2018), Accessed May 2018.