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State of Development of Biogas Production in Europe

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Abstract

The share of renewable energies in electricity production is still low in Europe but there is a political will to increase it in the future by the development of solar and wind energies but also by the development of electricity production from biogas. Biogas production from solid waste is developing in Europe but with important differences between countries. Germany is from far the country where biogas industry is the most developed with 62 % of the European biogas plants. However, the latest support schemes implemented in Germany (2012 and 2014) have strongly slowed down the German biogas market. Italy is number two for the number of anaerobic plants. Biogas industry developed very rapidly till 2013 when Italy had the highest feed-in tariff in Europe. However Italy has revised its support scheme to redirect the biogas market towards small size plants based on animal and agricultural waste. The development of biogas in France started significantly at the end of the years 2000 with the implementation of the first support scheme. However, the biogas market is developing rather slowly due to the rather low feed-in tariffs implemented in France. The example of Germany shows clearly that biogas market dynamism is directly linked to the support schemes and the feed-in tariffs implemented. Indeed, biogas industry in Europe was performing rather well since recently, but negative changes or cuts in the support schemes in some countries during the last two years, particularly in Germany and Italy, have slowed down a lot the biogas market, phenomenon which should last in the coming years though some countries like UK or France are maintaining their policies in favor of biogas. However, several factors could favor the development of the biogas market: The acceptance of digestate as a fertilizer, the possible ban of land-filling and the limitation of incineration of organic waste.

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1.0 Introduction

In Europe, electricity production is mainly based on fossil sources or nuclear power and the production of electricity by renewable energy is still low. In Germany for example, in 2014 more than 50 % of the electricity was produced from fossil sources, 15.9 % from nuclear power and 25.8% from renewable sources, mainly photovoltaic, wind and biomass (fig. 1a, Appunn 2015). The situation is very different in France where, in 2014, nuclear plants generated 77% of the electricity produced and renewable sources represented 17.8%, mostly from hydropower (fig. 1b, RTE 2015). However, the contribution of renewable energies in the electricity production will increase in the future, and France is planning to have 23% of the electricity produced from renewable energies in 2020 and Germany is targeting 35% in 2020 and up to 80% in 2050. When renewable electricity will be the dominant part in the total electricity generated, production will be mostly based on solar and wind energies. In this context, electricity by cogeneration from biogas produced by anaerobic digestion of solid substrates will play an important role taking into account its possible flexible production.

Anaerobic digestion of solid waste for renewable energy production is developing in Europe but, the situation is very different from one country to another. General data on biogas production in Europe will be presented in a first part of the paper and, in a second part; the current situation in three countries will be analyzed into details: Germany, Italy and France.

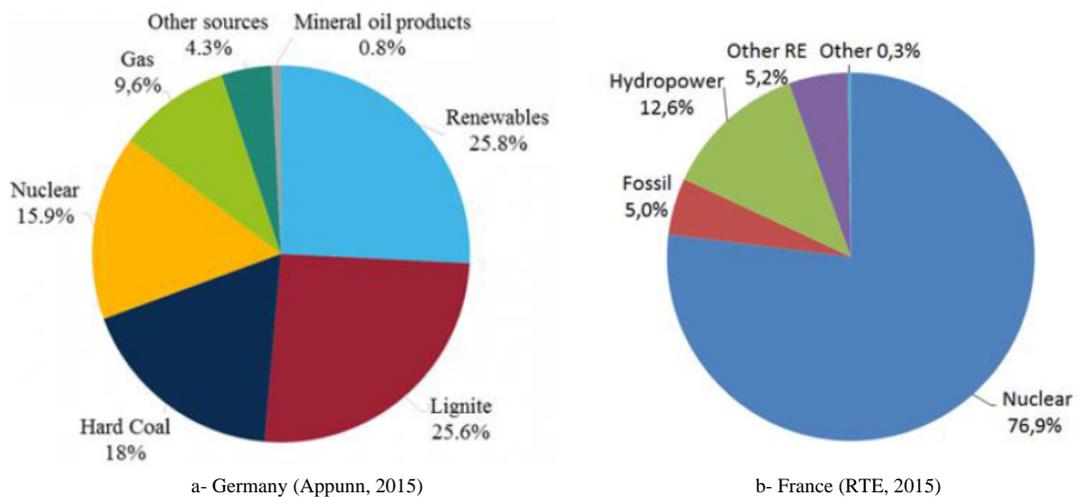


Fig. 1. Sources of electricity production in a- Germany and b- France

2.0 Biogaz Production in Europe

The data presented in this paper are based on the Biogas Report 2014 of the European Biogas Association (EBA 2014) published in December 2014. This report covers 27 EU countries (apart from Malta) and Switzerland. It contains compiled data on the number of biogas and biomethane plants, production, information on support schemes and predictions of the biogas market in the nearest future.

2.1 Number of plants:

In 2013, the total number of biogas plants in Europe was 14,572. Germany is from far the country where the biogas industry is the most developed with 9,035 plants in operation that is to say 62% of the total number of plants, followed by Italy (1,391 plants), Switzerland (620 plants) and France (610 plants), Fig. 2 (EBA 2014). The increase in the number of plants in 2013 compared to the number of plants in 2012 was rather low with 760 new plants which represent an increase of only 5.5%, which is much lower than the 12% increase of the previous year. This

is mainly linked to significant changes which occurred in different parts of Europe, mainly changes in support schemes. In Germany for example, the number of plants was increasing by more than thousand a year in the period 2009-2011, but after the Renewable Energy Act EEG 2012, the German market was dramatically slowed down and the increase in the number of plants in 2013 was only 335. A similar phenomenon occurred in Italy, where the Italian support scheme changed in 2013, also limiting the number of new biogas plants. In Italy, the number of plants was increased by 368 and 445 new plants in 2011 and 2012, respectively, but in 2013, the increase was only 127 new plants following the change in the Italian support scheme in 2013.

2.2 Type of biogas plants:

Figure 3 presents the different types of biogas plants in Europe per country (EBA 2014). The biogas plants are classified into: (i) landfill; (ii) plants treating sewage; (iii) Agriculture based biogas plants that run on energy crops, agricultural residues and manure and; (iv) Other which refers to industrial food and beverage and biowaste.

Among the 7 countries having the highest number of biogas plants (Germany, Italy, Switzerland, France, Czech Republic, Austria and UK), the situation is very different from one country to another. Indeed, Germany, Italy, Czech Republic and Austria are predominantly producers from agricultural sources and have 87%, 80%, 69% and 46% of their biogas plants operated with agricultural feedstock, respectively. Other countries have a rather mixed share of landfill, sewage sludge and agriculture based plants. France produces biogas mainly from organic waste and on landfills and Switzerland and the United Kingdom extracts biogas mainly from sewage sludge. However, a growing number of agricultural plants in countries like France or UK for example might reverse these trends.

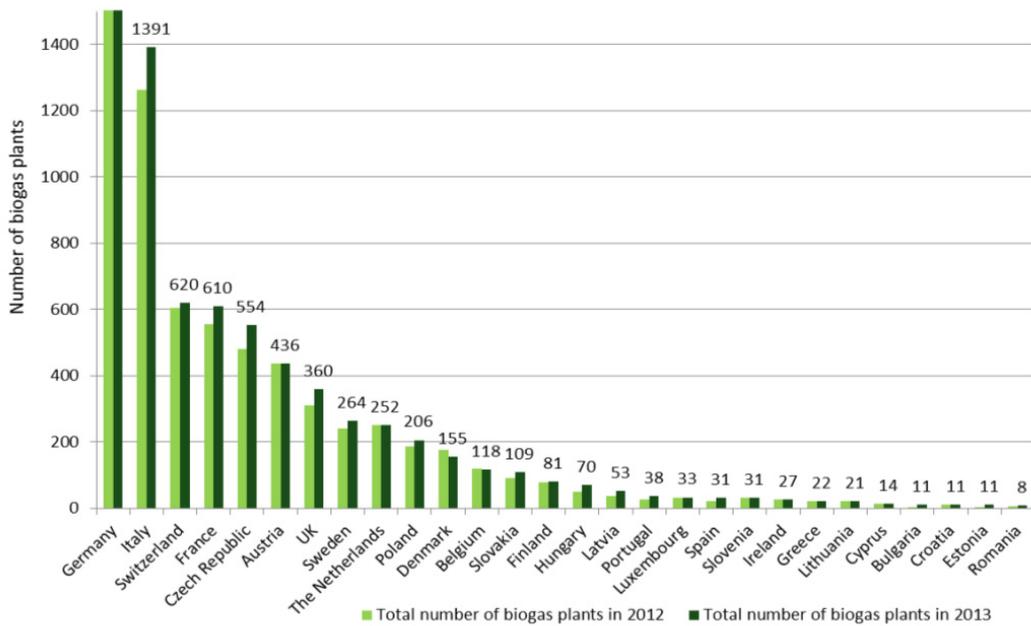


Fig. 2: Biogas plants in Europe in 2012 and 2013, Biogas Report 2014 (EBA, 2014)

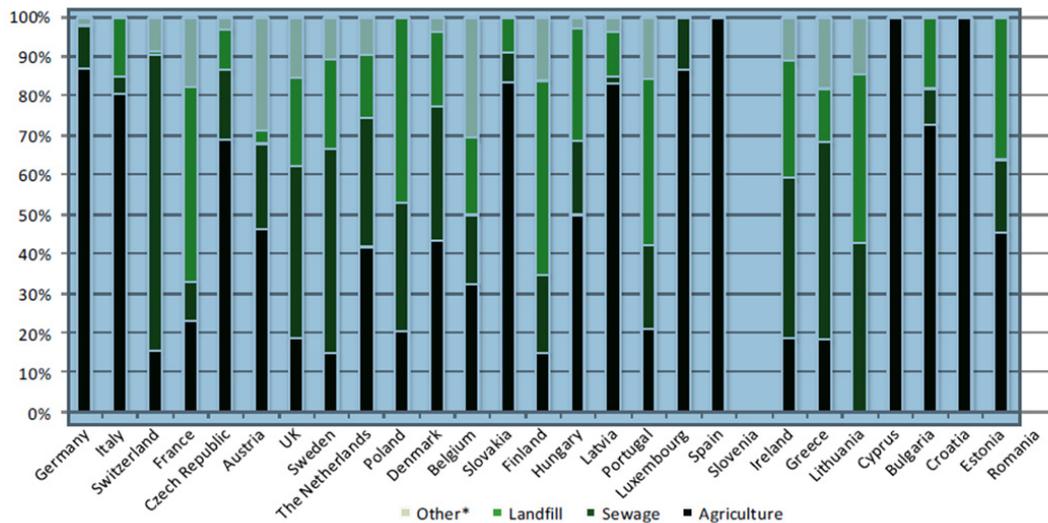


Fig. 3: Different types of biogas plants by country in Europe, Biogas Report 2014 (EBA, 2014)

Figure 4 shows an overview of the types of substrates used to feed the Biogas plants in Europe (EBA 2014). Agriculture based biogas plants that run on energy crops; agricultural residues and manure have the biggest share (72%) in the total number of biogas plants. The big share of agricultural biogas plants in Europe can be explained by the corresponding shares of such plants in the breakdown of leading biogas producing countries (Germany, Italy and the Czech Republic) which make up for almost 75% of total biogas plants and are predominantly producers from agricultural sources.

2.3 Electricity production:

In 2013, the total installed electrical capacity in Europe reached 7,852 MW and 47.5 TWh of electricity were delivered to the European network. All electricity currently produced from biogas in Europe could replace seven nuclear reactors. Apart from the electrical power, 48.7 TWh of thermal energy was also produced. The combined amount of electrical and thermal energy corresponds to an annual consumption of 5.4 million average European households, the number of households in Belgium and Slovenia put together.

2.4 Biomethane plants:

The number of biomethane plants in 2013 was 282 with a strong domination of Germany (154 plants) followed by Sweden (54 plants) and The Netherlands (23 plants). Biomethane industry is still at a very early stage in France (4 plants) and Italy (2 plants).

2.5 Support schemes:

The most widespread form of subsidizing Renewable energies is Feed-in Tariff (FiT) for electricity. Two examples of tariff structures for biogas plant in Germany and in France are presented below. Nonetheless, European Commission's long term goal is to move away from the FiT towards Feed-in Premium or other support instruments which, according to them, give incentives to producers to respond to market developments.

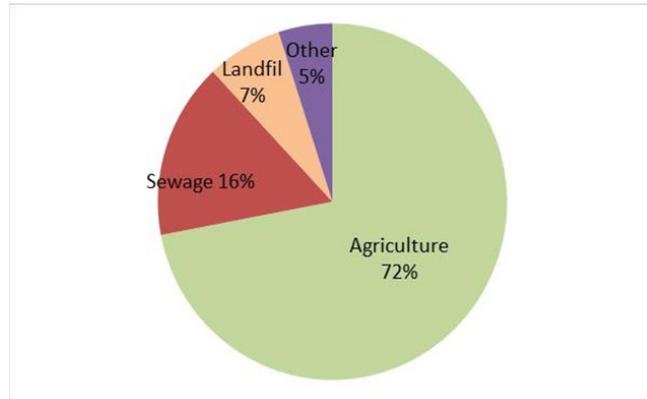


Fig. 4: Types of substrates used to feed the Biogas plants in Europe, Biogas Report 2014 (EBA, 2014)

3.0 Biogas Production in Germany

Germany has been promoting anaerobic digestion since the beginning of the 90's and this country is from number one in Europe for biogas production and dominates the market, not only by the number of plants but also services provided and the know-how.

In 2013, Germany had a total of 9,035 biogas plants in operation for an installed capacity of 3,543 MWe. 87% of the German biogas plants (7,850 plants) operate with agricultural feedstock, mainly energy crops; 980 with sewage and; 205 with other substrates (industrial food and beverage and biowaste). Total biogas production in 2013 was 65,731 GWh with 24,419 GWh of electricity and 34,762 GWh of thermal energy. Out of 9,035 plants, 154 plants were producing biomethane. The renewable energy sector employs 363,100 people out of which 41,000 jobs are in the biogas sector.

In Germany, the Renewable Energy Act (EEG) aims at promoting electricity generation from Renewable Energy Sources. It gives specific conditions for each type of RES with specific conditions for biogas production. This law came into place in 2000 and amendments were made in 2004, 2009, 2012 and 2014 with changes in the support conditions for biogas (Stolpp 2014). Figure 5 below gives an overview of the influence of the EEG on the number of new plants per year.

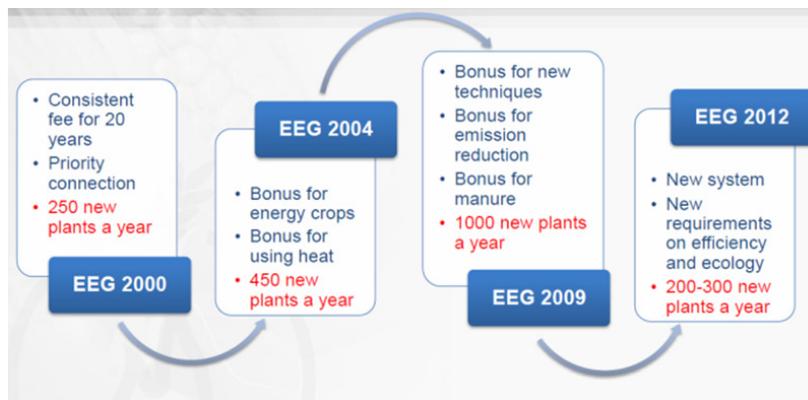


Fig. 5. Development of the renewable Energy Act (2000 – 2012) and its impact on the number of new biogas plants per year, Stolpp (2014)

The reform of the Renewable Energy Act in 2009 (EEG 2009) has stimulated the biogas market with high Feed-in Tariffs and between 2009 and 2011, about 1,000 new plants were built each year. The main consequences of the

EEG 2009 were a major increase in electricity production from biomass, job creation in the sector of biomass and the strengthening of rural areas. However, there were also some adverse side-effects such as: Competition for biomass use in regional areas, increased maize cultivation and shifts in the use of maize, shorter crop rotations, problems of acceptance amongst the population, etc.

On January 1st 2012, the amended Renewable Energy Act came into force (EEG 2012) including measures adopted to solve the encountered problems. The aim of this act was: (i) to limit the increasing cultivation of maize (60% by mass is the maximum admissible use of maize and cereal grain); (ii) to give greater support for residual matter and waste materials as well as for small decentralized slurry-based plants with the introduction of special conditions for 75 kW farm-based plants that run on at least 80 % slurry or manure, table 1 (Stolpp 2014); (iii) to simplify the EEG by adjusting the payment levels and reducing the number of bonuses; (iv) to link the EEG support to efficiency criteria (Efficiency requirements through introduction of a mandatory heat use of 60 % of produced electricity) and to encourage demand-driven electricity production (Premium for the supply of additional installed capacity for demand-driven power generation (flexibility premium)) and biogas upgrading to biomethane.

This amended act changed the support scheme with lower Feed-in Tariffs and the main consequence was a strong decrease in the German biogas industry, from 1,000 new plants per year to around 200-400 new plants per year. The tariff structure for biogas plants for EEG 2012 is presented in Table 1. There is a base tariff depending on the size of the plant with a special tariff for plants ≤ 75 kW (25 €cents per kWh). There is an additional tariff depending on the type of substrate (type 0, 1 and 2). Feedstock category 0 is the biomasses whose use does not lead to any entitlement of remuneration: Old bread, food leftovers, cereals (tailings), cereal waste, cereal vinasse from alcohol production, green cuttings from private and public garden and park maintenance and green strip grass, ...; Feedstock category 1 is: corn-Cob-Mix, cereals (whole crop), cereal grain, grass including agricultural grass, maize (whole crop), sugar beet, ...; Feedstock category 2 is: clover grass (as catch crop), landscape conservation material, lucerne grass (as catch crop), horse manure, cattle slurry, sheep manure, solid manure from pigs, straw, ... There is also a bonus for biogas upgrading and for biowaste.

On June 27th 2014 Germany revised again the Renewable Energy Sources Act (EEG). While the positive aspects of the new EEG are limited to the area of small plants producing biogas from manure and biowaste, where the features of EEG 2012 have remained unchanged, the negative aspects affect the entire industry. Indeed, two key points are to be underlined:

(i) The increase in biogas production in Germany will be capped to 100 MW annually; (ii) Feed-in Tariffs will be gradually withdrawn from all new plants above 100 kW. This new legislation entered into force on January 2015.

Today the German biogas industry is suffering from the new Renewable Energy Act 2012 which changed the support scheme and a further slowdown is expected, as the FiT were again reduced since January 2015 with the EEG 2014. Therefore, a lot of work occurs around plant repowering and “flexibilisation” of plants. In 2015 the biomethane industry will also certainly slow down due to the cancellation of bonuses for gas upgrading from January 2015.

4.0 Biogas Production in Italy

With 1,391 biogas plants, Italy is number 2 in Europe. 1,121 biogas plants, representing 80% of the biogas plants, are fed with substrates from agriculture and 60 plants with sewage. Biogas is also produced from 210 landfills. Until 2013, Italy had a high Feed-in Tariff of 28 Cts€/kWh for plants <1 MW which stimulated a lot the biogas market. The consequences of this high FiT were a big increase in the number of anaerobic digesters (+ 81 % of the number of plants in 2011) but with a rather important size (1 MW on average) and with energy crops as main substrate. However, the situation will change as a new order was promulgated in June 2012 with new FiT depending on the kind of substrate, the installed power, the use of heat and the technology used. The aim is to favor small size plants (< 500 kW) based on animal and agricultural waste and not on energetic crops. As a consequence, only 127 new plants were built in Italy in 2013.

The total installed capacity is 1,105 MWel. Generated electricity in 2013 was 8,890 GWh and thermal energy production was 11,110 GWh. Biomethane production is just starting with only 2 plants in operation in 2013. The biogas sector in Italy generated 3,670 jobs.

Table 1: EEG 2012, Tariff structure for biogas plants, Stolpp (2014)

	EEG 2012
Base tariff	
≤ 150 kW	14.30 € cents
≤ 500 kW	12.30 € cents
≤ 5 MW	11.0 € cents
≤ 20 MW	6.0 € cents
≤ 75 kW (special tariff for plants using ≥80% manure)	25.0 € cents
Feedstock category 1¹	
≤ 500 kW	6.0 € cents
≤ 750 kW	5.0 € cents
≤ 5 MW	4.0 € cents
Feedstock category 2	
≤ 500 kW	8.0 € cents
≤ 5 MW ²	8.0 € cents
Biogas upgrading bonus	
≤ 700 Nm ³ (~ 2.8MW)	3.0 € cents
≤ 1,000 Nm ³ (~ 4.0MW)	2.0 € cents
≤ 1,400 Nm ³ (~ 5.5 MW)	1.0 € cents
Biowaste bonus	
≤ 5 MW	16.0 € cents
≤ 20 MW	14.0 € cents

¹ A special rate is available for bark and forest waste wood feestocks (≤ 500 kW / 6.0 ct/kWh and ≤ 5 MW / 2.5 ct/kWh).

² 6 ct/kWh for manure plants > 500 kW to 5 MW.

Source: German Agency for Renewable Resources and German Biomass Research Center

5.0 Biogaz Production in France

In France, the first order setting FiT was promulgated in 2006. However, the biogas sector in France is slowly developing (+53 plants in 2013) because the French tariffs were lower than those of Germany or Italy at the same period. In 2013, there were 610 plants producing biogas with 309 digesters and 301 landfills. 140 plants were fed with substrates from agriculture, 60 plants with sewage and 109 with other (industrial food and beverage and biowaste). The total installed electrical capacity in 2013 was 259 MWel. Four biomethane plants were in operation in 2013. 1,700 jobs were created in the biogas sector in France.

In France, the FiT depends on the installed capacity, the kind of substrate and the use of heat. The base tariff is between a maximum of 13.37 c€/kWh for an installed capacity lower than 150 kW and a minimum of 11.19 c€/kWh for an installed capacity higher than 2,000 kW (Table 2, ATEE 2014).

A bonus can be added to this base tariff to favor the use of animal waste in small agricultural biogas plants (Table 3). Indeed, the maximum premium is for plants with a capacity lower than 300 kW using more than 60% of animal waste in their feed. There is no bonus for plants with a capacity higher than 1,000 kW.

An additional bonus which depends on the use of heat can be also added (table 4). The maximum bonus (4

c€/kWh) is when the energetic efficiency is higher than 70%. There is no bonus when the energetic efficiency is lower than 35%.

Table 2: Base tariff according to the installed capacity in France, ATEE (2014)

Maximum Installed capacity	Base price (c€/kWh)
≤ 150 kW	13.37
300 kW	12.67
500 kW	12.18
1,000 kW	11.68
≥ 2,000 kW	11.19

Table 3: Bonus for the use of animal waste in France, ATEE (2014)

Maximum Installed capacity	Maximum premium (c€/kWh)
≤ 300 kW	2.6
500	2.1
≥ 1,000 kW	0

% effluent	Premium
≤ 20%	0
20% - 60%	linear interpolation
≥ 60%	Max Premium

Table 4: Bonus for the energetic efficiency in France, ATEE (2014)

energetic efficiency	Premium
≤ 35%	0
35% - 70%	linear interpolation
≥ 70%	4,00

6.0 Future Prospect

Biogas industry in Europe was performing rather well since recently, but negative changes or cuts in the support schemes in some countries during the last two years, particularly in Germany and Italy, have slowed down a lot the biogas market, phenomenon which should last in the coming years. Indeed, in Germany, a stagnation of the industry is forecasted. For 2014, the number of new plants was only 94 (41 MW of installed power), and it is expected that in 2015 this value will be even lower. The 100 MWel cap on annual biogas production growth, introduced by EEG 2014, will most probably not be reached due to bad overall conditions. Indeed, since January 2015 all new plants above 500 kWel have to sell electricity directly to the market, and in January 2016 direct marketing will apply to all plants above 100 kWel.

However, other countries are maintaining their biogas-friendly policies which will stimulate the biogas market. The UK for example, has almost doubled the number of agricultural and waste based plants between 2011 and 2013 and the number of running biogas sites should be over 600 very soon. In France, there is a strong political will to develop the production of biogas and the French government has set a target of 1,500 biogas plants in 2020 including 1,000 biogas plants based on Agricultural feedstock. New FiT should be proposed end of 2015 in order to improve the profitability of biogas plants and to stimulate the French biogas sector.

An important point for the development of the biogas market is the fate of the digestate which is often problematic. A Fertilisers Regulation Proposal will be submitted to the European

Commission which proposes to recognize the digestate as organic fertilizer which can be sold across the EU. Another strong impact on the biogas sector could be the possible ban by Europe of land-filling and the limitation of incineration of organic waste as well as the significant increase of the EU recycling targets. This is in favor of anaerobic digestion as it is recognized as a recycling process.

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