D2.3 Data bank with existing incentives and subsequent development of biogas plants compared to national targets

Deliverable:	Data bank with existing incentives and subsequent development of biogas plants compared to national targets
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Executive Summary

This report aggregates information on existing European incentives for biogas plants compared with the national development of the biogas sector. A variety of different factors (socio-economic, political, technological) are likely to have an impact on the development of biogas production, which makes it difficult to assess the influence of national support schemes on biogas production. The data gathered for 30 different countries suggest that a mere **71.0% of the 2015 biogas production was likely to have been caused by the main support scheme in the country,** with an average of 3 years lag time between the start of the main support scheme (SS) and a significant rise in biogas production (average for FiT). This 71% share is likely to be much higher in practive, given that:

- this estimate could not be done for some countries such as the UK (14.4% of EU biogas production) because of the variety of support schemes in place;
- the effects of subsidies, tax incentives and secondary SS (other than the main one in the country) on the biogas production development have not been considered.

A scatter plot of all the gathered data allows us to visualise the biogas production per capita along with the average total income for biogas producers, per country, year and support schemes in Figure 0-1. The ellipses of confidence represent a 90% confidence area and are SS specific. Data presentation highlights that in Europe:

- FiT have been more efficient at increasing the biogas production per capita compared to FiP and GC (especially so for DE, AT, LV, IT and CZ)
- FiP have been more economically efficient (at production per capita above EU average, such as in DK)
- The different SS types display similar performance on average. Their specificities become more influential as the ratio 'average total income/production per capita' moves away from the EU average for the three SS (red box).

For more country-specific information, dynamic graphs can be found on the biogasAction website (FiT, FiP, GC, all SS) and allows the reader to follow the trajectories of the different EU countries starting in 2005.

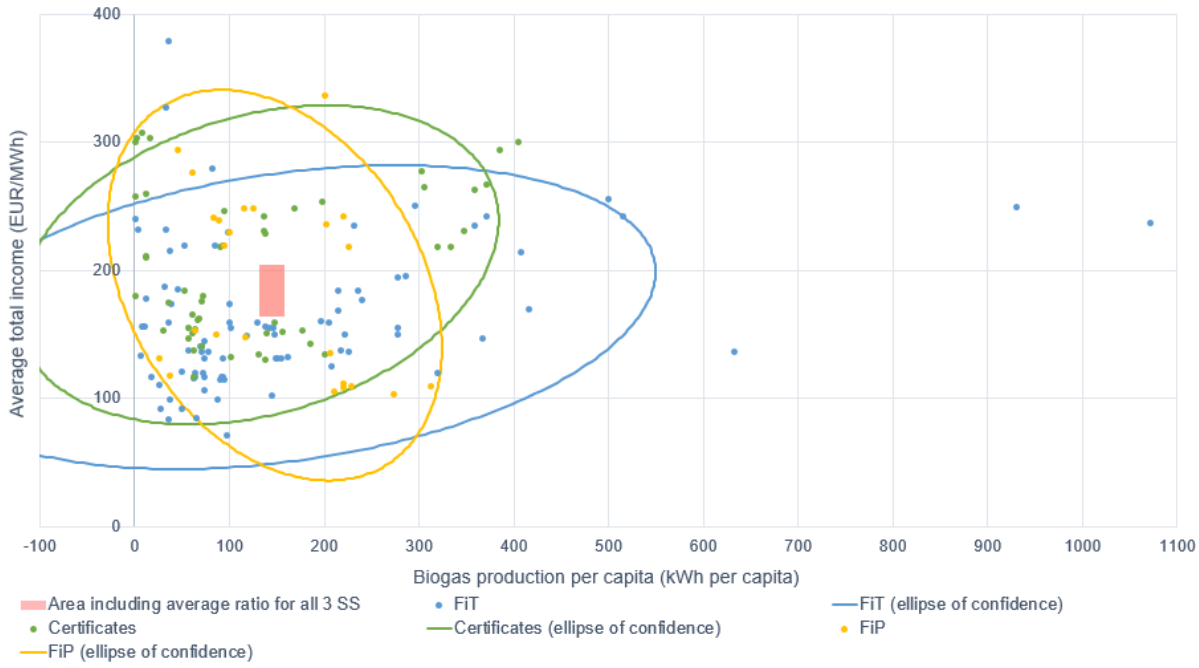

Figure 0-1: Biogas production per capita and average total income (max FiT/FiP/average GC price + average electricity price) for biogas producers per European country, year and support scheme for the period 2005 – 2015

The above findings clearly show that adequate support schemes are crucial for the development of renewable energy: the 2015 biogas production would not have reached 15.7 Mtoe without the national schemes in place through the different EU countries. Adequate support schemes are thus needed to

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secure new technological pathways in the biogas sector such as power-to-gas, dry AD and biomass gasification.

A summary of information of the different EU countries addressed in this report is provided in the following table. More details about the calculation process and the hypothesis made can be found in chapter 2 'Overview country by country'.

Country	Support scheme				Status of NREAP targets	
	Type (starting year)	Efficiency	Lag phase (year)	Increase of production (ktoe)	2014	2020
AT	FiT (2003)	Intermediate	2	254.45 (+657.4%)	Not achieved	Likely
BE	GC (2001)	Intermediate	2	169.1 (+393.5%)	Not achieved	Likely
BG	FiT (2011 – 2016)	Very low	3	19.6 ktoe (all)	Not achieved	Unlikely
CH	FiT (1991)	Very low	- (more data needed)	Unknown	- (no set target)	
CY	FiT (2009 – 2014)	High	2	-	Achieved	Unknown
CZ	FiT (2005 – 2014) FiP (2005 – 2014)	High	5	567.6 (+1339.6%)	Achieved	
DE	FiT (2000) FiP (2012)	Intermediate	2	7294.6 (+1403.4%)	Achieved	
DK	FiP (2009)	High	3	13.0 (+9.4%)	Achieved	Likely
EE	FiP (2003)	Low	3	9.0 (+315.9%)	No specific targets	
EL	FiT (2006) FiP (2012)	Intermediate	3	55.1 (+251.8%)	Not achieved	Unlikely
ES	FiT (1999 - 2013) FiP (2004 - 2012)	Low	1	146.4 (+227.1%)	Achieved	Unlikely
FI	FiP (2010)	Intermediate	3	42.8 (+170.9%)	No specific targets	
FR	FiT (2001)	Intermediate	1	345.4 (+278.8%)	Achieved	Likely
HR	FiT (2012)	Intermediate	1	25.5 (+344.5%)	Achieved	Likely
HU	FiT (2001)	High	5	79.7 (all production)	Achieved	Likely
IE	FiT (2005)	Intermediate	2	27.8 (+203.9%)	(no annual target)	Likely
IT	GC (1999) FiT (2008) FiP (2012)	Intermediate	3	1320.8 (+339.9%)	Achieved	
LT	Sliding FiP (2002)	Very low	5	23.4 (all)	Not achieved	Likely
LV	FiT (2009)	Intermediate	3	70.6 (+510.7%)	Not achieved	Likely
LU	FiT (1994, 2005) FiP (2001)	High	-	17.7 (all)	Not achieved	Unknown (IEC and biogas production data contradictory)
NL	FiP (2003) GC (1995)	Intermediate	3	115.5 (+154.6%)	Not achieved	Unlikely
NO	GC (2003)	Low	-	-	-	-
PL	GC (2005)	Low	3	155.3 (+311.4%)	Achieved	Likely
PT	FiT (2007)	High	3	70.5 (+682.0%)	Not achieved	Unlikely
RO	GC (2005)	Very low	3	18.3 (all production)	Not achieved	Very unlikely
RS	FiT (2009)	Very low	3	5.8 (all)	- (no set target)	
SE	GC (2003)	High	4	96.7 (+236.7%)	Achieved	
SK	FiT (2005)	High	4	144.4 (+3555.0%)	Achieved	
SI	FiT (2002) FiP (2002)	Intermediate	3	25.75 (+115.3%)	Not achieved	Likely
UK	GC (2002) FiT (2010) FiP (2014)	Intermediate	Unknown	Unknown	Achieved	

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Abbreviations List

FiP	Feed-in Premium
FiT	Feed-in Tariff
GC	Green certificate
IEC	Installed Electric Capacity
MWh	Megawatt-hour
NREAP	National Renewable Energy Action Plan
RE	Renewable Energy
RES	Renewable Energy Source
RO	Renewable Obligation
ROC	Renewable Obligation Certificate
SS	Support Scheme

AT	Austria	**IE**	Ireland
BE	Belgium	**IT**	Italy
BG	Bulgaria	**LT**	Lithuania
CH	Switzerland	**LU**	Luxembourg
CY	Cyprus	**LV**	Latvia
CZ	Czech Republic	**NL**	The Netherlands
DE	Germany	**NO**	Norway
DK	Denmark	**PL**	Poland
EE	Estonia	**PT**	Portugal
EL	Greece	**RO**	Romania
ES	Spain	**RS**	Serbia
FI	Finland	**SE**	Sweden
FR	France	**SI**	Slovenia
HR	Croatia	**SK**	Slovakia
HU	Hungary	**UK**	United Kingdom

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Methodology

This report covers the 28 EU Member States (minus Malta) and also includes Norway, Switzerland and Serbia. It compares national support schemes evolution with their primary biogas (source: EUROSTAT) and their national renewable energy targets from the National Renewable Energy Action Plans (NREAP). Different types of support schemes are introduced and a timeline of implementation in each country is presented. The effectiveness of the applied support schemes is analysed via the biogas production in the respective country.

Diversity of sources

Different data sources were used for compiling this report: the major ones are included in the bibliography & data source chapter at the end of this report

Disclaimer

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1. Introduction

1.1 Background Information

1.2 The importance of Support Schemes

Following the Paris agreement and the limitation of the global warming below 1.5 °C, Europe has to meet specific greenhouse gas emission mitigation in the next years. In order to do so, the development of renewable energies (RE) generation is essential. Biogas, as one of the most versatile RE, can help Europe meet its objectives. However, RE are quite young compared to conventional energy generation from fossil fuels and therefore need financial support during their emergence phase. Without governmental support, market forces might only result in limited integration of RE in market niches (Menanteau, Finon, & Lamy, 2003) (International Energy Agency, 2008).

Support schemes will reserve RE considerable time for learning effects and to reach mass production to reach an adequate level of economic performance. Thus, the eventual goal of support schemes is to achieve a smooth transition towards mass market integration of renewables to allow renewable energy technologies competitiveness with conventional technologies (Menanteau, Finon, & Lamy, 2003) (International Energy Agency, 2008).

1.3 Definition of support schemes

Support schemes are implemented into European and national policies with the aim of generating artificial market demand for renewable energy and thus stimulating technical progress and increasing the RE share in Europe. The two main approaches towards incentives frameworks are price-based versus quantity-based. Price-based approaches are usually Feed-in tariffs (FiT). They are applied for systems where utilities are obliged to purchase energy from green power generators at previously agreed Feed-in tariffs. For quantity-based approaches, authorities either define national targets and organise competitive bidding processes, or impose quotas on energy suppliers provided via tradable green certificates (GC) (Menanteau, Finon, & Lamy, 2003).

Feed-in tariff (FiT)

A Feed-in tariff is a technology-specific support scheme providing a technology-specific remuneration per unit of renewable energy. Public authorities are defining and guaranteeing the tariff for a specified time period. The following three criteria are typical advantages of a FiT:

i) long-term contract with producer (often 10 – 20 years)
ii) guaranteed grid access
iii) payment levels based on the RE generation costs. Payment levels usually are differentiated by technology type, project size, resource quality, and project location. Often there are tariff degressions which represent a declining of the tariff in following years (Couture, Cory, Kreycik, & Williams, 2010) (EurObserv'ER, 2015) (Menanteau, Finon, & Lamy, 2003).

FiT policies may include program or project caps: on the total capacity of RE allowed (usually differentiated by technology type), on the maximum individual project size (also often differentiated by technology type), or according to the total program cost (either total € per year, or for the multiyear program) (Couture, Cory, Kreycik, & Williams, 2010). Feed-in tariffs are the most used support systems in Europe.

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Feed-in premium (FiP)

A feed-in premium is a bonus to be paid above the prevailing, pre-specified benchmark market price. It is a technology-specific subsidy level per unit of renewable energy at a pre-set, fixed or floating rate. The premium can be designed to estimate the avoided externalities of RE generation, or to cover the RE generation cost by the total payment. The two typical FiP designs are either a constant (fixed and predetermined) price or a so-called sliding price allowing variations of the premium as a function of the prevailing price. The FiP, alike the FiT, is usually differentiated into different levels, e.g.: by plant size (Couture, Cory, Kreycik, & Williams, 2010) (EurObserv'ER, 2015).

Quota/green certificates scheme (GC)

In quota/GC system, the renewable energy share is stimulated by an obligatory target stating a specific share of renewable energy in the energy mix of producers, consumers or distributors (Couture, Cory, Kreycik, & Williams, 2010) (Menanteau, Finon, & Lamy, 2003). Often compliance is tracked by the trade of renewable energy certificates providing an additional supplementary revenue to electricity sales (Couture, Cory, Kreycik, & Williams, 2010). RE generators benefit by selling their energy to the grid at market price and by selling certificates on the green certificates market (Menanteau, Finon, & Lamy, 2003).

Fiscal incentives

Tax exemptions or reductions are usually additional (and minor) support systems. RE generators receive certain tax exemptions (e.g. carbon taxes) as compensation for the high competition of the RES market and its development (International Energy Agency, 2008). A tax paying entity is guaranteed a deducted amount of money on the declared taxes because of the use of renewable energy (EurObserv'ER, 2015). The impact of fiscal incentives is of course dependent on the applicable tax rate (International Energy Agency, 2008).

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2. Overview Country by Country

This chapter aims at a country by country analyses of the impact of the different national support schemes on the national biogas production. The analyses are divided into three main points (summary table, explanatory text and a summary graph) which are introduced below.

Summary Table

The summary table is divided into a section 'Support Scheme' and 'Status of NREAP targets'. The following points are considered for each country:

Support Scheme				Status of NREAP targets	
Type (starting year)	**Efficiency**	**Lag phase (year)**	**Increase of production (ktoe)**	**2014**	**2020**
FiT (2003)	Intermediate	2	254.45 (+657.4%)	Not achieved	Likely

Figure 2-1: example of a summary table (taken from the subchapter analysing Austria)

- The type of SS (FiT, FiP or GC), along with its starting year (and its termination year when relevant). When different SS are available in the country, the main one is underlined when relevant.

- The SS efficiency (High, Intermediate, Low, Very low). The SS efficiency is based on the ratio 'average total income/production per capita', and the value for the last year the SS was in place (default: 2015) is reported in the summary table. The average total income is calculated based on all the different countries using the considered scheme as their main SS. According to the different SS types, it is based on:

  - For FiT: maximum FiT available (EUR/MWh)
  - For FiP: average total income (average electricity price + maximum FiP +) (EUR/MWh)
  - For GC: average total income (average electricity price + average income from GC) (EUR/MWh)

  The SS efficiency is then determined as follows:

		Production per capita (kWh per capita)	
		Below average	Above average
Average total income (EUR/MWh)	Above average	Very low	Intermediate
	Below average	Low	High

- The 'Lag phase (year)' is the time shift which can be observed between the starting year of the main SS of a country, and a significant rise of its biogas production. As an example, this period was two years in the case of Austria (see Figure 2-2 below).

- The 'Increase of production (ktoe)' is a quantification of the amount of biogas production likely to have been caused by the main support scheme in the country. In order to estimate it, a linear extrapolation of the biogas production prior to the starting year of the national main support scheme has been calculated for the year 2015. The period considered for the extrapolation is indicated in the legend of each relevant graph (e.g.: in Austria, the relevant period was prior to

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2003) and can go back to as far as 1990 (limit of the Eurostat data). The increase of the 2015 biogas production compared to the supposed production (linear extrapolation) without SS is given as a percentage.

- The 'Status of NREAP targets' for 2014 (achieved/not achieved): indicates if the country has reached its NREAP targets for 2014. Note that some countries do not have yearly targets, and some are not part of the EU-28 and have therefore no official NREAP targets.

- The 'Status of NREAP targets' for 2020 (Likely, unlikely, very unlikely, unknown) is a basic forecast of the second half of the decade in the country, based on the legislative and biogas production evolution, as well as the level of ambition of the upcoming NREAP targets.

Explanatory text

The explanatory text highlights the evolution of the key pieces of legislation, provided context for the legislation and biogas production per capita evolution, as well as any background information deemed relevant.

Summary graph

The summary graph includes:

- The evolution of the most relevant SS tariffs/prices (primary vertical axis) in shades of blue
    - For FiT (as for Austria in Figure 2-2, taken as an example here): maximum and minimum FiT available, with the potential range of tariffs between the two illustrated as a striped area. Every full dot represents known data, and every dotted line a linear interpolation
    - For FiP: the average electricity price (dark blue) and the maximum FiP (along with the minimum FiP when relevant and available) in stacked columns
    - For GC: the average GC price, or the average income for biogas producers per MWh via GC (in the case more than one GC is awarded per MWh)

- The evolution of the biogas production (primary secondary axis) in orange

- The different key years for the national SS with the corresponding pieces of legislation when available, represented in boxes below the graph

- A linear extrapolation for the biogas production based on the production prior to the introduction of the main SS in the country represented in grey (see above for more information)

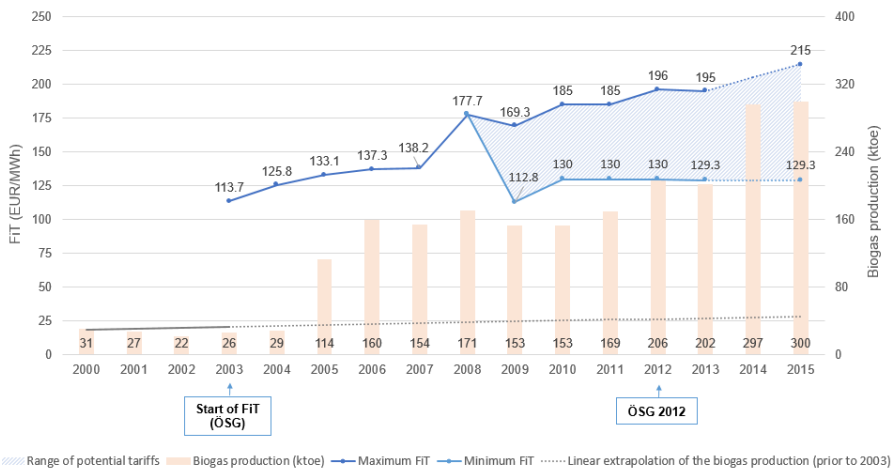

Figure 2-2: example of a summary graph (country considered: Austria)

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FiT as main support scheme

19 European countries used a FiT as their main support scheme in the timeframe 2005 – 2015: they include AT, BG, CH, CY, CZ, ES, FR, DE, EL, HR, HU, IE, IT, LV, LU, PT, RS, SK and SI. In order to visualise the evolution of the biogas production per capita according to the max FiT in place in the different countries more easily, a video is available on the biogasAction website.

As explained at the beginning of this chapter, the FiT efficiency estimation is based on the biogas production per capita in the country and the maximum FiT available for biogas producers, following the table below. The averages were calculated from all data gathered for the 19 countries using a FiT as their main SS: the average total income is 164.0 EUR/MWh, and the average production per capita is 168.7 kWh per capita.

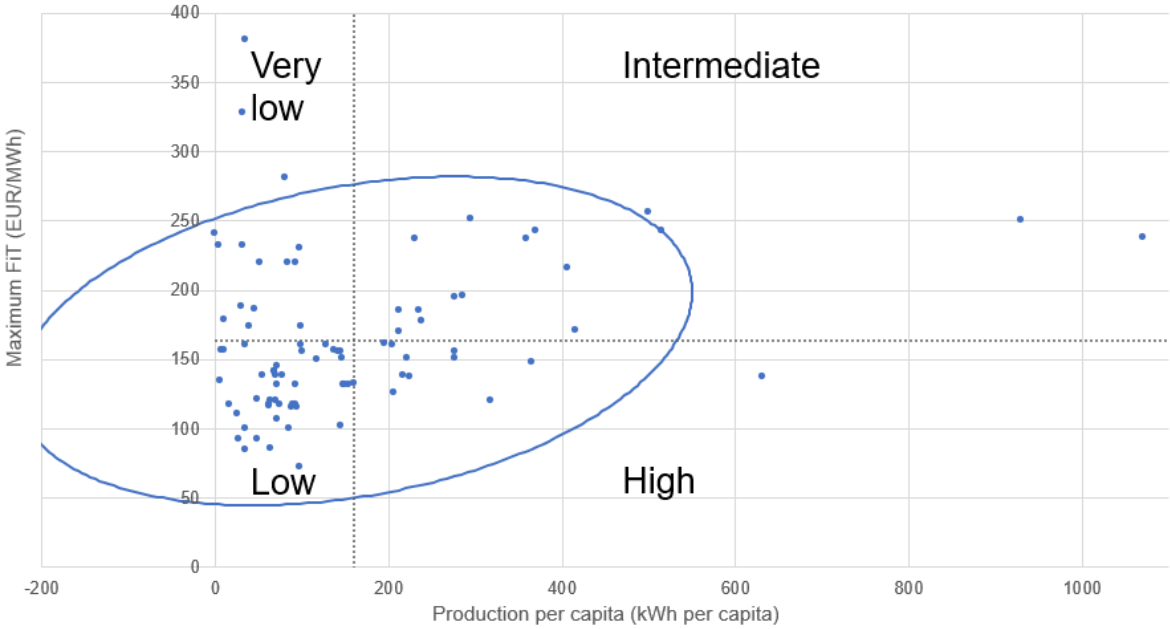

Figure 2-3: Maximum FiT and production per capita per year and country (with FiT efficiency zones)

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2.1 Austria (AT)

Support Scheme				Status of NREAP targets	
Type (starting year)	Efficiency	Lag phase (year)	Increase of production (ktoe)	2014	2020
FiT (2003)	Intermediate	2	254.45 (+657.4%)	Not achieved	Likely

Austria has a long history in promoting renewable energy sources. The support of biogas production via a Feed-in Tariff (FiT) truly started via the Green Electricity Act (*ÖSG Ökostromgesetz*), introduced in July 2002. Before that, the national biogas production stabilised between 25 and 30 ktoe. The FiT had a very significant impact on the national biogas production two years later (2005), which kept growing ever since (increase of more than 300 ktoe). The estimated increase related to the new FiT scheme is 254.45 ktoe, thus an increase of 657.4% compared to a linear extrapolation of the production growth prior to 2003. Within a decade (2005 and 2015), the production per capita increased from 160.9 to 407.0 kWh per inhabitant, making Austria one of the most productive European country per inhabitant (annual average increment of 24.6 kWh per inhabitant). The Green Electricity Act 2012 started the second significant rise of production in the country (between 2013 and 2015). Additional financial incentives are also available for biogas such as for investing in Residential Renewable Generation and Residential Efficiency.

The efficiency of the FiT in Austria is intermediate considering its high maximum FiT and high production per capita. However, the FiT has not allowed the country to reach its NREAP targets so far: in 2015, the IEC was 81.5 MW (100 MW expected). The low progression of the yearly NREAP targets (102 MW expected by 2020) make the country likely to reach its end of the decade target.

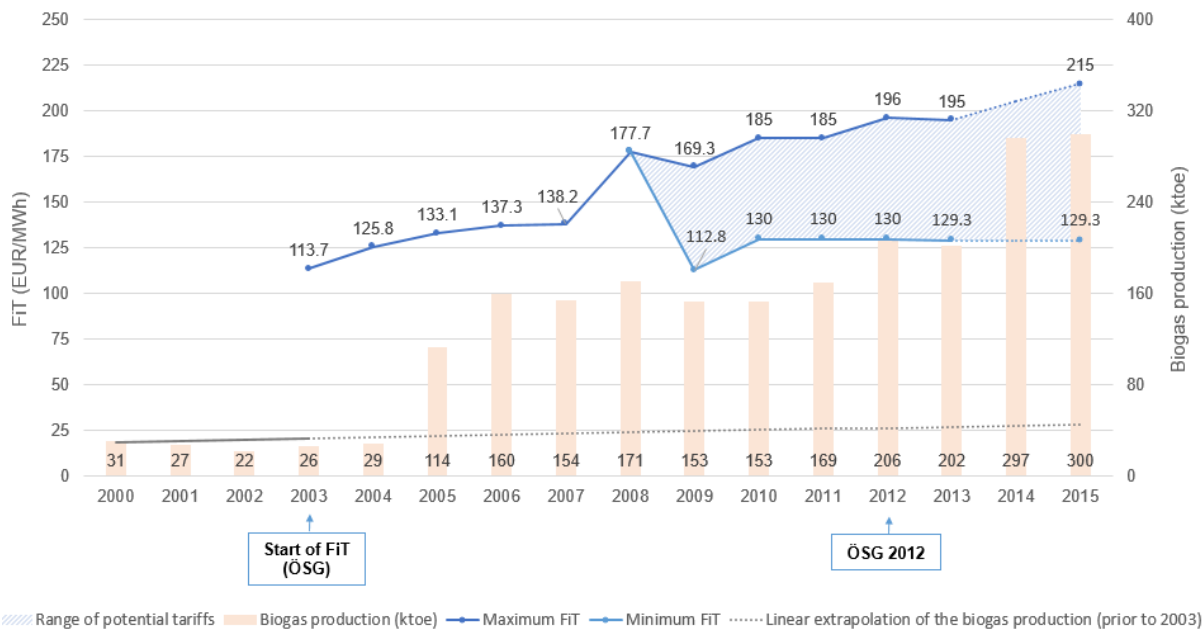

Figure 2-4: Evolution of the FiT, legislation and biogas production in Austria

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2.2 Bulgaria (BG)

Support Scheme				Status of NREAP targets	
Type (starting year)	Efficiency	Lag phase (year)	Increase of production (ktoe)	2014	2020
FiT (2011 – 2016)	Very low	3 years	19.6 ktoe (total)	Not achieved	Unlikely

The Renewable and Alternative Energy Sources and Biofuels Act, implemented in 2007, was the first legal framework relevant to biogas in Bulgaria. A tariff support scheme was started through the Energy from Renewable Sources Act (ERSA) in 2011, with tariffs depending on installed electric capacity (IEC) and substrate use, but new plants could only apply until 2015 (FiT ended in 2016). During the five years of application, Bulgaria achieved little biogas production: the start of the FiT helped increase the production between 2013 and 2015 (two years gap - roughly 17 ktoe). Per capita, the average increment is well below the European average with around 4.5 kWh per inhabitant, second lowest before Serbia. The Bulgarian tariff was one of the least efficient tariffs in Europe, with a performance index defined as 'very low' almost every year. This poor performance has increased the gap between NREAP targets (40 MW) and actual production in Bulgaria (IEC 10 MW). In 2014, only 25% of the production target were achieved. The target of 65 MW for electricity production from biogas by 2020 is highly unlikely to be reached, especially since the FiT scheme for new plants was stopped in 2016.

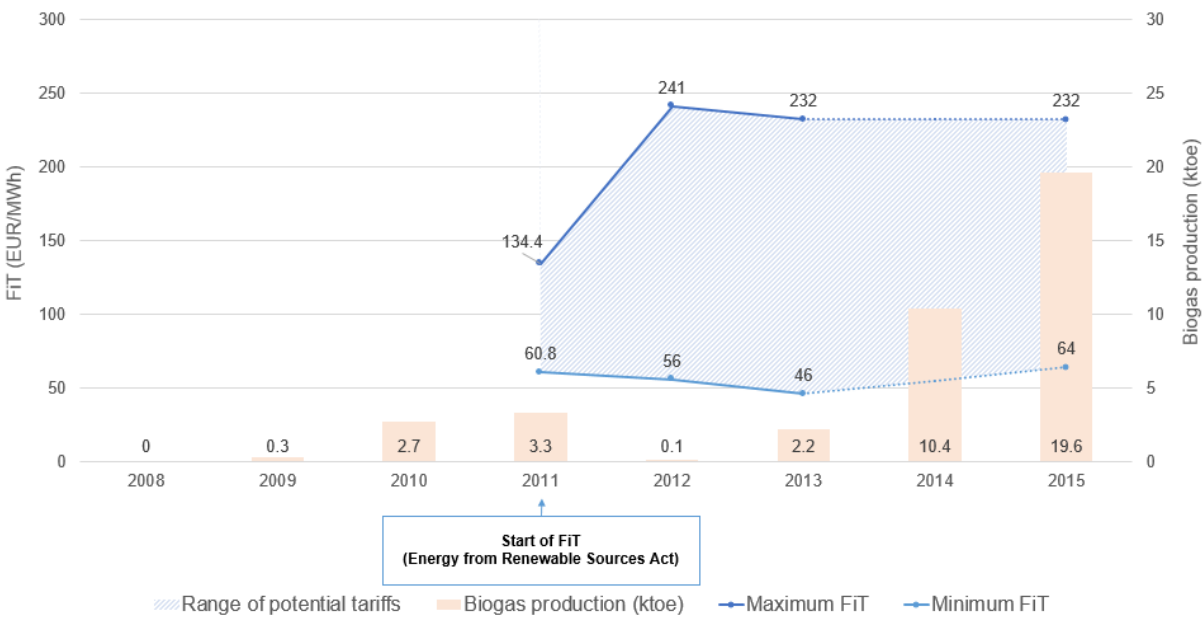

Figure 2-5: Evolution of the FiT, legislation and biogas production in Bulgaria

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2.3 Croatia (HR)

Support Scheme				Status of NREAP targets	
Type (starting year)	Efficiency	Lag phase (year)	Increase of production (ktoe)	2014	2020
FiT (2012)	Intermediate	1 year	25.5 (+344.5%)	Achieved	Likely

The legal framework for electricity production from biogas was launched in 2001 in Croatia with the 'Regulation on Incentive Fees to Promote Electricity Production from RES and cogeneration', although tariffs were only started 11 years later in 2012. The support scheme had a significant impact on biogas production the year it was started, with a rise of 24.6 ktoe between 2012 and 2015. Based on the production growth rate prior to 2012, 25.5 ktoe of the 2015 biogas production is likely to have been caused by the start of the FiT in 2012 (+344.5%). The increment of biogas production per capita during the same period is 20.1 kWh, in line with the European average. Investment support is also available for biogas plants via loan in the HBOR Bank scheme and the environmental Fund.

The performance of the Croatian FiT is remarkable, with a steady increase since its start from 31 to 99 kWh per capita (in 2015). The index reached the intermediate level of performance in 2015. This led Croatia to achieve almost twice the IEC target for 2014 (16 MW compared to an expected 8.1 MW). Given the above, the Croatian target of 40 MW in 2020 is easily achievable if the country sustains its production growth rate at a similar pace.

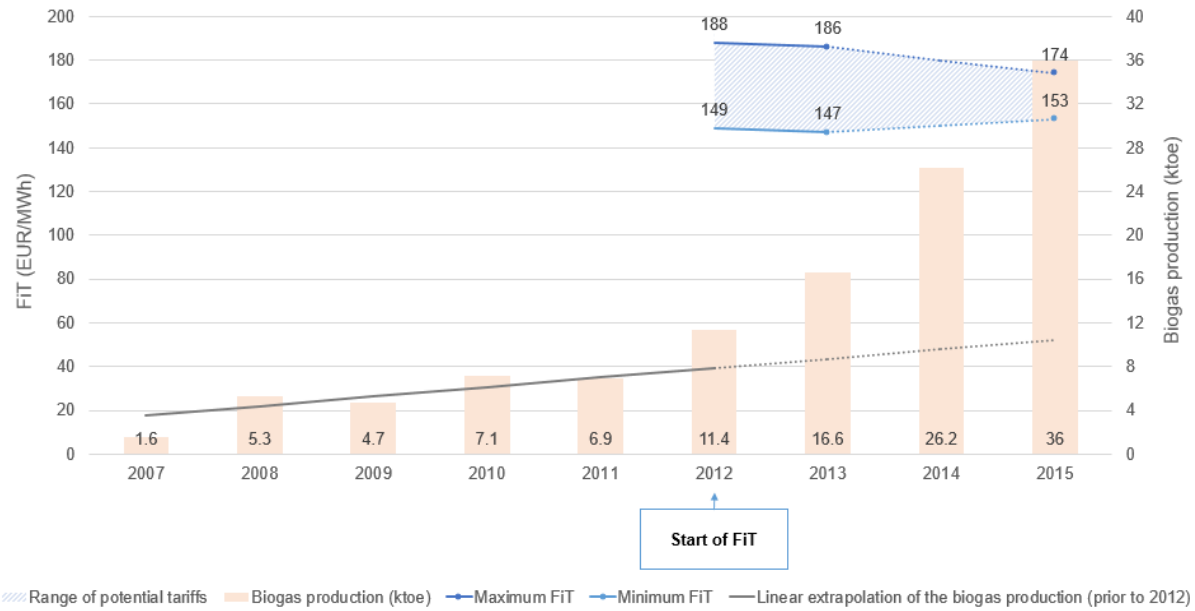

Figure 2-6: Evolution of the FiT, legislation and biogas production in Croatia

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2.4 Cyprus (CY)

Support Scheme				Status of NREAP targets	
Type (starting year)	Efficiency	Lag phase (year)	Increase of production (ktoe)	2014	2020
FiT (2009 – 2014)	High	2 years	-	Achieved	Unknown

Cyprus launched its first major biogas-relevant piece of legislation in 2003 with the Law on the Promotion of Renewable Energy and Energy Efficiency (for RES including biogas). A support scheme was truly started in 2009, for landfill gas only with tariffs from 114.5 to 131.6 EUR/MWh (depending on the bonus). The tariffs stayed remarkably stable until 2014, when the application process closed. The tariff had a significant impact on biogas production in the country, with a rise of 6.4 ktoe between 2009 and 2012 (the production stayed at the 2012 level ever since). The increment of biogas production per capita since 2009 is 17.9 kWh per inhabitant, below the EU average. The performance of the Cypriot FiT scheme is high: it went from intermediate to high between 2009 and 2010 and stayed in that category until 2013. The high performing support scheme allowed Cyprus to reach its NREAP target for 2014 (IEC of 10.4 MW compared to 8 MW expected), but the 2020 target (17 MW) might not be reached due to the halt of the FiT in 2014.

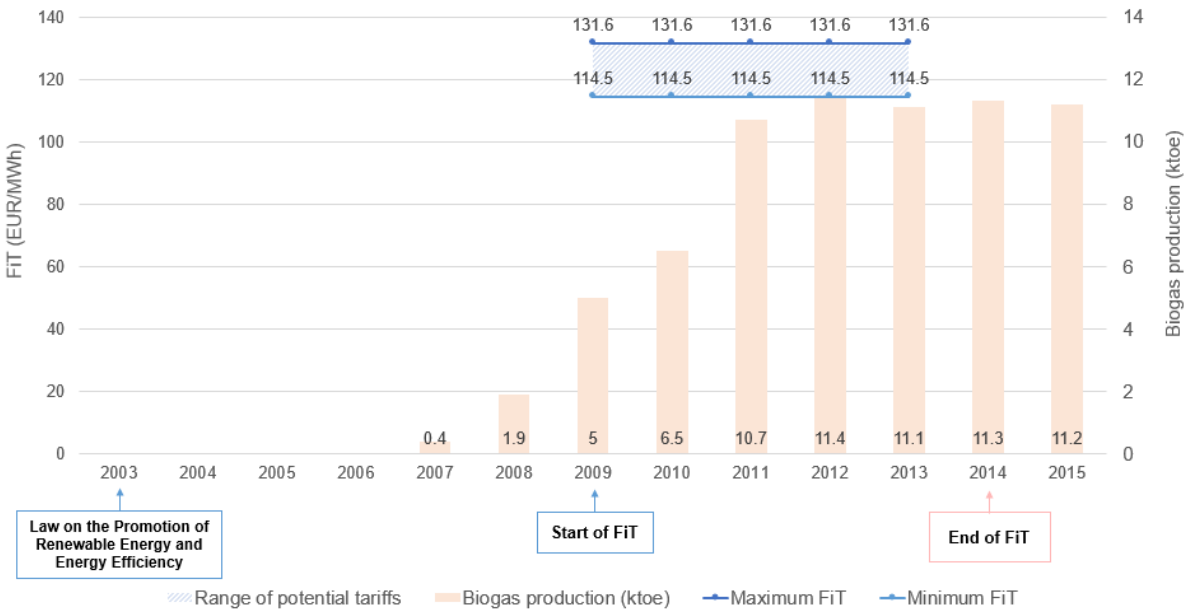

Figure 2-7: Evolution of the FiT, legislation and biogas production in Cyprus

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2.5 Czech Republic (CZ)

Support Scheme				Status of NREAP targets	
Type (starting year)	Efficiency	Lag phase (year)	Increase of production (ktoe)	2014	2020
FiT (2005 – 2014) FiP (2005 – 2014)	High	5	567.6 (+1339.6%)	Achieved	

The support for electricity production from biogas started in 2003 in Czech Republic with the bill on Promotion of Power and Heat Generation from Renewable Energy Sources. Tariffs were started two years after in 2005 via the 'Act on the Promotion of the Use of Renewable Energy Sources'. Biogas producers in Czech Republic can either choose a fixed tariff or a premium FiT (green bonus) on top of the electricity price. Between the introduction (2005) and the end (2014) of the Czech support scheme, the biogas production massively increased, compared to the production growth rate prior to 2005, 567.6 ktoe of the 2015 biogas production is likely to have been caused by the start of the FiT in 2005 (+1339.6%). This makes Czech Republic the second highest country in terms of production per capita, with an increase of more than 600 kWh per inhabitant between 2005 and 2014 (increment average of 61 kWh per capita per year). Many different investment subsidies were available for biogas producers, such as from the '*Operational Programme Enterprise and Innovations (ECO-ENERGY Programme)*', the '*Operational Programme Environment*', and the '*Operational Programme Business and Innovation for Competitiveness (OPPIK)*'.

A sharp increase of production started in 2009, 4 years after the start of the support scheme. The performance index for the support scheme evolved at the boundary between intermediate and high performance, for reaching the latest in 2013, last year of the tariff. This high performance led the country to meet its 2020 NREAP target already in 2014 (367 MW IEC in 2014 – 2020 IEC target of 364 MW).

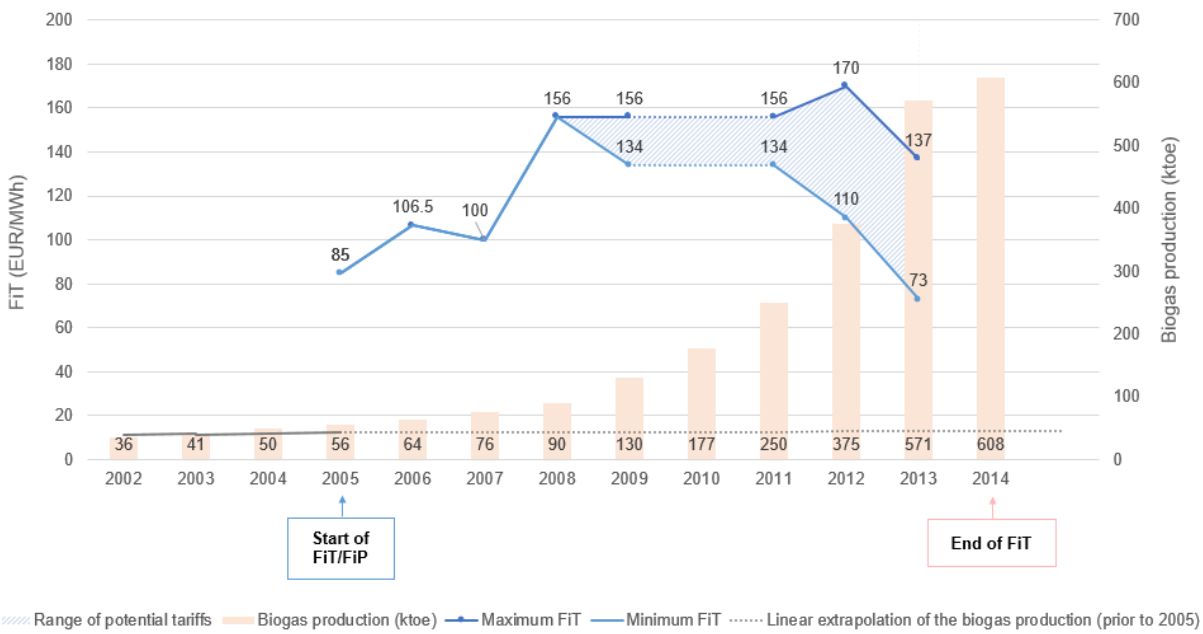

Figure 2-8: Evolution of the FiT, legislation and biogas production in Czech Republic

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2.6 France (FR)

Support Scheme				Status of NREAP targets	
Type (starting year)	Efficiency	Lag phase (year)	Increase of production (ktoe)	2014	2020
FiT (2001)	Intermediate	1	345.4 (+278.8%)	Achieved	Likely

France started the development of the biogas industry with the 'Renewable Energy Feed-in Tariffs (I)' in 2001 for installations below 12 MW, which was revised in 2002, 2006 and 2011. The 2001 FiT increased the production until 2004, and the second revision of the FiT (2006) started a steady increase until 2015. Based on the production growth rate prior to 2001, 345.4 ktoe of the 2015 biogas production is likely to have been caused by the start of the FiT in 2001 (+278.8%). Between 2006 and 2014, the biogas production increased by more than 260 ktoe, which is fairly low when related to the French population (increase from 3.9 to 10.9 kWh per inhabitant, far below the EU average). Different tax regulation mechanism ('*Crédit d´impôt développement durable*') and subsidies ('Prime '*Habitat mieux*') are made available for biogas producers.

The French FiT displays a low to intermediate efficiency, which nevertheless allowed the country to reach its NREAP targets so far (320 MW IEC in 2014 – 311 expected). The country will reach its 2020 IEC NREAP target for 2020 if the current installation growth is maintained.

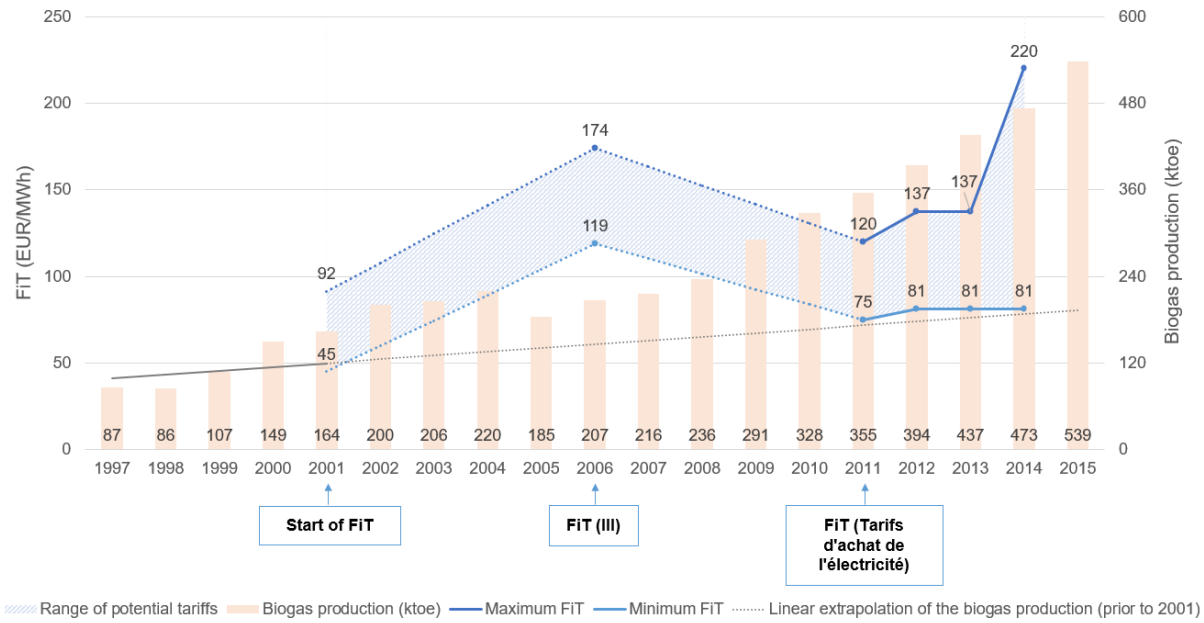

Figure 2-9: Evolution of the FiT, legislation and biogas production in France

This project has received funding from the European Union's Horizon 2020 research and innovation programme.

2.7 Germany (DE)

Support Scheme				Status of NREAP targets	
Type (starting year)	Efficiency	Lag phase (year)	Increase of production (ktoe)	2014	2020
FiT (2000) FiP (2012)	Intermediate	2	7294.6 (+1403.4%)	Achieved	

With the Electricity Feed-In Law in 1991, Germany is one of the first European countries that started to support renewable electricity generation. Tariffs for electricity production from biogas started 9 years downstream when the Renewable Energy Sources Act (Erneuerbare-Energien-Gesetz - EEG) superseded the Electricity Law in 2000. While before 2000 the German biogas production was stable (between 290 and 390 ktoe), the EEG started to have an impact 2 years later (2002), with a production that year of 1,270 ktoe. The EEG 2004 boosted the biogas production, starting in 2007 (3 years gap). The growth has been steady ever since through the different updates of the law (2009, 2012 and 2014), which makes Germany by far the largest biogas producer in Europe and in the world today. Based on the production growth rate prior to 2000, 7,294.6 ktoe of the 2015 biogas production is likely to have been caused by the start of the FiT in 2000 and its multiple revision over the years (+1,403.4%). Different loans ('*KfW Renewable Energy Programme – Standard*' & '*KfW Financing Initiative Energiewende*') and subsidies (Flexibility surcharge) are made available to the relevant biogas installations.

In terms of biogas production per capita, Germany is also the first European country with 1,124.9 kWh per capita. Even though Germany achieved a significant and unique increase in biogas production, its FiT efficiency is considered intermediate since other countries achieved quite significant results with lower maximum FiT (such as Luxembourg, Slovakia or Czech Republic). This significant increase also allowed Germany to reach its NREAP targets quite easily: 4,700 MW were already installed in 2014 although only 3,796 MW were required for 2020. Last updates of the EEG focused more on sustainability issues, by fostering small biogas plants with high use of manure (for biomass substrate) and biowaste.

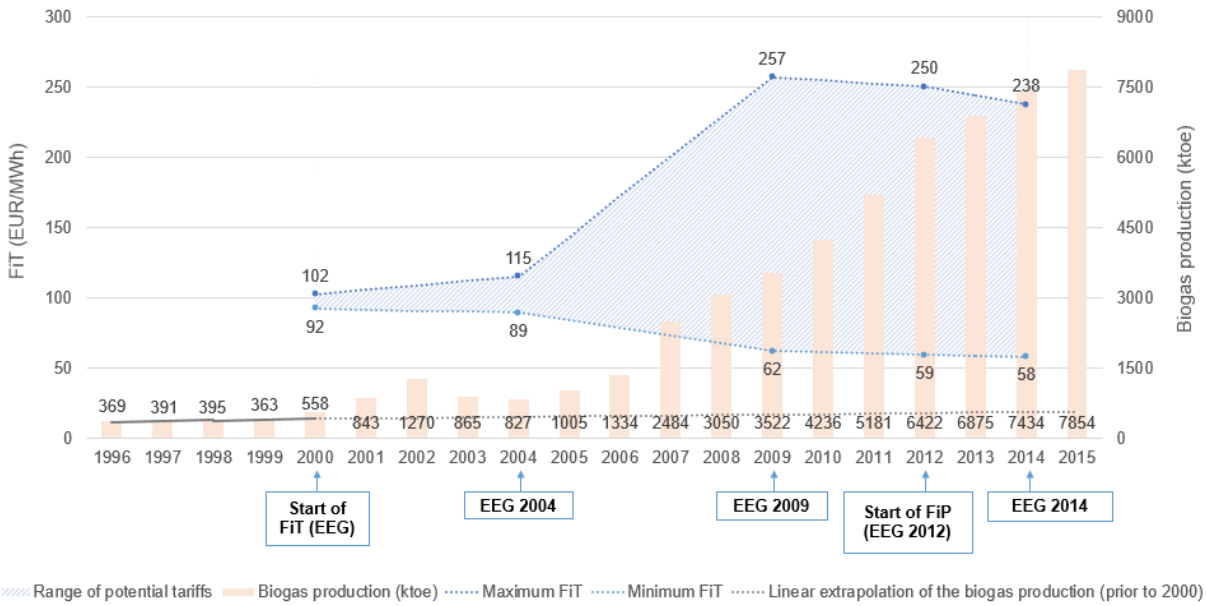

Figure 2-10: Evolution of the FiT, legislation and biogas production in Germany

This project has received funding from the European Union's Horizon 2020 research and innovation programme.

2.8 Greece (EL)

Support Scheme				Status of NREAP targets	
Type (starting year)	Efficiency	Lag phase (year)	Increase of production (ktoe)	2014	2020
FiT (2006) FiP (2012)	Intermediate	3	55.1 (+251.8%)	Not achieved	Unlikely

Greece started the promotion of green electricity from biogas in 2006 with a FiT. The tariff has had a clear impact on the biogas production in the country, starting in 2009 (3 years gap). A revision of the tariffs in 2010 allowed the country to reach its highest production in 2012, where it stagnates ever since. Based on the average production prior to 2006, 55.1 ktoe of the 2015 biogas production is likely to have been caused by the start of the FiT in 2006 (+251.8%). The Greek production per capita was 97.9 kWh in 2015 (well below EU average), with an average increment of the production per capita (6.3 kWh) well below the European average. Different investments subsidies (Development Law) are available to the relevant biogas installations.

The efficiency of the Greek FiT is intermediate, but is quite low: although the country achieved to boost its production with its tariffs, the increase is too low to fulfil its NREAP targets (47 MW IEC – 80 MW expected). Given the slow growth since 2012, this jeopardises the country's ability to reach its 2020 target (210 MW expected).

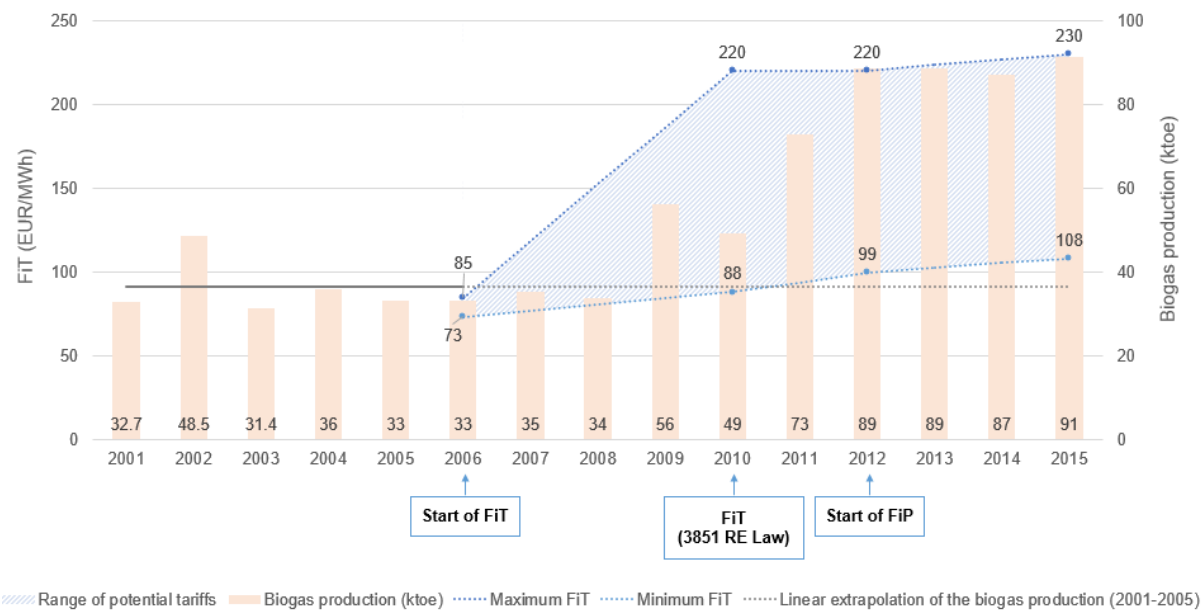

Figure 2-11: Evolution of the FiT, legislation and biogas production in Greece

This project has received funding from the European Union's Horizon 2020 research and innovation programme.

2.9 Hungary (HU)

Support Scheme				Status of NREAP targets	
Type (starting year)	Efficiency	Lag phase (year)	Increase of production (ktoe)	2014	2020
FiT (2001)	High	5	79.7 (total production)	Achieved	Likely

Hungary started to support its national biogas production in 2001 with the Electricity Act. A significant growth in biogas production can be observed starting in 2006, and the production kept increasing ever since. The Hungarian tariffs triggered the biogas production in the country, which was non-existent prior to 2001: the country increased its production from 6.7 to 79.7 between 2004 and 2015 (73 ktoe). The Hungarian tariffs are based on electricity demand: peak period (high tariffs), 'valley' period (intermediate tariffs), 'deep-valley' period (low tariffs) to foster the flexibility of electricity generation. The production per capita increased from 8.2 to 94.0 between 2005 and 2015 (average increment of 8.6 kWh per capita), which puts Hungary in the lowest fraction of the European ranking. Thanks to its efficient support scheme, Hungary managed to reach quite easily its NREAP target for 2014 (63 MW installed - 32 expected). The country is well on its way to reach the expected 100 MW by 2020.

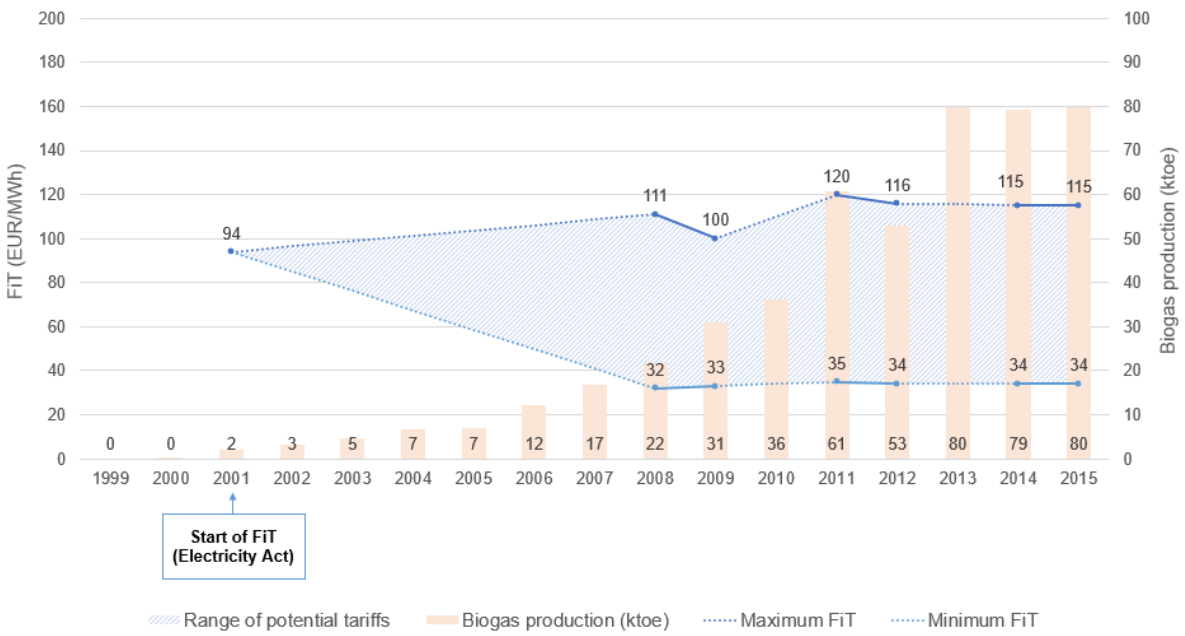

Figure 2-12: Evolution of the FiT, legislation and biogas production in Hungary

This project has received funding from the European Union's Horizon 2020 research and innovation programme.

2.10 Ireland (IE)

Support Scheme				Status of NREAP targets	
Type (starting year)	Efficiency	Lag phase (year)	Increase of production (ktoe)	2014	2020
FiT (2005)	Intermediate	2	27.8 (+203.9%)	(no annual target)	Likely

The biogas production in Ireland prior to the start of the FiT was already significant, mainly because of the high amount of production capacity installed in WWTP. Since then, Ireland started its support for renewable electricity from biogas in 2005, with a different support for landfill and biomass. The tariff started an increase in biogas production two years later in 2007 until 2010 (total increase of 23 ktoe). The tariffs were updated in 2011, with the introduction of CHP as a factor to determine the level of tariff available. Based on the average production for the period 1997 – 2004, 27.8 ktoe of the 2015 biogas production is likely to have been caused by the start of the FiT in 2005 (+203.9%). Since 2005 the production per capita increased from 97.0 to 137.2 kWh (average increment of 4.0 kWh), below the EU average. Thanks to its low maximum FiT, the efficiency of the Irish FiT has been high for a few years, before turning intermediate in 2012. NREAP targets for Ireland is 62 MW IEC before 2020 (no annual target), and although biogas production in the country stagnated since 2012, the progression of the IEC since 2011 shows that the country will reach its target.

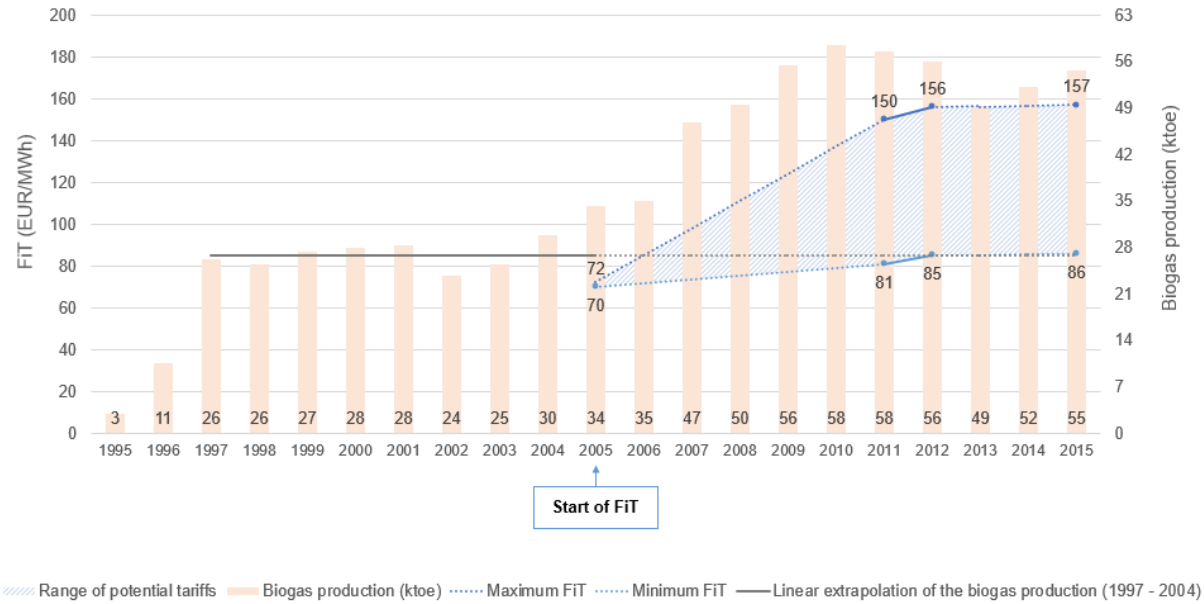

Figure 2-13: Evolution of the FiT, legislation and biogas production in Ireland

This project has received funding from the European Union's Horizon 2020 research and innovation programme.

2.11 Italy (IT)

Support Scheme				Status of NREAP targets	
Type (starting year)	Efficiency	Lag phase (year)	Increase of production (ktoe)	2014	2020
GC (1999) FiT (2008) FiP (2012)	Intermediate	3	1320.8 (+339.9%)	Achieved	

Italy started its support towards renewable electricity generation in 1999 with the introduction of the Green Certificates System (2% quota obligation of RES for energy supplier), which is likely to have started the biogas production in the country. In 2008, Italy added an "All inclusive" Feed-in Tariff for small renewable energy power plants as an alternative for biogas producer to the tradable certificates scheme (choice is left to them). The FiT had a significant impact on the national production: starting in 2011, the production grew steadily until 2014. Based on the production growth rate prior to 2007, 1320.8 ktoe of the 2015 biogas production is likely to have been caused by the start of the FiT in 2008 (+339.9%). Different tax regulation mechanisms are in place in the country for relevant biogas installations.

In 2012, Italy transformed the certificate scheme into a FiP. Between 2008 and 2014, the Italian biogas production per capita went from 81.3 to 375.2 kWh, making Italy one of the biggest producer both in absolute and per capita terms. The efficiency of the Italian FiT (ranked medium because of its high maximum FiT) and the significant production increase in 2011 allowed Italy to reach its 2020 NREAP target already in 2012.

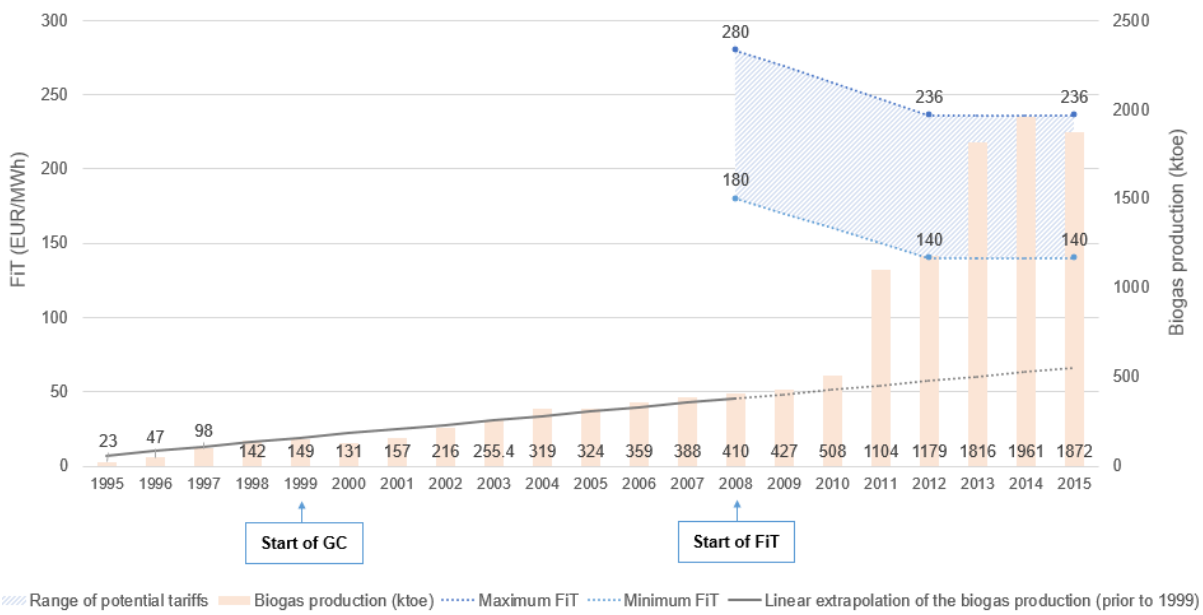

Figure 2-14: Evolution of the FiT, legislation and biogas production in Italy

This project has received funding from the European Union's Horizon 2020 research and innovation programme.

2.12 Latvia (LV)

Support Scheme				Status of NREAP targets	
Type (starting year)	Efficiency	Lag phase (year)	Increase of production (ktoe)	2014	2020
FiT (2009)	Intermediate	3	70.6 (+510.7%)	Not achieved	Likely

Latvia started to support electricity generation from biogas in 2009, which had a clear impact on biogas production 3 years later in 2012. Since then, the production continued to grow steadily to reach 87.8 ktoe in 2015, which is considerable for such a small country. Based on the production growth rate prior to 2008, 70.6.8 ktoe of the 2015 biogas production is likely to have been caused by the start of the FiT in 2009 (+510.7%). Different tax regulation mechanisms are in place in the country for relevant biogas installations.

Between 2009 and 2015, Latvia increased its production per capita from 52.2 to 514.1 kWh per inhabitant (average increment of 66.8 kWh per year), making the country the third largest biogas producer in Europe in production per capita. The country efficiency index for its tariff is classified as intermediate only because of its high maximum FiT. Even though the country massively increased its production (compared to its size), Latvia hasn't been able to catch up with its NREAP targets so far (58 MW IEC in 2014 – 62 expected). If sustained, the significant Latvian growth can allow the country to reach its 2020 target since the target grow slower in the second half of the decade.

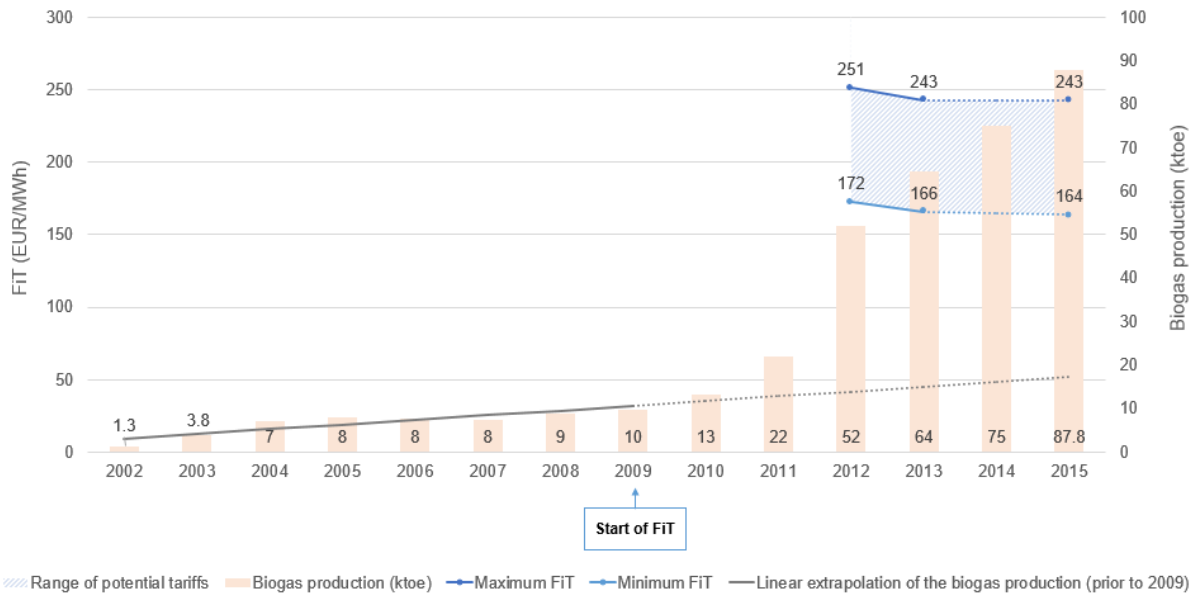

Figure 2-15: Evolution of the FiT, legislation and biogas production in Latvia

This project has received funding from the European Union's Horizon 2020 research and innovation programme.

2.13 Luxembourg (LU)

Support Scheme				Status of NREAP targets	
Type (starting year)	Efficiency	Lag phase (year)	Increase of production (ktoe)	2014	2020
FiT (1994, 2005) FiP (2001)	High	-	17.7 (all)	Not achieved	Unknown (IEC and biogas production data contradictory)

Luxembourg started early in supporting renewable energy and cogeneration: the first Feed-in tariffs for renewable energy and cogeneration was started in 1994, and then superseded by a new version in 2005. In the meantime, a FiP was started in 2001 and ended in 2008. The influence of the support schemes is clear and significant: while the first FiT is likely to have started the production in the country, the second FiT boosted the production, which has been growing steadily until 2015. The increase of production between 2005 and 2015 went from 5.7 to 17.7 ktoe (12 ktoe growth), and from 143.7 to 365.7 kWh per capita, putting Luxembourg in the high range of biogas producer (per capita). On top of the FiT and FiP, biogas installation can also apply for different subsidies ('*Régime d'aide à la protection de l'environnement et à l'utilisation rationnelle des ressources naturelles*', '*Régime d'aide en faveur des classes moyennes*'). Different subsidies ('*Régime d´aide à la protection de l´environnement et à l´utilisation rationnelle des ressources naturelles*') are made available to relevant biogas installations.

The efficiency of the second FiT in Luxembourg has been consistently high, due to the moderate maximum FiT it needed for achieving the growth of biogas production. Luxembourg has however not yet reached its NREAP targets: the country displayed 7.1 MW of IEC in 2011 (9 MW expected), and its 2020 objective is 20 MW.

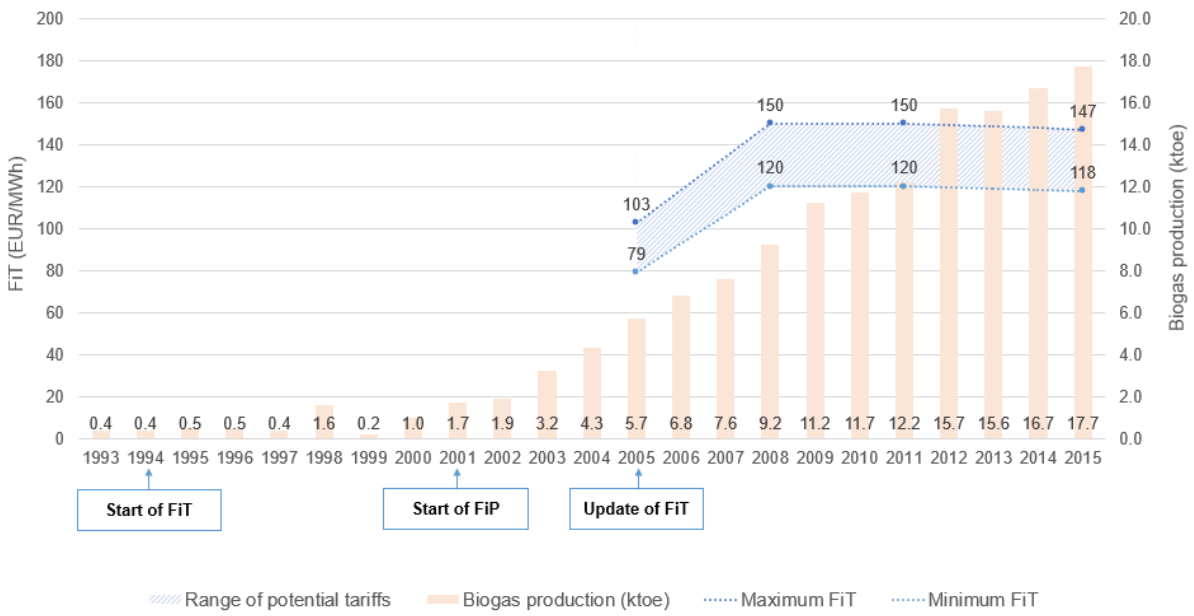

Figure 2-16: Evolution of the FiT, legislation and biogas production in Luxembourg

This project has received funding from the European Union's Horizon 2020 research and innovation programme.

2.14 Portugal (PT)

Support Scheme				Status of NREAP targets	
Type (starting year)	Efficiency	Lag phase (year)	Increase of production (ktoe)	2014	2020
FiT (2007)	High	3	70.5 (+682.0%)	Not achieved	Unlikely

Portugal started the support of renewable energy generation in 1999, in which biogas was included in 2007. A clear growth of the biogas production can be observed 3 years later (2010), and the production kept growing steadily until 2015. Based on the production growth rate prior to 2007, 70.5 ktoe of the 2015 biogas production is likely to have been caused by the start of the FiT in 2007 (+510.7%). Different tax regulation mechanisms are in place in the country for relevant biogas installations.

In terms of production per capita, the country went from 17.4 to 92.6 kWh for the same period, with an average increment of 9.2 kWh annually. The efficiency of the Portuguese FiT is high, due to its low maximum FiT and the increase per capita it created. Although the production is on the rise in Portugal, the country hasn't been able to catch up with its NREAP targets: 66 MW were implemented in 2014, while 105 MW were expected. If the current growth is sustained, the country will not be able to reach its 2020 target (150 MW IEC by 2020).

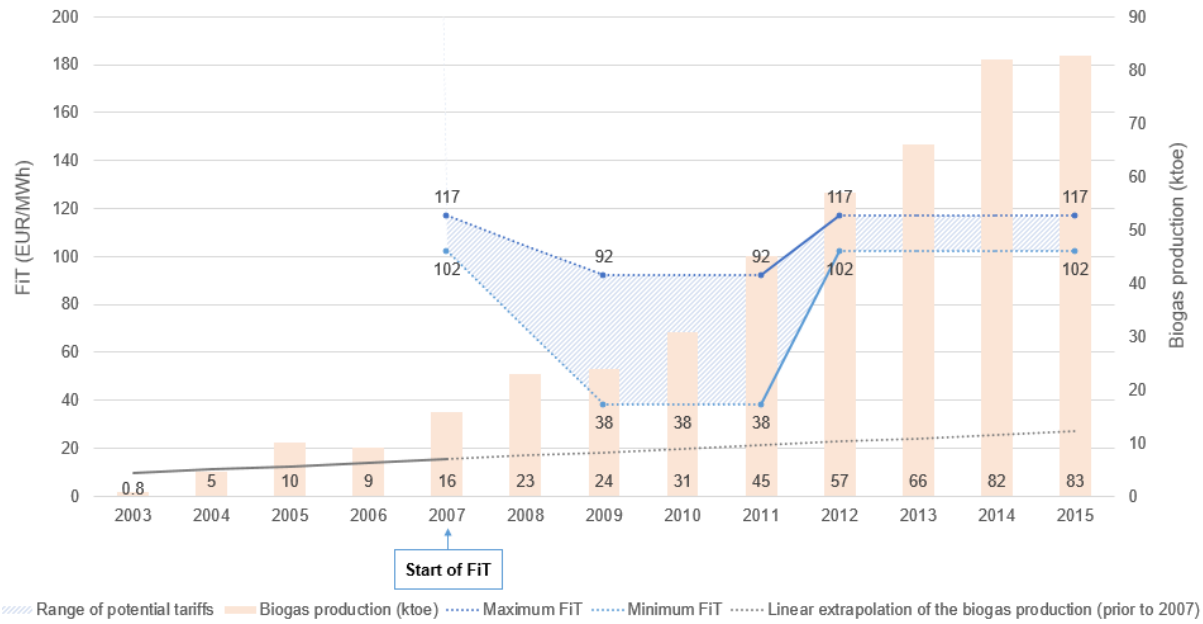

Figure 2-17: Evolution of the FiT, legislation and biogas production in Portugal

This project has received funding from the European Union's Horizon 2020 research and innovation programme.

2.15 Serbia (RS)

Support Scheme				Status of NREAP targets	
Type (starting year)	Efficiency	Lag phase (year)	Increase of production (ktoe)	2014	2020
FiT (2009)	Very low	3	5.8 (all)	Irrelevant	

Serbia started its support scheme for electricity generation from biogas in 2009, fairly late compared to other European countries. The impact of the support scheme can be clearly observed 3 years later (2012), and the biogas production has grown ever since. Between the introduction of the FiT and 2015, the biogas production increased by 5.8 ktoe. This increase is small: in terms of production per capita, Serbia displays the lowest score in Europe with 9.5 kWh per inhabitant (average increment of 2.4 kWh per capita). As Serbia is not part of the EU, it doesn't have any NREAP targets.

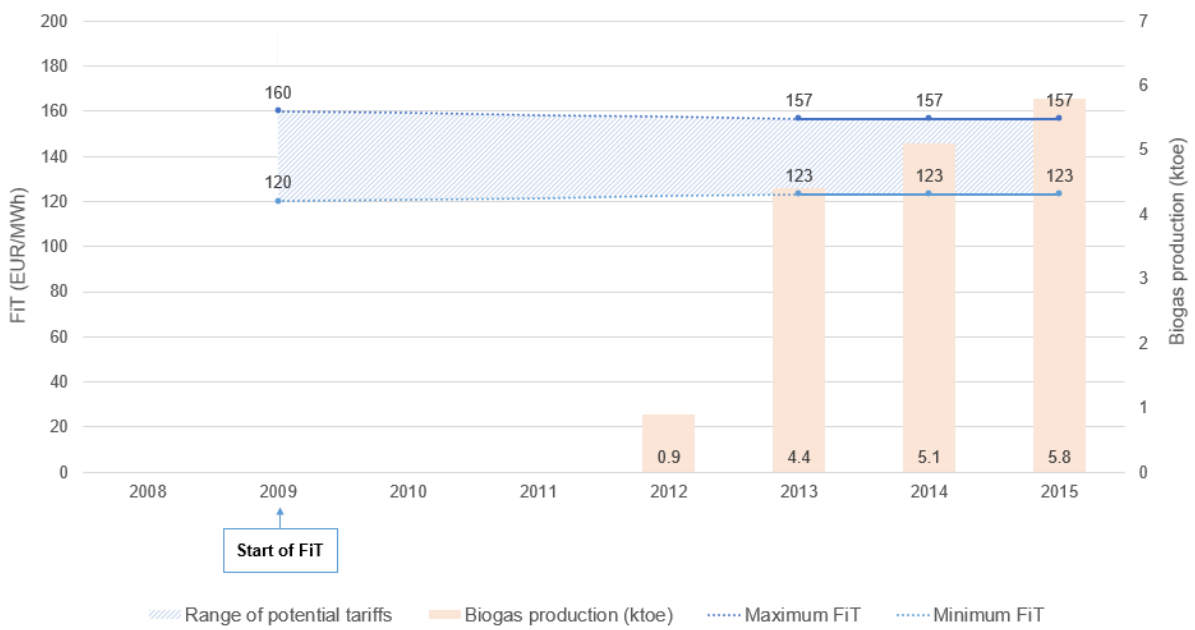

Figure 2-18: Evolution of the FiT, legislation and biogas production in Serbia

This project has received funding from the European Union's Horizon 2020 research and innovation programme.

2.16 Slovakia (SK)

Support Scheme				Status of NREAP targets	
Type (starting year)	Efficiency	Lag phase (year)	Increase of production (ktoe)	2014	2020
FiT (2005)	High	4 years	144.4 (+3555.0%)	Achieved	

Slovakia started the promotion of renewable energy generation from biogas in 2005, and a significant growth of the national production started 6 years later (2011) until 2015. Based on the production growth rate prior to 2005, 144.4 ktoe of the 2015 biogas production is likely to have been caused by the start of the FiT in 2005 (+3555.0%). Different subsidies ('*Operational Programme Environment*' and the '*Operational Programme Bratislava Region*') and tax regulation mechanisms (exemption form excise tax) are made available to relevant biogas installations in the country.

The production per capita went from 10.6 to 318.8 kWh per inhabitant during the same period. Slovakia displays one of the most interesting trajectory in Europe for biogas development: it started with a high maximum FiT and low production per capita (low efficiency FiT), and ended with the opposite ten years later (high efficiency FiT), making the country of the most productive per capita in Europe in 2015. This significant increase allowed Slovakia to reach its 2020 NREAP target already in 2014.

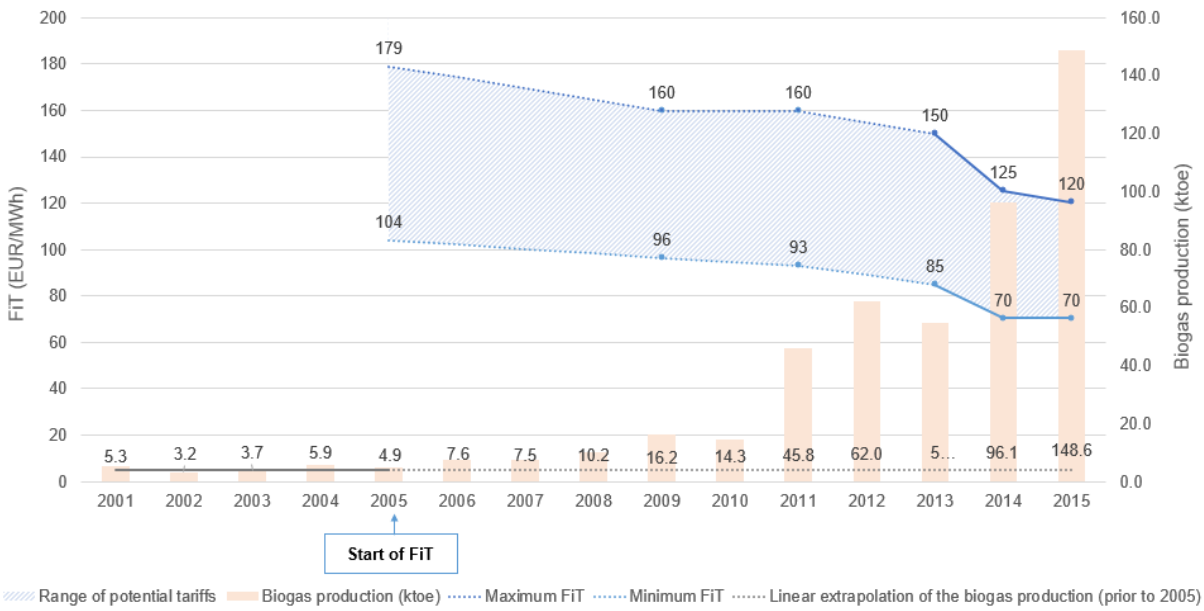

Figure 2-19: Evolution of the FiT, legislation and biogas production in Slovakia

This project has received funding from the European Union's Horizon 2020 research and innovation programme.

2.17 Slovenia (SI)

Support Scheme				Status of NREAP targets	
Type (starting year)	Efficiency	Lag phase (year)	Increase of production (ktoe)	2014	2020
FiT (2002) FiP (2002)	Intermediate	3	25.75 (+115.3%)	Not achieved	Likely

Slovenia started its support of renewable electricity from biogas in 2002 via the creation of a FiT and a FiP (open choice for biogas producers). These support schemes are likely to have boosted the biogas production in the country (no production data before 2004). An increase of both the FiT and FiP in 2006 boosted again the national production, with a significant increase 3 years later (2009). Based on the average production of 2000 – 2001, 25.75 ktoe of the 2015 biogas production is likely to have been caused by the start of the FiT in 2002 (+510.7%). Different subsidies (such as subsidy scheme of the Ministry for Infrastructure and Spatial Planning) and loans (Eco fund) are made available to relevant biogas installations in the country. Subsidies and loans are also made available for biogas installations (subsidy scheme of the Ministry for Infrastructure and Spatial Planning, '*Eko Sklad*' and 'Eco Fund' loan).

In terms of production per capita, Slovenia went from 39.6 to 167.4 kWh between 2005 and 2015 (with a peak at 215.6 kWh per inhabitant in 2012). Even though the production declined between 2012 and 2015 the Slovenian biogas production per capita is still average in Europe. The efficiency of the FiT for Slovenia has been performing quite consistently since its start, causing the biogas production increase. The biogas production in Slovenia has not been sufficient to reach the NREAP targets of the country: with the growth prior to 2012, the country would have met its target by the year 2017. With the recent decline, the country could not reach its 2014 targets. The average growth since 2009, if sustained, could make the country reach its objectives for 2020.

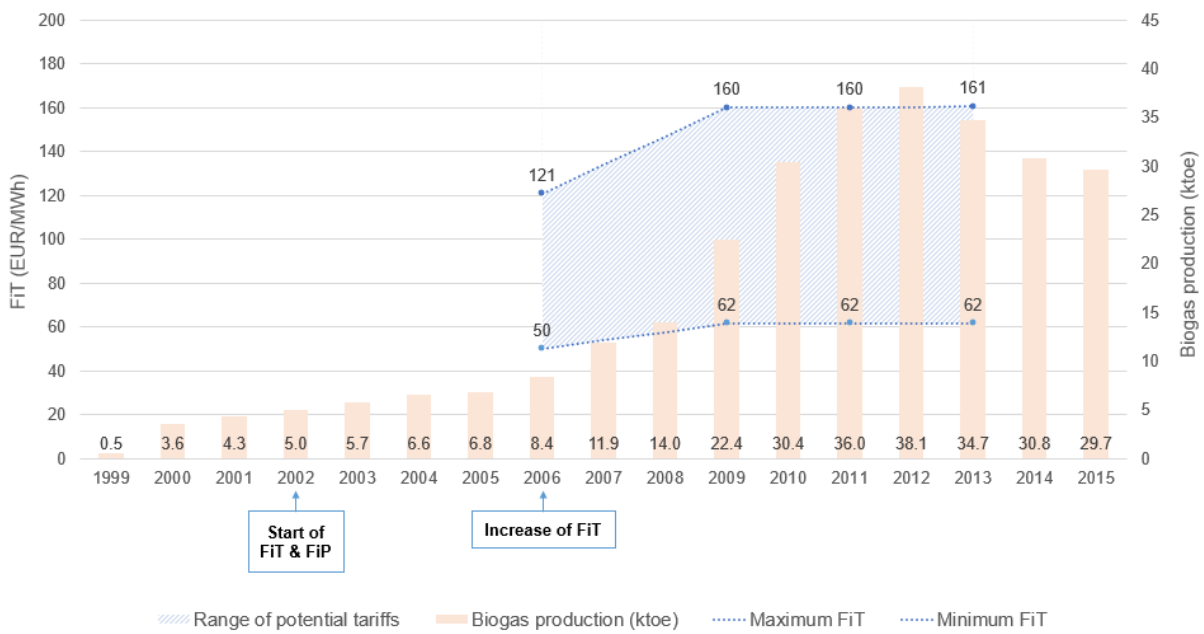

Figure 2-20: Evolution of the FiT, legislation and biogas production in Slovenia

This project has received funding from the European Union's Horizon 2020 research and innovation programme.

2.18 Spain (ES)

Support Scheme				Status of NREAP targets	
Type (starting year)	Efficiency	Lag phase (year)	Increase of production (ktoe)	2014	2020
FiT (1999 - 2013) FiP (2004 - 2012)	Low	1	146.4 (+227.1%)	Achieved	Unlikely

Spain started early its promotion of renewable energy: in 1997, the 'General Electricity Law 54/1997' established a plan for the promotion of renewable energy, followed by the start of feed-in tariffs for Small Scale Co-generation/Renewable Electricity Production in 1999. The tariff directly impacted the biogas production in the country one year later (2000), which kept increasing until 2004. In 2004, the support scheme is adapted and the new 'Special Regime for the production of electricity from RES' includes a bonus option. Since 2004 however, the biogas production has stagnated in Spain, with a peak of production in 2013. Based on the average production of 2000 – 2001, 25.75 ktoe of the 2015 biogas production is likely to have been caused by the start of the FiT in 2002 (+510.7%). Based on the average production of 1995 - 1998, 146.4 ktoe of the 2015 biogas production is likely to have been caused by the start of the FiT in 1999 (+227.1%). Different tax regulation mechanisms (business tax reduction) were made available to relevant biogas installations in the country.

The production per capita has decreased between 2005 and 2014 from 80.4 to 65.5 kWh per inhabitant, with a low FiT efficiency only due to its low maximum FiT. The 2013 production peak made Spain reach its NREAP target for 2014 (223 MW IEC, 205 MW expected), although the recent decline caused by the stop of FiT and FiP make it very unlikely for Spain to reach the NREAP target for 2020 (400 MW expected).

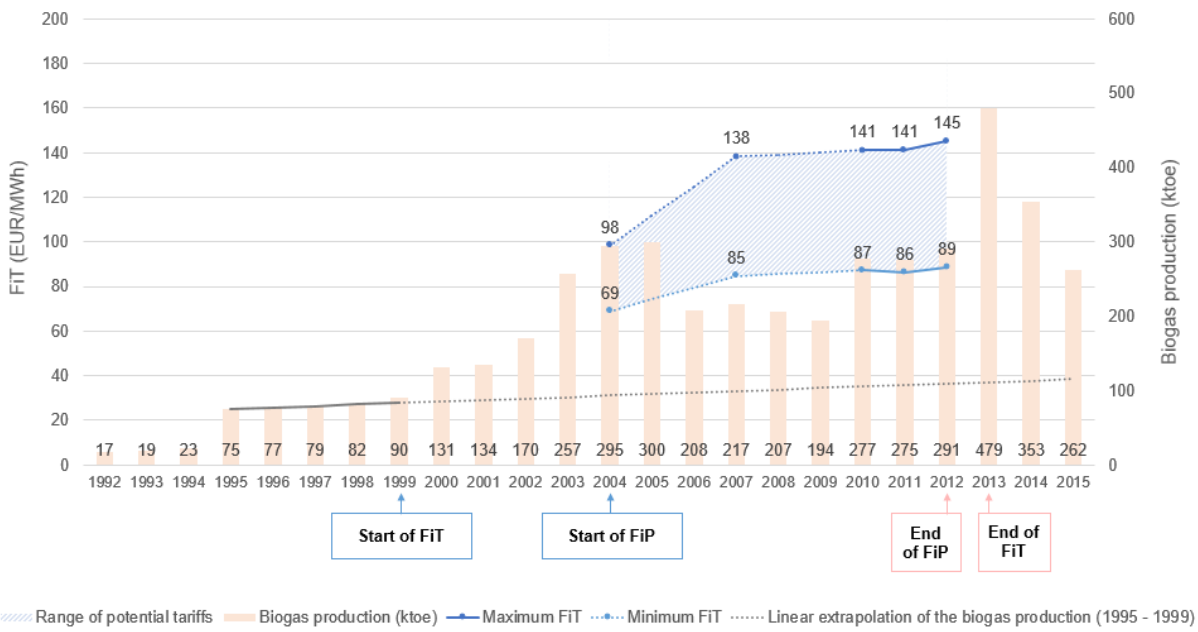

Figure 2-21: Evolution of the FiT, legislation and biogas production in Spain

This project has received funding from the European Union's Horizon 2020 research and innovation programme.

2.19 Switzerland (CH)

Support Scheme				Status of NREAP targets	
Type (starting year)	Efficiency	Lag phase (year)	Increase of production (ktoe)	2014	2020
FiT (1991)	Very low	- (more data needed)	Unknown	- (no set target)	

Switzerland started early in the promotion of renewable energy with FiT introduced by a Federal Energy Decree in 1991. Since then, the decree was superseded by the Energy Act in 1999 and the Electricity Supply Act in 2007, which both kept the FiT until now. Given the low amount of information concerning both Switzerland biogas production before 2007 and the evolution of the tariffs, conclusions are hard to draw for the country. However the early start of the FiT in the country is likely to have started the national biogas production in the country, which kept increasing afterwards. Biogas production from 2007 to 2015 went from 14.4 to 26.1 ktoe, so a 11.7 ktoe increase. The production per capita went from 22.4 to 36.9 during the same period (average increment of 1.8 kWh per inhabitant annually), which is low compared to other European countries. The efficiency of the FiT in the period 2007-2015 is very low, because of its high maximum FiT and its low output on the production per capita. The Swiss support scheme is quite unique in Europe given the significant range between the lowest (42.7 EUR/MWh for plants with an IEC below 100 kW installed on landfills in 2012) and highest (328 EUR/MWh for plants with an IEC below 5MW using agricultural feedstock the same year) amount of support possible. Given the status of Switzerland in Europe, there is no set NREAP for the country.

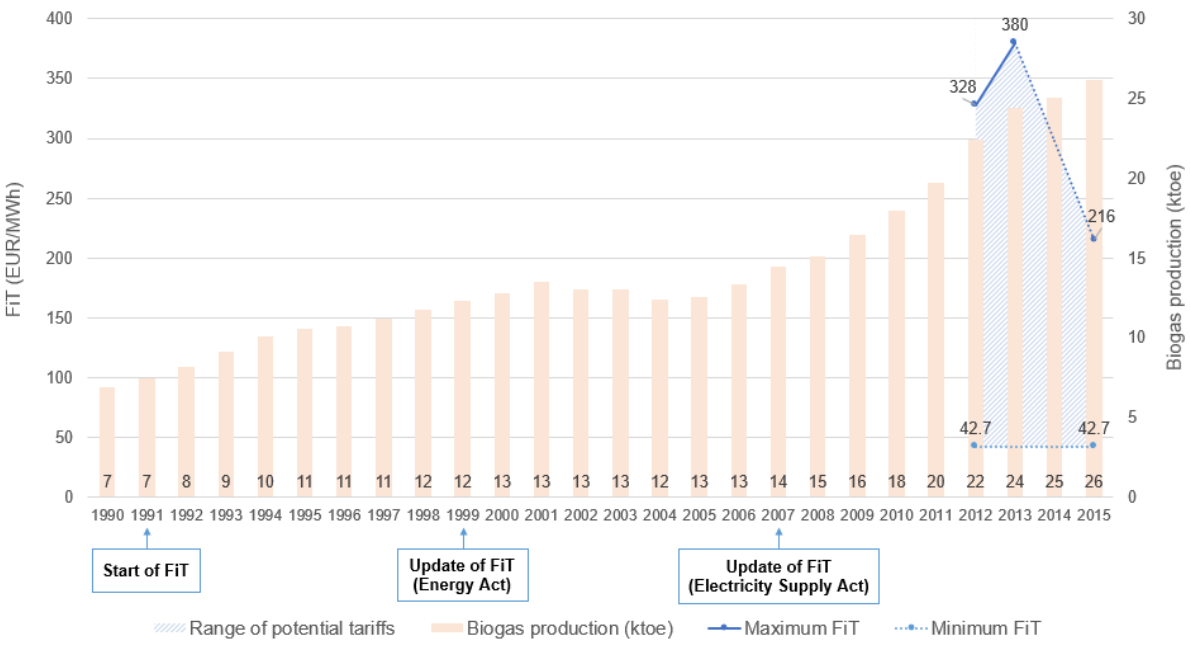

Figure 2-22: Evolution of the FiT, legislation and biogas production in Switzerland

This project has received funding from the European Union's Horizon 2020 research and innovation programme.

FiP as main support scheme

Five European countries used a FiP as their main support scheme in the timeframe 2006 – 2015: they include DK, EE, FI, LT, NL. In order to visualise more easily the evolution of the biogas production per capita according to the max FiP in place in the different countries, a video is available on the biogasAction website.

As explained in the beginning of this chapter, the FiP efficiency was estimated based on the production per capita in the country and the average total income (average electricity price + maximum FiP) for biogas producers, following the table below. The averages were calculated from all data gathered for the 5 countries using a FiP as their main SS: the average total income is 183.8 EUR/MWh, and the average production per capita is 135.2 kWh per capita.

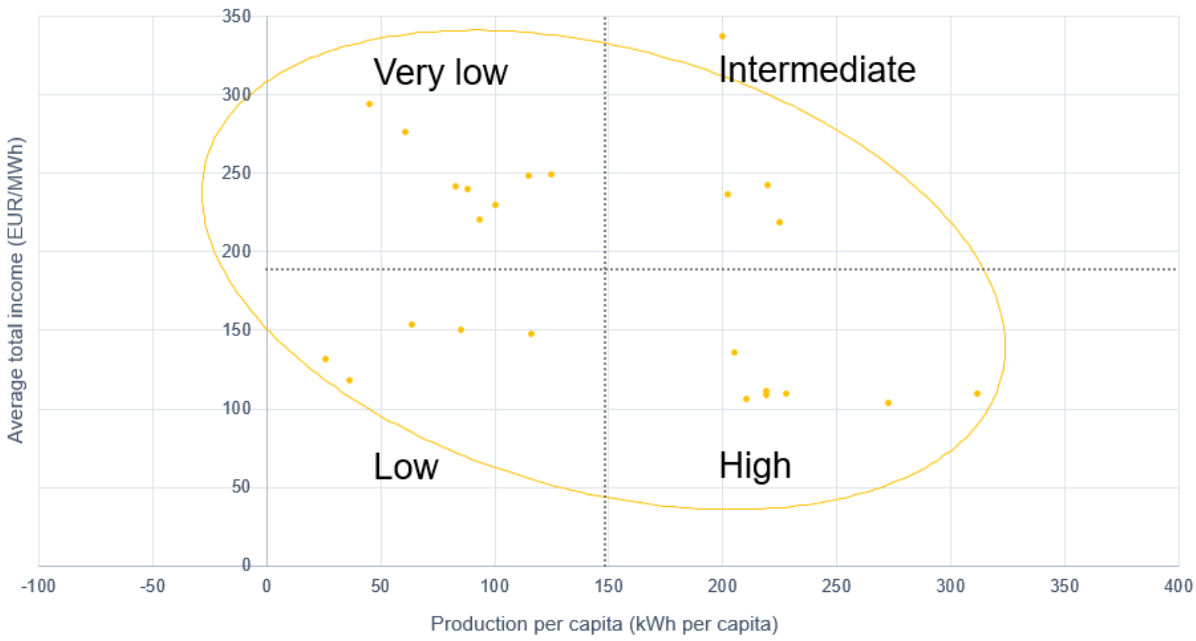

Figure 2-23: Average total income (average electricity price + FiP) and production per capita per year and country (with FiP efficiency zones)

This project has received funding from the European Union's Horizon 2020 research and innovation programme.

2.20 Denmark (DK)

Support Scheme				Status of NREAP targets	
Type (starting year)	Efficiency	Lag phase (year)	Increase of production (ktoe)	2014	2020
FiP (2009)	High	3	13.0 (+9.4%)	Achieved	Likely

Denmark started its program for renewable development in 1989 with an amended version of the Electricity Supply Act (from 1976) which introduced the obligations for power suppliers to purchase power from renewables generation and CHP. In 1993, the Biomass Agreement was published and set an objective to increase biomass use from 50 PJ to 75 PJ by 2000, and the year later the Electricity Supply act was also amended in 1994 to include the 'environmentally sound development' of electricity supply as a main objective. All the above, triggered and boosted the increase of the national biogas production. The introduction of CO_2 quotas, tradable emissions allowances and renewable energy certificates in 2000 (Electricity Reform Agreement) and the start of subsidies for Renewable Electricity Generation (2004) maintained the steady increase of production until 2009 and the start of the FiP. The Danish FiP sets a minimum bonus, and a statutory maximum of the amount bonus + market price of the electricity. This means that if the electricity price on the market exceeds this maximum, no bonuses are paid by the government and the exceeding amount might even be deducted from future bonus payments. The Danish FiP created a boost in biogas production 3 years after its start (2012), but its increase is relatively in line with the growth rate observed during previous years: 13.0 ktoe in 2015 (9.4% increase compared to linear extrapolation between 1990 and 2008). The Danish FiP efficiency is high due to its low maximum FiP and average electricity price, along with the significant rise in production and production per capita (from 210 to 312 kWh per inhabitant between 2009 and 2015). Denmark is likely to reach its 2020 NREAP, but its ambitious targets (349 MW IEC expected, 95 MW in 2014) stress the need to increase its growth rate.

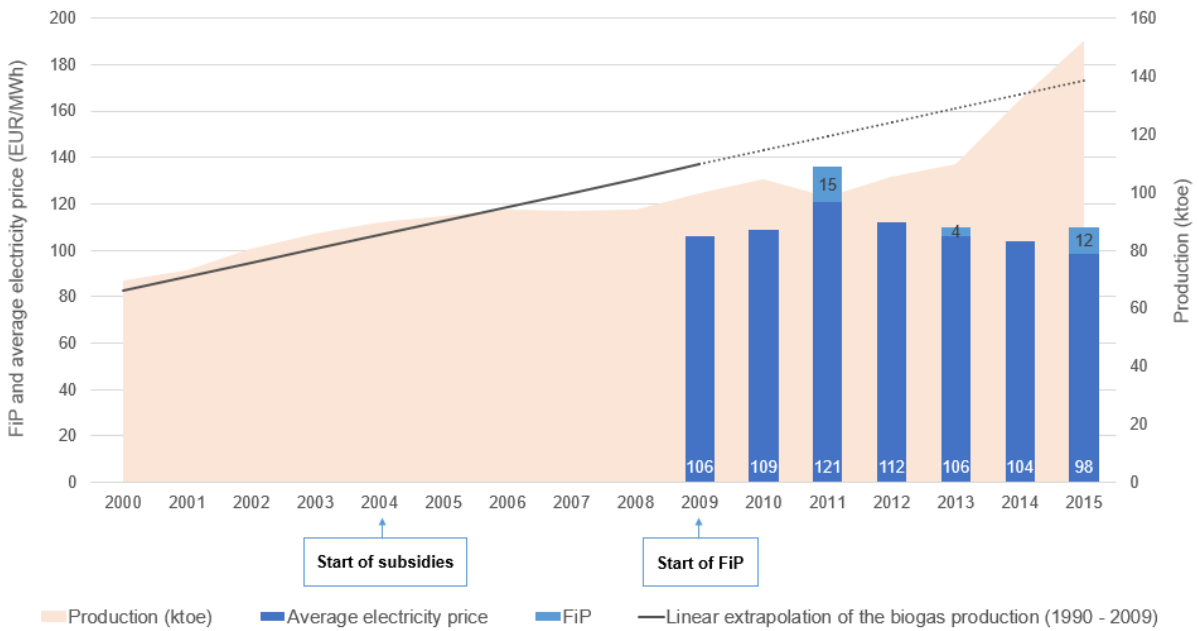

Figure 2-24: Evolution of the FiP, average electricity price, legislation and biogas production in Denmark

This project has received funding from the European Union's Horizon 2020 research and innovation programme.

2.21 Estonia (EE)

Support Scheme				Status of NREAP targets	
Type (starting year)	Efficiency	Lag phase (year)	Increase of production (ktoe)	2014	2020
FiP (2003)	Low	3	9.0 (+315.9%)	No specific targets	

Estonia started its promotion of renewable energy generation in 1998 with the Energy act (introduction of the obligation to purchase electric power from power producers connected to its network and who produced such power from water, wind or solar energy or biofuel). In 2003, the Electricity Market Act (EMA) started the premium system in the country with a bonus of 53.7 EUR/MWh, still in application in 2015. The biogas production was then boosted until 2007 and the new version of the EMA, which only had a significant impact 6 years later (2013). The FiP is likely to have caused a biogas production increase of 9.0 ktoe (315.9%) in 2015. The Estonian FiP efficiency is low, but the great increase in biogas production per capita in 2013 and afterwards brings the tariff close to the 'high' efficiency category. The biogas production per capita in the country went from 30.8 to 115.9 kWh per inhabitant between 2005 and 2015. Estonia doesn't have any set NREAP targets specific to biogas production. Different investment subsidies are made available to relevant biogas installations in the country.

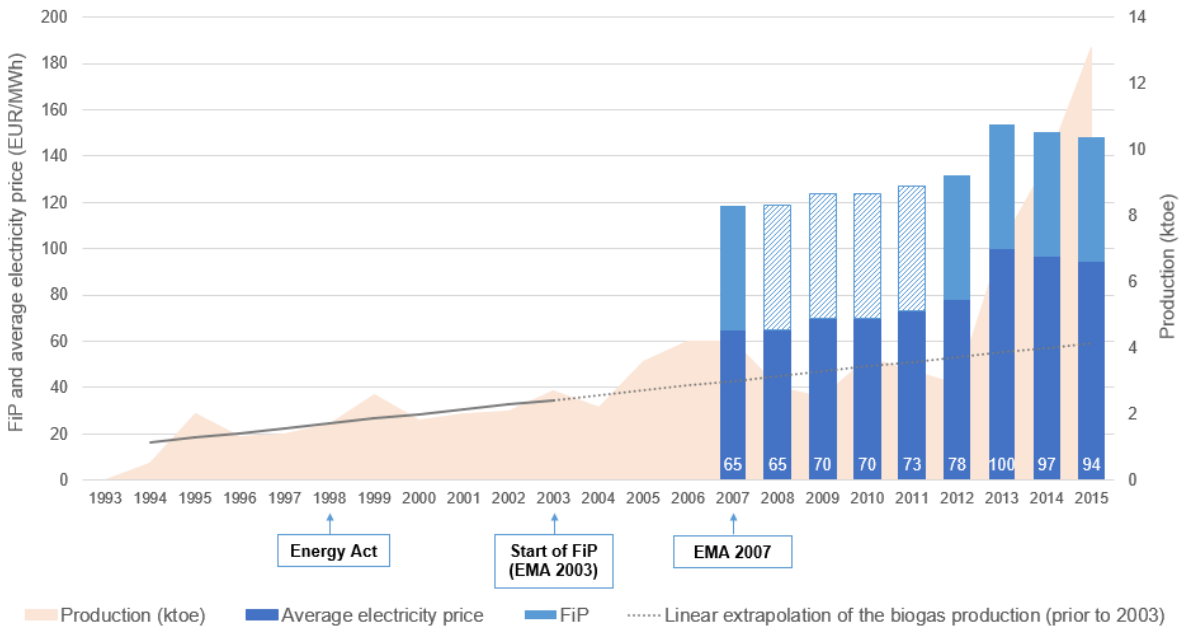

Figure 2-25: Evolution of the FiP, average electricity price, legislation and biogas production in Estonia

This project has received funding from the European Union's Horizon 2020 research and innovation programme.

2.22 Finland (FI)

Support Scheme				Status of NREAP targets	
Type (starting year)	Efficiency	Lag phase (year)	Increase of production (ktoe)	2014	2020
FiP (2010)	Intermediate	3	42.8 (+170.9%)	No specific targets	

Finland started its promotion of renewable energy in 1994 with the 'Bioenergy Promotion Programme' (purchase obligations), and the 'combined CO_2 and Energy Tax'. In 1999, the country started an 'Energy aid' scheme, which aimed at promoting renewable energy and energy efficiency, and started energy tax subsidies in 2002. Direct support of biogas production was only started in 2010 with a FiP of 83.5 EUR/MWh (potential 'heat bonus' of 50 EUR/MWh), still in force in 2015. The scheme had a significant impact starting in 2013 (3 years later): in 2015, 42.8 ktoe are likely to have been caused by the new support scheme (170.9% increase). Different investment subsidies (such as the 'Investment support for farmers') are made available to relevant biogas installations in the country.

The Efficiency of the tariff is intermediate thanks to its maximum FiP + average electricity price on the market (between 240 and 250 EUR/MWh of total income) and its high increase of biogas production per capita between 2010 and 2015 (from 87.8 to 219.3 kWh per inhabitant).

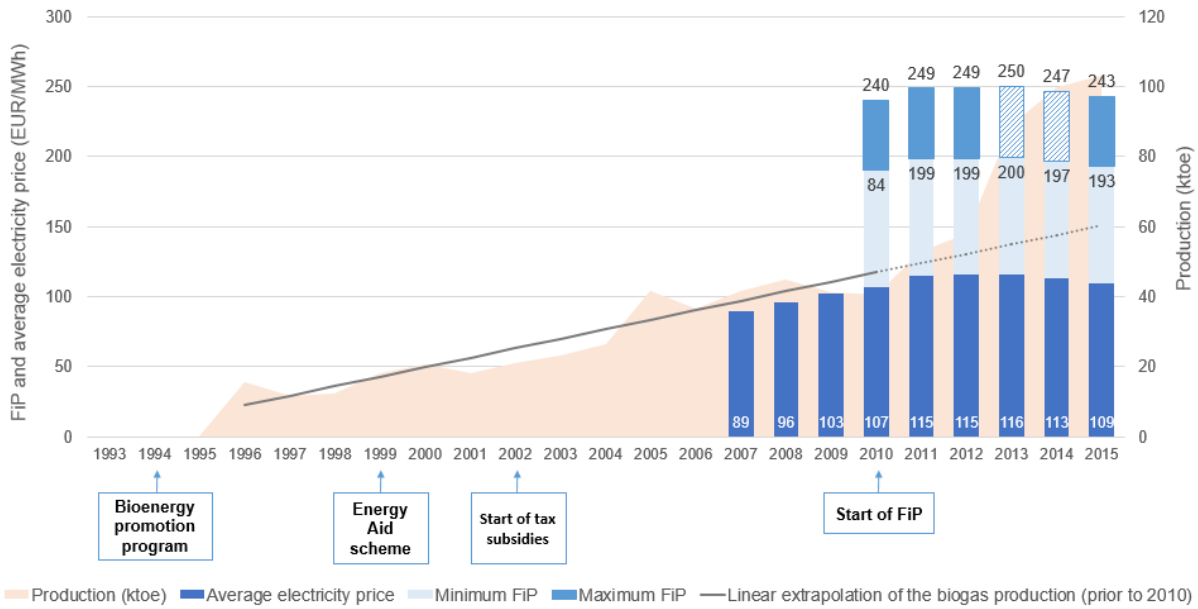

Figure 2-26: Evolution of the FiP, average electricity price, legislation and biogas production in Finland

This project has received funding from the European Union's Horizon 2020 research and innovation programme.

2.23 Lithuania (LT)

Support Scheme				Status of NREAP targets	
Type (starting year)	Efficiency	Lag phase (year)	Increase of production (ktoe)	2014	2020
Sliding FiP (2002)	Very low	5	23.4 (total)	Not achieved	Likely

Lithuania started its support for renewable energy generation in 2002 with the 'Law on Energy' which established setting purchasing prices of electricity generated from different renewable energy sources (FiP), a support confirmed in 2011 with the 'Law on Energy from Renewable Sources' which set targets for the national gross renewable energy consumption, with specific objectives for transport and heat. The production of biogas in Lithuania basically started with the FiP in 2002: it remained stable for 4 years, then started a steady increase in 2007, 7 years after the start of the support scheme. Different investment subsidies (such as the '*Climate Change Special Programme*') and loans (such as the '*Lithuanian Environmental Investment Fund*') are made available to relevant biogas installations in the country, along with tax regulation mechanisms (law on Excise Taxes) and the '*Environmental Pollution Tax exemption*' (for heat use).

The efficiency of the support scheme is considered to be very low because of its high maximum FiP (between 178 and 294 EUR/MWh, average electricity price included), however the country is increasing its production per capita rapidly (from 6.2 to 93.2 kWh per inhabitant between 2005 and 2015). The country might reach its ambitious NREAP target for 2020 (62 MW of IEC expected) if the growth rate between 2012 and 2015 can be sustained.

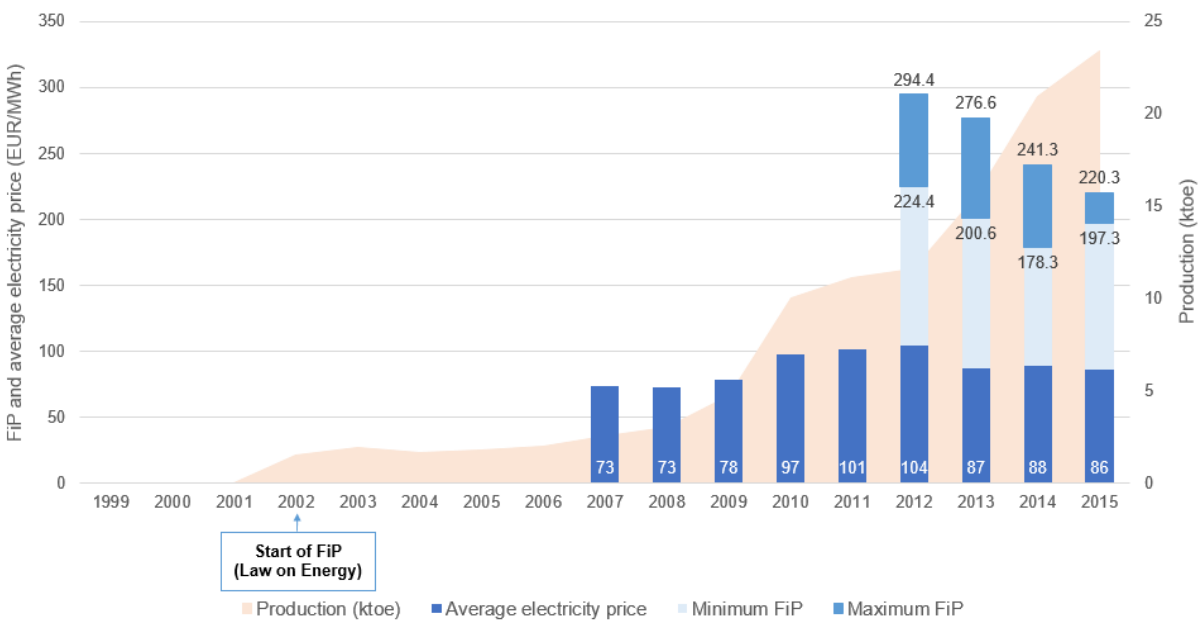

Figure 2-27: Evolution of the FiP, average electricity price, legislation and biogas production in Lithuania

This project has received funding from the European Union's Horizon 2020 research and innovation programme.

2.24 The Netherlands (NL)

Support Scheme				Status of NREAP targets	
Type (starting year)	Efficiency	Lag phase (year)	Increase of production (ktoe)	2014	2020
FiP (2003) GC (1995)	Intermediate	3	115.5 (+154.6%)	Not reached	Unlikely

The Netherlands started its promotion of renewable energy in 1995 with the start of the Green Funds (green certificates). Counterintuitively, the biogas production was on the rise before 1995, but then stabilised for ten years. To boost the national production, a FiP was started in 2003: the '*Environmental Quality of Electricity Production*' (*Milieukwaliteit van de Elektriciteitsproductie*) which pays a fixed premium on top of the price of wholesale electricity. This new support scheme had a significant impact on the national production 3 years later (2006), and the production kept steadily increasing until 2015. The Dutch government then started the SDE (*stimulering duurzame energie* - Renewable energy and CHP production aid scheme) in 2008, a modified FiT (such as in Denmark): a premium is paid if the electricity price goes below a certain amount, and no subsidy is paid by the government if the market electricity price is at or above a certain price. The same principle was applied in 2011 for the SDE +, which provides a feed-in premium (FIP) subsidy that covers the difference between wholesale market prices of electricity and cost price of electricity from renewable sources. Different tax regulation mechanisms (Reduction of environmental protection tax, Energy Investment Allowance, EIA scheme) are made available to relevant biogas installations in the country.

The efficiency of the different Dutch FiP is intermediate due to its high increase in production per capita (from 86.8 to 225.1 kWh per inhabitant between 2005 and 2015). The biogas production growth rate is however too low for the country to reach its NREAP targets: only 237 MW of production capacity were installed, while 346 MW were expected in 2014. The country needs to almost triple its IEC by 2020 (639 MW expected).

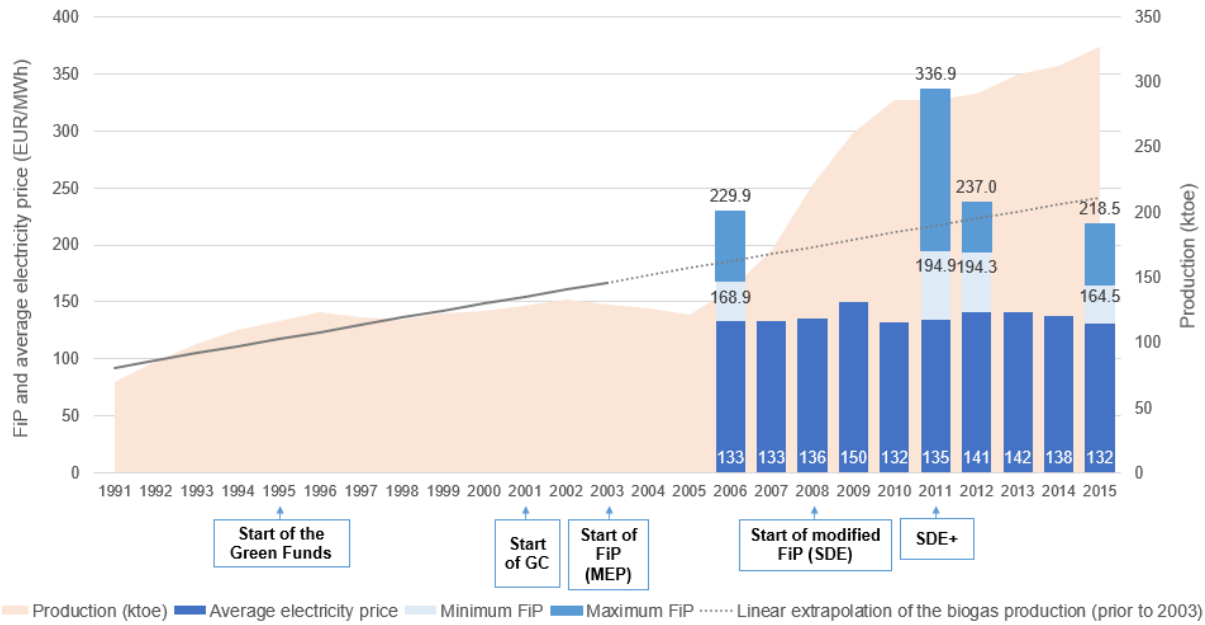

Figure 2-28: Evolution of the FiP, average electricity price, legislation and biogas production in the Netherlands

This project has received funding from the European Union's Horizon 2020 research and innovation programme.

Certificate/quota system as main support scheme

Six European countries used GC as their main support scheme in the timeframe 2007 – 2015: they include BE, NO, PL, RO, SE and the UK. In order to visualise more easily the evolution of the biogas production per capita according to the average income through GC in the different countries, a video is available on the biogasAction website.

As explained in the beginning of this chapter, the GC scheme efficiency was estimated based on the production per capita in the country and the average total income (average income through GC + average electricity price) for biogas producers. The averages were calculated from all data gathered for the 5 countries using a FiP as their main SS: the average total income is 204.3 EUR/MWh, and the average production per capita is 130.3 kWh per capita.

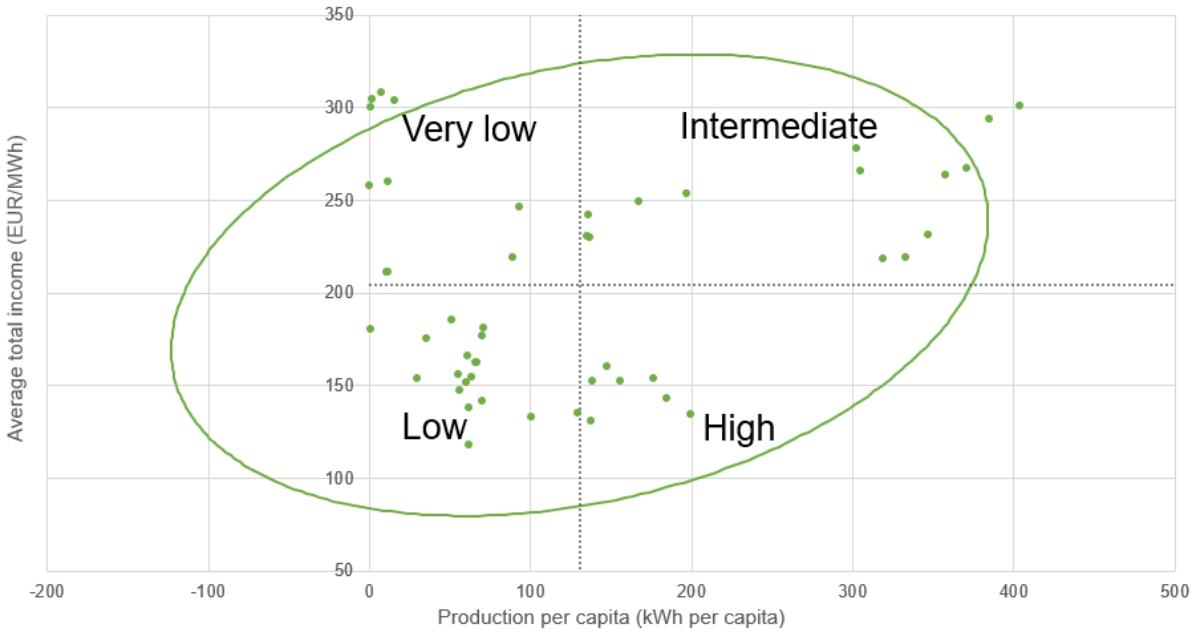

Figure 2-29: Average total income (average electricity price + average GC price per MWh) and production per capita per year and country (with GC efficiency zones)

This project has received funding from the European Union's Horizon 2020 research and innovation programme.

2.25 Belgium (BE)

Support Scheme				Status of NREAP targets	
Type (starting year)	Efficiency	Lag phase (year)	Increase of production (ktoe)	2014	2020
GC (2001)	Intermediate	2	169.1 (+393.5%)	Not achieved	Likely

Belgium started its support for renewable energy in the nineties with a few measures such as tax deduction for '*investments in energy efficiency & renewable energy by Enterprises*' (1992) and the '*Electricity Generation Fund*' (1996). A direct support for renewables was started in 2001 with the National Green Certificate Scheme (1 certificate per 1 MWh of electricity produced) which aimed at 6% of renewable power for Belgium by 2010. The start of the scheme had a significant impact on the national biogas production, which kept increasing ever since. Based on the production growth rate prior to 2001, 169.1 ktoe of the 2015 biogas production is likely to have been caused by the start of the GC scheme in 2001 (+393.5%). Different investment subsidies (Flanders: max 45 - 55 - 65% investment subsidy for small-medium-big company; Wallonia: 27,5% if <600 kWel; 22,5% if >600 kWel (for agricultural plants), '*Utilisation durable de l'Energie*' scheme) are made available in the country to the relevant biogas installations.

The average certificate price is different in the three Belgian regions (Brussels not represented), but is mainly between 80 and 110 EUR since 2002. The efficiency of the Belgian GC scheme is intermediate given the significant progression of the production per capita (103.3 to 234.6 kWh per inhabitant). The country is lagging behind its NREAP target (172 MW IEC, 195.8 MW expected), so a slightly boosted production growth would be sufficient for Belgium to reach its end of the decade objective.

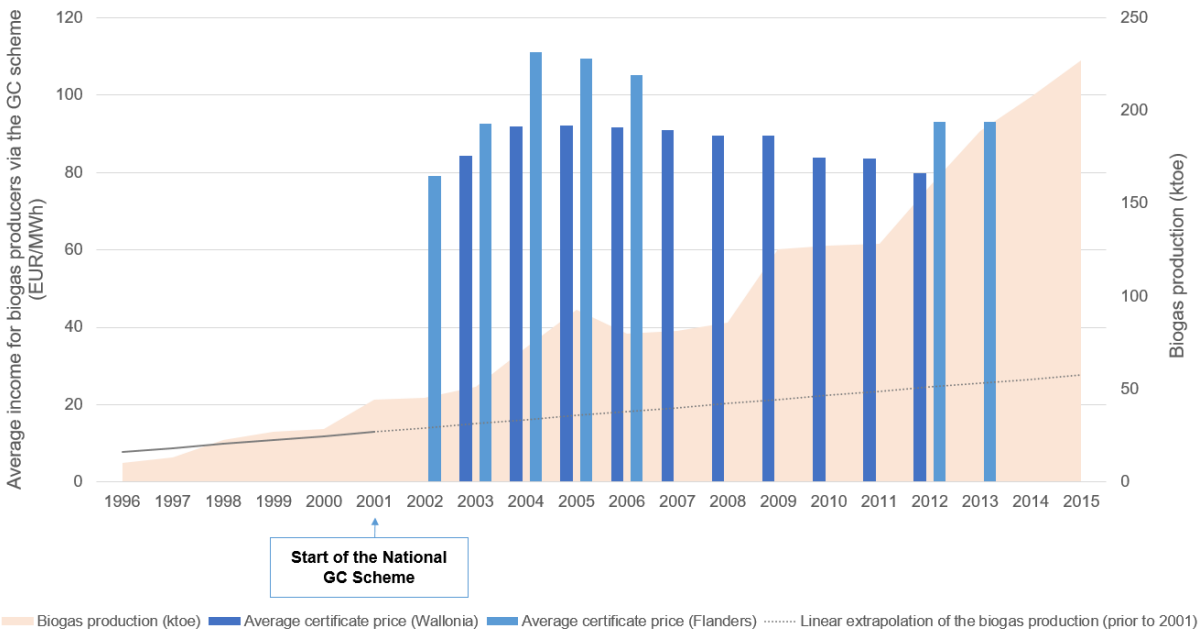

Figure 2-30: Evolution of the average income per MWh via GC, legislation and biogas production in Belgium

This project has received funding from the European Union's Horizon 2020 research and innovation programme.

2.26 Norway (NO)

Support Scheme				Status of NREAP targets	
Type (starting year)	Efficiency	Lag phase (year)	Increase of production (ktoe)	2014	2020
GC (2003)	Low	-	-	-	-

Although Norway started a direct promotion of renewable electricity from biogas in 2003 with the Electricity Certificates Act (one certificate for every MWh of renewable electricity produced, regardless of the generation technology employed), the biogas production in the country was already high (25.8 ktoe) and stable since 1997. Since the certificate system, the biogas production didn't increase significantly, apart from 2015 when the country gained 20 ktoe in just one year. The average price of the GC evolved from 19.2 to 32.1 EUR per certificate, and decreased since the country merged its certificate scheme with Sweden in 2012. The efficiency of the Norwegian certificate system is low since the country struggled to increase its production (and production per capita) between 2005 and 2014. The country doesn't have any NREAP targets since it is not a member of the European Union.

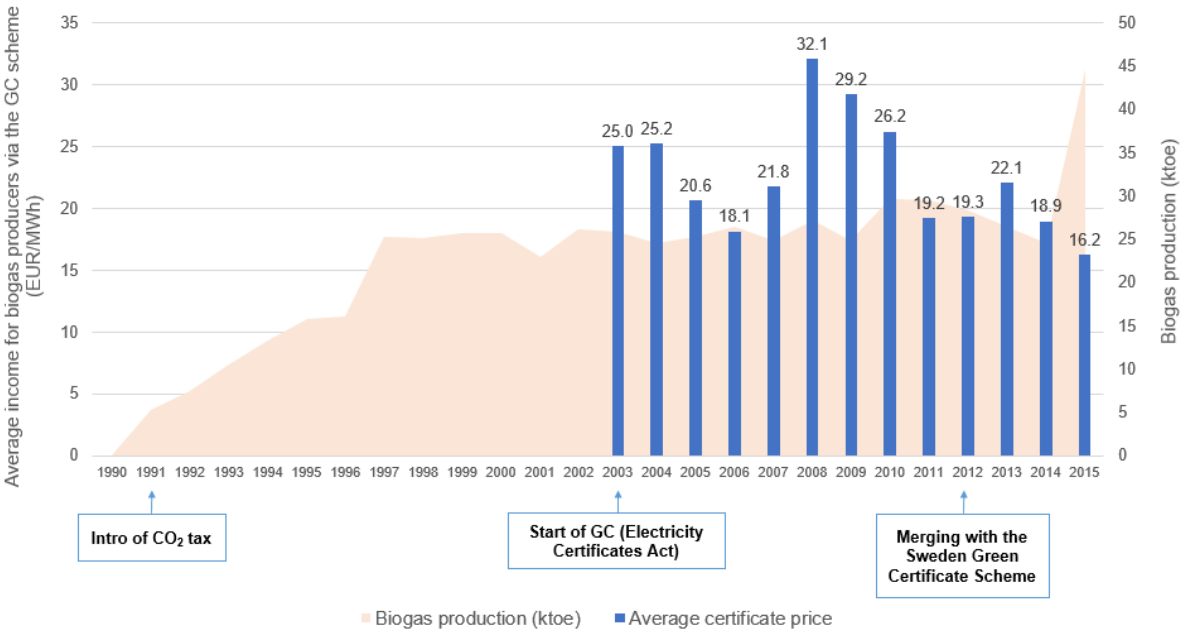

Figure 2-31: Evolution of the average income per MWh via GC, legislation and biogas production in Norway

This project has received funding from the European Union's Horizon 2020 research and innovation programme.

2.27 Poland (PL)

Support Scheme				Status of NREAP targets	
Type (starting year)	Efficiency	Lag phase (year)	Increase of production (ktoe)	2014	2020
GC (2005)	Low	3	155.3 (+311.4%)	Achieved	Likely

Poland started its support for renewable energy in 1997 with the Energy Law Act, which aims at developing for example independent electricity and gas system, independent power producers, renewable energy sources. The 2005 amendment of the Energy Law Act introduced a tradable green certificate scheme (1 GC per 1MWh of generated electricity), which truly helped to start developing the biogas production in the country increase 3 years later in 2008, and steadily increased since then to reach 228.8 ktoe in 2015, of which 155.3 ktoe are likely to have been caused by the green certificate scheme (linear extrapolation). Biogas installations are also eligible for specific loans (important financing mean in the country) and are eligible for tax regulation mechanisms.

The average certificate price has decreased since its peak in 2012, to reach 29.25 EUR in 2015. The efficiency of the scheme went from very low to low in 2013, and stayed in that category ever since. This didn't stop Poland from reaching all its NREAP targets so far, which sets the country in a conformable position in order to reach its 2020 objectives.

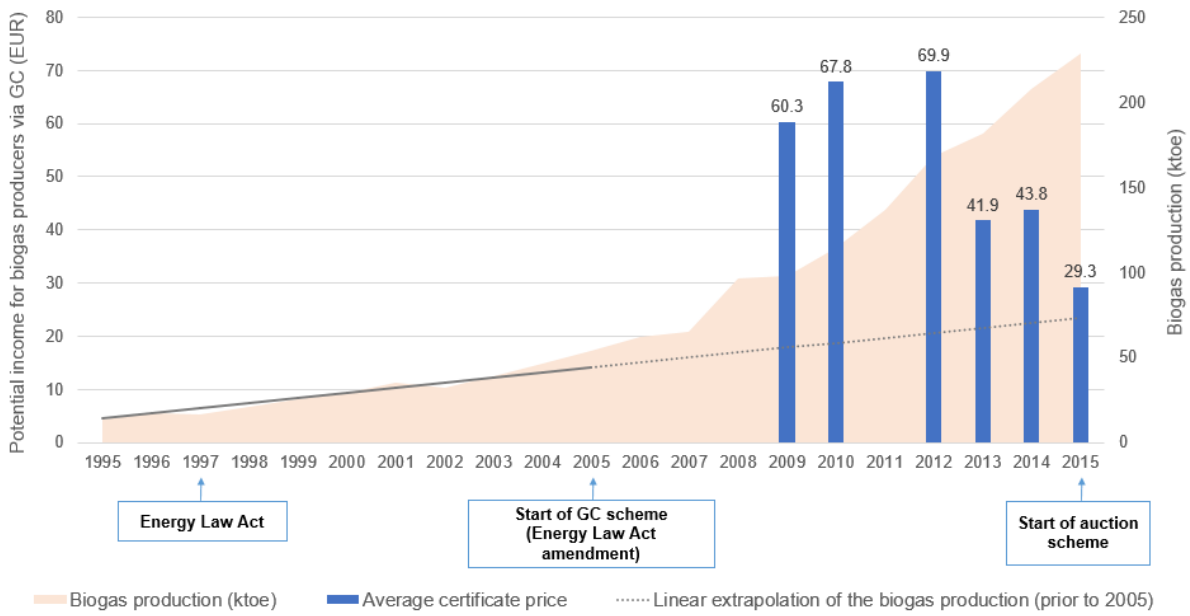

Figure 2-32: Evolution of the average income per MWh via GC, legislation and biogas production in Poland

This project has received funding from the European Union's Horizon 2020 research and innovation programme.

2.28 Romania (RO)

Support Scheme				Status of NREAP targets	
Type (starting year)	Efficiency	Lag phase (year)	Increase of production (ktoe)	2014	2020
GC (2005)	Very low	3	18.3 (total production)	Not achieved	Very unlikely

Romania started a scheme of tradable green certificates in 2005 to promote electricity generation from renewable sources. The impact on the national biogas production was however low, until combined with the Law No. 220/2008 (for the promotion of energy production from renewable energy sources), which created a significant rise of production in 2011.

The Romanian green certificates scheme is quite unique in Europe, as it allows two certificates per MWh produced from biogas, along with potential bonuses for highly efficient CHPs and biomass use from energy crops. Every MWh is thus eligible for up to 4 certificates, for a total price of 220 EUR in 2009 (+ electricity price). These high prices have however decreased since 2012 to reach a maximum of 117.4 EUR/MWh in 2015. In terms of biogas production per capita, Romania only reached an average yearly increment of 1.1 kWh per inhabitant since 2006, and the efficiency of its certificate scheme is classified as 'very low' thanks to both its high maximum price and low output in production. Different investment subsidies are made available in the country to the relevant biogas installations.

Romania has ambitious NREAP targets of 90 MW of IEC in 2014 and 195 MW in 2020, however its IEC is quite low (9 MW installed in 2015), which puts the country in jeopardy for reaching its 2020 objective.

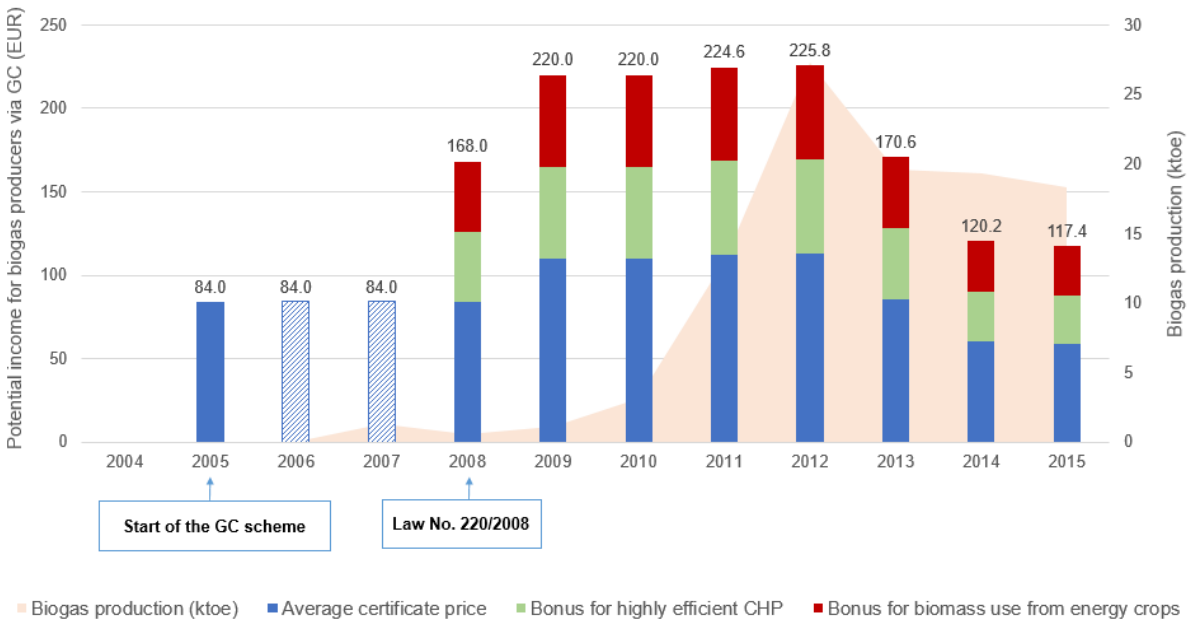

Figure 2-33: Evolution of the average income per MWh via GC, legislation and biogas production in Romania

This project has received funding from the European Union's Horizon 2020 research and innovation programme.

2.29 Sweden (SE)

Support Scheme				Status of NREAP targets	
Type (starting year)	Efficiency	Lag phase (year)	Increase of production (ktoe)	2014	2020
GC (2003)	High	4	96.7 (+236.7%)	Achieved	

Sweden started early in its support for renewable energy, with an Energy, Carbon Dioxide and Sulphur Taxation in 1991, a Renewables Tax Exemption for small-scaled renewable energy based electricity production in 1994, a Renewable Energy Investment Support Programme in 1997 and the start of Guaranteed Power Purchase Contracts (<1.5 MW) the same year. All the measures above increased the biogas production, which stabilised since 1999 around 30 ktoe. The start of Guaranteed Power Purchase Contracts was then included in a brand new green certificate scheme in 2003 (one certificate is issued for every MWh of electricity produced, regardless of the technology employed). This new scheme had a significant impact on the national biogas production 4 years later (2007), and the production kept growing steadily since then. In 2015, 96.7 ktoe are likely to be related to the green certificate scheme, an increase of 236.7M compared to a linear extrapolation of the growth based on years prior to 2003. Different tax regulation mechanisms (energy tax reduction) and investment subsidies are made available in the country to the relevant biogas installations.

The efficiency of the Swedish GC scheme is high, due to its very high increase in production per capita (from 38.5 to 199.7 kWh per inhabitant between 2005 and 2015) and low average green certificate price (between 18 and 31 EUR). Since 2012, the Swedish GC scheme is merged with the Norwegian one. Sweden already reached its 2020 NREAP target in 2015 with 95.5 MW installed (42 MW expected).

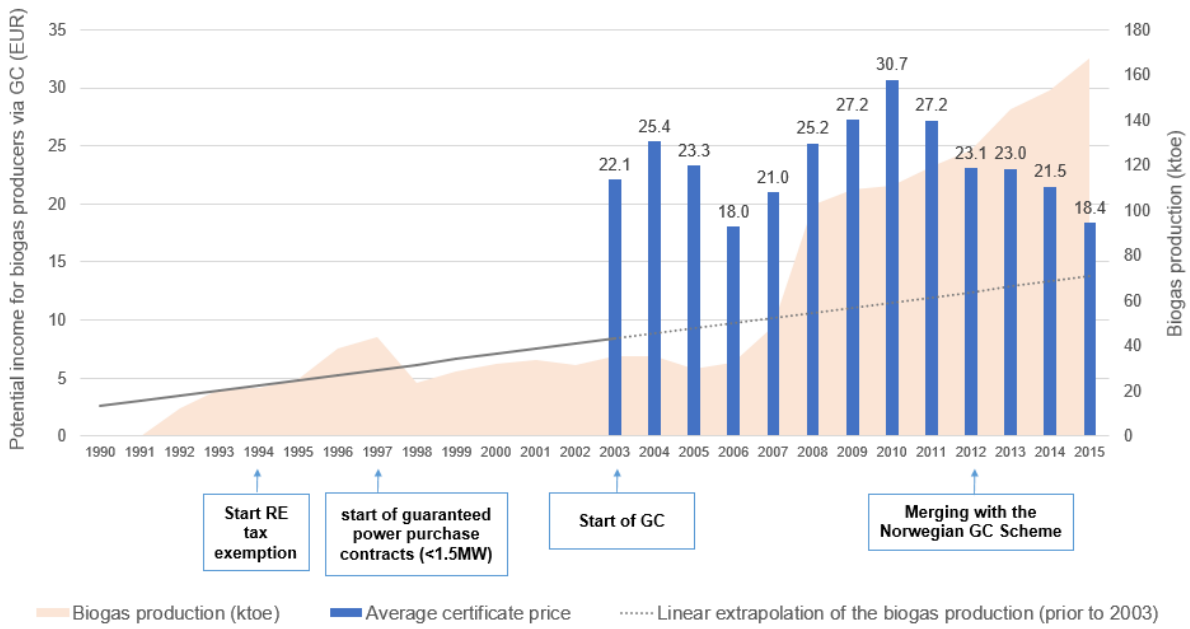

Figure 2-34: Evolution of the average income per MWh via GC, legislation and biogas production in Sweden

This project has received funding from the European Union's Horizon 2020 research and innovation programme.

2.30 United Kingdom (UK)

Support Scheme				Status of NREAP targets	
Type (starting year)	Efficiency	Lag phase (year)	Increase of production (ktoe)	2014	2020
GC (2002) FiT (2010) FiP (2014)	Intermediate	Unknown	Unknown	Achieved	

The legislation in the United Kingdom is quite complex and includes different support schemes. Officially, the main support scheme is the Renewables Obligation (RO, a green certificate scheme) started in 2002 (2005 in Northern Ireland). Two RO certificates (ROC) are awarded for each MWh produced from biogas. In 2008, a FiT was introduced via the Energy Act (and started in 2010), and in 2011 the Renewable Heat Incentive (RHI, a FiT for heat production) was launched. In 2013, the electricity market reform started a carbon price floor and the next year the 'Contract for Difference' (CfD), a switching FiP[1]. Investment support (*Bio-energy Infrastructure Scheme*) and tax regulation mechanisms (*Climate Change Levy, reduced tax rate for microgeneration, Carbon Price Floor*) are also available to biogas producers.

In terms of production, biogas production in the UK started its growth prior to 1990, and was then boosted by the non-fossil fuel obligation (technology-specific premiums) in 1990, and later the different support schemes put in place over the years (see above). The complex and periodically changing legislative framework makes it difficult to estimate the amount of biogas production that might have been caused by the RO scheme only. The efficiency of the RO scheme is intermediate, since the country went from 283.7 to 403.8 kWh per capita between 2005 and 2015. The country already achieved its 2014 NREAP target back in 2013 (1331 MW IEC, 1260 MW expected). It is important to notice that the UK is the only EU country with a decreasing NREAP target: it has thus already achieved its biogas target for 2020 (1100 MW expected).

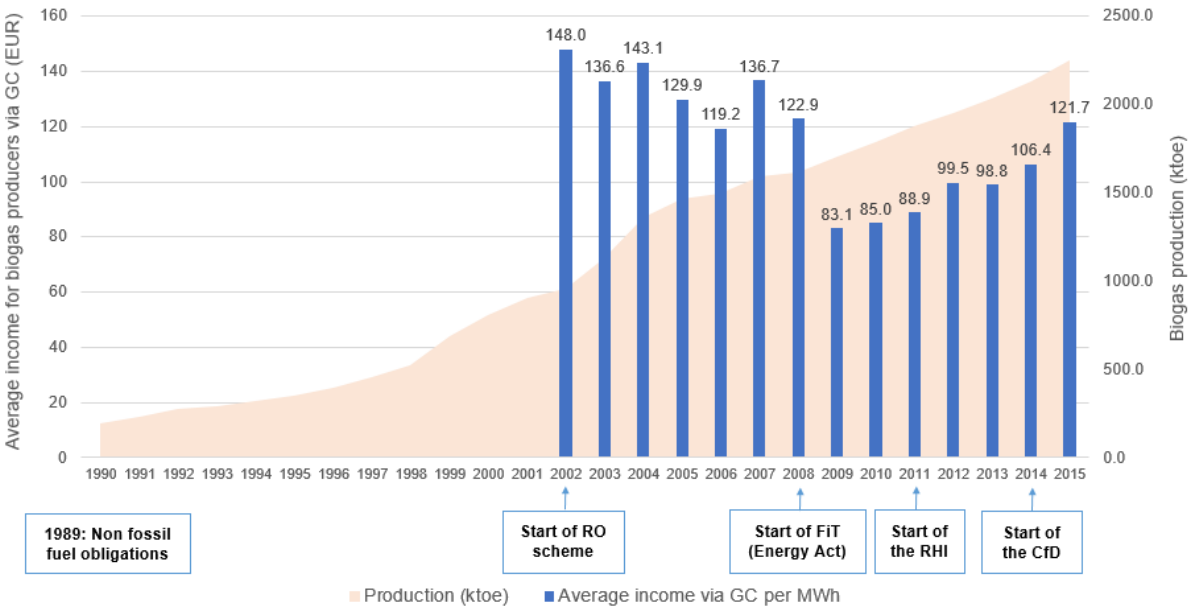

Figure 2-35: Evolution of the average income per MWh via GC, legislation and biogas production in the United Kingdom

[1] if the market price is lower than a 'strike price', the government pays a premium, but if not, the producer must pay back the difference to the government, such as in Denmark and the Netherlands

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3. European overview

The biogas production greatly increased in Europe in the last decade: from 2005 to 2015, the production went from 4.0 to 15.6 Mtoe (+390%) and from 94.1 to 355.8 kWh per capita (a yearly average increment of 26.2 kWh per inhabitant). Germany, in particular, increased from 558 ktoe in 2000 (start of the EEG) to 7,854 ktoe in 2015 (+1,406%) and became the largest biogas producer in Europe and one of the largest in the world.

Assessing the impact support schemes (SS) have had on the development of the biogas sector is a difficult exercise. In theory, the slope of the income evolution for biogas producers from SS would dictate the production increase/decrease in the country: the higher a SS, the more significant its effect should be. However this is not totally the case in practice: major support schemes show a clear impact on the rise of the biogas production, but the magnitude of the evolution is not only function of the main SS in the country. Based on comparisons between linear extrapolations of the biogas production prior to the introduction of their main SS and the real production with SS in place, this report estimates that a mere **71.0% of the European biogas production in 2015 is likely to have been caused by the major SS in place**. However, this number is very likely to be much higher in practice considering that:

- this estimate could not be done for some countries such as the UK (14.4% of EU biogas production) because of the variety of support schemes in place in the country;
- the effect of subsidies, tax incentives and secondary SS (other than the main one in the country) on the biogas production development have not been considered.

Intuitively, a great variety of additional factors are also likely to have a considerable impact on biogas and more generally renewable energy production, such as **socio-economic conditions** (the country wealth and the natural resources locally available, the population mindset, the degree of implication of the community during the development of installations - the infamous 'not in my backyard' phenomenon, the condition of the gas/electricity grid), the **political situation** (fluctuations of the political will, eventual national commitment(s) within international agreements, power balance between the different lobbies representing) and **technological conditions** (such as the innovation process, learning curves and maturity level of the relevant technologies). The multitude of factors at play is out of this this analysis reach and additional research is needed to assess the specificities of their role in the biogas production evolution: every European country has its own story to tell and need careful desk research coupled with interviews of key influencers in the country.

In order to assess the influence of every main SS across Europe and compare them to one another, a scatter plot is presented in Figure 3-3-1. The following data has been considered for the 'Average total income':

- FiT: as this SS is supposedly the unique income for eligible biogas producers, only the maximum tariff is included
- FiP: includes the maximum FiP when available (unique or average value) and the average electricity price per year and per country
- Certificates: includes the income one producer can get for 1 MWh of biogas produced via the GC scheme (the amount of GC per MWh can vary country per country) in addition to the average electricity price per country and per year

The graph includes ellipses of confidence for each set of SS (FiT, FiP, GC) representing the area where the probability to find a specific SS (given the production per capita) is above 90% (Chi-square test).

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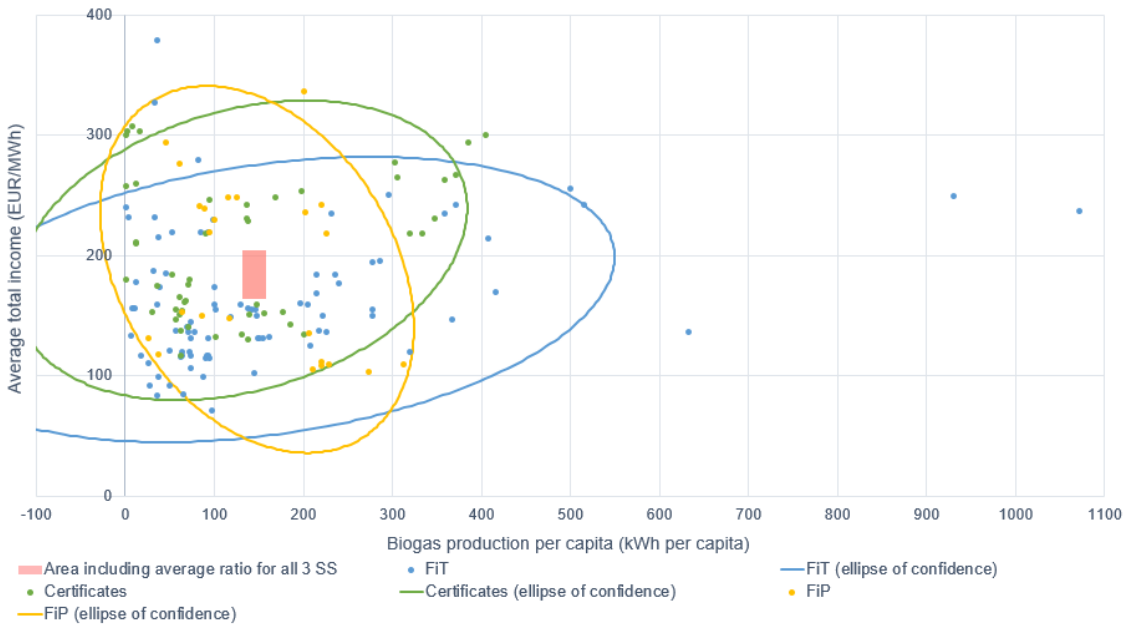

Figure 3-3-1: Biogas production per capita and average total income (max FiT/FiP/average GC price + average electricity price) for biogas producers per European country, year and support scheme for the period 2005 – 2015

Given that the vast majority of EU countries have developed their biogas production per capita during the period 2005 – 2015, the stretch of the ellipses along the positive horizontal axis in Figure 3-3-1 can be assimilated to the **general efficiency** of a set country to increase its biogas production per capita. In this sense, FiT have been more efficient compared to FiP and GC as its ellipse of confidence reaches almost 550 kWh per capita, while FiP and GC's ellipses reach respectively 325 and 385 kWh per capita. The countries displaying the most significant biogas production per capita rise using a FiT include DE, AT, LV, IT and CZ.

The orientation (long axis) of the ellipses is a relevant proxy for estimating the **economic efficiency** of the different SS for increasing the biogas production per capita: if the axis is closer to a -45 ° slope, the SS will lead to a higher production with a lower total income necessary. A slope of +45 ° achieves higher production per capita with a higher total income. In this sense, FiP (yellow ellipse) have been more economically efficient, while GC (green ellipse) have been the least. FiT (blue ellipse) have been of intermediate efficiency due to the high prices paid by the states, but closer to GC than to FiP.

All 3 ellipses are centred in a relatively small area (130.3 – 147.7 kWh per capita, 164.1 – 204.3 EUR/MWh, represented by the red box), meaning that the average ratio 'biogas production per capita/total income for biogas producers' is rather independent to the type of SS used. SS in Europe are thus highly **resilient** as long as the country ratio 'biogas production per capita/total income for biogas producers' is close to the EU average (the red box in Figure 3-3-1). However, the specificities related to their types become more influential as the production per capita moves away from the EU average.

The observations above need to be nuanced: only 6 European countries are using GC as their main SS (BE, NO, PL, RO, SE, UK) while 5 are using FiP (DK, EE, FI, LT, NL) and 19 have (had) been using FiT (AT, BG, CH, CY, CZ, DE, EL, ES, FR, HR, HU, IE, IT, LV, LU, PT, RS, SK, SI). Conclusions for FiT are thus much stronger, while conclusions for GC and FiP must be considered more carefully.

The lag phase between the start of the main SS in a country and an increase in biogas production is shown in the following histogram. The number of countries using FiT as their main SS is plotted and

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indicates that the lag period is 3 years on average, a typical period of time for developing a biogas project from planning to commissioning.

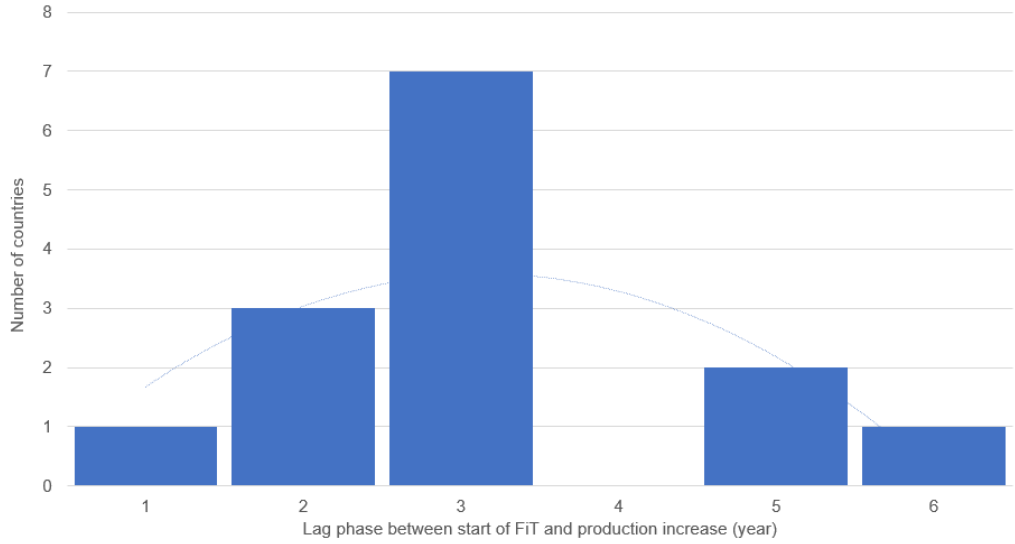

Figure 3-3-2: Histogram of the lag phase between the start of the FiT and the increase in biogas production for EU countries using FiT as their main support

As a summary, a SWOT (Strengths, Weaknesses, Opportunities, Threats) analysis is conducted on the influence and efficiency of national SS on national biogas production across the EU on the next page.

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Type of SS	Strengths	Weaknesses
FiT	- Generally, more efficient for increasing the biogas production per capita (see for example DE, IT, CZ, AT) - Stability of pricing greatly improves security for investment via financial security and transparency - Stability of pricing and purchase guarantee greatly benefits the development of emerging technologies	- Less cost-efficient than FiP (at high production per capita) - Not adjusting supply to demand - Costly for Member States - High involvement of the state in the market (creates economic distortion)
	Opportunities	Threats
	The financial burden of FiT might be alleviated through the reallocation of subsidies traditionally allocated to fossil fuels FF (such as coal and nuclear)	The rise of sliding FiT in recent years make it hard for biogas to compete with more cost-efficient RES
FiP	Strengths	Weaknesses
	- More cost-efficient than FiT (at high production per capita) (see DK) - Scheme more market-adapted (variations possible such as in DK or NL) - Cheaper than FiT	- Greater investor risks - Less cost-efficient than FiT (at low production per capita)
	Opportunities	Threats
	Given its flexible mechanism, FiP can be more reactive to market demand than FiT	- Along with rapidly changing EU legislation, the additional investment risk might deter potential investors - The rise of sliding FiP in recent years make it hard for biogas to compete with more cost-efficient RES
GC	Strengths	Weaknesses
	- Cheaper than FiT - Scheme fully based on market mechanisms	- Less cost-efficient than FiP and FiT (at high production per capita) - Greater investor risks
	Opportunities	Threats
	If well designed, a GC scheme can create great efficiency with well-distributed costs	Market mechanisms, if ill-designed, can make GC price too cheap/volatile to be truly efficient in boosting the biogas production

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4. Conclusion and outlook

Adequate support schemes have a great effect on the production of renewable energies and are as such crucial for the development of renewable energy. As of today, the positive impact of support schemes to help Europe in the energy transition is clear, however national support schemes were hard to secure. As highlighted by Claude Turmes in his recent publication (Transition énergétique, une chance pour l'Europe – February 2017), RE development was not acclaimed and national support scheme in particular were hard to accept for some: RE had to fight their way to reach the level known today. This report clearly shows that the 2015 biogas production would not have reached 15.7 Mtoe (linear extrapolation of production prior to implementation of support schemes) without the national schemes in place through the different EU countries.

Biogas is needed if Europe wants to truly achieve its ambitious climate targets for 2020 and 2030, and national support schemes are an essential part for it. Biogas is one of the most versatile renewable energy, with a mature technology developed and optimised for decades. Its development could be a significant part of the solution for the most polluting sectors in Europe:

- In the **electricity sector** (27% of EU gross GHG emissions), biogas is needed for offsetting future drawbacks of renewable energy, such as grid stabilisation from the variations of solar and wind energy generation, as well as the storage of electricity surpluses.
- In **transport** (20% of EU gross GHG emissions), biogas can directly be used in internal combustion engines after upgrading, and help decarbonising one of the most problematic European sector
- In the **industry sector** (19% of EU gross GHG emissions), biogas can play an important role as the necessary high temperatures can only be reached via the renewable energy from gas. The biogas can be upgraded into biomethane which is the same product as methane (natural gas), an energy vector widely used in the sector
- In **agriculture** (12% of gross EU GHG emissions, largest emitter of CH_4 by far), the digestion of agricultural by-products (straw, manure, etc) can directly decrease CO_2 and CH_4 emissions by avoiding the biocomponents to rot in the fields, with the additional advantage of generating electricity and heat with a CHP
- In the **residential sector** (9% of gross EU GHG emission), biogas can be generated from urban organic by-products (biowaste), and provide an efficient and long-lasting, renewable electricity and heat generation

The development of other technologies such as power-to-gas, dry digestion, and biomass gasification also constitute promising technological way forward and will increase the versatility of biogas in the future of European energy generation. Adequate support schemes for these technological paths are thus needed in order to help Europe in succeeding its energy transition from fossil to renewable energy use.

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5. Bibliography & data source

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6. Data source

- Biogas production: Eurostat dataset [nrg_107a]
- Population in EU countries: Eurostat dataset [demo_gind]
- Support schemes: RES legal archives, IEA RE database, custom research
- NREAP: JRC data portal

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