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ISABEL

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D1.2: Biogas landscape and specificities in the 3 targeted regions

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1. Introduction

Energy communities or community energy (EC) are / is now part of the local energy provision and they can favourably contribute to the low CO_2 economic transition in Europe. The future suppliers are citizen which now are involving in this process and phenomenon. Countries as Germany, Denmark and England have a well-known experience with the provision of Renewable Energy Sources (RES). Wind turbines, solar PV, and biogas installations are now part of our lives because the technology is ready to significantly contribute to decrease the Green House Gas (GHG) emissions.

Although the majority of European community RES projects are linked to solar and wind energy, biogas has also been part of this development with a slow acceptance outside Germany. ISABEL will focus on the promotion of biogas and encourage the use of biogas by local communities.

Before this aim can be achieved, ISABEL will find the reasons beyond this development. First the European policies and frameworks will be illustrated, while a description of the European energy production (***energy indicators***) and how this sector influence the society (***socio-economic indicators***) will follow.

Additionally to the general European data, the national policies and incentives in Germany, Greece and United Kingdom, that foster the energy production development will be outlined, as well as community energy developments in these countries, coupled with in-deep interviews with stakeholders. As a result, the gaps, the barriers and the support needy for a sustainable power production, will be illustrate revealed.

Figure 1: Biogas in the community source[1]

[1] Fachagentur Nachwachsende Rohstoffe e.V., 'Biogas - Bioenergie - Pressefotos - Grafiken FNR-Mediathek', accessed 15 April 2016, https://mediathek.fnr.de/catalog/product/gallery/id/719/image/1166/.

2. European Framework

Biogas, as a renewable resource as such is part of the **Renewable Energy Directive (RED)** and thus this is the political framework for all the European Union member countries[2]. The EU's Renewable Energy Directive sets a binding target of 20% final energy consumption from renewable sources by 2020. Additionally to the targets, the RED regulates the use of renewable electricity, heating, cooling and transport. To achieve this, EU countries have committed to reaching their own national renewables targets ranging from 10% in Malta to 49% in Sweden.[3]

According to RED Article 12, the contribution made by biogas is part of Green House Gas emission saving potential, and additional to the environmental advantages, biogas installations are part of regional infrastructure investment as well as they represent a significant contribution to the rural development because of the decentralized production of heat and power. Moreover, for farmers originate new incomes and opportunities[4].

In any case, renewable energy sources will continue to play an important role after 2020. EU member states have already agreed on a new renewable energy target of at least 27% of final energy consumption in the EU as a whole by 2030. This target is coupled with a cut of 40% greenhouse gas emission compared to 1990 levels[5].

According to the '***The state of Renewable Energies in Europe 2015***' report, the gross renewable energy consumption in 2014 was 15.9%, although the renewable energy consumption in the EU 28 grow in comparison to 2013 by 0.9%; it is a mild growth deceleration to the other years. Markedly is the gross electricity consumption with 28.15% in 2014. [6]

Besides these greenhouse saving facts, the renewable energy production is one of the most important developing industries in Europe, while the two main indicators show the socioeconomic impact of the renewable sectors across Europe: employment and sales turnover. In 2014 approximately 1.11 million direct and indirect jobs have been depending from the ten renewable sectors: wind power, solid biomass, PV, biofuels, heat pumps, biogas, solar thermal, small hydropower, waste and geothermal energy. Indeed 2014 the renewables have an economic value of € 143.6 billion[7].

2.1 Energy indicators

Before a deep introduction in the biogas key indicators, it is import to see its classification. There are different types and sizes of anaerobic digesters (AD) ranging from small farm digesters to larger multi-production plants for waste methane production. According to EuroObserv'ER the raw materials (***feedstocks***) describe and characterize the biogas production. Additionally, this characterization illustrates the development in the European countries and the political frameworks beyond this development.

- ***Landfill biogas*** is the captured gas inside the urban or industrial landfills
- ***Sewage sludge biogas*** is the gas from the wastewater treatment plants (as the name suggest from sewage sludge only)
- Other biogas (***Industrial biogas***) is the umbrella term for all gases produced from animal slurry, farming waste, green waste, food-processing waste, energy crops (maize, etc.)

[2] European Commission, *Renewable Energy Directive*, vol. Number 2009/28/EC, 2009, http://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX%3A32009L0028.
[3] European Commision, 'Renewable Energy - Energy - European Commission', *Energy*, accessed 15 April 2016, https://ec.europa.eu/energy/en/topics/renewable-energy.
[4] Ibid.[2]
[5] Ibid.[3]
[6] EurObserv'ER, 'The State of Renewable Energies in Europe (Edition 2015) 15th Report', accessed 1 April 2016, http://www.eurobserv-er.org/15th-annual-overview-barometer/.
[7] Ibid.[6]

Figure 2: Landfill **Source**[8]

Figure 2: Wastewater treatment plant **Source**[9]

Figure 3: Silage maize for biogas **Source**[10]

[8] pixabay, 'Landfill - Deponie', accessed 18 April 2016, https://pixabay.com/de/verdichtungsmaschine-deponie-681543/.

[9] pixabay, 'Sewage Sludge Biogas - Abwasser -B224', accessed 15 April 2016, https://pixabay.com/de/abw%C3%A4sser-b224-beleuchtet-780582/.

[10] Fachagentur Nachwachsende Rohstoffe e.V., 'Silobefüllung - Biogas - Bioenergie - Pressefotos - Grafiken FNR-Mediathek', accessed 15 April 2016, https://mediathek.fnr.de/catalog/product/gallery/id/719/image/1159/.

According to EurObserv'Er, approximate 14.9 million tonnes oil equivalent (Mtoe) primary energy were produced from biogas during 2014 in the European Union. Unquestionably the statistical data show that the production constant growth: 12.1 Mtoe in 2012 and 13.4 Mtoe in 2013. No doubt this RES sector has been growing particularly in one category: the other biogas was 72.4% of the produced output in 2014. In contrast, the other two categories produced 27.6% of the gas output during 2014: Landfill biogas and sewage plant biogas respectively produced 18.4% and 9.2% in 2014. Certainly this distribution isn't in all the countries equal as the European average e.g. while UK has been developed the landfill biogas technology, Germany has a success farm biogas CHP branch[11].

Table 1: Primary energy production from biogas in the European Union in 2013 and 2014* (in ktoe)[12]

	2013				2014			
Country	Landfill gas	Sewage sludge gas	Others biogas	Total	Landfill gas	Sewage sludge gas	Others biogas	Total
Germany	110.7	438.0	6326.3	6875.1	103.7	439.1	6891.3	7434.1
United Kingdom	1535.8	286.2	214.6	2036.5	1501.8	310.7	314.0	2126.4
Italy	403.2	48.6	1363.8	1815.5	393.9	51.1	1516.0	1961.0
Czech Republic	28.9	39.6	502.5	571.1	30.7	40.6	536.7	608.0
France	180.7	43.4	212.5	436.6	174.1	41.8	204.8	420.7
Spain	193.5	162.1	123.8	479.4	158.5	111.6	83.1	353.3
Netherlands	25.8	57.8	221.6	305.2	22.8	56.3	233.6	312.7
Austria	3.7	14.0	179.0	196.7	3.8	11.2	277.3	292.2
Belgium	28.4	23.7	136.9	189.0	26.8	21.9	157.6	206.3
Poland	51.5	85.3	44.5	181.4	49.0	91.0	67.1	207.1
Sweden	9.8	73.4	61.8	145.0	8.4	74.0	71.0	153.4
Denmark	5.2	22.4	82.4	110.0	4.3	24.3	94.2	122.8
Greece	67.5	16.1	4.8	88.4	67.1	15.6	4.2	86.9
Hungary	14.3	20.1	47.8	82.2	14.3	21.0	48.4	83.7
Latvia	7.0	3.0	55.0	65.0	8.0	2.0	65.0	75.0
Finland	29.7	15.4	12.9	58.0	30.5	14.8	15.8	61.0
Slovakia	3.4	14.8	36.8	54.9	3.4	14.8	40.3	58.4
Ireland	36.8	7.9	3.5	48.2	39.1	7.8	5.4	52.2
Slovenia	7.1	2.8	24.8	34.7	6.5	2.6	21.7	30.8
Romania	1.5	0.1	28.4	30.0	1.5	0.1	28.4	30.0
Bulgaria	0.0	0.0	12.0	12.0	0.0	0.0	27.0	27.0
Lithuania	7.1	3.6	4.8	15.5	7.7	6.9	6.3	20.9
Portugal	61.8	2.7	0.8	65.3	70.3	2.6	0.6	73.5
Croatia	0.4	2.3	13.8	16.6	5.3	2.9	18.1	26.1
Luxembourg	0.1	1.4	14.1	15.6	0.1	1.5	15.2	16.7
Cyprus	0.0	0.0	12.0	12.0	0.0	0.0	12.0	12.0
Estonia	6.3	0.9	0.0	7.2	8.5	1.1	0.0	9.6
Malta	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total EU	2820.1	1385.7	9741.3	13947.1	2740.0	1367.3	10755.1	14862.4

[11] Ibid[6].
[12] Ibid[6].

Chiefly the conversion from biogas into electricity is the most widespread technology; therefore it is a growing sector, as a proof of that are the last three years data 46.4 TWh in 2012; 53.6 TWh in 2013 and 57 TWh in 2014, that means 2014 was produced 4.9 Mtoe in the EU. Also 2014 the production growth 6.3% that is a really high production growth rate, but this can be the first signals of a deceleration because between 2012 and 2013 the production growth 13.4%[13].

Table 2: Gross electricity production from biogas in the European Union in 2013 and 2014 (in GWh)[14]

Country	2013 Electricity only plants	2013 CHP plants	2013 Total electricity	2014 Electricity only plants	2014 CHP plants	2014 Total electricity
Germany	8800.0	20435.0	29235.0	8728.0	22189.0	30917.0
Italy	3434.9	4012.8	7447.7	3527.8	4660.7	8198.5
United Kingdom	6032.4	611.8	6644.2	6232.0	668.6	6900.6
Czech Republic	55.0	2239.0	2294.0	56.0	2527.0	2583.0
France	774.8	731.8	1506.6	632.7	821.7	1454.4
Netherlands	55.0	925.0	980.0	46.0	959.0	1005.0
Spain	785.0	189.0	974.0	738.0	169.0	907.0
Belgium	108.5	665.3	773.8	133.7	735.2	869.0
Poland	0.0	690.0	690.0	0.0	816.0	816.0
Austria	572.0	58.0	630.0	563.0	52.0	615.0
Denmark	2.3	382.2	384.5	2.4	447.9	450.3
Latvia	0.0	287.0	287.0	0.0	350.0	350.0
Portugal	238.0	10.0	248.0	263.6	13.0	276.6
Hungary	92.0	175.0	267.0	88.6	168.4	257.0
Slovakia	117.0	96.0	213.0	120.0	100.0	220.0
Greece	38.2	177.2	215.4	36.2	183.5	219.7
Ireland	157.6	28.7	186.4	169.5	36.2	205.7
Finland	82.9	75.3	158.2	79.3	85.7	165.0
Slovenia	4.2	136.8	141.0	4.1	125.6	129.7
Croatia	19.3	58.4	77.7	46.3	68.0	114.4
Bulgaria	49.8	0.0	49.8	104.3	0.0	104.3
Lithuania	0.0	59.0	59.0	0.0	78.0	78.0
Luxembourg	0.0	56.5	56.5	0.0	60.5	60.5
Estonia	0.0	20.0	20.0	0.0	45.0	45.0
Cyprus	0.0	35.8	35.8	0.0	37.5	37.5
Romania	0.0	25.8	25.8	0.0	26.0	26.0
Sweden	0.0	20.0	20.0	0.0	14.0	14.0
Malta	0.0	3.0	3.0	0.0	3.0	3.0
Total EU	21419.0	32204.3	53623.3	21581.4	35440.6	57022.0

[13] Ibid[6].
[14] Ibid[6].

CHP (combined heat and power) is a widespread technology with great acceptance because it increases the efficiency and probably the feed-in legislations makes the Heat sales in the district heat grid attractive for new investments and community energy projects. For this reason this energy producing sector grew 19.6% between 2013 (464.6 ktoe) to 2014 (559.9 ktoe) and that is a high growth rate for this industry sector.

Table 3: Gross heat production from biogas in the European Union in 2013 and in 2014 (in ktoe) in the transformation sector[15]

	2013			2014		
	Heat only plant	CHP plant	Total heat	Heat only plant	CHP plants	Total heat
Italy	0.3	200.8	201.0	0.3	238.5	238.8
Germany	45.9	70.5	116.5	54.4	102.8	157.2
Denmark	1.7	31.0	32.7	5.8	35.3	41.1
France	2.4	14.4	16.8	2.4	18.9	21.4
Latvia	0.0	14.2	14.2	0.0	18.2	18.2
Czech Republic	0.0	11.6	11.6	0.0	13.5	13.5
Finland	7.5	1.8	9.3	7.7	3.0	10.7
Sweden	7.2	6.1	13.3	4.0	4.8	8.8
Slovenia	0.0	8.8	8.8	0.0	8.4	8.4
Poland	0.3	8.7	9.0	0.3	6.8	7.1
Belgium	0.0	5.2	5.2	0.0	7.1	7.1
Austria	1.9	4.4	6.3	1.8	3.0	4.7
Romania	0.9	2.4	3.3	0.9	2.4	3.3
Croatia	0.0	2.7	2.7	0.0	3.2	3.2
Slovakia	0.0	2.8	2.8	0.0	2.9	2.9
Estonia	0.0	1.6	1.6	0.0	2.5	2.5
Lithuania	0.0	2.3	2.3	0.0	2.2	2.2
Hungary	2.15	0.0	2.2	2.15	0.0	2.2
Netherlands	0.0	3.7	3.7	0.0	1.1	1.1
Cyprus	0.0	1.0	1.0	0.0	1.0	1.0
Luxembourg	0.0	0.3	0.3	0.0	0.5	0.5
Total EU	70.3	394.3	464.6	79.7	476.1	555.9

[15] Ibid[6].

2.2 Socio-economic indicators

As every industrial activity affects the social processes and the economy, its development leads to new technologies, laws and ecological challenges. The two socio-economic indicators measuring in the EurObserv'Er 2015 Report are: the ***employment*** (in a summary of direct and indirect jobs) and the ***turnover***.

Unquestionably with a rising primary energy production in the last years the mount of employees in this sector has been rising. According to the European Biogas Association and EurOberserv'Er in 2014 approximately 66.000 persons were working in the different production lines (installation of plants, component manufacturing, operation, maintenance and fuel supply), while biogas has a turnover of approximately 6.1 billion[16] [17]

The statistical data show that the leadership in the European marked, in the primary energy production and employment, has Germany. To make some relations to Germany frontrunner, if you add together all the employed people in the European Biogas sector, Germany with 48 300 still having almost 3.7-fold more people employed.

Table 4: Employment[18]

	2013		2014	
	Primary production (ktoe)	Employment (direct & indirect jobs)	Primary production (ktoe)	Employment (direct& indirect jobs)
Germany	6875.1	49200	7434.1	48300
Italy	1815.5	4200	1961.0	5000
France	436.6	3500	420.7	3500
United Kingdom	2036.5	2650	2126.4	2850
Czech Republic	571.1	1500	608.0	1200
Spain	479.4	1000	353.3	800
Austria	196.7	450	292.2	600
Netherlands	305.2	500	312.7	600
Poland	181.4	500	207.1	400
Belgium	189.0	500	206.3	350
Sweden	145.0	300	153.4	350
Latvia	65.0	250	75.0	300
Finland	58.0	200	61.0	250
Denmark	110.0	250	122.8	200
Hungary	82.2	300	83.7	200
Croatia	16.6	150	26.2	150
Greece	88.4	150	86.9	150
Ireland	48.2	100	52.2	150
Lithuania	15.5	100	20.9	150
Romania	30.0	150	30.0	150
Luxembourg	15.6	100	16.7	100
Portugal	65.3	150	73.5	100
Slovakia	54.9	100	58.4	100
Slovenia	34.7	100	30.8	100

[16] European Biogas Association, 'EBA Biomethane & Biogas Report 2015 - European Biogas Association', 2015, http://european-biogas.eu/2015/12/16/biogasreport2015/.
[17] bid[6].
[18] Ibid[6].

	2013 Primary production (ktoe)	2013 Employment (direct & indirect jobs)	2014 Primary production (ktoe)	2014 Employment (direct& indirect jobs)
Bulgaria	12.0	<50	27.0	<50
Cyprus	12.0	<50	12.0	<50
Estonia	7.2	<50	9.6	<50
Malta	0.0	<50	0.0	0
Total EU	13947.2	66600	14862.4	66.200

Although Germany in 2014 had the highest employed number (48.300) and the highest primary energy production (7434.1 ktoe), Italy had the highest turnover with € 2.7 billion with only 5000 employees in the sector[19].

Table 5: Turnover in million euros[20]

Country	2013 Turnover (M€)	2014 Turnover (M€)
Italy	2500	2700
Germany	1750	1640
United Kingdom	510	485
France	410	400
Czech Republic	145	150
Netherlands	130	150
Austria	65	110
Spain	120	90
Belgium	50	55
Poland	65	50
Sweden	35	40
Denmark	25	30
Greece	25	25
Finland	15	20
Hungary	20	20
Latvia	15	20
Slovakia	20	20
Ireland	10	15
Bulgaria	<5	10
Romania	10	10
Slovenia	10	10
Croatia	<5	<5
Cyprus	<5	<5
Estonia	<5	<5
Lithuania	<5	<5
Luxembourg	<5	<5
Portugal	15	<5
Malta	0	0
Total EU	5975	6080

[19] Ibid[6].
[20] Ibid[6].

3. Germany

The aforementioned facts indicate that Germany is the frontrunner in the biogas sector in Europe with approx. 7960 plans which produce roughly 3800 MWe electrical power. During 2013 the biogas electricity production was approx. 27.2 billion kWh, which is equals to 4.6 % of total electricity consumption in Germany. As a result, approx. 1.268.000 ha has been cultivated with bioenergy crops for the biogas substrate. In this blooming situation approx. 41.000 jobs are directly or indirectly related to this sector. Furthermore, in 2006 the first filling station providing biomethane as fuel was set up; currently there are about 180 filling stations offering pure biomethane and another 330 stations sell a mixture biomethane - CNG. Additionally, about 150 plants are injecting biomethane into the German natural gas grid[21]

Not enough stress can be laid on the fact that EurObserv'ER data base are estimated numbers that is the reason because they vary in size from the FNR data.

The German biogas production has a technical energetic potential of 440 PJ/a; therefore this RES sector could possible to produce approx. 7 % of total electricity consumption in Germany.

In essence this is the state-of-art in Germany, shortly afterward we will find out during this chapter, the political actions besides this development (3.1). Additionally; ISABEL focus on this country is the Federal State Baden-Württemberg, characterising the biogas landscape and development of this state (3.2). At the end in a stakeholders' interview summary, we will find the main gaps beyond this development as well as barriers.

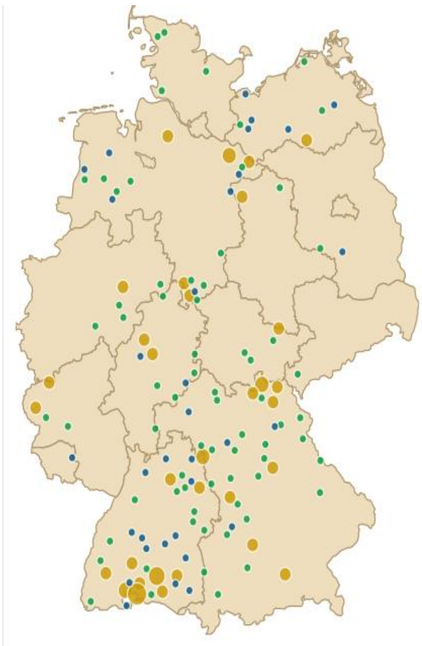

Figure 3: German Bioenergy Villages **Source[22]**

[21] Fachagentur Nachwachsende Rohstoffe e.V., 'Biogas in Deutschland 2015', 2015.

[22] Fachagentur Nachwachsende Rohstoffe e.V., 'Bioenergiedörfer - Wege Zum Bioenergiedorf', accessed 15 April 2016, http://www.wege-zum-bioenergiedorf.de/bioenergiedoerfer/.

3.1 Biogas Policies in Germany

The German national frameworks and programs began on March 2000, however, the last ten years open a crucial path for the biogas development as an important RES industry sector. As a result, the friendliest RES incentives in the European Union have been applied, and this country created a medium for research, develop and invest.

The ***Renewable Source Act ("Erneuerbare-Energien-Gesetz" – EEG***) regulates the feed-in tariff for electricity and until the EEG 2014 regulated the gas upgrading bonus, CHP-bonus (feed-in for local heat grid) as well as the substrate bonus (class I: energy crops, class II: ecological valuable substrates like slurry or landscape conservation material).

Four different amendments (EEG 2004, 2009, 2012 and 2014) were implemented during the last ten years with different aims and targets e.g. CHP-Bonus for a better energy efficiency. Although these amendments change the rules for the producers, every amendment had and has twenty years tariff guaranty. At the moment, the biogas plant started to produce electricity. Certainly, this guaranty helped the planners as well as give a clear invest risk for a period of time.

The German EEG laid out the biogas conversion into electricity, because the basic tariffs were and are primary for the electricity production. Besides these tariffs, the EEG bonuses created a new supply chain e.g. the technology bonus for the gas upgrading, as well as drove the CHP-technology in the communities. Furthermore, the feedstock production rose and therewith the development of new maize varieties as well as the selection of new crops as *Silphium perfoliatum* or sorghum.

In addition to the EEG, since January 2009 enacted '***The Renewable Energy Heat Act***' (***EEWärmeG***) determining the heat use requirements from renewable energies in new and public buildings.

Biomethane production was laid open since April 2008 because of '***The Gas Grid Access Ordinance***' (***GASNZV***) and '***Gas Grid Changes Ordinances***' (***Gas NEV***) came into force. These Acts and guidelines opened the new decentral feeding upgraded biogas into the natural gas grid.

The new biogas application as Biofuel was regulated under '***The Biofuel Quota Act***' (***BioKraftQuG***). The first impulse for this sector was Tax exemption until the end of 2015. In addition since 2015 the conversion from biofuel quota to greenhouse gas quota started.

On 1st August 2014 the latest amendment of '***The Renewable Energy Sources Act***' (***EEG 2014***) entered into forced. The amendment tries to increase the share of RES with a further development of the power generation technologies i.e. with the same amount of biogas plants more electrical power. However, this amendment limits the construction of new biogas plants and reduce the bonuses and incentives.

Some general EEG 2014 objectives:

- Reduce the increasing cost for RES and a better cost distribution
- Systematic management by increase of renewable energies
- Market integration stimulation
- Alleviating measure for land use conflicts

Objectives regarding biomass:

- Focus on the promotion of (mainly) waste and residual materials
- Restricted the new construction of biomass plants to max 100 Megawatt (gross) per year
- Abolition of bonus categories for substrates
- Abolition of the technology bonus for gas upgrading
- Introduction of an digression tariff system

Table 6: Policies environment for biogas

The Renewable Energy Source Act – Tariff scheme from 2004 to 2014

EEG 2004	EEG 2009	EEG 2012	EEG 2014
Basic tariff 8,40 – 11,50 ct/kWh	**Basic tariff** 7,79 – 11,67 –ct/kWh	**Basic tariff** 6,00 – 14,30 ct/kWh	**Basic tariff** 5,85 – 13,66 ct/kWh
		Special tariff for small slurry plants 25,00 ct/kWh	**Special tariff for small slurry plants** 23,73 ct/kWh
Biomass bonus **(crops a/o slurry)** 4,00 – 6,00 ct /kWh	**Cultivated biomass bonus** (energy crops) 4,00 – 7,00 ct/kWh	**Input substrate tariff** **- class I** (energy crops) 4,00 – 6,00 ct/kWh	**deleted**
	Slurry bonus (min. 30% slurry or manure) 1,00 – 4,00 ct/kWh	**Input substrate tariff** **- class II** (ecological valuable substrates as slurry or landscape maintenance residues) 6,00 – 8,00 ct/kWh	**deleted**
	Landscape maintenance residues bonus 2,00 ct/kWh		
CHP bonus 2,00 ct/kWh	**CHP bonus** 3,00 ct/kWh	**Mandatory heat use**	**No obligation use of heat**
Technology bonus (e.g.: dry fermentation, gas upgrading) 2,00 ct/kWh	**Technology bonus** (e.g.: gas upgrading, fuel cells) 2,00 ct/kWh	**Gas upgrading bonus** 1,00 – 3,00 ct/kWh	**deleted**
	Emission reduction bonus (formaldehyde emission) 1,00 ct/kWh	**deleted**	
		Bio-waste fermentation tariff 14,00 – 16,00 ct/kWh	**Bio-waste fermentation tariff** 13,38 – 15,26 ct/kWh

3.2 Baden-Württemberg Biogas Landscape Map

The federal State Baden-Württemberg was an example for the RES development in Germany, but during the last few years the other federal states have been expanding the RES production and supply. This is why during 2014 the cumulative German RES electricity demand was approx. 27% compared to Baden-Württemberg with only 18.3%[23].

Although this federal state influenced the biogas sector during the pioneer years, at the present time 893 plants are working with an electrical power of 319 Mw. Yearly, this means about 2,2 billion Kwh i.e. 2,8% of the electricity demand, whereas; the German biogas electricity production is more than 5%[24].

According to the statistical office in Baden-Württemberg approx. 24% of the farmland were cultivated with maize during the season 2014, in other words 200.000 ha were cultivated with this crop, with this in mind maize is almost the most produced crop, such as wheat a traditional crop with 232.00 ha in the same season 2014

Especially the citizen are felling that a vast extension of farmlands were cultivated with energy crops e.g. maize, this produced an acceptance problem for new biogas plants. On the contrary to these feelings and according to the statistical office, from the 125.400 ha silo maize only 35% were used for biogas production. In conclusion the vast part of farmland still producing animal forage[25].

One exceptional point to point out on this State is the civic participation and engagement. As an illustration from the 177 bioenergy villages in Germany, 58 are in Baden-Württemberg[26].

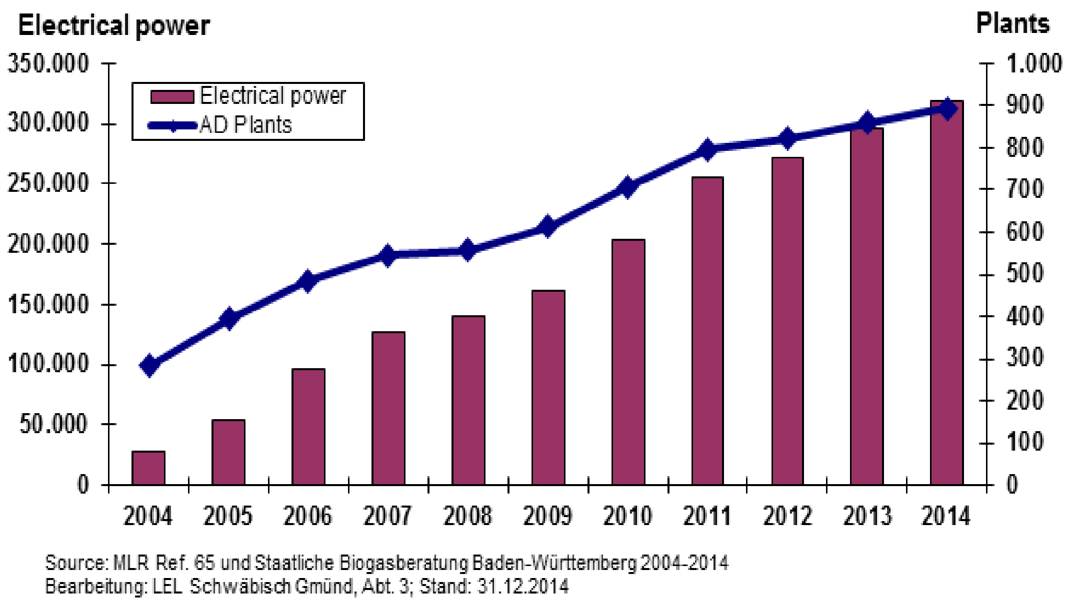

Figure 4: Development of Biogas plants in Baden-Württemberg[27]

[23] Bernward Janzing, 'Ein Pioneer Fällt Zurück', *Biogas Journal*, n.d., sec. 1_2016.
[24] Ibid[23].
[25] Ibid[23].
[26] Ibid[22].
[27] 'Entwicklung Der Biogasanlagen in Baden-Württemberg Sowie Den Stadt-/Landkreisen', accessed 14 January 2016, https://www.landwirtschaft-bw.info/pb/MLR.Landwirtschaft,Lde/Startseite/Erneuerbare+Energien/Biogas.

Table 7:10 years development of biogas plants in Baden-Württemberg[28]

Baden Württemberg	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Electrical power kW	27707	54347	96113	127315	140540	161766	202848	255928	271812	295798	319181
AD Plants	283	394	485	546	558	612	709	796	822	858	893
kW/AD Plants	98	138	198	233	252	264	286	322	331	345	357

Funding programmes

National government aid and funding programmes

- Granting loans with low interest rates for RES projects (KfW)
- Promotion of investments in local heat and biogas pipelines (KfW)
- Promotion of investments by the Agro-Investment-Programme (AFP) or by supporting programmes of the Federal States
- Assistance for consultation and diversification for farmers
- Funding of R & D by the research programme "Renewable Resources", managed by FNR on behalf of BMEL
- Other R &D programmes (BMUB, BMBF)

FNR R&D activities in the field of biogas *(on behalf of the Federal Ministry of Food & Agriculture since 2000)*

- 350 projects (funding: € 99.1 million)
  - 152 ongoing projects (funding € 43.8 million)
  - 198 completed projects (funding € 55.3 million)
- Staging of different workshops to identify need for research work with the topics: Process control, dry fermentation, digestate, microbiology, sanitation, emissions
- Staging and/or support of conferences e.g.: Conference "Digestate" *Februar 2015* FNR/KTBL-Conference "Biogas in agriculture"" *September 2015*
- Release of publications e.g.: "Guide to biogas", "Biogas – an introduction", "Biogas upgrading and feed-in"

Federal state Baden Württemberg programmes :

- Bioenergy Competition
- Bioenergy villages Promotion
- Demonstration projects of efficient energy use and RES use
- "Climate Protection Plus" funding by the federal state Environment Ministry, municipalities
- EMAS-Konvoi-Förderprogramm (EU-Eco regulation funding program)
- CO_2 reduction program in Baden-Württemberg
- Associations environment protection funding program

The Ministry of Environment, Climate and Energy Baden-Württemberg had during the funding period 2007 to 2013 a total of EUR 27.5 million from the European Regional Development Fund (ERDF) for the development of innovative environmental technologies, resource protection and risk prevention.

[28] Ibid[27].

3.3 Interviews summary

The eleven Interviews conducted cover a wide range of stakeholders (biogas farmers, Environmental NGOs, Energy Agencies, Communal Representatives, Administrations, Planers, Project Developers, Investors and Energy Providers). Thus the answers varied according to their knowledge and background. Anyway we tried to summaries the answers as good as possible in order to give an overview on the regional biogas landscape, namely outlining **biogas and its meaning for the energy transition in Germany**

National and regional scale

- **How do you assess the importance of biogas for Germany in general and specifically for the region?**
  - ✓ Biogas was and is important for the energy transition
  - ✓ Biogas is especially important on regional scale and for rural areas
  - ✓ It's impact on agriculture was and is strong
  - ✓ Additional source of income
  - ✓ Led to an intensification of agriculture

Barriers and opportunities

- **What are the current strengths of biogas production?**
  - ✓ Flexible in terms of input material
  - ✓ Seasonal shift of production is possible
  - ✓ Different storage possibilities (raw material, Gas, heat, power)
  - ✓ Local resources
  - ✓ Identity provider
  - ✓ Effective climate protection option
  - ✓ Possibility to preserve extensive grasslands
  - ✓ Additional income source and future perspective for farmers
  - ✓ Improves manure management
  - ✓ Combined use of heat and power (high efficiency)
- **What is the weakness of biogas production?**
  - ✓ expensive energy
  - ✓ bad image due to mismanagement in the past
  - ✓ increases tenancy costs
  - ✓ inflexible due to high costs of storage
  - ✓ too strong reliance on funding/subsidies (EEG)
  - ✓ existing plant often are too far away for heat utilization
  - ✓ negative impact on water quality and biodiversity
  - ✓ methane losses in existing plants

Future significance, scenarios

- **Can biogas be part of a future energy transition?**
  - ✓ Focus on residues, organic waste, manure
  - ✓ Diversification of output products
  - ✓ Joint ventures of several farmers
  - ✓ Short transport distances only

- ✓ Combined heat and power (for example bioenergy villages)

Specific needs for biogas production

- **What are relevant factors for biogas production? (E.g. electricity, heat production, biomethane, other?)**
  - ✓ Better storage solutions
  - ✓ Technology improvements / Innovations
  - ✓ Joint ventures
  - ✓ Better political frame conditions
  - ✓ Strong support from the communities
  - ✓ Heat concepts
  - ✓ More modular production to be more flexible
  - ✓ Several output products
  - ✓ Elaboration of policy criteria's
  - ✓ Knowhow and counselling
  - ✓ Regional improvement of power grids
  - ✓ More efficiency

Value chain

- **What should be considered in supply chains?**
  - ✓ Short transport distances
  - ✓ Focus on manure / residues / organic waste / landscape material
  - ✓ High overall energy efficiency

Production of biogas

- **What input materials do play a role in the production of biogas (waste, agricultural biomass, etc.)?**
  - ✓ So far mostly manure, residues and energy crops
  - ✓ Organic waste is used in non-agricultural biogas plants

Policy

- **How can funding, laws affect?**
  - ✓ Further support is needed due to high generation costs
  - ✓ Long term bioenergy policy needed (EEG)
  - ✓ Strong focus on heat utilization
  - ✓ Easier ways to receive funding
  - ✓ Funding should be linked to climate and environmental measures
  - ✓ Policies should not be to restrictive concerning waste and residues in agricultural plants

4. Greece

Around 61% of Greece's primary energy consumptions are covered through imports with the remaining 39% being covered through national energy sources, mainly lignite (77%) and RES (22%). Imported energy sources are mainly petroleum products that account for 44% of total energy consumption and natural gas with a share of around 13%.

At the end of 2013, the capacity electricity production was 19,604 MW, of which 61% are thermal power plants, 15% large hydro-power plants and 24% other RES.

In 2012, gross national electricity generation was 61 TWh, 83% of which from thermal power plants. This corresponds to a decrease of around 4% compared to the situation before the beginning of the economic crisis.

The share of RES in gross electricity consumption reached 17% in 2012, compared to a National Renewable Energy Action Plan (NREAP) intermediate target of 18.8%. Hydro-power contributed 7.5%, wind energy 6.3%, solar photovoltaic 2.7% and biomass 0.6%. For 2013, the share of RES is estimated to reach 23% of gross electricity consumption, compared to an NREAP intermediate target of 21.8%.

Greece has electricity interconnections with Albania, Bulgaria, Italy, FYROM (the Former Yugoslav Republic of Macedonia) and Turkey. In 2013, Greece imported 5.6 TWh and exported 3.9 TWh[29].

The anaerobic digestion in Greece has been used as a waste management method and is rarely accompanied by the production of biogas and energy. The method looks like that: the treatment of urban residues, the production of biogas and the further use of the residue as fertilizer.

The disposal of untreated waste has not being created significant environmental problems in comparison with other EU Member States until these days For this reason the implementation of biogas plants to reduce water and soil pollution, is a urgent issue. The large availability of raw material and the pressure of environmental legislation help by the creation of biogas plants. However; the Regulatory Authority for Energy (RAE) has issued 83 licenses for bioelectricity production, with total installed capacity of 441.4 MW.

46 biogas plants with a 146.5 MW power capacity:

- 7 licenses for MSW (41.33 MW)
- 7 licenses for water treatment plants (17.06 MW)
- 26 licenses for agricultural/animal breeding wastes (72.0 MW)
- 3 licenses for agricultural wastes (12.0 MW)
- 3 licenses for animal breeding wastes (4.12 MW)

37 biomass plants with a 294.9 MW power production[30]

In Greece electricity produced from biogas is:

- 2,06% of the total electricity production from RES 2015
- 4,35‰ of the total electricity consumption in 2012

[29] 'Greece Energy Situation - Energypedia.info', accessed 22 April 2016, https://energypedia.info/wiki/Greece_Energy_Situation.

[30] Operator of electricity market, 'CRES_Zafiris_presentation.pdf', accessed 22 April 2016, http://www.renewablesb2b.com/data/shared/02_CRES_Zafiris_presentation.pdf.

Table 8: Biogas plants in Greece[31]

Name	Municipality	Power (kW)	Type of Station	Application Date	Activation date
Athens Water Supply and Sewerage Company (EYDAP S.A.).	Piraeus	11.400	Self-producer	14/12/1995	13/3/2001
Municipal Enterprise for Water Supply-Sewerage of Volos Area (DEYAMV)	Volos	353	Self-producer	31/3/1997	26/6/2001
Bioenergy - Energy Ano Liosia SA	Fylis	6.500	SALE*	31/10/1997	4/5/2001
Bioenergy - Energy Ano Liosia SA	Fylis	7.800	SALE	31/10/1997	4/5/2001
Thessaloniki Water Supply & Sewerage Co. S.A	Delta	2.500	SALE	26/7/2001	23/10/2003
Bioenergy - Energy Ano Liosia SA	Fylis	9.692	SALE	5/2/2003	29/9/2006
Hlektor SA	Thermis	5.048	SALE	24/2/2003	23/11/2006
Biogas SA- Energy Recovery S.A.	Volos	1.720	SALE	27/3/2006	21/12/2006
Municipal Enterprise for Water Supply-Sewerage of Volos Area Larisas (DEYAML)	Larisas	600	selfproducer	21/3/2007	24/10/2007
GKASNAKHS ANTONIOS SA	Alexandria	250	SALE	26/1/2010	27/1/2011
HITAS FARM S.A.	Zirou	980	SALE	26/7/2010	28/8/2012
Komotini Biogas S.A.	Komotini	250	SALE	27/10/2011	24/10/2013
KARANIKAS ANTONIS L.T.D.	Alexandria	250	SALE	17/6/2011	5/6/2013
Biogas S.A.	Tirnavos	498	SALE	11/4/2011	18/3/2014
MANTMOYAZEL S.A.	Kastoria	252	SALE	20/10/2011	18/9/2014
Komotini Biogas S.A.	Komotini	245	SALE	9/4/2013	10/12/2014
MEGA GREEN FARM	Megara	500	SALE	28/2/2011	9/4/2015
PELLAS BIOGAS	Pella	950	SALE	21/4/2011	18/5/2015
BIOENERGY NORTH A.B.E.E.	Oraiokastro	999	SALE	7/2/2012	15/9/2015
19 plants		**50.787**			

* electricity production only for sale

Biogas plants of 50.787 MWe capacity are operating, mostly at solid waste landfills (SWL) and municipal wastewater treatment plants (MWTP).

- Installed power of solid waste landfills (SWL) and municipal wastewater treatment plants (MWTP): 45,613 MW
- Installed power of AD biogas plants: 5,174 MW

[31] Grid Operator, DEDDHE, 'ΔΕΔΔΗΕ Α.Ε. - Αιτήσεις Σύνδεσης Σταθμών ΑΠΕ & ΣΗΘΥΑ Αρμοδιότητας ΔΕΔΔΗΕ (Οκτώβριος 2015)', August 2015, http://www.deddie.gr/el/sundeseis-stathmwn-ananewsimwn-pigwn-energeias-ape/arxeia-aitisewn-armodiotitas-deddie/aitiseis-stathmon-ape-oktovrios-2015.

Table 9: Mature biogas plants[32]

Name	Municipality	Power (kW)	Type of Station	Application Date	Connection Contract Date
BIOENERGY MANTINEIAS SA	TRIPOLI	480	SALE *	27/7/2010	29/3/2011
AXIOS RIVER ENERGY COMPANY S.A.	CHALKIDONA	1.000	SALE	3/11/2010	10/10/2012
THRACE BIOGAS S.A. (I I I)	ORESTIADA	2.956	SALE	25/10/2011	22/10/2013
THRACE BIOGAS S.A.(I I)	ORESTIADA	2.956	SALE	22/11/2011	22/10/2013
THRACE BIOGAS S.A. (I)	ORESTIADA	2.956	SALE	7/2/2012	22/10/2013
LEYKOPOULOS EYAGGELOS - THEOFRASTOU NIKOLAOS S.A.	EORDAIA	500	SALE	7/9/2010	2/8/2013
ASIVISTA S.A.	AGRINIO	300	SALE	15/9/2011	9/9/2013
NIGRITA BIOENERGY	VISALTIA	998	SALE	7/6/2011	20/9/2013
GRIGORIADIS AND SOFOLOGIS	KOZANI	120	SALE	14/9/2011	24/1/2013
BIOGEN ENERGY E.Π.E.	SERRES	6.500	SALE	21/12/2010	21/3/2014
ABATO XANTHI BIOGAS	TOPIROU	500	SALE	31/5/2013	18/7/2014
EUROENERGY BIOGAS XANTHI A.E.	ABDIRA	999	SALE	5/4/2012	28/7/2014
ENGAIAI S.A.	CHALKIDONA	50	SALE	4/1/2013	13/8/2014
Gaiodynamics	OROPOS	1.000	SALE	9/3/2012	10/11/2014
Gaiodynamics	LAUREOTIKI	1.000	SALE	16/3/2012	10/11/2014
KATRIS SA	CHALKIDA	999	SALE	19/4/2013	31/12/2014
CHIROTROFIKI S.A.	SERVIA-VELVENTOS	99	SALE	31/5/2013	2/2/2015
LAGADA BIOGAS S.A.	LAGADAS	998	SALE	21/3/2012	17/3/2015
HELIOTOP S.A.	DOXATO	500	SALE	31/12/2012	18/5/2015
SOHOS BIOENERGY	LAGADAS	844	SALE	7/6/2011	10/8/2015
EPILEKTOS FARSALA BIOGAS	FARSALA	5.252	SALE	12/11/2010	21/1/2015
HITAS FARM S.A.	ZIROS	800	SALE	4/1/2012	21/7/2015

According to data available from Grid Operator, ΔΕΔΔΗΕ, the already activated biogas plants are 19. From these plants 10 are using maize and manure. The other 9 plants are using the captureted gas from municipal waste in the landfills.

Table 10:Power production of Biogas plants in Greece[33]

Month	Biogas-Biomas		CHP plants nat gas		Total	
	MW	GWh	MW	GWh	MW	GWh
Jan	47	19	229	119	5,072	843
Feb	47	17	230	108	5,080	838
Mar	47	19	230	120	5,080	879
Apr	48	18	230	113	5,136	949
May	49	18	230	108	5,159	886
Jun	49	18	230	102	5,173	893
Jul	49	18	230	102	5,190	1036

[32] Ibid[29].
[33] 'Σχέδιο Μηνιαίας Έκθεσης Σχετικά Με Την Εξέλιξη Του Ελλείμματος Του Ειδικού Λογαριασμού ΑΠΕ - 01_2016_Miniaio_Deltio_APE_SITHYA.pdf', accessed 19 April 2016, http://www.lagie.gr/fileadmin/groups/EDSHE/MiniaiaDeltiaEL/01_2016_Miniaio_Deltio_APE_SITHYA.pdf.

Month	Biogas-Biomas		CHP plants nat gas		Total	
	MW	GWh	MW	GWh	MW	GWh
Aug	49	18	230	102	5,190	1032
Sep	50	18	230	98	5,191	816
Oct	51	19	230	112	5,193	904
Nov	51	19	230	108	5,198	859
Dec	52	20	230	117	5,201	825
TOTAL	**52**	**222**	**230**	**1.309**	**5.201**	**10.760**

Table 11: Biogas & CHP Value (M€) and Weighted Average Energy Prices (€/MWh) in 2015

Month	Biogas-Biomas		CHP plants nat gas		Total	
	m€	€/MWh	m€	€/MWh	m€	€/MWh
Jan	2.0	103.5	6.4	161	118.1	140.1
Feb	1.8	103.9	6.2	156	112.0	133.8
Mar	1.9	103.5	7.2	157	130.4	148.4
Apr	1.9	104.1	6.1	156	158.0	166.6
May	1.9	104.2	4.9	152	160.9	181.7
Jun	1.9	104.6	4.4	153	158.6	177.5
Jul	1.9	104.6	3.6	151	185.0	178.5
Aug	1.9	103.8	4.0	155	179.9	174.4
Sep	1.8	104.2	3.7	159	150.0	183.8
Oct	2.0	105.3	4.8	151	140.6	155.6
Nov	2.1	107.6	5.0	148	132.7	154.5
Dec	2.2	109.4	5.3	141	124.0	150.2
TOTAL	**23.3**	**104.0**	**61.5**	**153.1**	**1,750.3**	**162.7**

According to EurObserv'ER Report 2014 the primary energy consumption in Greece during 2012 was 88.6 ktoe (1,030.42 GWh). This mount came from 69.4 ktoe produced from landfill gas, 15.8 ktoe produced from sewage sludge gas and 3.4 ktoe produced from other biogas plants[34]. Compared to 2014 the primary energy production has been decreased to 86.9 ktoe (67.1 ktoe landfill gas, 15.6 sewage sludge gas and 4.2 other biogas)[35]

Additionally the gross energy production during 2012 was 204.3 GWh (40 GWh produced from electricity plants and 164.3 GWh from CHP plants)[36]. Compared to 2014 the electricity production has been increased to 219.7 Gwh (36.2 GWh produced from electricity plants and 182.5 GWh from CHP plants)[37]

Currently; the total installed thermal capacity of biogas plants is 29.95 MW with :

- 2 plants (in Thessaloniki and in Athens) food industries producer only for thermal energy (1.18 MWth)
- 3 MWTP plants (in Chalkida, in Alexandroupoli and in Rodos) producing only thermal energy (3.12 MWth)

[34] 'Biogas Barometer 2014 | EurObserv'ER', accessed 31 March 2016, http://www.eurobserv-er.org/biogas-barometer-2014/.
[35] Ibid[6].
[36] Ibid[29].
[37] Ibid[6].

Moreover; these five plants in Greece the thermal energy has been used for the anaerobic process in digester (e.g. utilization of the recoverable heat in the leachates evaporators).

None of the existing biogas plants inject biomethane into the natural gas grid because the Public Gas Corporation (DEPA) has not developed medium and low pressure network infrastructure that serves the total area of Greece. So biogas plants cannot be connected to natural gas grid. Also, it is difficult to plan and take into account the profit of injecting the biomethane into the natural gas grid while preparing the feasibility study of a biogas plant.

Summarizing, CRES estimated that anaerobic digestion of animal waste, slaughterhouse waste and dairy could supply cogeneration units of total installed power of 350 MW, with average annual electricity production of 1.121.389 MWhel. This is an indirect reduction of about 729 kt CO_2/year[38].

4.1 Biogas Policies in Greece

Table 12: Feed-in tariff Scheme

LAW 3468/2006		**LAW 3851/2010**		**LAW 4254/2014 (New Deal)**	
Landfill, Sewage Biogas/AD Biogas		**AD Biogas ≤3MW**	**AD Biogas >3MW**	**AD Biogas ≤3MW**	**AD Biogas >3MW**
Interconnected System 73€/MWh	Non-Interconnected Islands 84,6€/MWh	Subsidy or Not 220 – 253€/MWh	Subsidy or Not 200 - 230€/MWh	Subsidy or Not 209 – 230€/MWh	Subsidy or Not 190 - 209€/MWh
		Landfill, Sewage ≤2MW	**Landfill, Sewage >2MW**	**Landfill, Sewage ≤2MW**	**Landfill, Sewage >2MW**
		Subsidy or Not	+Subsidy 94,45 – 114,36€/MWh	Subsidy or Not 114 - 131€/MWh	Subsidy or Not 94 - 108€/MWh

Draft Law under deliberation (2016 Law)

<u>*Two categories*</u>

- *"Small RES"* < 500 kW (all RES technologies except PVs and CHP from natural gas) and < 3 MW for wind parks - They can choose to be in Scheme Feed in Tariff or Sliding Premium
- *"Large RES"* > 500 kW Sliding Premium Scheme

<u>Feed in Tariff Scheme:</u> Every year the Ministry of Environment and Energy sets the entrance tariff by the time the contract with Market Operator (LAGHE) is signed. The tariff stays constant for the rest 20 years (contract duration).

<u>Sliding Premium Scheme:</u> Once the energy market is established, the Ministry of Environment and Energy will set the reference tariff every year (it is the tariff for project with IRR = 9-10%). RES will sell electricity to the system, having the benefit of priority, at a price that will be set daily. Also, every year the Ministry will set an invitation to tender for a desired installed capacity per RES technology.

[38] 'Final Report of the BiG>East Project', accessed 22 April 2016, https://ec.europa.eu/energy/intelligent/projects/sites/iee-projects/files/projects/documents/bigeast_publishable_summary_report.pdf.

Current Investment Incentives

L. 3908/2008 Developmental Law

- The duration was from 2011 till 2014.
- The financial support for RES was
  - For some technologies only tax incentives
  - Biomass and Biogas financial support and the choice YES/NO to tax incentives
- The subsidy rates ranged from min 10%-max 60% and depended on the size of investor and on the Region of the investment.
- For Central & East Macedonia & Thrace the subsidy rates ranged from min 30%-max 60%.

In 2016 waiting for New Developmental Law

Environmental Legislation - Specific Land Use Frame for RES (Ministerial Decree 49828/2008)

Where :

- In Article 6 - Exclusion areas and incompatibility zones, it stated the areas prohibited for sitting RES plants
- And in 18 - Criteria for sitting biomass or biogas energy plants

4.2 Central and eastern Macedonia & Thrace

Table 13: The livestock in Central and Eastern Macedonia & Thrace in 2013[39]

	Cattle				Ovine animals		Porcines		Poultry	
	Total		From them females							
	farms	Nr of cattles	farms	Nr of cattles	farms	Nr of animals	farms	Nr of animals	farms	Nr of animals
Eastern Macedonia & Thrace Region	**3,244**	**100,580**	**3,110**	**74,262**	**4,241**	**585,760**	**1,019**	**56,868**	**17,342**	**820,448**
DRAMA regional unity	422	23,110	404	16,788	550	91,727	109	28,247	843	16,417
KAVALA regional unity	256	7,868	243	5,463	829	113,480	208	7,214	2,030	89,934
EVROS regional unity	513	19,138	486	13,808	903	115,605	499	6,024	5,587	484,385
XANTHI regional unity	629	23,602	594	17,152	834	123,491	81	11,332	1,875	87,842
RODOPI regional unity	1,424	26,863	1,382	21,051	1,125	141,458	123	4,051	7,007	141,870
Central Macedonia Region	**2,809**	**164,503**	**2,371**	**113,533**	**5,245**	**815,981**	**1,351**	**125,109**	**13,634**	**5,966,671**
IMATHIA regional unity	226	14,993	128	4,284	401	54,851	97	18,085	1,843	1,511,421

[39] Hellenic Statistical Authority, 'Στατιστικές', 2013, http://www.statistics.gr/el/statistics/-/publication/SPK12/.

THESSALONIKI regional unity	642	62,228	595	49,365	909	161,756	195	17,220	960	1,300,832
KILKIS regional unity	425	21,358	328	15,286	756	146,404	142	2,138	1,725	708,260
PELLA regional unity	455	14,921	437	10,632	1,041	135,575	399	10,107	3,567	321,900
PIERIA regional unity	101	3,337	70	2,161	555	80,329	241	36,791	2,878	1,345,740
SERRES regional unity	848	42,869	713	29,222	1,258	179,780	239	12,340	2,170	613,050
CHALKIDIKI regional unity	111	4,797	101	2,584	325	57,285	38	28,427	493	165,468
Total Central & Eastern Macedonia & Thrace	**6,053**	**265,083**	**5,481**	**187,795**	**9,486**	**1,401,741**	**2,370**	**181,977**	**30,976**	**6,787,119**
Whole country	**15,899**	**614,992**	**14,394**	**442,547**	**94,448**	**8,686,117**	**18,941**	**767,958**	**189,252**	**27,882,413**
% of the whole country	**38.1**	**43.1**	**38.1**	**42.4**	**10.0**	**16.1**	**12.5**	**23.7**	**16.4**	**24.3**

As indicated ISABEL region constitutes more than 40% of whole country cattle and also important is the share of other animals such as porcine and poultry.

As described above, the feedstock composition is:

- energy crops such as maize, animal waste, slurry (liquid manure), slaughterhouse waste, waste from food industry
- wastewater and municipal solid waste

Licensing Procedure:

- While applying to RAE for getting the Generation License for > 1MWe installed power, the biogas plant owner company must document the origin of the biomass used for biogas production. This involves contracts with potential biomass providers.
- The Center for Renewable Energy Sources and Saving (CRES) has to make a Biomass Source Control audit before the activation of a biogas plant with > 1MWe installed power. This is a prerequisite for getting the installation license.
- Finally, the biogas plant owner company is obliged to keep an official record with the data of recipients, quantities and quality of the digestate.

4.3 Interviews summary

Biogas sector in Greece develops in an unstable environment because of the economic and political problems. Additionally to the society problems, the investors are reluctant because of the uncertain policies, regulations and finances. The danger is high that the projects will be concluded.

According to the interview analyses the feed-in tariff scheme (low 4254/2014) still adequate in spite of tariff reduction in approx. 10 %. Unquestionably the frequent legislation changes are the main problem in Greece and that jeopardized the biogas plans viability, as a result of this process the projects delayed because of the missing permissions. In addition the authorities don't have the sufficient know-how to understand the technical development and particularities of this sector.

Admittedly the economic crisis is the most important barrier for the biogas development as well as the missing funding support. The biogas projects are long period investments wherefore they need stable frameworks. Both stable frameworks as funding support are missed, for this reason the credit rates are high compared to other countries.

In fact the investors don't trust the government incentives because they are delay or no conform to the actual legislation. For this reason the investors prefer projects that aren't depending from government incentives.

Important to mention is the biomass supply, although the running biogas plants don't have problems with feedstock availability and volume, Greece biomass supply is characterized by the organization, infrastructure as well as know-how deficiencies. Therefore future biogas plants could have problems operating because of the complexity to increase the biomass supply.

The technical aspect could be considered as a barrier for biogas projects, because of the limited experience in planning and operation. Unquestionably Greece biogas manufactures industry cooperation with foreign firms can help by the know-how and knowledge transfer.

Public acceptance has been changing during the last years, because of the obvious positive environmental and economic impacts. Still, Greece needs further communication steps to guarantee the further development of this sector in the country.

Certainly; communities' involvement in biogas initiatives seems to be difficult because the grassroots cooperation tradition is not mature. Furthermore, cooperation tradition between private investors and local communities is not long enough and for the majority of entrepreneurs, is evaluated as unproductive.

The new Solid Management Legislation, becomes effective since 15.12.2015, is the first legislation trying to force the management of organic municipal waste. It is really innovative and that is the reason because it will be level as unrealistic.

In general the future of the biogas sector is positive, no matter which difficulties occur. As far the economic stability return, this sector is going to face a significant development, basically due to the current feed in tariff incentive and the vast amount of unexploited feedstock.

5. United Kingdom – England

Although the UK had the highest biogas production from landfill gas (1501.8 ktoe) in 2014[40], only "***waste-fed***" and "***farm-fed***" biogas plants are considered in this document, while biogas from landfill and from digestion of sewage sludge are excluded. This is because is considered that community energy initiatives will be mainly driven by biogas originating from the digestion of wastes and energy crops, while landfill and centralized wastewater plants are considered less ideal for England.

"***Waste-fed***" refers to installations where the contribution of municipal (e.g. food waste; green waste), commercial (e.g. food waste) and industrial wastes (e.g. brewery waste; animal processing wastes) towards the total feedstock requirement is greater than 50%. "***Farm-fed***" refers to installations where the contribution of agricultural feedstocks (e.g. manure; slurry; energy crops; crop wastes) towards the total feedstock requirement is greater than 50%[41].

The AD industry in the United Kingdom has experienced extensive deployment over the period 2014-2015 with 50 new plants coming online, increasing the total number of operational plants to 185. Meanwhile, total installed capacity of the sector has increased from 127MWe to 168MWe, the industry now capable of providing sufficient electricity for around 350,000 UK households. When further including the contribution of plants which inject biomethane to the gas grid, the total equivalent electrical installed capacity of the UK AD sector can be assumed to have increased to 235MWe (by the first of March 2015).

The development over the last 10 years (2005-2015) is significant, with total installed capacity increasing from 2 MWe installed capacity to 260 MWe predicted at the end of 2015[42] (See figure 5).

Of the new projects to have completed during 2014, 13 are waste-fed plants and 37 are farm-fed facilities, highlighting a gradual shift of the industry away from the processing of food and industrial wastes and towards increased utilisation of agricultural feedstock. This trend is mirrored in the development pipeline for AD where there are 500 projects under development, 204 of which have been initiated over the last year. Of these new projects, 156 are expected to use agricultural feedstocks while just 46 are expected to use predominantly food, municipal, commercial and/or industrial wastes.

Despite the growing dominance of farm-fed AD facilities in the United Kingdom, feedstock demands of the AD industry have developed relatively evenly during 2014. The use of manures and slurries in AD has risen by around 50%, although demand remains low in comparison to other feedstocks at around 636,000 ton per annum (tpa). Meanwhile, demand for crops has seen a 60% growth over 2014, rising from 750,00 tpa to 1.2 million tpa. Food and industrial wastes have experienced similar growth with demand for each having increased by around half a million tons; demand for food waste has increased from 1.4 million tpa to almost 2 million tpa while demand for "other" wastes has increased from just over 700,000 tpa to 1.2 million tpa.

[40] Ibid[6].

[41] The National Non-Food Crops Centre, 'NNFCC Report - Anaerobic Digestion Deployment in the UK — NNFCC', April 2015, http://www.nnfcc.co.uk/tools/nnfcc-report-anaerobic-digestion-deployment-in-the-uk.

[42] Department of Energy & Climate Change. 2015. Digest of UK Energy Statistics (DUKES).

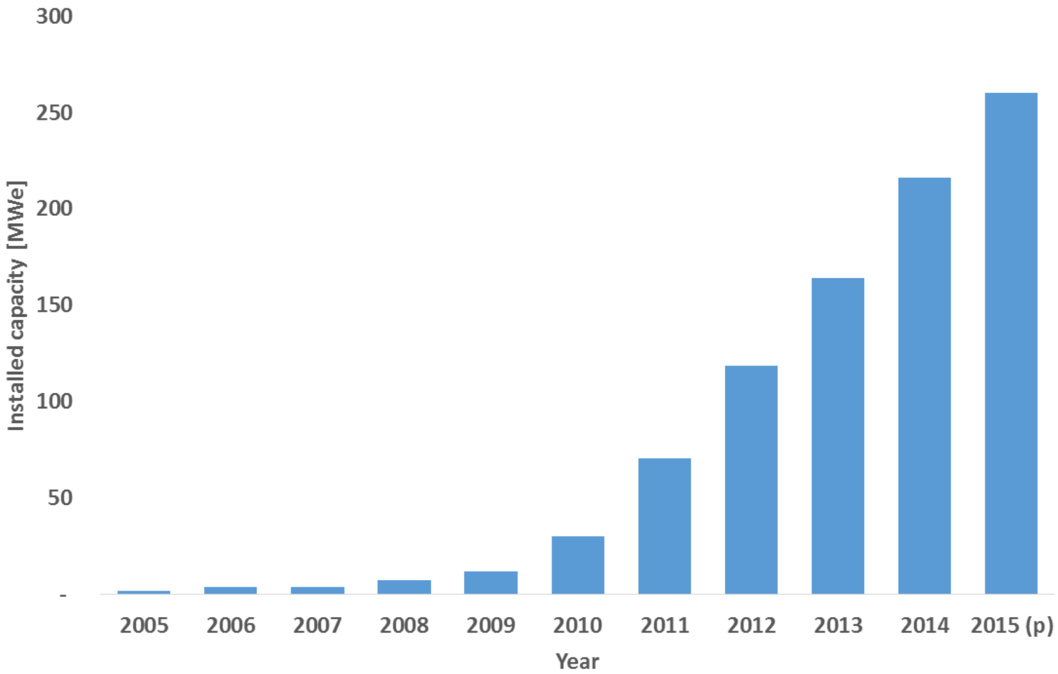

Figure 5: Total installed electrical capacity from anaerobic digestion in UK (excluding sewage and landfill gas) [43]

Feedstock requirements of plants in the development pipeline have progressed more unevenly. Anticipated demand for food waste by plants under development is currently just over 4.2 million tpa, only a very small increase on last year's projected demand. Conversely, anticipated energy crop requirements for plants in the development pipeline has increased by over one million tons, rising from 2.0 million tpa to 3.1 million tpa over the last year. Meanwhile, projected demands of manures and other wastes for plants in development have each increased by around 700,000 tpa. With future demand for all major feedstock groups increasing significantly except for food waste, these figures give a possible early indication that supply of food waste suitable for AD in the UK will be near capacity soon if accessibility improvements are not achieved.

The estimated amount of land required to serve the AD industry in the United Kingdom has increased from just under 17,000Ha to almost 28,000Ha over the last year, such that the industry is now anticipated to require around 0.5% of UK arable cropland. If all plants under development were to complete, land demand for the industry would increase to 96,000Ha. This is estimated assuming a crop yield of 45 fresh tonnes per hectare. Energy crop yields can vary largely across the UK, depending on the growing region and type of crop. However, this yield estimate is broadly representative of national averages for both maize and grass, the two dominant crops used for AD in the UK.

Of the AD plants operational in the United Kingdom, 31 are small scale plants (less than 250kWe), with a cumulative installed capacity of 3.6MWe, 53 are medium scale plants (250kWe to 500kWe) with cumulative installed capacity of 25.0MWe, and 76 are large scale plants (larger than 500 kWe) with cumulative installed capacity of 139.3MWe. There are a further 21 biomethane to grid plants in operation with a cumulative equivalent installed capacity of 67.8MWe. The remaining four plants produce heat or cooking gas only.

There are 185 operational AD plants in the United Kingdom with a total installed capacity of 235.4 MWe (including biomethane equivalent electrical), accordingly 102 of which are farm-fed with a 101.4 Mwe cumulative installed capacity and 83 of which are waste-fed with a 134.0 MWe cumulative installed capacity.

Of the 185 operational plants, 160 have a CHP installed, 21 are upgrading the biogas and inject it as biomethane in the gas grid, and the remaining 4 (relatively small plants) transform the totality of biogas to heat for local productive processes. Most of the waste heat from CHP is used to heat the digester and to dry

[43] Ibid[42].

the biosolids. We couldn't find consolidated information regarding the use of waste heat to other industrial processes or district heating, therefore no data is provided regarding the required heat production figures.

The 21 plants producing and injecting biomethane have an estimated production of 24.100 Nm^3 biomethane/hour. A further five BtG plants are in construction while another 25 projects are under development.

The total electricity generation in UK for 2015 was 337.7 TWh, with renewable generation being 83.3 TWh (24.7%). Anaerobic digestion accounted for 1.34 TWh (1.6% on the renewables and 0.4% on total electricity). For comparison, landfill gas produced 4.77 TWh (5.7% on the renewables and 1.4% on total electricity) and sewage sludge gas 0.87 TWh (1.0% on the renewables and 0.26% on total electricity)[44].

Although there are not direct statistical data available about the anaerobic industry from the national authorities; some indirect values can be obtained considering the employment coefficients provided in a report commissioned by The Department of Energy & Climate Change (DECC)[45]. These estimated values were developed from a survey with plant developers (see table 14). Using those values, and considering a total installed capacity of 235 MWe, it can be estimated that the biogas industry requires 996 full time employees, as for 2015. These values are quite different from 2850 direct and indirect jobs according to EurObserv'Er[46] during 2014.

Table 14:Average full time equivalent (FTE) employment required throughout the life cycle of the plant[47]

Development activity	Employment coefficient [FTE/MWe]
Plant design/development	0.21
Construction and commissioning	1.18
Operation and maintenance	2.35
Feedstock supply	0.50

A previous report commissioned by ***The Waste and Resources Action Programme (WRAP)***[48] estimated a figure of 482 employees in 2013, for the anaerobic digestion industry.

However, sector organisation ***Anaerobic Digestion and Bioresources Association (ADBA)*** predicts that the anaerobic digestion industry "has the potential to be worth £2-3 billion to the UK economy each year based on current gas prices, delivering more than 10% of the UK's domestic gas requirements and creating 35,000 UK jobs, largely in manufacturing and engineering"[49].

[44] Ibid[42].
[45] 'UK Jobs in the Bioenergy Sectors by 2020 - 5131-Uk-Jobs-in-the-Bioenergy-Sectors-by-2020.pdf', accessed 20 April 2016, https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/48341/5131-uk-jobs-in-the-bioenergy-sectors-by-2020.pdf.
[46] Ibid[6].
[47] 'UK Jobs in the Bioenergy Sectors by 2020 - 5131-Uk-Jobs-in-the-Bioenergy-Sectors-by-2020.pdf'.
[48] The Waste and Resources Action Programme, 'A Survey of the UK Anaerobic Digestion Industry in 2013 (ASORI) | WRAP UK', accessed 20 April 2016, http://www.wrap.org.uk/content/survey-uk-anaerobic-digestion-industry-2013.
[49] ADBA, 'Government | ADBA | Anaerobic Digestion & Bioresources Association', accessed 20 April 2016, http://adbioresources.org/about-ad/how-ad-benefits-everyone/local-authority-and-government/government.

5.1 Biogas Policies in United Kingdom

There are several different support mechanisms in place to incentivise uptake of renewable energy technologies. A summary of the schemes and policies of relevance to anaerobic digestion (AD) in the UK is provided in the following sections.

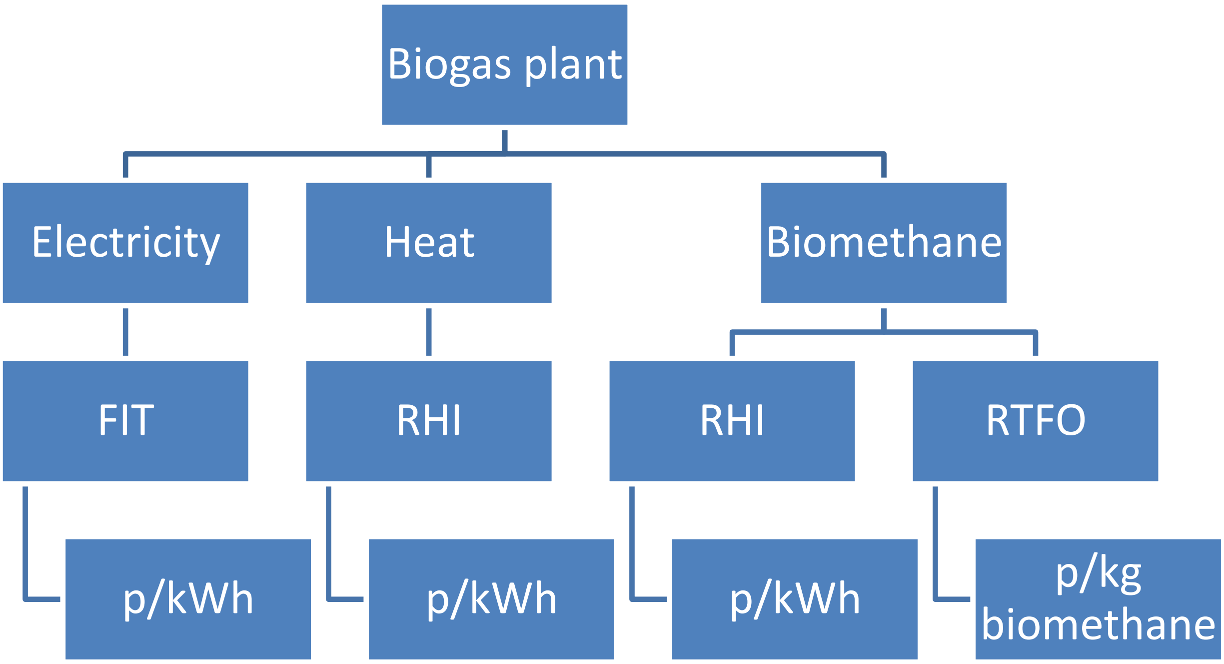

Figure 6: Sector division of policy and incentives in the UK

5.1.1 Feed-in Tariff (FIT)

The ***Feed-in tariff (FIT)*** scheme was introduced on 1st April 2010 with the aim of offering a guaranteed payment to encourage small-scale (<5MWe), low carbon electricity generation by businesses, communities and local developments. The Feed-in tariff currently provides support to the AD industry in England, Scotland and Wales. However, it is not available in Northern Ireland.

The UK Government's ***Department of Energy and Climate Change (DECC)*** makes the policy decisions about the FITs scheme. The energy regulator Ofgem administers the scheme. Certain energy suppliers (also known as FITs licensees) handle FITs scheme applications and make the FITs payments.

Eligible renewable generators can receive FITs payment in two ways[50]:

- **Generation tariff**. The energy supplier pays a set tariff for each unit (kWh) for each unit (kWh) of electricity generated, regardless of being used on-site or exported. Once the system has been registered, the tariff levels are guaranteed for the period of the tariff (up to 20 years) and are inflation index-linked
- **Export tariff**. In addition to the generation tariff, the energy supplier pays for exporting the surplus electricity not used on site back to the grid. Smart meters or fixed values are used to estimate the exported amount.

In April 2014, a flexible degression mechanism was introduced to control costs under the FIT scheme. Tariff reductions are applied annually on 1st April of each year when technologies exceed their expected deployment levels, although in exceptional circumstances where there has been significantly high deployment an interim six-month degression also applied. The tariffs have been subject to frequent degression since April 2014 and the resulting tariffs are shown in the table below.

[50] https://www.gov.uk/feed-in-tariffs/overview

Table 15: Historical and current FiT rates (p/kWh) for AD[51]

Tariff Date	Small scale (250kWe or less)	Medium scale (251kWe – 500kWe)	Large scale (501kWe – 5MWe)	Export Tariff
01 April 2014	12.46	11.52	9.49	4.77
01 October 2014	11.21	10.37	9.02	4.77
01 April 2015	10.13	9.36	8.68	4.85
01 October 2015	9.12	8.42	8.68	4.85
01 April 2016	**8.21**	**7.58**	**7.81**	**4.91**

The old FIT scheme closed on 14 January 2016. A new scheme opened on 8 February 2016, with different tariff rates and rules - including a limit on the number of installations supported:

- Introduction of quarterly Deployment Caps as a means of controlling costs, in place of the original degression mechanism;
- Removal of the ability to apply to extend plant capacity beyond that of the original accreditation;
- Introduction of new tariffs (for all technologies except AD).

A further consultation on AD tariffs and the potential introduction of Sustainability Criteria is expected this year.

The ***Deployment Cap*** mechanism has had a serious impact on the AD sector. This mechanism allows for an overall 5MWe of installed capacity for AD (across all scales) to apply each quarter, from April 2016. On 7th April 2016 ***Ofgem*** (***Office of Gas and Electricity Markets***) released their ***Feed-in Tariff (FIT) Deployment Caps Quarterly Report***, indicating that a total of 20.825 MWe had applied for pre- and full accreditation between 8th February and 1st April 2016, from 28 installations. Therefore, the fourth quarterly cap (for the tariff period 1stJanuary 2017 to March 2017) has been already reached, leading to a cumulative 40% degression across all tariffs for the AD sector by 1st January 2017.

For biogas plants having larger scales (> 5 MW), different financial mechanisms are in place by which the UK Government incentivises deployment of larger-scale renewable electricity generation, namely the Renewables Obligation (RO) and the Contacts for difference (CfD).

As it expected that community biogas very unlikely will have installed capacity above 5 MWe, these mechanisms are not reviewed in this report.

5.1.2 Renewable Heat Incentive (RHI)

The ***Renewable Heat Incentive (RHI)*** it's an innovative mechanism to support and encourage renewable heat production and use[52].

Often the heat produced by the anaerobic digestion site (e.g. through CHP) is used to maintain the temperature in the digesters. This heat does not attract any payments through the RHI. However, the heat

[51] https://www.ofgem.gov.uk/environmental-programmes/feed-tariff-fit-scheme/tariff-tables
[52] http://www.energysavingtrust.org.uk/domestic/renewable-heat-incentive

can be used for buildings and low temperature hot water or other processes, and these cases are considered eligible for RHI.

RHI payments are made to the owner of the heat installation over a 20 year period and tariff levels have been calculated to bridge the financial gap between the cost of conventional and renewable heat systems. This scheme applies in England, Scotland and Wales, with a similar scheme more recently introduced in Northern Ireland.

A flexible degression mechanism was introduced to the non-domestic RHI in April 2013 to control the budget. Tariffs are reduced for new recipients when deployment levels are shown to be higher than required to achieve the RHI renewables target of 12% in 2020. Unlike the FiT scheme where degression is based on pre-accredited and accredited electrical output capacity, the RHI degression mechanism is based on forecast monetary expenditure.

Monthly data published by ***DECC*** (***Department of Energy & Climate Change***) shows and estimate of the total amount of committed expenditure for each tariff and in total for the next 12 months. This includes applications accredited and received, as well as preliminary accreditations.

Although degression is triggered by forecast expenditure over the next 12 months exceeding the expected level, the level of degression is determined by the rate of growth in each technology since the previous degression. This methodology is more complex than FITs and it is therefore more difficult to forecast levels of degression beyond a quarter of a year.

Cumulative degression over a 12 month period can be significant if interim degressions do not reduce the rate of expenditure and appear to bring spend back in line with budget allocations.

The biomethane injection tariff underwent an early review in 2014, the outcome of which was the introduction of a new tiered tariff structure on 12th February 2015.

The historical and current RHI tariffs for AD are shown in the following table.

Table 16: Historical and current RHI rates for AD[53]

Scale	Tariff (p/kWh)					
	01 Apr 2014	01 Apr 2015	01 Jul 2015	01 Oct 2015	01 Jan 2016	01 Apr 2016
Biogas Combustion						
Below 200 kWth	7.5	7.62	7.62	7.62	7.62	6.94
200 – 599 kWth	5.9	5.99	5.99	5.99	5.99	5.45
600kWth and above	2.2	2.24	2.24	2.24	2.24	2.04
Biomethane Injection						
Tier 1 (up to 40,000 MWh/year)		7.62	7.24	7.24	6.52	5.35
Tier 2 (40,000 – 80,000 MWh/year)	7.5	4.47	4.25	4.25	3.83	3.14
Tier 3 (80,000 MWh/year)		3.45	3.28	3.28	2.95	2.42

5.1.3 Renewable Transport Fuel Obligation (RTFO)

The ***Renewable Transport Fuel Obligation (RTFO)*** requires suppliers of fossil fuels to ensure that a specified percentage of the road fuels they supply in the UK is made up of renewable fuels. Biomethane is eligible for Renewable Transport Fuel Certificates provided that it is dutiable and produced wholly from sustainable

53 https://www.ofgem.gov.uk/environmental-programmes/non-domestic-renewable-heat-incentive-rhi/tariffs-apply-non-domestic-rhi-great-britain

biomass. For biogas, 1.9 RTFCs may be claimed per kilogram of biomethane supplied. For biogas produced from feedstocks that are wastes, residues, ligno-cellulosic or non-food cellulosic materials, the number of certificates will be doubled to 3.8 and 3.5 RTFCs per kilogram of biomethane[54].

5.1.4 Sustainability Criteria

Under the RO and RHI, sustainability criteria have been put in place for energy derived from solid and gaseous biomass. From 1st December 2015 all scheme participants using non-waste biomass are required to meet the lifecycle GHG emissions and land criteria[55]. The standards apply to existing as well as new biomass installations. Similar criteria is being considered for the FIT scheme, which is likely to be consulted on this year.

Generators have to demonstrate a minimum greenhouse gas (GHG) saving of 60% against an EU fossil comparator, which equates to maximum supply chain emissions of 79.2gCO2eq/MJ for electricity (RO) and 34.8gCO2eq/MJ for heat (RHI). Generators accrediting under the RO after March 31st 2013 need to meet a lower electricity threshold of 66.7gCO2eq/MJ, with no single consignment exceeding the 79.2gCO2eq/MJ target. Furthermore, all biomass used must comply with a range of specified ‘land criteria’ relating to the origin of the feedstock and the land on which it was produced. These criteria consist of general restrictions on the use of biomass sourced from land with high biodiversity or high carbon stock value such as primary forest, peatland or wetland.

Generators are required to report to Ofgem on a per consignment basis; individual installations will be required to declare that their fuel complies with the sustainability criteria (monthly for RO and quarterly for RHI) and produce and submit an annual report to Ofgem.

5.2 Biogas landscape in Yorkshire and the Humber

Yorkshire and the Humber is one of nine official regions of England. It comprises most of Yorkshire (South Yorkshire, West Yorkshire, the East Riding of Yorkshire including Hull, the shire county of North Yorkshire and the City of York), North Lincolnshire and North East Lincolnshire.

Regulation and incentives are the same as at the UK level.

There are currently 13 operational AD plants in Yorkshire & Humber, seven of which are farm-fed (cumulative installed capacity of 7.1MWe) and six of which are waste-fed (cumulative installed capacity of 7.1MWe).
Of the AD plants operational in the region, one is a small scale plant (installed capacity of 200kWe), six are medium scale plants (cumulative installed capacity of 2.8MWe) and four are large scale plants (cumulative installed capacity of 6.9MWe).
There are a further two BtG plants in operation with a cumulative equivalent installed capacity of 4.2MWe.
AD plants currently operational in the region cumulatively require 39,500tpa of manure or slurry, 114,500tpa of crops, 127,000tpa of food waste, 500tpa of cropwaste and 20,000tpa of other waste feedstocks.
The estimated cropping area required by operational AD plants in the region is 2,500 hectares.

[54] ‘RTFO_guidance_part_two_-_carbon_and_sustainability_guidance_year_8.pdf’, accessed 22 April 2016, https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/481353/RTFO_guidance_part_two_-_carbon_and_sustainability_guidance_year_8.pdf.

[55] OFGEM – 2016 - Renewables Obligation: Sustainability Criteria – (accessed 20/04/2016) https://www.ofgem.gov.uk/system/files/docs/2016/03/ofgem_ro_sustainability_criteria_guidance_march_16.pdf

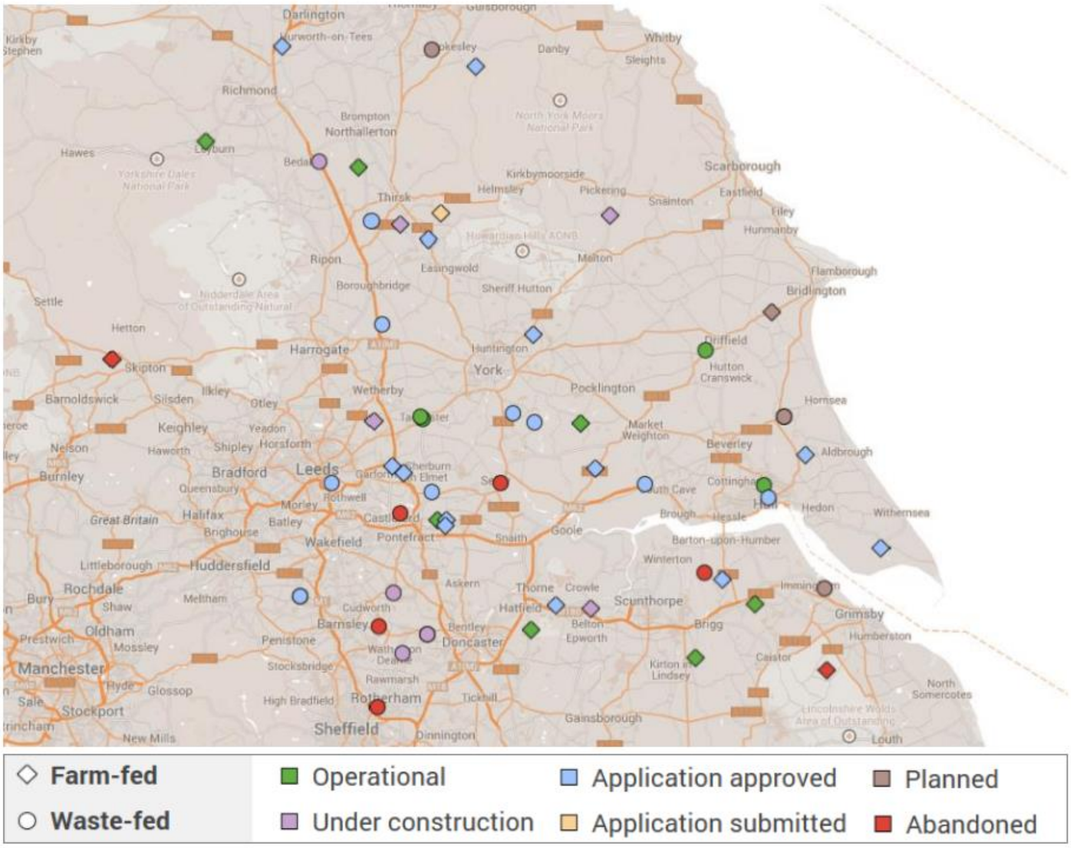

Figure 7: Map of AD projects in Yorkshire & Humber[56]

5.3 Interview summary

Nine interviews were conducted, with stakeholders belonging to different groups (project developers, technology providers, digester operators, farmers, academics, community group members) and different geographical regions. This summary attempts to give an overview of the main subjects emerged during the interviews.

5.3.1 Policy and Incentives

Recent changes in incentives and deployment caps have made the business cases for AD much more difficult, with smaller returns on investment, especially when the main income was from electricity generation and export to the grid. Biomethane injection has still higher incentives through the RHI (Renewable Heat Incentive), and in this case the return on investment is better. Different level of incentives between FiT (Feed in Tariff) and RHI are creating some tension in the sector.

At the same time, the other source of income through gate fees (for treating waste), has become smaller too. The competition for energy rich wastes has increased, and it is predicted that gate fees will become zero in the short term and that eventually biogas operator will need to pay a price to secure the provision of certain wastes.

Support from local councils have become scarcer, following recent cuts in their budget – both in terms of funding available (also very competitive) and officers employed to support the environmental and sustainability sector. An important source of funding which is still available from local council is the recycling credit, which awards £53 for each ton of waste to any group diverting the material through recycling.

[56] The National Non-Food Crops Centre, 'NNFCC Report - Anaerobic Digestion Deployment in the UK — NNFCC'.

It has emerged from the interviews how there is a need for incentives that look beyond the energy generation, to encompass the advantages that AD also contributes in terms of nutrient recycling, soil improvement, minor carbon footprint, odor management.

There is a perception that, given the changes in the income structure (with less importance of gate fees and electricity sales), a lot of plants will have financial problems in the short term.

5.3.2 Regulation

There is a perception that regulations have been developed through a “one size fits all” approach that does not take into account the local/geographical specificities. This is especially negative for small players, which need to follow the regulations which have been developed for big scale AD.

Digestate regulations have hindered the adoption of AD. In some cases regulations restricting spreading digestate on certain categories of land have forced plants in the past to shut. This has been particularly the case in Scotland in the past. It lead to the development of scientifically based standards for digestate production, such as PAS110. If those standards are reached, then the digestate can be sold to other farmers. However if standards haven’t been met, then there is an additional cost for AD plants to dispose the digestate.

At micro scale AD, there are grey areas which need to be regulated: certifications and insurance are overheads because there is no experience in these areas for micro scale AD.

5.3.3 Technology

At big scale, no technological breakthroughs are expected to be commercially available in the next few years. Basically the technology remained the same for the last 10 years (or more).

The technology at small scale still needs to be improved – still at prototype stage, and perceived as too expensive. More investment is needed to make the technology reliable, easy to use, replicable and certified. The required technology development could be run by a single company (whose main business model would be the selling of the AD technology), or through open source collaboration (and in this case, innovative business models need to be devised).

5.3.4 Supply chain

There is technical potential available in terms of food waste and other waste. However accessibility and costs are barriers for AD operators.

In general there is uncertainty in the operators and developers, regarding the availability of waste (especially food waste). Sustainable AD need a guaranteed feedstock for many years to reduce the investment risk. Big operators can spread the risk across their plants – it is more difficult for small operators and community projects. In many cases, household waste is not accessible to new AD plant, as local authorities have long term contracts with waste management companies.

In urban environments, the collection rate of food waste is low. Some interviewees mentioned that community AD projects could have an advantage in motivating residents to separate their food waste, compared to collection from big commercial waste management companies.

The use of digestate emerged as quite complex and finally expensive, due to some technical and organizational barriers (in addition to the restricting regulations mentioned above). Digestate management is accounted as a cost by most project developers, with the sale of digestate to local farmers not covering the cost of storage, transport and spreading to land. In urban environments, there is a need to find local use of digestate, avoiding the need to transport diluted digestate outside of the city.

5.3.5 Opinions on Community biogas

There is a need to for local communities to have access to professional services, to help with the development and management of projects.

Raising finance is difficult in general for AD, given the inherent risk in the long term operation of the plant (process stability and access to wastes), compared to more predictable technology and PV and wind. Patient capital seem to be needed to fund community AD projects.

It is important to have successful projects running, that can show how the technology and the overall community approach is viable

Many interviewees identified opportunity to work with schools in conjunction with local food business such as those that produce school dinners from local produce – at the same time considering the biogas plant as driver for “living lab” to coordinate research activities.

Housing estates offer good opportunities for local closed loop, providing employment, waste treatment, production and consumption of healthy food. In these cases, places for installing the AD system would be garages, basements, roofs, and central squares.

6. Conclusions & Implications

This report characterized, during a literature research, the AD sector in the EU and the countries: Germany, Greece and UK as the raw framework for the regions. The European Union has ambitious goals with the ***Renewable Energy Directive*** (**RED**) set a 20% of the final energy consumption from RES as aim.

How the European countries achieve this target is different from 10% in Malta to 49% in Sweden. The national strategies are different, and correspondingly to this fact the development and maturity level in the ISABEL regions differ significantly.

Further this literature analysis, this report contains 31 semi-structured interviews with a wide stakeholders' opinion from NGO's to planners. It has shown the gaps and the barriers beyond this sector and how different is the acceptance and problems.

This substantial difference show us the stakeholders' opinion between an undeveloped biogas sector in **Greece** with **no present** experience in local community projects based on our findings, the **United Kingdom** with a vast RES local community projects' experience but a middle biogas development and **Germany** who is the front runner with a vast expertise in biogas and local communities.

- **Greece** has a big social and economic crisis. Consequently, despite the good feed in conditions the investor and communities have problems to begin new projects and to find funding. Moreover, the lack of adequate know-how can be only offset by foreign firms. The energy potential from biomass and organic waste are there. Specially the Central and eastern Macedonia & Thrace region has an idle potential because the mount of dairy cattle. Currently the cooperation between communities and biogas producer is missing.
- The **United Kingdom** is a new comer in the AD sector with a vast experience with cooperatives and RES production. This country focused on "waste" as preferable feedstock; certainly the benefits using the organic waste and generally the use of residues are ecologically sustainable. Certainly the funding process in the UK is a problem because of the capital competition to other RES projects as PV and wind. These RES sector find easily capital because of the vast experience and the acceptance of such initiatives.
- Finally, **Germany** has the widest biogas infrastructure in the EU. Until 2014 the EEG pushed forward the development and establishment of biogas plants on agricultural farms. Since the last amendment of the EEG the biogas sector is concerned about the future. This country has the most expand network of consulting, planning and development of biogas projects e.g. district heating, new energy crops. However, a negative development was the feedstock production during the last years. Intensive growing of maize was extended with negative impacts for the environment on the one hand and decreasing acceptance for biogas on the other. The missing use of green waste for biogas and quality standards for biomass production as well as concepts for the multiple different uses of biogas and the further expansion the CHP technology because heat is wasted, is an open gap in Germany and seems like a barrier for the future use of bioenergy. Propositions and ideas to future (operator-) models, which go beyond the EEG need to be developed to secure future energy production out of biogas.

The common argument in the three regions is that the projects are influenced by the variable government policy. Moreover, this factor influences the funding and the further development in the regions.

The last decade show as in **Germany** how helpful for this sector can be a friendly incentives because they are the starter for the further development. Assuredly the sector got problems at the moment the incentives were scaled down. However, the funding and planning experience will help this sector in the future. The German experience can be use as example for other countries. **Greece** biomass potential is vast but the supply chain is still underdeveloped and as a result the biogas projects are not sustainable. The **UK** biogas sector has other problems, certainly the biogas production is increased but the community is not part of this development. The municipalities have long contacts with companies and they are using the organic waste to produce biogas but the communities are not part of this.

State-of-the-art	Germany	United Kingdom	Greece
Electricity production	+	+/-	-
Heat production	+	+/-	-
Used Farmland	+/-	+/-	+
Waste	-	+	-
Incentives/Policies	+	+	+
Potential	+/-	+/-	+
Bioenergie Villages	+	-	-
Know-how			
Technical support	+	+/-	-
Biomass production	+/-	+	+
CHP	+	+/-	-
Funding	+	+/-	-
Social Engagement	+	+/-	-
Community acceptance	+/-	+/-	-
Supply chain			
Feedstock	+/-	+	+
Disgestate	+/-	+/-	+
Future Scenario			
Biogas developing	+/-	+	-
Community acceptance	+/-	+/-	-
Incentives	+/-	+	+

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