AlgaeBioGas

Algal treatment of biogas digestate and feedstock production

D5.1

Market and Legislation Analysis

PUBLIC

Contract	ECO/12/333018
Instrument	CIP Eco-innovation - Pilot and market replication projects
Call Identifier	CIP-EIP-Eco-Innovation-2012
Project website	http://algaebiogas.eu/
Project coordinator	Robert Reinhardt
Task Leader	Marjeta Resnik
Contact e-mail	algaebiogas@algen.si
Start date of project	01. September 2013
Duration	36 months
Reporting Date	28. February 2015

Co-funded by the Eco-innovation Initiative of the European Union

European Commission | Executive Agency for Small and Medium-sized Enterprises

1 Summary 4
2 Project Abstract 4
3 Task Description and Objectives 5
4 Market Analysis 5
4.1 EU Biogas Market Overview 5
4.1.1 Size 5
4.1.2 Trends 7
4.1.3 Projected growth 9
4.2 EU Biogas Digestate Market Overview 10
4.2.1 Use of Digestate 11
4.2.2 Digestate supply 11
4.2.3 Digestate production costs, gate fees and digestate prices 12
4.2.4 Agronomic value of digestate 12
4.2.5 Market outlook for digestate 13
4.3 Target Market 13
5 Legislation Analysis 14
5.1 European Union Legislative Framework 14
5.1.1 Directive 2009/28/EC - Promotion of the Use of Energy from Renewable Sources 15
5.1.2 Directive 2008/98/EC - Wastes 18
5.1.3 Directive 1999/31/EC - Landfill of Waste 21
5.1.4 Directive 2010/75/EU - Industrial Emissions 22
5.1.5 Directive 2009/73/EC - Internal Market in Gas 23
5.1.6 Directive 2012/27/EU – Energy Efficiency 23
5.1.7 Directive 2000/60/EC - Water protection and management (Water Framework Directive) 24
5.2 Support Schemes 25
5.2.1 Support Schemes in 2014 25
5.2.2 Future Changes in Support Schemes 26
5.2.3 Legislative aspects for digestate 26
Target Markets 26
6.1 Finland 27
6.1.1 Biogas Industry 27
6.1.2 Use of digestate 28
6.1.3 Legislation 28
6.2 Germany 29
6.2.1 Biogas Industry 29
6.2.2 Use of digestate 29
6.2.3 Legislation 30
6.3 Slovenia 32
6.3.1 Biogas Industry 32
6.3.2 Use of digestate 34
6.3.3 Legislation 34

6.4 Spain....36
6.4.1 Biogas Industry....36
6.4.2 Use of digestate....36
6.4.3 Legislation....37
6.5 Sweden....39
6.5.1 Biogas Industry....39
6.5.2 Use of digestate....39
6.5.3 Legislation....40
6.6 United Kingdom....42
6.6.1 Biogas Industry....42
6.6.2 Use of digestate....43
6.6.3 Legislation....43
Future prospects....45
8 Conclusions....47
References....48

1 Summary

AlgaeBioGas technology implementation is strongly dependent on legislation and market in specific country. In this deliverable we collected information on biogas market across European Union, biogas digestate market, EU legislative framework considering biogas industry and more detailed information on predefined target markets: Finland, Germany, Slovenia, Spain, Sweden and United Kingdom.

Editorial note

Deliverables in AlgaeBioGas project necessary build on and refer to previous deliverables. Our aim is to make them self-contained readable documents which necessary involves some replication of contents of previous deliverables, either as verbatim or summarized quotes. We are aware that such text is annoying to someone reading deliverables in series, so we have decided to set such text in lighter colour.

Thus, if you are reading just this text, please find contextual and reference information in lightly set sections; if you are acquainted with the project context (like a reviewer), please ignore the text set in light typeface.

Previous deliverables (partially) quoted in this document:

- DoW Description of work (Annex I of the Grant Agreement)
- D6.1 Business plan

2 Project Abstract

AlgaeBioGas project is focused to market introduction of algal-bacterial treatment of biogas digestate. Using algae we can recycle CO_2 emissions and nutrients contained in the biogas digestate. Excess heat can also be productively used. Treated digestate is of such quality that it can be reused or released to the environment. Resulting biomass can be used as biogas substrate, possibly after extraction of specific components in biorefinery.

Classical biological (bacterial) waste water treatment successfully reduces the quantities of organic substances at the cost of significant CO_2 emissions and significant energy consumption for aeration. Mineral nutrients, flushed with the liquid phase of digestate, are lost in the bacterial sludge which is frequently deposited, incinerated or discharged to the environment.

Algae hold a great potential because of their high growth rate, easy production, better utilization of sunlight compared to conventional plants, shorter lifecycles and independence from fertile agricultural land. Biogas plants are rich sources of mineral nutrients, CO_2 and heat. By algal recycling we can close material cycles, provide feedstock for bio-refining various high value products and decrease competition between biogas and food use of agricultural crops.

The projects aims to set-up the first application as a demonstration centre and prepare all prefabricated technology, organization and marketing tools to market replication projects. The technology demonstration centre is not only be able to demonstrate the technology in full size at a demanding customers site, but also pro-

vides on-site support for customer's testing, analysis, evaluation, training and other activities required as part of a complex project.

Task Description and Objectives

Preliminary market analysis has identified differences in legislation as one of the important barriers to market penetration. To be able to propose our system to a customer at certain location we have to be able to speak in his legal and economic terms and this is largely determined by local legislation. As part of market analysis a legislation comparison is necessary. A preliminary comparative study will be made under this project.

Based on this specific EU regions will be defined as the first target market area. More detailed market analysis will be performed for these regions and a search for local partners will be initiated in perspective regions. Further, more elaborate market analysis will be performed in liaison with the selected partner.

Market Analysis

Under the task 6.1 Business plan preparation we prepared product or service plan, vision and mission statements, industry overview, market analysis, competitive analysis, marketing plan, operational plan and organizational plan. Under market analysis: demographic profile, situation and perspectives of biogas plants in Europe, psychographic profile, customer behaviours and target market opportunity were described.

In this deliverable we will update the market analysis with more recent data. This deliverable is still oriented towards data gathering, some of decision making and conclusions will be synthesised in the task 5.4 in conjunction with realistic performance expectations of the system and potential benefits created for a customer.

4.1 EU Biogas Market Overview

4.1.1 Size

Europe is the largest biogas market in the world, with over 13 800 biogas-producing digesters in operation in 2012 with over 7400 megawatts (MW) of installed capacity. The top three countries by number of biogas plants are Germany, Italy and Switzerland [2].

According to European Biogas Association (EBA) the number of biogas plants in Europe during the year 2013 increased with a total of 14 572. That was 760 more, compared to the number of plants in 2012. That is an increase of 5.5 %, much lower than the 12 % growth in previous year. Significant changes occurred in different parts of Europe, mainly due to recent changes in support schemes, which led to the expected outcomes [3].

The numbers of biogas plants in Europe and divided by the types are shown below:

Table 1: Number of biogas plants in 2012 and 2013 according to EBA [3]

Country	Number of biogas plants					
	Total 2012	Total 2013	Agriculture	Sewage	Landfill	Other*
Austria	436	436	201	95	15	125
Belgium	119	118	38	21	23	36
Bulgaria	3	11	8	1	2	0
Croatia	12	11**	11	0	0	0
Cyprus	15	14**	14	0	0	0
Czech Republic	481	554	382	98	56	18
Denmark	176	155**	67	53	29	6
Estonia	3	11	5	2	4	0
Finland	78	81	12	16	40	13
France	557	610	140	60	301	109
Germany	8700	9035	7850	980	0	205
Greece	22	22	4	11	3	4
Hungary	50	70	35	13	20	2
Ireland	27	27	5	11	8	3
Italy	1264	1391	1121	60	210	0
Latvia	37	53	44	1	6	2
Lithuania	21	21	0	9	9	3
Luxembourg	33	33	26	4	0	0
The Netherlands	252	252	105	82	41	24
Poland	186	206	42	67	97	0
Portugal	26	38	8	8	16	6
Romania	7	8	n/a	n/a	n/a	n/a
Slovakia	92	109	91	8	10	0
Slovenia	33	31**	n/a	n/a	n/a	n/a
Spain	22	31	31	0	0	0
Sweden	242	264	39	137	60	28
Switzerland	606	620	97	463	6	54
UK	312	360	62	146	75	52
TOTAL	13812	14572	10438	2346	1031	690

*Other – biowaste and industrial biogas plants
**Fluctuations due to different sources
n/a – not available

According to EBA the total installed electrical capacity in Europe in 2013 reached 7852 MW. Apart of the electrical power 175.3 PJ (48.7 TWh) of thermal energy was produced, too [3]. EurObserv'ER reports that about 52.3 TWh of biogas electricity was produced during 2013 in the EU. 13.4 million tonnes oil equivalent (Mtoe) of biogas primary energy were produced during 2013, which is 1.2 Mtoe more than in

2012 representing 10.2% growth. However, the biogas sector's momentum was more sluggish than in 2012 (16.9 % between 2011 and 2012, giving an additional 1.8 Mtoe) [4].

4.1.2 Trends

Biogas technology has been rising from 1950. It has survived faster and slower growth rates well correlated with oil price peaks. Biogas technology had two distinct development paths: (1) low-tech path deployed in rural areas of Asia where was used as sanitation and gas production technology in remote locations where no electrical power was available and (2) high-tech solutions in developed areas where the technology is used for several purposes: organic waste treatment (from different sources: agricultural waste, wastewater slurry, municipal and/or kitchen waste); this technology has truly gained momentum with increase of popularity of renewable energy sources. Biogas plants have now reached very advanced technology levels.

(i) Number of biogas plants

For 2013 EBA reports smaller increase in the numbers of biogas plants than in the years behind. In previous years biogas plants in Germany and Italy were doubling (Italy, 2012) or increasing by more than thousand a year (Germany, 2011). The German biogas industry is suffering from the new Renewable Energy Act (EEG). Further challenges and a significant slowdown in development are expected, as the FiT were reduced since August 2014, while from 2016 FiT for biogas plants above 100 kW are seen to be cut, capping the plants at 100 MW of installed capacity. Therefore, a lot of work occurs around plant repowering and "flexibilisation" of plants. Regardless of these changes, Germany still dominates the market, not only by the number of plants but also services provided and the know-how. Italy alongside with Germany occupies the top with 1 391 plants. The Italian support scheme changed in 2013, like in Germany, also limiting the number of new biogas plants, since those would be the plants affected by the decrease in FiT. Switzerland had 14 new plants built in 2013, but this presents the average growth over the last several years [3].

EBA reports positive trend in central Europe where Hungary, the Czech Republic, Poland and Slovakia have recorded continuous increases in numbers of biogas plants. The Czech Republic has opened 73 new plants, Hungary 20, Poland 30 and Slovakia 19. This resulted in an overall increase of 18% in the region. Countries that reported a relatively big number of new plants are those which are already forerunners in the total numbers: France with 53 new plants, the UK with 48 and Sweden with 20. Although UK is now having the majority of biogas plants based on landfill gas, in 2013 the biggest increase was in agricultural plants. This increase in the UK reached 13% in 2013. Sweden also opened new agriculture based biogas plants along with a smaller number of landfill biogas plants, a total growth of 7.5%. While most of the countries reported new biogas plants being commissioned, some countries reported the same numbers like the previous year, including Austria with 436 plants, the Netherlands with 252 plants and Ireland with 27. In the case of Austria, this occurred due to the local caps that were imposed over the last few years in these counties. Belgium even saw a closure of few plants: 2 landfill and 3 sewage based biogas plants in Wallonia [3].

Few countries that recently entered the biogas industry have even upgraded their capacities and opened new plants. Bulgaria has eight new plants with several more under construction, Estonia built eight new plants reaching eleven now. Romania

opened one new plant. Serbia got its first biogas plant in the north province of Vojvodina [3].

(ii) Type of biogas plants

According to EBA, agriculture based biogas plants that run on energy crops, agricultural residues and manure have the biggest share in the total number of biogas plants, making up to 2/3 of all plants. Germany and Italy have 86% and 80% of their biogas plants operate with agricultural feedstock respectively, while Austria and the Czech Republic have them slightly less in the overall share, 46% and 69%. Some countries however have all their production based on agriculture feedstock, like Croatia and Cyprus [3].

Other countries have a rather mixed share of landfill, sewage sludge and agriculture based plants, with France, Finland and Poland producing biogas mainly from organic waste and on landfills. The United Kingdom and Sweden extract biogas from sewage sludge. Finnish electricity and thermal energy generated from landfill biogas plants make up to 50% each in the overall biogas generated electricity and thermal energy although the number of biowaste plants is increasing. Landfill based plants in the UK generate the largest share of electricity (78%), but a growing number of agricultural plants might reverse this trend [3].

Although Greece has only three landfill based biogas plants out of 22, those represent 64% of the total installed capacities (two major plants with capacities of 23.4 MWel and 11.4 MWel) [3].

The big share of agricultural biogas plants in Europe can be explained by the corresponding shares of such plants in the breakdown of leading biogas producing countries. Germany, Italy and the Czech Republic make up for almost 75% of total biogas plants and are predominantly producers from agricultural sources [3].

(iii) Biogas Feedstock

Feedstock for biogas varies across Europe. However, countries like Finland, Sweden and Portugal have very limited use of agricultural feedstock. Sweden's 6 million tonnes of sewage sludge is fed into 137 plants. In case of the UK, the other country with the largest share of sewage sludge based plants - 1.6 million tonnes were processed in 146 plants. Agricultural based plants dominate, that is a fact, however the feedstock still varies and mostly relies on agricultural residues, mainly manure that is very often backed up with energy crops [3].

There is also a clear corresponding share of industrial feedstock (food and beverages industry) and the number of such plants in Belgium, UK and Switzerland [3].

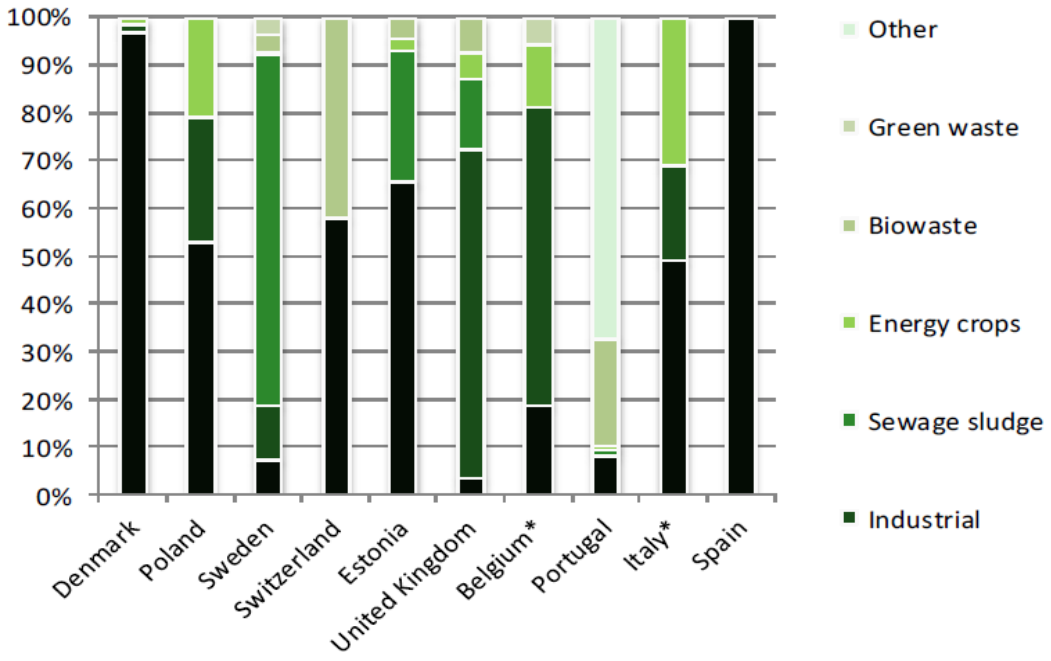

Figure 1: Biogas feedstock in several European countries [3]

4.1.3 Projected growth

The growth of biogas sector is influenced by policy changes and according to EurObserv'ER is expected to lose some of its impetus in 2014 in a number of countries whose sector expansion controlling policy changes will limit the future use of energy crops [4].

Comparing the 2013 biogas production goals for 2020 introduced in the National Renewable Energy Plans (NREAP), there is still a significant gap left in reaching the national goal of the EU countries. Some countries like Portugal have reached its 2020 goal or in case of Sweden, are well ahead of its goal. The UK, Austria and Germany have already reached more than 85%, 80% and 70% of their NREAP expectations respectively. The targets for these countries were from the beginning rather moderate and therefore, with the current growth factor, they will achieve their targets without any doubts. Central European countries especially the Czech Republic, Austria and Hungary continuously increase their production and with such trends they could meet the targets in the upcoming years. Serious doubts about reaching the 2020 goals are seen in the case of Poland and Spain, mostly due to their very high targets and an extremely slow or even nonexistent development of new installed capacities [3].

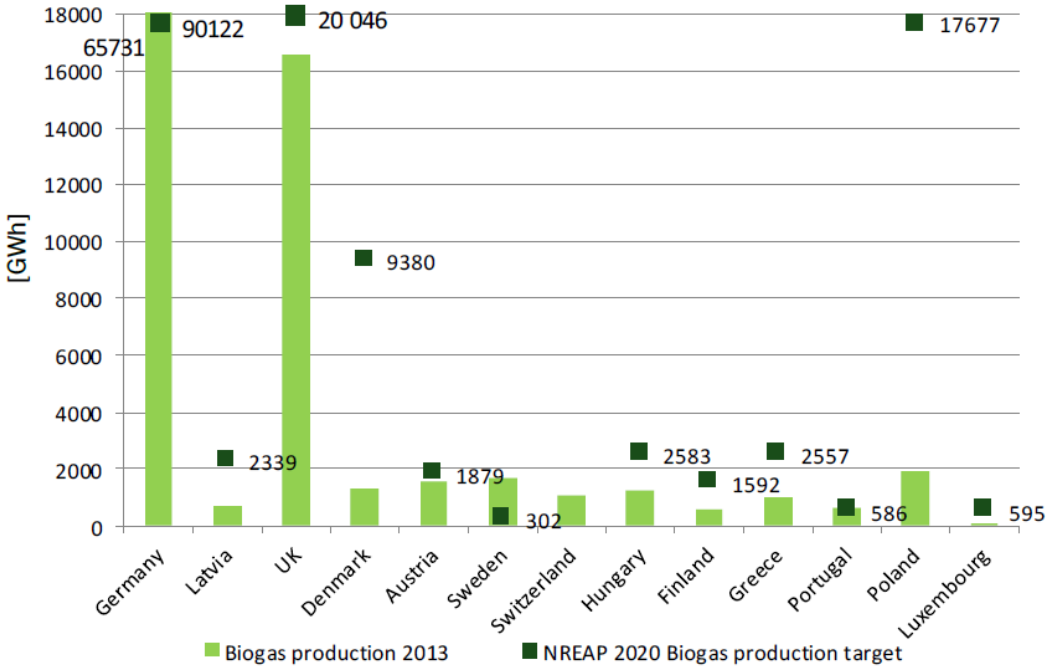

Figure 2: Biogas production in 2013 and planned biogas production (electricity, heating & cooling, transport) by 2020 as stated in the National Renewable Energy Action Plans (NREAPs) in chosen countries [3]

Developments beyond 2020 depend on the 2030 European Union targets for renewable energy and on governments of the member states. Biogas production could double in the years 2020 - 2030 in a scenario where all countries follow the example of France and United Kingdom, which have both introduced biomethane feed-in-tariffs for grid injection [2].

According to Shell international, the energy crisis is increasing significantly and the projections forecasted that the contribution of renewable energy resources would be sufficient to meet 50% global energy consumption by 2050. Nowadays, biogas production technology occupies a strategic location in the world market since it possess great impact on frequent economic issues raised during the past few decades such as depletion of fossil fuels, management of renewable energy resource, emission of greenhouse gases and replacement of chemical fertilizers. The improved recognition of biomass conversion in leading countries like Germany assists sufficient energy production that intend the necessity of extensive research interest on biogas to ensure comprehensive development of each country [5].

4.2 EU Biogas Digestate Market Overview

Digestate is produced continuously throughout the year from digestion unit. According to an estimate, a digester with installed electricity generation capacity of 1 MW produces an average of 100 m^3 digestate per day. Normal practice is that digestate is transported in distance of app. 10 km from biogas plant and used as fertilizer in agriculture, mainly for maize. But all the produced digestate cannot be applied on agricultural land immediately due to limitations of crop growth stage, soil type and its stabilization level, thus, it needs to be stored for several months [6].

Biogas digestate consists of 95% water on average and therefore presents logistical problem. Different technologies for treatment of biogas digestate exist and have been described in deliverable 6.1 Business plan.

4.2.1 Use of Digestate

According to the European Compost Network, the following trends are noted with regard to digestate use:

- Wet fermentation of bio-waste biogas plants:
  - In Central/Western Europe: the output is separated into a liquid and solid fraction whereby the solid fraction is post-composted and the excess liquid fraction that is not recycled to the process is mostly applied to agricultural land
  - In Scandinavia: the complete digestion residue is applied on agricultural land
- Wet fermentation of energy crops, manure and industrial/commercial waste (food industries, restaurants, former foodstuff etc.): the complete digestion residue is applied on agricultural land
- Dry fermentation: the solid digestion residue is generally post-composted together with bio-/green waste
- Approximately less than 3% of the digestates are further treated to specific products e.g. for pellets or as constituents for growing media or manufactured soils

According to EBA, new products like dried or pelletized digestates are increasingly released into the European market. With full upgrading by ultrafiltration and reverse osmosis, highly concentrated fertiliser and a purified aqueous stream of drinking water quality can be produced. These developments are rather new. Today, still more than 95% of the produced digestate in Europe is used directly in the agricultural sector as a liquid fertilizer.

In conclusion, it can be stated that digestate is often used in agriculture, either as a whole digestate fraction or following separation in a solid and liquid fraction. The solid fraction may undergo additional treatments such as post-composting or drying. The liquid fraction, when not used on agricultural land, may undergo a treatment similar to wastewater to produce a clean water fraction [7].

4.2.2 Digestate supply

The total amount of digestate produced in Europe is estimated at 56 Mtonne fresh matter/year. Europe-wide, the majority of the digestate is recycled in agriculture (80-97%). According to EBA, production costs range from 10 to 30 Euro per tonne for bio-waste treatment through anaerobic digestion, excluding investment costs. The figure depends on the technology used and the quality and purity of the input materials. Gate fees also largely vary on local conditions and regulations and especially on the energy content of the feedstock. For certain lipid derived materials with high gas potential, anaerobic digestion operators are even willing to pay for the waste [7].

4.2.3 Digestate production costs, gate fees and digestate prices

The sales price for digestate is generally slightly lower than for compost. Positive prices are seldom encountered and the digestion plants commonly pay intermediate companies or farmers for the land spreading of digestate. Furthermore, digestate is rarely sold at cost covering prices, with an average maximum price of 3 to 5 Euro/tonne for whole digestate. In the best cases, solid and post-composted digestates can be sold for up to 10 Euro per tonne. Noteworthy, however, is that dry pelletized digestates can reach prices of up to 150-250 Euro per tonne in the agricultural market. Additionally, digestates in all forms can reach higher prices when sold for private consumer use [7].

According to the EBA, several thousands of tonnes of dried digestate produced from energy crops and manure are already available in the market and sold to fertiliser factories as well as transported across the borders. Prices range from 5 - 30 € per tonne dried digestate, depending on the feedstock, content of nutrients and quality. Wet digestates are sold at prices of 0 to 8 Euro/tonne, whereas composted digestates generally generate prices of 0 to 50 Euro per tonne. The wide price span is explained by different demands in different EU regions, whereby regions with a high manure supply are characterised by lower digestate prices [7].

Treatment costs for composting and digestion in Germany are reported to be between 30 and 80 Euro per tonne. Additional composting following digestion adds an additional cost up to 30 Euro per tonne [7].

The study of Kiel Institute for the World Economy on how location decisions influence the transport cost of processed and unprocessed bioenergy digestate showed that processing is profitable for certain types of processing techniques and that disposal costs strongly depend on the plants' location. Processing of digestates is a rather young technique, and therefore there is potential for improvements in efficiency: e.g. better degrees of separation, lower machinery costs [8].

4.2.4 Agronomic value of digestate

According to the European Compost Network, the nutrient value for solid digestion products was about 11.7 Euro/tonne fresh matter and for liquid digestion products 6.7 Euro/tonne fresh matter. These data were valid for 2007 and went up by about 50% from 2005, due to the rising prices for mineral fertilisers. They are largely comparable with the nutrient values of compost. According to the German Quality Assurance Organisation of Compost (BGK), the fertiliser value for digestate (with 5.2 kg N/m^3 fresh matter, 1.6 kg P_2O_5/m^3 fresh matter, 2.3 kg K_2O/m^3 fresh matter and 2.2 kg CaO/m^3 fresh matter) was 6.38 Euro/m^3 fresh matter in April 2011. When including organic matter, the monetary value of digestate is calculated at 7.23 Euro/m^3 fresh matter [7].

Based on ammonia nitrogen content and phosphorous, digestate with 4% dry matter content is estimated to have an economic value of 4.5 Euro/ton digestate in Sweden [7].

4.2.5 Market outlook for digestate

Despite the low sales price for digestate, several Member States clearly experience an increasing trend for digestion and a shift from composting to digestion or to combined composting and digestion. This evolution is explained by the fact that municipalities are able to negotiate lower gate fees to bio-waste operators thanks to increased competition in the bio-waste treatment sector. Hence bio-waste operators are forced to generate revenue through other options, such as through the sale of electricity from biogas production. In Member States with emerging treatment facilities for biodegradable waste and a large history of landfilling, the market development seems to be less smooth. In the Czech Republic, gate fees for landfilling of 30-40 Euro/tonne include 20 Euro/tonne landfill tax that directly goes to the receiving municipality. Because of the latter policy, municipalities tend to largely support landfilling, as it provides a certain income, at the expense of anaerobic digestion. As a result, waste anaerobic digestion plants are orienting themselves towards industrial materials such as glycerine from biodiesel production, with a high biogas yield. Finally, high value products, such as biothermally dried digestate sells at prices that compete with industrially made fertilizers and could hence increase the revenues for digestion plants [7].

4.3 Target Market

Target market opportunity was identified under the task 6.1 Business plan as follows below.

Target groups for our technology are biogas producers that meet the following criteria:

- have technologically advanced production,
- appropriate size (at least initially the product will downsize poorly since there is some basic cost of the equipment independent of the size; later stages of the product development may provide more cost effective solutions),
- have appropriate land area available,
- use agricultural or food waste substrates.

It is possible to extend the target group also to biogas producers from wastewater sludge, but the business model, technology and objectives should be significantly modified – this is not subject to this phase of the technology & product development.

Other key actors are mainly local sales and implementation partners. These should be well positioned companies already active in biogas technology. Ideal partners would be biogas engineering companies since they have their customer base. Another type of partners may be suppliers of components / subsystems of our system.

Other stakeholders important for market development are also associations of biogas producers and similar organizations who can help deliver our messages to potential customers.

We estimate that our technology may be qualified for use for 2000 potential customers in EU. There are more than 10000 biogas operators in EU; we estimate that some 10% of them are ready for our technology today.

Biogas plants that offer greater opportunities for use of our technology are:

- Located on areas with specific soil condition, nitrate vulnerable zones (limited use for digestate on open fields)
- Located on areas with overprovision of nutrients (intensive farming)
- Problem of digestate storage
- In need of biogas substrates

Legislation Analysis

Legislation differs across EU states and influences the biogas sector growth. One of the weaknesses for implementing AlgaeBioGas technology that we identified in D6.1 are external influences that are connected to legislation.

External influences

- The legislation has strong influence on biogas industry. The example is the number of biogas plants built in Germany in 2012. The number in last year is 50-100 times lower than the year before.
- The value of benefits achieved by our technology i.e. algae biomass for feedstock is influenced by legislation and market of other feedstock

We identified that economic drive to use our technology highly depends on the legislative framework and some legislative issues can be solved by experienced local partner. From D6.1:

We have already described some of the issues considering the legislative policy in countries of potential customers; there may be additional ones that we do not even know of at the moment. We believe that an experienced local partner is the only possible solution that can lead to both sale closing and further support in construction, commissioning and maintenance.

The economic drive to use our innovative technology highly depends on the legislative framework, e.g. if a country uses “agricultural bonus” the replacement of agricultural crops with other feedstock sources can have a giant leverage just around the bonus threshold.

In this deliverable we examined the legislation that is influencing biogas sector and AlgaeBioGas implementation.

5.1 European Union Legislative Framework

There are directives and regulations in the agricultural, waste and environmental sector in the European Union concerning biogas sector. A compilation is presented in the table below. Following summaries of the relevant directives were collected from EUR-Lex, Access to European Union Law, website.

Table 2: Compilation of EU Legislation Framework related with biogas plants [1][9]

Directive 2009/28/EC Promotion and production of the use of energy from renewable sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC.	This Directive establishes a legislative common framework for the use of energy from renewable sources in order to limit greenhouse gas emissions ant to promote cleaner transport.

Directive 2008/98/EC Wastes	This Directive provides for a general framework of waste management requirements and sets the basic waste management definitions for the EU.
Commission Decision COM 2000/532/EC	*European list of wastes (LoW)*
Commission Regulation No 1069/2009	*Health rules as regards animal by-products (ABPs) and derived products not intended for human consumption (SANDACH), and repealing Commission Regulation (EC) No 1774/2002*
Commission Regulation No 142/2011	*Implementing Regulation (EC) No 1069/2009*
Commission Regulation No 185/2007	*Validity of the transitional measures for composting and biogas plants under Regulation (EC) No 1774/2002*
Directive 1999/31/EC Landfill	This Directive is intended to prevent or reduce as far as possible negative effects on the environment from the landfilling of waste, by introducing stringent technical requirements for waste and landfills.
Directive 2010/75/EU - Industrial emissions*	This Directive brings together Directive 2008/1/EC (the IPPC Directive) and six other directives in a single directive on industrial emissions.
Directive 2009/73/EC Rules for the internal market in natural gas	This Directive aims at introducing common rules for the transmission, distribution, supply and storage of natural gas. It concerns mainly natural gas, liquefied natural gas (LNG), biogas and gas from biomass.
Directive 2012/27/EU Energy efficiency	This Directive establishes a common framework of measures for the promotion of energy efficiency within the EU
Directive 2000/60/EC Water policy	This Directive establishes a common framework for Community action in the field of water policy, including key instruments in the protection of waters against agricultural pressures related with nitrates.

*Directive 2008/1/EC was replaced by Directive 2010/75/EU on industrial emissions. However, its provisions remain applicable until 6 January 2014.

5.1.1 Directive 2009/28/EC - Promotion of the Use of Energy from Renewable Sources

This Directive establishes a common framework for the use of energy from renewable sources in order to limit greenhouse gas emissions and to promote cleaner transport. To this end, national action plans are defined, as are procedures for the use of biofuels [9].

Act

Directive 2009/28/EC of the European Parliament and of the Council of 23 April 2009 on the promotion of the use of energy from renewable sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC (Text with EEA relevance).

Summary

This Directive establishes a common framework for the production of energy from renewable sources and the promotion of its use.

National targets and measures

Each Member State has a target calculated according to the share of energy from renewable sources in its gross final consumption for 2020. This target is in line with the overall 20-20-20 goal for the European Union (EU).

Moreover, the share of energy from renewable sources used in the transport sector must amount to at least 10% of final energy consumption in the sector by 2020.

National renewable energy action plans

Each Member State is to establish a national action plan for 2020, setting the share of energy from renewable sources in transport, in the production of electricity, in heating.

These action plans must take into account other energy efficiency measures, in particular the aim of reducing overall energy consumption. These plans will also establish procedures for the reform of planning and pricing schemes and access to electricity networks, in order to promote energy from renewable sources.

Cooperation between Member States

Member States can exchange an amount of energy from renewable sources using a statistical transfer, and set up joint projects concerning the production of electricity and heating from renewable sources.

It is also possible to establish cooperation with third countries. The following conditions must be met: the electricity must be consumed in the EU, the electricity must be produced by an installation constructed after June 2009, the quantity of electricity produced and exported must not benefit from any other support.

Guarantee of origin

Each Member State must be able to guarantee the origin of electricity, heating and cooling produced from renewable energy sources. The information contained in these guarantees of origin is normalised and should be recognised in all Member States. It may also be used to provide consumers with information on the composition of the different electricity sources.

Access to and operation of the grids

Member States should build the necessary infrastructures for the use of energy from renewable sources in the transport sector. To this end, they should: ensure that operators guarantee the transport and distribution of electricity from renewable sources, provide for priority access for this type of energy.

Biofuels and bioliquids

The Directive takes into account energy from biofuels and bioliquids. The latter should contribute to a reduction of at least 35% of greenhouse gas emissions in or-

der to be taken into account. From 1 January 2017, their share in emissions savings should be increased to 50%.

Biofuels and bioliquids are produced using raw materials coming from outside or within the Community. Biofuels and bioliquids should not be produced using raw materials from land with high biodiversity value or with high carbon stock. To benefit from financial support, they must be qualified as sustainable in accordance with the criteria of this Directive.

Context

The Directive is part of a package of Energy and climate change legislation which provides a legislative framework for targets for greenhouse gas emission savings in the EU. It encourages energy efficiency, energy consumption from renewable sources, the improvement of energy supply and the economic stimulation of a dynamic sector in which Europe is setting an example.

Related Act

Report from the Commission of 25 February 2010 to the Council and the European Parliament on sustainability requirements for the use of solid and gaseous biomass sources in electricity, heating and cooling

This Report sets out the results of the assessment carried out by the Commission on the requirements for a sustainability scheme for energy uses of biomass other than biofuels and bioliquids (i.e. solid and gaseous fuels in electricity, heating and cooling).

In its analysis of requirements for extending the EU sustainability scheme of solid and gaseous biomass in electricity, heating and cooling, the Commission has considered three principles which a European-wide policy on biomass sustainability has to meet: effectiveness in dealing with problems of sustainable biomass use, cost-efficiency in meeting the objectives, consistency with existing policies.

Based on this analysis, the Report concludes that at this stage it is not necessary to establish a binding and harmonised European scheme in this area. The existing measures are sufficient for ensuring that solid and gaseous biomass consumed at EU level in the electricity heating and cooling sectors is sustainable.

However, the Commission makes recommendations related to sustainability and strongly encourages Member States to take them into account in order to ensure consistency between existing or future national sustainability schemes. The recommendations are mainly based on the sustainability scheme included in Directive 2009/28/EC on biofuels and bioliquids.

The Commission specifies that between now and 31 December 2011, it will report on whether national schemes have sufficiently addressed the sustainability issues related to the use of biomass from inside and outside the EU and whether these schemes have led to barriers to trade and barriers to the development of the bioenergy sector. It will consider if additional measures such as common sustainability criteria at EU level would be appropriate.

Report from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions renewable energy progress report

The main objective of this report is to evaluate the progress made by the Member States in promoting the use of renewable energy to achieve the 2020 targets. It has found that the implementation of the Directive on renewable energy and national policies, as planned in the national action plans, has translated into significant growth in renewable energies in most Member States, since the Commission's last report. However, the obstacles to this growth are taking time to disappear and the perspective for 2020 is rather bleak. Additional measures will therefore be necessary at Member State level in order to continue progress towards the achievement of the objectives set.

These efforts should focus on:

- simplifying and clarifying the administrative procedures for planning and authorisation as well as for the development and use of infrastructure;
- managing renewal energy production in the electrical system;
- the effectiveness and efficiency of aid schemes for renewal energy.

Technological development and cost reduction are also crucial and this issue will be examined in a future Commission Communication on technologies and innovation in the energy sector.

5.1.2 Directive 2008/98/EC - Wastes

With a view to breaking the link between growth and waste generation, the European Union (EU) has provided itself with a legal framework aimed at the whole waste cycle from generation to disposal, placing the emphasis on recovery and recycling [9].

Act

Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 on waste and repealing certain Directives.

Summary

This Directive establishes a legal framework for the treatment of waste within the EU. It aims at protecting the environment and human health through the prevention of the harmful effects of waste generation and waste management.

It applies to waste other than: gaseous effluents, radioactive elements, decommissioned explosives, faecal matter, waste waters, animal by-products, carcasses of animals that have died other than by being slaughtered, elements resulting from mineral resources.

Waste hierarchy

In order to better protect the environment, the Member States should take measures for the treatment of their waste in line with the following hierarchy which is

listed in order of priority: prevention, preparing for reuse, recycling, other recovery (notably energy recovery), disposal.

Member States can implement legislative measures with a view to reinforcing this waste treatment hierarchy. However, they should ensure that waste management does not endanger human health and is not harmful to the environment.

Waste management

Any producer or holder of waste must carry out their treatment themselves or else have treatment carried out by a broker, establishment or undertaking. Member States may cooperate, if necessary, to establish a network of waste disposal facilities. This network must allow for the independence of the European Union with regard to the treatment of waste.

Dangerous waste must be stored and treated in conditions that ensure the protection of health and the environment. They must not, in any case be mixed with other dangerous waste and must be packaged or labelled in line with international or Community regulations.

Permits and registrations

Any establishment or undertaking intending to carry out waste treatment must obtain a permit from the competent authorities who determine notably the quantity and type of treated waste, the method used as well as monitoring and control operations.

Any incineration or co-incineration method aimed at energy recovery must only be carried out if this recovery takes place with a high level of energy efficiency.

Plans and programmes

The competent authorities must establish one or more management plans to cover the whole territory of the Member State concerned. These plans contain, notably, the type, quantity and source of waste, existing collection systems and location criteria.

Prevention programmes must also be drawn up, with a view to breaking the link between economic growth and the environmental impacts associated with the generation of waste.

These programmes are to be communicated by Member States to the European Commission.

Context

The generation of waste is increasing within the European Union. It has therefore become of prime importance to specify basic notions such as recovery and disposal, so as to better organise waste management activities.

It is also essential to reinforce measures to be taken with regard to prevention as well as the reduction of the impacts of waste generation and waste management on the environment. Finally, the recovery of waste should be encouraged so as to preserve natural resources.

This Directive repeals directives 75/439/EEC, 91/689/EEC and 2006/12/EC.

Related Acts

Proposal for a Council Regulation on defining criteria determining when recovered paper ceases to be waste pursuant to Article 6(1) of Directive 2008/98/EC on waste.

Biogas plants

Biogas plants are affected by requirement to obtain a permit as waste manager for the recovery and valorization of SANDACH products (Animal By-products Not Intended for Human Consumption). Plant promoters must obtain environmental authorization as waste managers, which will describe the amount and type of waste treated, the method used, as well as activities of monitoring and control process [1].

Several Regulations and Comission Decisions involved in waste management are:

European list of wastes (LoW)

Is established in the Commission Decision COM 2000/532/EC. This Decision establishes the classification system for wastes, including a distinction between hazardous and non-hazardous wastes. The LoW serves as a common encoding of waste characteristics in a broad variety of purposes like classification of hazardous wastes. Assignment of waste codes has a major impact on the transport of waste, installation permits, and decisions about recyclability of the waste or as a basis for waste statistics.

Commission Regulation No 1069/2009

EC of the European Parliament and the Council of 21 October 2009: laying down health rules as regards animal by-products (ABPs) and derived products not intended for human consumption and repealing Commission Regulation (EC) No 1774/2002 (Animal by-products Regulation). The Regulation categorises ABPs into three categories, which is based on their potential risk to animals, the public or the environment. The categories are: Category 1 material (very high risk) as defined in Article 8; Category 2 material /High risk) as defined in Article 9, and Category 3 material (Low risk) as defined in Article 10.

Commission Regulation N° 142/2011

EC European Parliament and of the Council of 25 February 2011: implementing Regulation (EC) No. 1069/2009 of the European Parliament and of the Council laying down health rules as regards animal by-products and derived products not intended for human consumption (SANDACH):

End-of-waste criteria

End-of-waste criteria specify when certain waste ceases to be waste and obtains a status of a product (or a secondary raw material). According to Article 6 (1) and (2) of the Waste Framework Directive 2008/98/EC, certain specified waste shall cease to be waste when it has undergone a recovery (including recycling) operation and complies with specific criteria to be developed in line with certain legal conditions, in particular:

- the substance or object is commonly used for specific purposes;

- there is an existing market or demand for the substance or object;
- the use is lawful (substance or object fulfils the technical requirements for the specific purposes and meets the exisitng legislation and standards applicable to products);
- the use will not lead to overall adverse environmental or human health impacts.

Such criteria should be set for specific materials by the Commission using the procedure described in Article 39 (2) of the Waste Framework Directive (so called "comitology"). A mandate to set end-of-waste criteria was introduced to provide a high level of environmental protection and an environmental and economic benefit. They aim to further encourage recycling in the EU by creating legal certainty and a level playing field as well as removing unnecessary administrative burden [10].

5.1.3 Directive 1999/31/EC - Landfill of Waste

The European Union has laid down strict requirements for landfills to prevent and reduce as far as possible the negative effects on the environment, specifically on surface water, groundwater, soil, air and human health [9].

Act

Council Directive 1999/31/EC of 26 April 1999 on the landfill of waste.

(iv) Summary

The Directive is intended to prevent or reduce the adverse effects of the landfill of waste on the environment.

It defines the different categories of waste (municipal waste, hazardous waste, non-hazardous waste and inert waste) and applies to all landfills, defined as waste disposal sites for the deposit of waste onto or into land. Landfills are divided into three classes:

- landfills for hazardous waste;
- landfills for non-hazardous waste;
- landfills for inert waste.

On the other hand, the Directive does not apply to:

- the spreading on the soil of sludges (including sewage sludges and sludges resulting from dredging operations);
- the use in landfills of inert waste for redevelopment or restoration work;
- the deposit of unpolluted soil or of non-hazardous inert waste resulting from prospecting and extraction, treatment and storage of mineral resources as well as from the operation of quarries;
- the deposit of non-hazardous dredging sludges alongside small waterways from which they have been dredged and of non-hazardous sludges in surface water, including the bed and its subsoil.

Member States must ensure that existing landfill sites may not continue to operate unless they comply with the provisions of the Directive as soon as possible.

Member States must report to the Commission every three years on the implementation of the Directive.

On the basis of these reports, the Commission must publish a Community report on the implementation of the Directive.

5.1.4 Directive 2010/75/EU - Industrial Emissions

The European Union (EU) defines the obligations to be met by industrial activities with a major pollution potential. It establishes a permit procedure and lays down requirements, in particular with regard to discharges. The objective is to avoid or minimise polluting emissions in the atmosphere, water and soil, as well as waste from industrial and agricultural installations, with the aim of achieving a high level of environmental and health protection [9].

(v) Act

Directive 2010/75/EU of the European Parliament and of the Council of 24 November 2010 on industrial emissions (integrated pollution prevention and control).

(vi) Summary

This Directive brings together Directive 2008/1/EC (the IPPC Directive) and six other directives in a single directive on industrial emissions.

Sectors of activity

This Directive shall cover industrial activities with a major pollution potential, defined in Annex I to the Directive (energy industries, production and processing of metals, mineral industry, chemical industry, waste management, rearing of animals, etc.).

Environmental requirements

Any industrial installation which carries out the activities listed in Annex I to the Directive must meet certain basic obligations:

- preventive measures are taken against pollution;
- the best available techniques (BAT) are applied;
- no significant pollution is caused;
- waste is reduced, recycled or disposed of in the manner which creates least pollution;
- energy efficiency is maximised;
- accidents are prevented and their impact limited;
- sites are remediated when the activities come to an end.

Application of best available techniques

Industrial installations must use the best available techniques to achieve a high general level of protection of the environment as a whole, which are developed on a scale which allows implementation in the relevant industrial sector, under economically and technically viable conditions. The European Commission must adopt BAT conclusions containing the emission levels associated with the BAT. These conclusions shall serve as a reference for the drawing up of permit conditions.

Environmental inspections

Member States shall set up a system of environmental inspections of the installations concerned. All installations shall be covered by an environmental inspection plan. The plan shall be regularly reviewed and updated.

Based on the inspection plans, the competent authority shall regularly draw up programmes for routine environmental inspections, including the frequency of site visits for different types of installations. The period between two site visits shall be based on a systematic appraisal of the environmental risks of the installations concerned. It shall not exceed one year for installations posing the highest risks and three years for installations posing the lowest risks.

5.1.5 Directive 2009/73/EC - Internal Market in Gas

The internal market in natural gas suffers from a lack of transparency which impedes its proper functioning. The European Commission therefore considered it necessary to redefine the rules and measures applying to that market in order to guarantee fair competition and appropriate consumer protection [9].

Act

Directive 2009/73/EC of the European Parliament and of the Council of 13 July 2009 concerning common rules for the internal market in natural gas and repealing Directive 2003/55/EC.

Summary

This Directive aims at introducing common rules for the transmission, distribution, supply and storage of natural gas. It concerns mainly natural gas, liquefied natural gas (LNG), biogas and gas from biomass.

5.1.6 Directive 2012/27/EU – Energy Efficiency

The 2012 Energy Efficiency Directive establishes a set of binding measures to help the EU reach its 20% energy efficiency target by 2020. Under the Directive, all EU countries are required to use energy more efficiently at all stages of the energy chain from its production to its final consumption. EU countries were required to transpose the Directive's provisions into their national laws by 5 June 2014 [11].

Act

Directive 2012/27/EU of the European Parliament and of the council of 25 October 2012 on energy efficiency, amending Directives 2009/125/EC and 2010/30/EU and repealing Directives 2004/8/EC and 2006/32/EC [9].

5.1.7 Directive 2000/60/EC - Water protection and management (Water Framework Directive)

The European Union (EU) has established a common framework for water protection and management, which aims to protect and restore aquatic ecosystems, and to guarantee long-term, sustainable water usage for individuals, businesses and the natural world [9].

Act

Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy.

Summary

This Framework-Directive has several objectives such as preventing and reducing pollution, promoting sustainable water usage, protecting the environment, improving the state of aquatic eco-systems and reducing the effects of floods and droughts. It has established a framework for the protection of: inland surface waters, groundwater, transitional waters and coastal waters. Its ultimate objective is to achieve a good status for all European Union waters by 2015.

Nitrates framework directive

The Nitrates Directive (Directive 91/676/EEC) forms an integral part of the Water Framework Directive and is one of the key instruments in the protection of waters against agricultural pressures. The Nitrates Directive (1991) aims to protect water quality across Europe by preventing nitrates from agricultural sources polluting ground and surface waters and by promoting the use of good farming practices [12].

Implementation

1. Identification of water polluted, or at risk of pollution.

2. Designation as "Nitrate Vulnerable Zones" (NVZs) of:

- Eutrophic river areas of land which drain into polluted waters or waters at risk of pollution and which contribute to nitrate pollution; or
- Member States can also choose to apply measures (see below) to the whole territory (instead of designating NVZs).
- The current status of NVZ and whole territory designations can be viewed using the map viewer on the website of the Joint Research Centre.

3. Establishment of Codes of Good Agricultural Practice to be implemented by farmers on a voluntary basis. Codes should include:

- measures limiting the periods when nitrogen fertilizers can be applied on land in order to target application to periods when crops require nitrogen and prevent nutrient losses to waters;

- measures limiting the conditions for fertilizer application (on steeply sloping ground, frozen or snow covered ground, near water courses, etc.) to prevent nitrate losses from leaching and run-off;
- requirement for a minimum storage capacity for livestock manure; and
- crop rotations, soil winter cover, and catch crops to prevent nitrate leaching and run-off during wet seasons.

4. Establishment of action programmes to be implemented by farmers within NVZs on a compulsory basis. These programmes must include:

- slurry spreading with trailing shoe system measures already included in Codes of Good Agricultural Practice, which become mandatory in NVZs; and
- other measures, such as limitation of fertilizer application (mineral and organic), taking into account crop needs, all nitrogen inputs and soil nitrogen supply, maximum amount of livestock manure to be applied (corresponding to 170 kg nitrogen /hectare/year).

5. National monitoring and reporting.

5.2 Support Schemes

The most widespread form of subsidising RES was Feed-in Tarrif (FiT) for electricity. Nonetheless, European Commission's long term goal is to move away from the FiT towards Feed in Premium or other support instruments which, according to them, give incentives to producers to respond to market developments [3].

5.2.1 Support Schemes in 2014

The highest support in 2014 was received by plant operators in Switzerland (380 €/MWh for plants up to 50 kWel with bonus for agricultural residues and bonus for heating use), Italy (276 €/MWh for plants with capacities up to 300 kW), Germany (273 €/MWh for plants up to 75kWel fed on manure), Latvia (233.12 €/MWh for plants up to 80 kW with efficient CHP) and Bulgaria (232 €/MW). However, the Bulgarian FIT is very difficult to predict on the longer run, as it is revised and according to the recent trends, decreased every year in June. Spain has switched to premiums in 2014, while support for biogas plants was ceased in Cyprus and the Czech Republic. Sweden, where one certificate is issued for each MWhel produced, has an established scheme based on CO_2 and energy tax exemptions, which supports the consumers and creates demand on biogas and biomethane, what makes certificates less important for growth of the sector. Luxembourg has increased the Feed-in-Tariffs for almost all renewable energy sources in 2014. Biogas incentive increased by 31% while biogas from sewage sludge raised by 44%. The new rules contribute to achieving the government's goal to increase the share of renewable energy by 2020 from the current level about 3 to 11%. The UK saw a launch of two new support schemes. On-Farm AD, launched in October 2013 to help support the development of new farm based AD in England. The fund will be applicable to plants below 250 kW which have access to slurry and/or manure. Rural Communities Renewable Energy Fund is a £15 million fund launched in June 2013. It provides up to £150 000 of funding for feasibility and preplanning development work to help community renewable energy projects become investment friendly [3].

5.2.2 Future Changes in Support Schemes

Since July 2014 all new support schemes have to correspond to the new Guidelines on State aid for environmental protection and energy. The aim of the guidelines was to bring more competition into renewables and to make them more competitive. In fact, the guidelines allow FIT only to biogas plants below 500 kW of electric capacity, while those between 500 kW and 1 MW can be granted a premium. From January 2017, all plants above 1 MW will undergo a technology-neutral bidding process, unless Member States can explain to the Commission why such bidding processes could not work in particular circumstances. These guidelines apply to the period up to 2020; however, they should prepare the ground for achieving the objectives set in the 2030 Framework. Also in 2014, the Council adopted a non-binding target for renewable energy of 27% and a binding GHG reduction target of 40% by 2030. Since there are no national targets but only a European one for 2030, it is very likely that only a handful of ambitious Member States will push on towards an energy transition and will invest into new technologies and capacities, while the rest of Europe will lag behind, feeling no obligation to contribute to the single EU target [3].

The guidelines and the recently established climate and energy targets for 2030 will shape the renewable energy policies and define biogas development in the coming few years. The first country introducing the new guidelines with even stricter rules was Germany. Since August 2014 all new plants above 500 kWel have to sell electricity directly to the market, and in January 2016 direct marketing will apply to all plants above 100 kWel [3].

5.2.3 Legislative aspects for digestate

Most member states generally regulate the quality and application of digestate and other bio-wastes through waste laws (e.g. DK) or fertiliser legislation (e.g NL), which are similar or identical as for composts. In the UK, digestate can receive end-of-waste status through the Quality Protocol. Also the Czech Republic provides product status for digestate via national regulation: biodegradable waste treatment decree (341/2008 Sb.) or fertilizer law (156/1998 Sb.). On a European level, the Animal By-Products Regulation also applies to anaerobic digestion facilities [7].

Target Markets

Our focus is entire European market, with focus on high potential markets Germany, Sweden, Spain, UK and small markets Finland and Slovenia. General information about existing biogas plants in different countries, the market conditions on biogas and green electricity production and digestate production and its use were roughly defined in Deliverable 6.1 Business plan.

Here we expand information on biogas especially biogas digestate and legislation for our target markets.

6.1 Finland

6.1.1 Biogas Industry

The Finnish Biogas industry has history since 1902, when the first experimental anaerobic digestion based experimental sewage treatment plant was taken into use in Helsinki. Biogas was taken into energy use in Helsinki in 1932. The first use was for heating and lighting. Combined heat and power production began in 1936 and traffic use in 1941. There are now about 100 biogas plants in use supported by many kinds of organizations. The Finnish Biogas Association published a catalogue of selected organizations active in the different fields. These fields include biogas, digestate, power, heat and transport fuel production, plant design and construction, financing, consulting and training [13]. The organizations are listed below.

Who is who?

Organizations and their activity areas

Organization	Planning and manufacturing of biogas	Biogas production	Financing	Digestate production	Consulting	Research, training and information	Plant components	Electricity/ Heat	Traffic	Waste/ Sewage management	Transportation of biogas
Ajanta Ltd			•								
Amomatic Ltd							•				
Aquaflow Ltd							•			•	
Autoliike Keijo Lehtonen Ltd									•		
Bioprocess Control Ltd					•	•	•				
Biovakka Suomi Ltd		•		•				•			
Dewaco Ltd					•	•	•				
Envor Biotech Ltd		•		•				•	•	•	
Forssan Vesihuoltoliikelaitos		•		•				•		•	
Gasum Ltd									•		•
Geo-Export Ltd/Ulvilan pumppupalvelu					•		•				
Goodtech Environment Ltd	•				•		•				
Haapajärvi vocational collage		•		•		•		•	•		
Höyrytys Ltd							•	•	•		
Oy Insalko Ltd	•				•		•				
Jeppo Biogas Ltd – Jepuan Biokaasu Ltd		•		•				•	•		
Kymen Bioenergia Ltd		•		•							
Lakeuden Etappi Ltd		•		•				•		•	
Puhas Ltd		•								•	
Sensorex Ltd							•				
Finnish Biogas Association						•					
Finnish Gas Association						•					
Stormossen Ltd		•		•				•		•	

Figure 3: Selected organizations in Finland active in different fields published by Finnish Biogas association [13]

In Finland, landfilling is the most common treatment for municipal solid waste. Separate collection of bio-waste started in the 90`s and it is generally only mandatory for bigger housing units. Single family houses are normally not included in the separate collection system but they are encouraged to home composting. Composting of separately collected bio-waste was first performed in open windrows. Several composting plants have been built at the end of the 90`s and the beginning of this century. Often bio-waste was treated together with sewage sludge in the composting plant. Many of the plants suffered from technical problems, because the composting systems coming from central Europe were not adapted sufficiently to the Finnish bio-waste, which is mainly kitchen waste. During the last years the interest for anaerobic digestion increased in parallel with a discussion on renewable energy and an electricity tariff support. Most of the composting and anaerobic digestion plants in Finland treat sewage sludge and green waste to some extent as

well. According to the reports of regional authorities circa 190 ktonne was composted and 42 ktonne treated in AD-plants 2008. The total capacity of installed anaerobic digestion plants for biodegradable waste in Finland is about 50 ktonne [7].

In Finland altogether 16 biogas reactor plants have been in operation at different municipal wastewater treatment plants by the end of 2013. Industrial wastewaters were treated anaerobically at three different plants. Farm-scale biogas plants were operating at 12 places. Municipal solid wastes were treated at 11 biogas plants. In 2013, the amount of biogas produced by the reactor installations was 59.1 million m^3 and the combustion of surplus biogas 5.3 million m^3. Production of thermal, electrical and mechanical energy was 260.8 GWh. As compared to the previous year, there was a slight increase in the total amount of the produced biogas and the energy. There were altogether 40 landfill gas recovery plants operating at the end of 2013. The amount of the recovered biogas was 94.8 million m^3. The amount of recovered biogas used for the production of electrical and thermal energy was 70.8 million m^3, producing 294.9 GWh [13]. Finland has very limited use of agricultural feedstock [3].

Finland is on track to decarbonise its transport sector. Biogas consumption in transport increased by 168% in 2013, while consumption for power and heat production decreased by 2%, when compared to the previous year. This means that the transport will be the dominant growth factor for biogas in Finland. In September 2014 at least 31 plants were under construction or in planning stage, all in possession of environmental permits [3].

By 2025, Finland would like to see 10% of its natural gas consumption replaced with biogas and syngas. In addition, the government provides grants up to 30% of investments in AD facilities and a €0.50€/MWh premium for those using the heat generated. The Nordic country also opened 3 new biomethane plants in 2013 bringing the total to 8, as well as 5 new biomethane filling stations bringing the total to 23. Finland sees biogas as an important tool not only to meet its 2020 renewable energy targets but also to reduce its dependence on imported natural gas [14].

6.1.2 Use of digestate

In Finland, biogas plant digestates and the mechanically separated solid fraction of digestates are typically used as fertilizers in agriculture. Their raw materials are not restricted by legislation; however, digestates solely produced from sewage sludge are more often utilized in landscaping than in agriculture. Liquid fractions of digestates can be used as fertilizers in agriculture if the raw materials contain a maximum of 10% of sewage sludge [15].

6.1.3 Legislation

Support scheme in 2014

The type of support scheme is Feed-in Premium (FIP), duration 12 years. The investment subsidy is up to 40% [3].

Digestate

The digestate from a farm-scale or farm-cooperative biogas plant is to be sold or handed over to third parties (i.e. other than the farmer or the partners in the coop-

erative), hygienisation may be required depending on the raw materials used, while the hygienisation is not compulsory, when the farmer or partners in the cooperative use the digestate themselves. The farmers, intending to use the digestate on their own fields, should also pay attention to the nutrients contained in the co-substrates. The farm(s) should have sufficient field area for the application of also these 'new' nutrients, additional to those already contained in their manure. Larger biogas plants intending to post process the digestate into marketable fertiliser products have no such problems, but rather prefer receiving more nutrients [16].

6.2 Germany

6.2.1 Biogas Industry

In 2014, 7 944 plants in Germany with a total capacity of 3 859 MW generated more than 26 billion kWh of electricity, firmly establishing the country's position at the top of the international rankings. There is no other country which will even approach Germany's results. The German biogas industry is in a correspondingly strong condition, with 41 000 people employed in the construction and operation of biogas plants in 2014 and an annual turnover of approximately 7.9 billion Euros. However, the domestic market is actually shrinking and the amendment to the German Renewable Energy Sources Act passed in August 2014 (EEG 2014) will exacerbate this. All the more reason for the industry to look towards the export markets. After all, the German biogas industry currently leads the way in terms of technology – not least because technological development here began much earlier than in many other countries. This goes from digester biology right through to cogeneration plants: A great deal of R&D has been invested in the former, especially with regards to energy crops, and the efficiency of the latter has increased dramatically in the past two decades. Mature thermal concepts are also a characteristic of the industry in Germany – such as the incorporation of biogas in bioenergy villages with a local heating system. The next step is now the integration of biogas into the electricity market. This could, for example, be through the provision of regulating power; Germany is far ahead of many other countries in this aspect, too [17].

6.2.2 Use of digestate

In Germany, the majority of the digestate is used without further treatment and only about 10% of the plants treating waste produce compost from the output of the digestion process. The liquid phase is separated after digestion and the separated fibre is generally post-composted. Only 6% of the quality assured digestate (BGK label) is produced as solid digestate in Germany. Liquid digestate (94% of whole digestate) is used directly as fertilizer in agriculture [7].

The share of manure input has a major impact on the amount of digestate produced during the fermentation process, since the energy content of manure is low. In a reform of the EEG in 2008, an additional bonus per produced energy unit was introduced. Plants receive this bonus if they apply a minimum share of 30% manure as an input. Hence, it can be expected that the share of manure and therefore the amount of digestates will increase. For the German federal state of Lower Saxony, conclude that transport costs of manure and other animal excrements have a significant impact on the profitability of farms. This indicates that transports of digestates could pose similar effects on profitability of biogas plants. In order to de-

crease transport costs of digestates, there are several technologies to reduce the water content with screw press separators, screening drum presses and decanter centrifuges being the most common ones. These techniques are sub-processing techniques and do not process the digestates to water or dry productions, but to a thin phase and a more or less solid phase. Both need to be spread on field, though the solid phase contains a much higher amount of nutrients and less water. Because of its nutrient content, the economic value of the solid phase is comparable to mineral fertilisers. The impact of processing on profit is most significant in regions with nutrient surpluses (Borken) or regions with high heterogeneity of land and a low share of agricultural land on total land area (Siegen). For solid digestates, the value of nutrients and consequently its possibility to substitute mineral fertilisers depends on regional nutrient balances and prices of mineral fertilisers. Presumably, disposal costs are thus higher in regions with high livestock densities (nutrient surpluses) [17].

Processing and transport costs of digestates are plant size specific, and there might be trade-offs between economies of scale in processing costs and diseconomies of scale in transportation costs. Another issue is whether there are regionally different costs for transportation of digestates which affect total disposal costs. Regional factors, affecting costs for digestates transports are availability of land the digestates can be disposed to as well as restrictions in disposal per area unit. Restrictions, in turn, are mainly determined by nutrients in manure from livestock production. Lower Saxony like other north-western parts of Germany is faced with (too) high nutrient concentrations in soil from livestock production, causing restrictions in manure and digestates disposal. In addition, particularly in these regions an extension of biogas production is observed and still expected to grow, adding additional pressure on land availability for the disposal of digestate. These restrictions cause transport costs of digestates that differ regionally [8].

6.2.3 Legislation

Support scheme in 2014

Type of support system for biogas is FIT. The highest FIT for biogas was 237.3 €/MWh. From 1.1.2016 degression of 0.5% per quarter. If cap of 100 MW is exceeded, degression will amount to 1.27% per quarter. Duration is 20 years. Tax reduction: Tax exemption is for use of biogas and biomethane in CHP and as fuel. Partial exemption for electricity tax, operation of CHP and biogas plant. Subsidies: KfW subsidies of up to 30% for biogas plants, KfW and BAFA subsidies for heat distribution networks, biogas pipelines and storage [3].

Sanitary regulations

In Germany there are high restrictions with regard to animal wastes and residues due to the risk of the spread infections (pathogens) from animal to animal or animal to human during the value chain production. Therefore, binding legal regulations and technical measurements exist (Nebenprodukte-Vo (EG) No. 1774/2002. If animal by-products are digested in a biogas plant, it has to be secured that the arrears from digestion of biogas plants can be utilized as fertilizers on soils. That means that the digestate cannot contain any other animal products than substrates declared as “animal by-products”. Animal by products are defined in §2 (2) No 2 KrWG and TierNebV Annex 4. According to these laws, animal by-products include manure, contents of stomach, intestine and rumen, milk and colostrums. Fur-

themore if animal by-products, non-pasteurized kitchen and food wastes are digested in a biogas plant, the plant is to be located with a complete separation from the feed, litter and stalls where animals are kept, in order to prevent the spreading of diseases (§3-5 TierNebV). The operators of biogas plants digesting animal by-products have to probe the digestate regularly to avoid harms [1].

During the process of producing electricity, also waste heat is generated, that can be utilized for process itself easily. However, the utilization of the self-produced electricity is not yet widely realized. The amount of 15-25% of the heat demand of biogas plants can be produced without additional costs of the biogas plants [1].

Environmental regulation and agricultural use of digestate

Regulations for organic wastes include substrates such as following: any deviant substrates need special assessment and permission from responsible local authority (Annex 1 (1a) BioAbfV):

Substrates	Examples	Add. Regulations
Plant residues, that are used for own use (distributed on own areas) -	- From horticulture - From agriculture - From fisheries	
Animal feaces (except waste water – needs to be collected and treated seperately) -	- Slurry - Manure (liquid and solid - Straw	Hygenic regulations for prevention of spreading of infections (Nebenprodukte Vo (EG) Nr. 1069/2009)
Wastes from forestry -	Plant residues from forestry	Material has to be broken up
Wastes from food and feed production, that cannot be consumed further	- Arreas from digestion from starch production, fruit and vegetable processing - Cereal residues - Molasses - Oilseed arreas - Colza cake	Nebenprodukte Vo (EG) Nr. 1069/2009 §10 (1) No1-2 §7 (1) No1
Wastes from alcoholic distillation	Mash, brewer grains from fruits, cereals and potatoes - Spent and hop grains	§7 (1) No1 §10 (1) No1-2
Degradable organic residues from kitchen and canteens	Organic wastes Contents of fat separators	Material from fat separators only applicable with anaerobic digestion
Cooking oils and fats Municipal organic wastes	Separated organic waste Organic market waste	§7 (1) No1

Products of animal origin, animal by-products are subject to the TierNebV rather than the BioAbfV:

Animal by-products, not meant for the human consumption	Content of stomach, intestine and rumen Manure Milk and colostrum	Only if stomach, intestine and rumen contents originate from by human edible animals
Slaughterhouse Wastes	Slaughterhouse body parts Skin, hooves, horns etc.	According to Verordnung (EG) No. 1774/2002

	Blood from non-ruminants Former foodstuff with animal origin

Non-hazardous digestate can be distributed to agricultural and horticultural areas with a limitation of 20-30 t DM of organic waste within three years according to §6 (1) BioAbfV and §8 (1) Düngeverordnung and § (1) No 1 Düngegesetz [1].

Additional requirements are needed for utilizing digested organic wastes for grassland and vegetable gardening. They need to be applied before plants are cultivated (§7 (1-2) BioAbfV) [1].

It is important to know the amounts of toxics in residues as co-substrates, whenever the digestate is utilized as farm fertilizer in the end. Since toxics cannot be separated from the rest of the digestate, they would harm soils and plants (BioAbfV).

Heavy Metal Limitations	mg/kg DM of digestate
lead	150
cadmium	1.5
chrome	100
copper	100
nickel	50
quicksilver	1
zinc	400

There is a need for regularly tests to probe the digestate in terms of pathogens, viruses and bacteria.

The institution managing and utilizing organic wastes is obliged to proof via supporting documents, that organic wastes had a proper disposal and how organic wastes have been treated and utilized (§11 BioAbfV) [1].

6.3 Slovenia

6.3.1 Biogas Industry

Use of biogas increased in period 2000-2012 for 951 %, especially in 2008. Growth was decreased in 2013 for 8,9%, which can be attributed to the intensification regarding feedstock [18]. The production of electricity power in Slovenia was 123.8 GWh in 2012. These are mainly agricultural biogas plants in size 1 MWe [19].

In Slovenia, in 2009, 32.4 kt of organic waste was collected, 19.2 kt from catering and 13.1 kt from households. In 2007, 2.9 kt of organic kitchen waste was composted and 2.8 kt was anaerobically digested [7].

Borzen, Slovenian power market operator, reports there were 32 biogas plants in operation (including landfill gas) in Slovenia with a rated output of 34.9 MWe of cogeneration units on 1-Jan-2015 [20].

Table 3: Slovenian biogas plants, name and net electrical power in kWe [20]

#	Unit name	Management company	Net E power (kW)	Primary sub-strate
1	Mala bioplinska elektrarna Flere	Bio Term d.o.o.	110	Agro biomass
2	BPE Organica Knaus 1	Bioplin Knaus, Dejan Knaus s.p.	250	Agro biomass
3	Bioplinarna Antares	Bioplinarna Antares, d.o.o.	500	Agro biomass
4	Bioplinarna Motvarjevci	Panvita Ekoteh d.o.o.	775	Agro biomass
5	Bioplinarna Jezera	Panvita Ekoteh d.o.o.	929	Agro biomass
6	Elektrarna na bioplin Ihan	Petrol d.d., Ljubljana	962	Agro biomass
7	Sistem za zajem emisij - bioplinarna Draženci	PP Energija, d.o.o.	970	Agro biomass
8	Elektrarna na bioplin Dobrovnik	Petios, d.o.o.	985	Agro biomass
9	Elektrarna na bioplin Ginjevec	Plinprom d.o.o.	985	Agro biomass
10	Elektrarna na bioplin Logarovci	Plinprom d.o.o.	985	Agro biomass
11	BPE Organica Arnuš 1	Branko Arnuš s.p.	999	Agro biomass
12	BPE Organica Gjerkeš 2	PETIOS, d.o.o.	999	Agro biomass
13	BPE Organica Jurša 1	SOLVUS d.o.o.	999	Agro biomass
14	BPE Organica Nova 1	Biomasne storitve d.o.o.	999	Agro biomass
15	BPE Organica Nova 2	Biomasne storitve d.o.o.	999	Agro biomass
16	BPE Organica Nova 3	Biomasne storitve d.o.o.	999	Agro biomass
17	BPE Organica Nova 4	Biomasne storitve d.o.o.	999	Agro biomass
18	BPE Organica Šijanec 1	iEnergija d.o.o.	999	Agro biomass
19	BPE Organica Vargazon 2	Pulverem d.o.o.	999	Agro biomass
20	BPN Organica Vargazon 1	Pulverem d.o.o.	999	Agro biomass
21	Bioplinarna Nemščak	Panvita Ekoteh d.o.o.	1459	Agro biomass
22	Bioplinarna Lendava	ECOS d.o.o.	7093	Agro biomass
23	Plinska elektrarna KOTO	KOTO d.o.o.	381	BioWaste
24	Bio future, družba za ravnanje z biološkimi odpadki d.o.o.	Bio futura d.o.o.	814	BioWaste
25	Bioplinska elekrarna Lokve	PETROL d.d., Ljubljana	999	BioWaste
26	SPTE	JP CČN Domžale - Kamnik d.o.o.	450	WW sludge
27	Bioplinska elektrarna Papirnica Količevo	Količevo Karton, d.o.o.	518	WW sludge
28	Mala plinska elektrarna Odlagališče Dogoše	SNAGA d.o.o.	308	Landfill gas
29	MPE Tenetiše deponija	KOMUNALA KRANJ d.o.o.	469	Landfill gas
30	Mala plinska elektrarna Snaga, Maribor	Snaga d.o.o.	625	Landfill gas
31	Mala plinska elektrarna Bukovžlak	SIMBIO d.o.o.	1669	Landfill gas
32	Plinska elektrarna Barje	SNAGA d.o.o.	2702	Landfill gas

Slovenia supports the use of energy from renewable sources, but this policy is also changing. Without appropriate support schemes there is no interest for the construction of biogas plants. In 2011, the Regulation on support for electricity from renewable energy sources was amended, which has restricted the use of the main crops for new biogas plants and consequently the interest of investors for the construction of biogas plants was reduced. Biogas is currently used for the production

of electricity and heat – the heat use is not sufficiently exploited. Purified biogas – biomethane could be also used for vehicle propulsion or for the distribution of natural gas in pipelines, but this is not subsidized. It is ironic that Slovenia has problems to comply with the 10% renewable fuels in transportation fuel by 2020 but no policy regarding biomethane as transportation fuel is in place. Development of agricultural biogas plants depends also on the agricultural potential which is between 86 and 147 MWe [19].

In Slovenia stagnation in production of RES from biogas was noticed in 2012 for agricultural biogas plants, which use biomass as incoming substrate, because of lack of substrates for AD and in spite of the fact that number of biogas plants increased in 2011 and 2012. Drougt and other weather impacts in agriculture caused problems with energetic plants crops. Some agricultural biogas plants applied for IPPC approval. Subsidies for produced electricity from biogas were 16,9 mio EUR in 2012 and 16,3 mio EUR for produced electricity from biogas 132,2 GWh in 2013 [20].

6.3.2 Use of digestate

Digestate is mainly directly used as fertilizer or dewatered and both fractions used as fertilizer. Couple of biogas plants have equipment for sludge drying (Belt dryer). In one biogas plant (KOTO) digestate is dewatered and liquid part treated as waste water in WWTP, solid fraction is dried in place and distributed to co-incineration plant.

In Slovenia, there were 11 anaerobic digestion plants in 2013, of which only 7 treat agricultural biomass. Digestate is spread on agricultural land, whereby restrictions apply on the amount of nitrogen according to the Decree concerning the protection of waters against pollution caused by nitrates from agricultural sources (Official Gazette of the Republic of Slovenia, no. 113/09). The other 4 anaerobic digestion plants treat mainly catering waste, slurry and silage (corn) and the digestate (mainly liquid) is also spread in agriculture when it meets the requirements of the Decree on the treatment of biodegradable waste (waste legislation) [7].

New legislation regarding biodegradable waste treatment in AD and use of digestate is in force since 2013 In Slovenia, Decree on the treatment of biodegradable waste and the use of compost or digestate. (Official Gazette No. 99/2013). This Regulation of the Government of the Republic of Slovenia lays down conditions of the treatment of biodegradable waste and the use and marketing of compost or digestate, in accordance with Directive 2008/98/EC of the European Parliament and of the Council on waste and repealing certain Directives. This Decree applies to biodegradable wastes listed in Annex 1 to the Decree. This Decree is composed of the following Sections: General provisions (Sec. 1); Treatment of biodegradable waste (Sec. 2); Use of compost or digestate (Sec. 3); Marketing (Sec. 4); Control (Sec. 5); Penalty provisions (Sec. 6); Transitional and final provisions (Sec. 7).

6.3.3 Legislation

Support scheme in 2014

Type of support system for biogas is FIT. The highest FIT for biogas was 160.56 €/MWh, duration 15 years. Additional subsidies are earned from Common Agricultural Policy from 40% - 70% [3].

One of the main stimulations is the guaranteed prices and premiums of electricity or the operating support, where every biogas operator may choose only one of them. The guaranteed purchase price consists of the difference between the operating support and the current electricity price, while the operating support is the current electricity price on the market.

In the year 2009 the Ministry of the Economy of the Republic of Slovenia, Directorate for Energy (which is in charge for the establishment of a legal framework for fostering of the RES use), adopted the new support schemes (the Decree is valid from 01.11.2009) for the electricity generated from renewable energy sources. Regulation supports for the electricity generated from renewable energy sources.

With market growths following obstacles were observed:

- Sustainable way of biogas production
- Energy crops
- Environmental permits (more generally construction and other permits – a project needs more than 25 endorsements/permits)
- Digestate handling
- Public opinion

Substrates

New legislation regarding biodegradable waste treatment in AD and use of digestate is in force since 2013 In Slovenia: Decree on the treatment of biodegradable waste and the use of compost or digestate (Official Gazette No. 99/2013).

The Decree aims to improve the efficiency of processing biodegradable waste and using compost and digestate. It lays down rules for the treatment and recovery of biodegradable waste, use of compost or digestate, as well as setting rules when compost and digestate ceased to be waste, which accord with the draft European End-of-Waste criteria.

The key points of this Decree include:

Defining a ‘positive list’ of separately collected biodegradable waste deemed suitable for aerobic and anaerobic treatment. Notably, municipal sewage sludge and mixed municipal waste are both excluded from the list;

Requiring plant operators to visually inspect incoming wastes, document consignments and daily operations in a diary. This includes assigning batch numbers to wastes, and monitoring sanitation parameters, such as temperature, moisture, turning regimes and hydraulic retention times. The anaerobic process must follow the treatment requirements set in the EU Animal By-Products Regulation;

Setting operational parameters, such as defining minimum distances from plants to residential areas, and requiring operators to maintain a log book detailing any complaints they receive about the plant, as well as meteorological data;

Establishing National Rules for Category 3 animal by-products derived from separately collected kitchen waste intended to be composted or composted following anaerobic digestion, and

Requiring analysis of the end product using an independent, accredited laboratory.

The Decree also places obligations on plant operators to record the quantities and end uses of compost and digestate. It sets out application rates, which are dependent upon the quality of compost and digestate and its intended use, e.g. whether it is used on agricultural or non-agricultural land. Threshold values for certain chemical contaminants have also been established for the first time [21].

Digestate

Digestate is spread on agricultural land, whereby restrictions apply on the amount of nitrogen according to the Decree concerning the protection of waters against pollution caused by nitrates from agricultural sources (Official Gazette of the Republic of Slovenia, no. 113/09). The other 4 anaerobic digestion plants treat mainly catering waste, slurry and silage (corn) and the digestate (mainly liquid) is also spread in agriculture when it meets the requirements of the Decree on the treatment of biodegradable waste (waste legislation) [7].

6.4 Spain

6.4.1 Biogas Industry

The biogas is an emerging energy source in Spain. After a failed trial to promote biogas production in the livestock sector during the 80's, most of the current biogas is produced as landfill gas. The current Renewable Energy Plan predicts an increase of the currently installed 156MW of biogas in 2010 to 204MW in 2014 and 400 MW in 2020. According to the IDAE (Institute for Energy Diversification and Savings www.idae.es) 83% of the total electricity injected to the grid produced by biogas used landfill gases in 2008. The contribution of livestock manure to biogas production is minimal and thus not registered. It is expected, though, that more than 50% of this biogas production in 2020 will come from agroindustrial plants as it is the most undeveloped and therefore the most promising sector in biogas [22].

Specific biogas plants for the primary sector are beginning to be implemented and several plants are now under construction. According to the CNE (National Energy Commission) there are 30 active biogas plants in Spain producing 159GWh in 2011, with an average of 1.23 MW installed per plant. More specifically in Catalonia, there are 12 biogas plants from the agricultural and livestock industries with a total installed power of 14MW and producing a total of 98GWh in 2011 [22].

6.4.2 Use of digestate

In Spain, in 2008, 504 ktonne of digestate from sewage sludge was produced in 185 plants. In general digestate or separated fibre from digestate is composted, the separate liquor is treated as wastewater or it is recycled into the process. The resulting compost is mainly sold to agriculture. Besides, digestate from the co-digestion of manure with other biodegradable waste is used directly in agriculture [7].

6.4.3 Legislation

Support scheme in 2014

Type of support system for biogas is FIP. Duration 15 years. A new remuneration system is in place. It consists in two remuneration concepts, a fixed amount depending on installed electrical capacity, under or over 500 kWel., and year of entering into service, and a second remuneration to compensate operation and maintenance [3].

The main regulations affecting biogas plants

The main regulations are summarized below:

- Environmental regulations: Law 22/2011 on waste, Law 1481/2001 on landfills, Law 16*2002 on IPPC, plan for biodigestion of animal slurry.
- Use of biogas: Royal Decree 413/2014 on electricity production from renewable sources, Order IET/1045/2014.
- Agricultural use of digestate: Royal Decree 506/2013 on fertilizers, Royal Decree 261/1996 on nitrogen from agricultural sources.
- Sanitary regulations: Royal Decree 1528/2012 on animal by-products.

Sanitary regulations

The Royal Decree 1528/2012 establishes the conditions for the application of the EU regulation on animal by-products (ABP). It does not modify the restrictions imposed by the Regulation EC 1069/2009. These restrictions are mainly related to the kind of materials allowed to enter the biogas plants and the required pre-treatment, and hygienic measures of the biogas plant using ABP.

Environmental regulations

Law 22/2011 on waste:

The objective of this law is to establish the legal framework for the production and management of waste, as well as the measures to prevent its generation and to avoid or reduce their negative impacts on human health and the environment.

The following materials are not considered as waste: straw and other natural material, agricultural or forestry, not dangerous, used in farms, forestry or bioenergy production.

There is a specific section in this law dedicated to the biowaste, promoting its segregated collection in order to use them in anaerobic digestion of composting processes.

Royal Decree 1481/2001 on landfills

This Royal Decree limits the amount of biodegradable municipal waste allowed to be disposed in landfills. The maximum amount in 2016 is 35% of the amount of 1995 (4.071.550 t).

Law 16/2002 on IPPC

The law on integrated pollution prevention and control (IPPC) establishes the obligation for the facilities in the Annex to abtain a unified permit (Integrated Environ-

mental Authorisation) that includes all environmental permits: environmental impact, waste management, water use and treatment, air emissions, etc.). The small scale biogas plants will probably not affected by this law, since the regulation establishes the limit in 50 tons per day, which is probably more than the daily feed of these plants.

Plan for biodigestion of animal slurry

The Spanish Ministry of Environment launched this initiative in 2008 with the main objective to reduce the GHG emissions from the farming sector. It is regulated by the Royal Decree 949/2009. It is intended to give grants for the investment in facilities by the Royal Decree slurries, even with low-tech scgemes. The co-digestion with other types of waste is limited, and therefore farms are the main beneficiaries of this initiative.

Use of biogas

Royal Decree 413/2014 on electricity production from renewable sources

This Royal Decree regulates the calculation of the feed-in-tariffs (FIT) for the electricity production from biogas. This applies to the biogas plants that are producing electricity and selling it to the grid. The FIT is composed by two parts: one to compensate the investment costs and other to compensate the operating costs, in both cases assuming that these costs are not recovered when the biogas plant is selling the electricity at the market price. The calculations assume that the adequate internal return rate is around 77.5%. The amount of working hours of the biogas plant that can be claimed for feed-in-tariff is much lower than the actual working hours of the biogas plant, that are usually more than 8000 hours/year. The feed-in-tariff can be changed every 3 years.

These measures, together with the tax on hydrocarbons applied to biogas (0.65 €/GJ) have caused a significant reduction of the biogas sector activity in Spain.

Order IRT/1045/2014

This order fixes the retributive parameters for the calculation of the FIT regulated by the above mentioned Royal Decree.

Draft of Royal Decree for self-consumption

This Royal Decree will regulate the energy self-consumption. In the current draft, a tax named “backup toll” is established for these facilities that are connected to the public electricity grid just in case the biogas plant is not operating. This backup toll applies even to the energy generated in the biogas plant and self-consumed by the industry. This measure has risen controversy in this sector. However, the definitive text of the regulation is still not available at the moment of writing this report.

Agricultural use of digestate

Royal Decree 261/1996 on the protection of water from the pollution caused by nitrates from agricultural origin

It limits the amount of nitrogen from agricultural sources to be applied to the land to 170 kg-N/Ha/year in the so-called “vulnerable areas”. This could be a limitation for the implementation of biogas plants in the areas where intensive farming is the predominant economic activity.

Royal Decree 506/2013 on fertilizers

This is the basic regulation of fertilizers in Spain. It includes the "organic biodegradable waste" as possible raw material to produce certain types of regulated fertilizers. It classifies the fertilizers according to their origin and establishes the minimum amounts of nutrients and organic matter that should be present in order to consider the materials as fertilizers or soil amendment. In most of the cases, the minimum amount of nutrients is much higher than the usual content in the digestate, and therefore a further treatment (usually composting) is necessary if the digestate is to be sold under this framework. However, it is possible to use the digestate in bulk without being considered as fertilizer or soil amendment in the sense of this regulation [1].

6.5 Sweden

6.5.1 Biogas Industry

In a Swedish perspective, biogas has been produced and used within sewage treatment plants since the 1960s. Biogas has been used as a vehicle fuel since the early 1990s. Today, there are 229 plants that produce biogas in Sweden amounting to 1387 GWh biogas. However, it is also possible to increase the total amount of biogas produced. The majority of the plants are sewage treatment plants where biogas is a by-product. Of the total biogas production, 44% was upgraded and used as vehicle fuel. Some of the biogas was also injected in the natural gas grid. However, only a small part of the south of Sweden has access to this grid, which means that the entire infrastructure for distribution of biogas needs to be developed for a new biogas system [23].

Biomethane

Sweden has the governmental aim to have a fossil-independent transportation sector by 2030. A public inquiry was open in August 2014 to show how fossil free transportation can be reached in 2050 and the results are expected to be important for the future governmental support for biomethane production in Sweden. The potential to produce biomethane from both biogas from anaerobic digestion and gasification until 2030 is estimated to be 10-20 TWh of biomethane if the conditions are right [24].

6.5.2 Use of digestate

In Sweden 389 ktonne fresh matter/year digestate was produced in 2008 (with an average dry matter content of 10%). The input material for anaerobic digestion consisted of source separated biodegradable fractions of municipal solid waste (17%), commercial food waste (18%), manure (24%), slaughterhouse residues (29%) and other biodegradable wastes (12%). in 2009, 97% of the digestate produced from anaerobic treatment plants was used in agriculture, mostly as whole digestate. Three of sixteen plants separate the digestate. One of them uses the separated fibre and the liquor phase in agriculture; the other two plants compost the separated fibre. Based on ammonia nitrogen content and phosphorous, digestate with 4% dry matter content is estimated to have an economic value of 4.5 Euro/ton digestate in Sweden [7].

6.5.3 Legislation

Support scheme in 2014

Type of support system for biogas is FIT or quota (Renewables Obligation Certificate); Renewable Heat Incentive (RHI). Highest FIT for biogas was 197 €/MWh (an inflation-indexed payment rate table is published every year prior to February 1. Duration 20 years. Tax reduction: Electricity from renewable sources is eligible for tax relief. Subsidies: On-Farms AD: launched in October 2013 to help support the development of new farm based AD in England. The fund will be applicable to subsidise 250 kW plants which have access to alurry and/or manure.

AD Loan fund: launched in 2011 to help support the construction of food waste digesters. The scheme offers loans of between £50 000 and £1 million.

Rural Communities Renewable Energy Fund: a £15 million fund launched in June 2013. It provides up to £150 000 of funding for feasibility and preplanning development work to help community renewable energy projects become investment ready [3].

Substrates

In Sweden, in the decade preceding the year 2009, landfilling nearly faded out completely, whereas biological treatment of biodegradable waste increased steadily. In 2009, 536 ktonne of biodegradable waste was treated by anaerobic digestion and 631 ktonne by composting [7].

Digestate

In Sweden all digestate from the biogas plants is used as a liquid organic fertilizer on the fields. The Digestate from source sorted household waste and restaurant waste is approved for ecological farming in all of Europe and is a fantastic fertilizer for most crops. Our field tests in Berga Agricultural school has every year given a higher yield of barley then mineral fertilizer both field have been given 90 kg ammonium Nitrogen per Hectar and year. The disadvantage is the large volumes you have to transport and store as we in Sweden must have a storage capacity of 10 months production to have the biofertilizer certified.

Sanitary regulations

The requirements for hygenization in Sweden follows European Union legislation on animal byproducts (ABPs) N^0 142/2011 including the never ending additions and changes to this regulation. This legislation also dictates limitations on how and under what conditions animal related agri-food industry by products can be used for biogas production [1]

Landfilling of organic waste is prohibited in Sweden since 2005. In 2002, a national environmental objective was instated aiming for at least 35 percent of food waste from households, restaurants and shops to be recycled through biological treatment, including home composting by 2010. This goal was not achieved, but nearly 25 percent of food waste is currently recycled by biological treatment [1].

The government has now decided to introduce a number of new milestones in areas such as waste management to be achieved by the year 2018. For example resource recovery in the food chain should increase by ensuring that at least 50 per-

cent of food waste from households, shops and restaurants is separated and treated biologically so that energy and plant nutrients can be recovered [1].

Environmental regulations

The Swedish Environmental Code (Miljöbalken MB, 1998:808) is a comprehensive legislation related to all environmental impacts. The Act came into force on 1 January 1999 and is based on the principle that we who are alive now should act in a way that does not harm the environment and depletes natural resources for the future. The use of land, buildings and equipment, which through emission or otherwise could harm health or the environment is termed environmentally hazardous activities [1].

According to the definition in the Environmental Code, biogas production ia an environmentally hazardous activity (Chapter 9, Section 1). A so-called environmentally hazardous activity does not need to be particularly dangerous. The definition is more relevant to determine whether an operator needs to seek permission for an activity of just notify the authorities about the activity [1].

For this purpose activities are divided into A, B and C operations with different limits and different requirements. The activities are also linked to activity codes. Biogas plants are classified based on the activity codes for gaseous fuels and biological treatment that can be found in the Environmental Inspection Ordinance (Miljöprövningsförordningen 2013:251).

Small scale agri-food biogas production at < 100 kW might be a C-activity covered by code 40.20 or 90.170 (substrate volume 10 < 500 tonnes/year), which means that notification of authorities would suffice.

Larger projects may be deemed a B-activity under codes 40.10 or 90.160 (methane production > 150000 Nm3/year and/or substrate volume >500 tonnes/year), which means that a permit would be required.

Operators of both types of activities would have to convince the regulator that measures have been taken to minimize any potential negative environmental impact of the activity in accordance with the Environmental Code. Proving this can be complicated and sometimes expensive as it may require consultant help to write the application and complete an environmental assessment of sufficient quality that will pass the regulator [1].

Agricultural use of digestate

In Sweden, there is a voluntary certification system in place for anaerobic digestate, the SPCR 12019. This SPCR is a quality assurance system for both the process and the quality of the end product, digestate. The requirements for the final digestate product according to this QAS are listed in "Annex 14: Swedish SPCR 120". However, as in the case of compost guided by SPCR 152 QAS, digestate complying with the SPCR 120 quality label continues to have a waste status. Substrates for certificated digestate should be clean, source separated and easily biodegradable. Sewage sludge is not included in the input materials list, but manure is allowed [25].

If the digestate is to be sold as fertilizer, i.e. not just used on own property, the digestate producing plant has to be approved by the Swedish Board of Agriculture. The European Union Animal By-Product regulations apply. The rules apply for storage and land application of digestate as for animal manure [1].

Rules exist for Nitrogen and Phosphourus application rates and timing of application SJVFS 2004:62, as well as maximum application rates of heavy metals SNFS 1994:2 and 1998:944. In addition, certain areas in Sweden are considered extra sensitive from nitrogen leaching or eutrophication perspective. These areas have stricter limits with respect to land application and additional rules about preventing ammonia emissions from storage of organic fertilizer (including digestate) through some type of storage cover (minimum natural crust) (SFS 1998:915) [1].

In Sweden the term biofertilizer is used exclusively for digestate certified according to certification system SPCR120. SPCR120 was created in 1999 as a voluntary certification system for digestate from biogas plants. The system is owned and so far financed by the association Avfall Sverige – Swedish Waste Management. In February 2013 there are total 14 biogas plants and 3 compost plants with certificates. The background to the system was to build market confidence for high quality products with origin in source separated organic waste. It was also important that the market actors regarded digested as different products compared with sewage sludge. During the 90's it was common that digestate and sewage sludge was regarede as the same products. Thus, the certification system for digestate does not accept any products from the sewage sector as substrate, i.e. sewage or septic sludges [1].

The system has a positive list for which types of substrates that are accepted. The substrates have to be clean and source separated organic wastes (e.g. organic household waste, organic waste from restaurants), manure and agricultural crops like silage. Organic waste with animal origin has of course to follow the EU animal byproduct directive (e.g. manure, slaughterhouse waste, meat from retail shops). In principle only substrates with food or feed origin are accepted [1].

A one-year qualification time is observed before a plant will get certificate. During this qualification year all analysis has to meet the requirements in the system like maximum heavy metal content (Cd, Cr, Cu, Hg, Ni, Pb and Zn), disease control and visible impurities. A plant with a certificate needs to have a documented and structured working procedure. Supervisory inspection is carried out by the certifying body through producer visits and inspection of the producer's self-monitoring system [1].

Certified digestate is widely accepted as fertilizer among farmers, food industry and authorities. Today all Swedish food industries or associations accept certified digestate as a fertilizer. Even the Swedish food certification system KRAV accepts certified digestate to be used as fertilizer, as long as the substrates follow what is accepted according to the EU directive for ecological production [1].

6.6 United Kingdom

6.6.1 Biogas Industry

The number of biogas plants in UK increased from 3 012 (in 2012) to 360 (in 2013), therefore UK is growing biogas market and interesting for our market analysis. Biogas plants in UK are agriculture (62), sewage (146), landfill (75) and other (52); other meaning biowaste and industrial biogas plants. Majority of UK biogas plants is based on landfill gas and generates 78% of electricity, but in 2013 the biggest increase was in agricultural plants-for 13%. The number of agricultural and waste based plants almost doubled between 2011 and 2013 [3].

UK produces 16 591 GWh/year, generates 6 636 GWh electricity and 0,4 GWh thermal energy [3].

The majority of substrates in biogas plants in UK represents sewage sludge; 1.6 million tonnes were processed in 146 plants; followed by biowaste, industrial feedstock and small procent of energy crops [3].

6.6.2 Use of digestate

According to the UK Organics Recycling Group, whole digestate may be suitable for use as biofertiliser, soil conditioner and, if sufficiently low in dry solids content, as foliar feed for plants. Separated liquor may be suitable for use as biofertiliser, soil conditioner and, if sufficiently low in dry solids content, as foliar feed for plants. Separated fibre may be suitable for use as biofertiliser, soil conditioner and mulch. In 2013, there were 111 anaerobic digestion facilities not related to wastewater treatment works, comprising 46 farm-fed installations (manures, slurries, crops), 47 food-waste fed installations and 18 industry fed installations (distilleries, dairies). The UK has developed an AD Quality Protocol, which defines end-of-waste for digestate. As of 2013, twelve plants are producing digestate certified to the Publicly Available Specification PAS 110 and the AD Quality Protocol [7].

There must be enough land in the vicinity of the digester that can accept the digestate within the restrictions of Nitrate Vulnerable Zones (NVZs), 62% of land in England and 4% in Wales falls within NVZs. If haulage and/or storage costs are prohibitive, there could be alternative routes like composting or using a sewage treatment works [26].

6.6.3 Legislation

Support scheme in 2014

UK has two support systems for biogas: FIT or quota (Renewables Obligation Certificate) and Renewable Heat Incentive (RHI). Highest FIT for biogas is 197 €/MWh (corrected according to inflation every year prior to Februaray 1). Duration of supporst scheme is 20 years [3].

The UK has two new support schemes. On-Farm AD, launched in October 2013 to help support the development of new farm based AD in England. The fund will be applicable to plants below 250 kW which have access to slurry and/or manure. Rural Communities Renewable Energy Fund is a £15 million fund launched in June 2013. It provides up to £150 000 of funding for feasibility and preplanning development work to help community renewable energy projects become investment ready. AD Loan fund launched in 2011 to help support the construction of food waste digesters. The scheme offers loans between £50.000 and £ 1 million [3].

Permit to spread digestate

Non waste feedstock: if you produce digestate from manures, slurries or energy crops (non-waste), no permits are needed to use digestate. If you produce digestate from waste feedstock, a government permit is and evidence of agricultural benefit are needed or Digestate Standard PAS 110 and AD Quality Protocol. Digestate is not considered as waste if it complies with the Anaerobic digestate quality protocol and produced digestate complies with the PAS 110 standard. Anaerobic digestate quality protocol was developed together with WRAP (Waste & Resources

Action Programme) for producing anaerobic digestate from different types of segregated bio-waste, including food and garden waste. The aim is to help produce a digestate that would not need to be classified as waste. With PAS110 approval, the digestate does not have to be registered as a "waste", which has regulatory controls. Digestate is registered through the biofertiliser certification scheme, administered by Renewable Energy Assurance Ltd [27] [26].

Structure of PAS110:

- Terms and Definitions
- Quality Management System (QMS)
- Hazard Analysis and Critical Control Point (HACCP) System
- Input Materials allowed
- Process Management
- Monitoring, Sampling and Validation - Dispatch and Labelling [28].

Digestate can be used as fertilizer on agricultural land, but certain rules apply:

Waste exemption U10: spreading waste to benefit agricultural land. Digestate goes under waste code 190604: Digestate produced only from the limited range of waste and conditions allowed under T24 and T25 exemptions only. Limit is 50 tonnes/ha/year; in storage limit is 200 tonnes. Following conditions apply: the place where waste that is stored or land which is to be spread must be at least 10 m from watercourse and 50 m from spring, well or borehole. Waste must be stored in secure location before is spread.

Waste must be stored in secure location before is spread and cannot be spread if the land is waterlogged, frozen or covered with snow/has been frozen for 12h or more in the 24 h before you want to start spreading. Records about the amount, nature and origin of all waste spread on land must be kept for 2 years. One can register for this exemption with the Environmental Agency. The same rules apply for waste exemption U11: spreading waste to benefit non-agricultural land.

Waste exemption T24: anaerobic digestion at premises used for agriculture and burning resulting biogas. This exemption allows farmers to anaerobically digest manure, slurry and vegetation on their farms to produce digestate that can be used as a fertiliser or soil conditioner. Waste used in anerobic digeston can be stored-up to 1250 m^3 of waste at any one time. Waste must be kept in digester for at least 28 days; collect and burn the produced biogas to produce energy; net rated thermal input of less than 0,4MW on the AD plant biogas burner must be used; combined net rated thermal input of less than 0.4 MW must be used if there is more than one burner associated with AD plant.

If the only waste feedstock to the AD process is farmyard manure or slurry only, digestate can be spread on agricultural land as a fertiliser or soil conditioner without being regulated as waste. The code of good agricultural practice and any requirements for Nitrate Vulnerable Zones must be taken into account.

Waste exception T25: anaerobic digestion at premises not used for agriculture and burning resulting gas. This exemption allows treating food and other biodegradable waste by anaerobic digestion to produce a digestate, which can be used to benefit land. The gas produced (biogas) must be used for generating energy.

Types of activity allowed under this exemption: a business or organisation, such as a hotel, prison or hospital using a small anaerobic digestion plant for their kitchen

waste producing digestate for use on the gardens and biogas to generate electricity sorting, screening, cutting, shredding, pulverising and chipping the waste to help the AD process.

Treating hazardous waste is not allowed, for treating waste that is an animal by-product an authorisation from Animal Health is needed.

Waste that can be treated under this exemption: plant tissue waste (trees, shrubbery, branches, leaves, foliage wood and vegetation), horse and farmyard manure only, paper and cardboard, biodegradable kitchen and canteen waste, fully biodegradable animal bedding, animal tissue waste, materials unsuitable for consumption or processing, biodegradable wastes from markets only. 50 m^3 of waste can be stored or treated up at any one time. Waste must be kept in digester for at least 28 days; produced biogas must be collected and burned by the anaerobic digester in an appliance; net rated thermal input of less than 0.4 MW on the AD plant biogas burner must be used; combined net rated thermal input of less than 0.4 MW must be used if there is more than one burner associated with AD plant.

Animal by products can include animal tissue waste or catering waste (used cooking oil, waste food) from kitchens and restaurants.

Future prospects

According to EBA the year 2015 will be an important indicator for the whole renewable energy industry. Six years since adoption of Renewable Energy Directive RED 2009/28/EC and five years after the introduction of National Renewable Energy Action Plans, Members States are halfway from their 2020 renewable energy targets. According to the project Keep On Track, half of the EU countries will fail to meet their 20% renewables target by 2020 and there are doubts about four other Member States reaching their targets, as progress stood in 2014. Biogas was so far performing well, but negative changes or cuts in the support schemes in some countries during the last two years are likely to take the wind out of Europe's sails in the coming years. Since July 2014 all new support schemes have to correspond to the new Guidelines on State aid for environmental protection and energy. The aim of the guidelines was to bring more competition into renewables and to make them more competitive. In fact, the guidelines allow FIT only to biogas plants below 500 kW of electric capacity, while those between 500 kW and 1 MW can be granted a premium. From January 2017, all plants above 1 MW will undergo a technology-neutral bidding process, unless Member States can explain to the Commission why such bidding processes could not work in particular circumstances. These guidelines apply to the period up to 2020; however, they should prepare the ground for achieving the objectives set in the 2030 Framework. Also in 2014, the Council adopted a non-binding target for renewable energy of 27% and a binding GHG reduction target of 40% by 2030. Since there are no national targets but only a European one for 2030, it is very likely that only a handful of ambitious Member States will push on towards an energy transition and will invest into new technologies and capacities, while the rest of Europe will lag behind, feeling no obligation to contribute to the single EU target. The guidelines and the recently established climate and energy targets for 2030 will shape the renewable energy policies and define biogas development in the coming few years. The first country introducing the new guidelines with even stricter rules was Germany, where experts are expecting stagnation of the industry [3].

At the EU level, important decisions are scheduled for 2015. After many delays, the Indirect Land Use Change (ILUC) dossier will be handed over to the European Parliament in January 2015. If the agreement is reached in April, full implementation of iLUC in Member States is expected in 2017. According to the present draft, biomethane for transport from dedicated crops (cereal and other starch rich crops, sugars and oil crops) will be capped at 7%. The rest of the 10% target is planned to be fulfilled with advanced biofuels and renewable electricity. As it stands today, biomethane from straw, manure, sewage sludge, bio-waste, biomass fraction of industrial waste and other non-food cellulosic material is considered as advanced fuels and the energy producer from them will be counted twice towards the 2020 targets. Another relevant dossier for biogas producers is the Fertilisers Regulation proposal which will be passed on by the European Commission to the European Parliament and the Council in early 2015. Although the final version of the proposal was not published yet, it is encouraging to see that digestate will be recognised as organic fertiliser which can be sold across the EU. The final vote on this is likely to take place either at the end of 2015 or in 2016. A dossier with a possible strong impact on the AD sector is the Commission's Circular Economy Package, which aims to ban land-filling and limit incineration of organic waste as well as to significantly increase the EU recycling targets. In this matter, AD is recognised as a recycling process. The recycling industry and environmental organisations asked the European Commission for a prompt implementation of the proposal, particularly after the Commission contemplated the withdrawal of its own proposal back in November. In 2015, we can expect negotiations between both co-legislators. From the very beginning EBA advocates for an ambitious regulation that requires the separation and reuse of waste materials in a sustainable way [3].

According to EurObserv'ER the sustainability requirements of biogas is called into question. The biogas and biomethane production conditions are at the centre of heated negotiations at European Union level. On 28 July, the European Commission published a working document on the sustainability of solid and gaseous biomass used for electricity, heating and cooling. In the section on biogas, the report highlighted the environmental issue stemming from the use of energy crops and encouraged the use of higher percentage of manure, slurry and other organic waste to improve the greenhouse gas emission performance of biogas installations. The report's main line is that the percentage reduction in greenhouse gas emissions from bioenergy such as biogas should be at least 70% less than fossil fuels, which is a higher target than 60% target actually defined by the Directive to come into effect from 1 January 2018 (for installations that start producing in January 2017). The sector feels that this percentage will be really hard to achieve, especially for biomethane production whose greenhouse gas emission performance level would be measured in comparison with natural gas, applying the new European Commission-proposed method, and no longer against the mean European fossil energy mix excluding fuel that was previously used and more advantageous. However the JRC (Joint Research Centre) report that accompanies the document, reckons that this target can be achieved provided certain production conditions apply with a 100% organic waste pathway or a co-digestion blends of 70% slurry to 30% maize. Negotiations between stakeholders over the wording of a draft directive being prepared for presentation to the European Parliament and European Council are expected to be tough. The European Commission has already warned that no draft directive on these sustainability criteria would be expected before 2020 [4]

8 Conclusions

Biogas digestate is mainly used as fertiliser, directly or after dehydration in liquid or solid form. Practice of its use differs across specific regions due to different climatic conditions, landscape, agriculture development and type, soil conditions (nitrogen vulnerable zones) and restriction regarding digestate application into the soil. It is mostly used as fertilizer although it requires big capacities for storage and the transportation costs are high. The liquid part achieves lower price on the market than solid part. If the digestate is treated in WWTP, this has a negative impact on the sustainability of AD processes because of the financial outlay required for treatment of digestate before being discharged into municipal water treatment plants or natural water bodies. The digestate contains nutrients, which can be further used for plant or algae growth. Algal–bacterial treatment is good solution, because digestate can be efficiently cleaned and nutrients recycled. With use of CO_2 from cogeneration unit we capture carbon and with use of digestate nutrients are recycled for algae biomass production. Produced algae biomass can be used as high energetic substrate for biogas production on site.

In this report we assessed biogas market situation with close look to potentially interesting markets. Legislation comparison shows that rules for digestate application in some European markets are more stringent than others. Interest in AlgaeBioGas technology implementation strongly depends on specific position of biogas plant. Developed markets are interesting with existing biogas plants which are interested to solve digestate storage and distribution problem and lower costs. Especially agricultural and other plants (industrial biogas treating biodegradable waste) which do not posses enough land for digestate spreading in 0-20 km range.

Germany is by far the biggest market and the biggest biogas industry, which is now looking towards exporting markets due to the shrinkage of domestic market. Lower Saxony, Borken and other north-western parts of Germany are faced with (too) high nutrient concentrations in soil from livestock production, causing restrictions in manure and digestate disposal. Siegen is a region with high heterogeneity of land and a low share of agricultural land on total area. The costs of digestate transportation are affecting the profitability of the plants and the impact of digestate processing on profit is more significant. Germany is a promising market for AlgaeBioGas technology because it is large, is facing digestate problems and has biogas building companies that are now expanding also on other markets. It would be advisable to search for sales partner among German biogas constructing companies.

Finland and Sweden have very limited use of agricultural feedstock. Finland mainly produces biogas from organic waste and on landfills, while Sweden. The information on biogas digestate use in Finland are scarce, but from what we found Finland is not a primary target for AlgaeBioGas technology implementation due to small market and agricultural use of digestate. Sweden uses majority of the digestate in agriculture, but is a growing market with 20 new plants in 2013, also with an agricultural plant. We should be considering Sweden as a potential market.

Spain has slow development of new installed capacities. Digestate from sewage sludge is generally composted, the separate liquor is treated as wastewater or it is recycled into the process. The resulting compost is mainly sold to agriculture. Besides, digestate from the co-digestion of manure with other biodegradable waste is used directly in agriculture. We should get more information on Spanish market and specific areas to assess the potential for implementing AlgaeBioGas technology.

Slovenia is a small market, but the biogas plant operators are faced with digestate problems. We are present on Slovenian market and have contacts to biogas plant operators. We will present technology, but are limited with the size of the market.

UK is quite big and growing biogas market. It has the largest share of sewage sludge plants in Europe. 62% of land in England and 4% in Wales falls within the restriction of NVZ and there must be enough land in vicinity of the biogas plant.

References

[1] Biogas3 Consortium, “European legislative and financial framework for the implementation of small-scale biogas plants in agro-food & beverage companies,” 2014.

[2] M. van Donk and M. Garcia de Mateo, “Biogas Market Snapshot 2014,” no. March, pp. 1–12, 2014.

[3] European Biogas Association, “Biogas Report 2014,” 2014.

[4] EurObserv’ER, “Biogas Barometer,” 2014.

[5] D. Divya, L. R. Gopinath, and P. M. Christy, “A review on current aspects and diverse prospects for enhancing biogas production in sustainable means,” *Renew. Sustain. Energy Rev.*, vol. 42, pp. 690–699, 2015.

[6] Paavola, Teija, and Jukka Rintala. "Effects of storage on characteristics and hygienic quality of digestates from four co-digestion concepts of manure and biowaste." *Bioresource technology* 99.15 (2008): 7041-7050..

[7] H. Saveyn and P. Eder, “End-of-waste criteria for biodegradable waste subjected to biological treatment (compost & digestate): Technical proposals,” 2014.

[8] R. Delzeit and U. Kellner, “How location decisions influence transport costs of processed and unprocessed bioenergy digestates: the impact of plant size and location on profitability of biogas plants in Germany,” no. 1730. Kiel Institute for the World Economy, Kiel, 2011.

[9] “Eur-Lex - Acess to European Union Law.” [Online]. Available: http://eur-lex.europa.eu/homepage.html. [Accessed: 05-Feb-2015].

[10] “European Commission - Environment.” [Online]. Available: http://ec.europa.eu/environment/waste/framework/end_of_waste.htm. [Accessed: 05-Feb-2015].

[11] “European Commission - Energy - Energy Efficiency Directive.” [Online]. Available: http://ec.europa.eu/energy/en/topics/energy-efficiency/energy-efficiency-directive. [Accessed: 05-Feb-2015].

[12] "European Commission - Environment - The Nitrates Directive." [Online]. Available: http://ec.europa.eu/environment/water/water-nitrates/index_en.html. [Accessed: 05-Feb-2015].

[13] "Finnish Biogas Association." [Online]. Available: http://biokaasuyhdistys.net/index.php?option=com_content&view=section&layout=blog&id=13&Itemid=102. [Accessed: 06-Feb-2015].

[14] European Biogas Association, "Swedish biogas and biomethane production keeps growing," *Newsletter October*, pp. 1–7, 2013.

[15] K. Suominen, M. Verta, and S. Marttinen, "Hazardous organic compounds in biogas plant end products-Soil burden and risk to food safety," *Sci. Total Environ.*, vol. 491–492, pp. 192–199, 2014.

[16] A. Normak, M. Edström, and S. Luostarinen, "Overview of Biogas Technology," 2011.

[17] Sunbeam GmbH; German Biogas Association (Fachvernabd Biogas e.v.), "Biogas an all-rounder," Berlin, 2014.

[18] M. Česen and M. Đorić, "Obnovljivi viri energije," 2014. [Online]. Available: http://kazalci.arso.gov.si/?data=indicator&ind_id=643. [Accessed: 29-Jan-2015].

[19] T. Poje, "Stanje in trendi v razvoju kmetijskih bioplinskih naprav v Sloveniji." Agricultural institute of Slovenia, KIS, 2013.

[20] "Borzen, Slovenian Power Market Operator." [Online]. Available: www.borzen.si. [Accessed: 29-Jan-2015].

[21] European Compost Network, "European Compost Network News," 2013.

[22] EUBIA, "A focused strategy for enabling European farmers to tap into biogas opportunities," 2012.

[23] M. Fallde and M. Eklund, "Towards a sustainable socio-technical system of biogas for transport: The case of the city of Linköping in Sweden," *J. Clean. Prod.*, pp. 1–12, 2013.

[24] IEA Bioenergy, "Biomethane - Status and Factors Affecting Market Development and Trade," 2014.

[25] O. Palm, "Swedish Certification Rules for Digestate." [Online]. Available: http://www.avfallsverige.se/in-english/swedish-certification-rules-for-digestate/.

[26] NNFCC, "Anaerobic Digestion." [Online]. Available: http://www.biogas-info.co.uk/index.php/regulations-qa#animal. [Accessed: 15-Jan-2015].

[27] C. Cavinato, "Digestate quality, standard and nutrient recovery potential," 2013.

[28] "GOV.UK." [Online]. Available: https://www.gov.uk/.