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Small-scale AD in agro-food companies: potential and barriers

BIOGAS^3
Sustainable small-scale biogas production from agro-food waste for energy self-sufficiency

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With the collaboration of all the BIOGAS^3 consortium

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1. Introduction

Anaerobic digestion (AD) in agro-food industries has a great potential in the European Union. The big amount of residues generated (several millions of tons), indicates an opportunity for energy production through this biological process, where the organic matter is degraded to a Biogas mainly composed methane and carbon dioxide.

In this report, overall information from the status of small-scale AD in the EU and a specific survey in each partner country, have provided a clear path on the current situation of this market, the barriers, potential and perspectives.

A first overview shows that some general and clear barriers can be found when searching for candidates to install viable biogas plants to produce energy. Waste characteristics and their production frequency, incentives to investment and bio-energy production or lack of a reliable regulation, are some of the reasons found to take other investment decisions.

On the other side, most of the companies assessed during the survey indicate they have been already considering the viability of a biogas plant or they would like to receive more information to check if there is a real potential for them. Some exceptions are found in few companies which wouldn't install a biogas plant due to internal policies or a variety of other factors.

2. Anaerobic digestion technology

2.1. Anaerobic digestion process

The anaerobic digestion is a biological process in which the organic matter is degraded by different populations of microorganisms, in the absence of oxygen, to form biogas and a digestate. Biogas is composed approximately by 50-60% methane and 40-50% carbon dioxide, and small amounts of other gases. Digestate is the remaining organic matter, which is more stabilized than the raw material. It is normally used as fertilizer or soil amendment.

The microbiological steps of the anaerobic digestion are described in 0. The process starts with the **hydrolysis**, in which the complex organic compounds (carbohydrates, proteins, lipids) are transformed into simple organic compounds (sugar, amino acids and fatty acids). These compounds are converted to volatile fatty acids in the second step, the **acidogenesis**. After this, the volatile fatty acids are used in the **acetogenesis** step to produce acetate, hydrogen and carbon dioxide. The **methanogenesis** is the last step, when methane is produced via two pathways: from acetate (acetoclastic methanogenesis) and from hydrogen and carbon dioxide (hydrogenotrophic methanogenesis).

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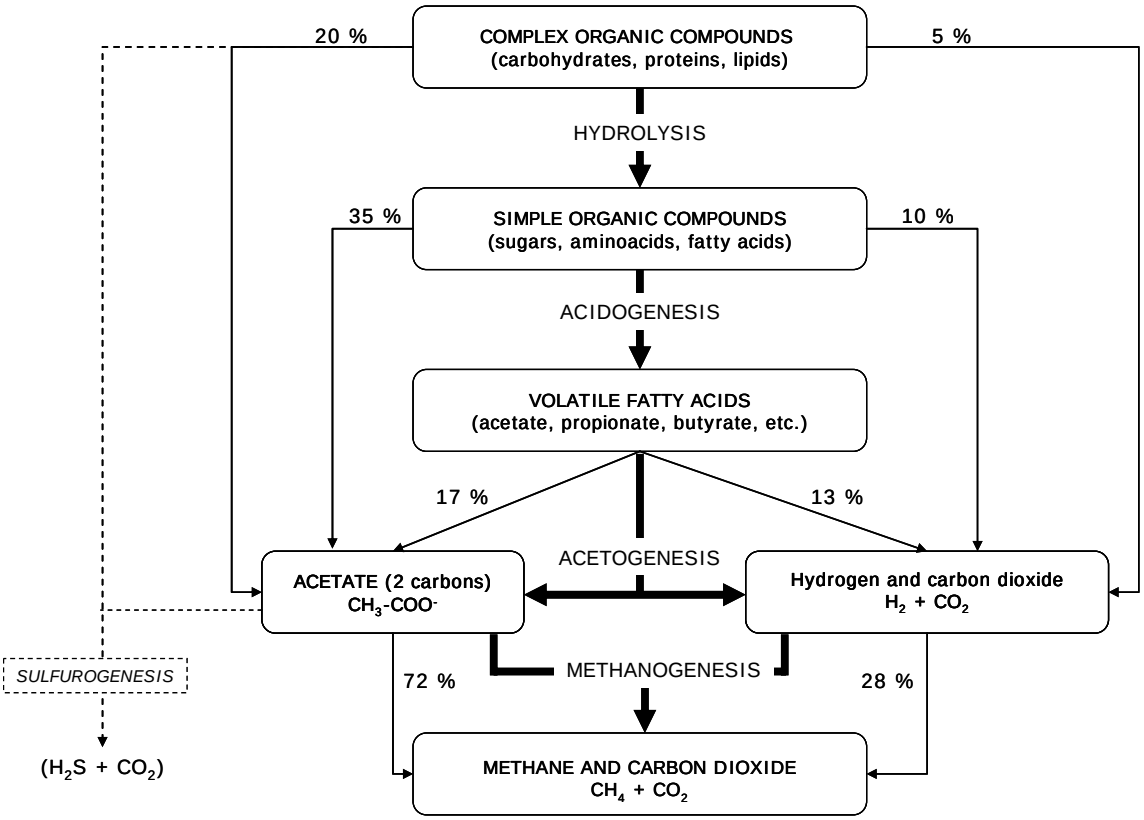

Figure 1. Steps of the anaerobic digestion process

Despite the complexity of the biochemical reactions occurring in the process, the technology to make it possible can be rather simple. The conditions required for the process are mild and easily achievable. The process runs at ambient pressure, and the temperatures are either in the mesophilic (35-38ºC) or thermophilic (50-55ºC) range. These temperatures are achieved by heat exchangers outside the digesters, or by hot water piping in the walls and the base of the digester. Anaerobiosis (absence of oxygen) is required, and therefore the digesters have to be gastight. The process runs correctly at neutral or slightly alkaline pH. This is usually achieved by the presence of alkalinity in the substrates, and it is naturally maintained unless organic overload or inhibition occurs.

There are two main types of digesters: complete mix and plug flow. Complete mix digesters are cylindrical, with a central mixer or several side mixers, and all the digester content is at the same concentration of substances. Plug flow digesters can be cylindrical or prismatic, usually horizontal, and the feed enters on one side and exits through the opposite side. The concentration of substances varies with the length of the digester. The mixer is usually slow and it is designed to favour the movement of the substrate towards the exit.

The predominant type of digester is the complete mix, and small scale plants are not an exception. However, small scale (<100kW) anaerobic digestion plants have some particularities and three different approaches are found:

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i) Self-built, low-tech biogas plants. Those are found usually in agricultural environments. Investment and O&M costs are kept to a minimum, but the efficiency of the process is also reduced.

ii) Standardised small-scale biogas plants. There are several providers in the market specialised at standard solutions for small-scale (<100kW) biogas plants. Those consist in either commercial products consisting in containerized plants that are transported to the site and installed very quickly (usually <30kW) or turnkey small plants (30-100kW). Investment costs are in the medium range between the approach i) and iii) since they are standardised solutions.

iii) Down-scaled biogas plants. Some "conventional" biogas plant constructors offer small-scale solutions as well. Those solutions are usually more tailor-made than the standard containerized plants, and therefore the investment costs can rise in these cases.

The best technological option depends on the particular conditions of each end-user (waste characteristics, final use of the energy produced, etc.). Some of these small-scale biogas plants are not optimised in this sense since some of them do not operate continuously (they are over-dimensioned for the amount of waste available). In spite of that, payback periods are similar to that obtained with bigger biogas plants (5-8 years).

2.2. Biogas

Biogas production from agro-food waste depends on the characteristics of the waste (organic matter concentration, biodegradability, pH, presence of inhibitors, among other factors). An overview of methane potential of common agro-food waste is given in 0.

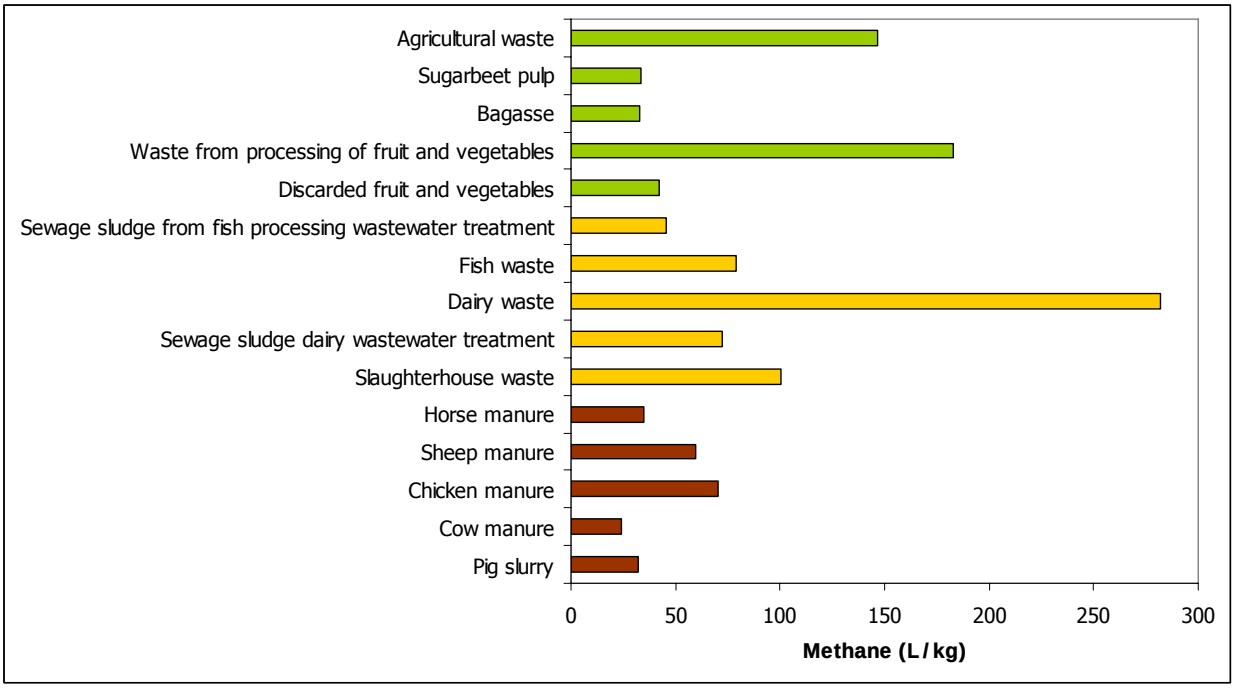

Figure 2. Methane production from several substrates (data from PROBIOGAS)

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The chemical composition of the biogas (50-60% CH_4, 40-50% CO_2) is similar to the one of natural gas, and can therefore be used in a similar way. Thus, the biogas can be used in an engine to produce electricity, a boiler to generate thermal energy, or a CHP engine to produce both. Before these applications, it is necessary to remove the H_2S, a pollutant commonly present in the biogas obtained from agro-food waste. The technology to remove H_2S is commercially available.

In addition to these conventional uses, it is also possible to transform the biogas in biomethane removing the CO_2 and the rest of gases, and use it as fuel in adapted vehicles. However, with the technology currently available, the economical feasibility is limited to bigger plants.

3. Agri-food sector in the European Union: opportunities and barriers to obtain biogas from their organic wastes

3.1. Agri-food sector in the European Union

3.1.1. General aspects of the agri-food sector in the EU

Europe's food and drink industry employs 4.24 million workers throughout all Member States, mostly in rural areas, 64% of whom are employed by SMEs.

As the leading employer in the EU, it also boasts a turnover of over €1 trillion and added value of €206 billion. The industry is a net exporter of food and drink products, with a positive trade balance of €23 billion. These are just some of the highlights of the Data and Trends Report published by FoodDrinkEurope[1]. In this report, the trade body representing Europe's food and drink industry offers a comprehensive picture of the structure and economics of the sector. This edition, the twelfth so far, shows that the sector remains stable, resilient and robust despite the crisis, and one of the very few to produce above its 2008 output level.

1 http://www.fooddrinkeurope.eu/uploads/publications_documents/Data__Trends_of_the_European_Food_and_Drink_Industry_2013-2014.pdf

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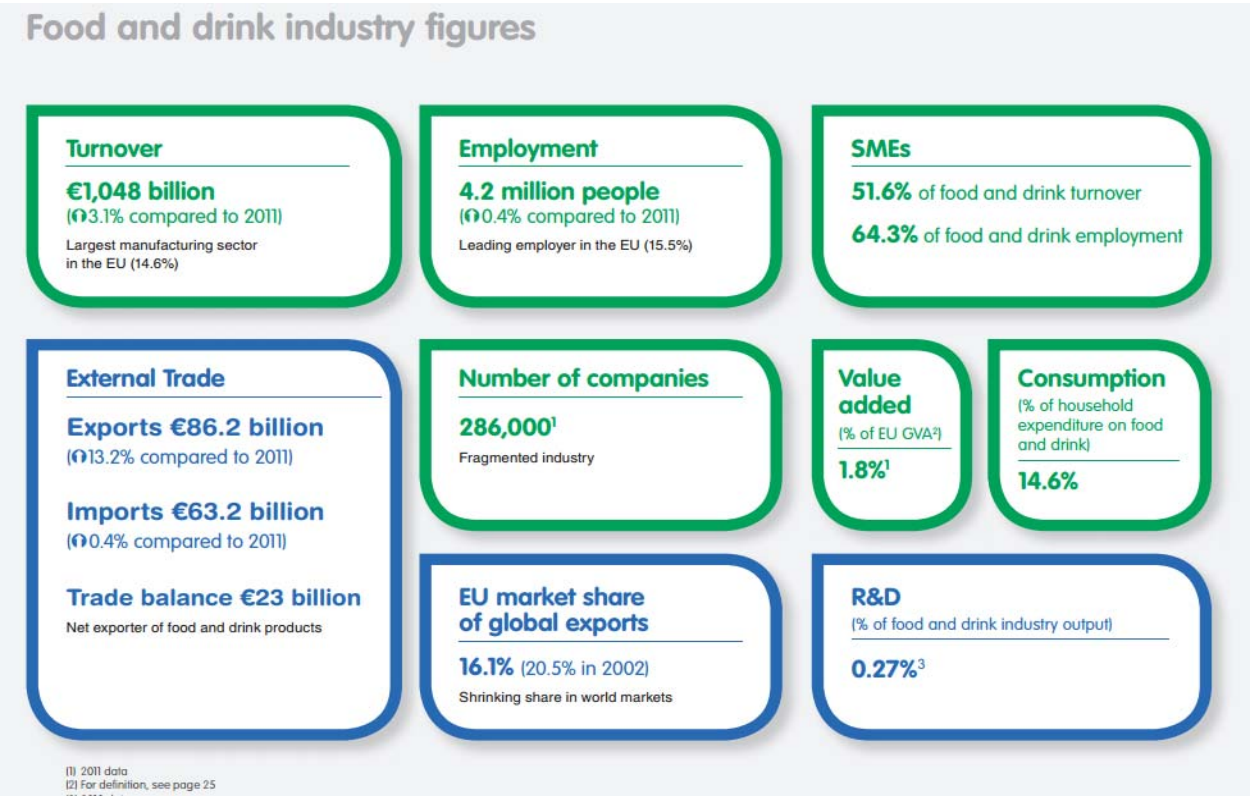

Figure 3. Food and drink industry figures in the EU

The EU food and drink industry, 2011-2012

		2011	2012	2012/2011 (%)
Turnover	€ billion	1,016	1,048	3.1
Value added	€ billion	206	-	-
Number of employees	million	4.22	4.24	0.4

Sources: Eurostat (SBS), FoodDrinkEurope calculations

Table 1. Food and drink industry key figures 2011-2012

The food and drink industry is a diversified sector. It is characterised by a wide range of company sizes with SMEs accounting for a large share of the activity.

For the first time in a decade, SMEs account for more than 50% of the food and drink industry turnover.

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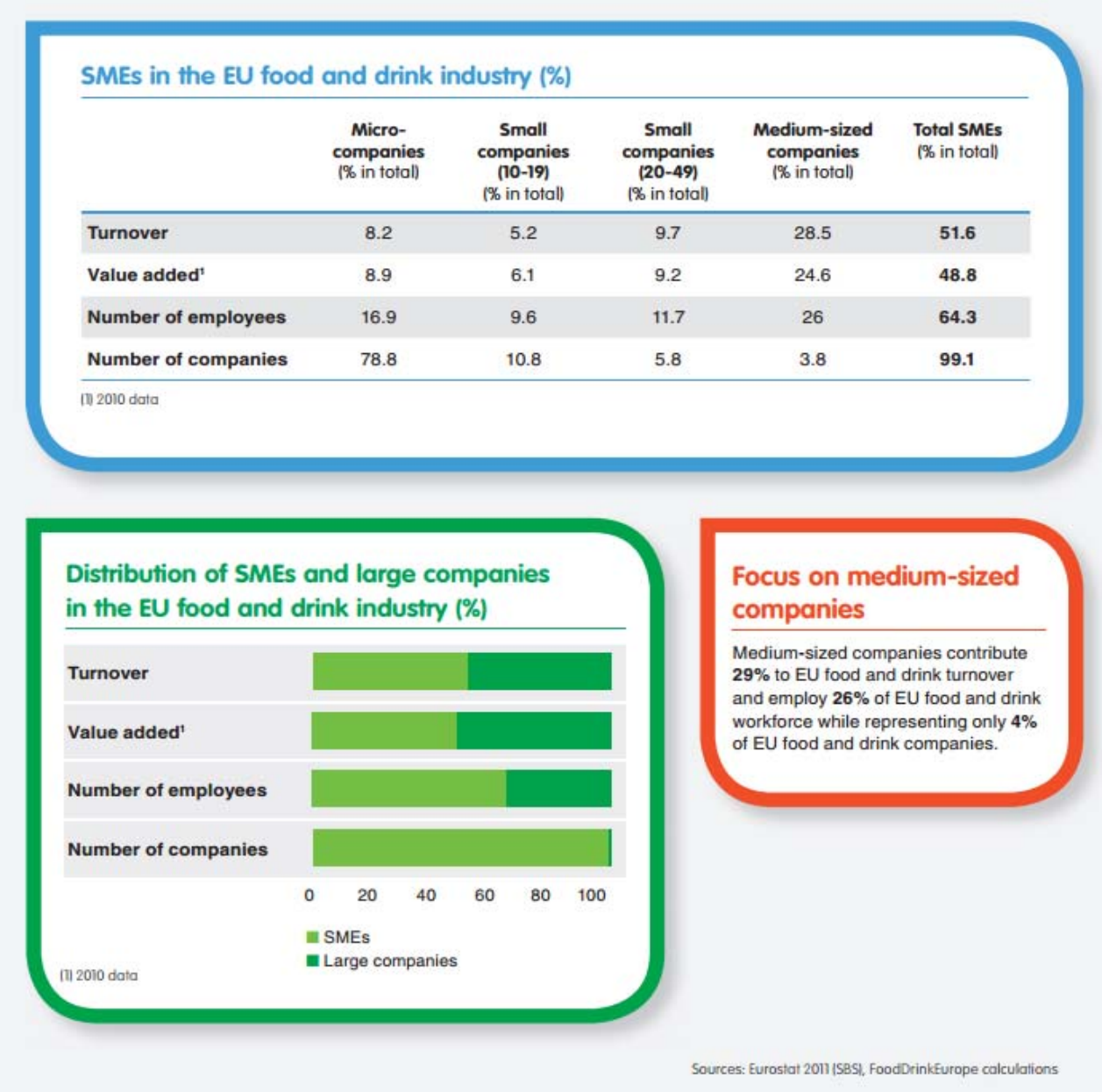

Figure 4. SMEs in the food and drink industry

3.1.2. Environmental impact: ratios of energy consumption and waste generation

Food Waste Generation in EU MS[2]

The main source of data on food waste generation was EUROSTAT, which provides data for Manufacturing, Household and 'Other Sectors' for all manufacturing sectors (MS) with few exceptions. An estimate of food waste for these three sectors is presented by MS using both EUROSTAT and available national data. The base year presented is 2006, the year for which the

[2] http://ec.europa.eu/environment/eussd/pdf/bio_foodwaste_report.pdf

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most recent EUROSTAT data was available at the moment of writing this report. The estimated annual food waste generation in the EU27 is approximately 89Mt, or 179kg per capita (see table below).

Table 2. Food waste generation in the EU27

Total Food Waste Generation in EU27 and in partners-countries: Best estimate				
	Manufacturing	Households	Other sectors	Total
EU27	34.755.711	37.701.761	16.820.000	89.277.472
France	626.000	6.322.944	2.129.000	9.078.000
Germany	1.848.881	7.676.471	862.000	10.387.000
Italy	5.662.838	2.706.793	408.000	8.778.000
Poland	6.566.060	2.049.844	356.000	8.972.000
Spain	2.170.910	2.136.551	3.388.000	7.696.000
Sweden	601.327	905.000	547.000	2.053.000
Source: http://ec.europa.eu/environment/eussd/pdf/bio_foodwaste_report.pdf				

A preliminary estimation, considering an average production of 100m^3 of biogas per ton of residue, would bring a potential (whithout any other considerations) of 3.500.000.000 m^3 of biogas for the food and drink industry sector. This would mean that the energy produced by biogas plants could cover next to 5% of the energy consumed in the EU by this sector.

Energy consumption in EU agri-food sector. Contribution of the technology to economic development (including energy market support) [3]

Important benefits for the sustainable development targets can be achieved through a better management of the energy use of agri-food sector. In the beginning of the 1990s, the food industry consumed 7% of the total electricity used by the global manufacturing sector; 94% of which was purchased and 6% produced through co-generation by the individual food industries themselves (Okos, *et al.*, 1998). Electricity consumptions constitute 15% of the food industry's energy needs. Fossil fuels are also used, with natural gas being the most widely used. The table below shows the eight industries that consume approximately half of the total energy used by the food industry.

[3] http://www.climatetechwiki.org/technology/energy-saving-agri-food-industry

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Table 3. Shares of agri-food industry (Source: Okos, et al., 1998)

Energy Inputs of Agri-food Sub-sectors	
Sector	**Percent of energy inputs**
Wet corn milling	15
Beet sugar	7
Soya bean oil mills	5
Malt beverages	5
Meat packing plants	5
Canned fruits and vegetables	5
Frozen fruits and vegetables	4
Bread, cake and related products	3
Source: Okos, *et al.*, 1998	

As mentioned above, the food industry uses energy for food preservation, safe and convenient packaging, and storage. Safe and convenient packaging is extremely important in food manufacturing and is also energy intensive. The newest packaging techniques require aseptic techniques and electro-chemical changes. Proper storage is also energy dependent. Freezing and drying are the most crucial methods of food storage. Freezing operations require a large portion of electricity used by industries. Drying procedures usually depend on fossil fuels. Older dehydration systems were designed to operate with maximum throughput, disregarding energy efficiency. Newer systems are designed with recirculating dampers and thermal energy recovery equipment to cut energy use 40%.

Approximately half of all energy end-use consumption is used to change raw materials into products (process use), which include process heating and cooling, refrigeration, machine drive (mechanical energy), and electro-chemical processes. Less than 8% of the energy consumed by manufacturing is for non-process uses, including facility heating, ventilation, refrigeration, lighting, facility support, onsite transportation, and conventional electricity generation. Boiler fuel represents nearly one-third of end-use consumption. This energy can be transformed into another energy source. For example, boiler fuel can be used to produce steam, which can have end uses.

Processing uses 78% of electricity in the agri-food sector, from which 48% is used for machine drive and 25% for process cooling and refrigeration. Non-process uses account for 16% of electricity use. Lighting, heating, ventilation and air-conditioning accounted for about 12 of the 16%. Distillate fuel oil is used mainly for boiler fuel (42%) and non-process uses (42%). Onsite transportation consumes the most distillate fuel oil in the non-process category. Processing consumes 9% of total distillate fuel oil, mostly by process heating. Like residual fuel oil, natural gas was mostly consumed as boiler fuel (62%).

3.2. Organic wastes from agri-food sector

3.2.1. Organic wastes disposal and treatment

Waste generated in agri-food waste has an organic nature, and is usually able to be degraded by microbial consortia under mild operating conditions.

There are different processes to treat organic waste, depending on the final product obtained:

- *Physical processes*
    - Compacting, or volume reduction for direct use as fuel.
    - Drying, to subsequently perform a thermal treatment.

- *Thermo chemical processes*, when high temperatures are used:
    - Direct combustion of biomass with air, which is used to produce electricity or heat.
    - Pyrolysis: Consists of heating without the presence of oxygen, which decomposes the raw material to end products obtaining more energy.
    - Gasification, which allows the production of hydrocarbons.

- *Biochemical processes:*
    - Alcoholic fermentation (aerobic) to obtain bio alcohol (vehicle fuel). Another aerobic process is composting, to obtain a biofertiliser.
    - Anaerobic fermentation, the biomass is fermented in the absence of oxygen. It produces biogas, often used on farms to enable combustion engines or heating, and biofertiliser (digestate).

- *Chemical processes*, such as the transformation of fatty acids for the production of biodiesel

Most of the organic wastes generated in the agro-food industry are in solid form; however contain up to 90% of moisture, therefore thermo chemical treatment such as incineration cannot be applied, without making a pre-drying or mixing with other drier biomass. To address sustainability in the treatment of organic wastes, environmental aspect, energy aspect and economical aspect of the treatment processes should be considered.

Biodegradable organic waste can be treated with or without air access. Aerobic process is composting and anaerobic process is called digestion. Composting is a simple, fast, robustand relatively cheap process producing compost and CO2 (Chiumenti et al. 2005, Diaz et al. 2007). Digestion is more sophisticated, slow and relatively sensitive process, applicable for selected input materials (Polprasert, 2007). In recent years anaerobic digestion has become a prevailing

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choice for sustainable organic waste treatment all over the world. It is well suited for various wet biodegradable organic wastes of high water content (over 80%), yielding methane rich biogas for renewable energy production and use.

The following table (Zupančič and Viktor Grilc (2012) shows typical solid and organic substance contents and biogas yields for most frequent organic wastes, treated with anaerobic digestion.

Table 4. Types of organic wastes and their biogas yield

Organic waste	TS[1] [%]	VS[2] in TS [%]	Biogas yield (SPB) [m^3kg^{-1} of VS]
Municipal organic waste	15-30	80-95	0.5-0.8
Municipal wastewater sludge	3-5	75-85	0,3-0,5
Brewery spent grain	20-26	80-95	0.5-1.1
Yeast	10-18	90-95	0.5-0.7
Fermentation residues	4-8	90-98	0.4-0.7
Fruit slurry (juice production)	4-10	92-98	0.5-0.8
Pig stomach content	12-15	80-84	0.3-0.4
Rumen content (untreated)	12-16	85-88	0.3-0.6
Vegetable wastes	5-20	76-90	0.3-0.4
Fresh greens	12-42	90-97	0.4-0.8
Grass cuttings (from lawns)	20-37	86-93	0.7-0.8
Grass silage	21-40	87-93	0.6-0.8
Corn silage	20-40	94-97	0.6-0.7
Straw from cereals	~86	89-94	0.2-0.5
Cattle manure (liquid)	6-11	68-85	0.1-0.8
Cattle excreta	25-30	75-85	0.6-0.8
Pig manure (liquid)	2-13	77-85	0.3-0.8
Pig excreta	20-25	75-80	0.2-0.5
Chicken excreta	10-29	67-77	0.3-0.8
Sheep excreta	18-25	80-85	0.3-0.4
Horse excreta	25-30	70-80	0.4-0.6
Waste milk	~8	90-92	0.6-0.7
Whey	4-6	80-92	0.5-0.9

TS^1 – total solids; VS^2 – volatile (organic) solids

Anaerobic digestion is a modern technology which allows the production of biogas from one or more substrates, efficiently and which is currently commercially available in all EU countries.

The production of biogas through processing agro-food industry residues in AD, involve relevant environmental benefits in the heat and power production, due to decentralization and regional investment promotion, and their contribution to the sustainable development in the rural areas and providing of further incomes to local business.

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3.2.2. Barriers identified in the implementation of biogas production in the agri-food sector

The following aspects have been identified through the conducted surveys as the most important barriers for the development and financial viability of a biogas plant:

1. Variability on characteristics and production time of the residues and other organic substances
2. Logistic costs. Intermediate stages (e.g. collection, transportation to the plant, storage…).
3. Diversity of technologies for Biogas Plants and perception available commercial plants are too big.
4. Competition with other products (compost, landfill, alcohol production, etc.)
5. Energy needs are sometimes different that energy produced by biogas plants and there are not incentives to sell energy to the grid.
6. In some countries, lack of regulation and financing or subsidies to biogas plants.

There is a general lack of knowledge and information not only to the farmers but also to the industries (owners) and the general public about the possible energy exploitation of wastes and their final uses (e.g. electricity, heat, injection to the grid, transport fuel). Generally, anaerobic digestion is used mainly as waste treatment but not accompanied with biogas production and energy production at the moment. The general approach is the concept of the disposal as waste after some treatment than promoting a valuable technique as biogas production and a source of fertilizer or compost. There is a lack of official documents describing a real technical potential for biogas, especially for biogas from agriculture.

Other important barriers are the financial items, financing investments of renewable energy systems remains a major concern. It will improve as costs fall and Renewable Energy Technologies become more competitive because many investors are willing and anxious to enter the energy sector. They are supported by new financial instruments that use private sector banks to create green investment funds with lower interest in commercially viable technologies. What is needed is clear and stable financial conditions and environment.

3.2.3. Perspectives of the biogas production using organic wastes from agri-food sector

In 2010, EU Member States submitted their action plans to meet the 2020 Renewable Energy Sources (RES) targets. Wind and (co-firing) biomass were the most prominent renewable energy sources in these plans. The realization of large scale offshore wind constitutes the main uncertainty in achieving these plans. The economic downturn, high investment cost (and financial risks) and potential issues regarding balancing of the grid and unstable subsidy schemes are likely to cause serious delays in the realization of levels of installed capacity consistent with the 2020 targets. Against this background, other renewable energy sources are being emphasized by policymakers and other stakeholders in the energy transition debate.

One example of these energy sources is biomass. Biomass is a generic term for different types of organic feedstock that can be used in a number of technological conversion processes to produce direct energy or secondary energy sources such as bio fuels and biogas that are applied

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further downstream in the energy supply chain. Sources of biomass are for example wood pellets, energy crops and agricultural waste.

Biogas is a secondary energy carrier that can be produced from many different kinds of organic materials via either a chemical process (digestion) or a thermal process (gasification). The latter is still in the R&D phase, but can potentially accelerate the development of biogas as it has the potential for larger produced volumes. Biogas is considered as carbon neutral as the carbon in biogas comes from organic matter (feedstock for biogas production) that captured this carbon from atmospheric CO^2 over a relatively short timescale.

In 2010, 10.9 mtoe of primary biogas was produced in the EU (van Foreest, 2012). Estimates of the potential of biogas vary significantly. The Institute for Energy and Environment in Leipzig calculated a theoretical potential for Europe of 166 Mtoe (≈200 bcm) in 2020. The European Biomass Organisation (AEBIOM) estimated a probably more realistic production of 39.5 Mtoe (≈48 bcm) in 2020, which corresponds to approximately 10% of EU natural gas consumption.

Biogas can be used as a fuel to generate heat and electricity. Alternatively, biogas can be upgraded and injected into the gas grid (biomethane). This option is gaining the interest of policy makers in traditional gas markets such as the UK, the Netherlands and Germany, but also of the gas industry. Targets for production are included in some national renewable plans and biomethane can be attractive for gas companies as a low carbon energy source that can be integrated in the overall gas portfolio and supplied through existing gas infrastructure.

Biogas energy recovery for both electricity and heat application has increased in the European Union. The main producer country is Germany. New markets are starting to emerge in its footsteps, but the economic crisis and regulatory restrictions do not auger well for their expansion (EurObserv'ER.2012).

3.3. Diagnosis of the agri-food industries in the European countries involved in the BIOGAS^3 project

Table5 shows target groups identified in each country involved in BIOGAS^3 project related with agri-food sector: agricultural, farms, food and beverage industries. This table includes general information of the agri-food target groups in each country at national, regional and local levels, as well as the identification of waste or substrate generated.

Table 5. Target groups of agri-food sector identified in each country involved in the BIOGAS^3 project

Country	Level	Industry	Agri-food wastes and agricultural co-substrate	Synergic and competitive uses
Spain 	National, special focus in Catalonia and centre Spain.	Meat processing and slaughterhouses: cow, pig and poultry.	- Manure and poultry wastes	- Competitive use as agricultural fertiliser. - Synergic use for external biogas production.
			- Meat processing wastes (fat, bones, rind, etc).	- Competitive use as animal food production.

Country	Level	Industry	Agri-food wastes and agricultural co-substrate	Synergic and competitive uses
	Northern Spain	Fish processing: Cannery, frozen.	- Fish processing wastes (fat, bones, rind, etc).	- Competitive use as agricultural fertiliser. - Competitive use as animal food production.
	East and southern Spain	Fruit and vegetable processing industries.	Fruit and vegetable wastes: Orange, tomato and green vegetables.	- Competitive use as agricultural fertiliser. - Competitive use as animal feed.
Italy 	National with main focus on Northern Italy	Fruit and vegetable processing.	Fruit and vegetable wastes.	- Synergic use for external biogas production. - Competitive use as animal food production.
		Chicken for eggs production.	Slaughterhouses and poultry wastes.	- Competitive use as agricultural fertiliser.
		Wheat and cereals.	Cereals bran	- Competitive use as animal food production.
		Meat processing.	- Slaughterhouse wastes, meat processing wastes (fates, guts, bones).	- Synergic use for external biogas production.
		Dairy products.	- Whey, scraps of cheese and product rejected.	- Competitive use as animal food production.
		Wineries, breweries and distilleries.	- Residues from malt. - Sludge and wastewater.	- None.
France 	National with special focus on Brittany and Lorraine regions.	Meat processing and slaughterhouse.	- Slaughterhouse wastes, meat processing wastes (fates, guts, bones).	- Competitive use as agricultural fertiliser: compost. - Synergic use for external biogas production. - Competitive use as animal feed.
		Dairy products.	Whey, white water	- Competitive use as animal food production.
		Farms.	Manure.	- Competitive use as agricultural fertiliser (compost). - Synergic use for external biogas production.
		Oil production.	Vegetable oil wastes.	- Competitive use for external biodiesel production.

Country	Level	Industry	Agri-food wastes and agricultural co-substrate	Synergic and competitive uses
		Fruit and vegetable processing	Fruit and vegetable wastes	- Competive use as Animal feed - Competive use as Oil processing from fruit stones cosmetic) -Competitive use as agricultural fertiliser (compost). - Synergic use for external biogas production (maybe unpacking necessary)
		Bakery	Residues of bread, fats	- Competive use as Animal feed -Competitive use as compost. -Competive use as biodiesel - Synergic use for external biogas production (maybe unpacking necessary)
		Breweries	- Residues from malt and yeast. Non editable beer.	- Competitive use as animal feed
Poland 	National (with main focus on Lublin and Mazovian voivodships)	Farms	Manure.	- Competitive use as agricultural fertiliser: compost, ploughing.
		Meat processing	Meat processing wastes (fates, guts, bones).	- None.
		Diary, bakery, brewery, cereal and starch processing	Whey, maize silage.	- Competitive use as animal feed
		Fruit and vegetable processing.	Fruit and vegetable wastes.	- Synergic use for external biogas production.
Sweden 	Southern and central Sweden	Farms: Small to medium size food processors with a particular focus on organic farms with on-farm food processing – all production categories.	Manure: slurry also solid manures such as deep litter, bed pack manure, horse manure and poultry litter.	Competitive use as agricultural fertiliser: composting and land spreading.
		Dairy and hog farms:	Manure.	

Country	Level	Industry	Agri-food wastes and agricultural co-substrate	Synergic and competitive uses
		Larger horse operations (riding schools, trotting rings, etc).	Manure.	
		Small to medium sized poultry operations.	Manure.	
		Fish processing.	Fish processing wastes (fat, bones, rind, etc).	None
Ireland 	National	Dairy farms and dairy processing.	Manure, whey, bed pack manure.	- Competitive use as agricultural fertiliser: land spreading. - Competitive use as animal feed.
		Meat processing and slaughterhouses: cow, pig and poultry.	Manure.	Competitive use as agricultural fertiliser.
		Fruit and vegetables processing	Root crops rejected, cereal waste etc.	- Competitive use as animal feed.
Germany 	National (special focus on lower Saxony)	Meat and fish (meat and meat products, fish and fish products)	Abattoir wastes, slurry, manure, fish offal.	- Competitive use as agricultural fertiliser. - Competitive use as animal feed.
	National	Bread, grain and sugar (22.6%) (bakery products, confectionary/candy, mills/grain production, sugar production)	Wastes from production of bread and dough, liquid or solid wastes from confectionary industry, mill dust, areas from sugar beet root	- Competitive use as animal feed.
	Regional (among others Bavaria, North-Rhine Westphalia)	Dairy (15%)	Whey (Molke)	- Competitive use as animal feed. - Synergic use for external biogas production.
	National	Processed organic products (17%) (fruits & vegetables, oils & fats, coffee & tea, instant meals & flavours)	Residues from biomass, pomace, pulp, press cake	- Competitive use as animal feed. - Synergic use for external biogas production.
	Regional (mostly southern states)	Beverages (12%) Alcoholic beverages: breweries & wineries Non alcoholic beverages	Distillery arrears, hop, brewer grains (Treber), mash arrears	None

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In order to obtain more information about the target groups identified and their potential to produce biogas a small-scale (<100kW) concept from their wastes, a general questionnaire was elaborated and sent to these agri-food companies. The questionnaire was translated to all languages of the countries involved in the project (English, French, German, Polish, Spanish, Swedish and Italian). The English version of the questionnaire is included in Annex 1.

The main aspects included in the questionnaire were focused to identify:

- Organic wastes in agri-food sector.
- Energy consumption.
- Degree of knowledge of the anaerobic digestion technology.
- Barriers of the implementation of anaerobic digestion to obtain biogas.

The results of the questionnaire are presented and analysed as follows.

3.3.1. France

Ways applied to contact with agri-food companies

AGRIA Lorraine, CRITT PACA and CASIMIR have contacted agro-food industries located in Lorraine, PACA and Auvergne regions of France, adding 14 companies. ITERG has contacted agro-food industries from the vegetable oil and fat sector located in France, adding 4 companies.

The contact has been done by sending mail to agro-food industries offering cooperation within BIOGAS3 project, by direct phone contacts with some industrials and by direct visits. Only few industrials answered to email solicitation, direct phone contacts were necessary to reach the objective of 50 questionnaires filled for France. Large industries were not interested in fulfil this questionnaire although biogas plants may be a solution of interest for their wastes.

Most of the information requested was received from 18 companies and the table with the overall information for the study was completed. Sometimes, companies don't want to answer to question related to energy consumptions. It's seems to be a competitive information for French companies. The information has been depurated and filtered in an Excel table, and exploited to obtain the results included in the report.

General analysis of the answers received

The questionnaires have been filled by:

- 4 Meat and meat products companies (22%)
- 4 vegetable oil and fat companies, as vegetable oil production and green chemistry production (22%)

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- 3 Dairy products companies (cheese, 17%)
- 2 Industrial bakeries (11%)
- 2 Vegetables and fruit processing companies (11%)
- 2 bakery's ingredient production companies (11%)
- 1 brewery (6 %).

Size of companies:

- 1 micro Enterprise (6 %) – Fruit cooperative
- 4 small enterprise (22%) – All sectors
- 13 medium enterprise (72%) – All sectors
- 0 large enterprises (0 %)

From the interviewed companies, 17 companies (94%) declared continuous type of production. The only enterprise with seasonal activities is the fruit cooperative.

Related to the number of working days per week, the companies have declared:

- 5 d: 6 companies (43%)
- 6 d: 3 companies (21%)
- 7d: 4 companies (29%)
- Other :1 company (7%)

And the number of hours per day were:

- <9h: 4 companies (31%)
- 9-14h: 2 companies (15%)
- 15-19h: 2 companies (15%)
- 20-24h: 5 companies (36%)

Companies that responded to the survey are mostly medium enterprise. Large enterprises are missing. Large enterprises generate a lot of organic by-products that can't be considered in this survey. These enterprises could be interesting in the project but don't have enough time to fulfill this questionnaire or don't want to give information on their process.

Ratios of energy consumption and waste generation

The organic wastes generated, characteristics and amounts found are described in the following paragraphs.

Two kind of organic wastes are generated:

- wastes generated as a result of an hazard during the production (bad quality of the final product or no selled products) (35% of wastes indicated by industrial) ,
- wastes generated during a normal agro-food processing (65% of wastes indicated by industrial).

Wastes generated as a result of a production hazard could be packed (13% of wastes indicated by industrial) that limit waste recovery.

The main types of organic waste generated in the industries are:

- Food powder in 1 plant

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- Meat residues in 4 industries, as fat, bones and other
- Sludges from waste water treatment plants are found in 4 enterprises
- Dairy effluent, as whey and other in 2 enterprises
- Bakery wastes as bread or bread dough in 2 enterprises
- No edible vegetable oil of fat in 2 industries
- Vegetable and fruit residues in 3 plants, as pieces of plants, kernels, hulls, skin
- Brewery production residues in 1 plant as yeast, no edible bier and other

Amounts of main organic waste produced:

- <50 t/year: 3 companies (17%)
- 50-100 t/year: 2 companies (11%)
- 100-500 t/year: 7 companies (38%)
- 500-1000 t/year: 1 companies (6%)
- 1 000-5 000 t/year: 2 companies (11%)
- 5 000-10 000 t/year: 3 company (17%)
- >10 000t/year: 0 (0%)

Most of companies that responded to the survey generated between 100 and 500 t/year of organic wasted. Note that no large companies answered the survey.

The main residues are mostly liquid or pasty (57%). The industrials rarely know the moisture or the composition of their wastes.

Almost 85% of the residues are produced along the year. Some residues are not produced all along the year because of seasonal activities (fruit production for example) and because it were generated during a hazard of production.

The following information is related to the energy uses. Nine companies didn't want to communicate their amount of energy consumption for confidentiality reason. The nine other companies indicate this amount:

Energy consumption – electric power (kWh/y):

- 250 000 – 400 000:1 companies (11%)
- 550 000 – 1 000 000:1 company (11%)
- >1 000 000:7 companies (78%)

Energy consumption – thermal power (kWh/y):

- <25 000: 2companies (22%)
- 25 000 – 100 000:2companies (22%)
- 5 000 000 – 10 000 000:1 company (11%)
- >10 000 000:4 companies (45%)

Energy sources: Many companies use various sources of energy (therefore the percentages below sum up to more than 100%)

- Heating Oil: 6%
- Natural Gas:77%
- Biomass: 11%

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The most intensive consuming processes at the industries are one or several of the following:

- Industrial cooling
- Production of steam for process heat
- Electric motors and electric equipment (different that cooling)

Organic wastes disposal and treatment

The organic waste generated on the industries is used or managed in several ways:

- used as animal feed (for 6 wastes, 16 %),
- used for compost (2 wastes, 5%)
- directed to WWTP on site (3 wastes, 4%)
- spread on fields (4 wastes, 11%),
- incinerated in an external site (1 waste 3%)
- used in external biogas plant (2 wastes, 5%),
- used for biodiesel production for vegetable oil wastes (1 waste, 3%)
- used for energy recovery as biomass directly on site treatment (1 waste, 3%)
- collected by an external enterprise (16 wastes, 42 %) (kind of treatment or valorization is not known)
- landfilled (2 wastes, 5%)

Note that in France, the treatment of meat residues is regulated by law. The organic residues of food-agro industries is often valorized as animal feed. Almost 5% of waste are directed to external biogas plant.

Related to the residues management cost, it is highly variable :

- waste get paid (6 wastes, 25%),
- waste cost is 0 (5 wastes, 21%)
- waste cost is between 1-5 €/t (3 wastes, 13%)
- waste cost is between 5-10 €/t (1 waste, 4%)
- waste cost is between 10-20 €/t (0 waste)
- waste cost is between 20-50 €/t (1 waste, 4%)
- waste cost is between >50 €/t (usually for meat residues) - (8 wastes, 33%)

The treatment of meat residues is often expensive. Waste used as animal feed got paid or the treatment is free.

Barriers identified in the implementation of biogas production in the agri-food sector

The following main barriers were identified

- Residues quality or quantity (not enough waste, seasonal production, packed waste): 37%
- Economic and Financing:16%
- Plants are too big or not suited for my company needs: 16%
- Not owners of the space: 11%
- My energy consumption is not regular: 5%
- Not enough information :5%
- Others wastes recoveries exist: 5%
- Other:5%

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Other barriers and concerns/limitation mentioned:

- Lack of space
- Investment too important
- Others wastes recoveries are effective.

Companies don't know the existence of small biogas plants able to treat a lower quantity of wastes.

Perspectives of the biogas production using organic wastes from agri-food sector

The perception of towards AD technology among has been positive – the average score was 7(range: 1-very negative, 10-very positive).

The French companies wish to receive more information about Biogas plants opportunities were 33%.

Main reasons to implement a biogas plant:

- Cost reduction in waste disposal: 43%
- Positive impact on environment: 31%
- other, income diversification: 16%
- Energy bill reduction: 5%
- Additional income from selling heat and electricity: 5%
- Energy self-sufficiency from energy provider: 0%

Companies see biogas plants as solution to reduce cost of waste treatment and as a solution greener than the others waste treatments. But companies don't see biogas plant as solution to production energy or to earn additional income.

Free Comments:

- Residues are currently valorized.
- The amount and kind of residues is not enough, and the use of heat internally is difficult

3.3.2. Germany

Ways applied to contact with agri-food companies

Barriers/ Market overview:

The agro-food industry in Germany is a branch with great importance. Not only is it one of the largest industry branches with a high turnover and many employees, the branch also has high demands in energy and a need to dispose high amounts of waste.

Naturally, many stakeholders involved in energy or waste disposal are interested in this branch. A first approach including a thorough study of literature showed the existence of a high number

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of researches done in this field. One comprehensive study "Appraisal to the biogenic potential of residues of the German agro-food and bioengineering industry" covering this topic has been conducted already (GAIDA et al., 2013), proving the following points:

1. Generally the agro-food industry in Germany is addressed often by associations, vendors and stakeholders in order to distribute information, conduct surveys or sell products. Hence this favored sector is saturated with information from different actors and consulted about their opinions. Therefore the perception and attitude of agro-food companies towards new requests can be quite negative in the beginning of a project.
2. Since many companies in Germany deal with the reutilization, recycling and disposal of organic residues, these wastes are a popular and sometimes valuable product. Consequently there is a large market and lobby interested in knowledge about waste streams and getting in contact with agro-food businesses generating organic residues.
3. Besides that, due to many legal regulations concerning hygiene, odor and contamination/ pollution, there are a high number of restrictions and obligations when disposing and reutilizing residues in Germany.
4. Therefore, it can be derived, that dealing and disposing waste of agro-food businesses already is managed to a high extend in companies.
5. Generally agro-food companies are not willing to hand out detailed information about internal processes due to fear of losing their market position or advantages (USPs).
6. Therefore addressing SME in the agro-food sector was connected with difficulties.

Although the approach was connected with a high interest rate of associations as well as companies, the companies did not want to publish their internal information about their waste and energy management.

<u>Approaching the target group – agro-food associations:</u>

- In the starting phase of WP2, RENAC researched and contacted around 50 associations (umbrella/small/large associations), institutes and multipliers related to the agro-food sector (table 6)

Table 6. Action plan in Germany

Date	Action
Start 22.05.	Mailing to 47 associations related to agro-food industry, umbrella/small/large associations
May-June	Further mails to nutrition unions or agro-food organizations, institutions, initiatives, research institutes (11)
Follow-up in the following weeks	Phone calls with these associations and organizations introduction of project and request to distribute questionnaire via mailing lists, newsletter, homepage

*Concrete commitment of distributing our questionnaire via newsletter/ homepage/ mailings (7)

→ over 25 associations interested, wanted to receive more information by e-mail

→ Until now more than 7 associations (table 7) showed high interest in the topic and the activities of Biogas3. There was concrete commitment of distributing the Biogas3 questionnaire via newsletter/ homepage/ mailings by over 7 associations. Furthermore, these associations are seriously interested in realizing a workshop, face-to-face activity or seminar together with

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RENAC for WP4. Therefore, these sectors of the German food & beverage industry will be the focus for the face-to-face activities of WP4.

- These following seven cooperative associations showed a high interest in the topic and the activities involved in Biogas3. They further can imagine realizing a workshop, face-to-face activity or seminar together for WP4. There will be the focus in the face-to-face activities of wP4 in terms of realizing joint workshops or seminars.

Table 7. Associations distributing information about BIOGAS3

Association	**Action**	**Feedback to questionnaire**
Food-Processing Initiative e.V. (FPI)	Distribution via newsletter FPI Info with around 1.000 recipients	-
Bundesverband der deutschen Süßwarenindustrie e.V.	Distribution via mailing in June with topic environment (269 members)	-
Fachverband der Gewürzindustrie e.V., Verband der Hersteller kulinarischer Lebensmittel e.V.	Distribution via mailing (~80 members)	-
Zentralverband der Deutschen Schweineproduktion e.V.	Published information on homepage, and via newsletter with around 1.100 recipients	1
Deutscher Kaffeeverband e.V.	Mailing to 140 members	2
Deutscher Weinbauverband e.V.	Small note on project in mailing	-
Der Deutsche Weinbau – Magazin	Article in magazine (half page) – editions 8.000, distribution 7.900	1
Further magazines will publish information of Biogas3 project in the following weeks (among others a German journal for the milling industry "Mühle und Mischfutter")		

It can be assumed that from the dissemination of the cooperating associations around 10.000 agro-food companies received information about Biogas3 and were invited to participate in the survey through mailings, newsletters, magazines.

However, despite the interest of associations for small-scale biogas production for self-sufficiency, companies did not respond well to the request for the questionnaire. It will be possible to demonstrate these aspects more transparently and faithfully as soon as Biogas3 will have reached a certain level of publicity and is perceived trustworthy by the target group.

Methodology (target group – agro-food companies):

- The second step was to research and contact SMEs in the agro-food sector directly

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- SMEs were researched through member lists of agro-food associations with potential to AD (acc. to FABbiogas report)
- The proceeding is shown in table 8.

Table 8. Approaching the target group directly

Date	Activity	Feedback
Until end of June	Research of a high number of SME in agro-food industry from member enterprises of associations	
25.06.2014 – 01.07.2014	First telephone contact: introduction of project Biogas3, researching contact person in charge of energy, environment and/or residue management and announcement of questionnaire, 130 SMEs	~60 are interested and would like to receive further information 1 filled questionnaire
25.06.2014 – 01.07.2014	E-Mail send to interested parties (~60 companies) including information and questionnaire of Biogas3	2 filled questionnaires
From 30.07.2014	Telephone calls, reminder calls	

- Although half of the contacted companies showed interest in the project and wanted to receive targeted information and a link to the questionnaire, the feedback to the questionnaire was quite low
- Reasons for not participating
    - No desire in indicating internal data, fear of losing market position to competing companies
    - Are not aware of the opportunities of anaerobic digestion within agro-food industry, yet
    - Showed interest in the workshops, promised to participate in survey but never did
    - Some companies already installed plants (e.g. waste water plant, biogas plant)
    - Do not have financial or spatial capacities for a plant on the long-run
    - Already had interest in biogas but for now they have a contract with a local/regional energy provider
    - General doubts that substrate is not suitable for biogas production
    - Fear, that the current Renewable Energy Law does not permit feasible biogas plants in Germany (II)
    - Some companies already dry their waste and burn it in own incinerator. According to an internal study, this is more feasible than owning a biogas plant. (II)
    - Already provide large-scale biogas plants with their waste (II)

Although there was little feedback of agro-food companies, the topic of Biogas3 "Sustainable small-scale biogas production from agro-food waste for energy self-sufficiency" does mean a

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new innovation for the agro-food sector in Germany. Even if there is little demand for new biogas plants at the moment, a combination of disposing waste while generating electricity and heat for energy self-sufficiency has high potentials in decreasing costs and increasing benefits for agro-food companies.

Despite the low response rate it was possible to gather all required information to conduct a thorough market study.

On the basis of the aforementioned report promoted by the German Federal Ministry for Food, Agriculture and Consumer Protection (Gaida et al., 2013), a general analysis about the agro-food market in Germany was conducted.

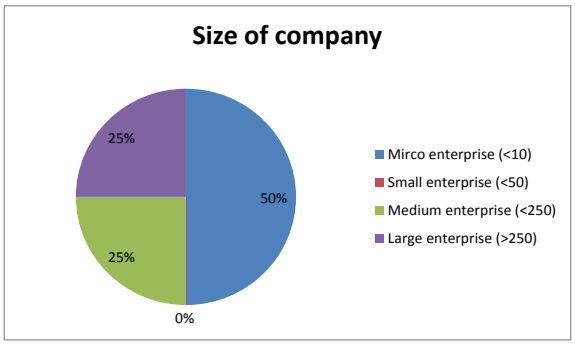
The report indicated industries with respective waste streams showing high potential for biogas production. These identified sectors were analyzed in detail by RENAC through an extensive literature study and consultation with the responsible associations, organizations and institutions of these sectors. Hence, surveys were carried out with people in charge of environmental, energy and disposal management. The experience and expertise of these respondents confirmed the findings of Gaida et al. and showed further opportunities or hindrances towards anaerobic digestion in the agro-food sector.

General analysis of received answers

Current status of respondents to questionnaire (the survey will be consecutively conducted throughout the project phase):

- 1 Agriculture
- 1 Bakery
- 1 Gourmet producer (mustard)
- 1 Winery
- 2 Coffee roasting plant
- 2 Vegetable production

Except one, all companies indicated a continuous type of production.



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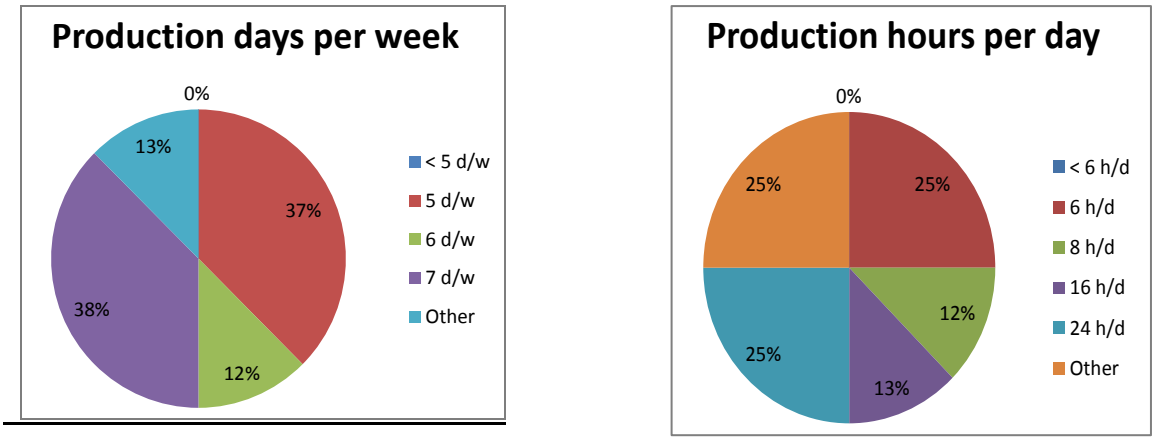

Figure 5. Size and production data of respondent companies

Ratios of energy consumption and waste generation

Within the energy demand of the German industries, the food and beverage industry holds a share of around 8 % (Meyer, 2013), shown in **Figure 6**. This energy demand is covered by the energy carriers gas (49 %), electricity (23 %), heating oil (21 %) and coal (7 %). In case of the agro-food industry, this energy demand accounts primarily for thermal utilization (70 %) and secondly for electrical utilization (30 %) (Meyer et al., 2000).

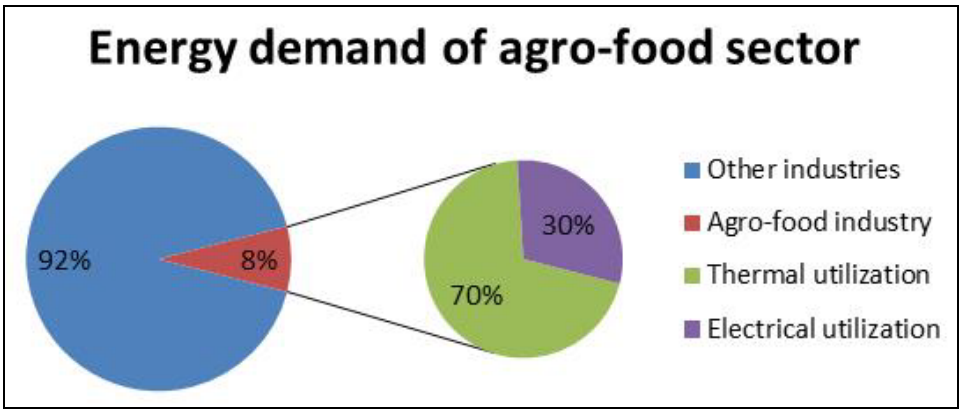

Figure 6. Energy demand of the agro-food sector

Generally the electrical energy demand for the production of food and beverages covers mainly the demand for power, thermal and cooling processes. Furthermore, electrical energy is used for transporting, filling and packing. The branches with a high demand for thermal energy are among others alcohol distilleries, malt, potato and sugar production. These branches use thermal energy for processes like distillation, roasting, steaming or drying (Meyer et al., 2000).

This electrical energy demand of the agro-food sector in Germany sums up to 15 TWh annually with an average electricity price of 130 €/MWh (Meyer, 2013).

The figure "Demand of electrical power" shows the distribution of electrical energy demand divided to the respective sector. The importance of the following branches within the agro-food industry with a high energy consumption is demonstrated.

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In terms of the energy costs in relation to the turnover of agro-food companies dairy production is the highest consumer. Milk needs to be refrigerated, heated, dried or frozen after processing. Therefore, the energy costs are the highest factor just after the costs of the primary product milk itself (Milchindustrieverband, 2014). The average annual energy costs in % of the turnover per year for the dairy industry was around 5% but ranged between 0.3 – 14.2 %.

The grinding and peeling mills as well as the production of starch and starch products generate the second highest energy cost with an average of 3 % in relation to their annual turnover (ranging between 0.3 – 8.2 %).

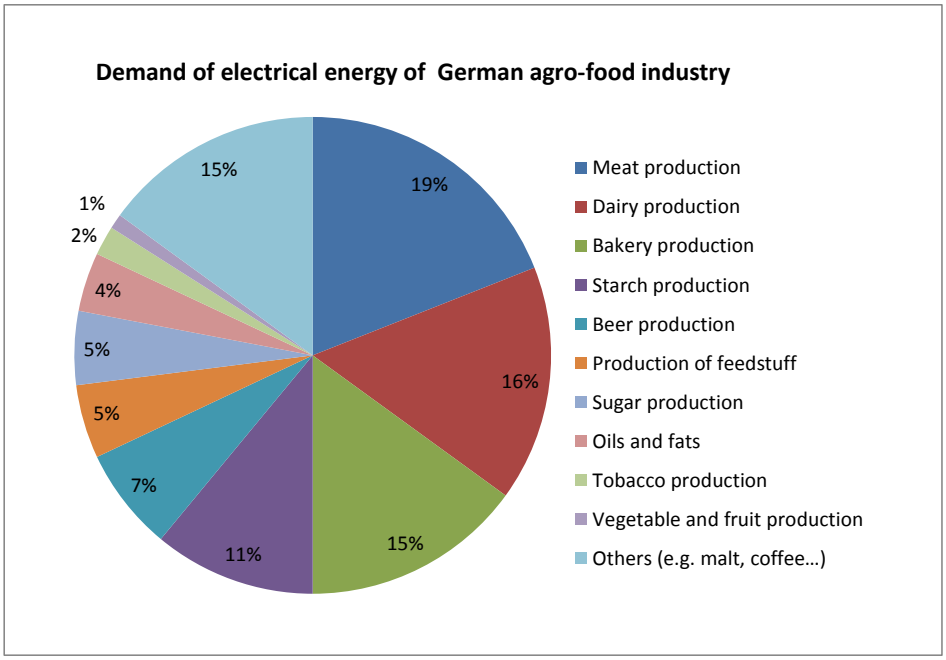

Figure 7. Electrical power demand in German agrofood sector (source: Meyer, 2013)

Producing and processing of vegetables and fruits can also be energy intensive. The average energy costs are around 2.2 % of the turnover (range 0.3 – 4 %). Fruit is processed to a variety of products: juices, frozen or dried fruits, dairy fruit products. Vegetables are mostly processed to pasteurized or frozen vegetables or are conserved in cans or glasses (NGG, 2013).

The fish and meat production also is a sector with high amounts of energy. In comparison to their total turnover the fish industry produces energy in the share of 2 % (ranging between 0.1 and 5.8 %) and the meat production holds a share of around 1.1 % (range: 0.3 – 3 %).

Table 9. Energy costs in the agrofood subsectors

	Average energy costs in % of annual turnover	Ranges
Dairy Production	5 %	0.3 – 14.2%
Grinding, peeling mills Starch and starch products	3 %	03. – 8.2 %
Vegetable and fruit production	2.2 %	0.3 – 4 %

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Fish industry	2 %	0.1 - 5.8 %
Beverages	2.2 %	0.3 – 3 %
Meat production	1.1 %	0.3 – 3 %
Production of oils and fats	1.1 %	0.3 – 3 %

(Meyer et al., 2000)

Industries with the highest average amount of energy consumption:

- 8,48 TWh/a Sugar industry
- 6,54 TWh/a Dairy processing
- 5,13 TWh/a Beer
- 5,00 TWh/a Meat processing
- 3,65 TWh/a Backery production
- 3,18 TWh/a Processing starch and starch products
- 1,96 TWh/a Raw oil and fats
- 1,82 TWh/a Confectionary products
- 1,49 TWh/a Waters, sodas, beverages
- 1,49 TWh/a Coffee, tea, coffee replacement

Organic wastes disposal and treatment

Waste generation of agro-food sector in Germany:

Regarding the questionnaire, the following information was obtained4:

The main types of organic waste generated by interviewed companies are:

- Farm fertilizer (manure)
- Maize
- Residues of fruit and vegetable production (peels, pomace etc.)
- Baking residues, chocolate
- Waste water/ sludge
- Coffee skins, defective production batches

Amounts of organic waste produced:

- <50 t FM/year: 3 companies (37,5%)
- 50 -100 t FM/year: none
- 100 -500 t FM/year: 1 company (12,5%)
- 500 -1,000 t FM/year: 1 company (12,5%)
- 1,000 -5,000 t FM/year: 2 companies (25%)
- 5,000 -10,000 t FM/year: none
- >10,000 t FM/year: 1 company (12,5%)

Utilization of organic residues:

- Production of feed: 2 answers
- Utilization as fertilizer: 2 answers

[4] The following figures are the results of the conducted Biogas3 survey in Germany, with eight respondents.

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- Industrial disposal: 1 answer
- Delivery to external biogas plants: 2 answers
- Delivery to compostation plant: 2 answers
- Delivery to combustion plant: no answer

Energy consumption – electric power:

- <25,000: 4 companies (50%)
- 25,000 – 100,000: none
- 100,000 – 250,000: 1 company (12,5%)
- 250,000 – 400,000: none
- 400,000 – 550,000: none
- 550,000 – 1,000,000: 1 company (12,5%)
- >1,000,000: 2 companies (25%)

Energy consumption – thermal power (heating water):

- <25,000: 6 companies (75%)
- 25,000 – 100,000: none
- 100,000 – 250,000: none
- 250,000 – 400,000: 1 company (12,5%)
- 400,000 – 550,000: none
- 550,000 – 1,000,000: none
- 1,000,000 – 2,500,000: none
- 2,500,000 – 5,000,000: none
- 5,000,000 – 10,000,000: 1 company (12,5%)
- >10,000,000: none

Energy consumption – thermal power (steam):

- No demand 1 company (12,5%)
- <25,000: 5 companies (75%)
- 25,000 – 100,000: none
- 100,000 – 250,000: none
- 250,000 – 400,000: none
- 400,000 – 550,000: none
- 550,000 – 1,000,000: none
- 1,000,000 – 2,500,000: none
- 2,500,000 – 5,000,000: none
- 5,000,000 – 10,000,000: none
- >10,000,000: 2 companies (25%)

The energy carriers used were gas (50%), oil (25%), solid biomass (12,5%), biogas (12,5%).
While the most energy intensive sectors in the companies were:

- Animal production
- Peeling and cooking
- Roasting
- Baking
- Packaging
- Cellar

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According to the German Food and beverage association (BVE), there are 5.290 agro-food companies currently operating (BVE, 2014, p.1). Table 10 shows the afore identified main sectors with their biogenic wastes (acc. to Gaida et al., 2013). Furthermore, the type, the amount and the utilization is indicated. The information was gathered through the report of Gaida et al., the national report of the IEE project FabBiogas and thorough interviews with representative parties of the respective agro-food associations.

Table 10. Agro-food sectors with respective waste streams and utilization paths, own table acc. to Gaida et al., 2013.

No	Sector	Amount of biogenic waste	Type of waste	Utilization
1	Slaughter and meat production	400,000 t dm/a (mainly in Nordrhein-Westfalen, Niedersachsen)	Bristle, hair, skin	Further Processing industry (e.g. leather)
			Pig flour, poultry meat flour, feather flour, blood flour	feed, fertilizer Thermal utilization
			Animal and food fats	Oil chemistry, feed or biofuels
			Rumen, intestine, animal carcasses	Potential for biogas production (acc. to Mr. Stachetzki)
2	Dairy production	800,000 t dm (whey ~6% dm content)	Raw milk produced to milk, cheese other dairy products →whey as byproduct	Whey as powder for further human alimentation feed in pig fattening farms
			Milk containing inhibitors, defective charges	Whey further processed in food or beauty products
				Biogas plants
3	Mills (Hulling or grinding) to produce starch	1.74 Mio t dm (~88% dm content)	Flour production →bran, grain, grid, powder, dust	Fibre used for feed for animals or humans, dust is mainly burned
			Starch production from maize, potato, wheat	Proteinrich feed
4	Fruit and vegetable production	130,000 t dm (80 % of fruit and 60 % of vegetables are imported)	Residues from fruit and vegetable production (seeds, peels, marc, pomace etc.)	Biogas, animal feed
			Marc, pomace	Production of alcoholic beverages
5	Oils and fats (from plants or animals)	6 Mio t dm	Slaughter by-products, oil seeds or fruits (soy, sunflower, rape) →oil shred (Ölschrot), press cake, peel of seeds	Oil shred full of proteins therefore valuable feedstuff (100% used for feed)
6	Bakery and dough products	470,000 t dm (~78% dm conent)	Dough and cutting residues	
			Old unsold bread	Sometimes produced to new products, feed – extra production step to unpack bread

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7	Sugar production	3 Mio t dm (produced mainly by huge companies)	Sugar beets → beet soil	Fertilizer on soil
			small parts of beets	Feed
			sugar beet pulp	Compost or export
			molasses	Production of yeast, utilized in biotechnology or pharmaceutical industry, in distilleries as secondary resource
8	Production of confectionary (cacao, chocolate, sugar, gum…)	47,700 t dm	Cocoa peels → with most potentials (~13 companies that roast cocoa in Germany)	Thermal utilization, feed
			Flushing batches	
			Many different residues	feed
9	Coffee, tea	14,530 t dm	Coffee/tea dust, failed batches, coffee bean skins, coffee ground	Biogas plants, thermal steam production
10	Production of seasoning, sauce, convenience food	63,700	Marc, pomace	Due to concentration of salt or extreme ph-levels are not suitable for utilization of biogas
11	Fish production	25,000 t dm (88 % imports) Utilization already optimized	By-catch or fish residues → Fish flour or fish oil	Animal feed (pigs, fish farms), feeding industry for small animals (dogs, cats, fish)

Selected Sectors according to their importance of their waste streams on the market:

Sector No 1 - Slaughter and meat production

According to Mr Stachetzki, the CEO of the Association of Meat Industry Germany[5] there are two main potential substrates of the meat industry: Animal carcasses, body parts and rumen, intestine contents. The first substrate is subject to the regulation of animal byproducts 1069/2009 and is not meant or digestible for human alimentation. Mainly these residues are sold profitably for the alimentation of animals or to pharma industries. This revenue probably is higher than profits from biogas production. However, the latter substrate already proved as suitable for anaerobic digestion and has further potential for the production of biogas.

Within the industry of animal meat production also farm fertilizer (slurry, manure) derives from production processes. Farm fertilizer already is a well-tested and utilized substrate for anaerobic digestion. In Germany exists a high amount of research concerning this substrate and its characteristics.

Mr Stachetzki states, that if the prices for oil still increase, alternative solutions to non-renewable resources are necessary and become valuable. Enterprises will then probably orientate themselves to renewable resources and energies.

[5] Interview conducted with Mr Detlef Stachetzki, Verband der Fleischwirtschaft e.V. (VDF e.V.) on the 18th August 2014

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Sector No 2 – Dairy production

Today there is a trend towards large scale dairy plants. Due to increased efficiency in processes nowadays only around 170 plants in Germany operate. Within the production processes in dairy, high amounts of whey accumulate, with an average dm content of around 6%. This whey is further processed to edible dairy products like soups, margarine, chocolate etc. and therefore stays in the cycle (Milchindustrieverband, 2014b). Another utilization path is the further processing of whey to feed-stuff due to its high nutritious contents. According to Mrs. Stein from the association of German milk industries[6], it is so far avoided to use whey as a substrate for biogas production, since it is full of nutrients and therefore a valuable feed stuff.

Yet, there is another residue that is difficult to dispose: Milk containing inhibitors, a liquid substrate. Inhibitors could be residues of cleaning agents, pesticides, residues of drugs (antibiotics). These substrates are found through testing the milk. Therefore, they occur in small amounts. Until now, it is only possible to anaerobically digest milk containing inhibitors if this milk is directly identified on the ground of the dairy farmer. If the milk is identified with inhibitors after it leaves this ground, the milk has to be disposed by burning. This disposal is cost-intensive and the industry is currently searching for disposal alternatives. According to the German regulation the milk has to be burned and cannot be digested in a biogas plant because of the strict fertilizer regulations.

If the regulation would allow this substrate for anaerobic digestion, the implementation of small-scale biogas plants would be well appropriate.

Sector No 4 – Fruit and vegetable industry

While the fruit and vegetable sector generally holds high potentials for the production of biogas, the CEO of the subsector of the fruit juice industry, Mr Heitlinger[7] does not see a great potential in biogas within this subsector. According to Mr Heitlinger, the substrates only occure in a short period during the year and produce too little substrate for own biogas plants. However, cooperations with other companies would be imaginable.

Nevertheless, due to the high methane yields of fruit and vegetable wastes there is a high potential of this sector concerning the production of biogas.

Sector No 5 – Production of oils and fats

Currently there are around 245 decentralized small and medium oil mills operating in Germany producing oils for rape fuels, biodiesel, feed and edible oil, technical oils. The byproduct of the oil producing process is press cake. Due to its high protein contents, press cake became a quite valuable and well-established feed stuff in the feed-stuff industry in Germany. However, Mr Ralf Gebhard, CEO of the Federal Association of decentralized oil mills and vegetable oil technology (BDOEL e.V.)[8] stated that there currently is more demand for press cake than for oil itself.

Sector No 6 - Sugar industry

[6] Interview conducted with Mrs Astrid Stein, Milchindustrieverband on the 21st August 2014
[7] Interview conducted with Mr Klaus Heitlinger, Fruchtsaftindustrie on the 2nd June 2014
[8] Interview conducted with Mr Ralf Gebhard, Federal Association of dezentralized oil mills and vegetable oil technology (BDOEL e.V.) on the 20th August 2014

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Mr. Ricke-Herbig[9] stated, that although melasses as waste product of the sugar production process is a substrate with high importance for the biogas production, the further potential is quite low. The sugar producing market in Germany is characterized by few big players, that are not SMEs and already have their recycle concepts of residues. Some of them already operate biogas plants with high success.

Barriers identified in the implementation of biogas production in the agri-food sector

The food and beverage industry is an important sector in the German economy with high demands of waste disposal and energy management. It can be assumed that there is ongoing effort of the branches to reduce their energy demand and energy costs and seeking for strategies for energy efficiency. The utilization paths of waste however are multifaceted.

Within the production processes several by-products and waste materials accumulate. By-products can be further processed to other products, for example feedstuff or material recycling and utilization. Wastes are either disposed, transported to large-scale biogas plants or incinerators.

Furthermore, the waste management in Germany is subject to various regulations leading to a complex legal framework of waste disposal. Some of these regulations may inhibit the utilization of organic waste for biogas production.

Within the questionnaire the following statements were made:

- Not enough information – 23%
- No incentives – 6%
- Too big plant according to our needs – 41%
- Not enough organic residues – 12%
- Inconstant production of waste – 12%
- Inconstant need of Energy – 6%

Other barriers and concerns/limitation mentioned:

- negative political framework
- too little space on company ground

Perspectives of the biogas production using organic wastes from agri-food sector.

With regard to the findings, a clear potential for biogas production for energy self-sufficiency in Germany is difficult to indicate in detail. Through the efforts of RENAC it was possible to list the branches with the highest potential for biogas production:

- Dairy production
- Meat production
- Vegetable and fruit production
- Bread and bakery production

[9] Telephone call with Mr Ricke-Herbig, Sugar Association on the 5th June 2014

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- Smaller niche sectors (like wineries, coffee roasters etc.)

Throughout the stakeholder interviews it was furthermore possible to approach and contact influential associations and receive valuable aggregated data of the branches. Consequently, a representative overview of the agro-food sector and its energy demand and waste management could be given. As a result, a high potential for the afore mentioned branches could be confirmed.

Since the agro-food industry in Germany is characterized by a high competitive market, companies seek for individual solutions to increase their competitiveness. Hence they are not willing to indicate or even publish any kind of information on internal data. It can be assumed that with increasing publicity and image of Biogas3 through dissemination activities and close contact to associations, contacting companies directly will be facilitated and workshops and face-to-face activities will reach their purpose.

Moreover, there is a potential for individual consultation with the companies throughout the up-coming face-to-face meetings. Within those meetings a situation and relation of trust could be established and directed individual solutions could be found together with suitable plant providers.

3.3.3. Ireland

Ways applied to contact with (specific or general methodology applied) agri-food companies

IrBEA has conducted a number of activities to contact agri-food companies as detailed below:

a. Direct contact has been made with a number of dairy farms who have in the past expressed an interest in developing biogas plants on their farms. These farms have completed surveys to aid future work in the area. In addition we have contacted central members of the Irish Holstein Friesian Association with the aim of disseminating information on small scale biogas to potentially interested farmers.

b. IrBEA has met with Bord Bia (The Irish Food Board – who are responsible for marketing Irish food products at home and abroad). Bord Bia are conducting an ambitious project called Origin Green, to enhance the environmental credentials of Irish food production. Collaboration with Biogas3 will provide Bord Bia with a unique avenue to reduce carbon emissions of food production.

c. IrBEA has visited two small biogas plants in Ireland to examine first hand the capabilities of small scale biogas – and be able to relate these findings to interested parties. IrBEA has also made contact with a number of interested parties who are developing small scale technology.

d. IrBEA is working with ERVIA (the state owned gas transmission and distribution network operator) who are interested in getting green gas on the grid. ERVIA will shortly be

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announcing a capital funding programme for demonstration projects. This fund will be able to give capital assistance to first movers in the area of small biogas.

IrBEA has had some very good successes early on in the Biogas[3] project, however one difficulty is in engaging directly with food processors, we hope to alleviate this issue in the closing end of 2014 by attending a series of Food Showcase events.

IrBEA has also encountered difficulties in getting farm owners to complete questionaires – instead farmers tend to be more interested in dialogue, this adds considerable time to gathering information but the quality of information and quality of contact is excellent (allowing good assessment of the true level of interest).

Perception of agri-food companies about BIOGAS[3] project. General aspects of the agri-food sector

IrBEA has had most success to date in dealing with farms, interest levels in biogas ranges from high interest down to scepticism. Main perceived barrier encountered is the capital cost of establishing a biogas plant. In recent weeks IrBEA has been able to work with the aforementioned ERVIA in developing capital support for small scale biogas. To date IrBEA has dealt with 5 dairy farms and 2 livestock farms.

In our discussions with Bord Bia we understand that a significant number of small scale cheese producers have difficulty in disposing of Whey, small scale biogas plants would be an ideal solution for some of these processors.

In our meeting with the CREST project (cross border project to promote development of renewable energy in the border region) we understand that a small number of pig and poultry farms would be interested in considering biogas as a partial solution to waste generated and also energy supply.

Ratios of energy consumption and waste generation

To date the predominant waste type is cattle slurry, with some discussion around pig slurry, poultry litter and whey.

Quantities are detailed as follows:

- Dairy farms – cattle slurry 400 tonnes, 600 tonnes, 1200 tonnes, and 29,000 tonnes per year.
- Pig Slurry – ranging from 600 tonnes to 8000 tonnes per year
- Poultry Litter – ranging from 250 tonnes to 1000 tonnes per year
- Whey – ranging from 50 to 600 tonnes per year

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Energy Usage

- Dairy Farms – following calculation of potential gas usage and of onsite energy usage we expect that CHP units will be essentially able to meet between 80% and 100% of all electricity demand. Heat demand on site is low and will be oversupplied to the tune of 3-400%
- Pig Slurry – All energy will be converted into heat and utilised onsite.
- Poultry Litter - All energy will be converted into heat and utilised onsite
- Whey - All energy will be converted into heat and utilised onsite

Organic wastes disposal and treatment

Currently all substrates described above are disposed of via direct land spreading as per normal farm practice. Normally this is not problematic – however Whey disposal to land while carried out does cause considerable odour problems.

Barriers identified in the implementation of biogas production in the agri-food sector

The predominant barriers are identified as follows:

1. Capital Cost and financial viability – the cost of biogas plants is falling however they are still quite expensive. The introduction of the ERVIA demonstration funding is expected to be able to assist greatly in alleviating this issue

2. Biogas knowledge and comfort with technology – biogas is not a common technology in Ireland with circa 15 plants in operation, therefore there is a considerable perceived risk to be undertaken by first movers.

3. Animal By-Products Regulations. The Department of Agriculture Food and Forestry impose strict measures on all plants treating animal by-products. This has proved a major barrier in the past. Since the Biogas3 project was given the go ahead we have lobbied DAFM to relax the rules for certain smaller farm based plants. An agreed format has been written and we expect this to be formalised (signed by the Minister) in the near future.

Perspectives of the biogas production using organic wastes from agri-food sector

Due to lack of familiarity with biogas plants potential developers of plants have tended to be quite neutral on their perspective. However some large industrial biogas plants in Ireland have received considerable local opposition at planning stage – therefore it will be imperative that this is managed carefully.

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3.3.4. Italy

Ways applied to contact with agri-food companies

In Italy, agro-food Companies have been contacted both by Tecnoalimenti and DISAFA. Different strategies have been applied to reach the largest number of companies (in agro and food production/transformation sectors). Tecnoalimenti, in particular, operated through the following ways:

a) took contacts with the own shareholders and the Italian food enterprises of its own Network; it meant to have direct contacts (through face-to-face introduction meetings and/or following telephone calls) in particular with so characterised companies:

- winegrowers associations,
- cheese factories,
- dairy companies,
- sausages producers,
- distilleries,
- oil mills,
- fruit and vegetable producer organisations and processing companies (juices, 4th *range products*, pickles and pickled, canned vegetables),
- wheat and cereals sector.

Overall, 40 agro-food companies have been reached and 22.5% of them completed the questionnaire.

b) took contacts with Italian Associations/Confederations/Cooperatives, to widely disseminate the questionnaire to agro-food SMEs. It meant that some meetings have been organised with the Presidents/directors/responsibles of these groups to introduce the topic, the expected objectives and the potential benefits for their affiliates.

- Tecnoalimenti contacted in particular:
- AIIPA (Italian Association of Food Product Industries and in the field of 4th *range products*)
- CONFAPI (Italian Confederation of small and medium private industry)
- Confcooperative (Italian Confederation cooperatives)
- Assolombarda (Association of industrial and service sectors in the area of Milan)
- Agrofood Cluster of Lombardy,
- Agribusiness Innovation Pole of the Piedmont Region.

The real and direct involvement/support was obtained only by AIIPA and Agrofood Cluster of Lombardy, who circulated – according to the data they provided us – respectively to about 276 contacts the message and the link to the Questionnaire. As a feedback, Tecnoalimenti received some telephone calls from the interested SMEs. However, compared to the catchment area, very few companies have joined the initiative (1.08%).

DEIAFA was operating by personal contacts with companies known by the extension network of the University of Turin. The companies selected were the ones that have large

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amount of food-waste (mainly slaughtering plants, meat processors, sausage producers), that justify the implementation of a small biogas plant itself. After a telephone contact were carried out face-to-face meetings with the agri-food companies persons in charge. This was done for the following reasons:

1) Explain the purpose of the questionnaire and the use of the data (privacy, non-commercial purposes, etc.)
2) Explain in the detail the questionnaire
3) Acquire trust from the people of the agri food companies.

Although few companies were contacted in this way, quite time consuming, almost all of them respond to the questionnaire. Totally 14 questionnaires were fully answered, of a total of 24 questionnaires made for Italy.

In general terms, about 330 Italian agro-food companies have been informed on BIOGAS^3 project and about 7% collaborated filling-in the proposed Questionnaire (24 total).

General analyses of questionnaire

Biogas production from waste fermentation can be applied to different agro-food sub-sectors. For this reason, Tecnoalimenti and DEIAFA contacted Italian companies operating in different points of the various production chains.

In particular, questionnaires from 7 companies of primary production (29% of total companies) and 12 companies of food transformation (50% of total companies) were analysed: other 5 reached companies perform both production and food transformation.

Two sausages producers (located in Emilia-Romagna region) have not filled-in the questionnaire, but have granted an interview to discuss their position with regard to biogas.

Several production chains were involved:

- 10 factories from meat sector (4 slaughterhouses, 4 sausages producers, 2 meat producers),
- 4 companies operating in wine sector,
- 3 from cereals sector,
- 3 from dairy sector, and
- 3 from vegetables production and transformation.

In addition, answers from 1 brewery, 1 company producing eggs and 1 oil mill were obtained.

According to the project's goal, small factories theoretically able to configure a small biogas plant (< 100 kWe) were principally involved: 12 micro enterprises (lower than 10 employees) and 9 small enterprises (up to 50 workers) filled-in the questionnaire. 3 enterprises up to 250 employees (ascribable to the category of medium-sized enterprises) were also reached, who actually represent consortia of small-scale producers (so they are in line with BIOGAS^3 project requirements).

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Most of the involved companies (83%) perform their production/transformation activities during the whole year so, theoretically, the production of waste to feed a digestor is continuous. But, among these companies, only 3 farms work 7 days per week and only one mill works 24 hours per day, while the other companies work, on average, 5 days per week and 8 hours per day. Only 4 seasonal factories were taken into account: they produce seasonal food such as wine, oil or canned vegetable.

Ratios of energy consumption and waste generation

To the big variety of reached companies corresponds, in the analysed answers, a large variety of waste types to be used for the production of biogas.

Factories from meat sector produce sewage and animal manure (primary production) and/or bones, blood, slaughter waste (transformation); obviously sewage were produced in greater amount than slaughter waste (on average 1000 tons/year vs 200 tons/year) but they have lower values of dry matter.

Wastes from vegetable production and transformation companies are pruning residues and husking waste, respectively.

Other wastes are typical of the specific nature of the company (grapeseed, pomace, bran and flour dust, whey) but, transversal to all production/processing chains, there is the presence of unsold and/or unsaleable products as waste. Interesting is the production of sludge from sewage treatment plant (cattle farm): it is an attractive potential fermentation substrate for biogas production.

The analysis of waste amount shows that, in most cases (45% of collected answers), the production is minimal (less than 50 tons/year) but in 2 cases (field and bran of cereals) the waste production is higher than 10.000 tons/year.

Within 24 collected answers about waste characterisation, more frequent are solid residues (17 vs 7) and dry matter represent, on average, 46% with a range from 3% (sludge from sewage treatment plant) to 90% (flour dust).

The majority of reached agro-food companies have low energetic requirements: 6 companies (27% of total answers) have minimum energy consumption (<25,000 KWhel) and 9 companies (41% of total answers) have low energy expenditure (range from 25,000 to 2,500,000 kWhel).

Despite low dimensions, 3 reached companies have very great energetic requirements (<100,000,000 kWhel): in two cases these values are due to the high number of working hours but for oil mill this is due to the specific nature of the process.

In many cases energy derives from thermal sources (both hot water at mean temperature of 66°C and steam); within other energy sources, 15 reached companies use gas, oil or fossile energy, 3 companies use renewable energy sources (geothermal, photovoltaic), 1 company uses methane but none uses specifically energy from biogas.

The most energy consuming parts are often represented by the processing steps of heating/cooling.

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Summarizing, the majority of reached companies have not a great production of wastes and also their energy consumption is, on average, low: the production of biogas from agro-food wastes could satisfy (at least in part) the energy demand and in particular the hot water requirements.

Organic wastes disposal and treatment

Basing on filled questionnaires, in most cases (48%) agri-food companies do not manage individually their wastes but authorised managers do it. In other cases, wastes are used within the same factory for landfill (6 cases on 29 answers) or are treated in situ (5 cases on 29 answers). Some agro-food companies sell their wastes and have an income: in particular, a medium enterprise of fruit packaging and distribution already sells its wastes to a biogas producer.

Summarizing from an economic point of view, in most cases agri-food companies have an income (9 answers) or have not spending from waste management (8 answers), but in other cases they have to pay a price up to 500 €/ton (a micro enterprise of breeding, slaughtering and sausages production).

Barriers identified in the implementation of biogas production in the agri-food sector

In terms of main barriers to implement a biogas plant, interviewed companies have put in evidence problems related to companies structure such as not enough wastes (3 answers) or inconstant waste production (4 answers), but the most frequent problems are closely related to BIOGAS3 project's goal. In fact, 6 reached companies currently know only plants too big according to their needs, 5 companies have not enough information about biogas production and 3 companies are not informed about incentives. From this point of view, BIOGAS3 project can strongly promote the sustainable production of renewable energy from the biogas obtained from agricultural residues and food and beverage industry wastes in a small-scale concept for energy self-suffiency.

Perspectives of the biogas production using organic wastes from agri-food sector

Despite some barriers to remove, biogas production from agri-food waste seems to be a promising sector in Italy.

Among 24 reached companies, there is a good understanding of this matter and only one had never heard about biogas (a small enterprise for flour production). On average, on a scale from 1 to 10, the interest in these issues is evaluated 7.

Different companies have shown their specific interest for the initiative and are represented by:

- a canned vegetable producer: it produces canned cabbages and has seasonal problems with the residues from vegetables husking (leaves),
- a cereal mill located in Umbria region: it has a lot of cereal bran to dispose of,
- a dairy products enterprise: it produces less than 50 tons of waste/year and delivers them to an authorised manager,
- a chickens raising for eggs production: it produces 500-100 tons of waste/year and uses it for landfill

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Winegrowers associations have also confirmed their interest on the topic.
In terms of main reasons to implement a biogas plant, the most important one seems to be the cost reduction for energy consumption (8 answers), followed by positive impact on environment (5 answers) and energy self-sufficiency (5 answers); 4 answers were collected for cost reduction in waste management, 3 for additional income from energy selling and only 2 answers for green marketing.

In this context, it is also important to underline that about half of the reached companies (7 on 15) are already equipped with a system for potential storage of biogas.

Free Comments:

- We are in a start-up step and need to verify the commercial perspectives
- Feasibility according to the company size
- Lack of use of the heat in the production process

3.3.5. Poland

Ways applied to contact with agri-food companies

Fundeko contacted 7 associations of agro-food producers (National Union of Agro-producers Groups, Association of Bakery Artisans of the Republic of Poland, Association of Polish Regional Breweries, Association of Polish Bakers, Union of Producers and Employers of the Meat Industry, Polish Chamber of Noodle, National Association of Dairy Cooperatives) – both by sending official letters offering cooperation within BIOGAS3 project and by direct phone conversation. None of the above associations demonstrated interest in any form of proposed cooperation (questionnaires, workshops, training, distribution of handbook, feasibility studies).

Subsequently, Fundeko created a database of small and medium size food producers (diary, meat, bakery, noodle, brewery, cereals etc.) based on public business registers. These 300 companies were contacted via e-mail in May (each company 2 times) with the request to fill in the Biogas3 questionnaire and with the offer of future trainings, handbooks and feasibility studies. Ca. 50% of the companies were also contacted via direct phone conversation. Unfortunately, there was almost no positive answer to this action of Fundeko (result: 3 questionnaires).

On the other hand, two Centers of Agricultural Counseling - from Mazowieckie and Lubelskie regions contacted Fundeko voluntary, communicating rather big interest in small scale biogas solutions among farmers. The two Centers declared cooperation in BIOGAS3 project activities. Following this idea, Fundeko contacted several farmers by direct face to face meetings (result: 20 questionnaires). Additionally, in order to reach the 30 questionnaires target, Fundeko appointed the Lubelskie Center of Agricultural Counseling to interview representatives of agro-food industry in this region (result: 10 questionnaires).

In total, more than 330 agro-food companies/farms were informed about the project, but only 33 questionnaires were filled in (10%).

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General analysis of received answers

The questionnaires have been filled in by:

- 27 farms (including 2 agricultural schools classified as farms due to the farming activity - animal and plant production)
- 2 fruit and vegetable processing companies
- 1 fish processing company
- 1 supermarket (with own bakery and own meat processing division)
- 1 food service company (gastronomy)
- 1 hotel/restaurant.

Size of companies:

- 26 micro enterprises (79%) – all farms10
- 3 small enterprises (9%) – agricultural schools (farms), supermarket (bakery + meat processing)
- 4 medium enterprises (12%) – fruit and vegetable processing, fish processing, gastronomy (food service)

All of the interviewed companies declared continous type of production. The average number of working days per week was 6,6.

Number of working hours per day:

- less than 6 h: 4 companies (12%)
- 6 h: 5 companies (15%)
- 8 h: 13 companies (40%)
- Other (more than 8 h) – 11 companies (33%)

GENERAL REMARK: Due to the high representation of farms (27 out of the total 33 companies) we think we may only conclude on some aspects of agricultural sector – for the other branches the sample is too small[11].

Ratios of energy consumption and waste generation

The main types of organic waste generated by farms are:

- plant material: residues from crop production (including straw), material from grasslands, beet leaves, maize silage
- animal material: pig and cattle manure (mostly solid, with high content of straw), pig and cattle slurry.

Other types of waste mentioned in the questionnaires:

- fruits and vegetables
- juices and water (used for vegetables/fruits cleaning)
- food waste (from food service and restaurant)

[10] The average size of Polish farm is ca. 10 ha (data of Agency for Restructuring and Modernisation of Agriculture). So an average Polish farm may be too small to maintain a biogas plant individually.

[11] Some more info on waste streams from agro-food industry and biogas production in Poland is available under: http://www.fabbiogas.eu/fileadmin/user_upload/Download/D2.1_National_Report_POLAND_english.pdf

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- fish waste cat.3
- meat waste cat. 3

Amounts of organic waste produced:

- <50 t/year: 3 companies (9%)
- 50 -100 t/year: 4 companies (12%)
- 100 -500 t/year: 18 companies (55%)
- 500 -1 000 t/year: 3 companies (9%)
- 1 000 -5 000 t/year: 4 companies (12%)
- 5 000 -10 000 t/year: 1 company (3%)
- >10 000 t/year: none

97% companies declared the main organic waste is solid. In case of the second potential substrate (which was declared by 19 companies), 47% was declared as liquid.

Energy consumption – electric power:

- <25 000: 16 companies (50%)
- 25 000 – 100 000: 8 companies (25%)
- 100 000 – 250 000: 1 company (3%)
- 250 000 – 400 000: 4 companies (13%)
- 400 000 – 550 000: none
- 550 000 – 1 000 000: none
- >1 000 000: 3 companies (9%) (fruit and vegetable processing, fish processing)

Energy consumption – thermal power12:

- <25 000: 19 companies (63%)
- 25 000 – 100 000: 6 companies (20 %)
- 100 000 – 250 000: 3 companies (10 %)
- 250 000 – 400 000: 1 company (3%)
- 400 000 – 550 000: none
- 550 000 – 1 000 000: none
- 1 000 000 – 2 500 000: 1 company (3%) (fruit and vegetable processing)
- 2 500 000 – 5 000 000: none
- 5 000 000 – 10 000 000: none
- >10 000 000: none

Only one company declared the use of steam, all the other companies use hot water, temperatures from 55 to 80oC.

Energy sources: Many companies use various sources of energy (therefore the percentages below sum up to more than 100%)

- Fossil energy: 55%
- Gas/oil: 64%
- Solid biomass: 12%
- Other: 60% (firewood, wood chips, combustion of straw or biomass in a coal boiler)

[12] 3 companies were not able to calculate the yearly consumption of thermal energy, therefore the calculation is based on 30 questionnaires

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Organic wastes disposal and treatment

The organic waste generated on farms is in all cases managed by on site treatment, which means: ploughing, compost, application on fields as natural fertilizer, feeding animals or handed over (for free) to other farms which apply the same methods. It is therefore difficult to asses the actual costs of such waste management – it's the cost of own work usually (declared as 0 or "difficult to calculate").
In case of fruit and vegetable processing (2 companies), the waste is handed over to some external biogas plants. Only the supermarket (with bakery and meat processing) declared high costs of waste management (>50 EUR/t).

Barriers identified in the implementation of biogas production in the agri-food sector

The following barriers were identified (please note that this was a multiple choice question, therefore the results sum up to more than 100%)

- Not enough information – 21%
- No incentives – 80%
- Too big plant according to our needs – 30%
- Not enough waste – 48%
- Inconstant production of waste
- Inconstant need of Energy

Other barriers and concerns/limitation mentioned:

- too expensive technologies,
- too high investment costs,
- lack of certainty as regards long-term profitability,
- lack of subsidies appropriate for small installations,
- lack of attractive credits,
- high pre-investment costs, including complicated, time-consuming preparatory procedures,
- lack of law on Renewable Energy Sources,
- lack of political will to promote RES.

Perspectives of the biogas production using organic wastes from agri-food sector

The perception of towards AD technology among has been positive – the average score was 7.5 (range: 1-very negative, 10-very positive).

However, this result is not representative for the whole agro-food sector in Poland – the questionnaire was filled in by persons interested in biogas production. The ones whose perception towards AD technology is negative refused to fill in the questionnaire[13].

[13] A large scale questionnaire performed by the Foundation for the Development of Polish Agriculture (FDPA) in 2013 among >1100 farmers show, that 67% of the responders have been interested in biogas solutions. The main barriers for biogas sector development for farmers are: administrative procedures, financial barriers and social opposition (lack of social acceptance for biogas projects). **Majority of the responders were interested in micro scale solutions (<40kWel),** although they were afraid that the new regulations (decreasing the level of support for micro-installations) will limit the possibility of development in this sector.

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Main reasons to implement a biogas plant (please note that this was a multiple choice question, therefore the results sum up to more than 100%):

- Cost reduction in waste disposal: 9%
- Cost reduction for energy consumption: 61%
- Additional income from selling heat and electricity: 82%
- Energy self-sufficiency from energy provider: 21%
- Positive impact on environment: 15%
- Image/green marketing: 12%
- Other: profitability, income diversification.

Free Comments:

- Lack of adequate policies / Policies, legal requirements are barriers
- Lack of national technologies
- Lack of stable laws / Lack of regulation for long term investments
- Investment-profit is not clear enough / Lack of certainty of profitability / Economic profitability is not assured / Lack of estability in investment
- Lack of financing
- I would search for a 10-20 kW biogas plant, and there are no such installations on the market
- Too high investment costs and lack of credits/subsidies
- My main doubts refer to the stability of profitability of investing in such technologies
- My energy needs are responsible for a big share of my expenses. I expect a technology adjusted to the size of my activity.
- I think that when the law gives a guarantee for a long term profitability, attractive options of financing will arise. Till then, I will not try.
- The company is too small

3.3.6. Spain

Ways applied to contact with agri-food companies

FIAB and AINIA directly contacted with members of the own FIAB associations, AINIA contacts, and other agro-food industries and associations, adding up to 170 companies. FIAB represents more than 5.000 companies from the food and beverage industry and involves sectorial associations from the main subsectors, which were also contacted indirectly through these sectorial associations.

The contact has been done by sending official letters, telephone calls and emails from FIAB and AINIA offering cooperation within BIOGAS^3 project, by means of the sectional associations and by direct phone contacts with some major market players. Then, the information was collected by direct visits to the industries, to gain face-to-face information about the current situation and obtain the most accurate data, also through internet questionnaires by a survey tool, and finally completed with telephone complementary data. The companies involved represent the most promising sectors in the country for biogas purposes, as vegetables and fruits, dairy products, vine production, fish industries, meat and derivates and others.

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Most of the information requested to was received from 50 companies and the table with the overall information for the study was completed up to approximately 95%. The information has been depurated and filtered in an Excel table, and exploited to obtain the results included in the report.

General analysis of received answers

The questionnaires have been filled in by:

- 1 Agriculture (2%)
- 2 Bakery (4%)
- 1 Cereals and crops (2%)
- 8 Dairy products companies, as milk, cheese and others (17%)
- 5 Fish products (11%)
- 14 Meat and meat products companies, as slaughterhouses, sausages production, etc. (29%)
- 11 Vegetables and fruit processing companies (23%)
- 2 Wine industries (4%)
- 4 Other (as prepared food) (4%)

Comments: Meat and meat products, and fruit processing companies was identified as a potential sectors considering the information from the questionnaires.

Size of companies:

- 4 micro enterprises (8%) – Dairy products
- 11 small enterprises (23%) – mainly meat and wine industries
- 12 medium enterprises (25%) – basically all are dairy products industries
- 21 large enterprises (44%) – most of them from dairy products, vegetables and fruits and meat and meat products.

From the interviewed companies, 31 companies (94%) declared continous type of production.

Related to the number of working days per week, the companies have declared:

- 5 d: 21 companies (44%)
- 6 d: 13 companies (27%)
- 7 d: 12 companies (25%)
- Other: 2 company (4%)

And the number of hours per day were:

- <9h: 18 companies (37%)
- 9-14h: 10 companies (21%)
- 15-19h: 8 companies (17%)
- 20-24h: 12 companies (25%)

Comments: Large enterprises present a similar figure than SMEs in the number of potential industries. Most of the companies work 5 days per week and less than 9 hours per day. Companies adding 6 or 7 days and more than 15 hours also represent a big group.

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Ratios of energy consumption and waste generation

The organic wastes generated, characteristics and amounts found are described in the following paragraphs.

The main types of organic waste generated in the industries are:

- Fish residues in 5 plants, as bones, skin, pieces and guts
- Manure in 2 plants
- Meat residues in 13 industries, as fat, rind, bones, parts and others
- Dairy product wastes in 3 plants
- Sludges from waste water treatment plants are found in 6 industrial plants
- Straw and grain residues in 2 plants
- Vegetable and fruit residues in 11 plants, as pieces of plants, skins, damaged fruits, etc.
- Wine production residues in 3 plants, as seed, skin, marc and lees

Secondary wastes found in those industries are basically the same kind of mentioned in main types.

Amounts of main organic waste produced:

- <50 t/year: 12 companies (25%)
- 50 -100 t/year: 2 companies (4%)
- 100 -500 t/year: 7 companies (15%)
- 500 -1 000 t/year: 5 companies (10%)
- 1 000 -5 000 t/year: 14 companies (29%)
- 5 000 -10 000 t/year: 2 company (4%)
- >10 000 t/year: 5 companies (10%)
- Others: 1 (2%)

Comments: meat and vegetables and fruits residues constitute the two main substrates found in the survey. 40% of the industries produce 1000-5000 tons of residues per year, which would allow the construction of 15-75kW biogas plants.

From the main residues, the moisture content is higher than 70% for 79% of the plants, between 70 and 50% moisture was found in 15% of the industries and less than 50% moisture in 3%. For the second residue the moisture contents are similar.

Almost 90% of the residues are produced along the year, continuously, while only 10% are produced in specific seasons. This latest ones are typically related to wine production, olive oil, or some crops.

The following information is related to the energy uses.

Energy consumption – electric power (kWh/y):

- <25 000: 5 companies (11%)
- 25 000 – 100 000: 3 companies (6%)
- 100 000 – 250 000: 0 company (0%)
- 250 000 – 400 000: 3 companies (6%)
- 400 000 – 550 000: 3 companies (6%)

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- 550 000 – 1 000 000: 1 company (3%)
- >1 000 000: 33 companies (69%)

Energy consumption – thermal power (kWh/y):

- <25 000: 12 companies (25%)
- 25 000 – 100 000: 3 companies (6 %)
- 100 000 – 250 000: 0 companies (0 %)
- 250 000 – 400 000: 3 companies (6%)
- 400 000 – 550 000: 3 companies (6%)
- 550 000 – 1 000 000: 3 companies (6%)
- 1 000 000 – 2 500 000: 5 companies (11%)
- 2 500 000 – 5 000 000: 5 companies (11%)
- 5 000 000 – 10 000 000: 1 company (2%)
- >10 000 000: 9 companies (19%)

35 companies declared the use of steam, with temperatures 170-180ºC. Some companies produce hot water at several temperatures directly (10-90ºC), but also some companies produce the hot water from the steam.

Energy sources: Many companies use various sources of energy (therefore the percentages below sum up to more than 100%)

- Fossil fuel (mix): 9 %
- Heating Oil: 24 %
- LPG: 3 %
- Natural Gas: 58 %
- Propane: 3 %
- Others: 3%

The most intensive consuming processes at the industries are one or several of the following:

- Industrial cooling
- Process heat
- Electric motors and electric equipment (different that cooling)

Comments: energy consumption found varies from one company to other considering the processes and the size. A wide use of natural gas is found in 58% of the companies, which helps the introduction of biogas as the conversion needs might be lower due to the existence of gas installations.

Organic wastes disposal and treatment

The organic waste generated on the industries is used or managed in several ways. It is collected by an Authorized Agent in 76% of the cases. Additionally, it is used for alcohol production in wine industries, valorisation, landfill, on site treatment, animal feed and others.

One dairy products plant in Spain has declared to have a biogas plant.

Related to the residues management cost, it is highly variable as usually the residue might have a secondary use, which has not a fixed cost. The range of cost-benefit for the residues

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management varies from an income of more than 50€/t to an expense of over 50€/t. In some cases the cost is 0.

Barriers identified in the implementation of biogas production in the agri-food sector

The following main barriers were identified, which correspond to the threats of Biogas[3] project.

- Residues quality or quantity: 37%
- Plants are too big for my company needs: 21%
- Not enough information :15%
- Economic and Financing:15%
- Not owners of the space: 3%
- Other:6%

Other barriers and concerns/limitation mentioned:

- Smells
- Plants are too big for my company needs
- Economic and Financing

Perspectives of the biogas production using organic wastes from agri-food sector

The perception of towards AD technology among has been positive – the average score was 7 (range: 1-very negative, 10-very positive).

The Spanish companies wish to receive more information about Biogas plants opportunities were 26, that means close to 80%

Main reasons to implement a biogas plant, which are also opportunities for Biogas 3 project :

- Energy bill reduction: 46%
- Energy self-sufficiency from energy provider: 12%
- Cost reduction in waste disposal: 30%
- No possible: 3%
- Positive impact on environment: 3%
- Image/green marketing: 3%
- other, income diversification: 3%

Free Comments:

- We can't see the biogas application because the variety of examples of plants spread throughout Spain.
- Biogas is already studied, and not get a return interesting for us to approve
- Biogas is not applicable for us
- For us it is not viable
- Low production of residues
- Biogas depends of company policy

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3.3.7. Sweden

Ways applied to contact with agri-food companies

Barriers/ Market overview. Production of biogas from organic residues is a well known concept in Sweden. Residues from food industry are commonly digested in municipal biogas plants together with organic waste from households. In many Swedish municipalities organic waste is separately collected in households and turned in to biogas which is upgraded and used primarily in city coaches. As biogas is generally well known in Sweden it is also known among agro-food companies. Some of the companies within the food industry, for example two of the largest breweries in Sweden, have their own biogas plants today. Production of biogas on a farm scale takes place at about 30 locations all around Sweden. The Swedish board of agriculture has during later years given a special grant, of up to 30 %, for investments in technology for farm scale biogas production. Because the demand for biogas in form of vehicle fuels is high in Sweden the competition for available organic residues is rising in some regions.

Approaching the target group – agro-food associations. To get in contact with interested agro-food companies JTI has distributed general information about Biogas^3 together with specific information on the questionnaire associated with WP2. A subpage was created on JTI:s website where the project is presented and where a link to the questionnaire was available during the collection of questionnaire answers.

Contacts were made within our networks to receive specific companies (persons) which would have an interest in participating through answering the questionnaire. The contact within our networks were representatives of:

- the LRF (national and regional)(http://www.lrf.se/In-English/)
- regional organizations Biogas Öst, Biogas Väst and Biogas Syd (http://www.biogasost.se/OmOss/InEnglish.aspx)
- Hushållningssällskapen (http://www.hush.se/?p=12286&m=4090)
- Jegrelius(regional institute of Jämtland)
- Eldrimner (http://www.eldrimner.com/1551.om_eldrimner.html)
- and more

The general information was distributed as follows:

- Information was included in an electronic newsletter from Bioenergiportalen (the "bio energy portal"),wich is a national resource and website for information and news regarding bioenergy (http://www.biogasportalen.se/In-English). Around 1 000 people receive the newsletter. The news updates are also available on the website.
- Information was distributed on mail to JTF which is a network for those interested in technology in agriculture (http://www.jti.se/index.php?page=jordbrukstekniska-foreningen). Within JTF are around 350 receivers.
- SIK, the Swedish Institute for Food and Biotechnology, informed about the project in a newsletter addressingcompanies in the food industry. The newsletter has around 30 receivers.

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Before the actual collection of answers to the questionnaire started a total number of 86 names (contacts within different companies) were listed as potentially interested in participating. Of these 86 names 60-70 were names which we received directly through contacts within our network. Around ten names were found through web-sites and literature/reports on biogas production capacity. The remaining names were those who on their own initiative made contact after reading about the project.

We distributed a link to the questionnaire through e-mail during june to a majority of these 86 names. This resulted in less than ten answers within a two week period. Since the number of answers was small a majority of the persons on the list were later contacted through phone calls. Phone contacts made clear that some of the persons which received the e-mail had not taken the time to read it. Many of the persons on our list were farmers, who often have little time to spare and therefore might not find the time to sit downand fill in the questionnaire. The phone contacts resulted in several additional answer to the survey, though the perception among many of the farmers is that farm scale biogas production is not profitable in the current market.In total 23 companies have answered the survey.

Three company representatives directly declined to participate after phone contact. They expressed an interest in the subject, but declined due to lack of time.

General analyses of questionnaire

The 23 Swedish companies which took part in the questionnaire have their main scope of practice in the following areas:

- Farming, not further précised, 10
- Milk production, 3
- Crop production, 2
- Meat and slaughter, 2
- Farming and forest, 1
- Food, 1
- Ready-cooked food, 1
- Pig and grain production, 1
- Horse breeding, 1
- Horse feed, 1

The scope of practice for the companies that answered the survey is dominated by farming of different sorts. It can be assumed that specific branches of the food industry, especially those dealing with processing of animals, should be more interested in biogas production since they could see direct economic benefits. Their having to consider the legislation of animal byproducts, including sanitization of residues,results in higher costs for handling of their organic residues.

Farmers handling manure are positive to applying digestion before using the manure for fertilizing, *if* it is economically profitable. For large scale animal production facilities a reduction ofresidue volumes and smell after digestion would be positive.

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In Sweden biogas production is generally seen as attractive due to the assumption of environmental benefits. The issue of small scale production comes back to economic aspects. Many respondents press on this issue. Extended cooperation between municipalities, agro-food companies and specialists was one suggestion aiming at increasing the number of small scale plants in Sweden. Another suggestion from the respondents was that governmental subsidies are needed if small scale biogas production is to become more frequently seen. Support from regional authorities has previously been possible through grants from the Swedish board of agriculture.

The companies were mainly micro enterprises, see Figure 8.

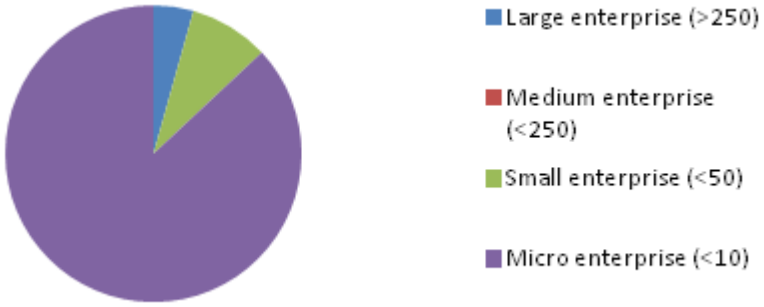

Figure 8. Size of respondent companies based on the number of employees

All except two indicated a continuous type of production. The production days per week and hours per day varied and are displayed in Figure 9.

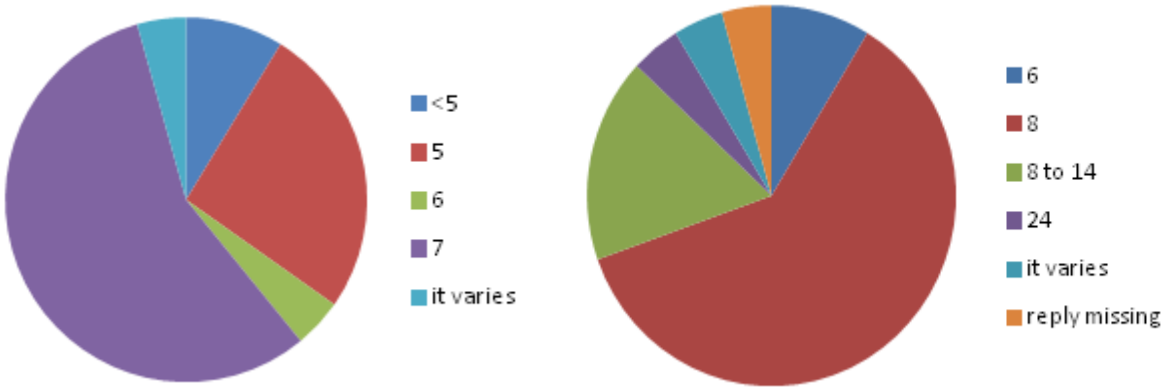

Figure 9. Production data

Ratios of energy consumption and waste generation

Energy demand of agro-food sector in Sweden:
A report from JTI "Jordbrukssektornsenergianvändning" (Edström et al, 2005) describes the energy demands within the agricultural sector and the associated food industry. The energy

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demand was calculated based on the energy use for activities associated with food production. Results showed that in the agricultural sector3.7 TWh of energywas consumed in direct use of which 60 % was fossil fuels, 30 % electricity and 10 % bioenergy. A later study calculated the direct use of energy in agriculture to 3.11 Twh (Baky et al, 2010).The food industry consumed an additional 7.5 TWh of fossile fuels (Edström et al, 2005). Less than 10 percent of the total energy consumption in the food industry came from bioenergy. The writers conclude that the agro-food industry could be an actor which drives the development towards extended use of bioenergy. Fuel for vehicles/machines and for refining processes could be replaced by renewable energy, where biogas in many cases could be an appropriate alternative. Linné et al (2008) calculates that only manure and plant residues constitutes a future potential of 10.8 TWh biogas per year. Thus theoretically there is a potential of energy self-sufficiency in agriculture.

There is a growing interest in the agricultural sector to produce biogas. Manure and ley are possible substrates from agricultural production (Baky et al, 2010).

Results from questionnaire:
The types of organic substrate generated in the companies answering the questionnaire were:

- Liquid manure, 14
- Mixtures of litter, solid manure and residues from feed, 9
- Crops (grain/legumes) and/or ley in different forms, 7
- Solid manure, 2
- Residues from slaughter, 2
- Potato peel / discarded potato, 2
- Residues from handling of eggs, 2
- Plant residues / residues after crop collection, 2
- Residues from production of dairy products, 1
- Residues from production of ready-cooked food, 1

The number of companies producing different volumes of main organic residues is shown in Figure 10.

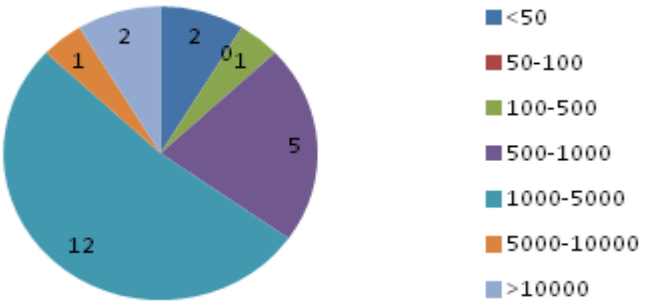

Figure 10. Number of companies producing different amount of wastes (in tons)

About two thirds of the companies (16 out of 23) declare that their residues are liquid, with TS from 5 % up to 20 %. The remaining companies have more solid residues.

The consumption of different types of energy in the companies is shown in the following figures.

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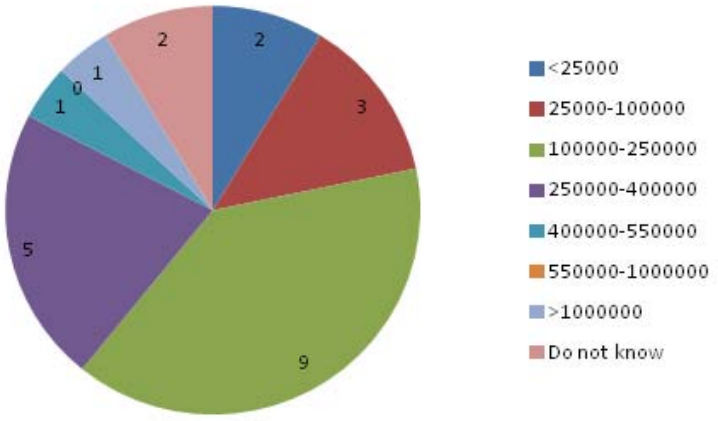

Figure 11. Electrican energy consumption by the companies answering the questionnaire

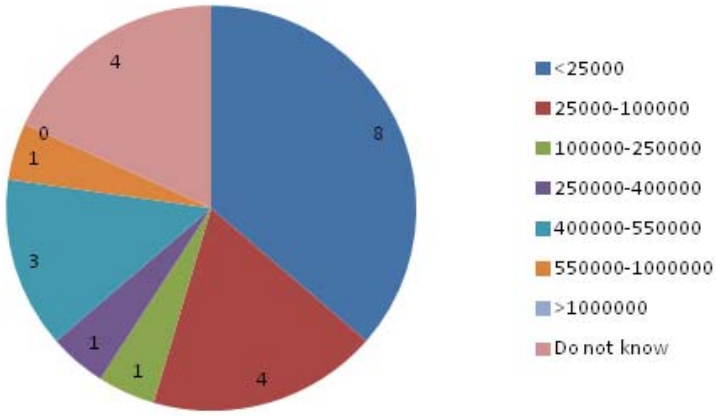

Figure 12. Thermal energy consumption by the companies answering the questionnaire

Of the 23 participating companies only four declared that they use steam. One declared a future need of steam.

The energy sources used were as listed in the following table.

Table 11. Main energy source at the different companies

	Number of companies	Percent
Oil/gas	4	17%
Fossil fuels	3	13%
Solid biomass, pellets	7	30%
Wood chips	2	9%
Electricity	4	17%
Grain/ley	2	9%
Geothermal heat	1	4%

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The most energy consuming processes at the companies varied. Many answered that either heating, drying or fuel for vehicles and machines were the most energy consuming activities. Some gave their answers in general terms, for example "pig production". Single persons answered that steam production, cooling or hot water was the most energy consuming activities.

Organic wastes disposal and treatment

Among the companies that participated in the questionnaire many were farms which handled organic residues in the form of liquid manure. Most of these companies currently spread the manure on their own land or in cooperation with other farms in the close vicinity. Some residues that could potentially be used for biogas production, such as ley, are today sold and some, such as residues from slaughter and egg production, make out a large cost for the company because they need to be handled by an authorised part. There is only one company which have residues that end up at a land fill (to put organic matter in land fills is generally forbidden since 2005).

Generally the handling of residues adds cost at the companies which participated in the questionnaire. Most of the participants are motivated to examine the possibility of biogas production because they see the possibility to reduce costs, for either waste handling or energy consumption. Further, many of the participants see biogas production as a means to get additional income from selling heat and energy. Many are motivated by energy self-sufficiency. Lastly, some mentioned smell as an issue that can be reduced by digestion.

As many of the companies which answered the questionnaire are farms the conclusions which can be directly drawn from these answers are not necessarily representative for other parts of the agro-food industry. Residues such as molasses from sugar production and marc from beer production can for example be used in animal feed and can therefore contribute an additional income to the companies. In those cases biogas production from the organic residues will probably not be as attractive.

In conclusion there is a will among the participants to make use of the organic residues produced and at the same time make a profit (alternatively to reduce costs).

Barriers identified in the implementation of biogas production in the agri-food sector

The most important barrier to implement biogas production among the companies which took part in the questionnaire was the economic aspect. Biogas production is interesting only if it is profitable and the payback period is acceptable. The general perception among the participants is that profitability is hard to achieve. Other concerns among the participants are that the amounts of available organic residues are too small, or that a plant would be to big compared to the company needs. Only two out of 23 company representatives say that they need more knowledge about biogas technologies.

Perspectives of the biogas production using organic wastes from agri-food sector

None of the participants in the questionnaire are unfamiliar with the concept of biogas production from organic residues. Biogas is generally known among the public in Sweden since it is used to fuel city buses in several of the larger cities. Other possible uses for biogas than as automotive fuel are probably not as well known.

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The perception of biogas production is generally positive among the participants in the questionnaire (it should be noted that this might be one of the reasons they chose to participate in the questionnaire). None of the participants have indicated that they are on the "negative side" of the scale, though some are quite neutral towards biogas technology. The average score was 7.8 (range; 1 – very negative, 10 – very positive).

Free Comments:

- I think that cooperation between municipalities, agro companies and specialists is needed. I also believe that the rules for handling need to be simplified.
- Our egg substance needs to be sanitized before it can be used for biogas production.
- We want to heat the farm and make on third electricity! We are building our own plant, on our own. But after 5 years it is still not ready. We would very much like help!!!
- Residues from agriculture or food industry that can be used as feed should not be used for biogas production. Give those products to the animals and then use the manure for biogas production.
- The profitability is too low. Governmental support is required.
- We are very interested in biogas production, but as we have understood it is very hard to get a positive economy. We have a lot of energy that is not utilized and after digestion there is less smell when the manure is spread. We see the smell issue as an important part, because people, in general, people are little understanding towards agriculture.

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5. List of tables

List of figures

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6. Annex 1. Questionnaire

https://docs.google.com/forms/d/1tgLllSgo3nTV_F0IN8cGN-dteGQZWRJdITUmhW_X_vM/viewform

BIOGAS3 Questionnaire Sustainable Small-scale biogas production from agro-food waste for energy Self- sufficiency

The aim of BIOGAS3 project is to promote the sustainable production of renewable energy from the biogas obtained of agricultural residues and food and beverage industry waste in small-scale concept for energy self-suffiency. This project is co-funded by the Intelligent Energy Europe Programme of the European Union, Contract N°:IEE/13/SI2.675801.

The consortium includes representatives of all key actors: agro-food industry associations (FIAB, ACTIA, TCA), research centres dedicated to agrofood industry and bioenergy (AINIA, JTI, DEIAFA, IFIP), bioenergy associations (IrBEA), and training and dissemination specialist oriented to renewable energies (RENAC, FUNDEKO). For futher information you can visit: www.biogas3.eu or by twitter @BIOGAS3project.

The objective of this questionnaire is to do a initial diagnosis from the agrofood industries and try to identify some important data as the organic wastes, energy consumptions and evaluate the degree of knowledge of AD (anaerobic digestion) Technologies.

Disclaimer: This information will be used within the project to provide the basis of market assessment and to provide contacts for partners activities. No information will be sold or distributed in any form without written consensus.

*Required

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7. Annex 2. Exemplary presentation of the responses of the questionnaire

	Substrate I	Amount (t FM/a)	Condition (+ dm content in %)	Occurance of substrates	Current utilization of substrate	Costs or revenues from disposal
1	Farm fertilizer (liquid manure)	500-1000	liquid, dm 15%	Constantly	Digestate, transport to external biogas plant	Receive revenues
2	Residues from peeling potatoes (steamed)	> 10000	Liquid, dm ~12%	Constantly	Own biogas plant	1-5 €/t
3	Wastes from bakery products	1000-5000	Solid, dm 90%	Year round	Production of feedstuff, industrial disposal	-
4	Sewage sludge (from waste water treatment of liquid mixing phase from mustard, ketchup, mayonnaise, sauce	100-500	Solid/liquid	Year round	Industrial disposal	-
5	Grapes, pomace/ marc	< 50	Pomace – dm	October	Digestate	-
6	Coffee Skins	< 50	100%	Constantly	Disposal to compostation plant	-
7	Coffee Skins	< 50	Solid	Year round	Disposal to compostation plant	Disposal via regular organic waste
8	Residues from onions	1000-5000	Peels	Year round	Transport to external biogas plant	20-50€/t

	Substrates II	Amount (t FM/a)	Condition (+ dm content in %)	Occurance of substrates	Current utilization of substrate	Costs or revenues from disposal
1	Maize	500-1000	Solid, dm 70%	Is stored in harvest	Feed stuff, transport to external biogas plant	Receive revenues
3	Chocolate and Fats	500-1000 and 500-1000	Liquid, dm 50% and solid, dm 85%	Year round	Feed stuff, industrial disposal	-
4	Residues from cucumbers	1000-5000	Solid (unknown dm content)	Year round	transport to external biogas plant	-
6	Roasted coffee	< 50	100%	Less	Disposal to compostation plant	-
8	Residues from vegetables	100-500	Peels	Year round	transport to external biogas plant	20-50 €/t