AGRI-FOR-ENERGY 2
WORK PACKAGE 4: BIOGAS & BIOMETHANE

BIOGAS & BIOMETHANE IN EUROPE

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A regional state of the art report will provide a regional situation of the sector with all relevant information for farmers highly motivated to invest in biogas plants eventually in the new technologies about biogas up-grading (biomethane). A clear description of the status quo will help to monitor the relative impact of the project at regional level. The most important information will be presented and used within the WSO key market start up activities. Relevant information at national level (e.g. legislation) and technologies will be included in information materials. The description of the regional situation is useful to monitor the relative impact of the project at regional level.

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A. INTRODUCTION

Biomass currently accounts for 2/3 of renewable energy in Europe and bioenergy will play a key role in achieving the ambitious targets approved by the renewable energy directive. 20% of the final energy consumption have to be provided by renewable sources by 2020. A great target compared to the share of 8,5% we have today. According to a study of the European Environmental Agency[1] the potential from agricultural is still largely unexploited and this sector is expected to have the highest growth rates in the coming years.

Within the bioenergy sector the increased use of biogas opens up new fields of applications where biomass has not played a major role so far. High tech process energy for industries, effective small scale power generation and transportation fuels. Biogas cogeneration plants have reached a parity of heat and electricity output (one kW electric for every kW thermal) through technological advances in recent years.

Biogas is a renewable energy (Paavolainen 2009), which can be used for production of electric power and heat, and after purification also biomethane. Biomethane can be used as automotive fuel or injected into natural gas network. Biogas process and is energy efficient, closed and controlled process. It is also developed technology which is a flexible energy production method. Plants of different scales can be constructed, different raw materials are suitable for the process, and an advantage is that the raw materials need no drying before utilisation in the process. Methane, carbon dioxide, nitrogen oxide and odour emissions are low. The materials used are hygienised in the biogas process, and the end product can be used as soil conditioner or as fertiliser.

Many European countries have established favourable conditions for electricity production from biogas (see feed-in-tariffs in chapter **Fehler! Verweisquelle konnte nicht gefunden werden. Fehler! Verweisquelle konnte nicht gefunden werden.**). Germany has a leading role in Europe with almost 4000 biogas plants, most of them on farms for cogeneration. New legislation often requires the use of heat as well in order to reach a better efficiency.

While the biogas sector grows impressively every year, it hasn't received the same attention as for example liquid biofuels for transportation. The majority of people are not aware that natural gas powered vehicles have been available for a long time and that biomethane could play an important role in the transportation sector. So far only Sweden has established a market for biomethane-driven cars.

Due to its relatively low prices for electricity, Sweden has traditionally used biogas for heat production (today around 50% of biogas) and focused less on electricity (8%). About 25% of the produced biogas is upgraded and used as vehicle fuel (the rest is flared or used for other applications). The upgraded biogas is injected into the existing natural gas grid in 7 sites with an injection capacity of 220 GWh (replacing 2% of the natural gas in the system). The injection capacity is planned to increase to 1.6 TWh (10-15 % renewable in the natural gas system) within 5 years.

In the European Union both the primary production of biogas and the gross electricity production from biogas increased by almost 18% between 2006 and 2007. The greatest share of this growth was achieved in Germany and German biogas companies expanded their business in 2008 as well, despite rising costs for substrate.

Small scale electricity production with biogas is very effective concerning the ratio of the co-generated heat and power. Technological advances in recent years allow parity in the energy output - 1 kW electric for every kW thermal.

[1] EEA 2006 "How much bioenergy can Europe produce without harming the environment?"

B. Biogas & Biomethane use in Europe: overview of partner countries

1. Austria

Biogas plants carry out a useful contribution towards an alternative and decentralized energy supply out of renewable energy sources. In line with national and international obligations, Austria has declared to increase the percentage of renewable energy, for the good of climate protection and the reduction of energy dependency. The gas crisis in the last couple of winters between Russia and Ukraine has shown the clarity of the European energy dependency. If the political framework is helpful, biogas has the potential to become a key technology, because the supply of energy can be used on different ways. The high quality energy carrier can be used as electricity and heat as well as a substitute for natural gas and gasoline. The local value of biogas as an energy carrier has been increased in fact of research and checking of new technologies, feed in the gas distribution system or the promotion of biogas as a fuel. In Contrast to heating stations where electricity is produced out of gas, nowadays there are new possibilities which indicate a new challenge for the whole sector. The feed in of biogas into the gas distribution systems or in local micro distribution systems indicate a high potential. In line with the liberalisation has opened the chance for producers on the Austrian gas market to feed into the public gas distribution system, if the fulfil the quality requirements.

Biogas production

The energetic use of the renewable energy source biogas plays an important role in the Austrian climate and energy strategy. At the moment 344 are plants in operation with an installed electric power of 92 megawatts. The production of electric power amounts to 650 GWh and covers approximately 1 % of the whole annual electricity acquirement of Austria. 200.000 Austrian households can be well provided with green electric power. The biggest share comes from agricultural plants which use energy crops – mainly silage maize - and slurry for the biogas production. The average electric plant size amounts to 300 kW. A large part of the biogas plants was installed in the years from 2002 to 2006 with the implementation of the first Eco-power law (feed –in tariffs). Numerous changes of the Eco-power law have led a decline of the feed-in tariffs. The consequence was a decline during the last years. In February 2010 the government has decided new feed-in tariffs. The tariffs depend on the size of the plant and range between 18,50 ct/kWh (< 250 kW) to 13,00 ct/kWh (>1000 kW). The tariffs are guaranteed for 15 years. A use of non-agricultural substrates reduces the tariff by 20%. A minimum overall efficiency of 60% for electricity and heat production is required. The use of more than 70 % of process heat is rewarded with 2 ct/kWh. In 2008, an additional bonus of 4 ct/kWh due the high prices for agricultural substrates was granted for existing plants. The heat can be sold freely on the market. A feeding in of biogas into the gas grid is possible with many restrictions. However, for economic incentives feed-in tariffs between 28 to 20 ct/kWh are necessary. Therefore, a new “biogas-boom” during the next years will not be expected.

Higher prices for raw material, low feed-in tariffs and the insufficient usage of waste heat have led that numerous biogas plants struggle for their economic existence. As a consequence the biogas operators explored for new options to enter the energy market. New fields on the biogas sector are the decentralised feed-in in gas grids and the usage as fuel for cars. In Austria there are 4 plants installed which produce biomethane for feeding in gas grids. Two plants produce biomethane as use fuel for vehicles (substitution for petrol). The biomethane market in Austria is negligible because the plants produce only 918.000 cubic meter biomethane per year - that is 0,01 % of the annual natural gas consumption. In 2009 the natural gas consumption in Austria was 9.5 billions cubic meters. A higher potential for the future are the regional, decentralised usage of biomethane in micro nets and the usage of waste heat for cooling.

New political and technical incentives are necessary for the future development of the biogas sector in Austria. Biogas plants have to become a future key technology because the provided energy services are multi-talented. The decentralised energy supply plays an important role for the regional development. Regional energy supply reduces the dependence on energy-imports and raises the regional added value by the creation of new jobs.

Development of biogas in Austria

The production of biogas for the energetic use is nothing new. The first combustion trial with marsh grass has been executed by Alessandro Volta around the year 1770. The English physics Michael Faraday had in the year 1884 some trials with biogas made out of dung. He suggested to use the dung from horses of the Parisian fleet for the production of gas which can be used for the road lightning. During the 2nd World War and in the post-war period the research for biogas out of agricultural disposals has been pushed.

A new biogas movement has started after the oil-crises in 1973. All over the world people where looking for solutions to escape from the dependency on oil. Besides the use of renewable energies, the biogas was getting more attention, like at the beginning of the last century where it has been used in the municipal energy supply for the first time. In the 80ies and 90ies, many of the plants have been installed at cattle breeding facilities for the lowering of external energy demand and for the bettering for the output of liquid manure. The plants had an average performance of less than 20 kW electrical. Besides the usage of liquid manure, there was the starting point of using small amounts of biogenetic litter for example of dripping. (Kirchmayer 2010)

During the 90ies, the European Union started in fact of the increasing energy dependency an intensive discussion about climate change and decree some terms of reference for the development of renewable energies. Austria started with the conversion of own federal state laws and in 2002 with a national law for supporting the feed in of renewable electricity (Green Electricity Act). The average performance of plants was increasing up to 250 kW electrical. The additional usage of renewable resources was possible in fact the continuous yield increase of the agricultural sector which led to an over production. (Kirchmayer 2010)

Production of „Green electricity“ in Austria

Around the year 2000, circa 120 biogas plants existed in Austria with an electrical installed performance of around 1.5 MW. The number of accepted biogas plants was increasing until 2009 up to 344 and an installed capacity of 92.97 MW. At the moment 1 % of the annual consumption of electricity is covered by the biogas plants. The produced energy of 650 GWh covers the electricity consumption of around 200.000 households. Nowadays the electrical average power of the plants is 300 kW. In comparison to the year 2003 where the electrical average power was at around 170 kW it is shown that there is a trend to build up larger biogas plants. In the meantime the effectiveness of plants has been increased sufficient up to 40 %, which is almost the performance of a caloric generating plant. In the future small plants should be promoted, which will have an efficient rejected heat system and the usage of local resources.

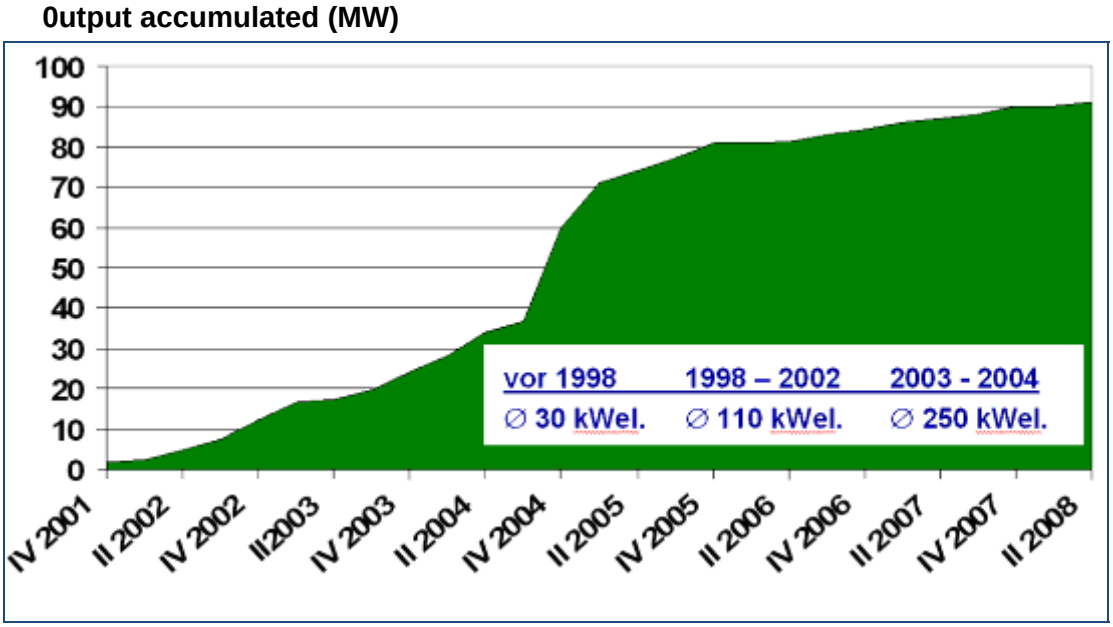


Fig.1: Development of accepted eco-electricity biogas plants in Austria (Source: E-Control 2009)

The plants are mainly concentrated in three federal states. 2/3 of the plants are in agricultural and cattle regions of Lower Austria, Styria and Upper Austria, because liquid manure and maize is predominantly used in the plants.

Accepted biogas plants by 31.12.2008		
State	**MW**	**Number of**
Lower Austria	35,33	100
Styria	17,49	47
Upper Austria	15,79	79
Burgenland	8,93	19
Carinthia	5,65	34
Vorarlberg	3,60	34
Tyrol	3,10	20
Salzburg	2,19	11
Vienna	-	-
accumulated	92,07	344

(Source: E-Control GmbH)

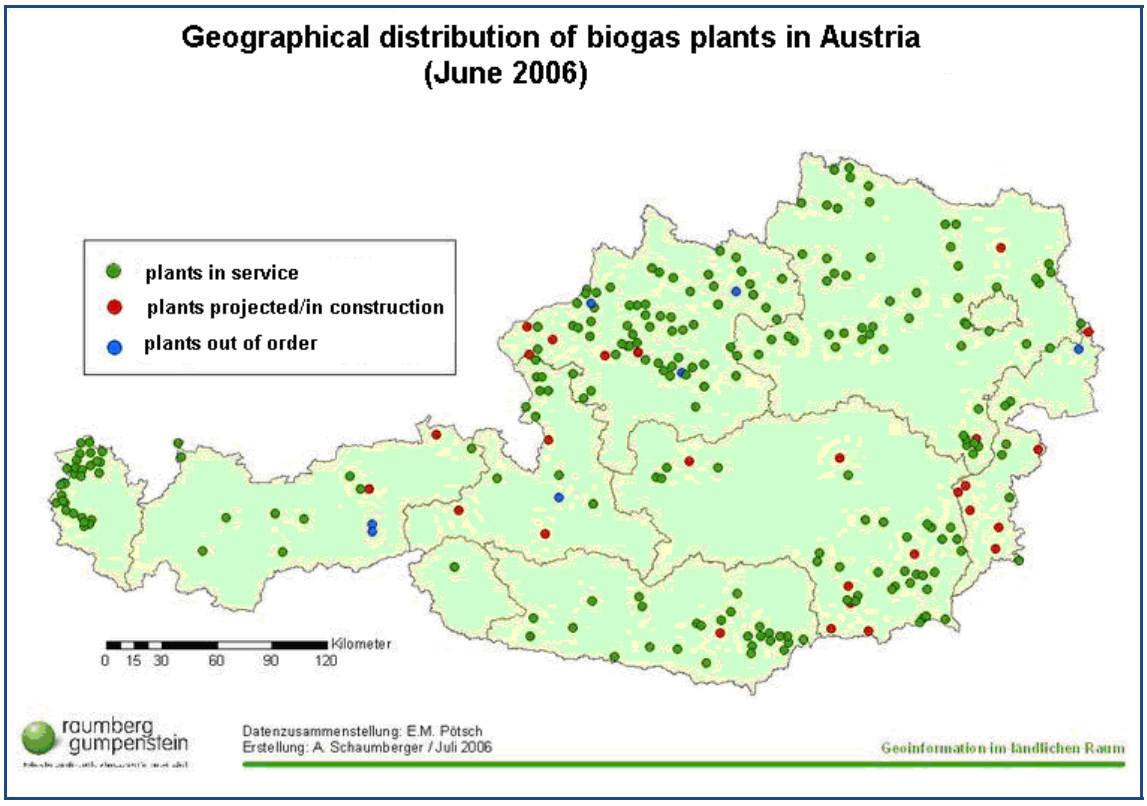


Fig.2: Source: Pötsch; Schaumberger 2006

Status quo: energy supply out of biogas

The common usage is the production of electricity, which is feed into the public distribution network. The use of rejected heat at the same time had a marginal relevance in the past. That was one major point why these plants where in public criticism. The usage of heat is limited for the heating of the biogas digester (process heat) and for agricultural buildings. There are only some few exceptions like the feed into the local heating system or the supply of industrial establishment. In case of the bad smell and the noise disturbance most of the plants are outside the city centres, which impedes an efficient distribution of heat. The sponsorship has respond to that situation and orders by building a new plant a efficient minima of 60 % fuel capacity factor, that means for the owner of a plant a usage of minima 25 % of the rejected heat through the year.

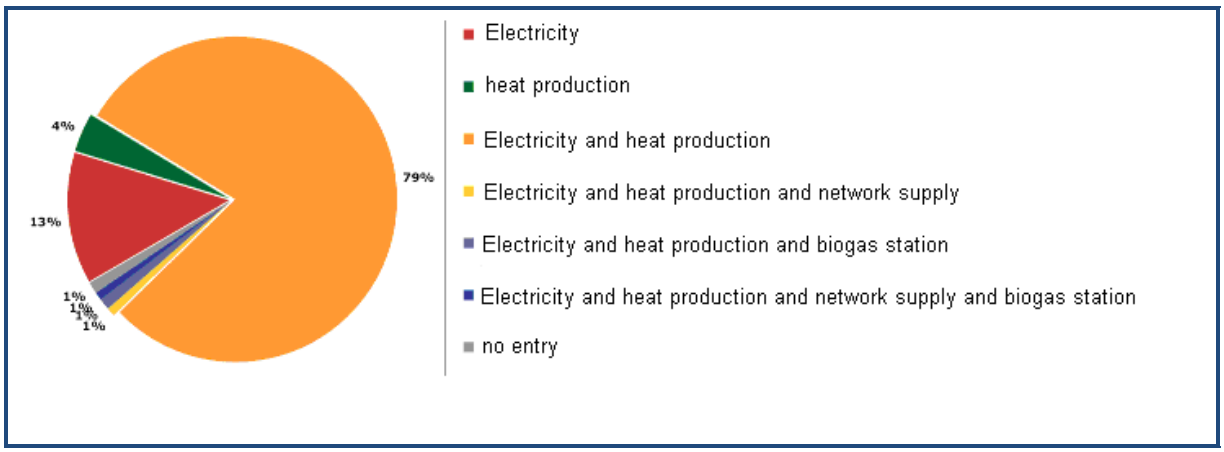


Fig.3: Usage of Biogas (Source: Tragner et al. 2008)

The lack of efficiency of biogas plant is one of the major reasons why in the last couple of years the feed in of gas into the natural gas distribution system was one of the main issues. There are numerous projects still running for the preparation of biogas towards a fuel or the feed into the domestic gas network. At the moment there are four plants which feed in the biogas into regional gas networks and two plants which offer biogas as a fuel. Biogas plants which are connected to the public gas distribution network import different proportions of there biogas production into the gas distribution network. At present the injected amount was circa 918,000 norm cubic meters bio methane. At an annual natural gas consumption of 9.5 billion cubic meters, it is only possible to substitute 0.01 % natural gas.

Table .1: Fact sheet Usage of biogas in Austria (Source: Kirchmayer 2010)

	Biogas	**Bio -methane**
Utilization	**Electricity / Heat / (cooling energy)**	**Fuel / natural gas substitute**
Number of plants in use in service	**324**	**4**
Market forecast 2010-2011 – projected plants	**0**	**1 - 2**
Average plant capacity (kW)	**270**	**-**
Average bio methane production (Nm^3/hour)	**-**	**80**

Biogas network supply

After a one-year preparation phase the first Austrian biogas conditioning and feed in plant in Pucking (Upper Austria) has been launched in 2005. For this reason it was possible for the first time to feed in

a renewable energy source into the gas distribution network and therefore a second comfortable energy transport way gained access. After a short phase of development the second biogas preparation plant in Bruck an der Leitha (Lower Austria) has been established.

Table. 2.: Biogas grid feed-in (Quelle: Kirchmayer 2010)

Biogas – grid feed-in	Pucking	Bruck/Leitha	Schwaighofen	Leoben
Initiation	2005	2007	2007	2009
Raw biogas-production (m^3/h)	10	180	50	140
Bio methane-feed in (m^3/h)	6	100	30	80

Biogas- grid feed-in: Pucking

Since 2005 in Upper Austria, the first biogas plant in Austria is in operation, which is feeding cleaned and refined biogas coming from cattle breeding into the existing gas distribution network. The specific challenge was to clean the biogas, for fulfil the standard for natural gas before it is feed into the gas supply network. For the first plant of biogas feed in Austria a location with a rural biogas plant has been chosen. In that plant biogas is been produced for more than 10 years with the husbandry of around 9000 laying hens, 1500 feeding hens and 50 pigs as well electricity with a block heating station with the power of 18 kWel. With a performance of 10 m_3 biogas per hour, the plant inject after the cleaning process 6 m_3. That is an annual amount up to 400000 kWh which corresponds to an average annual consumption of around 40 accommodations.

Biogas – grid feed-in: Bruck an der Leitha

In a pilot project, crude gas from the biogas plant in Bruck/Leitha should be cleaned to a natural gas quality and afterwards feed into the gas distribution network of the EVN and to gas stations of the project partner EVN, OMW and Vienna Energy, that also car-drivers have an access to the biogas. The plant delivers circa 800.000 m_3 methane per year. The plant could cover the half of the present consumption of all CNG-Automobiles in Austria. The low number of around 700 gas-powered automobiles on Austrian streets is caused by the fact of a non optimal gas station infrastructure and in comparison to diesel with the lower kilometres travelled by such a CNG-Car. An automobile with a pure CNG could drive distances between 300 up to 400 km. This corresponds to the distance between Vienna to Munich (355 km). Therefore an improvement in the distance in combination with a reduction of the gas consumption is one of the future targets. An extension of natural gas stations through numerous gas companies will lead into that direction and with the end of 2010, there should be around 200 natural gas or biogas stations running in Austria.

Biogas – grid feed-in: Schwaighofen bei Eugendorf

The biogas plant in Schwaighofen feeds in biogas into the natural gas distribution network and offers on separate gas stations “Bio-natural-gas”. The plant produces the biogas out of grass. With the biogas coming from t he gas station each CNG-Car can be refilled. The production of biogas is very effective. With biogas out of one hectare grass it is possible to drive 40.000 kilometres (one time around the globe).

Biogas – Feed In: Leoben

In this plant predominantly biogenetic waste coming from industry and municipal waste collecting points is been used to produce biogas out of it. The intended energy and disposal centre covers all categories from the substrate adoption over to biogas- and bio energy production up to a material and energetic utilization of residual materials (composting). The touch of a positive demonstrations project is been remarked with the fact that the biogas will be conditioned and injected into the public municipal gas distribution network of Stadtwerke Leoben. In the end of construction time there should be an annual biogas production of 2.5 million Nm_3. At the moment the plant is not in normal operation yet.

Biogas filling station

In 2007 there have been realized two Biogas preparation Projects in Eugendorf (Salzburg) and Margarethen am Moos (Lower Austria). In contrast to all the other concepts there is a direct use of the gas by the plants installed biogas station.

Biogas station: St. Margarethen on Moos

The biogas station started operations in 2007 and was the first in this vein in Austria. For the first time cleaned biogas which has the quality of natural gas in larger quantities was sold on a gas station. This project shows in Austria that the refinement is realisable with the state of the art. The biogas plant started the operations in 2005 and has produced electricity and heat for 120 households in the region. From now on, CNG-Automobiles can refuel at the biogas station their cars with cleaned biogas. The marketing runs under the name of "methaPUR". The production output amounts for 25 kilograms per hour. Afterwards the gas is stored in a high pressure accumulator with a capacity of 140 kilograms. A second accumulator is intended. 25 kilogram biogas equates a thankful with an operating distance of circa 500 kilometres.

Energy Policy Framework

The development of the biogas sector strongly dependents on energy policy frameworks. The "green" electricity coming from biogas is support via the ecological electricity tariff (Green Electricity Act), because an electricity production to market prices is at the moment not possible. With the adoption of the first ecological electricity law in 2002 a strong growth in the biogas was the result. In 2006 the law has been amended, which was resulting in a downgrade of the general conditions and led to a total investment stop. The continuous development and further enhancements of the technology have been stopped. For this reason further adaptations of the law have been made. At the moment the eco-electricity act from the year 2008 is valid.

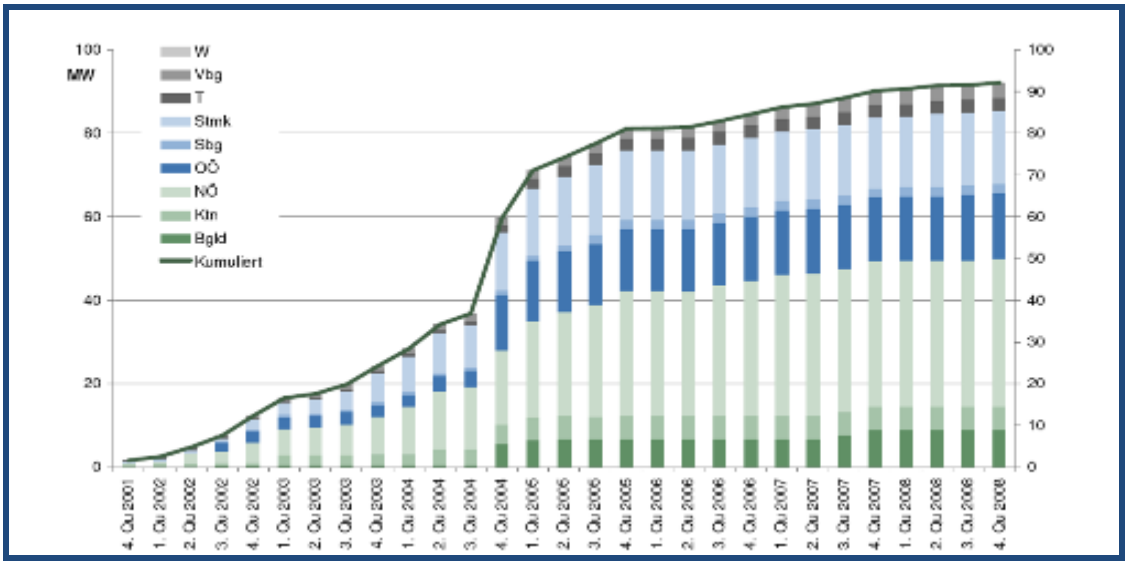


Fig.4: Development of biogas plants sorted after federal states (Source: E-Control 2009)

Besides the support via the ecological electricity tariff an investment support for a rebuilding or for changeovers of biogas stations as well for the construction of a district heating system for the use of the lost heat. With the support of biogas station it should be guaranteed that the 10 % addition target of bio fuels coming from the European Union can be reached.

Valid "Green Electricity Act" Tariffs for biogas plants at the moment (Status: February 2010)

Prices for the absorption of electrical energy produced in electricity production plants under the usage of biogas coming from absolute agricultural substrates are following tariffs for duration of 15 years valid in Austria.

Table.2: Tariffs eco-electricity act 2009 (Source: E-Control 2009)

Electrical shortage performance	Biogas (€ Cent/kWh el.)	Biomethane (€/Nm3)
Up to 250 kW	18,5	No Regulations
251 to 500 kW	16,5	
Greater than 500 kW	13,0	

Additional Framework of the valid "Eco-electricity act":

- By the usage of other absolute agricultural substrate the tariff will be reduced at 20 %
- Minimum fuel efficiency of 60 %
- Minimum liquid manure level of 30% for plants below 250 kW of electrical power
- For existing facilities, the Minister of economic affairs can also give in the future a surcharge of raw material costs up to max. 4 cents / kWh
- Existing plants can easily be extended (the existing plant component remains in the existing tariff regulation for the extension of each is the current rate is valid)
- For plants in which the tariff has expired, a succession plan have to be adopted (up to max. 20 years after commissioning, but only if at least 60% fuel utilization)
- Technology Bonus: gas processing and power generation for subsequent transmission through the gas system (2 cents / kWh).
- KWK bonus for new plants of 2 cents / kWh (70% waste heat required)
- 15 years collective term for new commodity dependent plants

Recent Developments

The current tariffs will not increase the willingness to invest substantially in the biogas sector. In the current tariff structure the economic implementation of biogas plants is hardly possible. The current tariff structure provides necessarily almost a complete utilization of waste heat (KWK bonus) for the entire year. In the summer months there is less a need of heat on many locations. Even the supply to the gas network is in the summer months a problem due to the low demand.

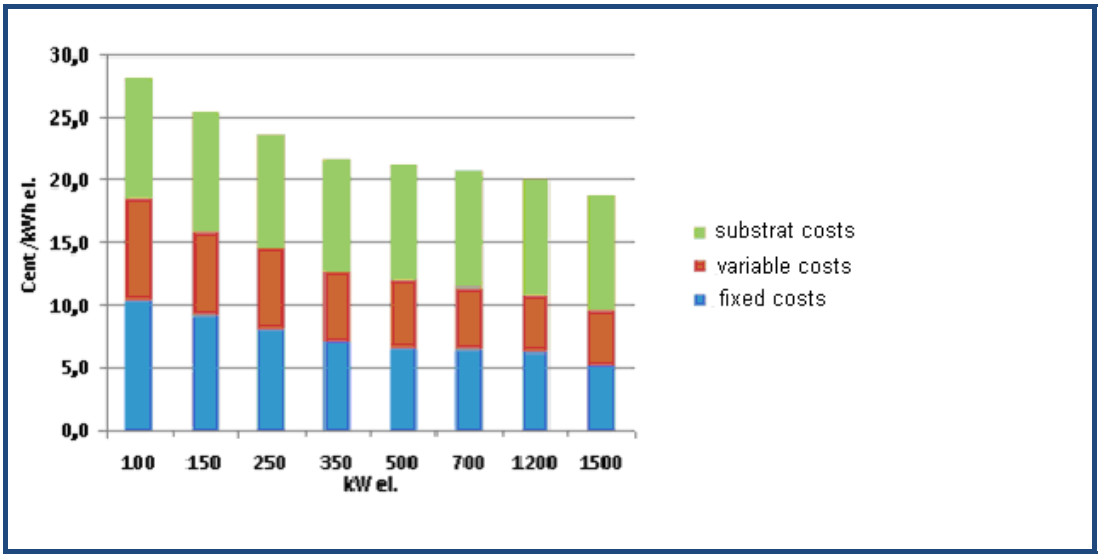


Fig.5: Necessary tariffs for the further development of biogas plants (Source: Kirchmayer 2010)

Substrate used in biogas plants

The convenient climate conditions and well-usable agricultural land enables the cultivation of a variety of renewable raw materials for processing in biogas plants. Based on the high alpine shares, which are primarily used for forestry, the resource potential is distributed very unequal. An extremely high density of biogas plants is mainly located in favourable areas of agriculture, as maize is by far the cheapest raw material for biogas production. The grassland areas have very large untapped potential uses (grass silage / green waste), which are used up due to higher raw material costs so far insufficient.

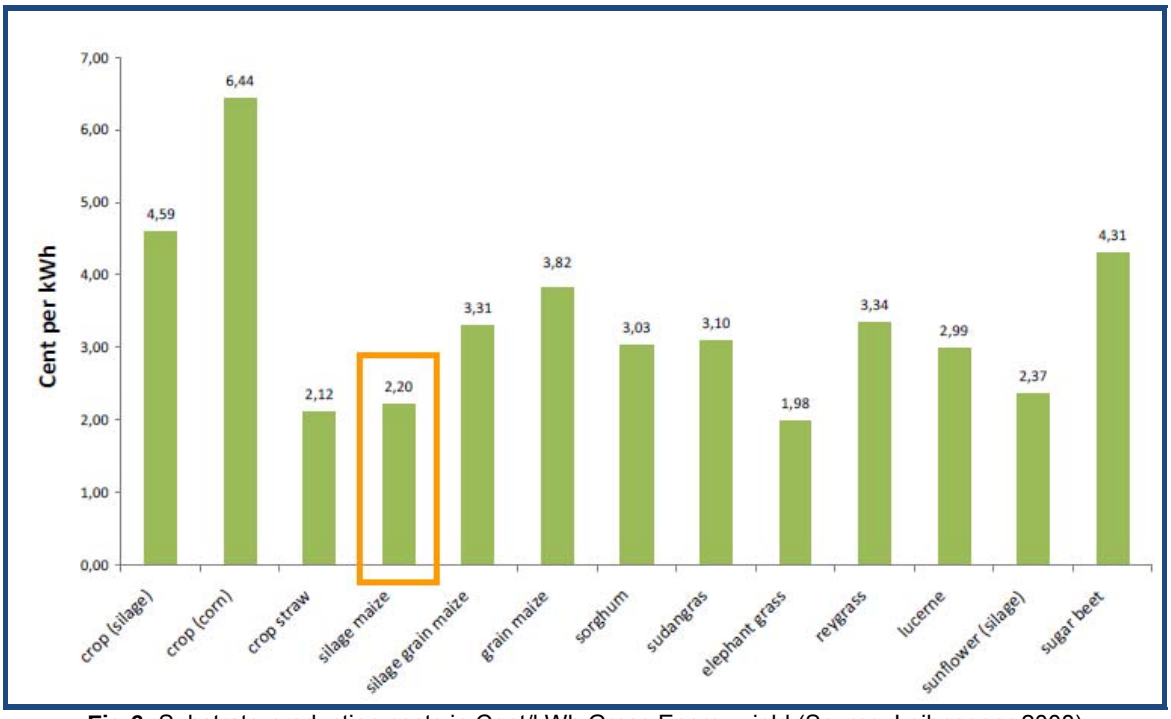


Fig.6: Substrate-production costs in Cent/kWh Gross Energy yield (Source: Loibnegger 2008)

For economical reasons, mainly energy crops (maize, grass silage, green waste) are used together with animal excrement (manure) as a substrate. The energy production occurs automatically in competition with food production, which always leads to public policy discussions Food products are only used in 40 % of the plants, although they have a particularly beneficial for the gas quality and profitability. Most plant operators cover their substrate requirements by domestic production, little more than a quarter entirely dependent on acquisitions.

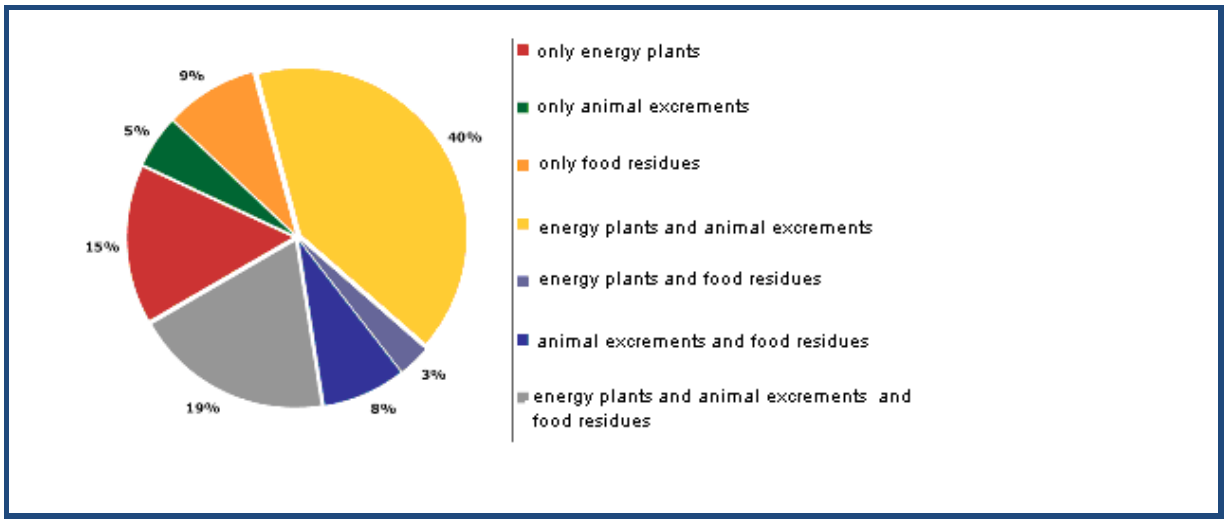


Fig.7: Substrate used in biogas plants (Source: Tragner et al. 2008)

By energy crops maize is the principal alternative and is used in two thirds of the plants. Grass silage and green waste are also used. The higher raw material costs make in many cases an increased use

unattractive. The use of grassland areas is still increasing in importance in the near future. The general trend of declining livestock production has a high potential in the future, as the preservation of diverse cultural landscape for the tourism industry is of great importance.

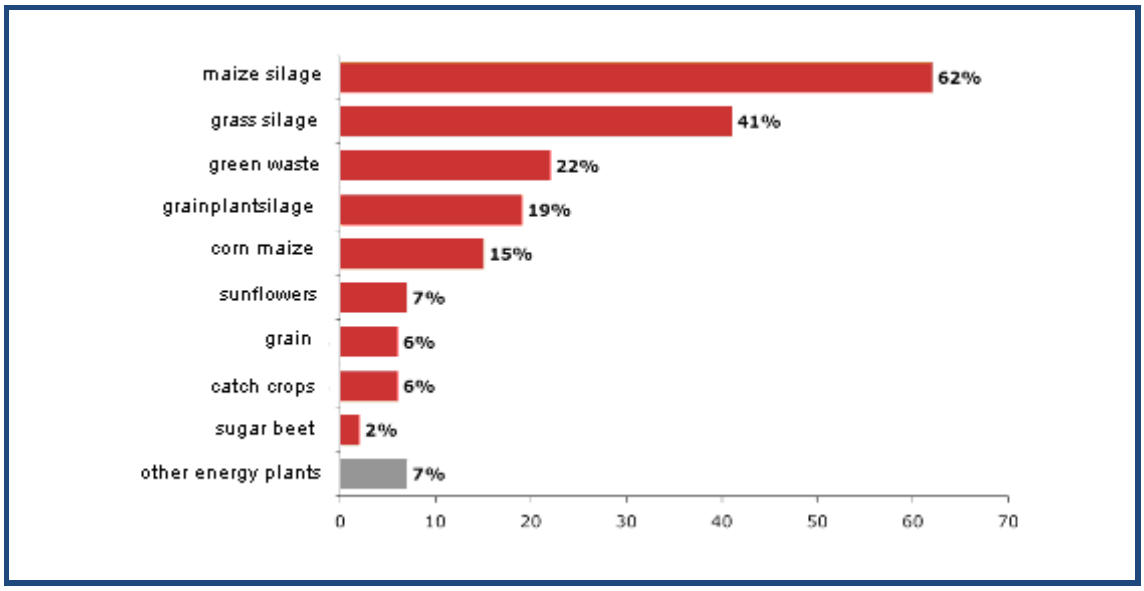


Fig.8: Energy plant use in biogas plants (Source: Tragner et al. 2008)

Future potential for the use of biogas

The variety of input materials allows the development of other, previously untapped energy resource. The existing potential corresponds, according to calculations by the " Arge Kompost and Biogas"

	Potential	currently used
Share of **electricity consumption**	**9 %**	1 %
Share of **gas consumption**	**22 %**	0,01 %
Share of **fuel consumption**	**23 %**	0 %

Possible biogas potential until 2020 in Austria			for biogas already used
	Hectare	kWh	%
Arable Land	**1.382.000**		
available for energy production	400.000		
therefore biogas	160.000	10.000.000.000	18 %
catch crops	100.000	2.000.000.000	3 %
possible straw amount	140.000	1.400.000.000	5 %
grassland perennial	**835.000**		
for energy production available	300.000		
therefore biogas	120.000	3.400.000.000	2 %
animal excrements	**Piece**		
beef stock	2.046.000		
therefore biogas	400.000	1.200.000.000	3 %
pig stock	3.154.000		
therefore biogas	800.000	200.000.000	3 %
poultry	11.077.000		
therefore biogas	3.000.000	60.000.000	5 %
Waste according to Waste Management Plan 2006	**t FS**		
Biogenetic waste of separated collection	550.000		
Amount of biogas	100.000	66.825.000	100 %
Garden and park waste	800.000		
Amount of biogas	-	0	0 %
Market waste	20.000		
Amount of biogas	10.000	7.000.000	40 %
Kitchen and canteen waste	150.000		
Amount of biogas	120.000	81.000.000	40 %
Offal of slaughter	240.000		
Amount of biogas	70.000	53.000.000	5 %
Slaughtering waste by processing	105.000		
Amount of biogas	30.000	59.000.000	5 %
Dairy waste	122.000		
Amount of biogas	20.000	5.000.000	5 %
Former foodstuffs	37.000		
Amount of biogas	15.000	14.000.000	40 %
Kitchens and food waste	51.000		
Amount of biogas	10.000	7.000.000	50 %
Sum		**19.000.000.000 19.000 GWh 68 PJ**	**12 %**

Fig.9: Source: Arge Kompost & Biogas 2009

Developments on the commodities market

As indicated, maize plant is the most cost effective energy plant for biogas production. Most of biogas plants put a greater extent in addition to the liquid manure. Commodity prices for maize were exceptionally high from September 2007 to 2008, which has resulted to economic difficulties in many plants. More than 50 % of the total annual costs depend on the buying of substrate, so fluctuations in the commodities market especially have a disastrous impact on the profitability of biogas plants. To ensure the economic security, the Federal Ministry has granted a raw material cost surcharge of 3 cents / kWh in the last two years. It is expected that price volatility will increase in the commodities market.

In the future, the use of grassland will gain on importance. The trend of declining livestock production has a high resource potential, as the preservation of diverse cultural landscape is for the tourism industry of great importance. However it can be used energy policies must be put in this direction. The use of grass for biogas production provides additional financial costs for biogas plants.

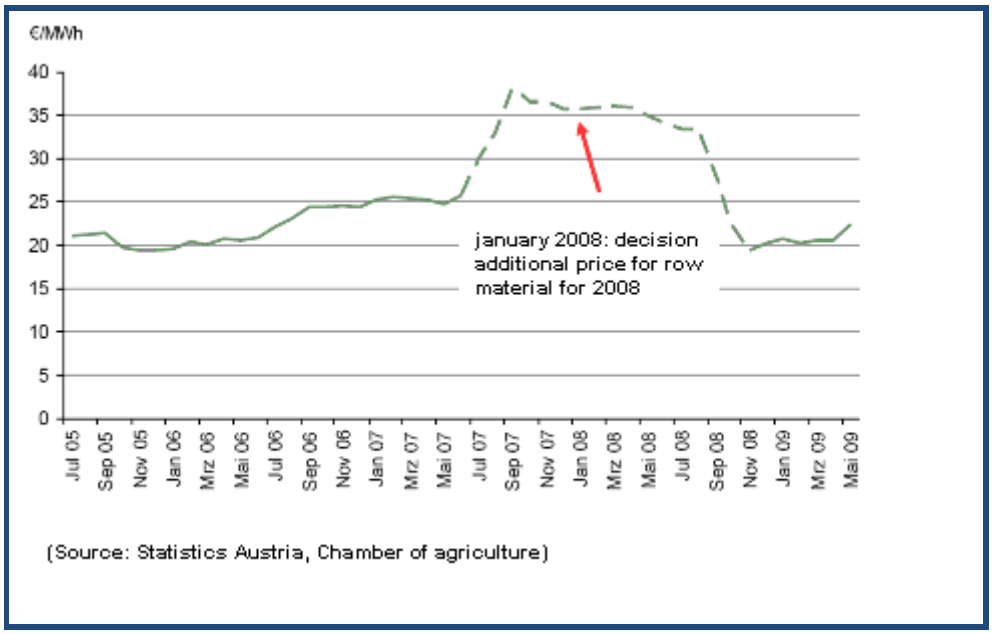


Fig.10: Development of the maize price (in Euro/MWh fuel thermal output) from July 2005 to May 2009 (Source: Landwirtschaftskammer Österreich)

The energy production in the perspective of food production

For economic reasons, mainly energy crops (maize, grass silage, green waste) are used together with animal excrements (manure) as a substrate. The energy production occurs automatically in competition with food production, which frequently leads to public, political discussions. Food products are only used in 40 % of the plants, although they have a particularly beneficial for the gas quality and profitability. To reduce the competition in the future, many research programs are in Austria running concerning the development of new, more efficient energy crops and new crop rotation systems.

Technologies in the biogas sector

Biogas is often referred as a multi-talent, because it is very versatile. The energy covers a broad spectrum of energy services. In addition to the usual power generation of the processed biogas to natural gas quality it is fed into the natural gas network or used as fuel for gas-powered vehicles. Another attractive possibility for energy recovery is partially or fully processed biogas with natural gas quality in biogas-micro-networks. In a biogas micro network purified biogas is conducted at low pressure to the consumers. Micro-networks, depending on the needs of consumers varying size and quality and therefore are a useful option for biogas plants.

Biogas Micro-networks can be operated independently and competitive like ordinary natural gas. The new options are for use specifically for those plants where it is a useful alternative to use their waste heat adequately.

Investment costs of biogas plants

The investment cost varies widely in practice, depending primarily on the size and design of the plant (measurement and control technology, automation, etc.). The smaller the plant, the greater the investment costs per installed capacity. Newer plants are subject to stricter safety regulations, which have contributed generally to an increase in investment costs.

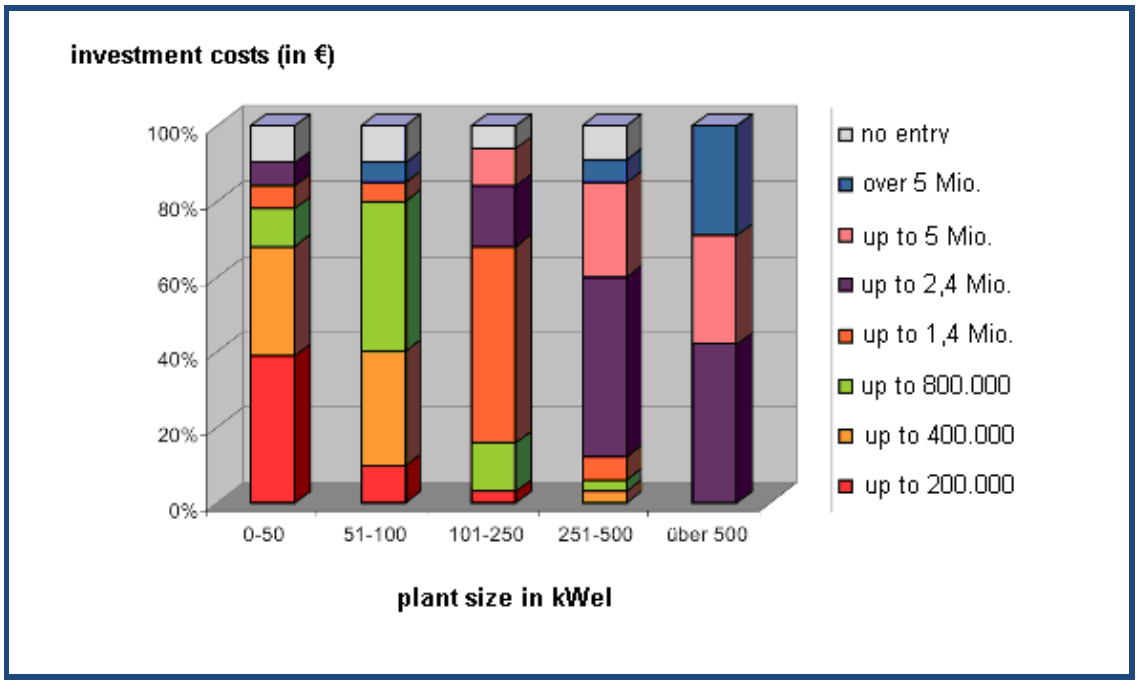


Fig.11: Survey of the investment costs of biogas plants (Source: Tragner et al. 2008)

Table.6: Investment costs of biogas plants (Source: Kirchmayer 2010)

Investment costs of biogas plants	
€/kW installed capacity 50 kW up to 300 kW	8.000 – 4.000
€/kW installed capacity from 300 kW up to1,5 MW	4.000 – 2.800
Investment Grant (€)	0

Biogas in agriculture

With the introduction of the Green Electricity Act 2002 there was an increased noticeable interest from the perspective of farms to use the energy from biogas in the form of electricity and heat. The production of biogas has for the farmer not only the advantage of obtaining a renewable energy source also the environmentally friendly disposal of organic waste, the extraction of organic manure and the reduction of odour emissions. The biogas is mainly used through a combined heat and power with power supply of surplus electricity. The heat produced is mostly used on farms operations.

The farmer as energy service provider - Energy self-sufficient place: Margarethen am Moos

More and more regions strive for sustainable regional energy supply. One example is Margarethen am Moos. In this place around 1,300 citizens living in 450 households. The power supply was based mainly on fossil energy.

The average consumption of the place includes:

ca. 1.6 Mio. kWh electricity (à 3.500 kWh)

ca. 9 Mio. kWh heat (à 20.000 kWh)

ca. 4,1 Mio. Automobile km (750 PKW à 15.000 km)

ca. 250 ha to supply with high quality plant and animal foods

Three years ago, 15 farmers built a biogas plant to produce electricity, heat and fertilizer production.

The system was gradually expanded and developed more and more to an all-round provider of electricity, heat and fuel.

As input materials are mainly used pig slurry, Sudan grass, green waste rye and corn.

Biogas plant produces per year	With the following biogas plant the energy consumption of the location can be covered (%)
Ca. 5 Mio. kWh electricity	320 %
Ca. 6.3 Mio. kWh heat	60 %
Fuel for ca. 1.9 Mio. PKW km	50 %

In total there are 1,200 hectares for Margareten am Moos available.

- for vegetable and animal food production ➜ 250ha
- Energy production of biogas ➜ 350ha

Retention of about 600 ha for food and feed production!

The example shows that food and energy production are compatible!

Conclusion

For the further expansion of the biogas sector, new energy policy pulses are needed. Biogas has the potential to become a future key technology, since the energy services provided are very versatile power, heating, cooling, fuel, natural gas substitute. Decentralized energy supply for future regional development is an indispensable contribution. On the one hand it reduces the energy import dependence and the other; it increases the local economy by creating new jobs. Currently 1,500 people work in the Austrian biogas industry.

2. Bulgaria

Bulgaria does not have any plants for biogas production yet. Now in the period of economic crisis farmers do not have enough resources to invest in biogas plants. A major constraint for the farmers is the high inerest rates of the credits.

Biogas potential

According to the calculations done in the NLTPPUB 2008-2020, taking into account the waste resources left from the livestock, the energy potential of the biogas might be used for electricity generation of about 470 GWh, which is about 14% out of the total current supply of RES (MEE, 2008).

Policy measures

Recently the interest in biogas project is growing especially with the expiring transitional period for the implementation of “nitrate directive”. The manure from the livestock production is also considered as a having great potential, which similarly to some of the other RES is insignificantly utilized yet. According to the NLTPPUB 2008-2020, one of the possible ways for utilization of the livestock wastes and biomass is for biogas production, which might be used as fuel for combined production of heating and electricity.
Despite the high potential for use of such renewable energy, such powers are not available in Bulgaria yet. So far, in Bulgaria there is not even a installation for production of biogas using the livestock

wastes, as the first plant is under construction. Its potential will be even less than 1% (600 toe) out of the assumed biogas potential. Nevertheless the good opportunity for farmers, such projects have not been implemented yet due mainly to the uncertainty of the State policy, structural problems in the livestock where the farms are very fragmented and the storage of manure and liquids isn't done in the proper way as well as the costs for investment in manure spots are high.
The current legislation do not provide specific biogas support instruments as feed in tariff, quota regulations, certificate mechanisms, taxations investment grants and/or other financial resources, which are considered as main obstacles for the development of biogas projects in Bulgaria.

The biogas production and use may contribute towards the 20%renewable energy target of the Directive "on promotion of the use of energy from renewable sources (2009/28/EC) which stipulates that "the use of agricultural material such as manure, slurry and other animal organic waste for biogas production has in view of the high greenhous gas emission saving potential, significant environmental advantages in terms of heat and power production and its use as biofuels. Bulgaria has a considerable potential for biogas production which until now remains unexplored. Currently no one commercial biogas plant is installed. This is due mainly to the following problems – lack of suitable policy and legislation in terms of tax incentives, financing grants etc., difficult access to credits high administrative burdens.

3. Finland

In Finland the generation of electric power in 2008 amounted for 56.6 GWh and the amount of heat 403.6 GWh. Almost the entire energy came from municipal landfills and slurry purification sites. There are 9 farmer-scale biogas plants. They use organic biomass from fields, livestock manure and by-products of the industry as raw materials. Biogas produced at the farms in 2008 corresponds to 1656 MWh of heat, 500 MWh of electric power and 28 MWh of biomethane for the use as automotive fuel. The Finnish Government is planning a guaranteed price for electricity produced by biogas and sold to national grid. At the moment the planned minimum production of electric power would be 300 kVA, which is too high for farms, if the farm does not acquire residues outside the farm. The price level of energy plants is, in many cases, too low.

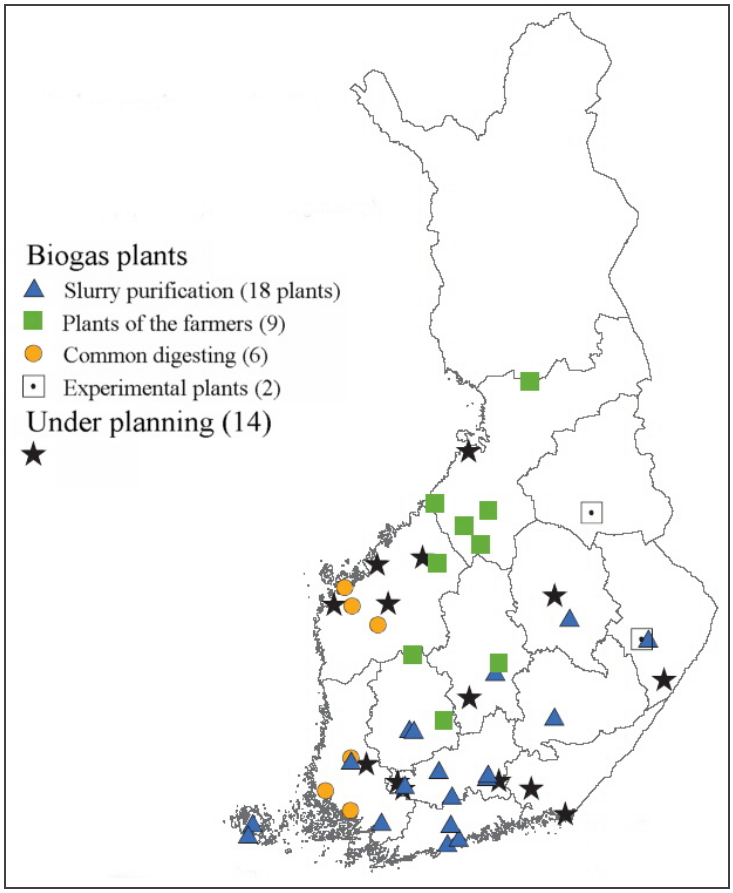
Few years ago twenty farmers in South-West Finland constructed a common biogas plant, the digester volume of which was 6700 m^3 and the nominal output of the generator 830 kW. At present they have constructed another biogas plant in Turku, and there are three new plants under construction. These plants produce annually several GWhs electric power and heat energy. Biovakka Suomi Oy has done business from the biogas brand.

In Southern Finland there is a natural gas network owned by Gasum Oy. Gasum have refuelling stations in the network area. Biovakka Suomi Oy also co-operates with Gasum Oy.

Biomethane markets in Finalnd are rather small because there are only about 500 cars, which can use methane as a fuel. Of these vehicles local buses of the city of Helsinki (about 200 busses) use the most of the methane consumption. Main usage for natural gas is the production of electric power and heat. In 2008 the natural gas consumption in Finland was 45 TWh.

Even though there are only few farm-scale bioenergy plants, there are several communal and industrial plants. The University of Jyväskylä has trained bioenergy specialist for several years. At present nearly all the plants have been designed in Finland. At Jyväskylä region there are three engineering offices connected to biogas production. Additionally, there are two internet pages reporting on the events and publication in the biogas branch: www.biokaasufoorumi.fi and www.biokaasuyhdistys.net/.

Biogas plants in Finland in 2009



Sources: Centers for Economic Development, Transport and the Environment VAHTI-data system and Bionova Engineering).

Biogas production

About 142 million m^3 of biogas was produced in Finland in 2008, which was 2.5% higher than in 2007. Digester plants produced 29.9 million m^3 of biogas and landfills 112.2 million m^3. Production of electricity from the biogas was 56.6 GWh and heat production 403.6 GWh as shown in table 2. Locally, several landfills and sewage sludge stations have started to produce electricity, for example landfills of Salo and Pori (source: web-pages of Sarlin Oy) produce electric power with several 60 MW micro turbines.

Small producers make heat and el usually to the own usage as table 1 tells. In Table 2 for farmers estimated production capacity of the biogas is near 2200 MWh annually. Some small producers sell el-power to the national el-net, but the amount is very small. Since the publication of the table 2 the small-scale biogas has increased, being about 800 000 m^3, and the annual production of biomethane is 41 000 m^3 (corresponding to 68 000 m^3 of biogas).

Development of the biogas and biomethane sector

The national target is to build twenty new large biogas plants and fifty small plants using agricultural raw materials by the year 2020.

It seems that in Finland also the farmers will build common biogas plants for several farmers in the future. Background for this is the guarantee price for larger plants (at least 300 kW_{el}, corresponding to 1 MW plant total), and also well working examples of the built plants of several MW. The proposed electric power tariffs require that the minimum output of plants is 300 kVA before it can get subsidies. This scale is, however, too high for individual farmers if the farm does not acquire waste materials outside the farm. The tariff level is, however, in many cases too low for utilisation of energy plants.

Policy measures

Finnish government and local authorities have positive attitude for biogas, they are interested in biogas and bio methane. Premier target seems to be the promotion and increasing of the local electric power production by biogas. Governmental target is to start tens of new biogas plants till 2020.

MTT, the Institute of Agrifood Research Finland, has built a full-scale model farm for training and biogas production, in Maaninka, figure 4. “The target is, that in 2020 there would be twenty large biogas plants and fifty small-scale plants in Finland using agricultural raw materials,” said Minister of Agriculture and Forestry Anttila, at the opening speech of Maaninka plant. MTT have also three other biogas research sites in Finland.

Figure 4. Research and training plant of Maaninka. Digester is 300 m^3. The plant includes also a second stage digester of 300 m^3. For research the temperature of digester can be varied between 20-55 deg. C. The usual temperature is 37 deg. C. About 80 kW of heat and 50 kW of decentralised electricity are produced with a high efficiency gas motor. Manure of 100 cows and different agricultural products are used as raw materials. (source:https://portal.mtt.fi/portal/page/portal/mtt/mtt/tutkimus/infrastruktuuri/maaningantutkimusalusta).

Also TEM, the Finnish Ministry of Employment and Economy, has planned to guarantee a higher production price, a feed-in tariff, to electric power produced by biogas, Kuuva et al. 2009.

Two ministries, the Finnish Ministry of Agriculture and Forestry (MMM), and the Finnish Ministry of Employment and Economy (TEM) subsidy the biogas production. The subsidies of MMM include farm investments, The ESF Operational Programme in mainland Finland 2007 – 2013, and subsidies for bioenergy production. The subsidies of TEM include energy subsidies and the feed-in tariff under preparation.

At the moment it is possible to get support for the construction investments of biogas plants. Support is granted for the year 2009 and in the 2010 the subsidies might be different. Maximum support for investment costs is 15% of the total investments. It is also possible to get support to loan and support for rents of the investment.

In the future there might also be possibility to get a guaranteed price for electric power produced by biogas plant. Production of biomethane does not get any extra support.

Feed-in-tariff

In the future there will be a guaranteed price for electric power, produced by biogas plants. Proposed guaranteed price is 83.5 €/MWh (subject is under discussion), and which will be given those plants, which will sell electric power to the national grid, and produce electric power at least 300 kVA. There are also discussions of the lower limits of kVA. A proposal has been made for payment of additional 50 €/MWh in CHP-heat production if biogas is used for heat generation and if the total efficiency of the plant exceeds 50%.

Biomethane as a vehicle fuel gets no extra support. On the basis of calculations it seems that the fuel is profitable even without subsidies.

A small producer, output less than 150 kW_{el}, sells electric power to the national grid and gets 35 – 40 €/MWh of the power. The situation is the same whether the producer is a large or a smaller one. Same producer produces biomethane for use as automotive fuel. The price of it is 0.72 €/Nm^3 (65 – 70 c/l as gasoline equivalents).

Potential of renewable resources

Production potential of biogas from different raw materials has been estimated in the figure 5. The present consumption is less than 10% of the estimated resources. The estimated theoretical amount of biogas production exceeds 600 million m^3/a (about 6.0 TWh/a of energy). It can be seen, that the most of present biogas becomes from landfills and municipal waste water sludge processing plants. The present share of biogas from agriculture is low.

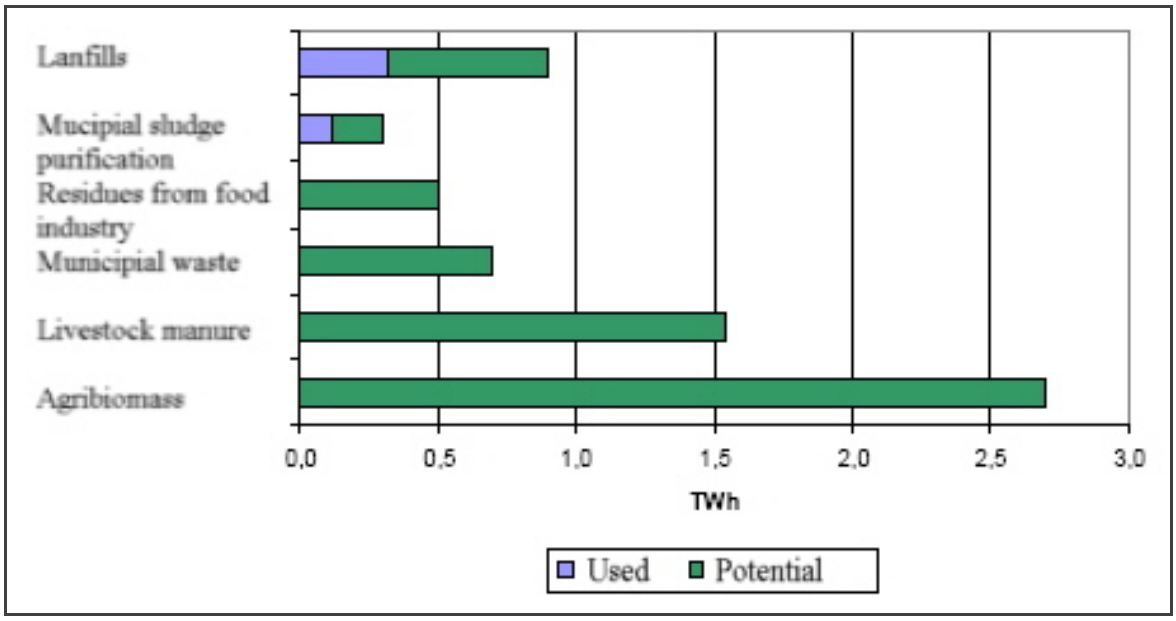


Figure 5. The theoretical energy production potential of biogas in Finland (Kuuva et al. 2009, original source: Pöyry Energy 2007 & VTT).

Possibilities for Finish farmers

The Finnish farmers know rather well the possibilities of biogas. There is plenty of guiding literature even in internet. Even though efforts have been made to increase the biogas production, the number of biogas producers has remained low. Why? Economy, techniques, difficult process, which needs looking after, lack of suitable raw materials, cooperation between farmers and producers of rawmaterial, low price of fossil fuels…. New "carrot" is the becoming feed-in tariff for biogas, but it needs still corrections before publishing. Tariff will guide the size of the plants, and planning and building of "small" plants is now in some kind of a transition phase, decisions of government are waited. The size of farms is also increasing. There have also been negative comments on the suspected amount of guaranteed price and the minimum scale of electric power production of 300 kVA.

Reject of the biogas process contains large amounts of phosphor, which can be circulated back into the fields. Nutrients become more expensive, and in the near future there will be lack if phosphorous nutrients. Farms save money in fertilizer costs, and also reduce the odour problems of liquid manure.

In larger scale there are some examples of utilisation of biogas in heat and power generation, even in private enterprises. Most of the Finnish biogas is, however, generated from municipal landfilling sites and purification station of urban slurries. Defferent kinds of municipal wastes can be used effectively all the time, and the massive waste materials are concentrated and easy to upgrade.

In Finland there is much raw material for biogas, especially in agriculture, as well as know-how on designing of the plants. The only difficulty is how to get people interested in this new way of production of clean energy. There is much interest in biogas, so the biogas markets will grow in the near future.

4. Germany

Since the renewable energy act was amended in August 2004, there has been an enormous growth in the use of biogas across the whole of Germany. The trigger for this positive development is the provision for remuneration payments for electricity from renewable resources. Furthermore, the 2009 amendment to the law provides for a graduated basic remuneration for biogas plants as well as bonus payments for the use of renewable resources, the use of slurry and for the worthwhile use of heat energy. Because of these provisions, biogas production in agricultural enterprises in Lower Saxony continues to be financially viable.

The production of biogas from biomass is one of the fastest growing segments of the renewable energy market. In the last five years, the number of biogas plants in Germany has more than doubled to about 4,000 and the installed electrical output has more than quadrupled.

At the end of 2008, there were 710 mainly agricultural biogas plants in operation in Lower Saxony with an electrical output of 2.7 MWh. This is an increase of 275 on the figure for 2006. The electrical output over this period increased by about 65 MW.

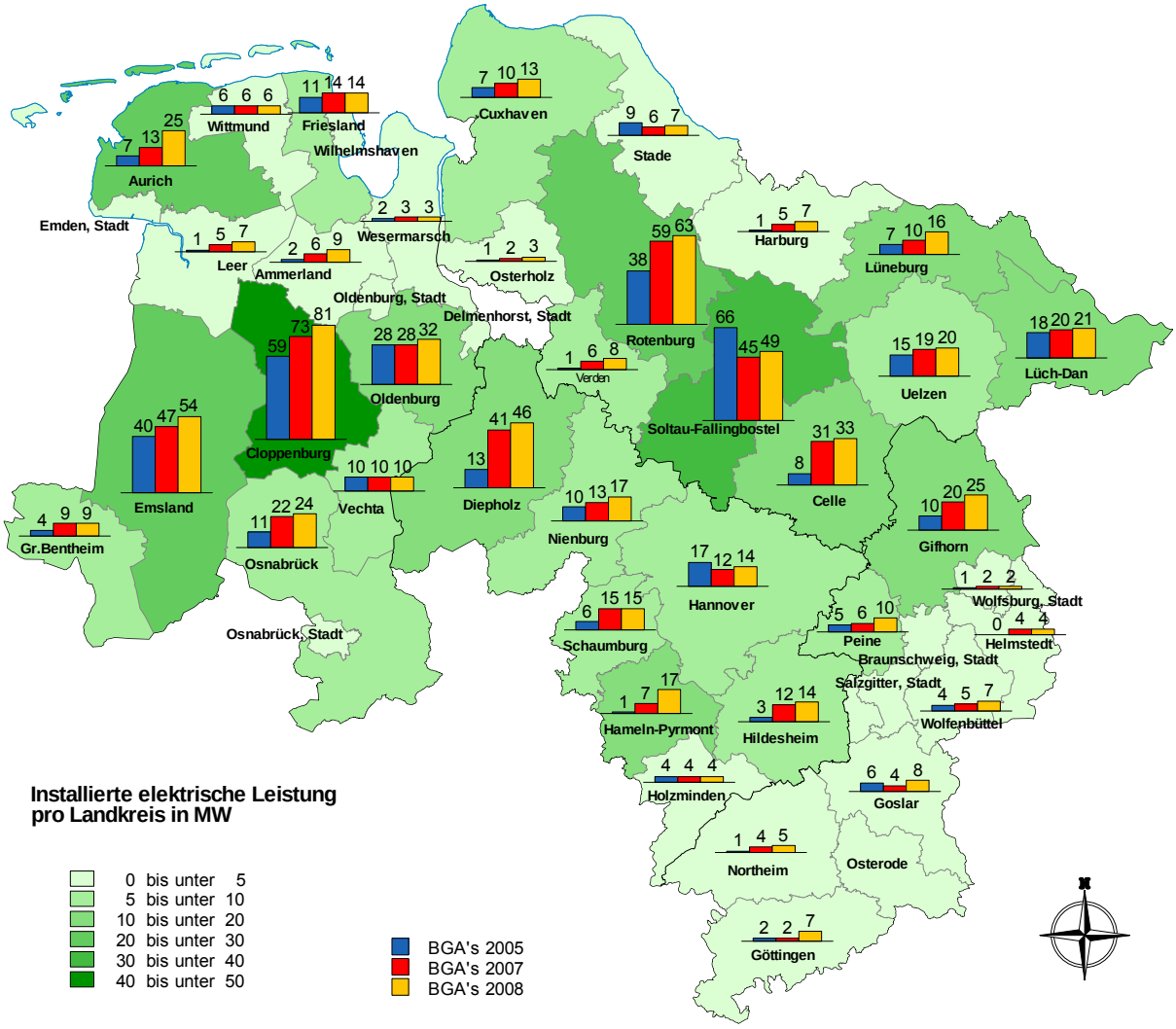


Figure 1: Number of installed biogas plants in Lower Saxony, 2005 – 2008

(Source: Lower Saxony Ministry of Environment and Climate protection,
Lower Saxony Ministry of Food, Agriculture, Consumer Protection and Regional Development
Compiled by 3N Centre of Experts)

There was a more modest increase in the growth of biogas plants in 2008 compared to the previous year as the pending amendment to the renewable energy act and the expected increase in remuneration caused investors to put their activities on hold.

2009 has seen yet again an increase in the growth of biogas plants. At the start of the year, about 180 biogas plants were being constructed or were in the authorisation or planning stage. The regional focus of biogas production is mainly in the regions Celle, Soltau-Fallingbostel, Rotenburg-Bremervörde and in the meat processing areas Cloppenburg, Oldenburg and the district of Emsland.

As well as in the regions named above, there has been particular growth in numbers in the districts Diepholz (33 plants), Celle (25 plants), Aurich (18 plants), Hameln (16 plants) and Gifhorn (15 plants). But biogas production has also increased in significance in the areas of arable farming in the southern part of Lower Saxony. Because of the high profitability of cereal production in the more fertile locations, however, growth was as expected more cautious and remained at a lower level.

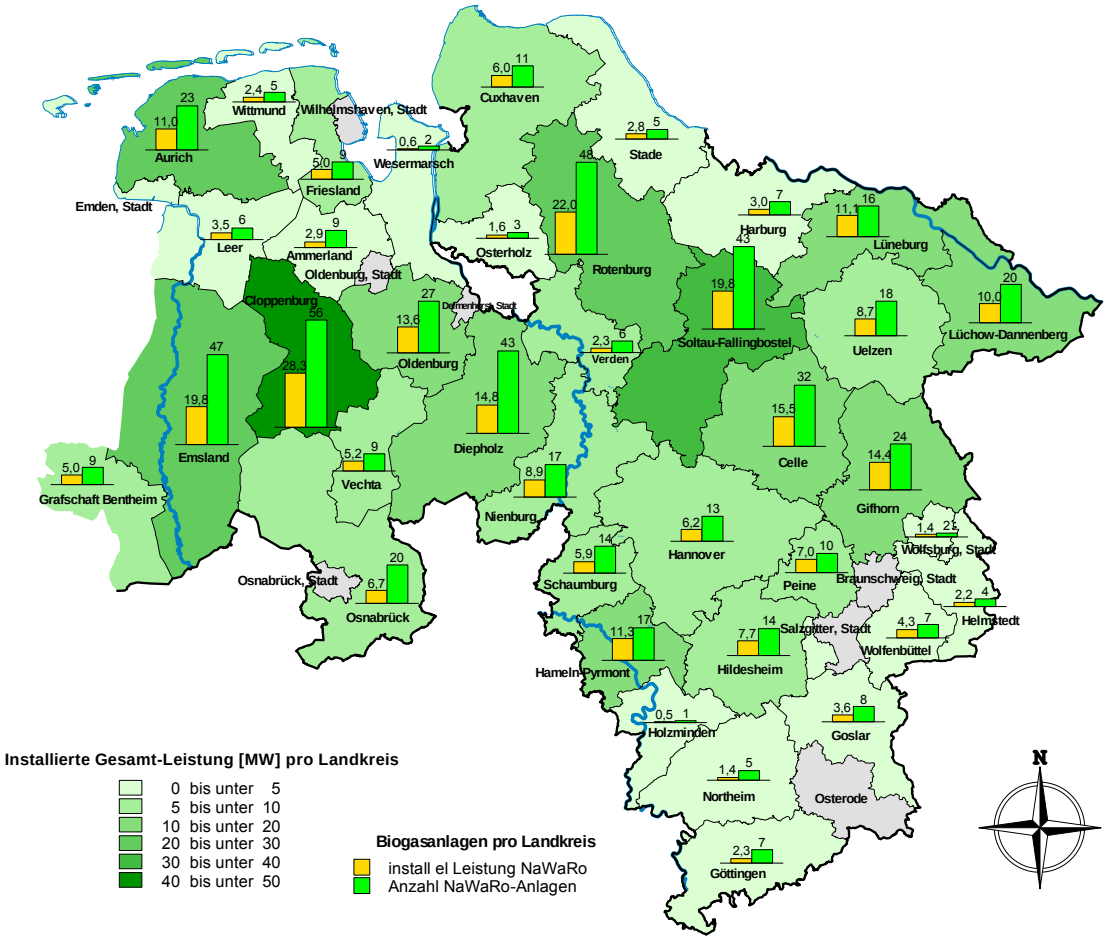


Figure2: Number and installed capacity of NaWaRo installations in the different administrative districts in Lower Saxony

(Source: Lower Saxony Ministry of Environment and Climate protection,
Lower Saxony Ministry of Food, Agriculture, Consumer Protection and Regional Development
Compiled by 3N Centre of Experts)

Of the 710 biogas plants, 610 operated purely on renewable resources. A further 100 plants used cofermentation processes. Leading the way is the district of Cloppenburg with 26 plants and an output of 15.6 MW, followed by Rotenburg with 16 plants and an output of 12.7 MW, Emsland with 7 plants and an output of 4.4 MW and Aurich with 1 plant producing 10.5 MW of capacity.

In the last two years, the size of plants has increased slightly in Lower Saxony to an average of 520 kWel, up from 500 kWel in 2006.

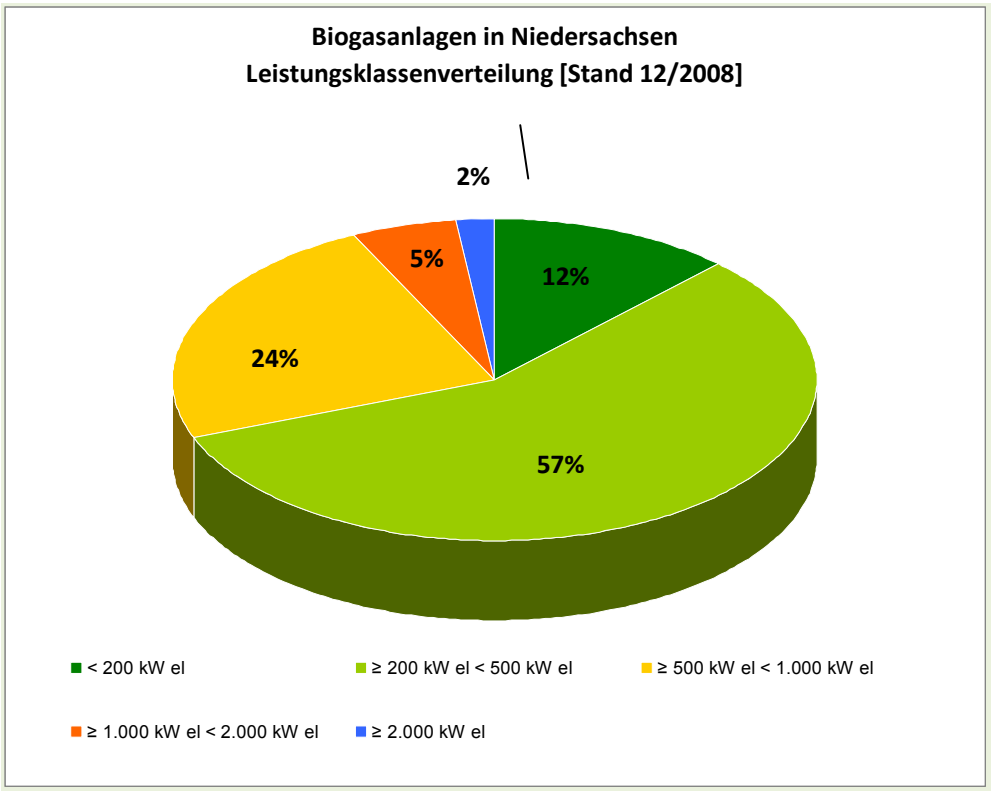


Figure 3: Capacity distribution of biogas plants in Lower Saxony in 12/2008

(Source: Lower Saxony Ministry of Environment and Climate Protection, Lower Saxony Ministry of Food, Agriculture, Consumer Protection and Regional Development. Compiled by 3N Centre of Experts)

The biogas plants in Lower Saxony can be classified into 5 different capacity groups. The largest of these with 57% of the biogas plants is found in the capacity range ≥200 kWel to 500 kWel. Next comes the capacity range ≥500 kWel to ≤1000 kWel. Approximately one in every fourth plant (24%) is found in this category. In the larger capacity ranges, 5% of the plants have an output between ≥1000 kWel and 2000 kWel and a further 2% have an output of more than 2000 kWel.

The smallest output range encompasses biogas plants which produce less than 200 kWel. A tenth of all plants in Lower Saxony have capacities in this range. There has been a steady increase in the numbers in this group because of the growth in so-called 'slurry plants', in which solid manure or slurry from the farm is used. Under the provisions of the new renewable energy act, such plants which operate with at least 30% slurry are benefited and are increasingly being built on agricultural enterprises.

In comparison, the biogas plants in southern Germany have a smaller capacity range. In Bavaria, the average plant output amounts to 210 kWel.

Through the introduction of the bonus payments for combined heat and power plants, the conditions applying to the use of heat energy while producing electricity from biogas have improved. There has been an increase in the amount of available heat energy used externally, after heat for operating the process has been extracted.

In the future, biogas plants will be become increasingly more efficient. Through process optimization, the retention time for the fermentation substrate in the plant will be reduced and higher flow capacities of the biomass will result in an increase in biogas output without increasing the size of the plant. Additionally, by 'repowering' a part of the existing plant, further rises in the output of the plant can be expected. A factor to be considered here is the limit at which authorization is required (permitted planning rules).

In 2008, there were approximately 4,100 biogas plants with an electrical output of about 1,400MW in the whole of Germany. As previously, the federal states of Bavaria (36%), Lower Saxony (17%) and Baden Württemberg (14%) have the highest numbers of biogas installations. However, Lower Saxony is in first place with regard to electrical output with a proportion of 26% of the German total.

At the end of 2008, the 710 plants (365 MW) in Lower Saxony produced about 2.7 million MWh of electricity over the year.

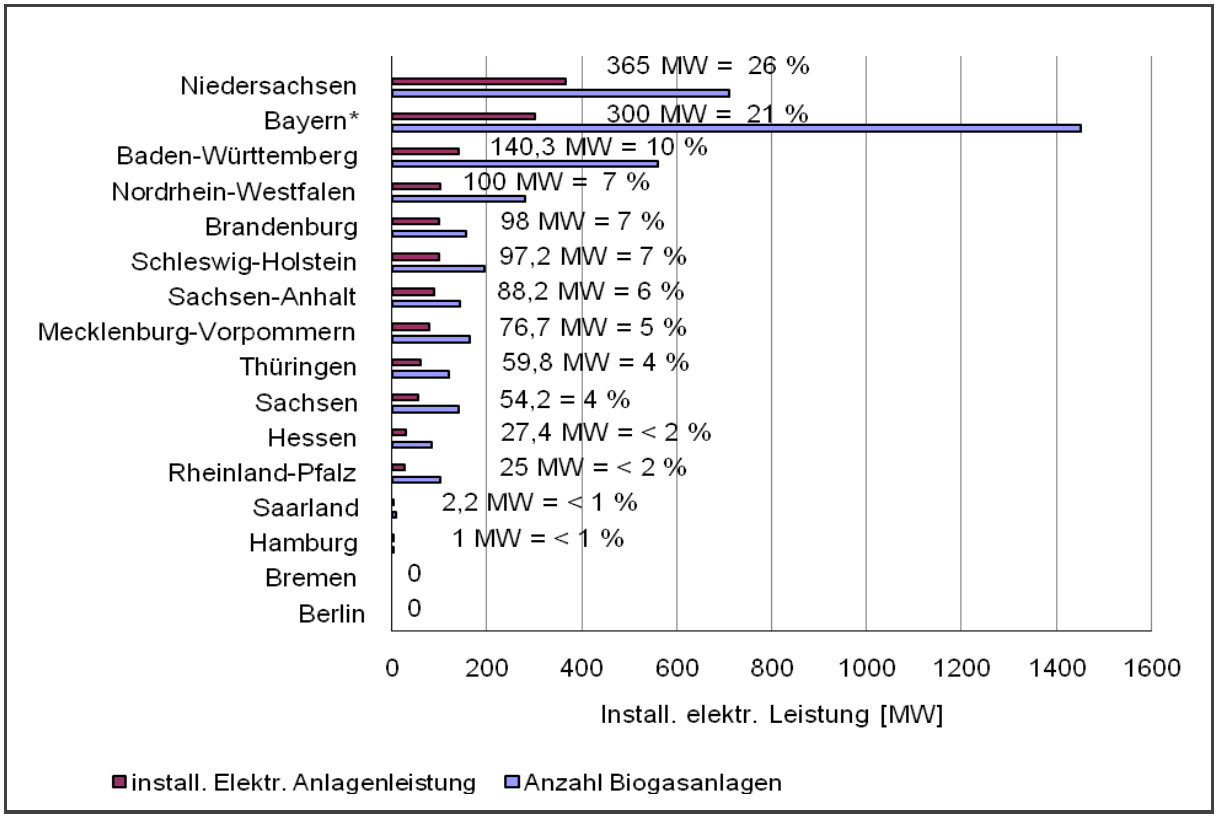


Figure 4: Distribution of in-service biogas plants and installed electrical system services in Germany (survey of the State institutions 2009)

[Source: German biomass of research centre DBFZ, "Development of electricity from biomass 2008" interim rport "]

Energy production and energy consumption from biogas

Following the amendment to the renewable energy act in 2009, the basis was created for the increased use of slurry in addition to energy crops. The renewable resources bonus is payable where whole crops or parts of crops are used which have not undergone any treatment other than that necessary for harvesting, storage and use. The new version of the law contains a positive/negative list which regulates the classification of raw materials which qualify for bonus payments.

The slurry bonus is paid after it has been verified that at least 30% of the slurry has been processed, as a proportion of the given upper limit of the plant capacity. This upper limit is also valid for demands for bonus payments with respect to the processing of landscape management materials. Under the renewable energy act, a combination of pure crop products with non-bonus by-products may be used together in the plant. In this case, a pro rata bonus payment is due. Even though large amounts of slurry and solid manure have up to now been used in biogas plants in Lower Saxony without receiving the slurry bonus, the new renewable energy rules will strengthen this trend.

New plants are mainly operated using renewable resources and slurry (biomass plants). About 100 plants in Lower Saxony produce biogas from biowastes, flotates, fats and other materials. The slight decrease in the number of cofermentation plants reflects the trend in converting existing plants from cofermentation to biomass and slurry following the amendment to the renewable energy act.

In order to guarantee security of future energy supplies, it will be necessary to strengthen the position of domestic suppliers. Biogas technology has an important role to play in this respect. Biogas can be used anywhere and is available throughout the year. The possibilities for use include production of electricity and heat energy as well as the manufacture of transport fuels.

Biogas production has particular significance in the low plains of Lower Saxony with its highly productive agriculture. Compared to the use of fossil fuels or liquid biofuels such as biodiesel, bioethanol and BtL fuels, local and regional value creation for biogas use is very high. Taking into account all revenue generation arising from the construction and operation of a biogas plant, a great proportion of this finance remains in the rural area.

Since 2004, about 500 new biogas plants with an investment volume approaching one billion euros have connected to the national grid. These investments, which are associated with the plant installation activities, have mainly resulted from regional enterprise. Additionally, the expenditure for operating the processes largely benefits local partners. However, operating costs may be affected by seasonal fluctuations (price changes in the raw materials sector, leasing costs etc.). It is only in the specialised areas of plant technology and operation that supra-regional services may be required, such as systems analysis for cogeneration plants. For most plants, the raw materials for the daily operation are produced entirely locally. The whole logistic system for raw materials, from cultivation to delivery and the final spreading of fermentation wastes back on the land, is almost exclusively in the hands of local labour. The revenue for the end product, nowadays mainly electricity, flows directly into the rural areas. The increased use of heat energy further enhances the value creation locally. In this way, this development contributes to the strengthening of rural areas.

Today, Germany is a world leader in the field of biogas technology. Enterprises based in Lower Saxony have a large share of this. In the future, the exporting of such technology will assume even greater importance. Even today, numerous biogas enterprises in Lower Saxony are active internationally and are laying the foundations for the long-term development of the business.

Development of the biogas & biomethane sector

At present, biogas is widely used in combined heat and power plants to generate electricity and heat. The electricity is fed into the national grid and remunerated in accordance with renewable energy act payments. Some of the heat energy is necessary for warming the fermenter vessel. The remainder can be transferred directly to heat buildings and agricultural units or be fed into a district heating network. It can also be used to supply external manufacturing processes with heat.

If manufacturers or other users of heat energy are situated at some distance, raw biogas can be piped to satellite CHPs to produce heat energy where it is needed. Increasingly, biogas plant operators are developing worthwhile concepts for energy use.

Alternative possibilities for the use of biogas result from its processing to natural gas quality. Through this refining stage, biomethane can be fed into natural gas pipelines or used directly as a fuel in motor vehicles. Where biomethane is fed into the distribution network, it is possible to transport it over larger distances and to plan for the inclusion of CHPs which achieve high usage rates over the year.

A further development in the use of biogas is the treatment of the gas to achieve the quality of natural gas. Preconditions for the establishment of biogas treatment include a suitable feed-in system, a satisfactory pressure level and proper arrangements with the receiving organisation, including sufficient capacity for take-up in the natural gas supply network. The advantages of this compared to direct use in the vicinity of a biogas plant lie in the temporal and spatial separation of production and consumption. Whichever technologies are applied, it will be important in the future to convert biogas to useful energy as efficiently as possible.

At present, there are six biogas plants in Lower Saxony which operate a gas treatment process. Other plants are currently under construction or at the planning stage.

Policy measures

The goal of the Federal Government already 2007 exceeded the share of renewable energy which was to increase power to at least 12.5 % by 2010: 2008 share of renewable energy was here already approximately 15 % (2007: 14 %).

The Objectives of the German Government Substitution of 6 bill. m3 natural gas by biomethane up to 2020. Today 3 % of this target is fulfilled by 21 running injection plants. In 2010 around 5 % of this target will be fulfilled. Around 1,000 biogas upgrading plants with an investment of 10 bill. Euro are necessary to reach the objective of the Government. In 2030 biomethane should cover 10 bill. m3 of current natural gas consumption.

Renewable Energy Act (EEG)

The Renewable Energies Act (EEG) came into force in a revised version in January 2009. The basic payment for plants which started production in 2009 continues to be graduated in accordance with plant output:

- up to 150 kW - 11.67 ct/kWh (increased by 1.0 ct/kWh)
- up to 500 kW - 9.18 ct/kWh
- up to 5,000 kW - 8.25 ct/kWh
- up to 20,000 kW - 7.79 ct/kWh

The payments will continue to be paid over a period of 20 years, as was previously the case. For every succeeding start-up year, payment is reduced by 1% and this also includes the bonus payment. For plants with an output greater than 5 MW, payment is granted only where the electricity is produced in a combined heat and power plant (CHP).

In addition to the basic payments, the following bonus regulations apply:

Renewable Resources Bonus:

Where whole crops or parts of crops are used which require no further treatment other than harvesting, storage and use in the bioenergy plant, a bonus payment is due as follows:

- liquid fuels up to 150 kW - 6.0 ct/kWh
- solid fuels up to 500 kW - 6.0 ct/kWh
- anaerobic fermentation up to 500 kW - 7.0 ct/kWh
- solid or gaseous fuels up to 5,000 kW - 4.0 ct/kWh
- Wood-fired plants up to 5,000 kW - 2.5 ct/kWh (excluding wood from landscape management and from short rotation plantations)

In the case of liquid biofuels, the upper limit of 150kW was introduced in order to safeguard the financial viability of higher-output combined heat and power installations using vegetable oil.

The amended version of the EEG contains a positive/negative list which regulates the classification of raw materials. Accordingly, palm oil and soya oil are only included where it can be shown that they originate from a sustainable cultivation.

The Renewable Resources Bonus is granted only in the case of the exclusive use of eligible materials. For biogas plants, the following additional rules apply:

Bonus for the use of at least 30% slurry in renewable resources plants:

up to 150 kW - 4.0 ct/kWh

up to 500 kW - 1.0 ct/kWh

Bonus for the use of at least 50% landscape management material in renewable resources plants:

up to 500 kW - 2.0 ct/kWh

Emissions reduction bonus:

Compliance with the formaldehyde limit values under German air quality laws for listed plants

up to 500 kW - 1.0 ct/kWh

A combination with pure vegetable by-products not eligible for bonus is possible (a pro rata payment of the renewable resources bonus is then due).

As a result of the experiences with less-effective heat energy use, the conditions for the CHP bonus have been tightened.

CHP Bonus:

When the following conditions are fulfilled, a bonus amounting to 3 ct/kWh is due. This applies also to old installations (start-up before 01.01.09) but only up to an output of 500 kW, where the following applies:

- Used for space heating, process heat, cold production under the positive list
- Not used within the installation (e.g fermenters or tank heaters)
- Replaces fossil fuels
- Extra costs for heat energy use of at least 100 /kWth

Technology Bonus:

The permitted technologies were retained, with the exception of the bonus for dry fermentation. Except in the case of biogas processing, however, use in combined heat and power or an electrical efficiency of at least 45% is now required.

In the case of biogas processing, a number of special rules apply:

- Max. 0.5% methane emissions
- Max. electrical consumption of 0.5 kWh per m3 raw gas

The production of required process heat, where this is carried out, to be from renewable energy sources.

- Level of bonus: 2 ct/kWh up to 350 Nm3/h
- Level of bonus: 1 ct/kWh up to 700 Nm3/h

In addition, the slurry and emissions bonus do not apply. For heat energy use, the CHP bonus is remunerated at only 2 ct/kWh in accordance with EEG 2009 rules. This represents a downgrading of the conditions for this technology.

KfW Renewable Energies Programme

The KfW Renewable Energies Programme was set up to support the long-term financing of measures for the use of renewable energies at a favourable interest rate. The following activities in the field of biogas are supported:

- Biogas processing plants which are set up to treat biogas to achieve natural gas quality prior to feeding into the natural gas supply network
- Biogas pipelines for untreated biogas (at least 300 metres linear distance) including the gas condenser, gas drying equipment and condensate trap (to the extent that the piped gas is intended for CHP use or for treatment to natural gas quality)

Conclusions

In order to guarantee security of future energy supplies, it will be necessary to strengthen the position of domestic suppliers. Biogas technology has an important role to play in this respect. Biogas can be used anywhere and is available throughout the year. The possibilities for use include production of electricity and heat energy as well as the manufacture of transport fuels.

Biogas production has particular significance in the low plains of Lower Saxony with its highly productive agriculture. Compared to the use of fossil fuels or liquid biofuels such as biodiesel, bioethanol and BtL fuels, local and regional value creation for biogas use is very high. Taking into

account all revenue generation arising from the construction and operation of a biogas plant, a great proportion of this finance remains in the rural area.

Since 2004, about 500 new biogas plants with an investment volume approaching one billion euros have connected to the national grid. These investments, which are associated with the plant installation activities, have mainly resulted from regional enterprise. Additionally, the expenditure for operating the processes largely benefits local partners. However, operating costs may be affected by seasonal fluctuations (price changes in the raw materials sector, leasing costs etc.). It is only in the specialised areas of plant technology and operation that supra-regional services may be required, such as systems analysis for cogeneration plants. For most plants, the raw materials for the daily operation are produced entirely locally. The whole logistic system for raw materials, from cultivation to delivery and the final spreading of fermentation wastes back on the land, is almost exclusively in the hands of local labour. The revenue for the end product, nowadays mainly electricity, flows directly into the rural areas. The increased use of heat energy further enhances the value creation locally. In this way, this development contributes to the strengthening of rural areas.

In Lower Saxony, a strong biogas industry has been able to become established which has, at a rough estimate, created about 1,500 new jobs. Well-known German plant manufacturers and component suppliers are now based in Lower Saxony. The jobs have been created along the entire value creation chain of biogas use: raw material delivery, traders, plant construction and component manufacture, deliveries, planning and advisory services, research and development.

Today, Germany is a world leader in the field of biogas technology. Enterprises based in Lower Saxony have a large share of this. In the future, the exporting of such technology will assume even greater importance. Even today, numerous biogas enterprises in Lower Saxony are active internationally and are laying the foundations for the long-term development of the business.

5. Italy

In Italy in the last decade in the agricultural and animal breeding sectors (pigs and cows) the biogas production is a consolidate practice which leads until now mainly to produce electricity to feed into the public electricity grid.

In term of numbers of plants installed and their capacity, the most important region in Italy are Lombardy, Emilia Romagna, Veneto, Piedmont and South Tirol, where numerous cattle sheds are present. At national level there are about 15.000 farm with more than 100 cows. More than 10.000 are located in the first 4 regions above listed.

The biogas sector is in the last 3-4 years knowing a strong expansion phase in term of rate of annually new plants which are going to be built due to the incentive scheme. It’s still remain a kind of unsure in term of feed-in tariff and therefore in term of opportunities to invest for potential investors.

In Sept. 2009 can be inventoried 401 AD biogas plants of which 235 are based on agricultural substrates. The annual rate of new plants can be estimated, unless for the 2010, of about 40-50 new plants.

The prevalent size of the plant is 150-200 kWe and about 25 plants have a capacity of 1 MWe.

In Italy there is no biomethane plant based on agricultural substrates.

Observing the surrounding condition (cars, national fossil methane net), biomethane it’s also a promising market even though at the moment any plant is in operation in Italy and the legislative framework is still to be defined.

Energy production and energy consumption from biogas

In the Italian biogas plants it is used mainly as substrates animal slurry and manure (cows and pigs, potential estimated 130 billion t/y), agroindustrial residues and energy crops (mainly maize silage, also sorghum). Of them about 50% operate in co-digestion of manure with energy crops and residue of agri-industrial residues (inter alia tomatoes, potatoes, onions and other vegetables residuals).

Normally a 1 MW el. output needs a 250-300 crops surface (maize silage) to be fed in co-digestion with manure. Normally in the flat area (alongside Po rivers) the harvesting productivity (whole plant) with irrigation supply facilities can reach 45-50 t/ha/y maize and a second harvesting during the same year (e.g. Triticale) can be further more harvested about 30-35 t/ha/y.

GSE (Dec. 2008) in Italy reports a production of about 1.6 TWh electricity (+10,5% compared to Dec 2007) from biogas of which 85% comes from landfill (1.355 GWh) and from agricultural 14% (ca. 230 GWh). The whole biogas sector represents about 0.47% of the national total consumption which in Italy

The potential of biogas in Italy has been estimated in about 20 TWh/y which a power capacity installed of 2.700 MWel or in term of biogas produced is about 6.5 billion Nmc (CRPA.it). In Italy is consumed annually about 80-85 billion Nmc of fossil methane (Russia, Libya, Algeria and near east) (trend increasing) and the methane national production is about in 8 billion NMc (trend decreasing).

At the moment (January 2010) there is no biomethane plant (upgrading biogas) in Italy based on agricultural and agri-industries residues.

Concerning the development of plant number, in December 2008, including the landfills biogas plants (141 plants with a total power of 210 MWe), there were around 360 operating plants with a total capacity of 345 MWe. In Sept. 2009 there were **401** plants qualified by GSE (see below) and the power installed has reached 345 MWe.

There are around 20-25 biogas plants which have a power of 1 MWe (Sept. 2009).

Development of the biogas & biomethane sector

In Rome there is a private company (AMA) managing waste which is processed and subsequently landfilled. It produces a considerable amount of biogas used mostly for their own electric power plant and partly to provide biomethane for AMA waste collection vehicles (collecting HD). (Biogasmax.co.uk).

Summing up some figures about biogas and biomethane plant in Italy

ITALY	BIOGAS	BIOMETHANE
N° plants in operation	401 (09/09)	0
Trend for the 2010-2011 (foreseen new plants)	30 - 50	1 – 2
Medium EE power size (kW)	150-200 kW	-
Average Nm^3/y (bioCH4 prod.)	-	-

Energy policy measures

Biogas is mainly used for generating electricity and the heat production is usually dissipated except for those which is used for the warming-up of the fermenters. In few cases a small amount of the heat is use for heating the farmers' house and maybe the building dedicated for "direct products marketing" on farm.

4.1 Regional and national energy policy measures for biogas & biomethane

At regional level can be granted financial contribution to biogas plant whit a limit of max 40% of the total investment otherwise the "all-inclusive feed-in-tariffs" will decade.

In the northern regions it has been recently released - in the framework of the Rural Development Plan (2007-2013) - a granting scheme for supporting biomethane productions (Measure 311) where incentive can reach max 40% of the total investments. A biomethane project can get more "evaluations points" into the list of the project presented and above all is granted to those farmers which subscribes a supply contract with a public fleet company which can run on biomethane.

FISCAL ADVANTAGES: by Law in Italy if you are a farmer as defined by the Civil Code and the farmer sell either power or heat the income related is a part of the so called "Agrarian income" which level of taxation comes from the land surface cultivated (owned/rented) and independently of what is cultivated (see level of income) on it. A limit is that the at least 50% in term of the biogas production must derives from substrate produced within the farm.

Support schemes of biogas & biomethane

In Italy is in force since 15 August 2009 the so called "All-inclusive feed-in-tariffs" which pays for electricity produced from biogas dedicate to the agricultural entrepreneurs which are mainly running small-medium plants. Before that data (18th December 2008) the price of the "All-inclusive feed-in-tariffs" was 220 €/MWh + VAT (20%). Farmers must release an invoice to the GSE which monthly pays to the biogas-electricity producers.

There is no incentive or rule in order to increase the whole plant efficiency and to use the exceeding heat produced by the engine.

Potential of renewable resources

Substrate used (contribution to the energy production, biogas in %)

Classes Power output (e.g.)	Biogas	Biomethane
150 – 500 kW	**mainly used slurry and manure** **Manure: 40% biogas**	**-**
500 kW – 1.5 MW	**mainly Energy crops like: maize silage and triticale, agricultural residues** **Manure: 5-7% biogas** **Silage: 80-85 % biogas** **Agricultural residues: 5-7 % biogas**	**-**

Currently it can be roughly estimate agricultural land used for is ranging from 20.000 – 25.000 hectares mainly maize silage.

For at the end of this year "all-inclusive feed-in-tariff" might be modified by Law so that it's foreseen for at least this running year (2010) a steady increase of the numbers of plant but remain unsure for potential investors the next step and the tendency for the further sectors developments.

Conclusions

As conclusions can be reported that biogas sector needs in Italy can be like following summarized:

- a clearer and concrete procedure (above all administrative) to plan, start and running a biogas plant;
- possible use of digestate for agronomic purposes also when is co-digested animal manure and agricultural residues;
- increase efficiency of plants and introduce a kind of bonus to use the generated heat
- incentive on biomethane as fuels

A consistent part of animals are located in small-medium recoveries (50-100 heads each) and it would be important to introduce or "force through incentives" farmers to collaborate in some way (consortium) to build up and run common biogas plants.

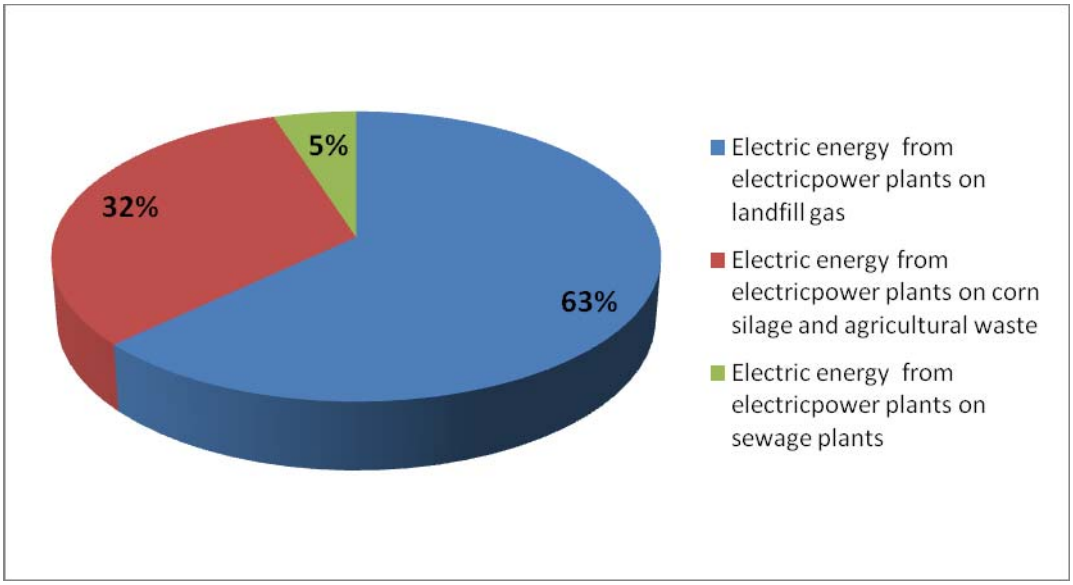
6. Slovenia

One of renewable energy sources is the biogas. Biogas could produce from different raw materials: land fill gas, sewage plants or green biomass, manure and other agricultural waste. In that document principally describes biogas from manure, green biomass and agricultural waste. Those types of biogas installations have positive effect on development of rural areas.

Take into consideration that Slovenia is small country and all statistic data and policy directives are mostly available and prepared on the national level we decided to prepare our report on national level.

Energy production and energy consumption from biogas

In year 2006 consumption of electricity from renewable energy sources in Slovenia was 24,4 %. The main percent of "green electricity" was from hydroelectric power plants (97 %), 2 % was produced from biomass, and 0,9 % (11,9 ktoe) was produced from all biogas electric power plants.



Picture 1 Percentage of different power plants on biogas in Slovenia (Biogas barometer 2008, EurObserv'ER)

Proportion of electrics generation from biogas in primary production in year 2007 was 11,9 ktoe. At most electric energy was produced from electric power plants on landfill gas (63 %), 5 % was from sewage plants and 32 % was produced from agriculture waste and corn silage (Picture 1) (EurObserv'ER 2008, Bioplin).

Development of biogas power stations started after year 2002, when regulation about repurchase electrical power from qualified producers has been adopted. With this regulation assured repurchase and higher premium of green electricity was assured.

First biogass plants were installed on two bigger farms and the interest has increased after the feed-in law was introduced in 2002. Since then the biogas use is promoted mainly with feed-in tariffs by. In last year's mainly smaller plants, between 0,5 and 1,0 MWe, were build or planned.

According to our data five biogas installations on agricultural waste, manure and corn silage were in operation in year 2007. Their total installed electrical power capacity was 3,6 MW (Table 1).

Table 1 Biogas power plants on agricultural waste and corn silage.

	Instaled capacity (MW)
Farm Ihan	0,526
Biogas plant on farm Frele – Letuš	0,120
Biogas plant Nemščak - Skupini Panvita	0,853
Biogas plant on farm Kolar – Logarevci	1,569
Biogas plant Motvarjevci (Panvita)	0,500

In Slovenia biogas plants produce mainly electrical energy. The heat is still considered as the secondary product and is usually used just for heating their owner buildings and not for selling.

Biogas as motor fuel in Slovenia is not used jet. But it could be interested for self-supply on biggest farms.

Energy policy measures

The Slovenian Biofuel Policy is based on EU legislation which is translated into the Slovenian laws and ordinances in order to promote and support biofuel use and production.

Slovenia has two important goals to reach till 2020:

25 % energy from renewable sources in final energy
10 % energy from renewable sources in transport.

In May 2009, the new **scheme in support to green electricity production** came into force, with which the state wishes to promote and hasten, among other renewable energy sources, the use of biogass for the production of green electricity. The renewed scheme concerns two decrees, i.e.: the Decree on support for electric power produced from renewable energy sources (2009), and the Decree on support to electric power produced in co-production of heat and electric power with high yield (2009). The framework for the preparation of the scheme in support to the production of green electricity is the EU Directive on stimulation of electric power production from renewable energy sources on the internal electricity market (2001).

Potential of biogas plants

According to collected data they were planning to build 20 biogas plants with total powe capacity of 23 MW. Realization of all that biogas plants will be exceeding all further expertises in Slovenia.

Table 2 Biogas plants in the plan (study case HSE, 2009).

New installations	Capacity [MWe]			Production [GWhel]		
	2010	2011	2012	2010	2011	2012
Landfill gass	3,3	5,5	6,0	23	39	42
Waste water treatment plants	1,5	2,6	3,1	8	13	13
Biogas	**2,8**	**3,8**	**4,4**	**14**	**19**	**22**

Nine of them will use biogas from agricultural waste, manure and green biomass for electric production. Sum of their total installing power will be around 11 MW (Table 3). All new planned biogas electric power plants are planned to be on bigger farms in Slovenia. With realisation of his plan the

capacity for further development of biogas installation with capacity around 1 MW or more, will be used.

Table 3 Biogas installations on agricultural waste, manure and corn silage that are in the planning (Project: BiG>East, 2008).

Location	Raw material	Biogas plants	
		Production:	Capacity [MWe]
Farm Cvek	agricultural waste, manure and corn silage	Electrical power	2,100
Ptuj	agricultural waste, manure and corn silage	Electrical power	1,460
Domžale	agricultural waste, manure and corn silage	Electrical power	1,000
Ilirska Bistrica	agricultural waste, manure and corn silage	Electrical power	1,100
Arja vas	agricultural waste, manure and corn silage	Electrical power	1,400
Pivka	agricultural waste, manure and corn silage	Electrical power	1,400
Mlajtinci	agricultural waste, manure and corn silage	Electrical power	2,100
Gea	agricultural waste, manure and corn silage	Electrical power	0,342
Motvarjevci	agricultural waste, manure and corn silage	Electrical power	0,835

Only remaining unexploited potential stays on smaller farmers, where biogas plants with electrical capacity up to 300 kW could be built. According to expertises total installing capacity of biogas plants on small farms is up to 3 MW (D. Jug, 2007). The main barrier for development of small biogas plants are relative small farms with fragmented agricultural activity. They have not enough agricultural waste and agricultural land, and the owner have not interest to invest in biogas installations. The solution could be in partnerships and in organising of farmers associations.

Biomass-technologies

Two types of technology for production of biogas are known: discontinuously and continually. Biogas installations are built on agricultural areas where intensive livestock farming are developed. The main materials for biogas production are corn silage and manure. Gas is used mainly for electricity production. Wastes that stay after biogas production are used for fertilization on the fields.

Conclusion

Potentials for production of biogas from manure, agricultural waste and green biomass are very limited in Slovenia. Biogas is mainly used for production of electricity; heat is treated as by product and is mainly not used for district heating. Biogas plants are built at bigger stockbreeding farms, also as a part of manure treatment. Their usual installed power capacity is between 0,5 and 1,0 MW. The potential for big biogas plants in Slovenia is almost used, some unused potential remains on smaller farms, but only for small plants (installed capacity less than 0,5 MWe).

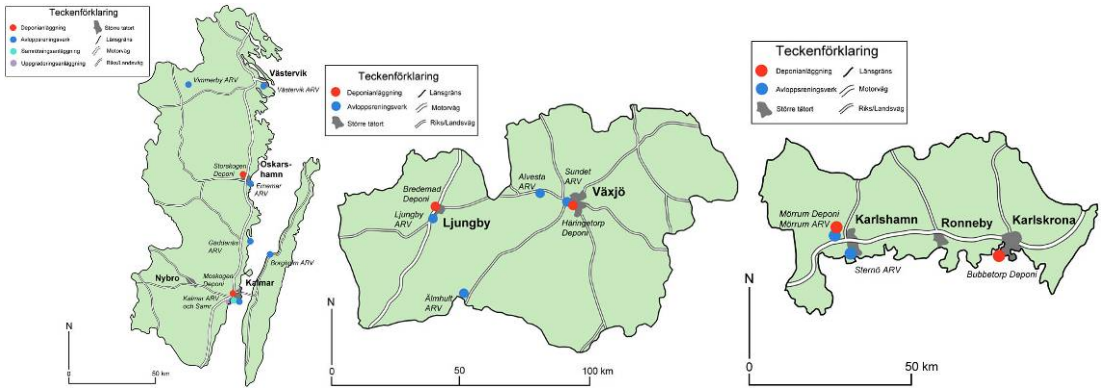
7. Sweden

Energy production and consumption from biogas

About 1 359 GWh biogas were produced in Sweden in 2008. The biggest share comes from sewage water treatment plants. Approximately 44 % or 605 GWh biogas are produced in sewage water treatment plants, circa 27 % or 369 GWh is produced from landfills, 18 % or 240 GWh in Co-digestion plants and 10 % or 130 GWh is produced in industrial plants. Small scale biogas production (farm scale) stands for about 1 % or 15 GWh of the total biogas production in Sweden.

The production of biogas has increased with 12 % since 2006. Growth can be seen within the whole biogas sector and above all for co-digestion and industrial plants. Reduced production output from landfills is expected in the future, due to the prohibition to deposit organic waste since 2005. At the same time an increase is predicted for co-digestion plants, industrial plants and farm scale biogas plants.

Today there are about 20 biogas plants in the southeast of Sweden (County of Kalmar, Kronoberg and Blekinge). Currently mainly waste and sewage is digested in biogas plants in this region. Approximately, 51 GWh biogas were produced in the southeast of Sweden in 2008.



Deponianläggning = landfill plants
Avloppsreningsverk = sewage water treatment plants
Samrötningsanläggning = Co-digestion plants
Uppgraderingsanläggning = Upgrading plants

Biogas use (heat, electricity, transport fuel)

The biogas produced in Sweden today is mainly used for heat production. The heat is delivered to customers or used by the producer for heating of their own premises or as process heat. Of the biogas produced 2008, 53% or 720 GWh was used for heating purposes, 4% or 59 GWh for electricity production, 26% or 355 GWh was upgraded to vehicle gas, 14% or 195 GWh was burnt off, and for 2% or 30 GWh the use is unknown. Vehicle gas increased by 7% compared to 2006, which was the largest increase among the sectors of use.

The total volume of upgraded biogas injected into the natural gas grid was 133 GWh. Injection into the natural gas grid takes place at Laholm, Falkenberg, Helsingborg, Malmö, Bjuv and Göteborg.

Also in the southeast region the main part of the biogas produced was used for heat production.

In the County of Kalmar there are nine biogas plants, of which two landfills. The total biogas production in 2008 was 27 GWh, which was a decrease by 24% since 2006. The total digestion chamber volume was 14,120 m^3.[2]

In the County of Kronoberg there are six biogas plants, of which two landfills. The total biogas production in 2008 was 13 GWh, which was an increase by 4% since 2006. The total digestion chamber volume was 6 483 m^3.[3]

[2] http://www.biogasportalen.se/

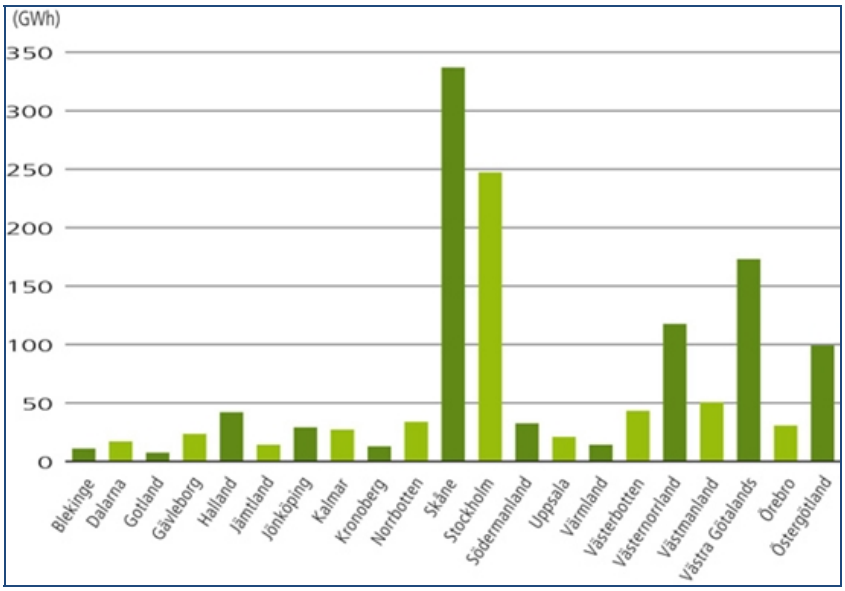
In the County of Blekinge there are four biogas plants, of which two landfills. The total biogas production in 2008 was 11 GWh, which was an increase by 5% since 2006. The total digestion chamber volume was 1500 m^3.[4]

Altogether there are 19 biogas plants in the southeast region which produced 22 103 m^3 biogas in 2008.

Development of biogas - and methane sector

The geographical distribution of data on counties shows that biogas production is largest in the big city areas.

Figure 1 Biogas plants in Sweden, preliminary statistics 2008[5]



More than half of the biogas (the landfill gas included) is produced in the counties of Stockholm, Västra Götaland and Skåne. Also the counties of Västernorrland, Östergötland, Västmanland, Västerbotten and Halland produce relatively large amounts of biogas. The other counties (13) produce only 20% of the biogas. The County of Skåne has the largest number of plants (43), followed by Västra Götaland (29) and Stockholm (18), the figures include landfills.

Example of region: southeast Sweden (Kalmar, Kronoberg, Blekinge)	Biogas	Biomethane
Number of plants in use	19	2
Trend for 2010–2011 (plants planned)	3	3
Mean production m^3/year	22 103	x

[3] http://www.biogasportalen.se/
[4] http://www.biogasportalen.se/
[5] Source: www.biogasportalen.se

Trend of biogas production

Based on about 50 planned and ongoing biogas projects around Sweden the prognosis for the total biogas production 2012 is over 3.5 TWh/year. Some of the planned projects however, as it looks today, are lacking complete financing.

The goal for biogas production according to the biogas section of Sweden Energy Gas Association is 3 TWh/year. This includes biogas from digestion and thermal gasification.

Energy policy, goals and measures

General overview

	EU goal 2020[6][7][8]	**Sweden goal 2020**[9][10]	**County of Blekinge**	**County of Kronoberg**	**County of Kalmar**
Carbon dioxide emissions	total decrease of emissions by at least 20% compared to the level 1990	40% lower emissions of carbon dioxide compared to the level 1990	2010: decreased emissions of carbon dioxide from fossil fuels to 3.8 tonnes per capita and year	2010: emissions of carbon dioxide from fossil fuels decreased to 3.5 tonnes per capita and year 2050: fossil fuel free	2010: maximal emissions of fossil carbon dioxide 4.4 tonnes per person
Renewable energy	share of renewable energy of used energy increased to 20%	at least 50% renewable energy	2010: 50% self-sufficiency, largest possible share of renewable energy 2015: increased share of electricity from wind power and Combined Heat and Power, 0.19 TWh electricity produced from wind power	2010: at least 2 TWh/year produced from biofuels, 50% of the energy used should be renewable	2030: fossil fuel free region
Transport sector	10% renewable transport fuels compared to 2005 and at least 10% share of renewable of transport fuels diesel and gas	10% renewable in transport sector	6% renewable in transport sector	2010: 6% renewable in transport sector	2010: 20% lower emissions of carbon dioxide from transports compared to 1995

Regional and national energy policy measures for biogas and methane

The share of bioenergy has increased steadily in Sweden in the last years. The largest part of the increase has taken place in the industry and at the district heating plants. The biomass used in the Swedish energy system consists mainly of wood fuel, black liquor, crude tall oil and ethanol. The large expansion of biofuels has occurred thanks to an ambitious goal for renewable energy, and the Swedish government has decided to continue fulfilling the goal. Investments in bioenergy contribute to a safe and sustainable energy supply and to creating growth and job opportunities. Biofuel gives rise to a chain of activities which in their turn create job opportunities.

[6] http://ec.europa.eu/environment/climat/climate_action.htm
[7] http://europa.eu/legislation_summaries/index_en.htm
[8] http://www.regeringen.se/sb/d/8857
[9] http://www.regeringen.se/sb/d/8857
[10] http://www.regeringen.se/content/1/c6/12/00/82/4932050b.pdf

The electricity certificate system is a market based system to support electricity production from renewable energy sources. More information about how the electricity certificate system works can be seen in Figure 6 The electricity certificate system, www.energimyndigheten.se
GRAPHICS: **THOMAS ÖHRLING /INFO**.[11]

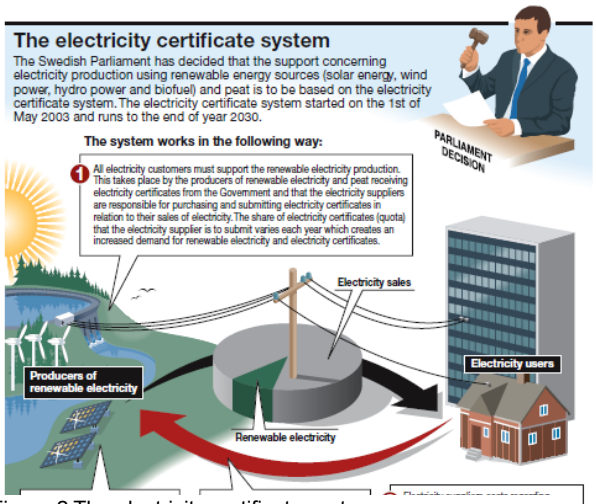
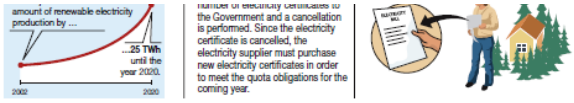


Figure 2 The electricity certificate system, www.energimyndigheten.se
GRAPHICS: THOMAS ÖHRLING /INFO

Since decades there have been energy taxes on electricity and fuels. In 1991 Sweden, as one of the first countries in the world, introduced a carbon dioxide tax. Current energy taxes have as a goal a more efficient use of energy, to encourage biofuel use, to create incentives for companies to decrease their impact on the environment and create favourable conditions for electricity production within the country.

A green tax reform was introduced 2001. During a ten-year period the taxes on energy use and emissions shall increase by more than 30,000 million Swedish kronor (3,000 million euro) and at the same time the taxes on work shall decrease by the same amount.



Sweden has 16 national environmental objectives. Among these "Natural Acidification Only", "Reduced Climate Impact", "Zero Eutrofication" and "A Good Built Environment" are examples of objectives where the biogas process can contribute to reaching the goals.[12]

Since 2005 it is prohibited to deposit organic waste on landfills. Organic waste could for example be digested in biogas plants instead.

The Swedish government has given Swedish Energy Agency the commission to develop a strategy for increased use of biogas.

Biogas can play an important role to decrease the impact of transports on climate and create more jobs locally and regionally. Swedish Energy Agency after consultation with Swedish Board of Agriculture and Swedish Environmental Protection Agency will develop a long-term strategy covering all sectors and suggest measures which both in the short term and in the long term contribute to increased biogas use.

The suggestions for measures together will constitute a common platform for the future development concerning production, distribution and use of biogas in Sweden. The strategy and the common priorities should particularly consider cost efficiency and energy efficiency, the transport sector's dependency on fossil fuels, the environmental goals, the development of relevant initiatives within the EU and internationally and the Swedish industry's competitive force.

In the strategy possible obstacles for a continued development should be identified and suggestions for solutions presented. The commission also includes an analysis of the importance of the steering instruments, the research and other public efforts to the competitiveness of biogas, and for industrial actors' possibility to strengthen their international competitive force. Another part of the commission is to investigate the prerequisites for a Swedish regulation allowing conversion of tractors for gas fuel.

The commission should be finally presented to the Government Offices 12 May 2010.

Funding for biogas

In October 2009 the government made a decision on a new funding for biogas. The funding is meant for spreading of already available technique which is not yet competitive on the market and will be used for projects contributing to increased production, distribution and use of biogas and other

[11] http://www.energimyndigheten.se/Global/F%C3%B6retag/Elcertifikat/NY_GRAFIK2_SWE.pdf
[12] http://www.miljomal.nu/

renewable gases. The government contributes with 50 million Swedish kronor per year for the period 2009–2011. To receive funding a project must be favourable from a climate perspective, energy efficient and resource efficient and have the technical potential for development and competitiveness. The highest amount of funding for a project is 25 million Swedish kronor. The new funding could therefore be of interest for those who intend to start larger projects.

The new funding complements both the means for research, development and innovation which the Swedish Energy Agency disposes of and the funding for manure based biogas production available from the Swedish Rural Development Programme comprising 200 million Swedish kronor during 2009–2013. The funding will facilitate the development of enterprises, adjust them to new conditions, increase the quality of the production, strengthen the competitiveness and improve the environment and the animal welfare.

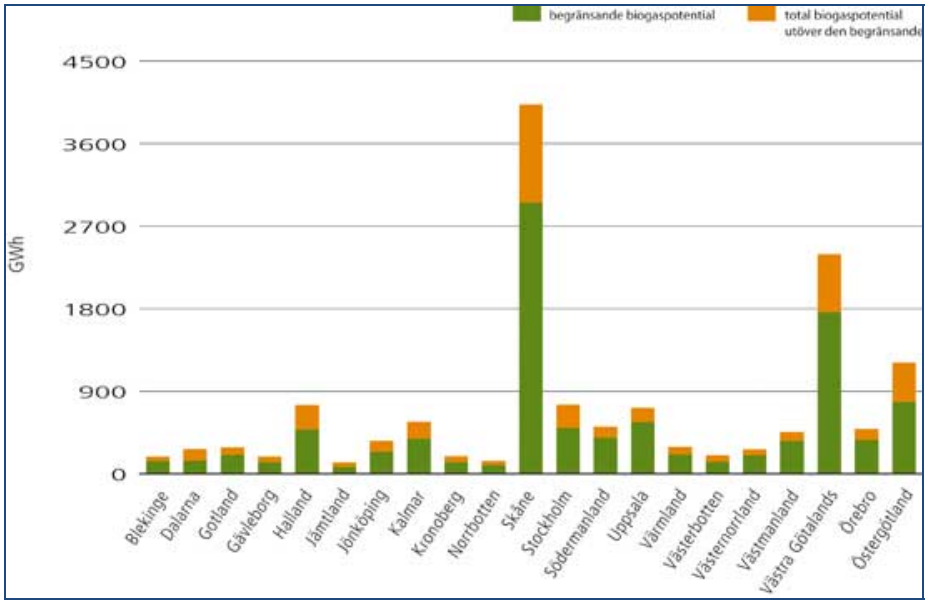
The Government has earlier given the Swedish Energy Agency the commission to develop a national biogas strategy and suggest measures contributing to increased biogas use. Swedish Energy Agency handles the new funding.

Potential for renewable sources

Substrate used

Power	Biogas	Biomethane
< 150 kW	**Manure and crops**	**Cellulose rich wood material**
> 1 MW	**Sewage, sludge from sewage plants, waste**	**Cellulose rich wood material**

Biomass production



A study of the total biogas potential from natural rest products in Sweden was made in 2008. Natural rest products are all kinds of organic material available from households, restaurants, large-scale kitchens, shops, parks, gardens as well as all sewage sludge, manure, residues from crop production and rest products from different kinds of industries. The study was divided into potential for digestion and potential for thermal gasification of raw material from forest.

The counties with the highest biogas potential, total as well as limiting, are the Counties of Skåne and Västra Götaland. The reason for this is above all the large agricultural and animal production and the main part of the food industries which are found in these counties.

The County of Stockholm has a relatively high limiting biogas potential due to a large population giving rise to larger amounts of food waste and sewage sludge.

Included in the basic data for the category Övrigt (Other), total biogas potential with limitation, are above all slaughterhouse waste and other materials already digested at Swedish biogas plants. From competitive reasons these amounts are not presented divided on counties. In the category Other also the biogas potential from park and garden waste is included.

a) From agriculture

Forest residues are an important potential for future biogas production. The total energy potential of residues and rest products from forestry and forest industries is estimated to be about 59 TWh per year.

Methane production from wooden raw material is done with thermal gasification, yet unproven in a large scale. It is therefore difficult to tell when this technique will be commercially available.

According to theoretical calculations Sweden could produce 17 TWh biogas each year. Agriculture is calculated to stand for as much as 80 percent (14 TWh) of this potential. Half of the amount of energy (7 TWh) would come from straw, 3 TWh from manure and urine, 3 TWh from pasture crops and 1 TWh from haulm and sorted out potatoes.[13] This results in about 10% of the total agricultural area being used for growing crops for digestion.[14]

b) From residues and rest products

The total biogas potential from domestic raw materials, excluding raw material from forests, amounts to more than 15.2 TWh/year, of which the total biogas potential with limitation is estimated to be 10.6 TWh/year.

Of the total biogas potential from domestic residues and rest products about 70% comes from agriculture. Food waste from households, restaurants, large-scale kitchens and shops, and rest products from food industry and other industry stands for one quarter. The remaining 5% of the total biogas potential comes from sewage sludge.

Of the total biogas potential with limitation 75% comes from agriculture. Estimated that about 60% of all food residues from households, restaurants, large-scale kitchens and shops can be digested this share will be 7%. Rest products from food industry and other industry make up about 10%.

7% of the total biogas potential with limitation from domestic residues comes from digestion of sewage sludge. It is estimated reasonable to digest most part of all the sewage sludge in Sweden, which makes the biogas potential from sewage sludge almost as high in the limited biogas potential as in the total biogas potential.

Biogas potential

Different reports show there is a potential for as much as a ten times higher production, or about 14 TWh per year in Sweden. In this potential is assumed for example that about 10% of the agricultural area is used for growing crops for digestion. If also the possibility to produce methane from cellulose rich wood materials, so called biomethane, is considered the potential for production of methane from domestic raw materials will be nearly 100 TWh.

Food production versus energy production

In the potential mentioned for future Swedish biogas production is included, besides biogas from organic waste, also digestion of various crops. If land today lying fallow (10–15% of cultivated area) is used for energy production there will be no direct competition with food production. Also rest products

[13] www.bioenergiportalen.se

[14] Biogas ur gödsel, avfall och restprodukter – goda svenska exempel, Gasteknisk Center, Svenska Gasföreningen och Svenska Biogasföreningen, 2008

from food production can be used for biogas production. A possible situation of competition might come up if this area should be used for production of some other energy source.[15]

Biogas technology

Upgrading plants and use of biomethane in Sweden

Sweden	Number of upgrading plants	Production (Nm^3)	Use
Water scrubber	25 (1 in the County of Kalmar)	About 28 millions[16]	Different vehicles
Pressure Swing Adsorption, PSA	7		
Chemical absorption (AMINE)	2		

Production costs

Economic conditions, investment costs, government and regional funding systems and steering instruments are perishables and the level and design is changed over time. This is an example of calculations from Swedish Gas Centre and Swedish Gas Association.

Kostnadspost	Kostnad rörlig del (kr/kWh)	Kapitalkostnad, fast del (kr/kWh)	Kostnad totalt (kr/kWh)
Biogasanläggning	0,16	0,24	0,40
Torkanläggning	0,001	0,015	0,016
Blåsmaskin	0,006	0,002	0,008
Biogasledning	-	0,10	0,10
Uppgradering	0,08	0,07	0,15
Tankstation, inkl Högtryckskomprimering	0,115	0,05	0,165
Eget gaslager, lastväxlarflak	0,02	0,02	0,04
Marknadsrisk	0,04	-	0,04
Fackling, 10 % av rågas	0,024	-	0,024
Summa per kWh	0,45	0,50	0,94
Moms	0,11	0,12	0,24
Summa kr/kWh ink. moms	**0,56**	**0,62**	**1,18**

Table 1 Cost items, variable part, fixed part (capital cost) and total cost for a biogas plant with 200 m^3 digestion chamber volume[17]

[15] Biogas ur gödsel, avfall och restprodukter – goda svenska exempel, Gasteknisk Center, Svenska Gasföreningen och Svenska Biogasföreningen, 2008

[16] Year 2007, source: http://www.sgc.se/dokument/Biogas_Internationellt_Perspektiv.pdf

[17] Gårdsproduktion av biometan, en jämförelse av produktionskostnader och marknadsvärde för olika avsättningsalternativ, rapporten är framtagen av LRF, Svenska Gasföreningen och E.ON Gas Sverige AB, LRF Konsult och Svenska Biogasförening

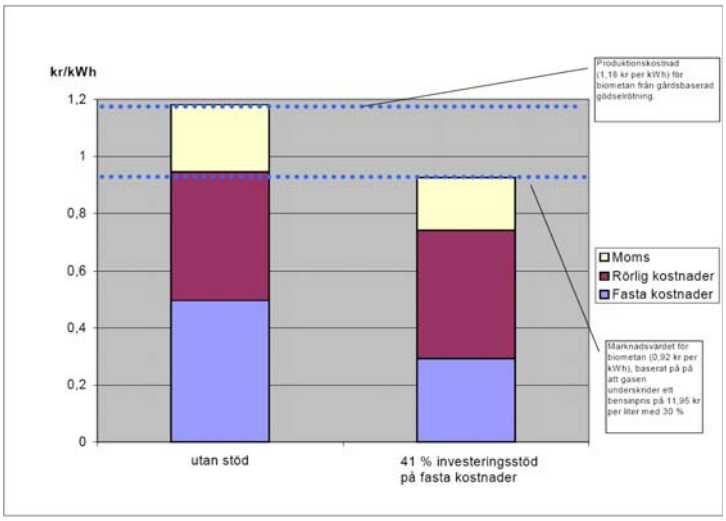


Figure 3 Production costs and market value for biomethane distributed via stand-alone filling station[18]

The economic conditions change over time and it is difficult to find business ratios since almost no plant looks like another one. Biogasportalen[19] has compiled a number of studies on this area, with no aim to be exhaustive:

Farm biogas plants

Mer biogas! Realisering av jordbrukspotentialen (More biogas! Realisation of the agricultural potential) – The study gives an economical analysis of production and distribution of gas as well as biomanure. The starting point was seven agricultural biogas plants, with a production ranging from 2.5 GWh/year to >100 GWh/year.

Biogas på gården – en introduktion[20] (Biogas on the farm) – This brochure gives an overall description of how to produce biogas from the farm's resources. On the last pages there are possibilities to make own calculations. To go deeper into the subject the material Affärsutveckling för gårdsbaserad biogas (Business development for farm based biogas) can be ordered from LRF.

Basdata om biogas[21] (Basic data on biogas) – In Germany there are thousands of biogas producing farm plants. In a German handbook for farm biogas, investment costs have been compiled for six plants of different sizes producing Combined Heat and Power. Manure and energy crops are the primary substrates for digestion. The Combined Heat and Power units used are dual fuel engines in the two smallest plants and Otto engines in the larger ones.

Co-digestion plants

An evaluation presenting the investment costs in Swedish kronor per tonne digested waste per year for co-digestion plants, mixing different kinds of digestible waste and sometimes also manure and energy crops, was published by Avfall Sverige, Swedish Waste Management, in 2005. The investigation was based on four existing plants digesting only pumpable waste and one existing and five planned for digestion of household waste and other semi-solid waste.

The results from this investigation showed that the investment costs for plants digesting pumpable waste amounted to 850–1,600 kronor per tonne waste. For plants digesting household waste and other semi-solid waste the costs amounted to 2,200–8,600 kronor per tonne waste.

[18] Gårdsproduktion av biometan, en jämförelse av produktionskostnader och marknadsvärde för olika avsättningsalternativ, rapporten är framtagen av LRF, Svenska Gasföreningen och E.ON Gas Sverige AB, LRF Konsult och Svenska Biogasförening

[19] http://www.biogasportalen.se/BliProducentAvBiogas/Ekonomi/Investeringskostnader.aspx

[20] http://www.lrf.se/PageFiles/5703/Biogas_pa_garden_LR.pdf

[21] http://www.sgc.se/dokument/BiogasfolderA5.pdf

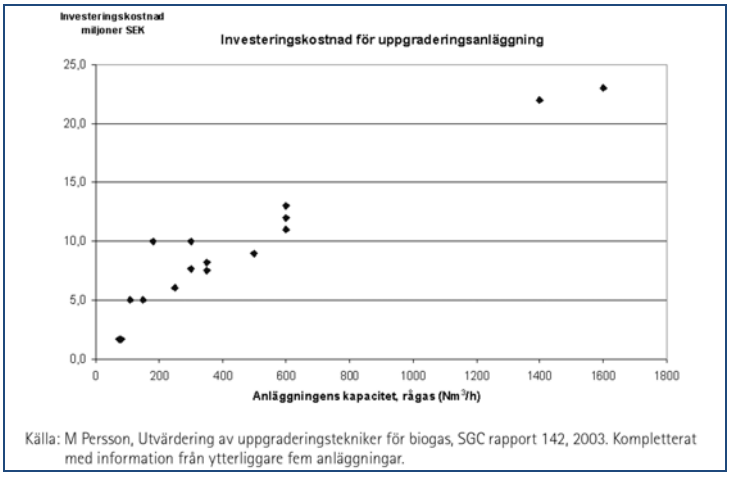
Table 2 Investment costs co-digestion plants[22]

	Investering (kr/ton)	Investering (kr/ton TS)
Pumpbart avfall[1]	850 -1600	5 900 – 23 000
Hushållsavfall och andra halvfasta avfall[2]	2200 – 8600	8 000 – 30 700

[1] Baseras på data från fyra befintliga anläggningar.
[2] Baseras på data från en befintlig och fem planerade anläggningar.
Källa: Utvärdering av storskaliga system för kompostering och rötning av källsorterat bioavfall, RVF Utveckling 2005:06.

Upgrading plants

Utvärdering av uppgraderingstekniker för biogas (Evaluation of upgrading techniques for biogas) – The report presents the relation between capacity and investment cost for 16 upgrading plants exclusive of compressors and buildings. The investments were made between 1996 and 2006 and the data presented in the report are not adjusted to this.



Källa: M Persson, Utvärdering av uppgraderingstekniker för biogas, SGC rapport 142, 2003. Kompletterat med information från ytterliggare fem anläggningar.

Figure 4 Investment costs upgrading plants[23]

Conclusion

Sweden today has come a long way concerning biogas use and is a forerunner concerning cleaning of biogas to vehicle gas quality. The investment in biogas plants has been going on for several years, but still, in several regions, demand for biogas is larger than supply.

C. Conclusions

Based on different studies and the experience of member countries the realistic potential for biogas until 2020 can be calculated for the EU 27.

AEBIOM assumes that 25Mio ha agricultural land (arable land and green land) can be used for energy in 2020 without harming the food production and the national environment. This land will be needed to produce raw materials for the first generation fuels, for heat, power and second generation fuels and for biogas crops. In the AEBIOM scenario:

[22] Källa: http://www.sgc.se/dokument/BiogasfolderA5.pdf
[23] Source: http://www.sgc.se/dokument/BiogasfolderA5.pdf

- 15 Mio ha land is used for first generation biofuels (wheat, rape, sugarbeet, etc.)
- 5 Mio ha for short rotation forests, miscanthus and other solid biomass production and
- 5 Mio ha for biogas crops.
- On this basis the potential for biogas in 2020 is estimated as follows:

Biogas potential in 2020

Origin(according to template for National Renewable Energy Action Plans)	Potential Billion m³ Biomethane	2020		
		Assumed percentage of use until 2020	Primary energy Billion m³ Biomethane	Primary energy Mtoe
Agriculture	**58,9**	**62%**	**36,4**	**31,3**
Agricultural crops directly provided for energy generation (5% of arable land; calculation in annex)	27,2	100%	27,2	23,4
Agricultural by-products / processed residues	31,7	28%	9,2	7,9
straw	10,0	5%	0,5	0,4
Manure	20,5	35%	7,2	6,0
rest (landscape management)	1,2	40%	0,5	0,4
Waste	**19,0**	**50%**	**9,5**	**8,2**
Biodegradable fraction of municipal solid waste including biowaste (biodegradable garden and park waste, food and kitchen waste from households, restaurants, caterers and retail premises, and comparable waste from food processing plants) and landfill gas	10,0	40%	4,0	3,4
Biodegradable fraction of industrial waste (including paper, cardboard, pallets)	3,0	50%	1,5	1,3
Sewage sludge	6,0	66%	4,0	3,4
Total	**77,9**	**59%**	**45,9**	**39,5**

- Source: AEBIOM

By June 2010 the member states of the European Union had to develop their renewable energy action plans (REAP). These plans will present the detailed targets for final heat, electricity and transport, the share of RES in each of these markets, the measures to reach the targets and to mobilize more energy from biomass. It is of outstanding importance that the member states integrate energy from biogas in an appropriate way in these plans. This publication will support the member states in this task.

It is recommended that until 2020 at least 35% of the manure, 40% of the available organic waste suited for biogas production and the sludge of water treatment is used to produce biogas. If this raw material is supplemented by energy crops, cultivated on 5% of the arable land, biogas could contribute in average 2 to 3% of the electricity production, 1 – 2 % of the transportation fuels and 1 % to the heat supply. Each member state shall elaborate a biogas concept within the national action plans which defines in detail the contribution of energy from biogas to the heat, electricity and fuel market.

In a second step the measures will have to be defined, that will be taken to reach these targets. Important measures in this context are:

- The integration of the waste policy of the communities in the energy concept
- The financial support for the needed infrastructure such as biogas pipelines, upgrading stations, biogas plants, heat networks to use the heat from cogeneration plants
- Various incentives to increase the number of gas driven vehicles
- Feed in tariffs especially conceived to use manure and green cuttings or catch crops for biogas production
- Green certificate schemes in favour of biogas (for countries without feed-in tariffs)
- Fair grid access for biomethane without fees for using the grid

Therefore, in order to have this potential, the following **policy measures** are necessary to implement at European and national levels.

EU level	National and regional level
Regulate/ensure an easy access to the electricity and gas grids (priority for biogas, guarantee, non discrimination, free access). This proposal has been included into the renewables directive and according laws have already been introduced in several member states (e.g. GNZV in Germany), where it has proven to be a stimulator for market development. **EU should urge member states to ensure the long lasting investment security in nREAP. The regulation should guarantee the long term price.** Biogas is particularly capital intensive and needs long term financing possibilities and security of income. The German feed in system offering fixed and high prices up to 20 years has proved to be very successful. **Specific directives like waste framework directive and water framework directive and nitrates directive should be reviewed to take the specific needs of biogas into account.** Biogas project developers have to face many	**Make biogas projects eligible for EU funding of Rural Development.** The regional authorities responsible for the planning and implementation of support to Rural Development under the EU Common Agricultural Policy should make the additional funds available through the "Health Check" (3.2 bln Euros in 2010 to 2013) for the "new priorities" (one of which is renewable energy) fully accessible for investments into all types of biogas projects. **Make biogas for transport competitive as compared to fossil fuels (CO_2 tax and lower excise duties).** Biomethane for transport competes with fossil natural gas as the vehicle technology is similar. Governments should look for ways to improve this competitiveness for the end users for example by introducing a general CO2 tax, which led to a favorable development in Sweden. Biomethane could receive special subsidies (e.g. a bonus per m³ biomethane used as fuel) in countries where natural gas is detaxed, most prominently Italy (which has by far the highest number of gas driven vehicles). This incentive should bridge the gap between the costs of natural gas and

regulations related to waste management, soil protection, prevention of water table pollution by nitrogen, etc. The excess of such non technical barriers is a main obstacle to a quicker implementation of biogas plants in Europe. In the future directives should better take the biogas case into account. **Fully consider biogas in the European Biofuels Technology Platform (EBTP)** It seems that the EBTP is focusing very much on biodiesel, bioethanol and the so called second generation biofuels, while biomethane is almost not considered. This is a mistake because biomethane is highly productive per ha, has an enormous potential, and is technologically ready both for production (upgrading of biogas) and use in natural gas engines. The CO_2 balance is extremely high (more than 100% reduction because of avoided methane emission in reference scenario without biogas). **Finalize the biowaste regulations (make it clear and sharp) in order to reduce the barriers for biogas use.** The landfill directive is banning progressively biowaste from landfilling, but many member states are still lagging behind the EU targets for maximum percentage of biowaste going to landfills. This is partly due to the lack of alternatives. Biological treatments are so far not regulated at EU level. A possible Biowaste directive might close this gap and propose standards. **Fertilizer legislation** Treated digestate should be allowed to replace artificial fertiliser all over Europe. This could be tied into GHG reductions through reduced use of oil.	biomethane as transport fuel. **Incentives for eco-cars should be introduced (e.g. tax advantages, lower parking fees, allow circulation during high emission period).** Biomethane cars have especially low emissions (NOx, particulates) and should be promoted by providing advantages such as low tax (upon buying them and using them), lower parking fees (successfully implemented in Swedish cities), and permission to drive even during period of high pollution. **Public transportation should run on biogas, incentives for biogas-taxis and company cars.** Bus fleets with steady and regionally bound fuel consumption are a perfect first step to introduce biomethane and biomethane filling stations to urban areas. A significant tax reduction for company cars running on biomethane would offer a great market for clean cars. **Support of regional gas infrastructure** The gas grid capacity should be adapted in order to allow biomethane injection into the system. **Adopt design of green certificate systems** The current systems often only aim at the most cost-efficient solutions and do not take into account GHG savings, use of waste or advanced biofuels – all of which favorable to biogas. **Eliminate the barriers to get permissions for building biogas plants.** Getting permits for new biogas plants is a long lasting process in all member states. Regulations are too numerous (see above) and the public misperception is the rule (misunderstanding about odors, transport, waste handling, pollution). Efforts should focus on communication and coordination between relevant administrative

	bodies for permits. **Support R&D for energy crops, biogas technology, fermentation biology, efficiency of energy use.** Biogas is highly productive per ha and is versatile regarding its uses. Still the potential for improvements through R&D are significant (best crops and by-products for fermentation, automatisation, biological process enhancement, cleaning, use in micro-turbines and fuel cell, etc.) **Accept digestate as a replacement of artificial fertilizer to meet crop needs.** The nitrate directive limits the organic fertilizer to a maximum of 170 kg N/ha. It is a pity that in some cases mineral nitrogen is used instead of biogas digestate because this limit has been reached. Digestate is an upgraded organic fertilizer with advantages (nitrogen less susceptible to water pollution, homogeneous, better management and storage opportunities) and should be better promoted and used instead of artificial fertilizers. **Fully include biogas into the nREAP.**