Kompetenzzentrum
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Nachwachsende Rohstoffe e.V.

Biogas in Lower Saxony

Inventory 2014

Niedersachsen

Biogas in Niedersachsen

Inventur 2014

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1. Introduction

Biogas in Lower Saxony

Lower Saxony occupies the leading position in the development of renewable energy from biogas and wind in Germany. Biogas is increasingly becoming the ‚integrated service provider' in the German energy system and through the efficient use of power-heat cogeneration and electricity output tailored to demand can play a key role in future energy policy. In addition to this, biogas can provide a service to agriculture through the avoidance of methane emissions in fertilizer management and by the assurance of nutrient cycles.

Today, about a quarter of the renewable electricity can be supplied from the 1,546 biogas plants in Lower Saxony. The many operating heat recovery concepts for biogas plants supply communities, businesses and private households with largely CO_2-neutral heat energy. This means new value creation concepts and enterprise possibilities for communities and citizens. The increasing number of energy cooperatives and joint operator arrangements is evidence of this.

Further options for use are provided by the processing of biogas and subsequent feed-in to the gas network, such as the use of biomethane as a fuel and the storage of energy sources in the gas network for later provision to meet demand for heat and electricity. In Lower Saxony, there are already 26 plants feeding in biomethane.

New processes combine the fluctuating provision of wind energy with storable biomethane. The first ‚power to gas' pilot plant in the world made by the company AUDI AG produces hydrogen in Werlte through the use of ‚spare' wind energy by means of a hydrolysis process. This reacts with the CO_2 of the biogas plant to produce methane which is stored in the gas network and can be supplied to natural gas vehicles as a regenerative fuel. An important factor here is that even for the CO_2 source, no fossil fuels are used.

The efficiency of biogas plants has been increased over the years through improved plant operation and better use of substrates. This is clearly shown in the reduced area requirement for energy crops per MW of installed electrical output. However, there is still a need to accelerate the diversification in the cultivation of energy crops. The use of slurry and manure in biogas plants in arable regions supports the efforts to reduce nutrient excesses in livestock regions and contributes to the sustainable use of phosphorus and nitrogen.

For Lower Saxony, biogas has in the last few years grown to become a significant economic factor. The strong and critically evaluated growth in the number of biogas plants in the meat-processing regions has already been slowed by a 2012 amendment to the Renewable Energy Act.

The brochure ‚Biogas in Lower Saxony' gives the latest position on biogas production and use in the state and is now available in the sixth edition.

The biogas inventory 2014 relates particularly to the course of development since 2011 and considers the plants in operation up to December 2013. In addition, plants which are under construction or awaiting planning permission which should be operating in 2014 have been listed. In the years 2012 and 2013, numerous applications to extend biogas plants and for the installation of satellite cogeneration plants were approved. Here, a differentiation has to be made between the number of listed applications and the number of new biogas plants actually established. Increases in capacity have been given for the existing old plants rather than assessed as new plants. The same counts for satellite cogeneration plants which are accounted in terms of the output performance of their central biogas plants.

The following evaluation is based on the data recording of the state ministries, state and regulating authorities, our researchers, publications of government ministries, technical authorities, technical associations, energy suppliers and also information provided by questionnaires sent to biogas plant operators.

2. Development and progress of biogas production and use

The biogas sector has undergone a considerable level of development. At present in Germany, there are about 7,850 biogas plants with an electrical output of about 3500 MW in operation. In 2013, biogas provided 18% of the electricity from renewable energy sources, amounting to about 4.7% of the countrywide electricity demand (source: BMUWi 2014).

At the end of 2013 in Lower Saxony, there were 1,546 predominantly agricultural biogas plants in operation with an installed electrical output totalling 877 $MW_{el.}$ These plants produce about 25% of the renewable electricity in Lower Saxony and make a considerable contribution to the provision of renewable energy in the heat energy market via district heating networks.

This development has been facilitated and supported by the relevant provisions of the Renewable Energy Act (REA) in force since 2000. The growth of new plants is directly related to the current REA grant conditions. The number of new plants in the period 2011 to 2013 was therefore lower than the comparable high-growth periods 2009 to 2011 (529 plants) and 2007 to 2009 (276 plants). In comparison to 2013, the number of plant extensions was clearly higher in 2012. This can be explained by the fact that the more favourable conditions of the REA 2009 encouraged many investors to operate new plants.

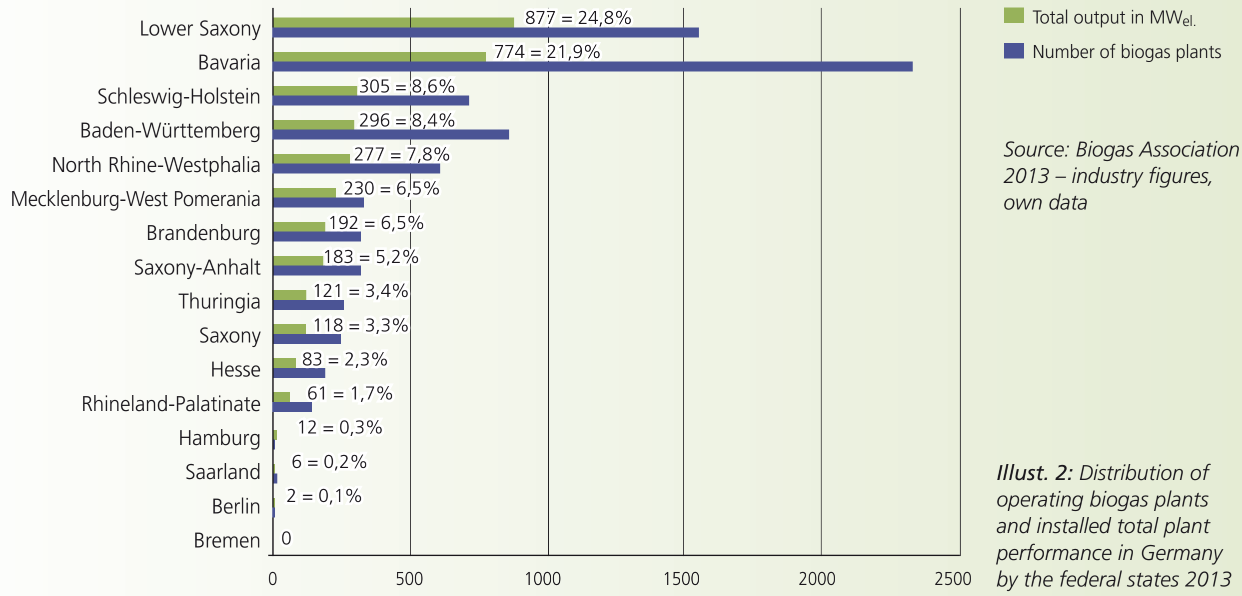
2.1 Development and number of biogas plants

Illust. 1: Number and installed capacity of the biogas plants in Lower Saxony, 12/2013
Source: Niedersächsisches Ministerium für Ernährung, Landwirtschaft und Verbraucherschutz; Niedersächsisches Ministerium für Umwelt, Energie und Klimaschutz; 3N Kompetenzzentrum Niedersachsen Netzwerk Nachwachsende Rohstoffe e.V.

In Lower Saxony, there are 1,546 plants in operation with an installed electrical total output of 8 $MW_{el.}$ Compared to the biogas inventory of 2011, the number of plants has increased by a total of 141, that is, by 10%. The installed electrical output of biogas plants increased in the comparable period by 18%.

In 2014, a very small growth in the number of biogas plants is expected. The installed electrical output is provisionally expected to rise to about 885 $MW_{el.}$ The future construction of new plants will consist mainly of small slurry plants up to 75 $kW_{el.}$ or extensions of older installations in order to adapt more efficiently to a flexible electricity production. At present, it is not apparent whether the plants currently in the planning stage will start operation in the coming years.

The basis of the output figures given in this study are taken from the approved electrical outputs from the district administrations and the factory inspectorates. However, these approvals are not always fully exploited in all plants. For the actual electrical output which is achieved, a level of about 90% of the approved outputs can be assumed.



Source: Biogas Association 2013 – industry figures, own data

***Illust. 2:** Distribution of operating biogas plants and installed total plant performance in Germany by the federal states 2013*

In a comparison of other federal states, Lower Saxony and Bavaria are in the leading positions. In consideration of the plant output across Germany (3537 $MW_{el.}$), the share for Lower Saxony is practically unchanged at 24.8%. With respect to the number of plants, Lower Saxony is in second position with 19.6%. The average installed output for biogas plants in Lower Saxony is around 567 $kW_{el.}$ compared to a national average of 449 $kW_{el.}$

2.2 Increase in plants using renewables and co-fermentation

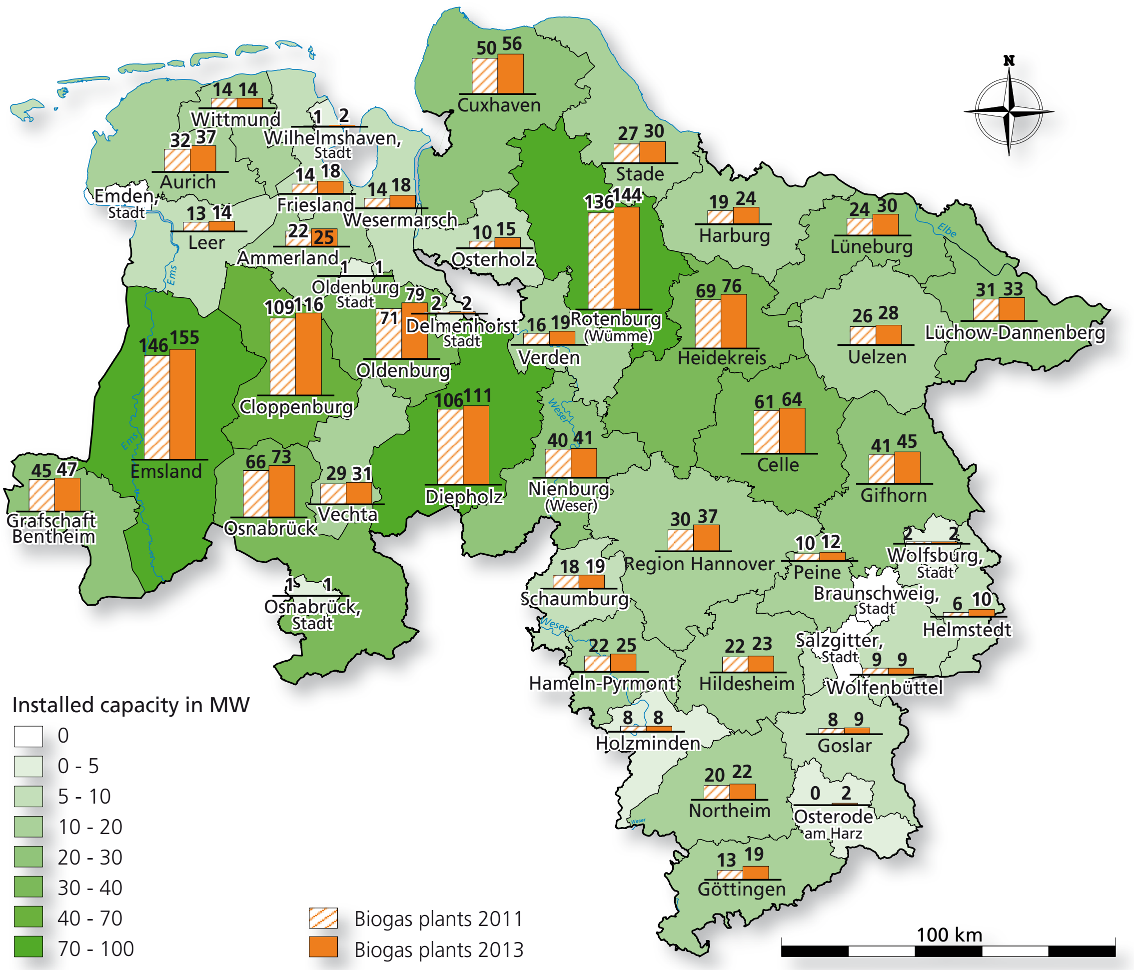
Of the total of 1,546 biogas plants, 1483 of these (96%) were operated in 2013 as renewable resources plants. These plants operate with energy crops, fodder residues and farm fertilizer (slurry and manure) and have a total electrical output of about 814 $MW_{el.}$ The new construction of plants in 2012 and 2013 was at a low level and clearly below the level of previous years.

The widely varying differences in the distribution of plants using renewable resources is reflected in the area distribution of biogas production and in the performance figures for ‚installed output by area'.

The decrease in the number of co-fermentation plants has continued through the comparable time period.

A total of 63 plants, 5 fewer than in 2011, operated in 2013 using co-fermentation materials such as fats, flotation tailings and organic wastes. However, these plants have a slightly increased total electrical output of 63.8 $MW_{el.}$ (2011: 58 $MW_{el.}$). Co-fermentation plants too have an ‚area requirement' for the spreading of nutrients/fermentation residues of about 400 – 500 ha per $MW_{el.}$ according to the material used.

2.3 Regional distribution of biogas plants

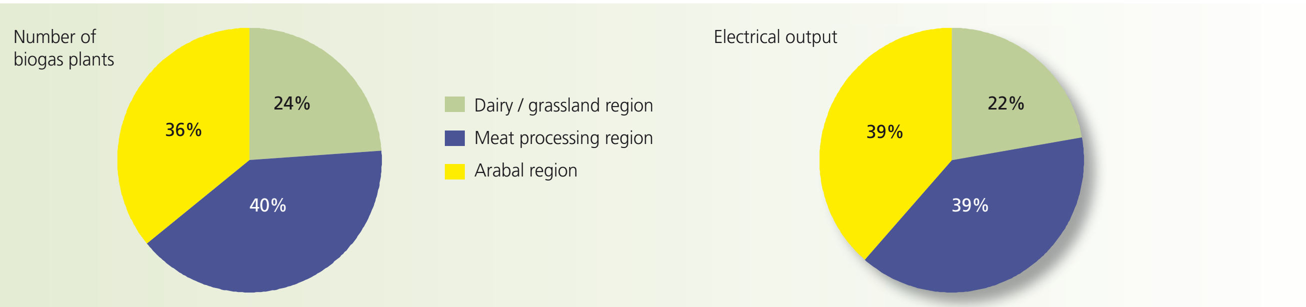


Illust. 3: Number and installed capacity of biogas plants in Lower Saxony 2011 and 2013

There are clear regional differences within Lower Saxony. 40% of the plants in the state are operated in the meat processing areas. In contrast to the inventory for 2011, these regions show a slightly lower installed output of 340 $MW_{el.}$ compared to the arable regions with an output of 343 $MW_{el.}$ Currently, about 36% of the biogas plants are to be found in the arable regions of Lower Saxony. On productive arable lands, the high profit yield in cereal production has meant that the uptake of biogas production has been more cautious, although differences can be seen in the various district administrations.

A total of 373 biogas plants (2011: 335), that is, 24% of the number of plants in Lower Saxony, are located in districts with a high area of grassland. Here, as well as the application of slurry, the farmers exploit synergies through the utilisation of grassland growth and the resulting fodder residues.

In Lower Saxony, the mixed farming region Rotenburg-Bremervörde and the livestock region have developed with the districts of Emsland, Cloppenburg and Diepholz into regional centres. The highest ‚net growth in plants' is also to be found in these regions.

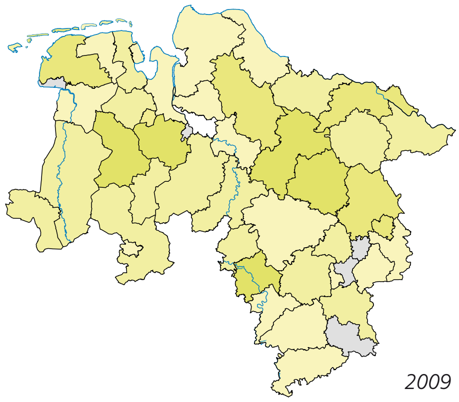


Illust. 4: Distribution of biogas plants by region in Lower Saxony, 12/2013

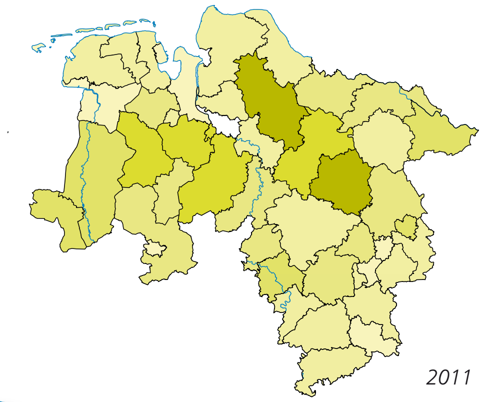
2.4 Installed capacity by area

The most important relationship between land use and the number of biogas plants is represented by the installed electrical output per hectare of agricultural land. With these operating figures, the regions can be exactly compared. For the average across the state in 2013, there was 0.31 $kW_{el.}$ of output per hectare of agricultural land.

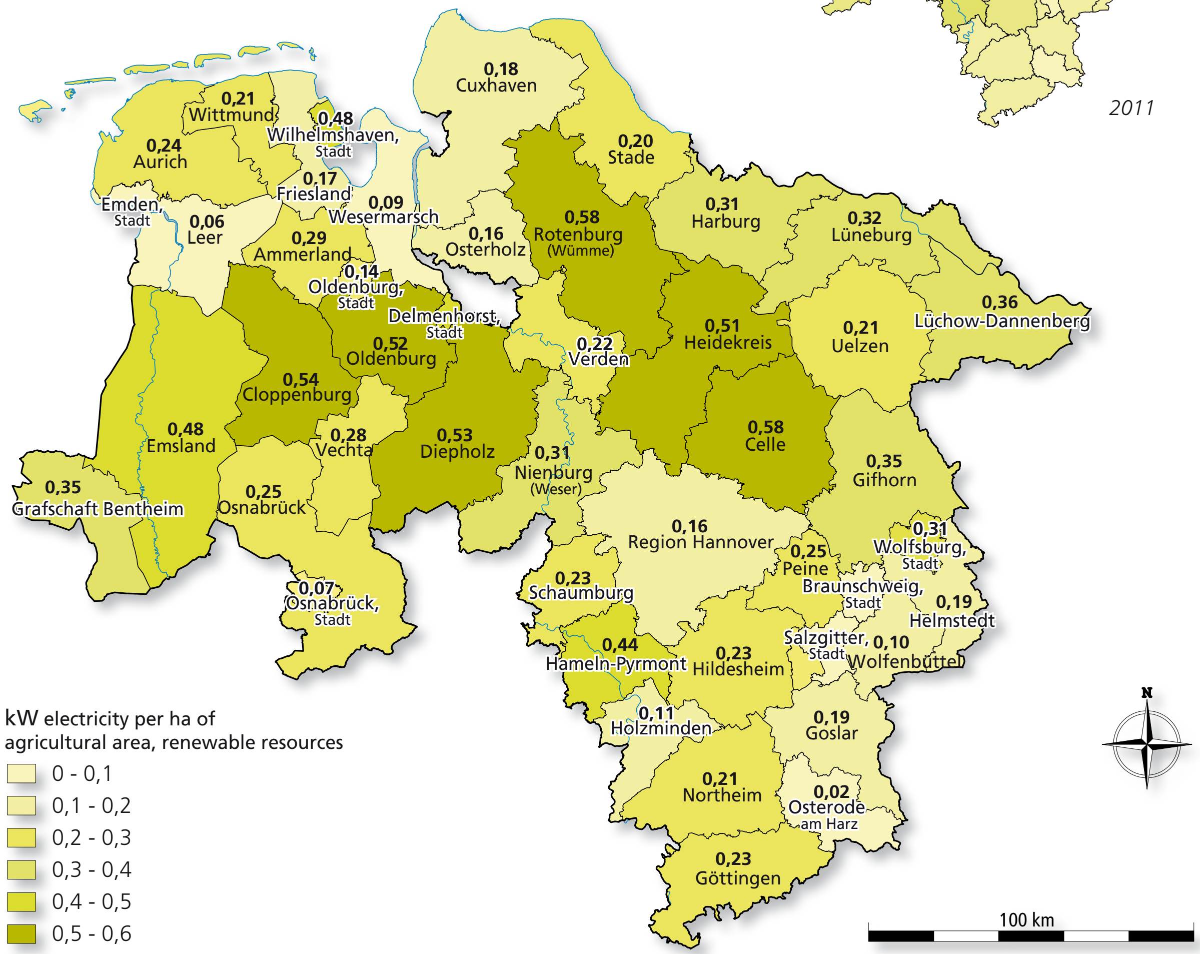
A comparison of the installed output per area in the periods 2009, 2011 and 2013 show the course of development in the regions.



2009



2011



Illust. 5: Biomass biogas plants installed electrical power in kW/ha utilised agricultural area in Lower Saxony 2009-2013

2.5 Output classes

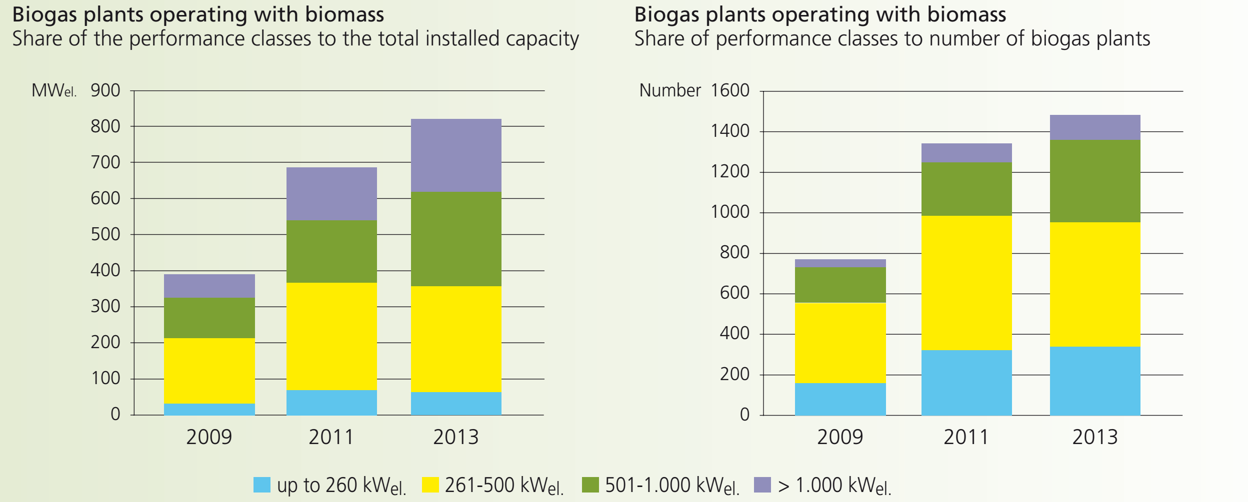
If one compares the output classes, clear differences in the number of plants can be seen between renewable resources and co-fermentation plants. As in the biogas inventory for 2011, the plants are assigned to four classes.

The average plant output for all operating biogas plants in 2011 was at 529 $kW_{el.}$ and this increased to 567 $kW_{el.}$ in 2013. The average output in Lower Saxony therefore remains clearly over the national average of 449 $kW_{el.}$ (source: Biogas Association and own data).

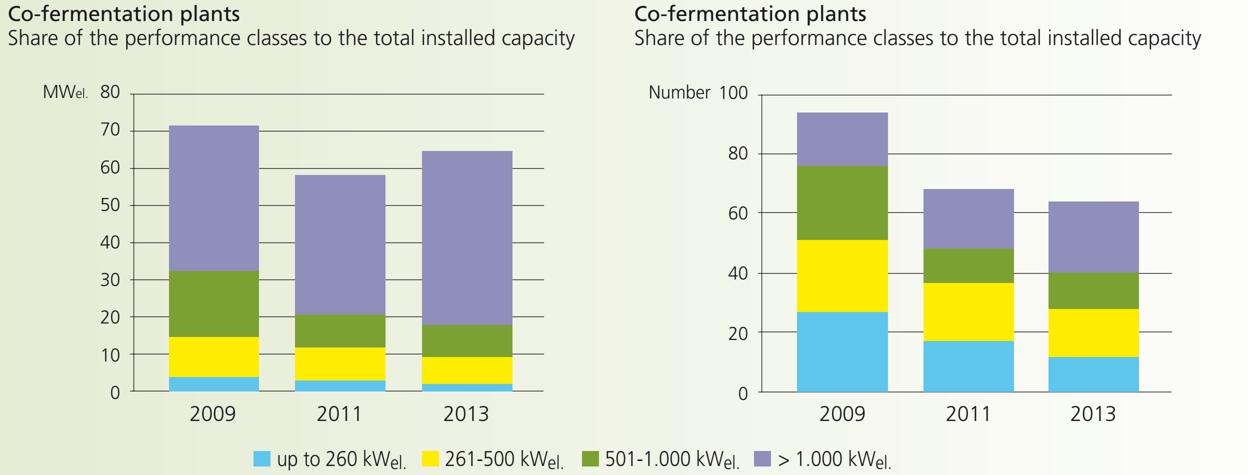
42% of all the renewable resources plants in Lower Saxony produce a total of $MW_{el.}$ in the output class 260 – 500 $kW_{el.}$, having over 35% of the installed electrical output for biogas plants.

In Lower Saxony, almost one renewable resources plant in four is smaller than 260 $kW_{el.}$ There are 393 plants in the output class 500 $kW_{el.}$ to 1000 $kW_{el.}$ This output class produces almost over a third of the installed output with 262 $Mw_{el.}$ Only 9% of the renewable resources plants are in the output class over 1000 $kW_{el.}$

In the case of co-fermentation plants, the output class above 1000 $kW_{el.}$ dominates. In the output class from 500 $kW_{el.}$ to 1000 $kW_{el.}$ the number of plants has remained constant, though the output has reduced by 0.4 $MW_{el.}$ The share in the output class 260 $kW_{el.}$ to 500 $kW_{el.}$ has reduced to 5%. In the output class up to 260 $kW_{el.}$ the number of plants here experienced the greatest decrease. There is a clear trend towards plants with a higher installed electrical output.



Illust. 6: Distribution of performance classes (in $kW_{el.}$), the biomass biogas plants, Stand 12/2013



Illust. 7: Distribution of performance classes (in $kW_{el.}$) of Co-fermentation plants

2.6 Heat energy use of biogas plants

The combined production of electricity and heat in cogeneration power stations (CHP) at or near biogas-producing plants represents the most frequent type of biogas use. As well as the selection of location, the proximity to heat energy consumers is growing in importance. In addition to the establishment of heat networks directly connected to customers, frequently external combined plants have been installed close to the customers. These satellite CHPs are supplied directly via biogas pipelines. In this way, heat loss is avoided which would otherwise arise from the operation of heat energy pipes. Also, customers and residential areas which are located further away can be connected up. The REA supports the use of heat energy in various forms.

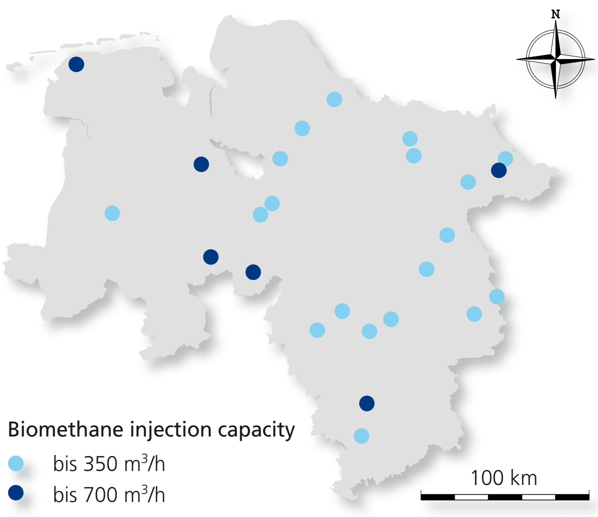
At the end of 2014 in Lower Saxony, there were about 430 satellite CHPs in operation with an output of 140 $MW_{el.}$ This amounts to a 16% share of the total output for satellite CHPs. They supply many types of customers, including residential areas, community buildings, commercial enterprises, horticultural and agricultural enterprises. The distribution pipework is in most cases provided by the biogas plant operators but to an increasing extent they are operated by the consumer, such as in the case of cooperatives. According to a survey carried out by the German Centre for Biomass Research, 70% of all biogas plants in Lower Saxony supply heat energy, meaning that about 3 million MWh of heat from biogas plants is used externally. This contributes to a reduction in greenhouse gas production through the reduced use of fossil fuels and generates profit from the sale of heat energy.

2.7 Biogas feed-in

In the case of biogas plants in locations where the heat energy cannot be fully used, the processing of biogas offers new possibilities.

Where the raw biogas is processed to natural gas quality, it can be fed in to the natural gas network. In 2013, 26 plants supplied processed biogas to the network. Across the whole of Germany, the number was 154 plants. The feed-in capacity of plants in Lower Saxony amounts to a total of 9,300 cubic metres of biomethane per hour. With a constant level of feed-in over the year, it can be calculated that 1% of the natural gas demand in Lower Saxony can be met.

In the last year, the biomethane market has developed strongly. At the start of the development, the practical knowledge of market stakeholders was not great but in the meantime, a more flexible market has developed with specialist operators, from the gas business and including new participants from commerce and accounting. The amendment to the REA 2014 led to the withdrawal of the largest commercial drivers of biogas processing and feed-in. The abolition of the technology bonus meant that new projects no longer had a commercial basis. In addition, the amended version of the commissioning provision makes it impossible to convert old natural gas CHPs to operate on biogas. It is likely that biogas processing will be limited to gas from waste and residual materials with transport links.



Illust. 8: Biogas plants with Biomethane injection 12/2013

3. Developments in the use of substrates

In order to generate the installed electrical output from the 1,546 biogas plants, about 22.2 million tonnes of substrate was needed in 2013.

Of this, about 13.2 m.t. was vegetable material, delivering round 82% of the energy. As well as biomass cultivation on arable fields and grassland, vegetable waste products and fodder residues are used.

Using information obtained within the framework of the regulation on the movement and use of farm fertilisers, the Chamber of Agriculture Lower Saxony has calculated that in the financial year 2013/2014, about 7.4 million tonnes of fertiliser such as slurry, solid manure and fermentation residues was supplied to biogas plants and energetically used. This amounted to about 11% of the total output. Of the total input, about 33% is slurry and solid manure meaning that round 15% of the existing farm fertilizer potential is energetically used.

In the meantime, about 70% of all Lower Saxony biogas plants are using farm fertilizer, as confirmed by a study of the German Biomass Research Centre. There has been a clear increase in the use of slurry, manure, dry chicken manure and fermentation residues since 2005 and this is in direct relationship to the introduction of the renewable materials bonus in the REA 2004. The use of farm manure has increased in parallel to the use of energy crops. This shows the direct technical relationship between the various materials.

The use of slurry and manure in biogas plants reduces the proportion of cultivated biomass in the substrate mix and offers further synergies for the farm enterprises, such as the reduction of emissions and smell nuisance from the spreading process. There are also hygienic advantages and greater efficiency in nutrient availability as well as better transportation of the fermentation substrates. Where the latter is used in biogas plants in arable regions, this contributes to nutrient export from the meat processing region and to a sustainable nutrient utilisation of phosphorus and nitrogen.

In the financial year 2013/2014, about 1.2 million tonnes of fermentation residues were used in the substrate mix in biogas plants. A further 1.6 million tonnes of organic bio-waste and animal by-products (without farm fertilizer) were used in co-fermentation biogas plants.

Thus, in 2013 about 40% of the input substrates in Lower Saxony biogas plants were by-products and waste materials.

Tab. 1: Input materials in Lower Saxony biogas plants, Source: Lower Saxony Ministry for Food, Agriculture and Consumer Protection 2014; Nutrients Report – Chamber of Agriculture Lower Saxony 2014

Fermentation input 2013	Mass flow quantity (Mio. t)	Share of electrical output (%)	CO_2-Reduction (Mio. t)
Agricultural wastes such as slurry and solid manure, fermentation waste	7.4	11	0.8
Energy crops such as vegetable by-products	13,2	82	2,2
Biowaste (fats, flotation tailings and organic wastes)	1,6	7	0,3
Total	22,2	100	3,3

4. Energy crop cultivation

4.1 Land requirement

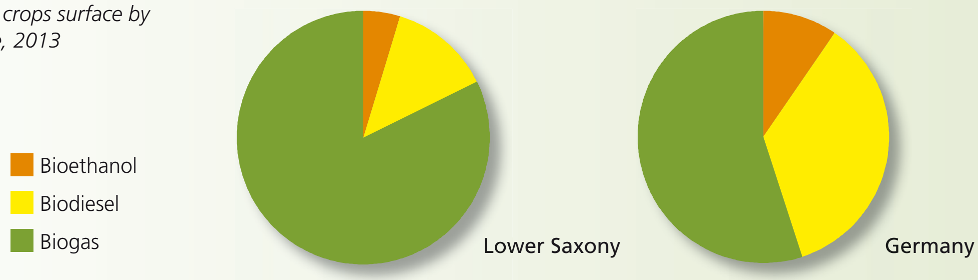
Lower Saxony has over 2.6 million ha of farm land (FL) of which about two-thirds (around 1.9 million ha) is used as arable land (AL) and about 0.7 million ha as grassland.

Across Germany in 2013, about 2.1 million ha of land was used for energy crops for electricity and heat energy generation or for the production of fuels. In Lower Saxony, energy crop cultivation has since 2011 increased by 30,000 ha to 341,000 ha (12.9% of the FL). 82% of this land is used for biogas production with a high area and energy efficiency. The average across the state for biogas production from biomass increased to 10.6% of the FL (9.3% in 2011).

The efficiency of biogas plants could be increased through improved plant operation and the optimised use of substrates, so the area requirement per generated kWh has continually reduced. Despite higher biogas capacities, area requirements for biogas production have remained virtually constant for various reasons, including the increased use of farm fertilizers in the substrate mix, the use of by-products and fodder residues, the application of dual-crop systems and the use of catch crops.

In 2013, a total of 260,000 ha of cultivation was used for biogas, of which maize accounted for 220,000 ha (85%) because of its high efficiency. Other energy plant cultivations (30,000 ha) such as whole cereal and sugar beet, grasses, cup-plant, szarvasi grass, crop combinations, sunflower, sida and catch crops have become a regular addition to the substrate mix in many farms. In particular, sugar beet has become economic and on a par with maize with regard to processing techniques. 24% of all biogas plants in Lower Saxony are located in grassland regions. About 20,000 ha of grassland, mainly late growing, are used for biogas substrate production. The use of fodder residues (maize and grass silage) offer high synergies and optimise the land use efficiency in the livestock sector.

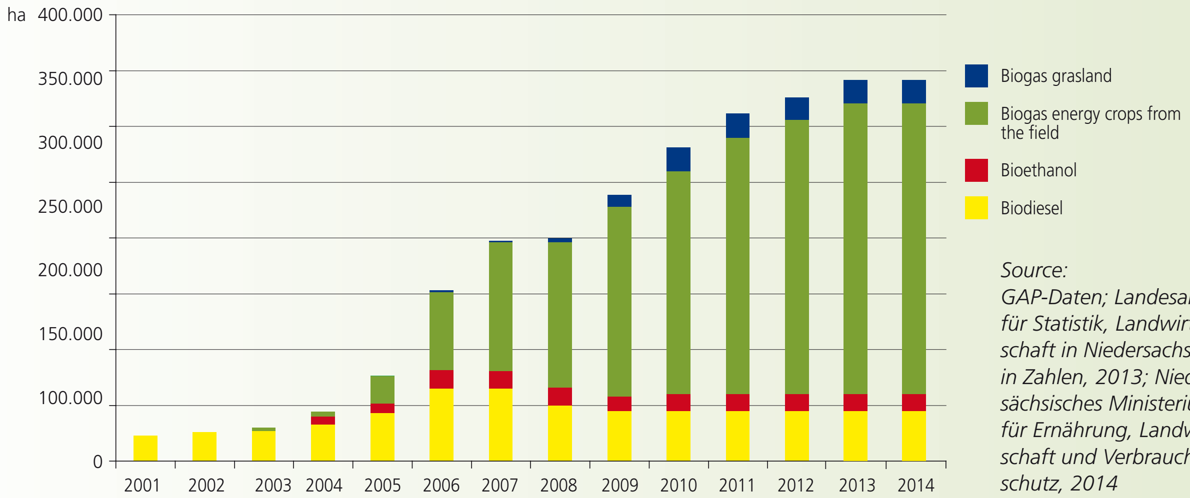
Illust. 9: Energy crops surface by the range of use, 2013



	Lower Saxony	Germany*
Area of land under cultivation in ha	2.639.468	16.700.000
Energy crops in ha	341.000	2.114.500
Share of the utilised agricultural area	12,9%	12,7%
of Biogas	10,6%	7,0%
Product line		
Bioethanol	4,4%	9,5%
Biodiesel	13,2%	35,3%
Biogas	82,1%	54,7%
Solid fuels (SRC, Miscanthus, etc)	0,3%	0,5%

Tab. 2: Energy crops surface by the range of use, 2013

*Source: GAP-Daten 2013; Niedersächsisches Ministerium für Ernährung, Landwirtschaft und Verbraucherschutz; *FNR e.V., 2013*



Source: GAP-Daten; Landesamt für Statistik, Landwirtschaft in Niedersachsen in Zahlen, 2013; Niedersächsisches Ministerium für Ernährung, Landwirtschaft und Verbraucherschutz, 2014

Illust. 10: Development of the cultivation of energy crops in Lower Saxony, Germany

4.2 Regional issues

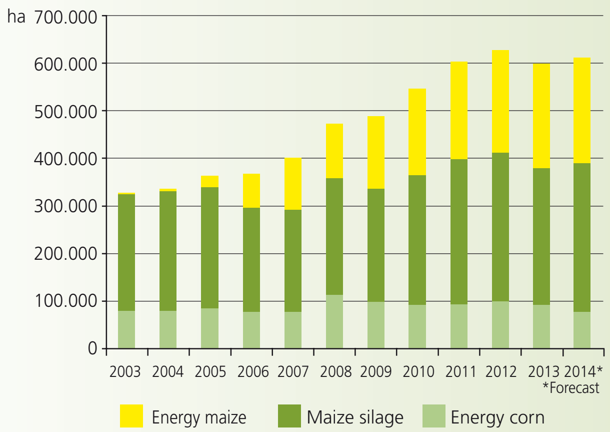
With respect to the installed biogas plant output for renewable resources installations, there are clear regional differences in Lower Saxony, as described earlier. This is directly related to regional energy crop areas. The area requirement for the supply of raw materials to a biogas plant operating with renewable resources and with an output of 500 $kW_{el.}$ varies from 150 to 230 ha. depending on the yield potential of the location, the substrate mix in use and the efficiency of the plant. The efficiency of biogas plants has steadily risen in the last few years. A large proportion of biogas plants use slurry as well as energy crops and this further reduces the land requirement.

In the case of an average land requirement of 0.34 ha per $kW_{el.}$ installed output, on average across the state, 10.6% (9.3% in 2011) of the agricultural land is required to produce substrate for biogas production. With an increase in the installed renewable resources output of 129 $MW_{el.}$ the land usage has increased only by 1.3% compared to 2011. The area requirement per $MW_{el.}$ installed output has reduced by 5%.

4.3 Energy crops in practice

In 2013, the area of maize under cultivation in Lower Saxony was 599,687 ha, about 29,000 ha below the level of 2012 and on a comparable level with 2011 (603,084 ha). Energy maize has a share amounting to 37% (2011: 34%). Because of its good yield efficiency and financial attractiveness, maize remains the leading cultivation as an animal feed and raw material for biogas production.

The use of agricultural land is regionally specific and there are clear differences with regard to the crop rotation proportion of maize, which can vary from 50% on agricultural land in livestock regions to 3% on agricultural land in southern Lower Saxony.

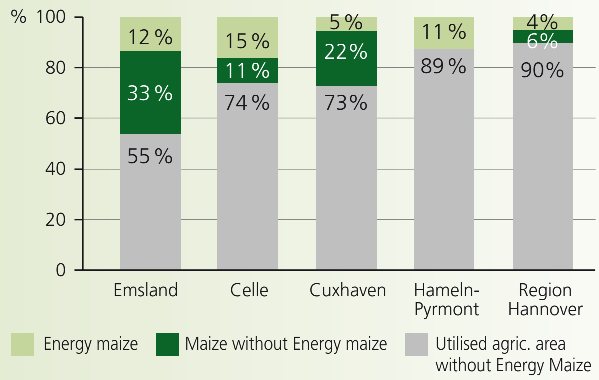


Illust. 11.: The increase in cultivated land for maize and energy maize in Lower Saxony

The proportion of energy maize was determined for the regions based on the installed electrical plant output for renewable resources biogas plants at the end of 2013. The proportion of raw materials from grasslands and the proportion of other energy crops such as maize were considered. On average, the biogas plants in Lower Saxony using renewables are able to cover their energy crop requirements up to 85 – 87% with energy maize (source: operator survey DBFZ 2012).

While maize cultivation for biogas in the meat processing regions has increased the already high level of cultivation associated with livestock farming, maize in the arable regions has extended the crop rotations.

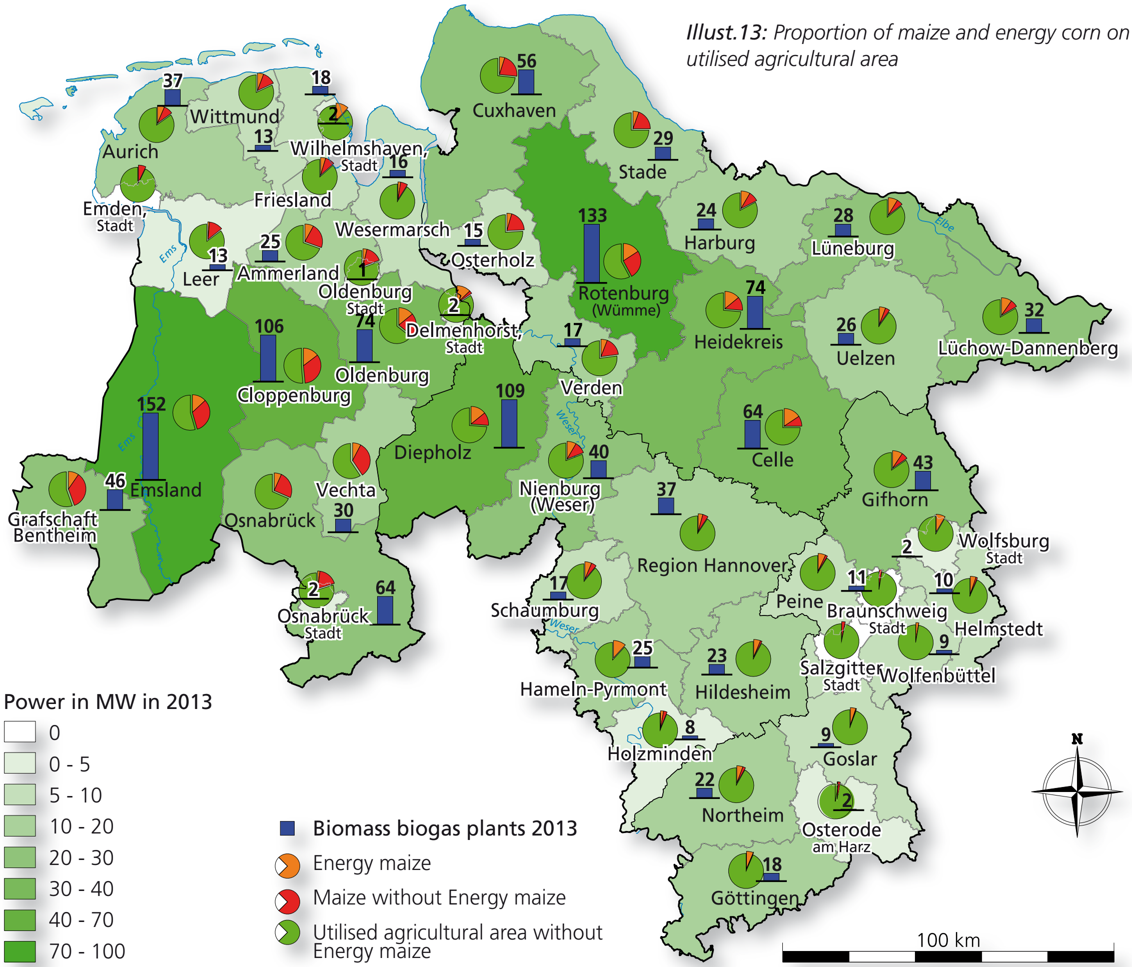
Fig. 12 gives an overview of typical district administrations in livestock regions (Emsland, Cuxhaven), a region of light arable/mixed farming (Celle) and an arable farming region (Region Hannover, Hameln-Pyrmont).



Illust. 12: Agricultural land use and energy share of corn on the example of selected regions

The integration of other cultivations in the raw materials supply concept for biogas plants is therefore all the more important. The increasing use of other energy crops such as whole crops, sugar beet, mixed cultivations, grass and wild plants has become more and more established in the last few years. Further reasons include the increase in the yield performance of these cultures, the positive effects from the fermentation biology achieved through the substrate mix and advances in harvesting and processing technology. Particularly in regions with a high level of maize cultivation, soil loosening can occur in the crop rotation. Sugar beet has excellent fermentation qualities and delivers high gas yields per hectare. In order to achieve a continuous feed, it is necessary to ensure a year-round supply and conservation of the beet. This requires technical solutions for the cleaning and storage, currently available from various machinery manufacturers. The processing chain from the field to the fermenter is well-tested and has become very effective. There are also technical and financial aspects of the various storage systems such as earth pits, high silos and mobile silos to consider. In this respect, biogas beet proved itself to be on a financial par with maize as a feed substrate in the EDR-Interreg ‚Green Gas' sub-project.The results are published on www.biogasruebe.3-n.info.

Other cultivations such as sorghum, sunflower and field grasses extend the range of energy crops. The possible yield potentials have been confirmed by positive plant breeding results and the results from countrywide and state-specific cultivation and harvesting trials.



Illust.13: Proportion of maize and energy corn on the utilised agricultural area

Substrat and variants	Cost (€/t)	DM (%)	oT (%)	Biogas (l/kg oT)	Methane content (%)	Energie (kWh/t)	Production costs (ct/kWh)
Beet pulp Earth pits	50,49	23	96	800	55,8	986	5,12
Maize silage Earth pits	61,67	32	95	650	51,6	1020	6,05
Beet pulp High silo	53,83	23	96	800	55,8	986	5,46
Maize silage High silo	58,91	32	95	650	51,6	1020	5,78

Tab. 3: Production costs of substrate variants for sugar beet in high silos or earth pits and variants for silo maize in moveable silos, from the project ‚Biogas Beet'

4.4 Biodiversity and wildlife protection

Flowering strips offer protection and cover to the 70% of wildlife which live in the field margins. Open strips in large maize fields, flowering margins along access roads and ditches and conservation strips contribute to the ecological utilisation of fields and to improving the landscape.

In 2014 in Lower Saxony, a total of 24,704 ha of strips with flowering mixes were established. In many regions, positive experience has already been gained. Also in 2014 and in the framework of agri-environmental measures, 9,900 ha of annual and 200 ha of perennial flowering land was established. Under the project ‚Energy from Wild plants' of the Lower Saxony hunting association ‚Landesjägerschaft Niedersachsen e.V. (LJN)', further results and experiences will be collected and practical concepts developed for nature conservation integrated with land use by promoting wild plant cultivations in biogas crop rotations.

4.5 Competition in land use

The production of high-quality foods will remain the central focus of agriculture in Lower Saxony. However, a coexistence of food production, bioenergy and the material use of biomass (e.g. starch for the chemical industry) is possible, despite competition over land and resources.

Market price fluctuations for agricultural raw materials and the evaluation of indirect land use changes have led to critical discussions on the use of agricultural raw materials as food or fuel. In a statement ‚Bioenergy – challenges and shared responsibility', the advisory board for renewable resources at the Lower Saxony Ministry for Food, Agriculture and Consumer Protection spoke in favour of the cultivation of energy crops, under the premise that the pre-eminence of food provision and the protection of other functions of the landscape for human benefit was to be assured, but at present this is necessary to achieve the aims of energy transition. Respecting the cultivation of energy crops, it was necessary that issues of direct and indirect land use changes should be considered. In addition, the possibilities for use of bioenergy should be dependent on the eco-balance and sustainability assessments so that a high degree of sustainable development can be achieved.

The development of leasehold costs and selling prices for agricultural land shows clear regional differences in Lower Saxony and is subject to various influences. In regions with a relatively high number of biogas plants, a high demand for land can affect the lease price. The areas affected include the livestock regions in which the lease prices are already above average. In other regions, the leasing price levels have remained low despite a relatively high share of energy crops on the fields.

5. Biogas an integrated service provider

5.1 »Lower Saxony Farm«: Sustainable biomass use in biogas plants based on farm fertilizer potential in Lower Saxony

In Lower Saxony, various issues concerning agricultural production can be differentiated: efficient land cultivation, intensive dairy farming and/or highly concentrated meat processing centres characterise many agricultural enterprises. Added to this across the state in the last few years is biogas production. In the meantime, incidental nutrient excesses in the form of farm fertilizers require a state-wide nutrient balance through transfer to regions where there is a need. The relevant phosphate balances in the meat processing regions show clear excesses of up to 54 kg P_2O_5/ha agricultural land. In the arable regions on the other hand, there are negative balances indicating a need for mineral fertilizer application. From this it can be seen that there is a large potential for a nutrient exchange across Lower Saxony.

The objective of the project ‚Lower Saxony Farm' is to demonstrate the potential and the financial and ecological effects of a more comprehensive use of available farm fertilizer in biogas plants within the state's arable farming regions.

The provisional results show that on the one hand, the 149 biogas plants in arable regions which only use renewable raw materials can be supplied with sufficient farm fertilizer, and on the other hand, the 337 biogas plants already using farm fertilizer in this region could increase their use, without there being a serious supply bottleneck.

With the use of farm fertilizer, there are broad operational effects on the individual biogas plants. From the financial perspective, the movement and utilisation of single fertilizer loads means an increase in the transport value and energy density of the transported product. From the ecological viewpoint, the CO_2 equivalent shows that the transport of farm fertilizer to biogas plants in arable regions is worthwhile. Positive CO_2 balances are achieved to a considerable extent from using farm fertilizer in biogas plants because of reduced storage losses, the saving of alternative substrates and a reduction in the need for mineral fertilizers.

5.2 The role of biogas in electricity production tailored to demand

In contrast to solar and wind power plants, bioenergy plants are able to be oriented to fluctuating demand for electricity. This quality can play an important role in the mid-term transition of energy supply to 100% renewable energy.

The most widely used form of direct electricity marketing is the provision of electricity balancing. This involves an integrated service provision from the four supply network operators in Germany in order to balance temporary differences between electricity demand and supply. Through this service, the maintenance of network frequency is ensured and with that, the reliable operation of the Germany electricity network is guaranteed. If the electricity consumption exceeds the existing availability in the network, so-called positive electricity balancing is applied. If the supply is greater than demand, negative electricity balancing is applied. Biogas plant operators can contribute to this by, for example, temporarily closing down the CHP. Depending on which model is being used, this service is in operation either a few times each day or a few times each month, from 2 to 15 minutes.

The generation of electricity over a longer time period tailored to demand is rewarded with a flexibility premium, of which the level is oriented to the availability of the variable feed-in performance. If a feed-in supplier departs from the base load by moving his electricity generation from hours with low market value to hours with high returns, he can increase his income correspondingly. Biogas plants have the possibility of increasing their electricity generation to a maximum of five times the hitherto output. These provisions can also be used by plants which started up during earlier versions of the REA. The returns are composed of the flexibility premium and the supply income but are subject to market fluctuation as well as electricity balancing availability.

At the end of 2013, about 4,000 biogas plants across the country with a total output of 1,900 $MW_{el.}$ took part in the direct marketing of electricity (market premium), corresponding to 55% of the installed output. The use of heat energy does not conflict with electricity generation tailored to demand. 87% of the participating biogas plants continue to supply customers with heat energy. The flexibility premium is claimed to a lower extent. At the end of 2013, 295 plants with a total output of 150 $MW_{el.}$ were participating. The most important conditions for direct electricity marketing relate to a sufficient storage capacity for raw gas and heat as well as sufficient take-up capacity by the local electricity network to increase feed-in levels. In the case of an exceedance of the storage capacity or a high heat demand, excess electricity can be converted to heat in a power to heat process.

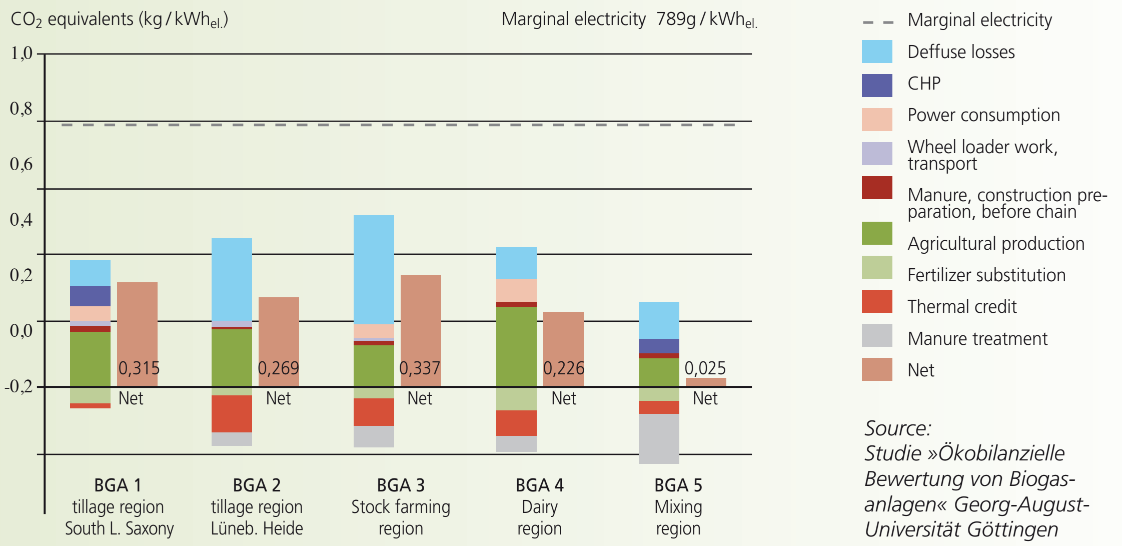
The transition to the flexible operation of biogas plants has led to an extension of CHPs without increasing the generation of electricity. It is accepted that 30% of the output that was installed in 2012 and 2013 can be assigned to this move to flexibility. For the yearly average, therefore, only 70% of the newly installed output is fed in. The installed output in Lower Saxony of 877 $MW_{el.}$ therefore reduces by 30% to 844 $MW_{el.}$ for 2012 and 2013.

5.3 Climate protection through biogas

The commission on climate protection of the Lower Saxony state government established in their recommendations on the climate protection strategy that the substitution of fossil fuels with bioenergy from agriculture would not per se make a contribution to climate protection because in this case too, greenhouse gas emissions arise in the course of the production of renewable energies and valuable resources (such as arable land, nutrients, water) are needed. For an evaluation of the climate protection performance of bioenergies, it is necessary to consider both the net CO_2 equivalent avoidance and the resource efficiency of the emission reduction. The potential climate protection performance of bioenergy is strongly affected by the type of utilisation (WBA, 2007).

In Lower Saxony, biogas plants save about 3.3 million tonnes of harmful CO_2 each year (0.64 kg CO_2,eq./ $kWh_{el.}$), according to calculations of the HAWK in Göttingen, and in this way make an important contribution to climate protection. The Georg-August University in Göttingen carried out an eco-balance assessment of the potential environmental effects of five biogas plants in typical Lower Saxony regions. In the impacts category ‚climate change', according to the study, 452 to 764 g CO_2 equivalent was saved per kWh of feed-in electricity (see fig. 16). One factor relevant to the results is the regionally specific substrate availability, whereby a high input of farm fertilizer has a positive effect on the assessment. Other influencing factors include the heat utilisation concept in play and the gas density of the fermentation tank and the fermentation residue storage. It is not in every impact category that biogas plants perform better than comparable fossil fuel systems. Emissions of nitrogen compounds (e.g. ammonia) which are released during fertilizer application lead to negative results in the impacts categories ‚acidification' and ‚eutrophication'. For this reason, it is necessary to apply low-emission techniques and prompt working in, particularly when applying organic fertilizers.

Illust. 14: Results of ‚Climate change' impact category



Source: Studie »Ökobilanzielle Bewertung von Biogasanlagen« Georg-August-Universität Göttingen

5.4 Value creation in rural areas

For the agrarian state of Lower Saxony with its highly productive agriculture, biogas technology is of particular significance. If one observes all the cash flows arising from the construction and operation of a biogas plant, it can be seen that the major part of this remains in the rural area. This was investigated as part of the study ‚Socio-economic evaluation of biogas production in Lower Saxony' carried out by the Georg-August University in Göttingen, which considered various regions in the state using a representative sample. The biogas plants in the study had an average size of 740 kWel. and the majority were directly connected to agricultural enterprises. The most import study results are given in table 4 below.

The developments in the field of bioenergy, particularly with regard to biogas production, are of considerable importance to the structural and financial development of agriculture in Lower Saxony as well as to value creation and spending power in rural areas.

Tab. 4: Regional financial effects of investments and operation of biogas plants

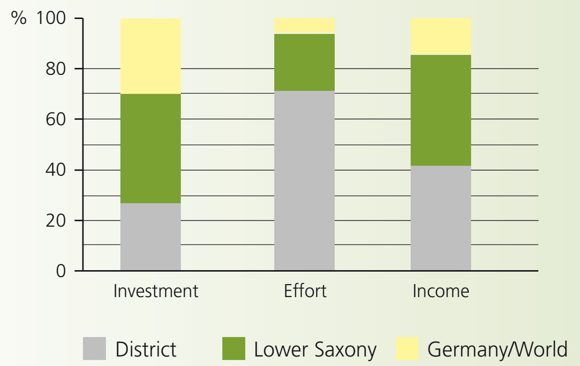
Reference units Area	Amount per 1 MW installed el. output in LS. in €	Total amounts in Lower Saxony to 2012 or per year* (783 MW) in thousand €	Of which in/out Lower Saxony in thousand €	Of which in/out rest of Germany and world in thousand €
Investments	3,990,473	3,124,542	2,186,040	938,502
Annual expenditure	1,382,404	1,082,422	1,023,864	58,559
Annual yield	1,833,901	1,435,945	1,249,041	186,904
Job effects	2,49 full-time	app. 1.944 full-time in Lower Saxony	1 full-time in a biogas plant 1.25 full-time across supply chain in Lower Saxony.**	

** Valid for the categories annual expenditure / yield; ** Calculated using the Leontief multiplier effect, Source: Guenther-Lüebbers, Plaas, Theuvsen: Bioenergieland-Niedersachsen, Socio-economic evaluation of biogas production, April 2014*

It was only with the possibility of an entry into biogas production that future prospects for many agricultural enterprises were opened up. In the course of the extension of biogas production, considerable investment resources have flowed into rural areas, creating jobs and revenues. These positive effects of biogas production have until now, however, been poorly quantified; they therefore carry less weight in public discussions than other previously quantified and rather problematical effects of development such as the influences on leasing costs.

The investments which are associated with the construction of a plant have their effects mainly in the regional environment.

On average, about 27% of the investment sum goes to the district administrations in which the plants are constructed; a further 43% remains in Lower Saxony and only 30% of the investment sum goes to the rest of the Federal Republic of Germany or abroad (fig. 17). The high level of the investment sum, amounting to 70%, which goes to enterprises in Lower Saxony in the course of plant construction can be put down to the fact that many plant components can be supplied from stall construction technology and these enterprises are traditionally well-represented in the state.



Illust. 15: Regional economic effects through investment and operation of biogas plants

The economic effects arising from the ongoing operation and the yields of biogas production are on a recurring annual basis, in contrast to the usually one-off investment. Over 50% of the yearly expenditure of an average biogas plant is for the purchase of the substrate, including the costs of recovery and spreading of fermentation residues. Other costs arise through repair work (7.35%), rising with the age of the plant, and the necessary fuels (about 9%). 72% of the total expenditure remains within the district in which the plant has been constructed. Biogas plants therefore contribute considerably to value creation in the area and also to the development of the regional economy. The beneficiaries of the cash flow are mainly other agricultural enterprises but include retailers and craft businesses.

The financial yields from the end products electricity and water flow directly to the rural areas. Numerous communities in Lower Saxony have used this opportunity and set themselves up as a bioenergy village or as a 100% renewable energy region. The yields arise for the most part from the energy suppliers because of the possibility of feeding in electricity from renewable sources into the existing network. About 42% of the yields come from the sale of power in the administrative district in which the biogas plant is located and a further 44% comes from the rest of Lower Saxony. The yields from the sale of heat energy result from the sale to private households, commercial enterprises and public buildings located in proximity to the biogas plant.

6. Outlook

In 2013, the bioenergy industry employed about 126,000 people across the country, with about 55,000 of these in the biogas sector (source: BMWi 2014). The business opportunities for the biogas industry in Germany have, however, clearly deteriorated since the REA 2012 and there has been a restriction of further expansion.

Biogas can make a significant contribution to the sustainable management of nutrient excesses in livestock regions and nutrient requirements in arable regions, particularly with respect to phosphorus, a commodity in short supply worldwide. Through the use of fermentation residues, solid manure and separated slurry fractions in biogas plants in arable regions, vegetable biomass is replaced and energy is obtained. At the same time, there is a reduction in emissions and nutrient losses, of significance for climate and soil protection. In the meantime, various processes for the treatment of fermentation residues and slurry are being tested that should prove themselves under practical conditions.

Process optimisation systems offer further opportunities for existing plants. New techniques based on the biology of the ruminant stomach are being developed, opening the possibility of using waste materials with high cellulose contents such as straw and landscape management materials more efficiently in producing biogas. Biorefineries and cascade use concepts connect the production of specific substances such as proteins and base chemicals with the subsequent energetic use of residual materials in biogas plants.

The power to gas technologies and procedures used for methane production connect the electricity and gas supply networks and build a bridge between the fluctuating wind energy and a supply of methane tailored to demand. It is necessary here to further develop the research projects in this field and to open the market framework to these innovative procedures.

The currently agreed European climate protection and energy objectives provide for binding greenhouse gas reductions of at least 40% (of the 1990 levels), a reduction in energy consumption of 27% and the extension of renewable energies to a share of at least 27% of the energy usage.

In a future energy system oriented much more towards renewable energy supplies, biogas can become an integrated service provider and make a decisive contribution in the process of energy transition, on the one hand through the production of electricity tailored to demand and on the other, through the option of biomethane as an energy store and through feed-in to the existing gas supply network.

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