# IRENES case study factsheet: Lower Saxony, Germany

## 1. Lower Saxony - a short profile

Lower Saxony is the second largest of the 16 federal states of Germany, covering an area of approximately 47,614 km². Around 8 million people live in 971 towns and municipalities. In addition to the state capital Hanover, there are seven other major cities (see Figure 1; Nds. Staatskanzlei, 2020a).


*Figure 1: General map of Lower Saxony (Nds. Staatskanzlei, 2020b)*

Lower Saxony has a natural boundary in the north by the North Sea and the river Elbe. In the southeast, the state border runs through the low mountain range of the Harz Mountains. While poorer sandy soils predominate in the north-east, high-yield soils with high natural fertility can be found in the middle east and south-east.

The importance of Lower Saxony, and in particular the Hannover region, as a crossroads of the most important European north-south and east-west transport axes continues to grow. Lower Saxony's economy is characterised by the automobile industry and its suppliers. Agriculture and the food processing industry have a comparably strong position (Nds. Staatskanzlei, 2020a).

Agriculture in Lower Saxony cultivates a total of 2.6 million ha, which corresponds to around 60% of the total area. Farm sizes range from a few hectares in specialised horticultural farms to large arable farms with several hundred hectares. The average size of farms in Lower Saxony is 83 hectares. About 3/4 of all farms keep animals, mainly dairy cattle and pigs (LSN, 2016; ML Nds., 2020).

In Lower Saxony, around 5.1 % of the area is protected as nature reserves, and a further 6.8 % of the area belongs to two national parks (NLWKN, 2020).

# 2. Policy Context

## 2.1. The national level

### 2.1.1. The Climate Protection Plan 2050

In its Climate Protection Plan 2050, the German government has agreed on sectoral targets that distribute the total reduction of greenhouse gases by at least 55 percent required by 2030 among the emission sectors energy, buildings, transport, industry, agriculture and waste management (other). These targets, together with the resulting annual greenhouse gas budgets of the sectors, are laid down by law. Their achievement of targets is to be monitored by an external council of experts and precisely determined annually (BMU, 2016).

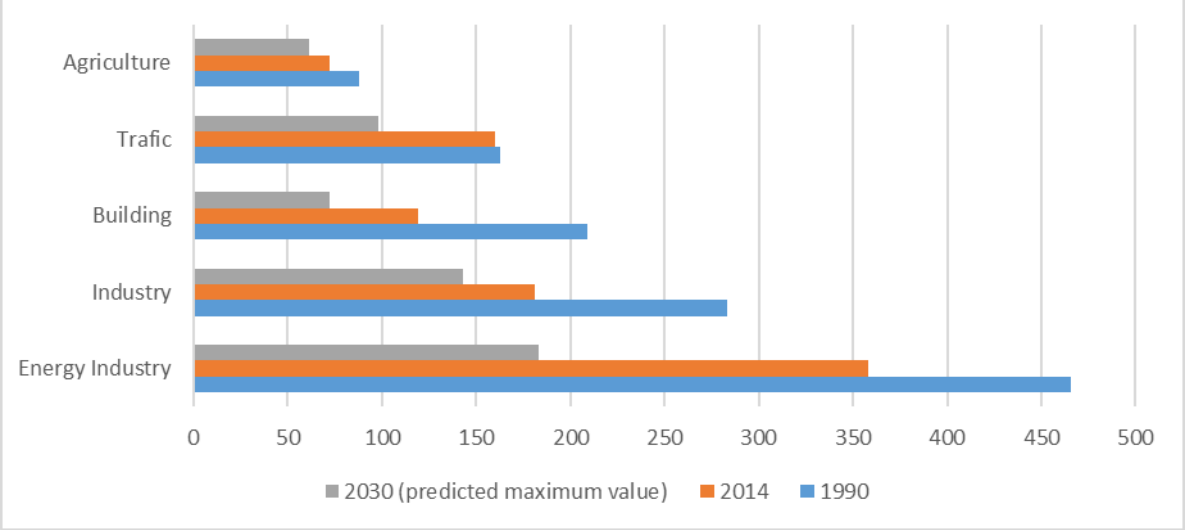


*Figure 2: The sectoral targets for 2030 in the German Climate Change Plan 2050 (in million tonnes $CO_2$ equivalents)*

The greatest savings are to be made in the energy supply sector (see Figure 2). This is to be achieved in particular through the expansion of renewable energies.

### 2.1.2. Climate Protection Programme 2030

The Climate Protection Plan sets out the overall objectives of climate protection policy in Germany. Since September 2019, these have been concretised by the Climate Protection Programme 2030 and implemented through legislation and funding programmes (BMU 2019).
In this context, the Federal Government will retain its Cabinet Committee ("Climate Cabinet") and assign it the task of reviewing annually the effectiveness, efficiency and targeting of the measures introduced. If a sector fails to meet its prescribed targets, the responsible minister will be required to undertake follow-up action.

The following measures have been adopted for the energy sector:

- Gradual reduction of coal-fired power generation to a total of 17 GW in 2030 and termination of coal-fired power generation in 2038
- Expansion of renewables to 65 % share of gross electricity consumption by 2030
- Electrification of sectors such as heat and transport – increasing electricity demand
- Conversion of the heating networks to renewable energies and unavoidable waste heat
- Energy Efficiency Strategy 2050 (EffSTRA)
- EU Cooperation
- Investment programme "Energy efficiency and process heat from renewable energies in the economy"

The federal states are in regular intensive exchange with the federal government on, for example, the development and implementation of climate protection goals, programmes and concepts, monitoring, participation processes, climate protection laws and support programmes. To this end, the Standing Committee on Climate Protection was set up in 2017 as part of the federal/state working group "Climate, Energy, Mobility - Sustainability" (KliNa) (BMU, 2019).

### 2.1.3. Renewable Energy Sources Act

The targets for the expansion of renewable energies from the Federal Government's climate protection plan are laid down for the federal level in the "German Renewable Energy Sources Act" (EEG, 2017). Since 2000, it regulates the priority feed-in of electricity from renewable sources into the power grid and guarantees fixed feed-in tariffs for its producers.

In the first period of the law, politically fixed prices were used to promote the development of technology. The EEG 2017 introduced competitive bidding. The amount of the required feed-in tariff for electricity from renewable energies is thus determined via auctions.

The aim of the Act is to increase the share of electricity generated from renewable energies in gross electricity consumption to

1. 40 to 45 percent by 2025,
2. 55 to 60 percent by 2035, and
3. at least 80 percent by 2050.

This expansion is to take place continuously, cost-efficiently and in a grid-compatible manner.

### 2.1.4. Renewable Energies Heat Act

The "Renewable Energies Heat Act" became law on 1 January 2009 (EEWärmeG, 2008). It stipulates that owners of future buildings must cover part of their heating requirements from renewable energies. Accompanying the Act, the Federal Government has also further increased its extensive promotion programme, the so-called "Market Incentive Programme for Renewable Energies". It supports building owners in getting started with heat from renewable energies.

## 2.2. Policy Instruments in Lower Saxony

### 2.2.1. Guidelines for a sustainable energy and climate protection policy for Lower Saxony

In August 2016, the former state government adopted the "Guidelines for a sustainable energy and climate protection policy for Lower Saxony" (MU Nds., 2017b). It contains the following essential points:

- Reduction of greenhouse gas emissions by the year 2050 by 80 to 95 percent compared to the base year 1990.
- Almost complete conversion of the energy supply to renewable energies by 2050 at the latest (ML Nds. 2017)
- Exploiting as fully as possible the potential for energy efficiency and energy saving.

Lower Saxony will push ahead with the expansion of the grid at the various voltage levels in order to make the grid fit for the requirements of volatile power generation. Energy storage systems in particular will play a key role in the future power supply system due to their potential for network and system services and their scalability.

With the possibilities of regional planning, Lower Saxony will contribute its share to the expansion of renewable energies. Legal support such as the wind energy decree will help to realise a sustainable expansion of renewable energies.

### 2.2.2. Lower Saxony Climate Law

In addition, the draft of a "Law to support climate protection and adaptation to the consequences of climate change (Lower Saxony Climate Law)" is currently being discussed in the state parliament (*Nds. KlimaG*, 2020). This law is intended to set targets for the reduction of greenhouse gas emissions, for the protection and establishment of carbon reservoirs and for adaptation to the consequences of climate change and to create the necessary implementation instruments.

The Act is intended to oblige the state government to draw up and update an energy and climate protection programme, to monitor it regularly and to inform the public. In addition, the state government supports the municipalities in their measures to reduce greenhouse gases.

Since about 80 percent of Lower Saxony's greenhouse gas emissions are energy-related, the use of energy in particular is to be changed. This means saving energy, increasing energy efficiency and expanding renewable energies.

## 2.3. Lower Saxony Spatial Planning Programme

The hierarchical planning system in Germany does not provide for top-down planning of energy plants at national level. All necessary actions to increase the share of renewable energies are delegated to the lower planning levels.

The Federal Spatial Planning Act (Raumordnungsgesetz (ROG)) stipulates that a "cost-effective, safe and environmentally friendly energy supply" must be achieved (*ROG.* ROG, 2017). The aim is to create "spatial conditions for the expansion of renewable energies, for the economical use of energy and for the preservation and development of natural sinks for climate-damaging substances and for the storage of these substances" (ROG §2 para. 2).

To concretize these principles, the Standing Conference of Ministers responsible for Spatial Planning adopted "Concepts and Strategies for Spatial Development in Germany", which in addition to the legal requirements also refer to the objectives of the climate protection plan (BMVI, 2016).

In the spatial planning programmes of the federal states, energy yield targets are formulated in the context of energy supply, or minimum area shares for renewable energy generation are defined.

The state Lower Saxony stipulates to the lower level, regional planning, that the share of local energy sources and renewable energies, in particular wind energy, solar energy, hydropower, geothermal energy, biomass and biogas, is to be expanded in a spatially compatible manner. Regional planning should draw up regional energy concepts with the municipalities and integrate them into the regional spatial planning programmes (ML Nds., 2017).

The Lower Saxony spatial planning programme sets the framework for this, e.g. by not using forests for the generation of wind energy because of their diverse functions, especially their importance for climate and ecology.

Transmission lines as well as locations and areas required for securing and developing regional energy production and distribution should be defined in the regional spatial planning programmes. In doing so, the interests of human health, settlement development and the landscape should be taken into account by ensuring sufficient distances.

For the use by photovoltaic systems, already sealed areas should be used. Agriculturally used and undeveloped areas, to which the regional planning restriction for agriculture applies, may not be used for this (ML Nds., 2017).

#### 2.3.1. The Lower Saxony Wind Energy Decree

The Lower Saxony Wind Energy Decree is also intended to support the expansion of wind energy use and provide guidance for regional planning authorities (MU Nds. 2016). The decree regulates the technical supervisory responsibilities of the state, such as emission control, construction and nature conservation issues. The decree and corresponding guidelines are intended to support an environmentally and socially compatible expansion of wind energy use in Lower Saxony.

The spatial planning programme of Lower Saxony refers to the expansion of renewable energies and to the fact that the regional plans are to be designed accordingly (ML Nds. 2017). The wind energy priority areas are to be secured in binding regional plans. Specific expansion targets will be set for 10 districts with particularly high wind speeds. In the Wind Energy Decree, supplementary area potentials were calculated for all districts of Lower Saxony.

# 3. Energy mix in Germany and Lower Saxony

## 3.1. RES and the primary energy consumption

The importance of renewable energies for energy supply is continuously increasing in Germany and Lower Saxony. In 2019, the share of renewables in Primary energy consumption (PEC) in Germany reached 14.8 percent (BMWi, 2020b). In Lower Saxony, by 2017 this figure had risen to more than 19 percent PEC. The forecasts predict an increase to almost 23 percent for 2019 (see Figure 3; MU Nds., 2020).

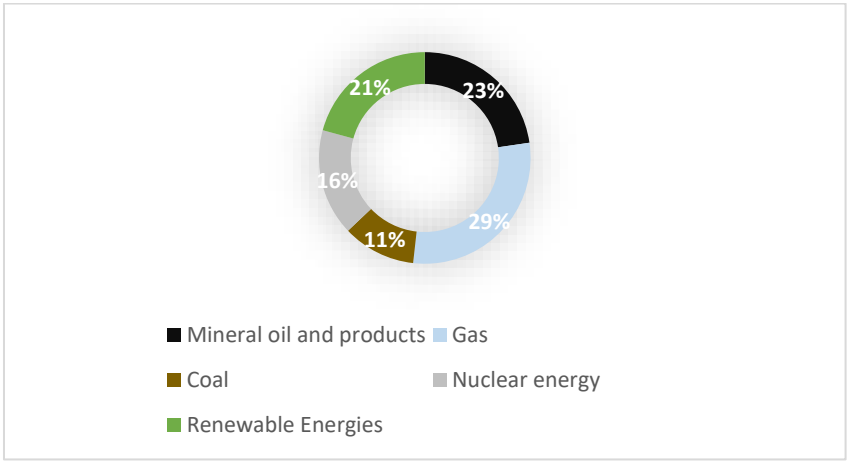


*Figure 3: Primary energy consumption in Lower Saxony in 2017*

In 2017, PEC in Lower Saxony amounted to around 367.6 billion kWh. Compared to the previous year, this was a slight increase of 0.6 percent, but the forecasts for 2019 (358.3 billion kWh) show a significant decline again. For Lower Saxony, a decrease in PEC between 1990 and 2019 of around 10 percent is recorded. Nationwide, the PEC also shows a downward trend until 2019 by about 14 percent (MU Nds., 2020).

## 3.2. RES and gross electricity generation

At 52 percent in 2019, the share of renewable energy sources in gross electricity generation in Lower Saxony has reached its highest level up to now. Over 49,7 billion kWh of electricity was generated from renewables in 2019 (see Figure 4; MU Nds., 2020). Nationwide, a renewable share of 42.1 percent of gross electricity generation was achieved in 2019 (BMWi, 2020a).

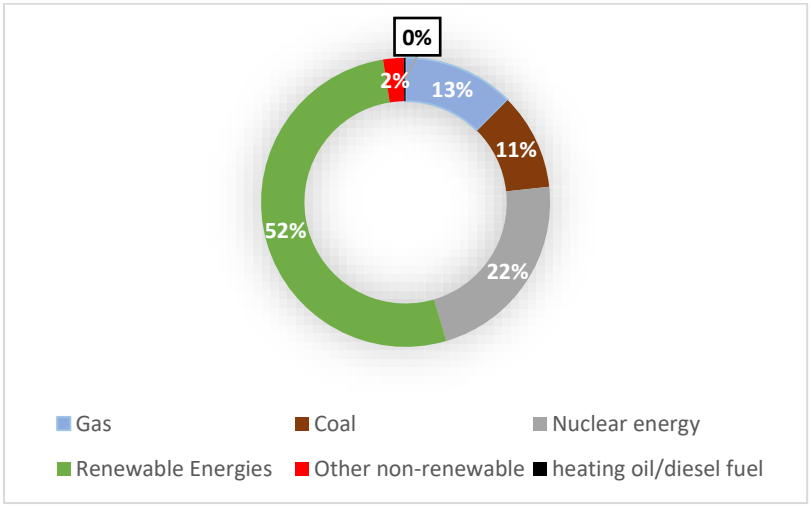


*Figure 4: RES and gross electricity generation in Lower Saxony in 2020*

Wind power generation in particular increased sharply in Lower Saxony in 2018, partly due to the good wind year, and accounted for 69 percent of total gross electricity generation from renewable energy sources. It should be noted in this context that offshore wind power generated in the North

Sea and feeded-in in Lower Saxony is statistically attributed to the State of Lower Saxony. The forecast for 2019 expects up to 74 percent of renewable electricity from wind energy.

The shares of biomass (around 20 percent) and photovoltaics (6.5 percent) regress slightly compared to the previous year. Hydropower plays only a minor role in electricity generation (MU Nds., 2020).

## 3.3. Solar energy

Photovoltaics (PV) ranks third among the renewable energies in Lower Saxony in terms of electricity generation. In 2019, about 3.23 billion kWh of electricity were produced by photovoltaic (PV) in Lower Saxony. The total installed PV capacity in Lower Saxony in 2018 was around 3,890 MW (MU Nds., 2020).

In Lower Saxony, the share of solar park systems is only 14.5 % (AEE, 2020). According to the market data register, around 258 plants on 2031 ha are currently in use (see Figure 5). As this database is currently being set up, it can be expected that slightly more systems have been realised in practice (Bundesnetzagentur, 2020).

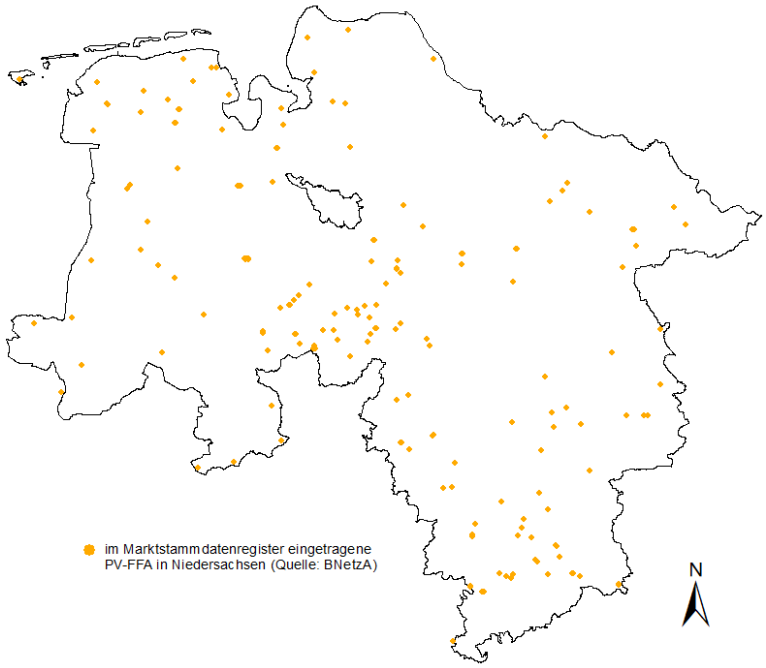


*Figure 5: Solarparks registered in Lower Saxony (Bundesnetzagentur, 2020)*

In solar thermal energy, a medium is heated which can be used to produce hot water or to support heating systems. In 2017, heat generation via solar thermal energy in Lower Saxony amounted to 635 million kWh (MU Nds., 2020).

## 3.4. Wind energy

The use of wind energy has become an integral part of electricity generation. In 2019, 36.6 billion kWh of electricity were produced by wind power (onshore and offshore) in Lower Saxony.

Wind energy on land is not only a comparatively inexpensive form of renewable energy, it has generally matured into a competitive form of electricity generation. Its expansion is indispensable for the success of the energy transition. 2019 was the year in Germany with the lowest number of new

wind turbines in over 20 years. As of 31 December 2019, the cumulative number of wind turbines recorded increased to 29,456 with a total capacity of 53,912 MW (Deutsche WindGuard, 2020).

Lower Saxony is consolidating its position as the number one wind energy state in Germany (see **Fehler! Verweisquelle konnte nicht gefunden werden.**). At the end of 2019, 11,325 MW (6,342 turbines) were installed in Lower Saxony. That is 21 percent of the nationwide wind energy output on land, which totals 53,912 MW (29,456 turbines) (MU Nds., 2020).

Especially in the northwest of the country, where the potential for generation is high, many plants have already been installed (see Figure 6).

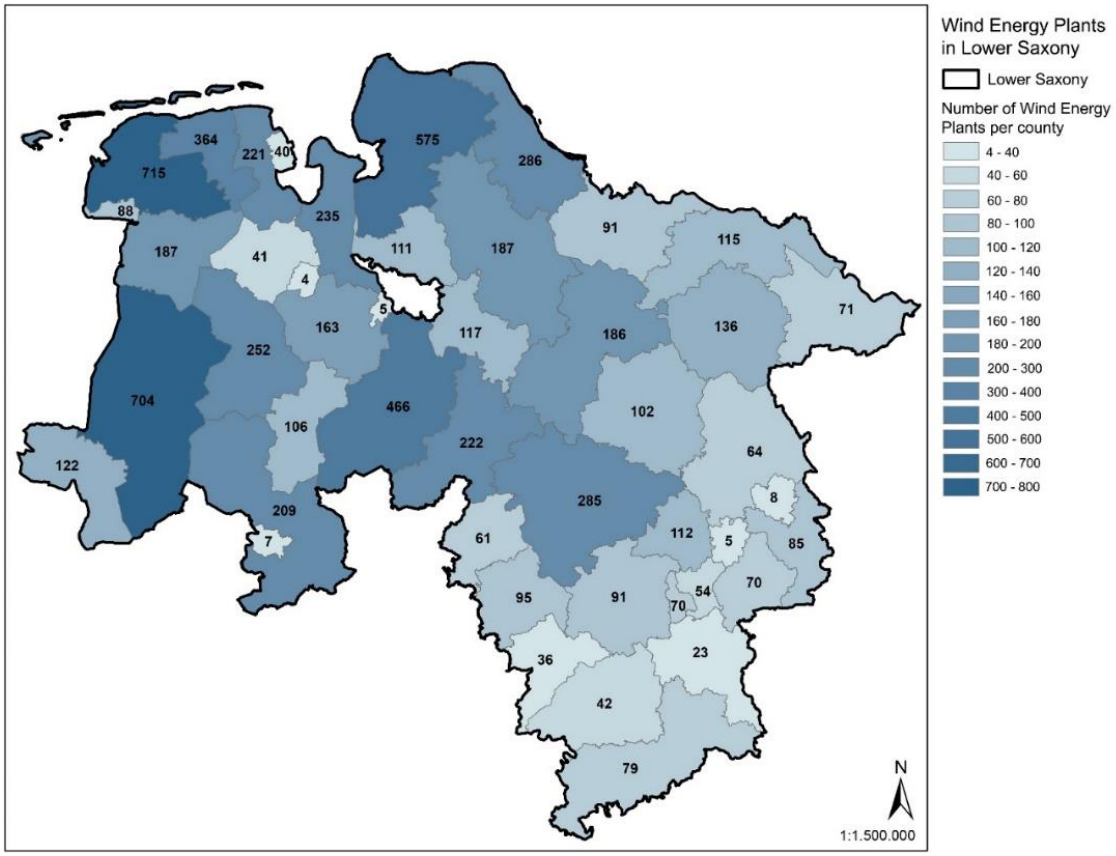


*Figure 6: Number of Wind Energy Plants per County in Lower Saxony (Source: (Bundesnetzagentur, 2020)*

In recent years, the use of wind energy in Germany has also picked up considerably at sea. In 2019 alone, 1,111 MW of offshore wind energy capacity was added, which was fed into the grid for the first time. This means that a total of around 7,516 MW of offshore wind power was connected to the grid at the end of 2019. More than half of this (60 percent) is connected to the grid via Lower Saxony. Further projects are under construction. By 2020, the installed capacity is expected to rise to up to 7,700 MW, with technical development making significant progress. (MU Nds., 2020)

The offshore wind turbines newly connected to the grid in 2019 have an average turbine output of 6.9 MW and an average rotor diameter of 155 metres. In the coming years, the plant capacity is expected to increase to 10 MW and more.

As a cost-effective, efficient and comparatively low-conflict form of electricity generation from renewable energies, offshore wind energy is therefore of particular importance for the further implementation of the energy system transformation. (MU Nds., 2020)

## 3.5. Biomass

At the end of 2018, 1,662 biogas plants (mainly agricultural) with a total electrical output of 892 MWel were in operation in Lower Saxony (see Figure 7). These plants generate 18 % of the renewable electricity in Lower Saxony and make a considerable contribution to the provision of renewable energies in the heating market via local heating networks. (3N, 2019)

97 % (1,608 plants) of biogas plants were operated with renewable raw materials in 2018. These plants, which are managed with energy crops, feed residues and farm manure (including liquid and solid manure), have a rated output of around 843 MWel. Approximately 22.8 million tonnes of input substrates were required for this. Of this, around 13.25 million tonnes are plant substrates, i.e. cultivated biomass from arable and grassland areas, plant by-products and feed residues. The biogas plants now use around 8.2 million tonnes of farm manure such as liquid manure, solid manure and fermentation residues. (3N, 2019)

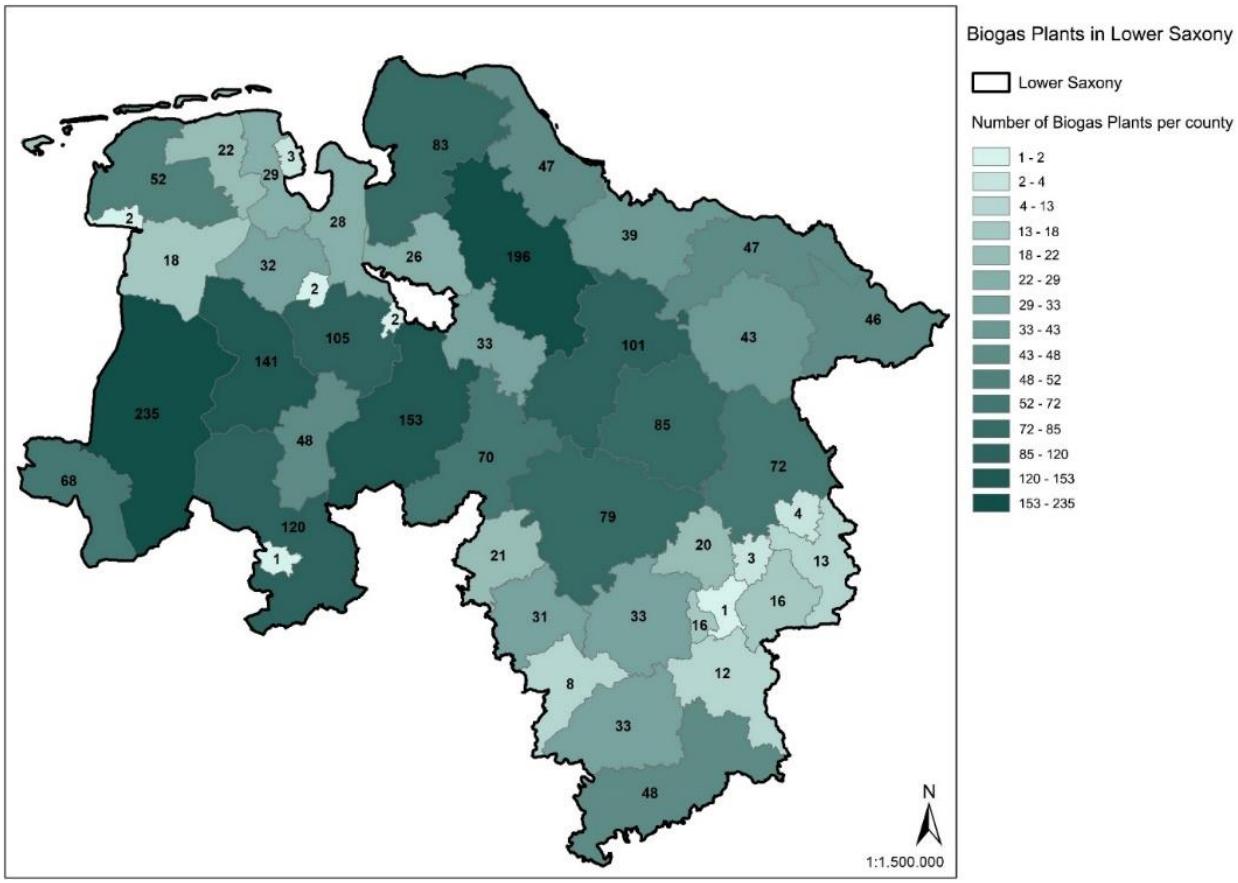


*Figure 7: Number of Biogas Plants per County in Lower Saxony (Source: (Bundesnetzagentur, 2020)*

A further 1.3 million tonnes of biowaste and animal by-products (excluding manure) are recycled in the co-fermented biogas plants. Thus, in 2018, about 42 % of the input substrates in biogas plants in

Lower Saxony were by-products and residual materials. Co-fermentation plants include plants that use food waste, fats or even slaughterhouse waste either proportionally or exclusively, as well as fermentation plants that use organic waste and municipal residues (green waste) to produce biogas and are operated in conjunction with composting plants (3N, 2019).

The cultivation of energy crops for biogas in Lower Saxony takes up 282,000 ha (about 10.7 % of the agricultural area), of which 267,000 ha are arable crops and about 16,000 ha grassland. Among the arable crops, maize accounts for the largest share (85 %) with 227,000 ha. Other energy crops such as whole grain plants/GPS and sugar beets, field grass, flowering plants, interspersed silphy, szarvasi (Hungarian giant wheat grass), mixed crops or sunflowers are also only cultivated on 40,000 ha. (3N, 2019)

Due to its high yield, maize remains the leading crop as animal feed and raw material for biogas production. There are regional differences in agricultural land use with regard to the proportion of corn in crop rotation. In areas with high biogas and livestock density, the increasing cultivation of maize for biogas production and livestock farming means that in some communities maize accounts for almost 50 % of the arable land. (3N, 2019)

In addition to competing with food and energy crop production, the continued cultivation of energy crops has led to high nutrient surpluses in the region due to the additional accumulation of fermentation residues, and thus to further pollution of nature and especially of groundwater. The state government wants biogas plants to be operated more flexibly in the future to supplement the fluctuating feed-in of wind and solar power. The use of energy crops - such as maize - is to be significantly reduced. As a contribution to climate protection, the state government is committed to increasing the use of liquid manure as a substrate in future (MU Nds., 2017a).

## 3.6. Geothermal energy

Geothermal energy close to the surface (e.g. via geothermal collectors or geothermal probes) is already widely used in Lower Saxony to supply heat to houses. In total, more than 16,200 near-surface geothermal plants are installed in Lower Saxony. Of these, about 360 plants achieve an output of more than 30 kW (large-scale plants). Deep geothermal energy offers potential, as it provides heat completely independent of time of day and weather conditions. Deep geothermal projects (drilling depth > 400 m) have not yet been implemented in Lower Saxony. The GeneSys research project on the use of deep geothermal energy exists in Hannover. Within the framework of the project, geothermal energy with a thermal output of 2 MW is to be extracted at a drilling depth of almost 4 km. Feasibility studies for deep geothermal projects have been carried out at several locations with the support of the State of Lower Saxony. In addition, the use of former deep boreholes offers economic potential. (MU Nds., 2020)

## 3.7. Hydropower

In Lower Saxony, hydroelectric power plants generated around 194 million kWh of electricity in 2018 and 223 million kWh in 2019. It was thus comparatively low in 2018, particularly due to the "record summer" and the associated low water levels.

For ecological reasons and due to the geographical features of the region, a major expansion of hydroelectric power is not feasible in Lower Saxony. However, research is currently being conducted into the expansion of hydroelectric power at low gradients. Furthermore, no significant changes are

foreseeable in the coming years with regard to the use of hydropower in Lower Saxony. (MU Nds., 2020)

# 4. Landscape Planning in Lower Saxony

Landscape planning has a long tradition in Germany and is well established as a central planning instrument of prevention oriented and proactive nature conservation, which comprises biodiversity as well as natural resources, landscape aesthetic and recreation (landscape functions /ecosystem services). Since the Federal Nature Conservation Act was passed in 1976, landscape plans have been drawn up for virtually the whole country: landscape programmes are set up on federal state level und landscape structure plans are set up for regions. In this way, an information base and objectives system was set up, beyond the planning levels, over virtually the whole area of the country.
Landscape plans are one of the standard tools of nature conservation, spatial planning and sectoral authorities as well as local communities, all of which can make relevant decisions on the basis of the differentiated comments on the condition and development of nature and the landscape.
In addition, landscape planning provides the public with environmental information. Landscape planning has been developed during the past decade to a generally accessible and easy to update information base (Haaren and Galler, 2012).

The complex interaction of all the factors such as soil, water, air and climate, plants and animals, beauty and the recreational value of nature and landscape as well as the effects of existing and foreseeable land usages, are analysed and assessed within the landscape planning. As a result, extensive basic information about nature and the landscape (their actual as well as their past and foreseeable development) is available for the whole area.

The objectives, requirements and measures described are oriented so that they can be implemented in the field of tasks and activities of the various sectoral planning and land usages (cross-sectional orientation). The landscape planning addresses different target groups: the nature conservation authorities, other planning authorities and approval & licensing authorities as well as the interested public.

Within the scope of landscape planning, the sensitivity of subareas to use for certain forms of renewable energy (wind, solar, energy plants) can be determined. Similar to the priority areas for wind power utilisation, which prove their worth as a control instrument in regional and urban development planning, on this basis suitable or exclusion areas for solar parcs or for energy crop cultivation can be shown, too (Haaren and Galler, 2012).

Landscape planning is also an information basis for controlling the use of nature and landscape-related funding. It shows spatially concretely where there is an increased need for action from a nature conservation point of view and, if necessary, presents multifunctional, cross-sectoral relevant measures. On this basis, statements can be made as to where subsidies, e.g. from the European agricultural and structural funds, can be used efficiently.

## 4.1. Landscape Planning and the Ecosystem Services Approach

Landscape planning records and evaluates the values and functions of nature and landscape in a spatially concrete manner and thus provides an important basis for determining the potential use and economic value of ecosystem services. The significance of an area for the provision of various

services can thus be represented in a spatially concrete way and taken into account from a precautionary point of view (Haaren et al., 2008).

There are overlaps in content and methodology between the landscape planning legally anchored in the Federal Nature Conservation Act and established in planning practice and the approach of ecosystem services: Both record and evaluate the functionality and performance of the ecosystem using "landscape functions". In landscape planning, usually public services and goods are dealt with which are insufficiently or not at all considered on the market and for which there is therefore a state duty of care. Ecosystem services on the other hand also include private (market) goods such as food. An important part of the ecosystem services approach is also accounting and economic valuation. In this respect there is a challenge for landscape planning to extend its methodological spectrum and prepare for monetisation (Haaren and Galler, 2012).

# 5. Lower Saxony Multifund Programme in the Structural Funds period 2014 - 2020

The Lower Saxony's Operational Programme (OP) for the European Regional Development Fund (ERDF) and the European Social Fund (ESF) for the 2014-2020 programme period was adopted by the European Commission on 12 February 2015. It is the only programme in Germany that includes both funds, ERDF and ESF (Multifund Programme). Another special feature is that the Multifund Programme also includes two target area categories: one part of the country is classified as a transitional region, another as a more developed region. This classification has hardly any noticeable effect on the individual beneficiary, but it does play a role in the implementation and, in particular, in the accounting of the programme vis-à-vis the European Commission.

The range of fields of action represented in the OP comprises a total of 40 different support measures, which are focused on the areas mentioned in 8 priority axes:

- Promotion of innovation
- competitiveness of SMEs
- Reduction of $CO_2$ emissions
- Sustainable and environmentally sound development of areas and landscapes
- Employment through equality and regional approaches to securing skilled labour
- Employment and regional social service innovation
- Poverty reduction through active inclusion
- Education, training and vocational training

For the ERDF, the priorities are to strengthen investment in small and medium-sized enterprises, research and development and climate protection. Here 1,678.48 million € are available (690.79 million € funding by the EU). The ESF makes important contributions above all to the integration of people at a disadvantage in the labour market and the fight against poverty, but also in the qualification of employees in companies. Some 570.76 million € can be made available (287.52 million € EU contribution).

The expected reduction in EU funding in the new programming period makes it necessary to set priorities in the funding possibilities.

Thus, in future, environmental and climate protection will be bundled in one strategic objective. Targeted investments will be made to further expand expertise in the field of renewable energies and sector coupling, to exploit the potential for energy efficiency and emission avoidance and to conserve natural resources.

Sustainable development of natural resources, conservation and restoration of areas of high natural value, natural waters and biodiversity, and adaptation to the consequences of climate change are to be achieved.

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