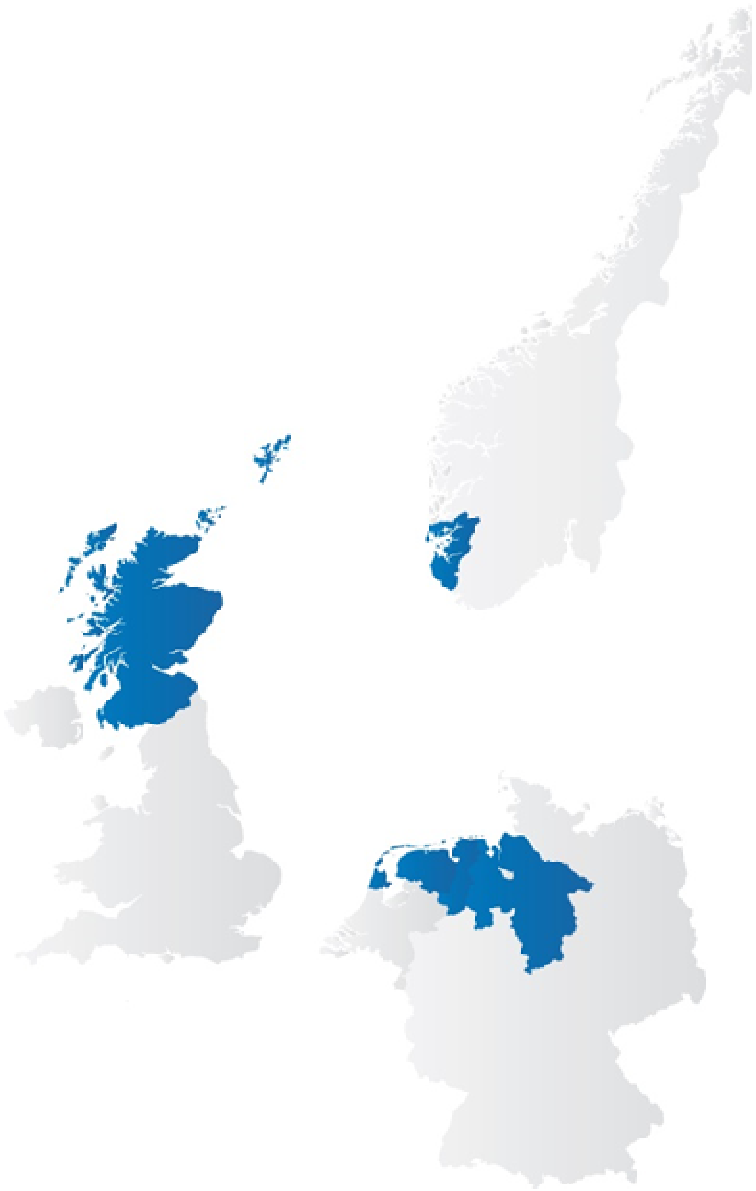
European North Sea Energy Alliance



Regional Report of Wachstumsregion Ems-Achse e.V.

efzn
Energie-Forschungszentrum Niedersachsen

SEVENTH FRAMEWORK PROGRAMME

EMS ACHSE
Jobmotor Nordwest

European North Sea Energy Alliance

Regional Report of Wachstumsregion Ems-Achse e.V.

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1 Wachstumsregion Ems-Achse e.V. at a glance

The Ems-Achse stands for a joint economic region to advance economic growth and increase employment. This is achieved through development and implementation of different projects and the advancement of communication between the companies to gain and amplify knowledge. The economic region Ems-Achse, founded in 2006, profits from the close and faithful collaboration between companies, local authorities and academic institutions. One year after the founding, the Wachstumsregion Ems-Achse consisted of 43 Members (37 companies and 6 municipalities). In the following 4 years (2007-2011) the number increased drastically: today there are more than 400 members. This can be ascribed to successful projects like the completion of the Autobahn A 31 (13 years earlier than planned) which leads from the north to the south of the region and the harbour "Eurohafen Emsland" (in 2007). Both projects have been and are very important for the infrastructure of the whole region and have shown what can be achieved if the members of the Ems-Achse are joining forces. All together there are 429 members[1].

SMEs:	**326**
Large Companies:	**39**
R&D:	**2**
Universities/Universities of applied sciences:	**3**
Local Authorities:	**59**

The Ems-Achse stands for promotion of economic growth and is at the forefront of providing new jobs: From 2005 to 2010 the average peak of job-increase has been 14,3% for the Ems-Achse region, whereas the average peak of Lower-Saxony has been 6,5%.[2]

Six working groups, chaired by the administrative districts, have been formed, addressing and advancing the main topics of the regional economy. Many renowned projects have been realized which are strengthening the transnational collaboration and the different industries. All cluster-members can take part in these groups which are meeting on a regular basis, hosting workshops and networking events to increase the exchange of information and collaboration. Within this structure the Landkreis Aurich is responsible for the theme "Energy".

[1] Dated March 2013.
[2] Kröcher, Uwe, Beschäftigungsboom im Nordwesten – vor und während der Krise, Regio Report, Oldenburg, Juni 2011

1.1 Geography

The Wachstumsregion Ems-Achse is located in the most north-western part of Germany. In the North it borders on the North Sea, in the West is the Dutch-German border and in the South North Rhine-Westphalia. The municipalities forming the region are: Landkreis Aurich, Landkreis Wittmund, Landkreis Leer, Landkreis Grafschaft Bentheim, Landkreis Emsland and the city of Emden.

All together this is an area of 7003 km² with a population of911.354 inhabitants.

County	Population	Size km²
Landkreis Aurich	188.267	1287
Landkreis Emsland	314.765	2882
Landkreis Graftschaft Bentheim	135.022	980
Landkreis Leer	165.168	1086
Landkreis Wittmund	56.784	656
Stadt Emden	51.348	112

Figure 1:Counties of Ems-Achse

From 6 East Frisian Islands in the very North to small foothills of a low mountain range (90m) in the very south – the landscape of the region is quite diverse.

The districts Aurich and Wittmund have been shaped by the direct access to the Sea. Tourism and fishery are mportant parts of local economy. Seaports gave distinction to the city of Emden and district of Leer. The county of Emsland is the biggest district in the region and builds together with the district Grafschaft Bentheim the southern part of Ems-Achse, where one can find all kinds of different landscapes: from open fields to forest and moor. Also first small hills give a different touch to the area in contrast to the North. What unifies the different landscapes is the river Ems which flows right through the region and gave his name to the Wachstumsregion.

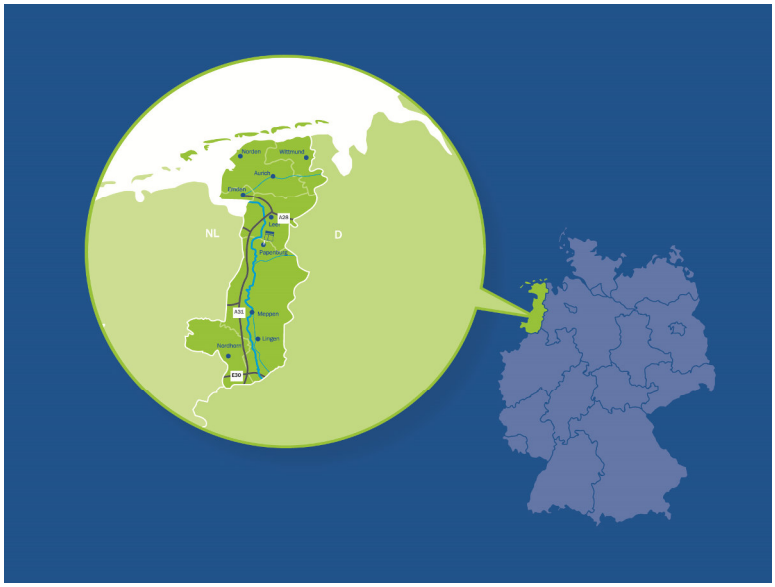


Figure 2: Location Ems-Achse

The whole region always relied on agriculture. The land is fertile and the population rate is relatively low. After drying up the moor, in the more southern parts, the first peat was cut and a new source of income was developed. Around 1800 turf production was commercialized and one can say that this was the beginning of a long history in the energy sector.

In the 1940s natural gas and oil fields have been developed - Pumping stations, pipelines, oil fuel units, residential centers of the petroleum industry, new shops and numerous industrial enterprises are besides highly mechanized turf factories features of this era.

Of originally 11 oilfields in the district Emsland 7 are producing oil up to now. Peak oil was reached in 1968 already and nowadays the oil produced in Germany covers the demands of the country to 2,5-3%. But even if Germany never had a history of an oil producing country, the landscape in the southern parts of the Ems-Achse is characterized by grasshopper pumps.

Another geographical attribute of the northern parts of Ems-Achse contributes to the reputation as “region of energy”:
Some of the largest German salt deposits were found in East Frisia which can be used to store oil and gas. These salt deposits were formed around 250 million years ago due to the drying out of seas with a high salt concentration. The pressure of very thick and heavier overlying sediments, which have then squeezed up the salt, formed salt domes with very large volumes.

The German federal government decided to build a federal crude oil reserve in Etzel since the particular conditions met the demands:
„The local salt dome [in Etzel] extends over a length of 17 kilometres and a width of 5 kilometres and upward from a depth of more than 4000 metres to within 750 metres of the earth’s surface. Few locations in Germany or indeed in Europe compare to Etzel’s favourable conditions for the

construction of caverns. The location was also ideal in terms of its proximity to the North Sea and the Niedersachsenbrücke jetty just 25 kilometres away in Wilhelmshaven."[3]
After the construction of pipelines and pumps, leaching started in 1973. One of the biggest German natural gas reserves was recently put into operation in Jemgum.
Both sites, Etzel and Jemgum are still being expanded and when construction is done there will be 33 caverns with a storage volume of approximately 700.000 m^3 – 750.000 m^3 each in Jemgum[4] and 144 caverns in Etzel. Up to now 62 caverns have been build in Etzel with a storage volume of approximately 38.000.000 m^3.[5]

Other economic possibilities arose from the boom of renewable energy.
Conditions have been proven to be very fruitful for the formation of "windparks", with wide and windy plains especially in the northern parts. With biogas and renewable resources one could settle on the long tradition of farming. Farmers in the Ems-Achse region are not only producing agricultural products, today they also produce electricity and heat. Some even establishes local heating systems which deliver thermal heat for whole villages.

1.2 Economy

Within the Ems-Achse region all kinds of industries and branches are located. Nonetheless there are 6 economic focal points which can be attributed to the region. Although all sectors are spread over the whole region, one can see certain concentrations in the different districts. Therefore every county takes responsibility of an economic field which has a prominent status in their district.
As a result, six working groups have been formed, as already mentioned before in chapter 3:

Energy (Aurich)
Logistics (Emden)
Maritime Collective Economy (Leer)
Mechatronics (Emsland)
Synthetics (Grafschaft Bentheim)
Tourism (Wittmund)

Besides the connection of all fields via numerous supply chains the topics themselves overlap. This overlap is especially significant within "Energy" - very obvious in mechatronics, and more unapparent in, for example, matters of tourism[6].

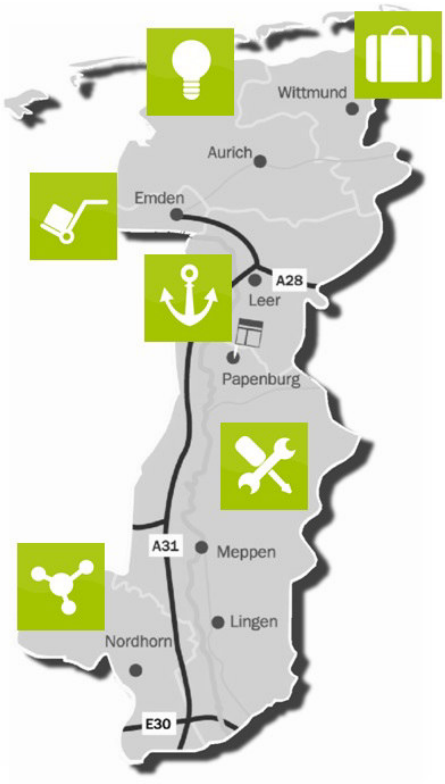


Figure 3: Working Groups Ems-Achse

[3]IVG Caverns GmbH, Kavernenspeicher Etzel – Versorgungssicherheit für Erdgas und Erdöl, Friedeburg, Juni 2011
[4]Astora gmbh& Co. Kg, http://www.speicher-jemgum.de/Projekt/, as of September 2013
[5]IVG Caverns GmbH, http://www.ivg.de/investment/caverns/kavernen-informationszentrum-etzel/, as of September 2013
[6] For example, there is a wind energy plant with an observation deck which can be visited and the city of Aurich is building the "Energie-Erlebnis-Zentrum-EEZ" (Energy Adventure and Experience Center) right now. When new plants and facilities are planned, matters of tourism have to be taken into account as well.

The energy industry is an important economic factor for the Ems-Achse and the region relies on its economic power. "The manufacturers of plant and equipment for renewable energy units and their suppliers dominate the sector […] Alongside the core business of energy supply the region is also the location for cable manufacturing and pipeline construction companies as well as a wide range of associated service industries."[7] The region is characterized by a diverse mix of industries with many highly specialized small and medium sized companies, but also large companies, international market leader among them, which are located all over the Ems-Achse.

Also other sectors profit from the generation of energy from renewables: Many farmes count on wind energy, solar power and biogas. Some even run large district heating networks with their biogas plants, distributing heat for whole villages.

Another aspect of the energy industry is logistics. With the third largest and most western German North Sea Port in Emden the Ems-Achse has to offer a harbor with many years of experience in offshore and onshore wind. "The port is used for several wind farms in the German bay as a base for the pre-assembly, transportation and maintenance of the off-shore wind turbines."[8] The other important traffic routes are the Autobahn 31, the rail track Ruhrgebiet-Emden, the Dortmund-Ems-canal and in the south the intersection of Autobahn 30 to Amsterdam, Hannover and Berlin.

The success of the energy sector as an economic key area of the region is also mirrored in the employment figures of the region: Whereas in the eastern parts of Lower Saxony employment reduction was the case in the energy sector during the years 2000 and 2009, the western region was able to increase employment. In the Landkreis Aurich, for example, more than 1000 jobs have been created during this period[9]. To make sure that the trend continues upwards the Ems-Achse values international collaboration and its advantages like economic growth, international impact and increasing competitiveness.

Sustainable energy supply is a core challenge faced by all European regions.
Theoretically huge parts of the Ems-Achse are able to supply themselves with sustainable energy only. Some municipalities are even producing more than they would need (Landkreis Wittmund 133%, Stadt Emden 119%, Landkreis Aurich 100%[10]). But to guarantee a stable supply with renewable energy, we are in the need of solutions especially depending grid stability. In the face of the intended German nuclear power phase-out in 2022 this issue becomes even more important. With projects like *hec* and *NEND* and the Energy Efficiency Resolution (signed by all municipalities in April 2008) the Ems-Achse is preparing for the upcoming challenges.
Furthermore, with the caverns in Jemgum and Etzel, the region is a very important part of federal security of energy supplies.

1.3 Education/Research

Measured against the size of the area there are not that many universities and research institutes as elsewhere. Nevertheless or probably because of that Ems-Achse maintains good contacts to research organisations and universities outside the regional scope. Despite these other contacts and cooperations, the view should be maintained on the cluster and its members and the region

[7]Kröcher et al, Potenzialstudie Energieregion Nord-West, Oldenburg/Hannover, Mai 2013, S. 10.
[8]Stadt Emden, http://www.emden.de/de/wirtschaft/homeport/main.htm
[9]Brand, Harms, Rietzler, Energieland Niedersachsen, Eine Studie der Nord/LB Regionalwirtschaft im Auftrag des Institutes der Norddeutschen Wirtschaft e.V., Dezember 2010
[10]Deutsche Gesellschaft für Sonnenenergie, Energymap, Regierungsbezirk Weser-Ems, URL: http://www.energymap.info/energieregionen/116/178.html, as of October 2013

itself in the following passages. To begin with, an overview of the German education system is given.

1.3.1 German Education System

„All pupils in Germany enter the Grundschule which in almost all Länder covers grades 1 to 4. Following the primary school stage, secondary education in the Länder is characterised by division into the various educational paths with their respective leaving certificates and qualifications for which different school types are responsible. Once pupils have completed compulsory schooling they move into upper secondary education. The range of courses on offer includes full-time general education and vocational schools, as well as vocational training within the *duales System* (dual system). The tertiary sector encompasses institutions of higher education and other establishments that offer study courses qualifying for entry into a profession to students who have completed the upper secondary level and obtained a higher education entrance qualification. As part of lifelong learning, continuing education is assuming greater importance and is increasingly becoming a field of education in its own right. In response to the vast range of demands made on continuing education, a differentiated structure has been developed.“[11]

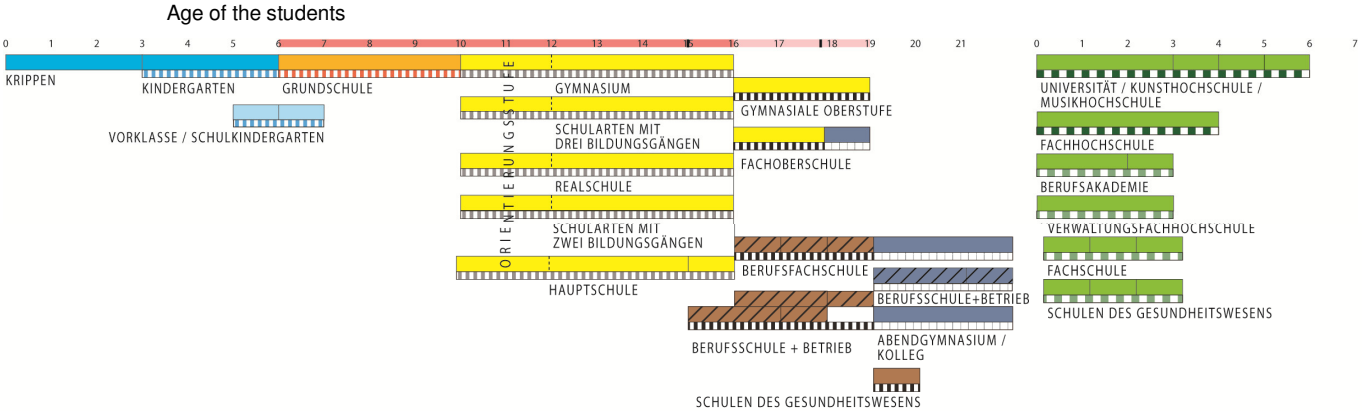


Figure 4: German education system[12]

1.3.2 Energie-Forschungszentrum Niedersachsen – EFZN

The "Energie-Forschungszentrum Niedersachsen" (Energy Research Centre of Niedersachsen) located in the German Lower-Saxon city of Goslar, or in its short version the "EFZN", is a scientific institution of the "TechnischeUniversitätClausthal" (in short the "TU Clausthal" or in English the "Clausthal University of Technology") in cooperation with the universities of Braunschweig, Göttingen, Hannover and Oldenburg. The focus of EFZN lies on issues pertaining to the entire energy-generation and energy-utilisation chain from the raw-material source to disposal. An average of 80 researchers from the fields of natural science, engineering science, law as well as

[11] Eurypedia, European Encyclopedia on National Education Systems, https://webgate.ec.europa.eu/fpfis/mwikis/eurydice/index.php/Germany:Overview, as of October 2013
[12] Eurydice, Education Structures, http://eacea.ec.europa.eu/education/eurydice/documents/facts_and_figures/education_structures_EN.pdf, as of August 2013

the social and economic sciences works together under the same roof, thus facilitating an interdisciplinary approach to energy research.

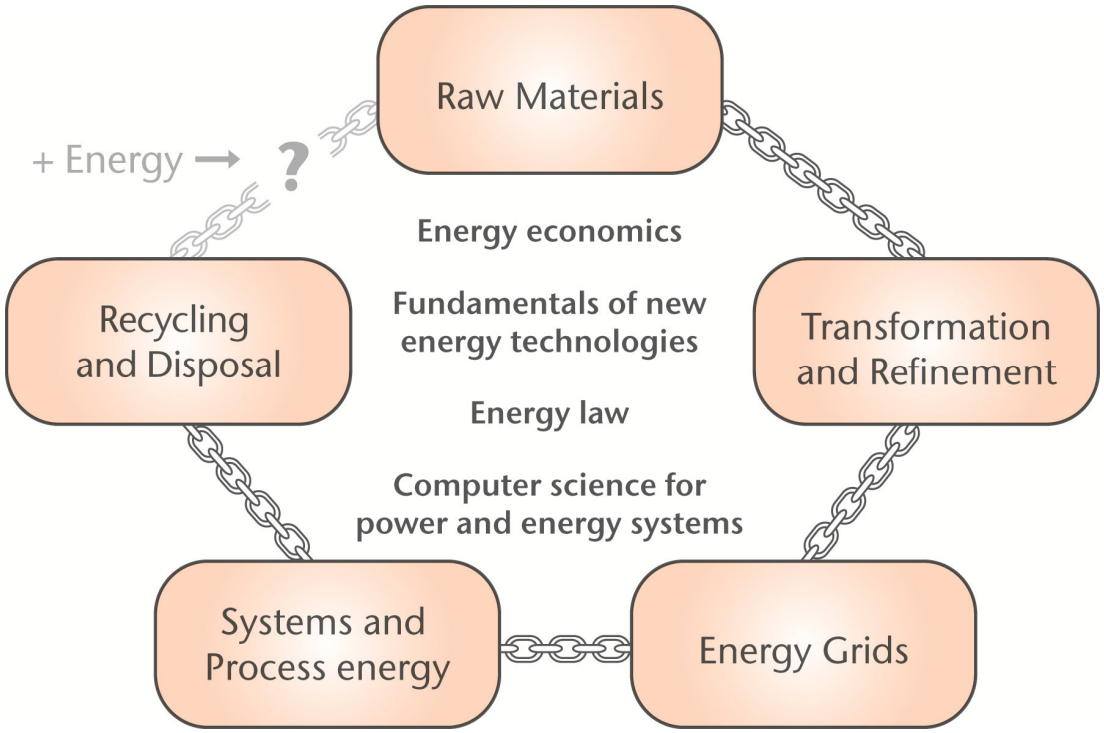


Figure 5: Energy Chain, EFZN[13]

The EFZN joined the Ems-Achse in July 2011 to strengthen the competence in energy-research, since the EFZN combines energy research in Lower Saxony and ensures representation of all the universities of Lower Saxony, who are involved with energy research.

1.3.3 Universities of applied sciences

There are two universities of applied sciences located in the Ems-Achse region:

Hochschule Emden/Leer
The university consists of two different sites in the cities Emden and Leer.
The college in Leer is renowned for nautical sciences and shipping management. These fields of education are closely related to the energy industry in the way that mostly the whole logistic and supply for offshore windparks is carried out by maritime economy. The Hochschule Emden/Leer is also involved in two research projects: *MariTIM*, which deals with maritime technologies and innovation and *North Sea Supply Connect* which aimed at connecting (among others) SME suppliers and manufacturers of energy production, distribution, consumption and energy efficiency technologies along the North East Corridor of the North Sea.

In Emden the students can get their degree in various fields of engineering, for example a bachelor/master of engineering in *environmental technology*, *energy efficiency, electrical*

[13] Energie-Forschungszentrum Niedersachsen, Energy Chain

engineering, computer science or *machine construction and design*. The focal points of research in the field of engineering are on industrial computer science and sustainable technologies but there are also socio-scientific and pedagogic research topics[14].

Hochschule Osnabrück – Campus Lingen
The Hochschule Osnabrück runs a campus in Lingen – the faculty for management, culture and technology. Students can choose for example between business and management studies, machine construction or industrial engineering and operations research. In different laboratories students can transfer the gained knowledge into practice. The teachers work closely with companies in the region and together projects in different disciplines are realized, for example renewable energy, technical product development, software development or logistics.

1.3.4 Institutions & Networks

Probably due to the spatial distances to the universities, a lot of institutions and networks have been founded and are located in the region. They are very well known and enjoy a good reputation.

Some of those networks are integrated in the Ems-Achse cluster. The ones dealing with energy in a narrower and also broader sense are for example:

3N Kompetenzzentrum - Niedersachsen Netzwerk Nachwachsende Rohstoffe e.V.
3N is the lower saxonian competence center for regrowing resources and bioenergy, located in Werlte. As a non profit organisation it supports the lower saxony network of renewable energy and resources. More than 32 enterprises, local authorities and institutions are members of this platform. 3N functions as contact point and source of information for economy, agriculture, forestry, science and citizens. Furthermore 3N participates in regional, national and European projects, prepares studies on different topics and is also active promoting the advantages of regrowing resources with exhibitions and workshops.

3N is also responsible for the Klimacenter Werlte, next to the office. The Klimacenter illustrates what regrowing materials have to offer: the building functions as a reference object to the use of

- Bioenergy (wood pellet heating, firewood heating, energy efficiency)
- Building materials (insulating materials, flooring, paint and lacquer)
- New materials (biodegradable plastics, natural fiber composites, bionics)

Craftsmen can use the Klimacenter as an exhibition and demonstration object, companies are able to present their products and customers can take a close look at different techniques. It is also possible to rent laboratories and meeting facilities.

CCN – Climate Center North
In 2010 the county of Aurich founded the Climate Center North to promote the topic of energy efficiency within the Ems-Achse.

The CCN sees itself as a hub for manufacturing companies and technology providers in the field of energy efficiency and aims to support the development and application of new technological solutions in this area. This can save resources, CO_2 and costs. Furthermore competitiveness and innovation capacity of enterprises and institutions will be increased.

[14]Hochschule Emden-Leer, Forschungskerne der Hochschule, http://www.hs-emden-leer.de/forschung-transfer/forschung/forschungskerne.html, as of September 2013

Some activities of the Climate Center North are for example:

- Prepare overview of energy and CO_2 consumption for the region
- Introduction of energy management systems for SMEs
- Implementation of a course for Energy Representatives

Mariko
The Mariko is the maritime competence center of the region. It is headquartered in Leer and interlinks the maritime expertise of the region. The Mariko supports its national and international partners in matters of education and training, qualification and research, but also marketing.
The relation to energy stems from the offshore wind industry and green shipping technologies.

Energieeffizienzagentur Landkreis Emsland e.V.
Since 2011 this "Agency for Energy efficiency" is working with companies in the administrative district Emsland and illustrates measures for saving energy and efficient usage. Assistance is also offered when it comes to questions of funding opportunities.

1.3.5 Innovative SMEs and industry

Innovative SMEs are important for technological progress. Besides the competences universities and other research institutions have to offer, companies and municipalities work together closely to benefit from each other's knowledge or facilities. One example is the project "Kalte Fernwärme" (Cold district heating) in Aurich:

- The dairy Rücker in Aurich uses their 30 °C warm waste water to heat the huge multipurpose hall of the city. Up to one million litre sewage daily can be used for environmental-friendly heating. In 2011 the project was honoured by the initiative „Deutschland – Land der Ideen".

Besides SMEs also industry has got headquarters in the Ems-Achse region, amongst others:

- Enercon, GE Energy, BARD Offshore, Volkswagen, Meyer Werft

Needless to say, large companies usually have their own research departments but just to name a few activities:

- Right now Enercon is building an innovation centre in Aurich which could accommodate about 700 research and development engineers on an area of 30.000 m^2.
- The Volkswagen factory in Emden is trying to become a "Blue Factory" – a label for CO_2 neutral production. Numerous projects related to environmental protection and sustainability have been already initiated.
- The Meyer Werft is very active in projects dealing with new drive systems and components for their ships.

The Ems-Achse region also often functions as a testing location for innovation and technology for companies and research institutes from outside the borders of the member districts:

- The German car company Audi invested 20 Million Euro in a facility in Werlte which uses electricity to convert Water and carbon dioxide in methane on an industrial scale (6 MW). It is the first facility in the world which can produce these amounts. The basic idea

is to produce gas with spare electricity from wind energy which can be stored and used to fuel cars.

- Haren was part of a testing region in the project “Smart Country”. Goal of the project was the realization and evaluation of innovative concepts of distribution networks. It was funded by the Federal ministry of Economics and Technology, project partners are energy supplier RWE, TU Dortmund together with ABB AG and Consentec.

1.3.6 Interreg

The Ems-Achse or rather the member institutions and counties are frequently taking part in Interreg IVa and b projects. The majority of these projects deal with energy, resource efficiency and sustainability.
For example:

Groen Gas
The most recent project with a total volume of 10 million Euro, funded by the Dutch Ministry of Economic Affairs, Agriculture and Innovation, provinces Drenthe, Groningen, Friesland, Overijssel and Gelderland as well as the German federal states of Lower-Saxony and North Rhine-Westfalia. A total of 63 project partner from all parts of the triple helix work together in 17 sub-projects to remove bottlenecks along the whole value chain of biogas. Topics are: Processing of biogas, law and regulations, infrastructure, green gas as fuel etc.

Nachhaltige Energien Niederlande Deutschland - NEND
NEND is a cooperation of local authorities in the northern Netherlands and north western Germany. The aim of NEND is to strengthen the position of the region in the field of production and use of renewable energy. Based on different aspects of the region both sides of the border, NEND deals with four themes:
Energy efficiency, sustainable building, biomass, solar energy

Hansa Energy Corridor - HEC

- The Hansa Energy Corridor was a collaboration between 9 partners located in Northern Netherlands and Northwest Germany:
- Rijksuniversiteit Groningen
- Hanze University Groningen
- Provincie Groningen
- Stichting Energy Valley
- Landkreis Aurich/Wachstumsregion Ems-Achse e.V.
- Energie-Forschungszentrum Niedersachsen
- Oldenburger Energiecluster OLEC
- Carl von Ossietzky Universität Oldenburg
- Jacobs University

To develop the energy transition eight key areas were addressed within the starting phase of the platform. All of these themes shared that they are addressing key challenges within the European energy system based on an interdisciplinary approach, which covered technological, social, economic as well as regulative and legal issues.

Energy-Gateway
The homepage www.energy-gateway.eu is derived from the project Hansa Energy Corridor. It strengthens the region by displaying the different scientific, economic and political competencies and also public and private commitment. The internet platform is divided in larger regional

projects which are described in detail on single subpages and three interactive maps on which municipal projects, locations of companies and universities are linked.

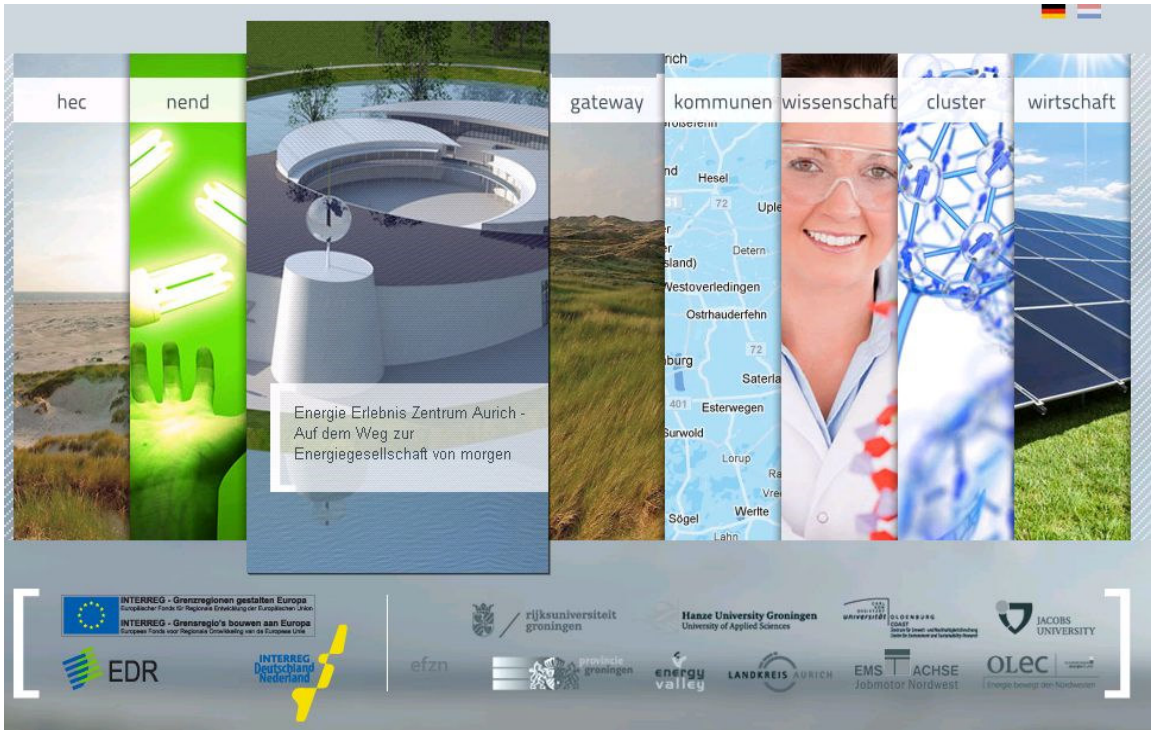


Figure 6: Screenshot of http://www.energy-gateway.eu/

2 Description of the regional energy system

The chapter on description of the regional energy system has the aim to explain the meaning and impact of the Energiewende in Germany and also gives an insight into the national and regional energy system. Concerning the Energiewende the “Erneuerbare Energien Gesetz” (Renewable Energy Law) plays a major role in Germany. Many profound changes in the way of energy generation have been accelerated and enabled by this law.

2.1 Summary of the national and regional energy system

This sub-chapter delivers concrete figures and data concerning energy consumption, gross electricity generation, the gas and electricity supply both in Germany (national level) and in Lower Saxony (regional level).

2.1.1 Prologue: Energiewende[15](energy transition)

Germany has drawn a lot of international attention for its aim to switch to a renewable energy economy and leave nuclear and fossil energy behind. Hence, in the aftermath of the nuclear reactor core meltdowns in Fukushima, Japan in March 2011, the German Government presented a set of decisions known as the Energiewende (energy transition) in June 2011. It refers to a fundamental transition to a decarbonized energy system based mainly on variable renewable energy (RE), e.g. wind and solar power, with the emphasis on increasing energy efficiency without the use of nuclear energy. The Energiewende is based on an earlier 'Energy Concept' that was agreed on by the same coalition government of Christian Democrats and Free Democrats in September 2010, which has already laid out a long-term perspective until 2050 for the transition towards a RE-based energy system.

2.1.2 Energy consumption[16]

The energy consumption is divided into primary energy consumption and final energy consumption. In the following, numbers and figures on the German and Lower Saxony energy consumption are given.

Primary energy consumption (PEC)

The PEC indicates how much energy is used in an economy in order to deliver all energy services (such as production, heating, moving, telecommunications, computer lighting etc.).

Final energy consumption (FEC)

FEC refers to what the energy is actually consumed by final consumer. The consumption applies to both primary fuels (oil, natural gas, hard coal, brown coal, nuclear energy and renewable energy) and secondary energy carriers (refined by conversion of primary energy sources such as electricity and petroleum products).

[15]The German energy transition; Finnish Institute of International Affairs Briefing paper 128; May 2013, p3

[16]2013 Niedersachsen.de;
http://www.umwelt.niedersachsen.de/umweltbericht/nutzungsfelder/energie/grundlagen/energie-89115.html

Primary energy consumption (PEC) in Germany (2012)[17]

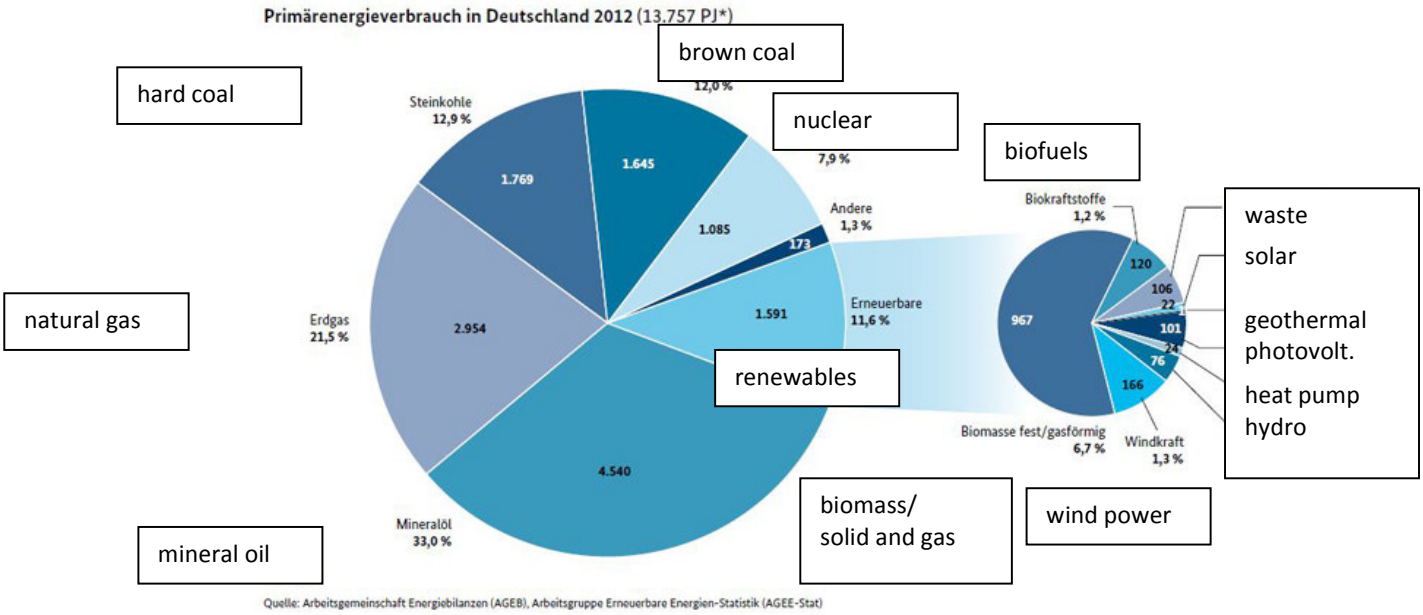


Figure 7: PEC in Germany 2012[18]

Primary energy consumption in Lower Saxony[19]

In 2010, primary energy consumption of Lower Saxony amounted to 1,480 petajoules. The share of renewable energy in primary energy consumption reached 12.3 percent in 2010 (2008: 10.3%).

The final energy consumption (FEC) in Lower Saxony has remained almost constant in recent years. Due to economic fluctuations, FEC has declined in 2009 towards 904 petajoules (PJ). However, in 2010, final energy consumption with 948 PJ returned back to the level of the previous year 2008 (946 PJ) and 2006 (953 PJ). In 2002, the FEC was still at 961 PJ and, hence, slightly decreased since then.

[17] 2013 Bundesministerium für Wirtschaft und Technologie www.bmwi.de; http://www.bmwi.de/DE/Service/suche,did=540366.html

[18] http://www.bmwi.de/BMWi/Redaktion/PDF/E/energiestatistiken-energiegewinnung-energieverbrauch,property=pdf,bereich=bmwi2012,sprache=de,rwb=true.pdf. p1; Arbeitsgemeinschaft Energiebilanzen, Arbeitsgruppe Erneuerbare Energien Statistik

[19] 2013 Niedersachsen.de; http://www.umwelt.niedersachsen.de/umweltbericht/nutzungsfelder/energie/grundlagen/energie-89115.html

2.1.3 Gross electricity generation

Table 2 shows the gross electricity generation in Germany (2011). In the following the focus is held on the gross electricity generation in Lower Saxony.

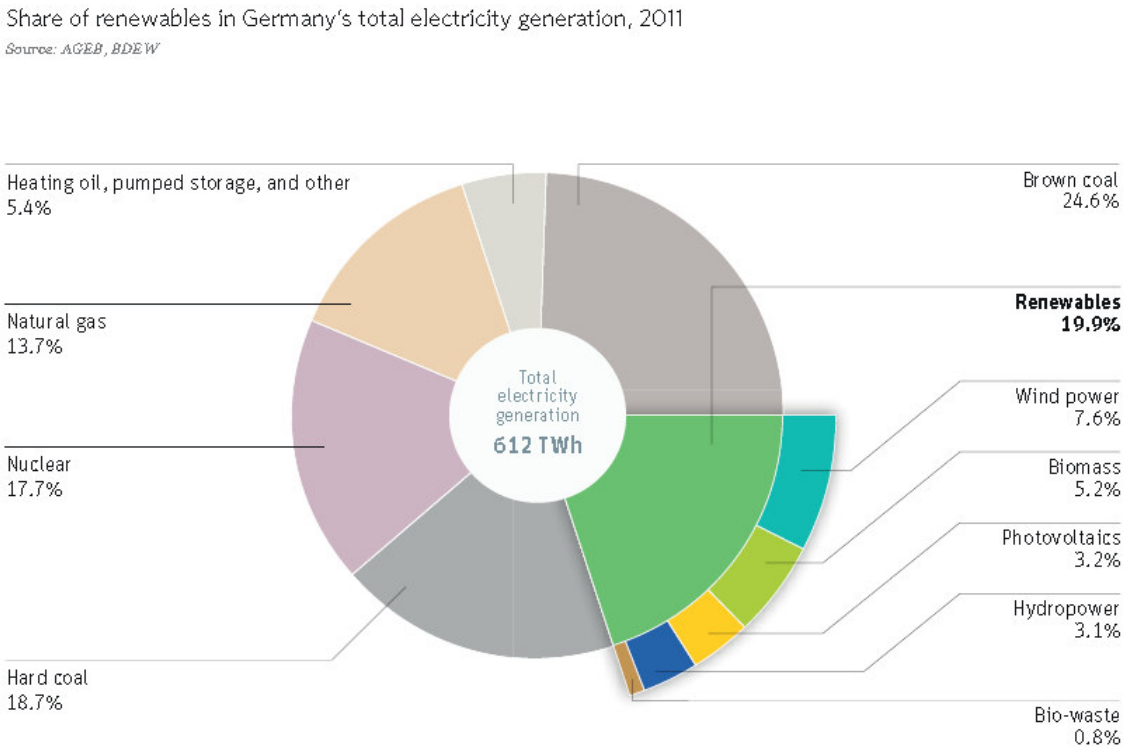


Figure 8: Share of renewables in Germany's total electricity generation[20]

Gross electricity generation in Lower Saxony[21]

The gross electricity generation in Lower Saxony in 2010 was based on almost 46 percent nuclear energy, to approx. 19 percent on hard coal and brown coal, 10.5 percent to oil and gas, and almost 22 percent renewable energy. As for electricity production from renewable energy sources, wind power dominates, followed by biogas and biomass. The proportion of solid biomass and biogas has become firmly established in electricity production from renewable energy sources.

As for house heating in Lower Saxony, natural gas - more than 50 percent of households heat with natural gas -is used primarily, followed by fuel oil, district heating and electricity. Coal is used only to a small extent

[20] 2013 Niedersachsen.de;
http://www.umwelt.niedersachsen.de/umweltbericht/nutzungsfelder/energie/grundlagen/energie-89115.html

[21] 2013 Niedersachsen.de;
http://www.umwelt.niedersachsen.de/umweltbericht/nutzungsfelder/energie/grundlagen/energie-89115.html

2.1.4 The German electricity and gas grid[22]

The German electricity grid

The German electricity grid, across all voltage levels, has a length of nearly 1.6 million kilometres. More than 900 local and regional energy companies organize the distribution of electricity in their network areas.

The electricity flows at different voltage levels through power lines from the power plants to the customers. Low-voltage systems connect small local power consumers such as individual households. At the regional level, electricity is distributed via medium voltage networks. The range of customers includes major consumers such as businesses.

The backbone of the energy infrastructure are the transmission networks. They are the "power highways" of the Republic. These highways transport on the high voltage level of 220 and 380 kilovolts large amounts of electricity over long distances directly from power plants to the distribution networks in the regions. In addition, the transmission networks connect the German electricity grid with that of neighboring countries and, thus, enable the cross-border exchange of energy in Europe. The four transmission system operators (TSOs) 50 Hertz, Amprion, TenneT and EnBW are responsible for the modernization and expansion of high and very high voltage networks in Germany.

Operators and their regulation zones

The transmission network in Germany is historically divided into four regions, so-called regualtion zones. The TSOs are responsible for the high voltage networks in their areas. 50 Hertz operates the high voltage grid in northern and eastern Germany. The net area of Amprion is mainly in the west and southwest. EnBW is responsible for most of the high voltage network in Baden-Württemberg. The network of TenneT pervades throughout Germany, ranging from the Danish border in the north to the Alps in the south. Overall, the transmission network has a length of more than 35,000 kilometers supplying power to the 82 million inhabitants in Germany. For Lower Saxony, the TSO TenneT is responsible.

Natural gas

Natural gas plays an important role with a primary energy consumption share of 21.6% in the energy mix of the Federal Republic of Germany.

For the next few decades natural gas will still make a significant contribution to the energy supply in Germany. By far the most important market for natural gas is still the heat market. Gas today is, however, not focused on the heat market, but characterized - in addition to its function as a base material in the chemical industry - as a flexible and diverse energy source in the heating market, the power generation, energy storage and as a future perspective as storage option for electricity from renewables and mobility. Natural gas compared to other fossil fuels is more climate-friendly, as its use is associated with lower CO_2 emissions.

Biogas (Biomethane) can be refined with appropriate treatment techniques to reach natural gas quality and be fed into existing natural gas networks and, thus, can contribute to relief both in the heat, power and fuel markets.

Natural gas power plants can play an important role in balancing power fluctuations from renewable energy sources, as these are subject to considerable fluctuations depending on the weather and season.

Another important and promising application for the German natural gas grid is the use as a giant storage for several billion kilowatt-hours of energy by converting electricity from renewable

[22] www.netzentwicklungsplan.de

sources into hydrogen or methane and feed into the natural gas grid. Promising research and demonstration projects are running currently with the aim to bring this technology to large-scale operation in the next decade.
Finally, natural gas also plays an increasingly important role in mobility as a cost-effective and environment friendly fuel.
Due to the high import dependence, gas supply security instruments play a central role

The German gas industry[23]

The gas industry in Germany is one of the "infrastructure industries". It is privately organized on three stages:

- Production and import
- Transport and transmission
- Final distribution

In 2012[24], more than 35,500 employees worked in the approximately 900 companies in the gas supply industry.
Further in 2012, about 88 percent of the consumed natural gas was imported mainly from Norway, Russia and the Netherlands (2011: around 86 per cent). In 2011, the energy consumption for gas in Germany amounted to approx. 2.230 petajoules (PJ). The largest consumer group in final energy consumption by sector was industry with approx. 920 PJ (41 %), closely followed by households with approx. 870 PJ (39%).

The third internal market package established a planning instrument at European level for the build up and maintenance of the network infrastructure necessary for the requirements of an internal EU market. The national implementation was carried out in the electricity and gas supply Act (Energy Economy Act – EnWG). Since December 2010 the (EU) Regulation No. 994 / 2010 on measures to ensure the security of gas supply the supply security is in force. The German gas market is characterized by a wide variety of privately organized market actors in the areas of gas networks, storage operations and trade.

[23] http://www.netzentwicklungsplan-gas.de
[24] Federal Statistical Office 2012

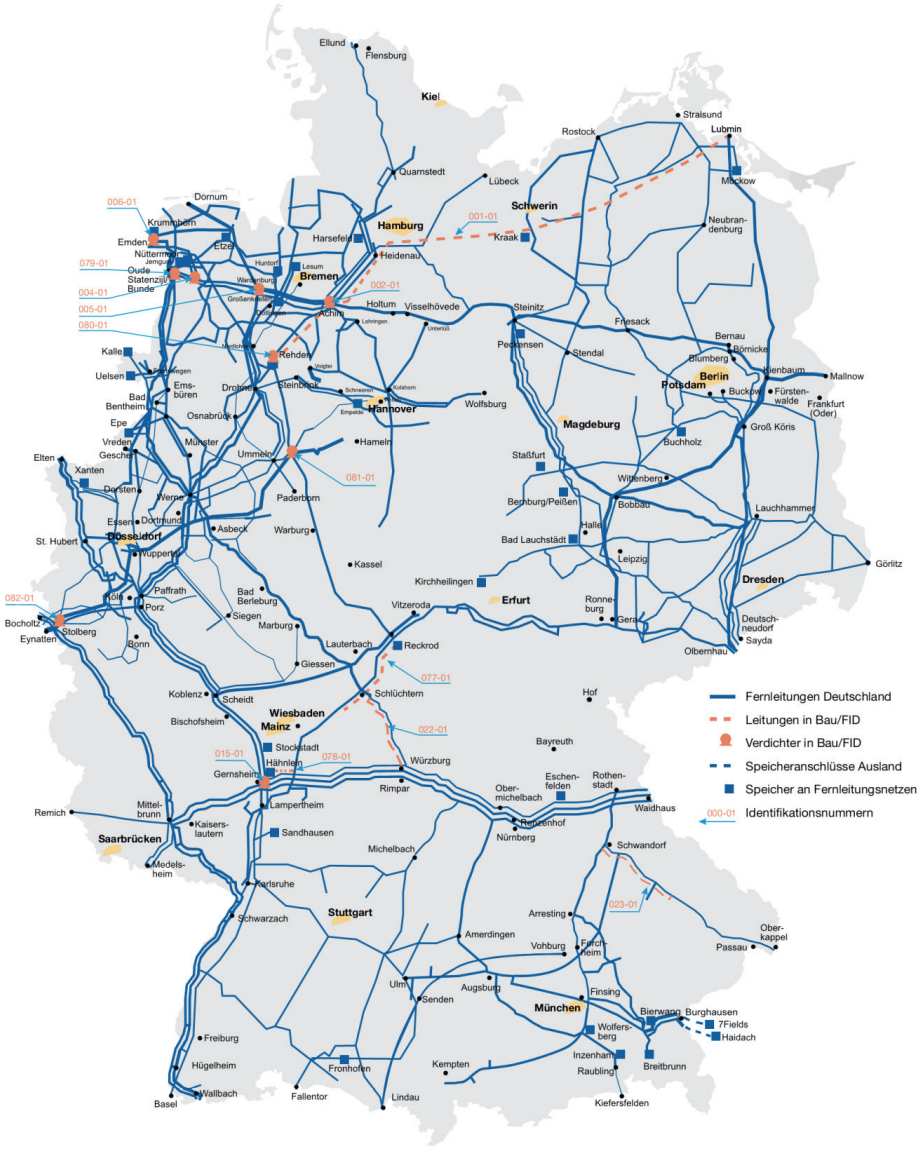


Figure 9: The German gas grid[25]

[25] http://www.netzentwicklungsplan-gas.de; Netzentwicklungsplan Gas 2012 der deutschen Fernleitungsnetzbetreiber; p25

2.2 The Lower Saxony energy system

This sub-chapter delivers a detailed description of Lower Saxony's functional areas in the energy industry and the potential of energy generation and production in Lower Saxony.

2.2.1 Overview of the functional areas in the energy industry[26]

In parts of Lower Saxony the energy industry has gained a significant importance for the regional economy. It is expected that this trend will increase substantially in the coming years, especially in the coastal regions. The structural transformation of the German energy system, the transformation process of energy production from fossil fuels and nuclear energy to energy production from renewable energy sources is becoming a major driver of employment and economic development. In addition to the maritime industry and tourism, the energy industry is on the way to establish itself as a major growth driver especially in the relatively underdeveloped coastal areas.

Within the complex energy industry several functional areas must be distinguished

Supply role for industry and households: Traditionally, municipal utilities and major energy suppliers - in Lower Saxony especially companies such as E.ON and EWE - take over the task of basic supply of electricity, gas and heat. In addition, the manufacturing of machinery and equipment for the electricity supply plays a significant role.

Exploitation and conversion of energy raw materials: A second aspect of the energy industry is the exploitation and conversion of energy raw materials, predominantly mining of stone and brown coal and - to a lesser extent - also the production of oil and natural gas. Lower Saxony plays a leading role throughout Germany in the field of gas and oil production

2.2.2 Regional focal points of energy production in Lower Saxony

The locations of energy utility companies are distributed throughout the entire country (Bundesland). In addition to some 50 municipal utilities, the two major providers E.ON and EWE AG Oldenburg are active on the Lower Saxony market. They supply both industrial and commercial customers as well as households with electricity, gas and heat.

EWE AG is the fifth largest energy provider on the German electricity and gas market, besides the other big providers Vattenfall, RWE, E.ON and EnBW. Furthermore, the municipal utility of Hannover (capital of Lower Saxony) belongs to the larger companies that provide energy. Other municipal public utilities are mainly of regional importance. Some of them dispose of their own power stations to generate electricity or heat and are usually owned by the regional distribution networks for district heating, electricity and gas.

For many providers, the services range has expanded over the last years and went beyond the mere supply of electricity, gas and heat towards e.g. consulting services. With the liberalization of the electricity and gas markets, the municipal utilities no longer have a local monopoly, but are in competition with other trans-regional and national providers. The municipal utilities are focused on maintaining their traditionally close ties with their customers through better and enhanced services.

The territorial focus of power supply is with the large power plants, particularly in the more densely populated regions. These regions are also priority sites of industrial production at the same time. As part of the modernization of power plants complexes, a territorial shift is taking place towards the coastline. The coastal regions are also priorities for electricity production from

[26]Energieland Niedersachsen: Struktur, Entwicklung und Innovation in der niedersächsischen Energiewirtschaft. Eine Studie im Auftrag des Institutes der Norddeutschen Wirtschaft e.V. (2010), p20ff

(onshore and offshore) wind energy as well as for the provision of energy from biogas. By the current structure of the establishment of offshore wind fields, the Lower Saxony coast will continue to grow for the provision of important future energy.

The two renewable energy sources wind and biomass are also widely scattered inland. For wind energy, sites with high wind levels are crucial. Both can be characterized by their high degree of decentralization compared to the traditional structure of large power plants. Particularly for the coastal regions new source and sink concepts have to be developed to react on the production sites from wind, biomass and geothermal energy located in North and North West Germany and the high energy consumption that incurs in the South and West of Germany making it necessary to rethink and adapt the transmission systems

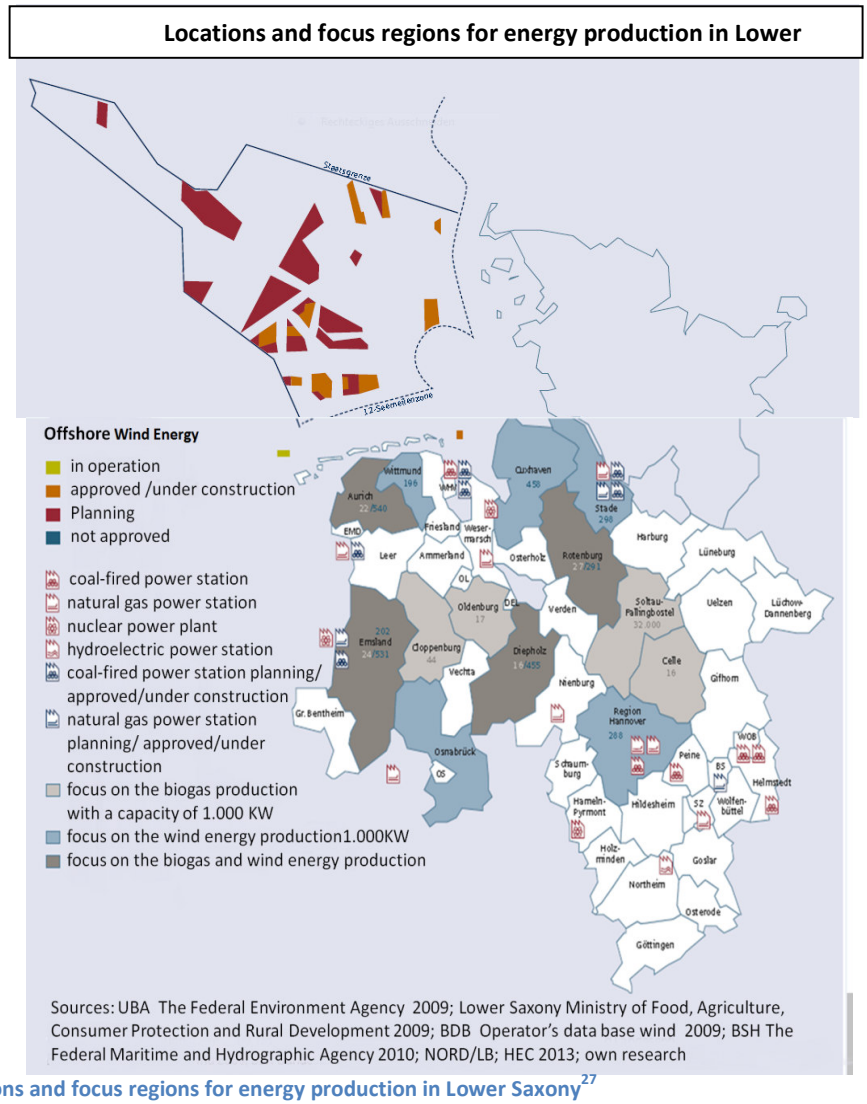


Figure 10: Locations and focus regions for energy production in Lower Saxony[27]

[27] Energieland Niedersachsen: Struktur, Entwicklung und Innovation in der niedersächsischen Energiewirtschaft. Eine Studie im Auftrag des Institutes der Norddeutschen Wirtschaft e.V. (2010), p21f

2.2.3 Potential of energy generation and production in Lower Saxony[28]

The structural change in the German energy production in favor of renewable energy is becoming a driver of value added and employment. The energy sector of Lower Saxony has the potential to provide new economic stimulus, particularly in the rather underdeveloped coastal regions, but also in other rural areas.

Responsible for this are two lines of development: Firstly, a continuation of the wind energy boom in offshore installations (offshore wind parks) is expected in the coming years. On the other hand, new and more efficient clean coal power plants will be constructed. They should preferably be built on the coast or on the banks of the river Elbe close to Hamburg. This is mainly due to the high import rate for hard coal, for which a sea accessibility is a favourable cost factor.

2.2.3.1 Fossil fuels[29][30]

Lower Saxony is one of the regions in Germany in which oil and gas exploitation still has a considerable share. In addition, brown coal is mined in the region of Helmstedt (East Lower Saxony). With the exception of brown coal mining, the amounts of fossil fuels exploited in Germany are relatively low compared with the level of consumption. However, in oil and gas production Lower Saxony has a leading position in Germany (95 percent of Germany's total natural gas production). This means for Lower Saxony that more gas is produced than consumed.

In 2008, 16 percent of the demand of natural gas was covered by production within Germany. However, the overall production rates are declining. Natural gas production in 2006 was 3 percent lower than in 2004. Crude oil production decreased by as much as 7 percent in the same period. In Lower Saxony, many oil fields/ oil reservoirs are known to have been exploited by only 20 to 30 percent. Fossil fuels will continue to be of great importance for the energy supply in the near future. Despite the impressive growth of renewables, coal will continue to play a major global as an energy carrier.

In 2008 in Lower Saxony, stone and brown coal covered more than 13 per cent of primary energy consumption (in Germany a total of nearly a quarter). Mineral oil is the second most important energy source with a 26.5 percent share in primary energy consumption, slightly behind natural gas with 27.6 percent. The natural gas consumption was 2010 approx. 88 billion cubic meters in Germany. Domestic production had accounted for 14 percent of which 95 percent came from Lower Saxony. The most important supply country was Russia (32 per cent), followed by Norway (28 percent).

2.2.3.2 Conventional power plants[31]

Traditionally, Lower Saxony is characterized by a strong and powerful industry. Therefore appropriate power plant capacity has been installed to satisfy the energy demand of the established industry. Currently, there are preparations ongoing in Lower Saxony to plan seven new coal-fired power plants of Stade, Wilhelmshaven, Emden and Dörpen (Emsland). Further to these large power plants a number of smaller coal plants (<100 MW) is in operation in Lower Saxony. In addition, some gas-fired power plants are operated. These are used primarily as peak load power plants.

[28] Energieland Niedersachsen: Struktur, Entwicklung und Innovation in der niedersächsischen Energiewirtschaft. Eine Studie im Auftrag des Institutes der Norddeutschen Wirtschaft e.V. (2010); p25ff

[29] 2013 Niedersachsen.de; http://www.umwelt.niedersachsen.de/umweltbericht/nutzungsfelder/energie/grundlagen/energie-89115.html

[30] Energieland Niedersachsen: Struktur, Entwicklung und Innovation in der niedersächsischen Energiewirtschaft. Eine Studie im Auftrag des Institutes der Norddeutschen Wirtschaft e.V. (2010), p25f

[31] Energieland Niedersachsen: Struktur, Entwicklung und Innovation in der niedersächsischen Energiewirtschaft. Eine Studie im Auftrag des Institutes der Norddeutschen Wirtschaft e.V. (2010), p25f

Table 1: Existing and planned power plants in Lower Saxony (> 50 MW) in 2012)[32]

Existing and planned power plants in Lower Saxony > 50 MW				
Name/ Location	Operator/ company	Capacity (MW)	Operating mode	Expected runtime
Buschhaus/ Helmstedt	E.ON Kraftwerke GmbH	352	Brown coal	2017
Emden	Statkraft Markets GmbH	430	Natural gas	2013
Emsland/ Lingen	KLE GmbH (RWE/ E.ON)	1329	Nuclear	2021
Emsland/ Lingen (B+C)	RWE Power AG	934	Natural gas	ca. 2024
Emsland/ Lingen (D)	RWE Power AG	876	Natural gas	ca. 2050
Stöcken 1+2 Hannover	GKH (Hannover/ VW/ Continental)	230	Hard coal	ca. 2030
Linden Hannover	Stadtwerke Hannover AG	90	Natural gas	ca. 2050
Grohnde/ Emmerthal	GKHK Grohnde /E.ON/ Stadtwerke Bielefeld)	1360	Nuclear	2021
Hallendorf/ Salzgitter 1	Salzgitter AG	253	Natural gas	2025
Heyden /IV) Petershagen	E.ON Kraftwerke GmbH	875	Hard coal	ca. 2027
Huntdorf	E.ON Kraftwerke GmbH	321	Natural gas	2018
Hannover-Herrenhausen	Stadtwerke Hannover AG	87	Natural gas	2020
Mehrum 3 Hohenhameln	Kraftwerk Mehrum GmbH	690	Hard coal	ca. 2020
Robert Frank/ Landesbergen	Statkraft Markets GmbH	487	Natural gas	2013
Stade	Dow Chemical GmbH	193	Natural gas	2013
Wilhelmshaven	E.ON Kraftwerke GmbH	54	Natural gas	ca. 2013
Wilhelmshaven	E.ON Kraftwerke GmbH	757	Hard coal	2022
Wolfsburg Nord	VW KW GmbH	111	Hard coal/ nat. gas	ca. 2035
Wolfsburg West	VW KW GmbH	281	Hard coal	ca. 2035

Figure 11: Locations and focus regions for energy production in Lower Saxony[33]

2.2.3.3 Nuclear power[34]

In Lower Saxony, the use of nuclear energy for electricity generation began in 1968 with the Lingen nuclear power plant. With the nuclear power plants Stade, Emsland and Grohnde the use of nuclear energy in Lower Saxony was developed in the first instance. At peak times, up to two-thirds of the public electricity supply was ensured in this way. In the nuclear power plants in Lower Saxony uranium and a mixture of uranium and plutonium (mixed oxide - MOX) are used as fuel. The mixed oxide fuel comes from the reprocessing of spent fuel and reduces the consumption of fresh uranium fuel.

[32] Power plants in Northern Germany. A review commissioned by the Chamber of Commerce North (2012); p3

[33] Energieland Niedersachsen: Struktur, Entwicklung und Innovation in der niedersächsischen Energiewirtschaft. Eine Studie im Auftrag des Institutes der Norddeutschen Wirtschaft e.V. (2010), p21f

[34] Energieland Niedersachsen: Struktur, Entwicklung und Innovation in der niedersächsischen Energiewirtschaft. Eine Studie im Auftrag des Institutes der Norddeutschen Wirtschaft e.V. (2010); p26

Meanwhile, the phase-out of the use of nuclear energy has begun. Currently, two nuclear power plants - Grohnde and Emsland - are operated along with a nominal capacity of 2,830 megawatts. However, they will be shut down within the next decade.
In particular the shut down times are as follows:

- Nuclear power plant Weser (Unterweser) in August2011
- Nuclear power plant Grohnde in December 2021
- And the Emsland nuclear power plant in December 2022

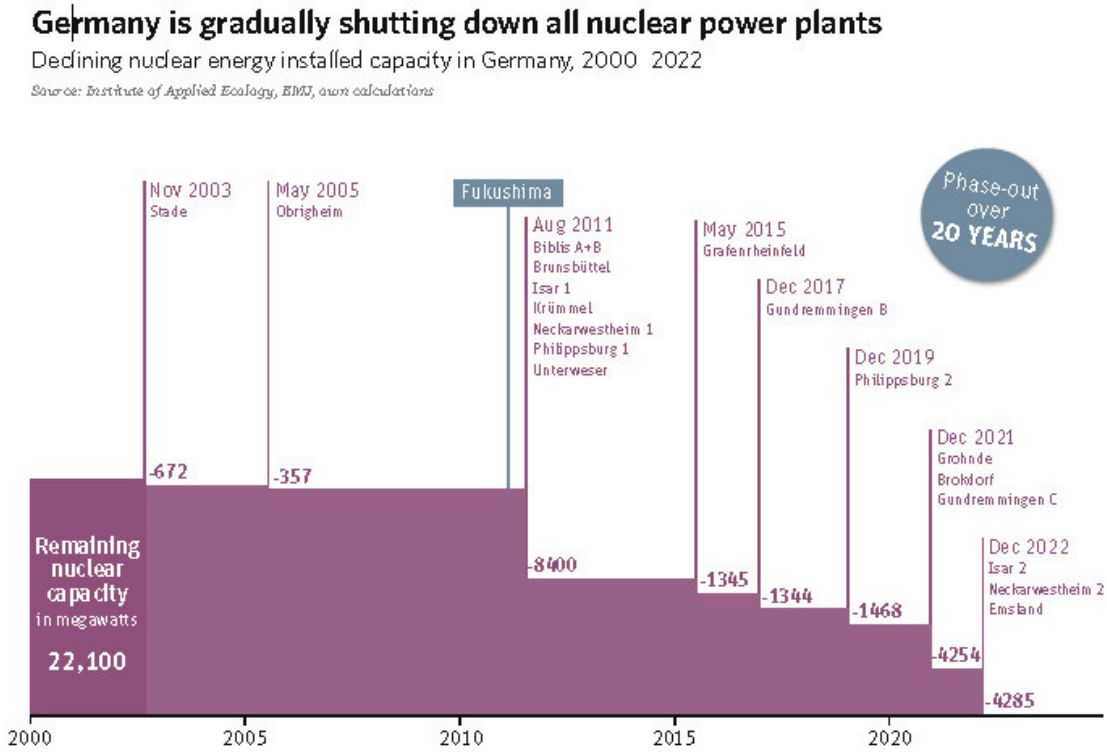


Figure 12: Declining nuclear energy capacity in Germany 2000-2022[35]

2.2.3.4 Wind energy[36]

Wind energy is an essential component of a sustainable energy policy. Therefore, it is essential to further increase the installed wind power capacity in order to reach the target - 100 percent energy supply from renewable energy sources - in Lower Saxony. To achieve growth, older wind turbines are replaced by more modern and more powerful ones (Repowering). Due to the construction of new high performance wind turbines, a larger distance to residential buildings is often required for these installations.

35 Energy Transition - The German Energiewende; Craig Morris & Martin Pehnt; an initiative of the Heinrich Böll Foundation; released on 28 November 2012; www.energytransition.de, p32

36 Energieland Niedersachsen: Struktur, Entwicklung und Innovation in der niedersächsischen Energiewirtschaft. Eine Studie im Auftrag des Institutes der Norddeutschen Wirtschaft e.V. (2010); p26

Comparing onshore wind energy by Bundesländer:
By the end of 2011, one quarter of installed power in Germany is located in Lower Saxony (7.039 out of 29.075 MW)

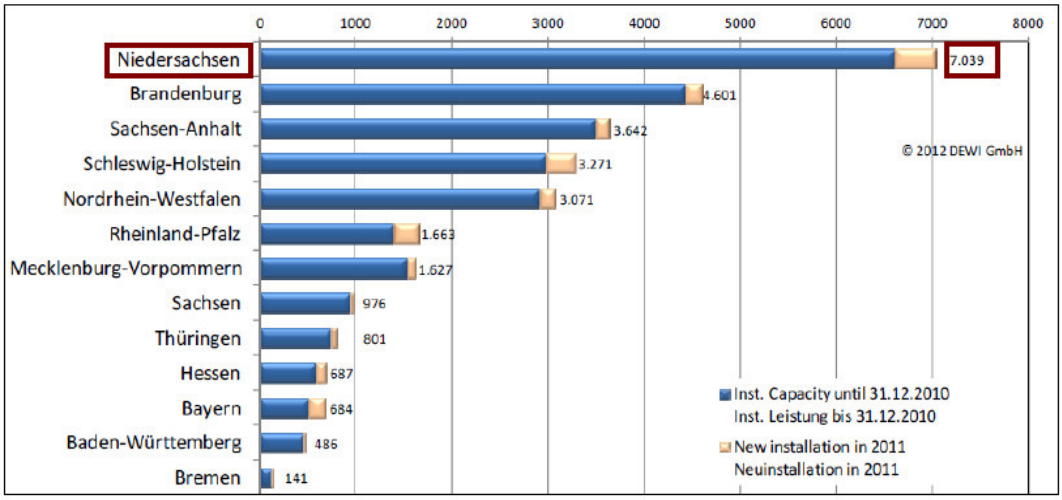


Figure 13: Comparison onshore wind energy by Bundesländer[37]

At the end of the year 2009, 5.268 onshore wind power plants with a total capacity of 6.4 GW of electric power were installed in Lower Saxony. Hence, with 24.9 percent almost a quarter of the total wind power capacity of Germany is currently provided by wind power plants in Lower Saxony. The figure above shows the latest numbers in which this trend continues.

Not only because of the good wind conditions in the North Sea which promise a rich wind energy harvest, the coastal sites are highly interesting when the focus turns to production and installation sites as well as a test field for offshore wind farms. Compared to inland sites, offshore production facilities are especially favored because of the less complicated transportation of parts and components of wind plant parts. Approved so far are 21 offshore wind fields from the Lower Saxony North Sea coast with 1.571 wind turbines with a maximum capacity of more than 7.4 GW of electric power.
Cuxhaven offers a good example. The city at the mouth of the river Elbe is home port for the offshore expansion. Therefore, many companies have settled here. These include inter alia AMBAU (offshore base elements) , CSC Cuxhaven Steel Construction GmbH (components and assembly for offshore foundation bodies) , BIFAB Germany GmbH (production offshore foundation bodies) , Otto Wulf GmbH & Co KG (diving, towage and salvage company), DEWI OCC - Offshore certification Centre GmbH (research, certification), DEWI (onshore test site for offshore wind turbines)
The district of Aurich benefits from the upcoming offshore wind energy boom. Renowned, technologically leading production companies for wind turbines as Enercon, Prokon, Bard and more have their headquarters.

[37] http://www.tfd.uni-hannover.de/fileadmin/redaktion/Vorlesung_Pruefungen/05_Birkner_Klimaschutz_in_Niedersachsen.pdf; p23

The planned wind farms off the German North Sea coast face unique technology challenges, as the offshore wind farms can only be built in relatively great distance from the coast, different to near-shore facilities, e.g. in Denmark and UK. The solution for technical and infrastructural problems associated with a greater water depth, in particular the logistical requirements for the construction of wind farms and in their operation, may give the businesses involved a significant competitive advantage on the global market. In addition, there is another challenge regarding the offshore wind farms grid connection between plant operators and transmission system operators who are obliged to connect the wind farms to the power grid.

In summer 2009 the first units in the two wind farms "alpha ventus" were built and connected to the electricity grid. For the wind farm "alpha ventus", which is designed as a test site, wind turbines with a total capacity of 60 megawatts (MW) will be installed. In the wind park "BARD Offshore 1", at a water depth of up to 40 meters, a total of 80 wind turbines with an overall capacity of 400 MW were be installed in 2010. The timing for the construction of further wind farms also depend on the options for grid connection of the equipment. By 2015 it is expected that offshore wind farms with a total capacity of approximately 3,000 MW will be installed along the German North Sea coast.

The presently ongoing boom in offshore wind turbines creates new jobs, especially for the Lower Saxony North Sea coast. At the end of 2009, about 2,000 people are directly employed in the offshore wind energy industry in Lower Saxony. In the long term, according to estimates by the government of Lower Saxony, 10.000 permanent jobs can be created by the offshore wind energy. In addition, further employment in other branches of industry is generated, e.g. in skilled crafts, trade and service providers who work in the wind energy industry.

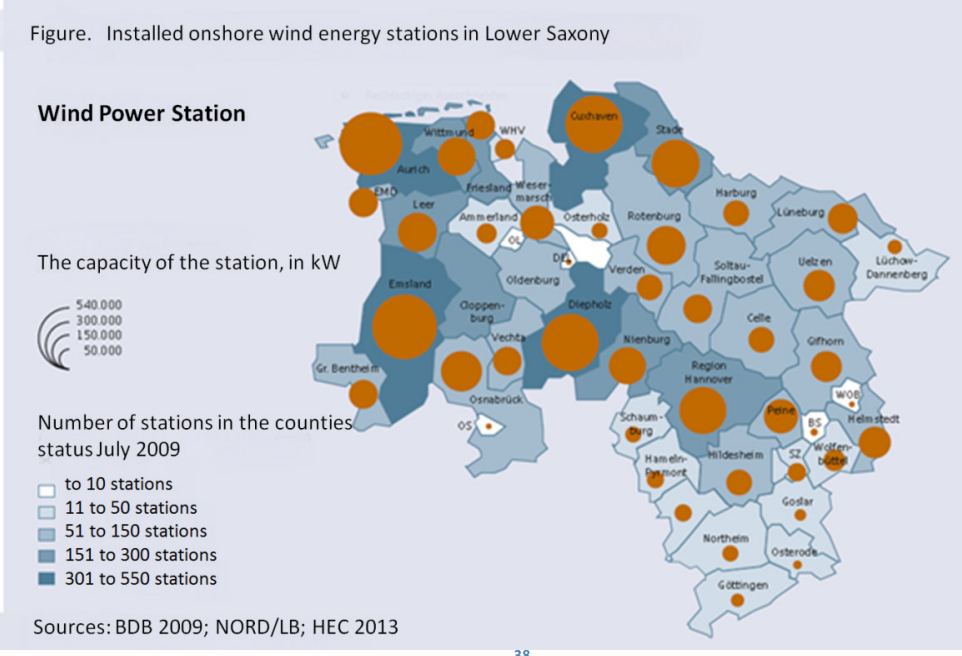


Figure 14: Installed onshore wind energy stations in Lower Saxony[38]

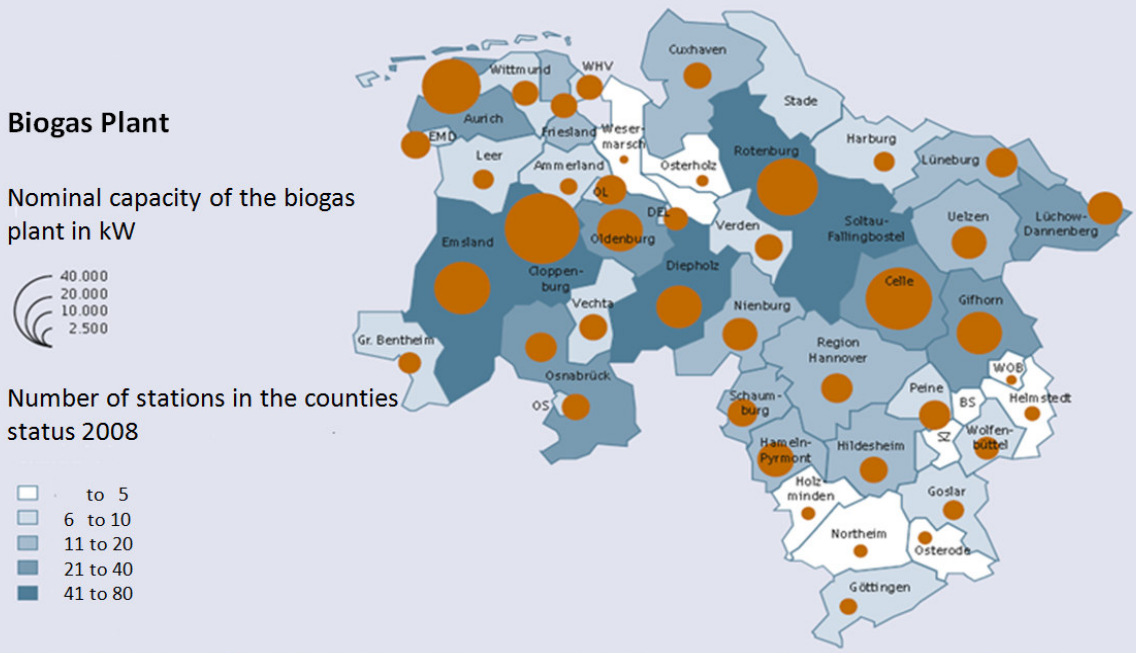
[38] Energieland Niedersachsen: Struktur, Entwicklung und Innovation in der niedersächsischen Energiewirtschaft. Eine Studie im Auftrag des Institutes der Norddeutschen Wirtschaft e.V. (2010); p27

2.2.3.5 Biogas and biomass[39]

Further to wind energy, the production of energy from renewable resources such as heat, electricity, gas or fuel, has taken a remarkable upswing in Lower Saxony in recent years. Biogas is currently used mainly in cogeneration/ combined heat and power (CHP) plants for cogeneration of electricity and heat. The feed-in of upgraded biogas into natural gas networks is of increasing importance and further use as fuel is currently discussed. By mid-2008 3.891 bioenergy plants with an installed total capacity of 1.376 MW in Germany were installed. The nationwide capital expenditure in 2008 was at 500 million Euros. For 2009 780 new plants with about 1 billion Euros of investment were estimated in Germany.

For 2008 in Lower Saxony, a total of 710 biogas plants with a capacity of 365 MW were in operation. In that year Lower Saxony generated nearly a third (32 percent) of overall bioenergy in Germany. Since 2004, the energy has grown rapidly by putting into operation biogas plants. Thus, the area for energy crops has increased by nearly 30.000 hectares to over 200.000 hectares in 2007. In that year (2007) 10.6 percent of the arable land was covered by energy crops. Thus, Lower Saxony is below the national average of 14.9 percent. Although there is still growth potential for bioenergy production in Lower Saxony, further expansion will reach limits, mainly because of the cultivation of energy crops in competition with other forms of use such as food production.

Figure. Installed biogas plants in Lower Saxony



Source: Ministry of Food, Agriculture, Consumer Protection and Regional Development,2008.

Figure 15: Installed biogas plants in Lower Saxony[40]

In 2007, 54 percent of the biogas plants in Lower Saxony had an electrical output of more than 500 kW (516 kW average). By 2010, the share of bio-energy in primary energy consumption in Lower Saxony is expected to increase from 6 percent to 8 percent. The territorial focus of biogas

[39] Energieland Niedersachsen: Struktur, Entwicklung und Innovation in der niedersächsischen Energiewirtschaft. Eine Studie im Auftrag des Institutes der Norddeutschen Wirtschaft e.V. (2010); p27

[40] Energieland Niedersachsen: Struktur, Entwicklung und Innovation in der niedersächsischen Energiewirtschaft. Eine Studie im Auftrag des Institutes der Norddeutschen Wirtschaft e.V. (2010); p28

plants are located in the counties of Cloppenburg, Rotenburg (Wümme), Diepholz, Emsland and Soltau-Fallingbostel. Nearly three-quarters of the plants are concentrated in 15 of the 46 Lower Saxonian counties.

By investing in biogas plants (estimation in recent years range around 800 million Euros), a strong biogas industry has developed in Lower Saxony. Furthermore, renowned German plant manufacturers and component manufacturers have their headquarters in Lower Saxony and here mostly in rural areas.

In addition to the use of biogas in Lower Saxony, further energy production plants with solid biomass fuels, such as fuel wood, timber from landscape management, wood residues from wood processing, recycling wood, are in operation. Furthermore, biofuels such as biodiesel, rapeseed oil fuel, ethanol and biogas produced from renewable raw materials are generated in Lower Saxony.

An important future field of bioenergy use may also be in the field of auto mobility. Biodiesel is well established in the German market for some time already. Volkswagen, one of the world's largest manufacturer of automobiles, has kicked off a major R&D program in the area of natural gas -powered vehicles (EcoFuel).

The feed-in of biogas into the natural gas network is at the beginning of development. In this respect, the use of bioenergy will continue to gain in importance in the coming years. The production of synthetic fuels from biomass in diesel quality is in development

Reference projects known in Europe such as the bioenergy villages Jühnde and Beuchte which cover their electricity and heat demand almost entirely from bioenergy sources, refer to new forms of decentralized and self-contained local energy supply which may become more important in the upcoming future.

2.2.3.6 Hydropower[41]

Hydropower has a very high annual availability with the highest proportions in the winter at peak demand times may thus contribute to the coverage of base load. In Lower Saxony there are about 250 plants that generate electricity by hydropower. Their installed capacity is about 60 megawatts. In Lower Saxony, about 0.4 percent of electricity is covered by hydropower. However, the generation depends on rainfall and fluctuates from year to year. The potential for energy production from hydropower are largely exploited in Lower Saxony. Other projects such as the use of small hydropower plants are discussed. From there, further options could be developed.

2.2.3.7 Solar Energy[42]

Solar energy is also usable in several respects. However, Lower Saxony is not spoiled by sun. Solar radiation is some 15 percent lower than in Southern Germany, with the consequence that the solar yield is correspondingly smaller and the cost of solar electricity is higher. By the end of 2012, 121,484 photovoltaic systems with a capacity of approximately 3,000 megawatts were installed in Lower Saxony

At suitable locations, eg. single-family homes, 50 to 65 percent of the hot water needed each year can be covered by solar energy. During summer, most of the demand for hot water can be provided via the solar system.

[41] 2013 Niedersachsen.de;
http://www.umwelt.niedersachsen.de/umweltbericht/nutzungsfelder/energie/grundlagen/energie-89115.html
[42] 2013 Niedersachsen.de;
http://www.umwelt.niedersachsen.de/umweltbericht/nutzungsfelder/energie/grundlagen/energie-89115.html

2.2.3.8 Geothermal energy[43]

Geothermal energy is a sustainable energy source that is climate-friendly, baseload-capable, decentralized, domestically available and virtually inexhaustible. The potential that geothermal energy holds is neither exhausted in Lower Saxony nor in entire Germany.

The use of near-surface geothermal energy (up to 100 m depth) is used with the technology available today to supply only the heat supply and cooling of buildings. Deeper geothermal resources can also be used to generate electricity. However, the investment costs and finding risks are very high. In addition, there are considerable geological risks in the exploitation of geothermal resources.

Currently, geothermal systems have been used in Lower Saxony with about 10 percent of all new buildings. 7,000 near-surface geothermal heat pump systems with an installed capacity of about 70,000 kilowatts are estimated. In addition to solar thermal systems, condensing boilers and plants with combined heat and power, the use of geothermal heat pumps offer a great growth potential in the heating of building in Lower Saxony.

2.3 Energy generation in the Wachstumsregion Ems-Achse

As mentioned before the energy industry has a long tradition in the region. Besides the power generation from renewables there are 4 fossil power plants:

StatkraftMarkets GmbH Gaskraftwerk Emden	Emden	naturalgas/steamturbine	cold reserve, rated power 430 MW
RWE Power AG Kraftwerk Emsland	Lingen	natural gas	rated power 1.696 MW
BP Europa SE Raffineriekraftwerk Lingen	Lingen	fuel oil/natural and refinery gas	rated power 68 MW
RWE Power AG/E.ON Kernkraft GmbH KKW Emsland	Lingen	uranium	rated power 1.329 MW

Figure 16: Power plants in the Wachstumsregion Ems-Achse[44]

[43] 2013 Niedersachsen.de; http://www.umwelt.niedersachsen.de/umweltbericht/nutzungsfelder/energie/grundlagen/energie-89115.html

[44] Bundesnetzagentur, Kraftwerkliste 2013, http: http://www.bundesnetzagentur.de/SharedDocs/Downloads/DE/Sachgebiete/Energie/Unternehmen_Institutionen/Versorgungssicherheit/Erzeugungskapazitaeten/Kraftwerksliste/Kraftwerksliste_2013.xls?__blob=publicationFile&v=7, as of October 2013

Due to favorable natural conditions and efforts of the public authorities and citizens, the number of renewable power plants is very high already but still increasing, whereas solar and wind energy plants predominate.

Number of plants (renewables)	Waterpower	Wind	Biomass	Solar	total
Aurich		531	47	3.718	4.296
Emden		76	2	363	441
Emsland		488	212	9.208	9.910
GrafschaftBentheim	1	76	51	1.693	1.821
Leer		139	25	2.757	2.921
Wittmund		241	25	1.383	1.649

Figure 17: Number of renewable power plants in different counties of Wachstumsregion Ems-Achse[45]

	Waterpower		Wind		Biomass		Solar		**total**	
	Installed capacity [MW]	Generated power [GWh]	Installed capacity [MW]	Generated power [GWh]	Installed capacity [MW]	Generated power [GWh]	Installed capacity [MW]	Generated power [GWh]	Installed capacity [MW]	Generated power [GWh]
Aurich			640	1.473	19	115	77	59	**736**	**1.646**
Emden			145	334	20	130	8	6	**173**	**470**
Emsland			662	1.093	97	496	284	198	**1.043**	**1.788**
Grafschaft Bentheim	0,05	0,17	117	171	38	248	47	28	**202**	**448**
Leer			152	273	9	37	52	37	**213**	**347**
Wittmund			231	590	11	68	30	23	**272**	**681**

Figure 18: Installed capacity and generated power[46]

[45] Adopted from: Kröcher et al, Potenzialstudie Energieregion Nordwest, Oldenburg/Hannover May 2013
[46] Adopted from: Kröcher et al, Potenzialstudie Energieregion Nordwest, Oldenburg/Hannover May 2013

3 Policies for research and technological development (RTD)

The following chapter is going to give some insights on the existing strategies for research and technical development - from the Wachstumsregion Ems-Achse itself to actors on a regional and national level. Since different funding measures are often linked to these policies, an overview of some relevant programs will be given. These programs are limited to a national and federal state level.

3.1 Clusterstrategy

The Wachstumsregion Ems-Achse is a model of regional economic growth and development with clearly defined and dynamic growth centers. Since the industrial fields of the region are very divers, working groups consisting of the cluster members deal with the different strategic areas (Energy, maritime collective economy, mechatronics, synthetics, logistics, tourism and skills shortage(cross-disciplinary))[47].
With these working and project groups and the individual bodies of Ems-Achse[48], it is possible to develop specific strategies for each area and to constantly question and adjust those if necessary.

In the field of Energy, the strategic core areas are recorded in the Energy Resolution[49] which was signed by the steering committee in April 2008. In general it states that the members and partners of Ems-Achse recognize the opportunity the energy sector offers for the local economy. At the same time the partners are aware of their environmental responsibility and seek to promote the efficient use of energy and the development of renewable energy. Measures and goals which have been decided on are for example:

- Energy management for commercial and public sector
- Increase of energy efficiency in public and private buildings
- Education and benchmarking – for example the annual “Ems-Achse Energy Efficiency Award”
- The public authorities will ensure the prerequisites for planning of renewable energy plants of any kind - today and in the future (repowering of wind energy plants will play a major role)

The resolution is used as a guideline and cluster strategy the members agreed upon.

3.2 Smart Specialization

The counties and cities of the Weser-Ems region and therefore also the Wachstumsregion Ems-Achse want to contribute to optimal frame-conditions for future-oriented economic activity in the north west of Lower-Saxony and have formulated a regional strategy for smart specialization. The strategy "Wissensvernetzung in Weser-Ems 2020" is based on an intensive consultation process that the counties and cities pursued in Weser-Ems for more than a year with proven top-level representatives from business and science in the region. It is aligned with

[47] Compare 3.2 Economy
[48] Managing board, steering group, advisory board
[49] Official name: “Entschließung zur Energieeffizienz und dem Ausbau regenerativer Energieerzeugung in der Wachstumsregion Ems-Achse“

the initial-principles of "smart specialization", which the EU has defined as a prerequisite for the future regional development.
The three fields of action ("Wissensdrehscheiben") are: Energy, Food Industry and Maritime Economy.[50]
It was possible to already interlink this strategy with ENSEA in a first workshop "Wissensdrehscheibe Energie".

3.3 Internationalization

A good portion of the industry members of Ems-Achse are global players and are active at international markets. Based on their experiences we will try to make these strategies accessible to the other members of the cluster who are interested but not yet involved in international business.

Historically, university cooperation and academic exchange has always been focused on internationalization, e.g. in joint international publications, participation in international conferences and joint international projects between academic partners from different countries and continents.
Along with that, the energy research centre has signed several cooperation and project agreements with European and international partners, such as:

- Rome/ Italy
- Edinburgh/ UK
- Stavanger/ Norway
- Groningen/Netherlands
- Sichuan/ China
- Nigeria

Alike with the energy research centre Lower Saxony, the cooperating universities in Lower Saxony

1) Technical University of Clausthal
2) Leibniz University of Hannover
3) Technical University of Braunschweig
4) Georg-August University of Göttingen
5) Carl-von-Ossietzky University of Oldenburg

have a long history of internationalization, cooperation agreements and strategic alliances.
This entire network from energy research centre Lower Saxony including the 5 universities is complemented by the further roll-out of the ENSEA cluster in the future (associated partners).

[50] Arbeitsgemeinschaft der Landkreise und kreisfreien Städte in Weser-Ems, Wissensvernetzung in Weser-Ems 2020, Westerstede, March 2013

3.4 Actors facilitating research and technological development

There is a broad range of actors dealing with innovation on a national and regional level.

Despite the universities, universities of applied sciences and other research institutes, the chambers of crafts, chambers of commerce, the counties and municipalities are offering counselling to facilitate technological development and to stimulate innovation. They address company founders, innovators and mostly SMEs with specific funding programs or guidance.

To facilitate research the federal government and the different states offer a lot of funding possibilities:

„The funding of research in Germany is as diverse and differentiated as the German research landscape itself. The Federal Government and the federal states (Länder) act independently with regard to the funding and organisation of research, although they coordinate their efforts in joint bodies and sometimes in joint initiatives. They are also joined by private donors and companies that provide a high degree of funding for research and development. Additionally, the European Union provides extensive funding for research through a wide variety of measures."[51]

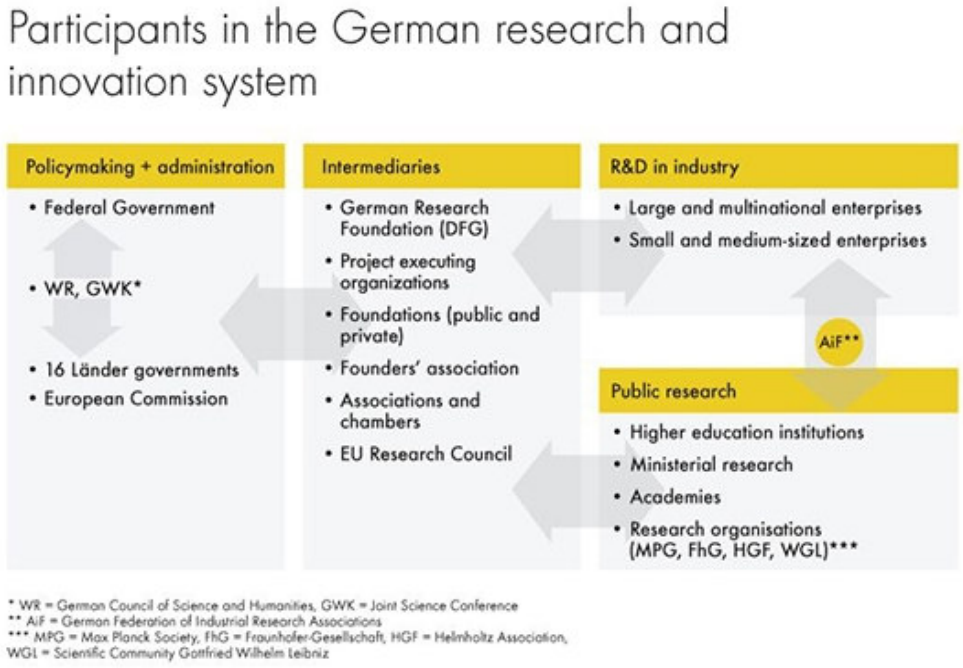


Figure 19: Participants in the German research and innovation system[52]

[51] Research in Germany, Research Funding System, http://www.research-in-germany.de/dachportal/en/Research-Funding/Research-Funding-System.html, as of October 2013

[52] Federal Ministry of Education and Research, How does government funding work, http://www.research-in-germany.de/dachportal/en/Research-Funding/Research-Funding-System/How-does-government-funding-work.html, as of September 2013

3.5 Relevant policies at national and regional level

In 2006 the German Federal Government launched the so called High-Tech Strategy[53]. After 4 years it was decided to continue as High-Tech Strategy 2020 with the aim to create leadmarkets, intensify cooperation between science and industry, and continue to improve the general conditions for innovation. Overall there are 17 areas the strategy is focussing on, concerning „Energy" the most relevant are:

- CO_2-neutral, energy-efficient and climate-adapted cities
- Intelligent restructuring of the energy supply system
- Renewable resources as an alternative to oil

In the governments draft budget for 2014 the funding for projects under the umbrella of the High-Tech Strategy is 2.1 billion Euro, which is 17% more than in 2009.

The administration of Lower Saxony is aiming at promoting innovative advances. "To this end, its Ministry of Economic Affairs, Employment and Transport is launching state-level initiatives in areas of activity that hold particular importance and promise for the federal state's economic development. These initiatives are setup in those fields where a future trend to this effect is discernible, where markets show clear movement in this direction, and where there is existing potential."[54]
The current initiatives are:

- Adaptronics;
- Fuelcell and battery technology;
- Healthcare management - Life Sciences Niedersachsen;
- Microsystem technology;
- Nano-innovations and materials innovations;
- Telematics;
- Satellite navigation (GAUSS);
- Food industry;
- Logistics;
- Aerospace industry, Niedersachsen Aviation

These initiatives persist for usually three years and the state government provides a budget from which innovative projects may be financed.

In the following relevant funding opportunities for research and innovation are described more detailed. The list is not exhaustive but will give an overview of some national and regional programs.

[53] Compare: Federal Government, High-Tech Strategy, http://www.2012.hightech-strategie.de/en/350.php, as of October 2013
[54] LowerSaxony, state-level technological initiatives, http://www.lower-saxony.de/portal/live.php?navigation_id=28550&article_id=99179&_psmand=1016, as of October 2013

3.5.1 National level

On the national level mostly the Federal Ministry of Economics and Technology and the Federal Ministry of Education and Research offer monetary possibilities to facilitate R&D.

Federal Ministry of Economics and Technology:

- **6. Energieforschungsprogramm der Bundesregierung (engl.: 6th Energy-research program of the federal government)**

The program is carried out together with the Federal Ministry of the Environment, Natural Conservation and Nuclear Safety, the Federal Ministry of Food, Agriculture and Consumer Protection and the Federal Ministry of Education and Research.
The strategic focus is on the priority areas renewable energy, energy efficiency, energy storage systems, grid technologies and the integration of renewable energies into the energy system. For the funding period from 2011 to 2014 2.24 billion Euro are/have been available.
Companies, research institutions and universities can apply. Whereas companies have to take 50% of the costs themselves, research partners may get a funding-quota of 100%.[55]

- **BMWI-Innovationsgutscheine (go-inno)**

With these „innovation coupons "the ministry is funding external consultancy services to facilitate innovation and increase competitiveness of companies, including skilled crafts and trades. The coupon will compensate for 50% of the costs. The program is divided into two different areas: "innovation management" and "resource- and material efficiency". The funding is not restricted to certain industries or branches but it is only available to SMEs (in exceptional cases companies with less than 1000 employees may apply).[56]

- **High-Tech Gründerfonds**

Together with partners from German industry, the Ministry of Economics and Technology supports entrepreneurs by financing them "on attractive terms and actively supporting their management teams with a strong network and entrepreneurial expertise"[57]. High-Tech Gründerfonds Management GmbH will provide initial financing of up to 500,000 EUR in the form of a subordinated convertible loan, and acquire a 15% nominal share of the company. They will also reserve a further 1,5 million EUR for follow-on financing. The loan will have a term of 7 years. The contribution of the entrepreneur to the financing must be 20% of the investment.

Eligible for funding are companies located in Germany which have been operating for less than one year and are based on a technological innovation which offers strategic competitive advantages.

- **SIGNO**

This initiative aims at helping universities and SMEs to protect their innovations and make use of them commercially. For both the funding quota is 40%. Universities can apply if they want to development strategies to collaborate with economy or improve the application of research results. SMEs find advice and financial help on how to apply for a patent. There is also an internet-platform where innovations and investors are brought together (www.innovationmarket.de).

[55] Bundesministerium für Wirtschaft und Technologie, Förderdatenbank, http://www.foerderdatenbank.de/Foerder-DB/Navigation/Foerderrecherche/inhaltsverzeichnis.html?get=6d69ab0c2543e7448c16c5345c79c40d;views;document&doc=7510
[56] Bundesministerium für Wirtschaft und Technologie , BMWI-Innovationsgutscheine, http://www.bmwi-innovationsgutscheine.de/go-inno/index.php
[57] High-Tech Gründerfonds Management GmbH, http://www.en.high-tech-gruenderfonds.de/

Federal Ministry of Economics and Technology/Aif - Arbeitsgemeinschaft industrieller Forschungsvereinigungen:

- **IGF – Industrielle Gemeinschaftsforschung**

The overall goal is to bring together basic research and economic application. The program helps SMEs to solve their common problems through joint research activities, mainly carried out by universities and non-profit research institutes. The participants share their results with everyone involved in the projects because they also share the risks.
Cornet - Collective Research NETworking, transnational projects

Federal Ministry of Education and Research:

- **KMU-innovativ**

KMU-innovativ (engl.: SME-innovative) is a program to help SMEs finance world-class research. SME are very often precursors of technological progress but for most of them the financial risks to undertake necessary research activities are too high.
The program is divided into different topics, the one concerning energy is mostly "Technologies for resource and energy efficiency". Funding is available for high-risk industrial research and pre-competitive development projects which are interdisciplinary and application-oriented. The funding rate may rate up to 50%.

- **Zentrales Innovationsprogramm Mittelstand - ZIM:**

This "Central Innovation Program for SMEs" funds individual projects, cooperation projects and so called cooperation-networks with a funding quota up to 45 %.
There is no restriction to topics. Fundable are R&D projects of SMEs to develop new products, procedures or technological services. Within "cooperation-networks" also the management activities of the network is fundable, since a new network is going to be developed around the project activities.

Kfw – Kreditanstalt für Wiederaufbau:

The Kfw is the business development bank of the German federal government and one of the world's leading development banks. The bank is committed to improving economic, social and ecological living conditions all around the world on behalf of the Federal Republic of Germany and the federal states. "KfW committed EUR 29,2 billion worldwide for climate protection and environmental projects in 2012. KfW is Germany's largest environmental and climate bank. As a promotional bank that seeks to initiate new developments with its loans, it is important for KfW to promote sustainable investments that benefit environmental and economic development equally. This is a central theme that also guides its funding activities. For example, KfW does not finance any projects that are likely to have unacceptable ecological or social impacts. For this reason all KfW bonds are so-called "green bonds", which socially responsible investors (SRI) can purchase with a good conscience."[58]
Private customers, companies and public institutions can make use of investment credits with favorable conditions if they meet the different requirements. Usually funded are infrastructural measures but there are also programs for, e.g., education, start-ups or international projects of companies to accelerate innovation in German economy.
One of the different programs is executed with the Federal Ministry of the Environment, Natural Conservation and Nuclear Safety:

[58] KFfW Group, 2000 till today, https://www.kfw.de/KfW-Group/About-KfW/Identität/Geschichte-der-KfW/2000-bis-2010/, as of October 2013

- **BMU Umweltinnovationsprogramm (UIP)**

Funding is available for large-scale technological processes and combination of different processes which reduce or avoid ecological impacts. The technique has to be new or must be combined with other processes in a new way and has to be used the first time in Germany on a large-scale basis. Eligible applicants are domestic and foreign commercial companies in Germany as well as other natural and legal persons of private law, municipalities, counties, community organisations, municipal associations, corporations and other public institutions as well as companies linked to local authorities. However, applications of SMEs are preferred. In this program funding will be provided as interest subsidy to reduce the cost of an by the KfW refinanced bank loan or as an investment grant.

Besides the KfW there is the Landwirtschaftliche Rentenbank, Germany's development bank exclusively for agricultural economy. "The bank focuses on granting standard promotional loans as well as special promotional loans at particularly favourable interest rates for agribusiness and rural areas."[59] The bank offers funding possibilities for energy projects and innovation in the agricultural energy sector in the form of favourable conditions for loans.

3.5.2 Regional level (Lower Saxony)

Ministry of Economics, Labor and Transport:

- **Zukunft und Innovation Niedersachsen**

Goal of the program is to strengthen the innovation capacities of economy in Lower Saxony. It is divided into 5 different areas

A. Technology-based projects dealing with societal problems
B. Dialog between Science, Economy and Civil Society
C. Technology-Contests
D. Collaboration of Schools, Universities and Economy
E. Support of applications for national and EU-programs

The eligibility requirements and funding opportunities differ from area to area.

Ministry for Environment, Energy and Climate:

The ministry is funding research and development of new technologies in the field of renewable energy, energy conservation and fuel cells. It especially supports small and medium-sized enterprises, which develop products of renewable energy and/or innovative techniques for energy efficiency and energy saving measures. Collaborations with universities are desirable.
Emphasis is on the topics:

- Fuel cells
- Energy Saving
- Fuels of the future

[59] Landwirtschaftliche Rentenbank, http://www.rentenbank.de/cms/beitrag/10011592/262501/?, as of October 2013

For SMEs the funding-quota is 45% or less. The funding itself is processed by the N-bank.

N-Bank:

The Investitions- und Förderbank Niedersachsen, or so called N-Bank, is the business development bank of Lower Saxony.

"All federal subsidy schemes aiming to back the regional economy, labour market and education, as well as grants for housing and urban development, are processed centrally in the N-Bank."[60]

There are specific programs for industry, private individuals and public institutions. Several are dealing with innovation and matters of energy efficiency.[61]

[60] NBank, profile english, http://www.nbank.de/_downloads/Die_NBank/NBank_Profile_englisch.doc.pdf, as of October 2013

[61] Nbank, Übersicht Förderprogramme, http://www.nbank.de/Service/Uebersicht_Foerderprogramme.php, Stand October 2013

4 Description of the methodology

The aim of WP2 is to generate metrics that provide insight into the following areas of interest for comparing the ENSEA research driven regional energy clusters (and their parent countries):

- Research strengths in the sector, public institutions
- Research strengths in the sector, private institutions
- Effectiveness of existing linkages and collaborations
- Skills availability
- Talent attraction
- Capacity for EU and international engagement

Additional information was also collected on:

- Background economic data including public and private spending on R&D, numbers of researchers, size of workforce for each of the ENSEA regions (or for the parent country if regional data was unavailable).
- Comparator metrics for a few leading and newly emerging countries (to include China (and the Sichuan region of China).

The collection methods for the ENSEA SWOT analysis were in general:

- Use of a consultant to collect data for all the ENSEA regional clusters using metrics defined in the European Innovation and Regional Innovation Scoreboard
- Desk-based research to capture analyses of aspects of local energy innovation systems and gather relevant statistical material
- Interviews with key institutions in energy research and innovation in the cluster to collect detailed information that is not available from the desk research
- Regional workshops with local companies or Higher Education Institutes (HEIs) to identify any perceived barriers to increased energy innovation and to help evaluate the effectiveness of current research and policy support
- Social Network Analysis to capture the linkages between stakeholders within and between the ENSEA clusters

Since some of the methods did not apply to all of the partners, some measures had to be left out or supplemented accordingly. For example, the methodological framework of the Innovation Union Scoreboard (IUS) and the Regional Innovation Scoreboard (RIS) do not match with regions of the Ems-Achse. It was possible to provide data for Lower-Saxony but one cannot draw conclusions for the cluster region itself from these figures.
For the German partner Wachstumsregion Ems-Achse an intense desk-based research was conducted. As part of the research in order to easily understand and compare the focus of activities in energy within the clusters a matrix was designed to be filled in as much as possible by each region. The purpose of the matrix is to provide a guide for the SWOT assessment activities by identifying levels of triple helix (research, Government and company) activity being carried out by each region. The original Matrix was later used in a simplified form due to problems collecting relevant data and filling it in.

To get the necessary information recent studies were used and a list of companies in the energy industry within the region was prepared and divided into SMEs and non SMEs. In some cases it was possible to obtain turnover and number of employees but since these figures were not available for most of the SMEs it was decided not to make use of them. In addition to a regional workshop with about 100 participants held in September, a survey among the identified companies was conducted. The answers were integrated into the different thematic SWOTs. To get an overview of the research activities of the scientific partners of Ems-Achse, the Energie-Forschungszentrum Niedersachsen also conducted desk-based research and a survey to collect regional data “research strength in the sector”.
Therefore, following the WP2 Matrix agreed among the ENSEA consortium, economic data on public spending was collected and evaluated. The Federal Government in Berlin offers a huge data portal (www.foerderportal.de) in which all funded projects in Germany are listed.
Hence, within the framework of a Boolean search, the project database was analyzed to find out the number of research projects and the amount of funding in each of the Matrix categories. In order to collect respective data the Boolean search was conducted as follows:

- Terms "energy" AND "biomass" for renewable energy and biomass
- Terms "energy" AND "geothermal" for renewable energy and geothermal
- Terms "energy" AND "hydropower" for renewable energy and hydropower
- Terms "energy" AND "offshore wind" for renewable energy and offshore wind
- Terms "energy" AND "onshore wind" for renewable energy and onshore wind
- Terms "energy" AND "solar" for renewable energy and solar
- Terms "energy" AND "marine power" for renewable energy and marine power

The same methodology was applied for all other the categories power plants, grids, etc. including their respective sub-categories, e.g. coal-fired plants, gas and steam plants, biomass plants in the category power plants.

The output was a comprehensive set of data describing amongst others the following items:

- The Ministry Department that enabled the research project, e.g. Federal Ministry of the Environment, Federal Ministry of Economics, Federal Ministry of Finance, Federal Ministry of Agriculture etc.
- The beneficiary including the Bundesland and city where the beneficiary is based
- The executing institution including the Bundesland and city where the executing institution is based
- The topic of the research project
- A short description of the research project in clear text
- The lifespan of the project , i.e. start date and end date (only projects from 2008 onwards were evaluated, those projects that ended before 2008 were taken out of further data processing)
- Total amount (€) that was spent on the research project
- Additional information on the project's profile

In a second step, the data set was further analyzed and processed. Two filter streams were opened in order to be able to describe the overall situation in the Federal Republic of Germany (16 Bundesländer) as well as to describe the situation in the Bundesland at focus, i.e. Lower Saxony.

In order to complement the study, the following 5 major universities and technical universities based in Lower Saxony and with their respective Departments that are aligned with energy topics and being part of the structure of the Energy Research Centre of Lower Saxony were surveyed both by direct contact and interviews:

1. Technical University of Clausthal
2. Leibniz University of Hannover
3. Technical University Carolo-Wilhelmina of Braunschweig
4. Georg-August University of Göttingen
5. Carl-von-Ossietzky University of Oldenburg

The data feedback from the university survey together with the Federal Government database analysis was then merged and summarized. From there, the data was transferred to the simplified regional matrix describing the role of research in terms of number of projects in the respective field of research as well as the round figure of money spent on the research(quantitative data).

The figures provided give an overview of the number of research projects concerning energy, the research topics and the round figure of funding.
All results were used to prepare the following SWOT-analyses.

5 SWOT Analysis

For the Wachstumsregion Ems-Achse different SWOT analyses have been created – the first reflects the cluster in the context of the German energy transition and further SWOTs cover the different economic focus points of the energy sector in the region. This was regarded necessary because the region covers various types of renewable energy generation which are basically different in technical aspects and also have different requirements.

5.1 Ems-Achse overall

Strengths	Weaknesses
▪ Dynamic economic development, headquarter of large companies ▪ Good interregional transport connection ▪ Moderate location-related costs for companies ▪ High quality of life in the region, partially tourist region ▪ existence of various industry networks, also in the area of energy efficiency and energy in general ▪ highly developed corporate structure concerning renewable energy; emphasis on: - Wind energy - Bio energy - Solar energy - Energy storage – underground - Technology providers in the field of energy supply/infrastructure - Energy hub for fossil energy ▪ Implementation of large energy projects (in a regional and international context)	▪ Low density of universities and research institutions (in Ems-Achse region) ▪ Partially significant demographic change with stagnation of population number

Opportunities	Threats
▪ Interdisciplinary and cross-sectoral approaches may increase competitiveness in the region ▪ Further development of networking and cooperation promotes capacity for innovation and the region's profile ▪ Target-oriented training and education of employees ▪ Increase of technology transfer to SMEs ▪ Internationalization offers new opportunities for growth and new markets for economy ▪ Development of a clear profiling strategy	▪ Demographic change and growing qualification requirements of the economy increase the competition for skilled employees ▪ International competition requires a clearly defined profiling strategy of the regions ▪ Increasing cost pressure in the area of production ▪ Developments on the energy market ▪ Developments on the financial market – availability of investment funds

5.2 Wind Energy

Strengths	Weaknesses
▪ Wind energy is a central element of the German „Energiewende" ▪ Important location for wind power generation ▪ location of important technology providers with a high level of vertical manufacturing and worldwide sales and distribution[62] ▪ Corporate structure with a high proportion of SMEs in project planning and construction ▪ Offshore wind energy under development ▪ Location of ports with expertise in the offshore industry and logistics ▪ Innovation capability of companies ▪ Regional production conditions ▪ High regional involvement of companies ▪ Strong reliable industry networks ▪ <u>Research activities:</u> FORWind Centre for wind energy research Offshore: - Modelling of wind fields - Wind performance forecast systems based on energy meteorology (interface between renewable energies and atmospheric physics) Onshore: - Cross-linked multi-phase transport techniques (subsea, off-/ onshore) - Onshore wind atlas for Germany	▪ Complex and diverse business areas demand high standards from the qualification of employees – a huge demand for highly specialized and interdisciplinary skilled workers is generated ▪ Increasing use of repowering possibilities ▪ Due to a lack of storage technologies wind power cannot be used as base load ▪ Offshore technology is very capital-intensive

[62] Kröcher et al., Potenzialstudie Energieregion Nordwest, Oldenburg/Hannover Mai 2013, p. 74.

Opportunities	Threats
▪ Growth spurt from offshore; ▪ New priorities of funding strategies ▪ Economical implementation of existing research to applicable technologies ▪ Development of qualification strategies, if possible already during first education (training on the job, university, apprenticeship etc) ▪ Strengthening and further cooperation of industry networks and cluster ▪ Support of the Triple Helix-approach ▪ Development of suitable storage methods ▪ Power to Gas	▪ Strongly dependent on regulations ▪ Uncertainties concerning connection to the grid (offshore) ▪ High costs and risks in the offshore-sector ▪ Developments on the energy market ▪ Spatial concentration of production of plants ▪ Slow network expansion (grid) ▪ Other legal restrictions ▪ Complex approval and licensing procedures ▪ Access to investment funds - financial markets ▪ Continuation of German „Energiewende“ ▪ Political uncertainties ▪ location of onshore-wind energy plants, authorization process ▪ Amendments of the Erneuerbare Energien Gesetz (EEG) ▪ Lack of qualified personnel ▪ Need, requirement of land and competition for areas ▪ Power generation varies considerably with wind regime

5.3 Bio Energy

Strengths	Weaknesses
▪ The region is a leading generation site as well as a location of technology providers[63] ▪ Innovation capability of companies ▪ Regional production conditions ▪ High regional involvement of companies ▪ Strong reliable industry networks ▪ Research activities: - Bionics: Implementation of natural fermentation of input materials into technical solutions - Genetics: Genetic increasing of the carbon content in the power plant - Optimization of process control of biogas plants - 2nd generation biofuels (BtL) - Sustainability assessment	▪ Complex and diverse business areas demand high standards from the qualification of employees – a huge demand for highly specialized and interdisciplinary skilled workers is generated ▪ Corporate structures characterized by small and medium-sized businesses - problem for internationalization strategies[64] ▪ Increasing risk because of shortage in raw material supply ▪ Declining profitability of investments/cost effectiveness of plants depending on the legal framework (EEG-German Renewable Energy Law)
Opportunities	**Threats**
▪ New perspective: direct marketing[65] ▪ Provider of balancing energy ▪ Important role in ensuring the base load in regional virtual power plants ▪ Economical implementation of existing research to applicable technologies ▪ integration of waste management in energy supply offers great potential ▪ Development of qualification strategies, if possible already during first education (training on the job, university, apprenticeship etc.) ▪ Strengthening and further cooperation of industry networks and cluster ▪ Support of the Triple Helix-approach	▪ Non acceptance of local residents ▪ Developments on the energy market ▪ Slow network expansion (grid) ▪ Other legal restrictions ▪ Complex approval and licensing procedures ▪ Access to investment funds - financial markets ▪ Continuation of German „Energiewende“ ▪ Political uncertainties ▪ Amendments of the Erneuerbare Energien Gesetz (EEG) ▪ Lack of qualified personnel ▪ Emergence of overcapacities – a significant expansion of capacities is not expected ▪ Conflicting uses of input materials for biogas plants with comestible goods and land usage ▪ Reasonable utilization of digestates

[63] Kröcher et al., p. 134.
[64] Kröcher et al., p. 14.
[65] Kröcher et al., p. 106.

5.4 Solar Energy

Strengths	Weaknesses
▪ It is possible to integrate solar panels in already existing structures (for example roof areas). There are no conflicts with other kinds of utilization ▪ Very large numbers of diverse companies in the region ▪ Strong user- and service-orientation of enterprises ▪ Innovation capability of companies ▪ Regional production conditions ▪ High regional involvement of companies ▪ Strong reliable industry networks ▪ Research activities: - Sun house concept (vessel-solar-combination, small-scale storage) - Next generation silicon wafer cells	▪ Lack of open area (large-scale) plants ▪ Large numbers of small photovoltaic units ▪ Trend to overcapacities of products, but technology providers are rare ▪ Complex and diverse business areas demand high standards from the qualification of employees – a huge demand for highly specialized and interdisciplinary skilled workers is generated ▪ Declining profitability of investments/cost effectiveness of plants depending on the legal framework (EEG-German Renewable Energy Law) ▪ Significant power fluctuations depending on the weather
Opportunities	**Threats**
▪ Economical implementation of existing research to applicable technologies ▪ Development of system solutions in the field of PV combined with storage options for the user ▪ Increase of efficiency ▪ Development of qualification strategies, if possible already during first education (training on the job, university, apprenticeship etc.) ▪ Strengthening and further cooperation of industry networks and cluster ▪ Support of the Triple Helix-approach Development of suitable storage methods	▪ Local conditions rather disadvantageous (sunshine duration) ▪ Particularly dependent on national policy of subsidies ▪ High risk due to storm damage (for example hail) ▪ Costs of electricity are high compared to other technologies ▪ Increasing number of trade rivals worldwide ▪ Developments on the energy market ▪ Slow network expansion (grid) ▪ Other legal restrictions ▪ Complex approval and licensing procedures ▪ Access to investment funds - financial markets ▪ Continuation of German „Energiewende“ ▪ Political uncertainties ▪ Amendments of the Erneuerbare Energien Gesetz (EEG) ▪ Lack of qualified personnel

5.5 Geothermal Energy

Strengths	Weaknesses
▪ Favorable natural conditions[66] ▪ Geothermal energy is available at any time - base load provision is possible ▪ Research activities: - Energy atlas CCS vs. deep ground geothermal energy - Research alliance on geothermal energy and high performance drilling (GEBO) - Drilling Simulator Celle	▪ As generation site as well as a location of technology providers of minor importance ▪ Exploration is expensive
Opportunities	**Threats**
▪ Development potential for energy production (capabilities for base load) ▪ Part of the concept for the German "Energiewende" ▪ Economical implementation of existing research to applicable technologies ▪ Development of qualification strategies, if possible already during first education (training on the job, university, apprenticeship etc) ▪ Strengthening and further cooperation of industry networks and cluster ▪ Support of the Triple Helix-approach	▪ Local acceptance issues of large-scale applications (Uncertainty of geophysical reactions) ▪ Developments on the energy market ▪ Slow network expansion (grid) ▪ Other legal restrictions ▪ Complex approval and licensing procedures ▪ Access to investment funds - financial markets ▪ Continuation of German „Energiewende" ▪ Political uncertainties ▪ Amendments of the Erneuerbare Energien Gesetz (EEG) ▪ Lack of qualified personnel

[66] According to: Geodatenzentrum Hannover, Nibis-Kartenserver, http://nibis.lbeg.de/cardomap3/?TH=545.314, asof September 2013.

5.6 Marine Power

Strengths	Weaknesses
	▪ Little potential ▪ Particularly strong competition with other uses
Opportunities	**Threats**
▪ Long-term perspectives ▪ Synergies between energy and maritime economy	▪ Growing acceptance issues concerning large-scale projects

5.7 Hydro Power

Strengths	Weaknesses
▪ Pump storage power plants can be run highly flexible ▪ High efficiency, up to 95% ▪ Low costs of operation ▪ Longevity ▪ Research activities: - Mini-hydropower stations	▪ Little development potential in Lower Saxony due to topography
Opportunities	**Threats**
▪ European cooperation in the area of hydro power	▪ Growing acceptance issues concerning large-scale projects

5.8 Fossil Energy

Strengths	Weaknesses
▪ Region is important location for conventional power plants ▪ National importance in converting – region as energy hub[67] ▪ Innovation capability of companies – development of new business areas ▪ Regional production conditions ▪ High regional involvement of companies ▪ Strong reliable industry networks ▪ <u>Research activities:</u> - Post-combustion CO_2 separation - Efficient transformation of fossi energy carriers in power plants - power plant simulation	▪ Finite energy source in the long run ▪ Complex and diverse business areas demand high standards from the qualification of employees – a huge demand for highly specialized and interdisciplinary skilled workers is generated
Opportunities	**Threats**
▪ Economical implementation of existing research to applicable technologies ▪ Development of qualification strategies, if possible already during first education (training on the job, university, apprenticeship etc.) ▪ Strengthening and further cooperation of industry networks and cluster ▪ Support of the Triple Helix-approach	▪ Growing number of coal-fired power stations is not likely ▪ Declining acceptance concerning winning and production ▪ Developments on the energy market ▪ Slow network expansion (grid) ▪ Continuation of German „Energiewende“ ▪ Political uncertainties ▪ Lack of qualified personnel

[67] Kröcher et al., p. 27.

5.9 Energy Storage

Strengths	Weaknesses
▪ Region is leading in underground storage ▪ Favorable geological conditions for underground storage[68] ▪ Innovation capability of companies – development of new business areas ▪ Regional production conditions ▪ High regional involvement of companies ▪ Strong reliable industry networks ▪ Research activities: - Battery test centre for electro mobility and energy storage - POWER TO GAS and other energy storage schemes to store and utilize renewable energy - Underground pumped storage stations - Compressed air storage	▪ Complex and diverse business areas demand high standards from the qualification of employees – a huge demand for highly specialized and interdisciplinary skilled workers is generated
Opportunities	**Threats**
▪ Growing need for storage technologies ▪ Economical implementation of existing research to applicable technologies ▪ Development of qualification strategies, if possible already during first education (training on the job, university, apprenticeship etc.) ▪ Strengthening and further cooperation of industry networks and cluster ▪ Support of the Triple Helix-approach ▪ Power to Gas ▪ Further development of hydrogen technology, storage of hydrogen in caverns[69]	▪ Growing acceptance problems ▪ Developments on the energy market ▪ Slow network expansion (grid) ▪ Continuation of German „Energiewende“ ▪ Political uncertainties ▪ Amendments of the Erneuerbare Energien Gesetz (EEG) ▪ Lack of qualified personnel

[68] Accordingto Landesamt für Bergbau, Energie und Geologie, Salzlagerstätten, http://www.lbeg.niedersachsen.de/portal/live.php?navigation_id=665&article_id=555&_psmand=4, as of September 2013.
[69] Crotogino, Hamelmann, Wasserstoff-Speicherung in Salzkavernen zur Glättung des Windstromangebots, http://www.ipp.mpg.de/ippcms/ep/ausgaben/ep200802/bilder/wasserstoff_speicher.pdf, as of August 2013

5.10 Energy Supply/Infrastructure

Strengths	Weaknesses
▪ A large share of the distribution networks belongs to regional/local actors ▪ Leading technology providers (cable manufacturing, computer science for power and energy systems)[70] ▪ Central »hot spot« in the international distribution system, especially for Norway/ Scandinavia ▪ Innovation capability of companies – development of new business areas ▪ Regional production conditions ▪ High regional involvement of companies ▪ Strong reliable industry networks ▪ <u>Research activities:</u> - Sustainable planning of low voltage utility grids (e-home) - ICT infrastructure for reliable electricity supply along with decentralized power generation (Smart Nord)	▪ Complex and diverse business areas demand high standards from the qualification of employees – a huge demand for highly specialized and interdisciplinary skilled workers is generated ▪ Load management relatively inflexible in base load operation so far
Opportunities	**Threats**
▪ Internationalization of the power grid infrastructure ▪ Smart Grids ▪ Gas network essential for the German "Energiewende" ▪ Power to Gas - Technology ▪ Decentralized power generation by gas-fired plants ▪ Economical implementation of existing research to applicable technologies ▪ Development of qualification strategies, if possible already during first education (training on the job, university, apprenticeship etc) ▪ Strengthening and further cooperation of industry networks and cluster ▪ Support of the Triple Helix-approach	▪ Growing acceptance problems concerning network expansion ▪ Garantie of network security ▪ Slow network expansion (grid) ▪ Continuation of German „Energiewende" ▪ Political uncertainties ▪ Lack of qualified personnel

[70] Kröcher et al., p. 136.

5.11 Triple-Helix Matrix

Based on the data of the different SWOTs and the background studies which were used the following preliminary findings have been drawn about the relative strengths of Wachstumsregion Ems-Achse and Science represented in Lower-Saxony. The focus is on thematic areas identified as being of interest for the ENSEA-partnership as a whole.

Explanatory notes:

- In the column “Science Lower Saxony” the number of projects and the overall amount of funding are listed, both for Lower-Saxony and for Germany in brackets underneath.
- The “Government” column is describing the responsibilities and tasks of the local authorities.
- The company column shows the number of SMEs and non-SMEs working in that field in the Ems-Achse region.

The colors express
Green: Expertise for further development
Amber: Basis for further development
Red: Limitations or relevant only to a limited extent
Grey: Not applicable

Themes	Science Lower Saxony	Government	Company base Ems-Achse	Overall for region
Supply flexibility	19 projects/ 10.7M€ (D: 292/ D: 193.4M€)	Municipal energy providers covering renewable and conventional energy production	Non-SMEs 17 SMEs 15	
Storage	126 projects/39.9M€ (D: 603/ D: 474.2M€)	Authorization processes Public hearings/concerns of the public Realization of Interreg IVa project NEND-Nachhaltige Energie Niederlande Deutschland (8 M€)	Non-SMEs 6 SMEs 1	
Carbon Capture & Storage		Moratorium until 2015 (in Lower Saxony)		
Demand flexibility	n.a.	Climate Center North- energy efficiency cluster for SMEs Emsländische Energieeffizienz Agentur energy efficieny regulations for public buildings Ems-Achse Energy Efficiency Resolution Realization of Interreg IVa project NEND-Nachhaltige Energie Niederlande Deutschland and HEC-Hansa Energy Corridor (1.2 M€)	Non-SMEs 3 SMEs 5	
Grid / Infrastructure	6 projects/ 1.2M€ (D: 39/ D: 15.2M€)	Authorization processes, but limited by Federal Net Agency Public hearings/concerns of the public	Non-SMEs 12 SMEs 13	Dependent on speed of grid/system expansion
Integration Methods	23 projects/n.a.	growing importance		Currently only academic focus
Boundary Conditions	all faculties are involved in the topic, very broad range	development and implementation of regional funding programs Execution of region, national and European funding programs Counselling for start-ups and SMEs Municipal climate protection programs EEG-German Renewable Energy Law (Federal)	Not applicable	

Renewable generation	180 projects/ 129.1M€ (D: 1.758/ D: 1.004M€)	Authorization processes Public hearings/concerns of the public Realization of Interreg IVa project Hansa Energy Corridor	Non-SMEs 23 SMEs 243	
In Detail				
Wind onshore	10 projects/ 5 M€ (D: 25/ 11,9 M€)	Realization of Interreg IVa project HEC-Hansa Energy Corridor (1.2 M€)	Non-SMEs 6 SMEs 25 Windparks 19	
Wind offshore	50 projects/ 60,5M€ (D:244/ 179,4 M€)	Realization of Interreg IVa project HEC-Hansa Energy Corridor (1.2 M€)	Non-SMEs 5 SMEs 15	
Solar	75 projects/ 43,6 M€ D: 1.070/ D:627 M€	Realization of Interreg Iva project NEND-Nachhaltige Energie Niederlande Deutschland (8 M€)	Non-SMEs 4 SMEs 91	
Geothermal	12 projects/12,4 M€ D: 62/ D:45,1 M€		Non-SMEs 1 SMEs 1	
Biomass	33 projects/ 7,5 M€ D: 342/ D: 134,5 M€	Realization of Interreg IVa project NEND-Nachhaltige Energie Niederlande Deutschland (8 M€) GroenGas(8 M€)	Non-SMEs 5 SMEs 37	
Hydro	D:12/ D: 4,1 M€			
Marine Power	D:3/ D: 0,9 M€			
Engineers, consultants etc.			Non-SMEs 2 SMEs 55	

6 Summary & Conclusion

The Wachstumsregion Ems-Achse, with its diverse activities and competencies in the energy sector, has emerged as a location of renewable energy in a relatively short period of time. Through the cooperation with the EFZN the scientific know-how could be expanded for the region in addition to the existing scientific institutions and universities.

The research for WP2 has shown that companies in the Ems-Achse region have a good innovation development and are widely linked within the industrial sector. Furthermore, it can be stated that the special situation in Germany with enacting the “Erneuerbare Energien Gesetz” (Renewable Energy Law) has brought a positive stimulus to the development of innovation in the field of renewable energy.

At the same time, funding and support programs in the field of energy have been provided – in the scientific as well as in the scope of federal and state governments. Within the Wachstumsregion Ems-Achse energy projects involving the complete triple helix, business, science and politics/administration were consistently implemented successfully. This has also significantly contributed to the apparent good performance of the Ems-Achse region.

However, a successful energy transition in Germany requires even greater efforts of system integration or balancing of our energy system than today. Also, the system expansion should be pursued to the required extent. Grid stability and system security and the promotion of the development and testing of suitable storage methods have to play a central role in our efforts.

The set of SWOT analyses shows very vividly the strengths and weaknesses, but also the opportunities and risks of the Wachstumsregion Ems-Achse. It is essential to benefit from these strengths and opportunities at a local level and to extend and develop them further in an international context together with our partners in the ENSEA-region. Likewise, common solutions are developed to diminish risks and provide expertise as required from the stakeholders in the region. This step takes place in the creation of a so-called Joint Actions Plan.

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