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Analysis of energy context: County of Osterholz

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Baseline Paper

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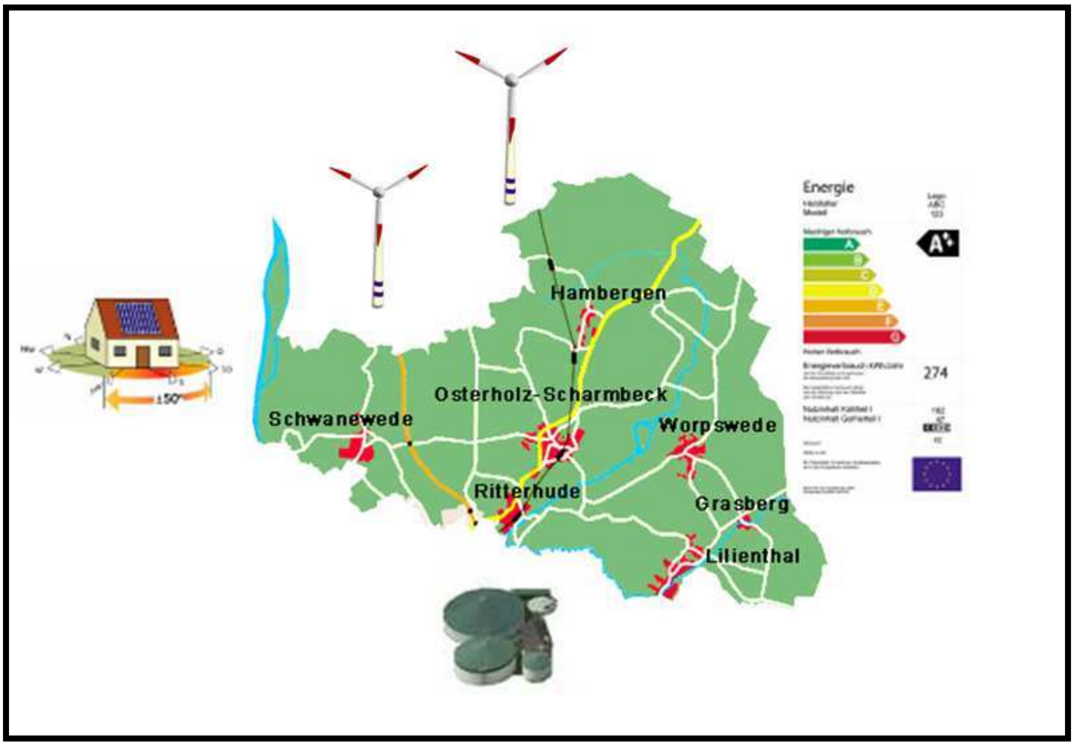

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Content

1 Introduction

1.1 Background of the study

Our current global energy supply (electricity, heat and fuel) is based on the fossil fuels coal, gas, oil and uranium. These raw materials are going to run out in the foreseeable future. At the same time the global energy demand is increasing. The logical consequence of rising demand and declining supply are increasing prices. The dwindling fossil fuel reserves are also situated in a few countries in the world. The other countries are experiencing increasing energy import dependence as well as the financial burden of rising energy costs. A supply of safe and affordable energy is one of the most important conditions for a stable economy. An energy supply based on fossil fuels can no longer offer this perspective.

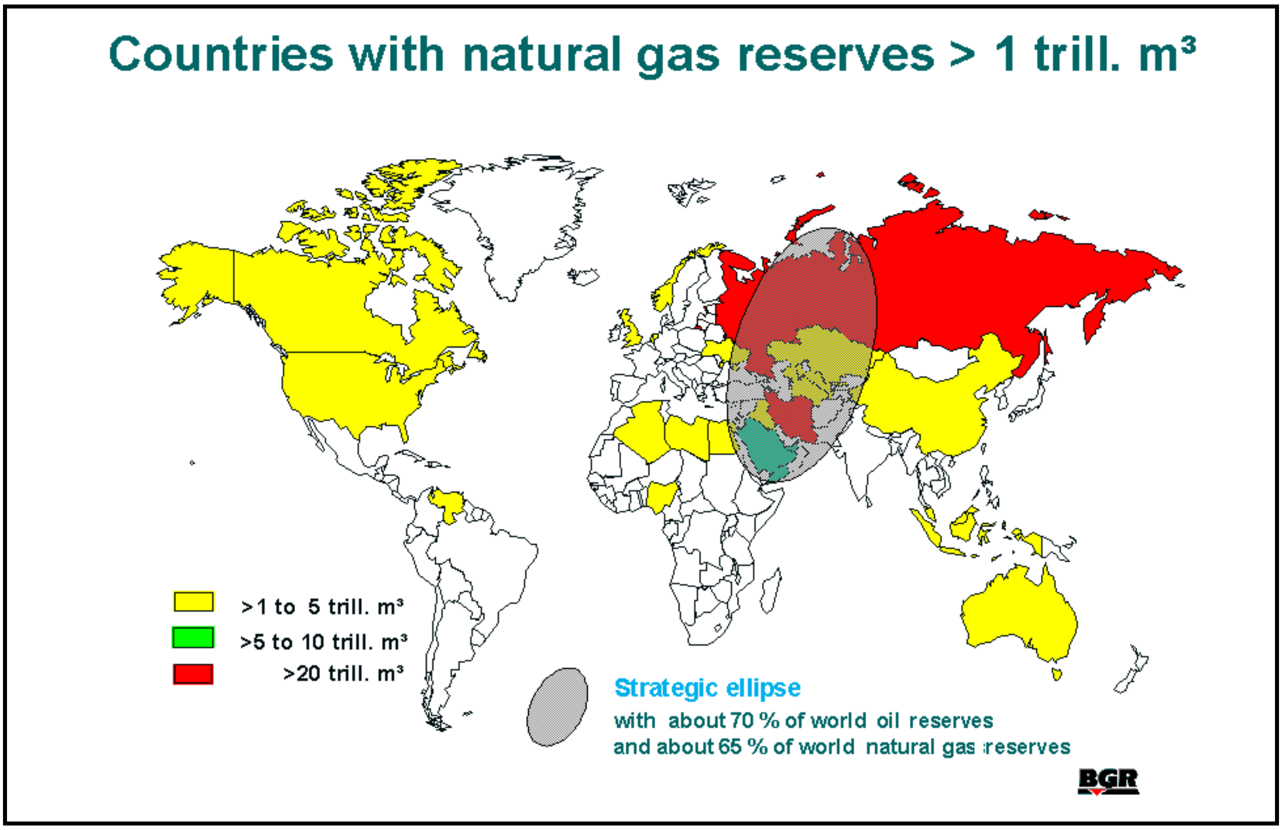


Figure 1: concentration of world oil and gas reserves

Source: Federal Institute for Geosciences and Natural Resources Germany (Homepage 2007)

In addition to the discussion in recent years about the range of fossil fuel reserves, another more pressing danger is come to the fore. Climate change has become perhaps the greatest threat to human life on earth. Climate changes have taken place often in the history of the earth. The problem with the current climate change is the speed of the change. Scientists fear that neither man nor the natural ecosystem can adapt quickly enough. If the global temperature increase by 2100 is to be no more than 2.5 - 3 °C, and assuming a moderate grow th in world population, then each of the 10 billion people in 2100, must only emit about one tonne CO2of annually [IPPC 2002 p.70]. For Germany this means a necessary 75% reduction in CO2 emissions by the year 2050 (based on the year 2000).

How much and how fast the climate will actually change, we will only know with 100% certainty when it happens. That the current form of global energy supply causes the largest share of anthropogenic emission of greenhouse gases however, is beyond dispute [DLR / IFEU / WI 2004 p.8].

The current challenge is therefore not (yet) a power supply problem but a climate problem. Our present energy supply being fossil fuel based is thus not only the major cause of climate change but also offers neither dependable supply nor price stability. The resulting need for a new basis for our energy supply can be easily understood. Renewable energy from wind, hydro, biomass, solar and geothermal energy could be the basis of such a new, secure supply offering price stability and environmentally sustainablilty.

1.2 Problem statement

This study arose from the question as to the actual potential of renewable energies and the possible barriers to the expansion of thier use. The natural potential of renewable energy worldwide is about the 3,000 times the annual energy demand [Fishedick et al. 2000]. The technically usable portion of this potential is currently estimated at about six times the annual global energy demand [Greenpeace 2003 p.5]. Thus, it is theoretically technically possible to fully meet these needs with renewable energies.

If this potential is to become the new basis of global energy supply, the implementation must not only be technically feasible but also economically and socially sustainable.

Numerous completed projects demonstrate the feasibility of various renewable energy technologies. Whether a complete global energy supply based solely on renewable sources is feasible, remains to be proven. There are various challenges that must be met for a complete coverage of energy demand using only renewable energy sources. Next to fundamental challenges, such as base-load capacity there are specific location-bound factors such as infrastructure, potential conflicts of use, production and demand fluctuations and the economic (financial) management and public acceptance must also be taken into account.

Central hypothesis of this study is that a sustainable energy supply (environmentally, economically and socially acceptable) from renewable sources of energy is possible. Due to their decentralized nature of the technologies the implementation of the use of renewable energies takes place at specific locations with specific conditions. This leads to the conclusion that this hypothesis should be tested in a specific location. Using the specific county of Osterholz in Lower Saxony this study aims to prove inductively, that a complete coverage of the energy needs of a specific location using only renewable energies is possible. The county's electric power, heat and fuel requirements and the renewable energies potential are determined. A methodical approach in this case increases the transferability of the results.

2 Existing Energy infrastructure

2.1 Energy situation in the county of Osterholz

In addition to global effects such as climate change and dwindling fossil resources, there are directly palpable economic impacts of the current energy supply in the county of Osterholz (OHZ). The use of renewable energies in the district Osterholz is hardly widespread. Only about 2% (see below) of the energy demand is met by renewable energy from within the county. Initial calculations show that each year about 150 million Euros are spent in the county for electricity and heat alone. For the most part this money flows out of the county to a few big energy companies and thus makes very little contribution to the regional value added.

2.2 Description of the county

The county of Osterholz is located in the north of Germany directly above the city of Bremen. The county is characterized by the moor landscape which makes up approximately one third of the total area of the county. Early settlers came to harvest the peat soil of the marshes to win fuel. The county is composed of the municipality of Osterholz-Scharmbeck, five-unit (Grasberg, Lilienthal, Ritterhude, Schwanewede and Worpswede) and an integrated municipality (Hambergen) with five member communities.

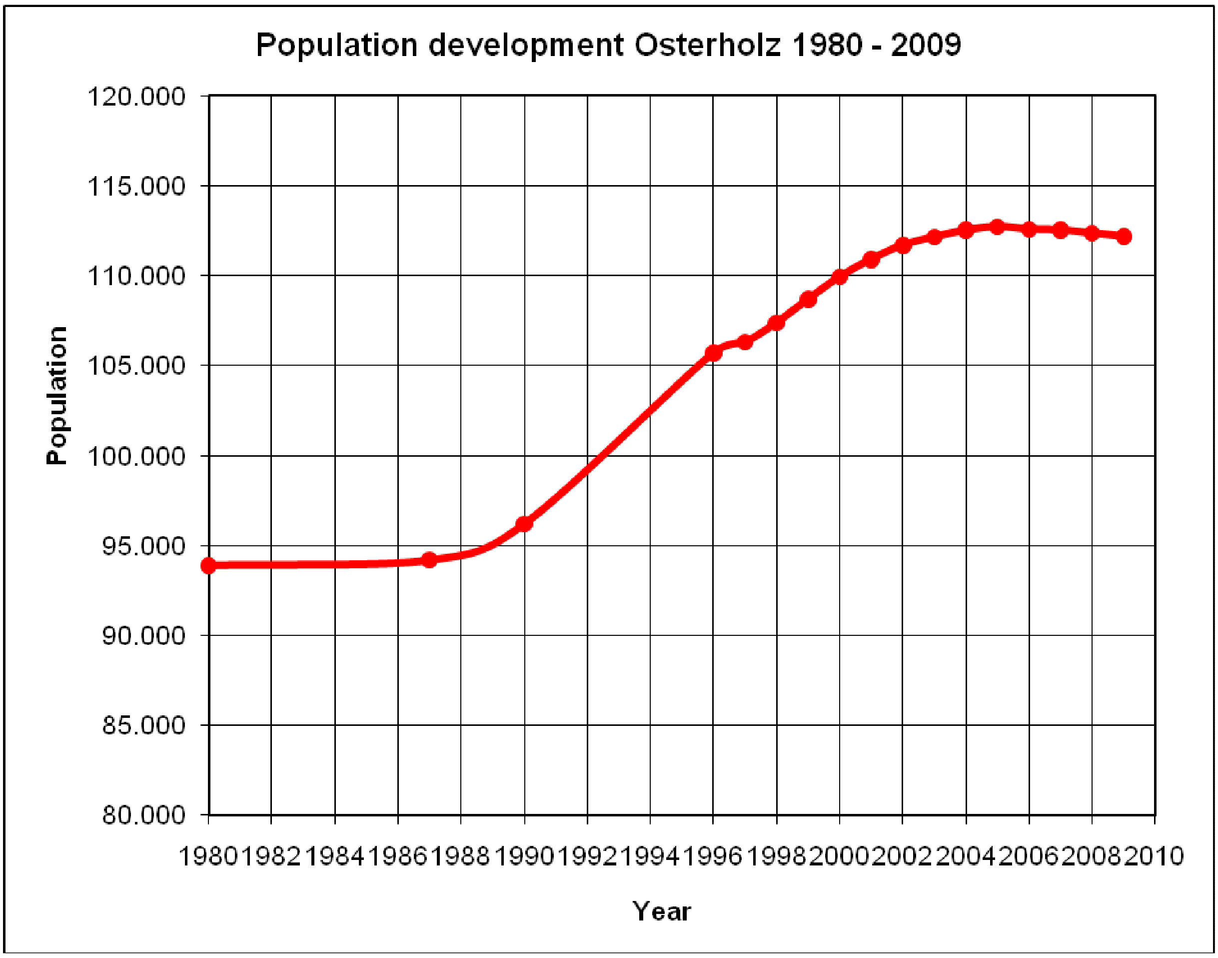
Figure 2: Location of the county of Osterholz

Source: Niedersächsische Landesregierung (Homepage 2009)

In the centre of the county is the city Osterholz-Scharmbeck with about 30.000 inhabitants. In the south the county borders the city-state of Bremen. The urban structure of the southern municipalities Ritterhude and Lilienthal blend into the northern outskirts of Bremen almost seamlessly. In general the county is characterized by its close proximity to Bremen and is strongly influenced by commuters. With a total area of 651 km² and 112,200 inhabitants, Osterholz has a population density of 172 inhabitants per km², similar to the nationwide average (population density in Germany being 231 inhabitants per km²).

2.3 Demographics 1980 - 2007

In the last 90 years Osterholz has experienced a considerable increase in population. The zenith of growth however appears to have been exceeded, and for some years the population of the county is stagnating or even retrogressive. This corresponds well to the overall German trend.



Source: Own presentation from [LSKN 2009]

Figure 3: Population development in the county of Osterholz 1980-2009

2.4 Current power supply and power demand

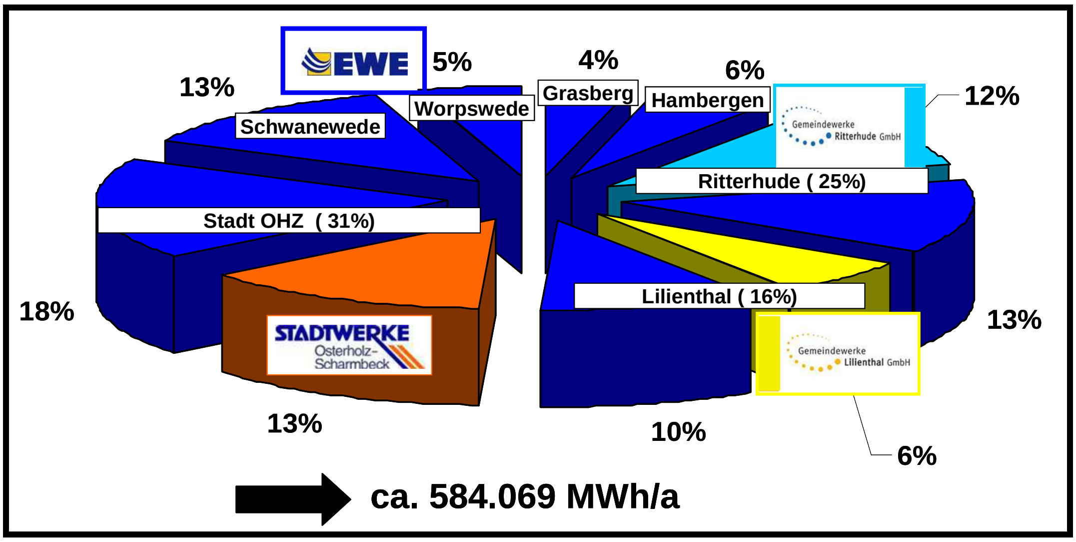
The power supply in Osterholz is regulated primarily by two operators. Stadtwerke Osterholz, (formally three entities: Stadtwerke Osterholz-Scharmbeck and municipality works Lilienthal and Ritterhude) and the EWE AG.
The biggest being EWE which also has the biggest market share.
The total electricity demand in Osterholz is about 584.069 MWh per year. This equals an average consumption of 5.184 kWh/a per person. The German average is 8.283 kWh/a per person. The lower electricity consumption in Osterholz can be attributed to the lack of heavy industry in the district (industry being responsible for 47% of electricity consumption in Germany) and to the fact that much of the working population of Osterholz work outside the district.

The electricity generation, apart from the small share of renewable energies (see below), and six smaller CHPs, takes place entirely outside the county boundaries. The current consumption of each municipality was determined by inquiries to the network operators, and is summarized in the table below.

Electricity demand 2007	
Municipality	**MWh/a**
Grasberg	22.251
Hambergen	32.148
Lilienthal	95.342
Osterholz-Scharmbeck	185.468
Ritterhude	146.967
Schwanewede	73.861
Worpswede	28.033
Total (District Osterholz)	**584.069**

Source: The EWE AG, Stadtwerke Osterholz, and own calculations (2008)
Table 1: electricity needs of the county of Osterholz for municipalities

The distribution and extent of the power delivery of energy companies are shown in the chart below.

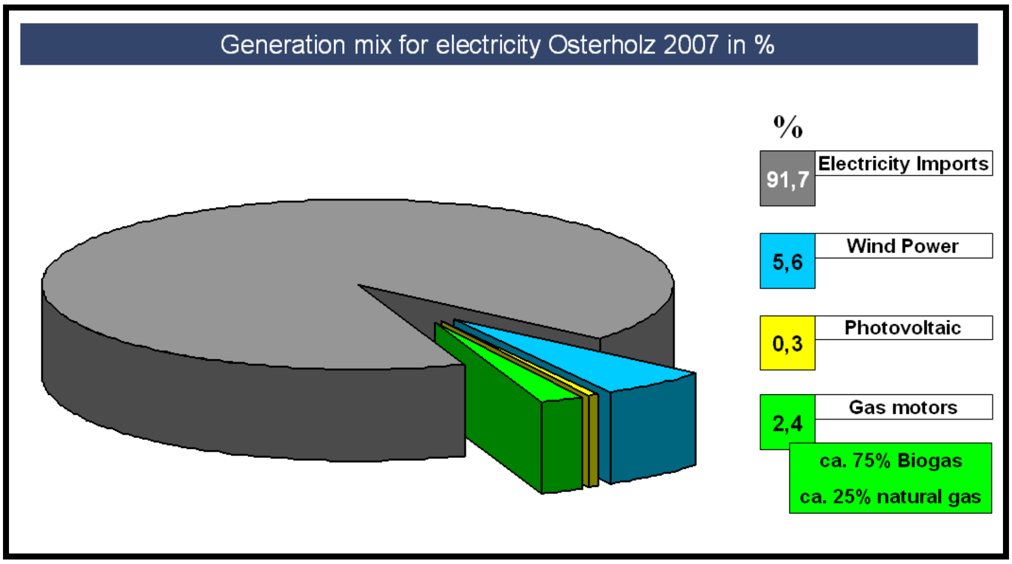


Source: The EWE AG, Stadtwerke Osterholz, and own calculations (2008)

Figure 4: power consumption and utility of the municipalities in Osterholz 2007

The total electricity demand in the district of Osterholz was about 584.069 MWh/a in 2007. According to the utility the demand for electricity is currently increasing by 1,5 – 2% per year due to larger and more numerous electrical devices in the private households.

Currently over 90% of the electricity demand in Osterholz is met by electricity imports. 5,6% of the electricity demand is met by locally installed wind turbines, 0,3% from local photovoltaic plants and 2,4 from gas motors mainly running on biogas. The graph below shows the generation mix for electricity in Osterholz.



Source: The EWE AG, Stadtwerke Osterholz, and own calculations (2008)

Figure 5: electricity generation mix in Osterholz 2007

The electricity imports can be seen has having the average German generation mix.

German electricity mix 2008	
Source	**Percentage**
Brown coal	23%
Nuclear	23%
Black coal	20%
Renewables	15%
Natural gas	13%
Other (Oil, etc)	6%

Source: Verivox

Tabel 2: German electricity sources 2008

2.5 Current heat supply and heat demand

The majority of heat in Osterholz is supplied on the basis of natural gas. The percentage of natural gas coverage being about 70% to 75% in the areas supplied by the Stadtwerke Osterholz and 40% in the more rural areas covered by the EWE AG. It is assumed that the rest of the heat supply is covered mostly by oil and a low percentage by liquid gas, electricity and wood fired stoves. In addition, the waste heat from the already mentioned CHPs is used. For new development areas the natural gas coverage is usually close to 100%.

The heat requirement of individual municipalities is based on information provided by utility operators and on own calculations. The results are summarized in the table below.

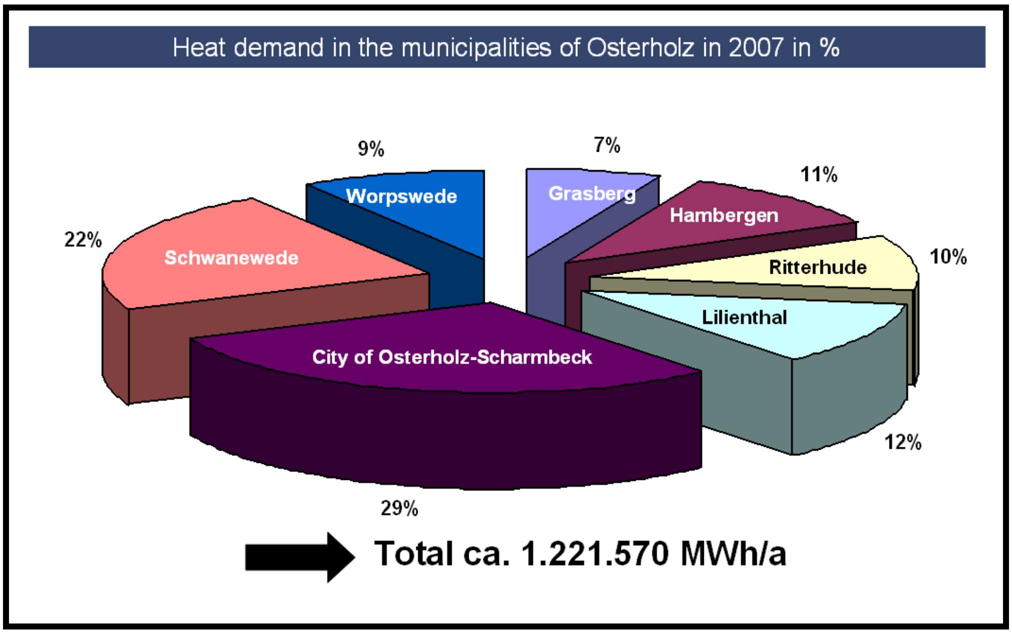
	Wärme [kWh]					
Gemeinde	EWE AG (Erdgas)	Stadtwerke OHZ (Erdgas)	Gemeinde-werke (Erdgas)	Heizöl	Sonstige Wärmequellen	**Summe Wärme**
Axstedt	2.885.105	0	0	3894891,106	432765,6785	6.779.996
Grasberg	34.316.951	0	0	46327884,37	5147542,708	80.644.836
Hambergen	39.230.340	0	0	52960959,14	5884551,016	92.191.299
Holste	2.567.948	0	0	3466729,755	385192,1951	6.034.678
Lilienthal	52.444	0	114.361.000	34308300	3812033,333	148.721.744
Lübberstedt	2.142.921	0	0	2892942,767	321438,0852	5.035.863
Osterholz-Scharmbeck	313.715	277.100.000	0	83130000	9236666,667	360.543.715
Ritterhude	0	0	92.285.000	27685500	3076166,667	119.970.500
Schwanewede	114.686.052	0	0	154826170	17202907,78	269.512.222
Vollersode	9.102.631	0	0	12288552,02	1365394,669	21.391.183
Worpswede	47.124.908	0	0	63618625,94	7068736,216	110.743.534
LK Osterholz (Summe)	**252.423.015**	**277.100.000**	**206.646.000**	**485.400.555**	**53.933.395**	**1.221.569.570**

Source: The EWE AG, Stadtwerke Osterholz, and own calculations (2008)

Table 3: Heating demand in Osterholz for single municipalities and natural gas suppliers

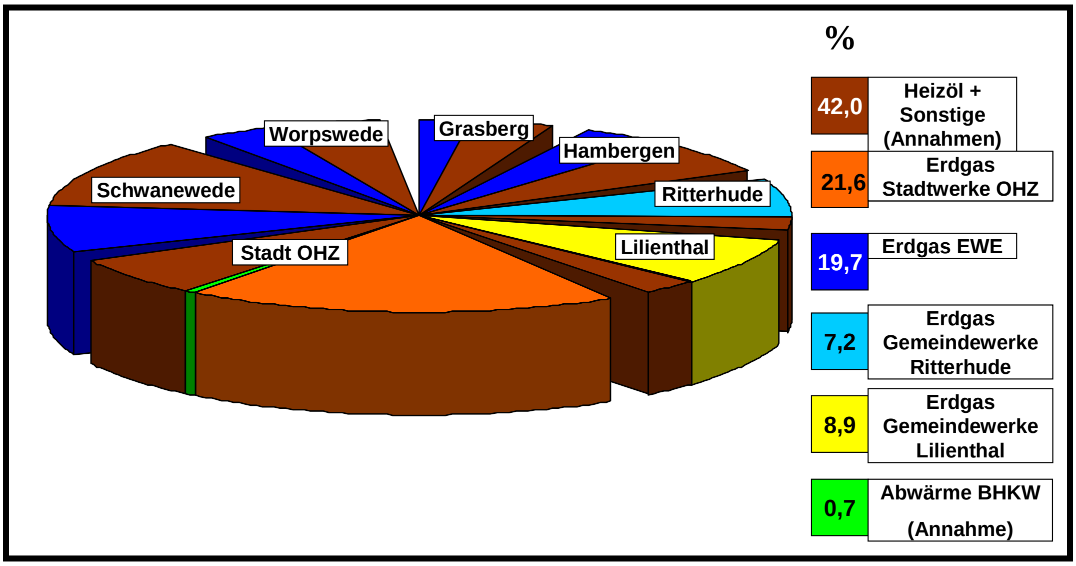
The total heating demand in the district of Osterholz was 1.221.570 MWh in 2007. This equals 10.841 kWh/a per person and corresponds well to the German average of 12.625 kWh/a per person.

The distribution and extent of the heat supply of utilities are shown in the diagrams below



Source: The EWE AG, Stadtwerke Osterholz, and own calculations (2008)

Figure 6: heat demand of the municipalities in Osterholz 2007



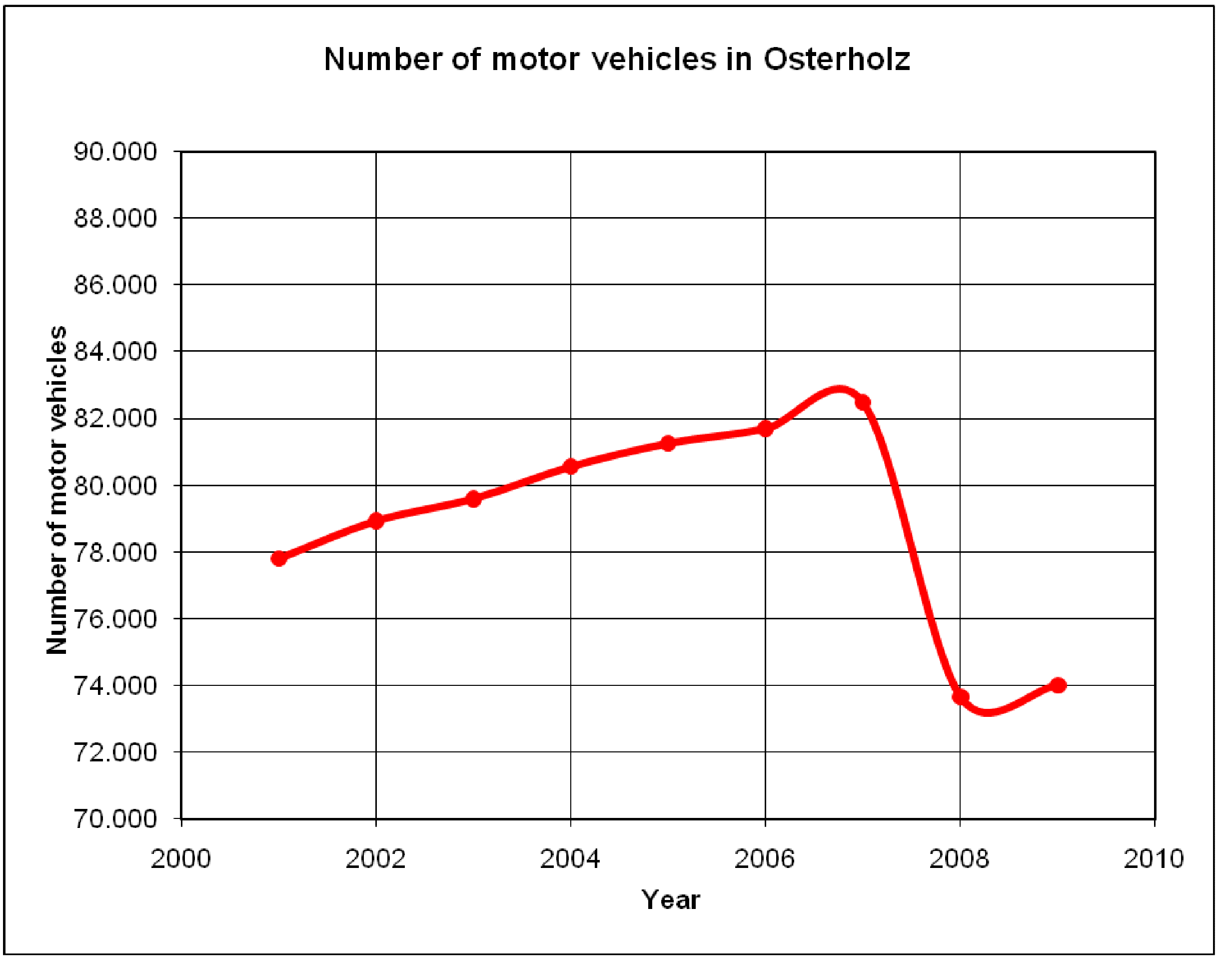
Source: The EWE AG, Stadtwerke Osterholz, and own calculations (2008)

Figure 7: heat and heat sources of the municipalities in Osterholz 2007

2.6 Vehicle inventory and assessment of fuel consumption

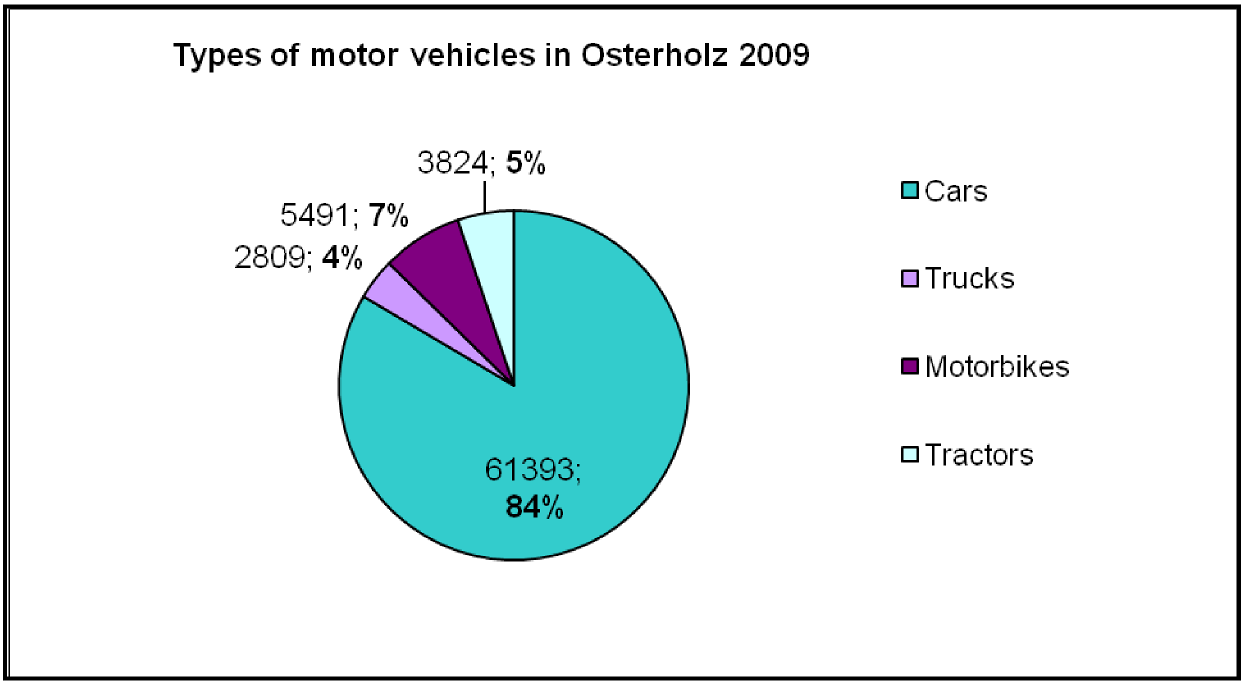
The development of the number of motor vehicles in Osterholz is shown in Figure 8. In 2009, the number of cars per 1000 inhabitants was 545 [LSKN 2010]. By comparison, the German average in 2009 was only slightly lower with 504 cars per

1000 inhabitants [Federal Statistical Office 2010]. The distribution of vehicle types coincides very well with the German average. (See Figures 9 and 10).



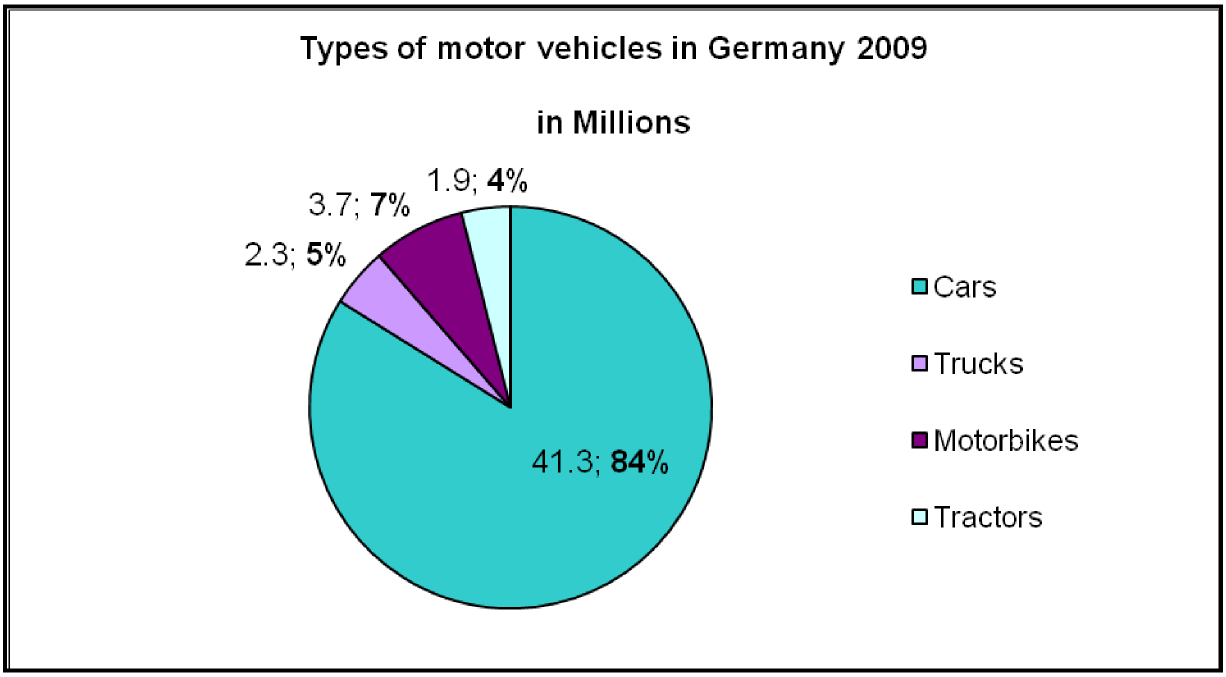
Source: Own depiction from [LSKN 2009]

Figure 8: Development of motor vehicle fleet in Osterholz 2001-2007



Source: Own depiction from [LSKN 2010]

Figure 9: motor vehicle types in Osterholz 2009



Source: Own depiction from [LKN, 2009]

Figure 10: motor vehicle types in Germany 2009

Because of missing data on the exact fuel consumption in the county, and because of the above-identified good matches to the national average, the fuel consumption in

Osterholz is calculated per head of population based on the German average fuel consumption per capita and adjusted for the difference between numbers of cars per 1000 inhabitants. The national average fuel consumption for 2007 was 7734 kWh / a [UBA 2007]. This corresponds to about 770 litres of diesel per inhabitant per year. Based on the current population of 112 200, the calculated total fuel consumption for Osterholz equals 938 340 MWh / a or 93 million litres of diesel per year.

2.7 Current use of renewable energies for power generation

Compared to neighbouring counties Osterholz currently uses only very little of its renewable energy potential.

Wind power

In Osterholz, there are currently 39 wind turbines with a total capacity of 45 megawatts. These turbines have a maximum total height of 100 m and an average plant capacity of less than 1 MW. The total electricity produced annually with the existing wind turbines is about 70,000 MWh. This represents approximately 6.5% of the annual electricity demand. Figure 11 shows the locations of wind power and biogas plants.

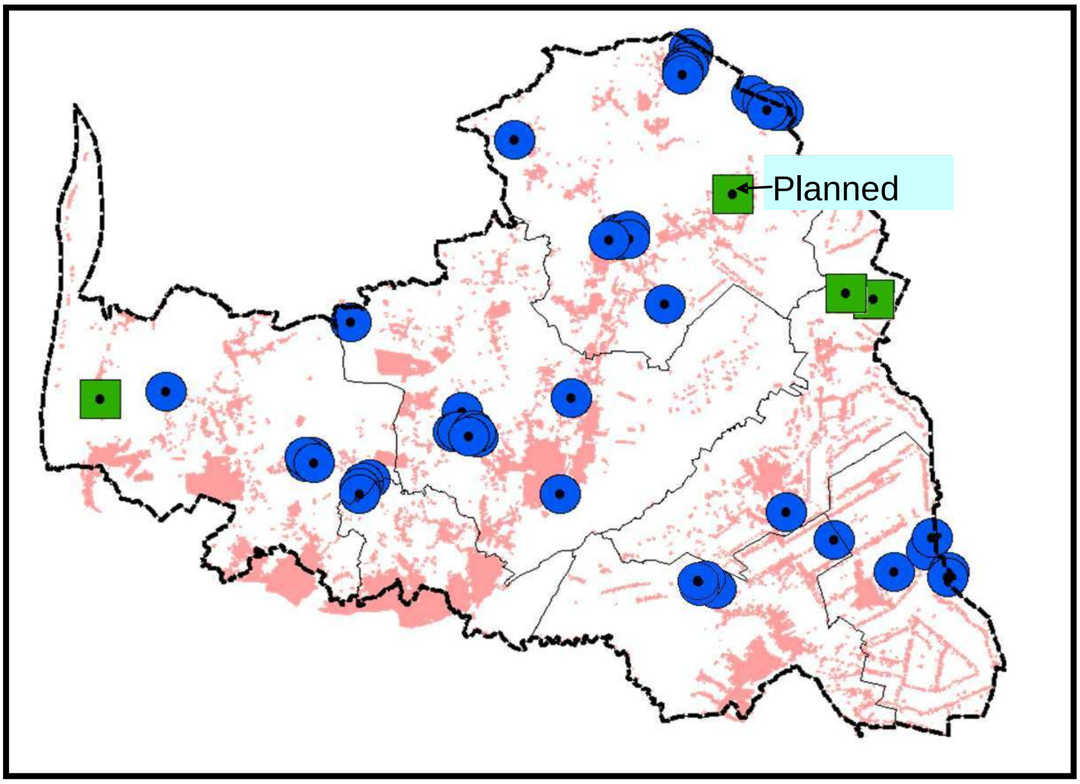


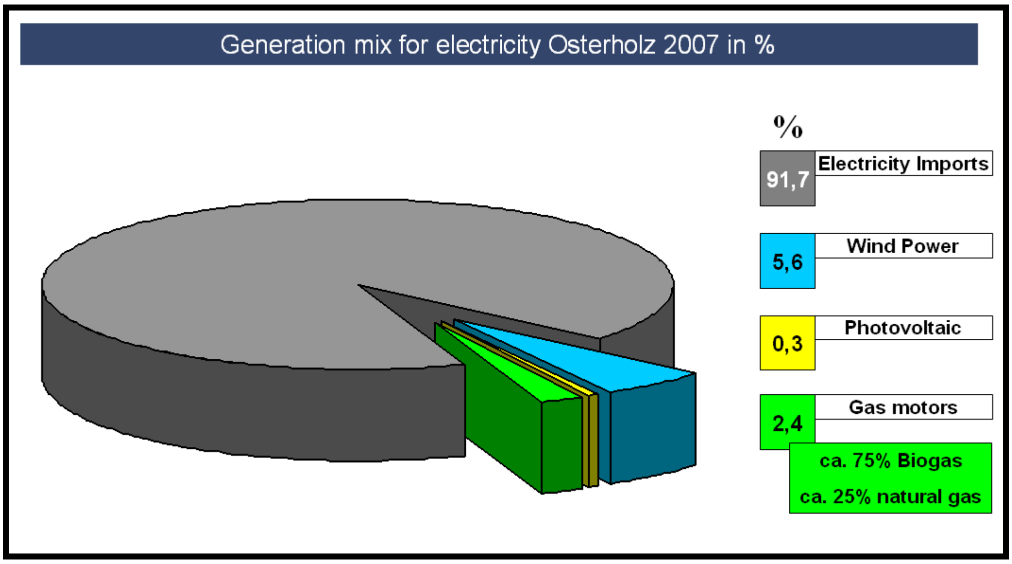
Figure 11: Existing wind power and biogas plants in Osterholz

Biogas

The three existing biogas plants are located in the municipalities of Worpswede and Schwanewede. The two biogas plants in Worpswede currently run at an installed capacity of 500 kW each. Both plants want to increase their capacity to 1 MW each. The biogas plant in Schwanewede has an installed capacity of 800 kW. In 2007 the three plants together generated enough electricity to meet about 1.7% of the county electricity demand. Two further biogas plants with a capacity of 500 kW are to be realized in Osterholz-Scharmbeck and Hambergen.

Photovoltaic

In Osterholz, there are currently several public and commercial solar plants as well as numerous private plants on roofs on private. Overall electricity, generated with photovoltaic in 2007 was 1.690 MWh. This represents approximately 0.3% of the county's electricity demand. Figure 12 shows the current share of renewable energies in electricity production in Osterholz. Overall, around 7.6% of electricity demand is currently won from renewable energy sources in the county.



Source: The EWE AG, Stadtwerke Osterholz, and own calculations (2008)

Figure 12: Share of renewable energies in electricity demand in Osterholz

Renewable heating

In addition to the heat of two biogas plants, there are currently no large district heating plants using renewable energy. A collection of data on the number of individual solar thermal plants as well as an accurate estimate of the private use of wood fired heating was not possible in the context of this study. The current average wood use in Lower Saxony is only 3.0 cubic meters of wood per hectare (Fm / ha) forest [NMlR 2002 p.37-39]. In Osterholz this corresponds to a timber volume of 18 870 Fm / a (6290 ha forest area). Assuming that 50% of this timber is used for private heating, the timber has an average energy content of 2,800 kWh / Fm and the efficiency of wood stoves used is 70%; about 18 500 MWhth of heat per year can be assumed to be coming from biomass from the forests of Osterholz. Together with the usable waste heat from the two biogas plants (about 8600 MWth) this equals an annual heat output of approx 27 100 MWhth. This represents approximately 2.1% of the total heating demand in Osterholz. The county also has five CHPs based on natural gas that generate about 9400 MWhth of heat per year: four CHPs in Ritterhude and a plant in Osterholz-Scharmbeck, which supplies two schools and a swimming pool with heat.

2.8 Forecast of future energy demand

To plan the future energy supply of the district, it is necessary to establish how the current energy demand could develop in the future taking into account different assumptions. The amount of future energy demand will depend largely on the success of various energy efficiency and energy saving measures. In addition to local renewable energy production, these measures are is the most important lever for the realization of a sustainable energy supply in Osterholz. To take account of this possible effect, two different scenarios are presented.

Estimation of population development

Besides the energy saving effect, the future energy demand is largely dependant on the population development. The State Office for Statistics and Communication Technology Lower Saxony (LSKN) develops forecasts for the population development in the various counties. For the first January 2021 the population of Osterholz is projected to be 114 623. This minor growth reflects the existing trend towards stagnation. (see Figure 3).

Estimation of future energy saving and energy efficiency potentials

An investigation of site-specific energy efficiency and energy saving potential was not part of this work, it is therefore made on the basis estimates of the German Energy Agency (dena) the assumption is that using appropriate measures the heating and electricity demand can be reduced by 40% and 30% respectively by 2030.

Estimation of future fuel demand

A study by the Institute for Energy and Environmental Research in Heidelberg (ifeu) estimates that fuel consumption in Germany, despite an increase in total distance driven, will be approximately 20% lower in 2030 than in 2005 [IFEU 2005] . At the same time a slight shrinking of the German population to around 80 million is expected. The decrease in fuel consumption is expected primarily through improved efficiency of the vehicles. Assuming that the number of inhabitants of the district increased slightly (see above), a corresponding increase in vehicle numbers in Osterholz can be assumed. Overall a reduction of about 10% in fuel demand by the year 2030 in Osterholz is assumed.

3 Determining the existing renewable energy potential in Osterholz

In order to determine the renewable energy potential in Osterholz in the most efficient way a methodical approach was chosen. In the first step, the fundamental suitability of individual technologies was investigated for the site. Then the possible limitations to this potential were processed in the order that the biggest influences were expected. Below the potential of various renewable energy technologies in the district of Osterholz is presented.

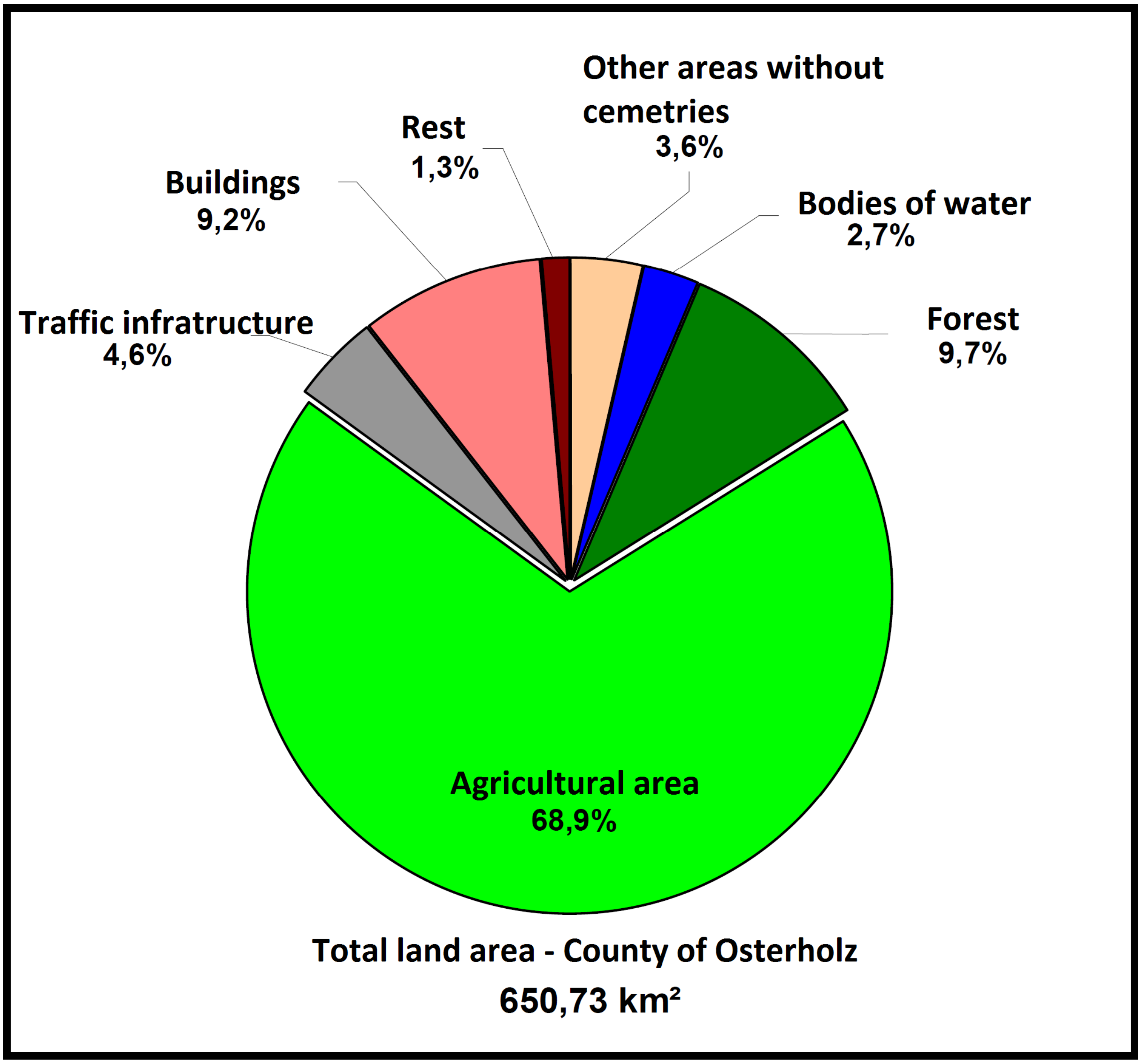
3.1 Biomass potential

Determination of the critical factors

To determine the biomass potential in Osterholz, first the important key data was compiled from which the biomass potential can be derived. These include:

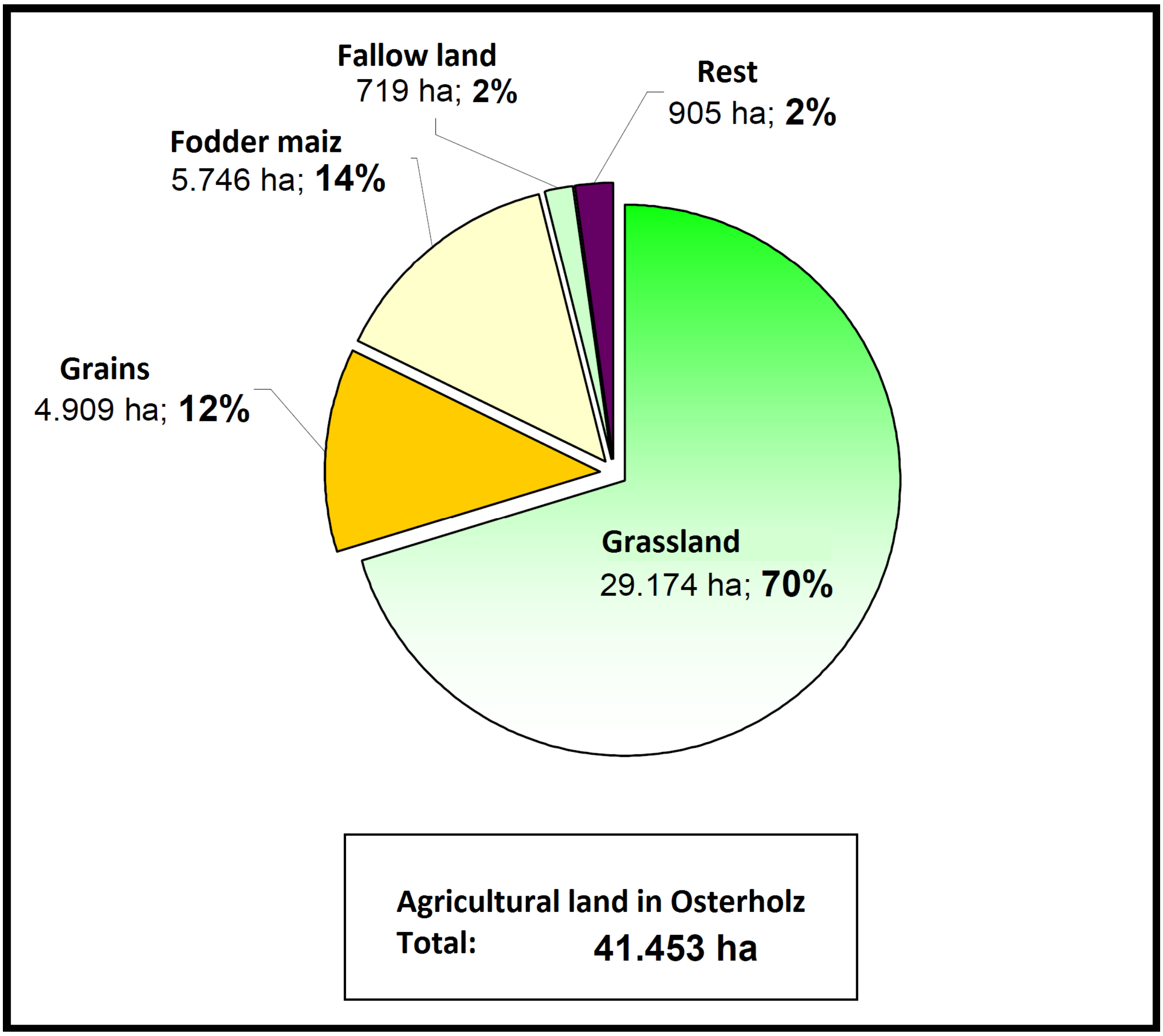
- the agricultural area
- the livestock units
- the current land use and
- the forest areas

Based on these figures, a first estimate was made of the biomass potential. The necessary data can be drawn from the survey of the State Office of Statistics Lower Saxony [NLS 2006] and is summarized in the graphs below. Figure 13 shows the types of land-use in Osterholz. The county is characterized by agricultural land use, this making up almost 70% of the total county surface area Figure 14 shows the current use of agricultural land. Figure 15 shows the agricultural land and livestock units in each municipality in the county Table 4 shows the distribution and types of forests.



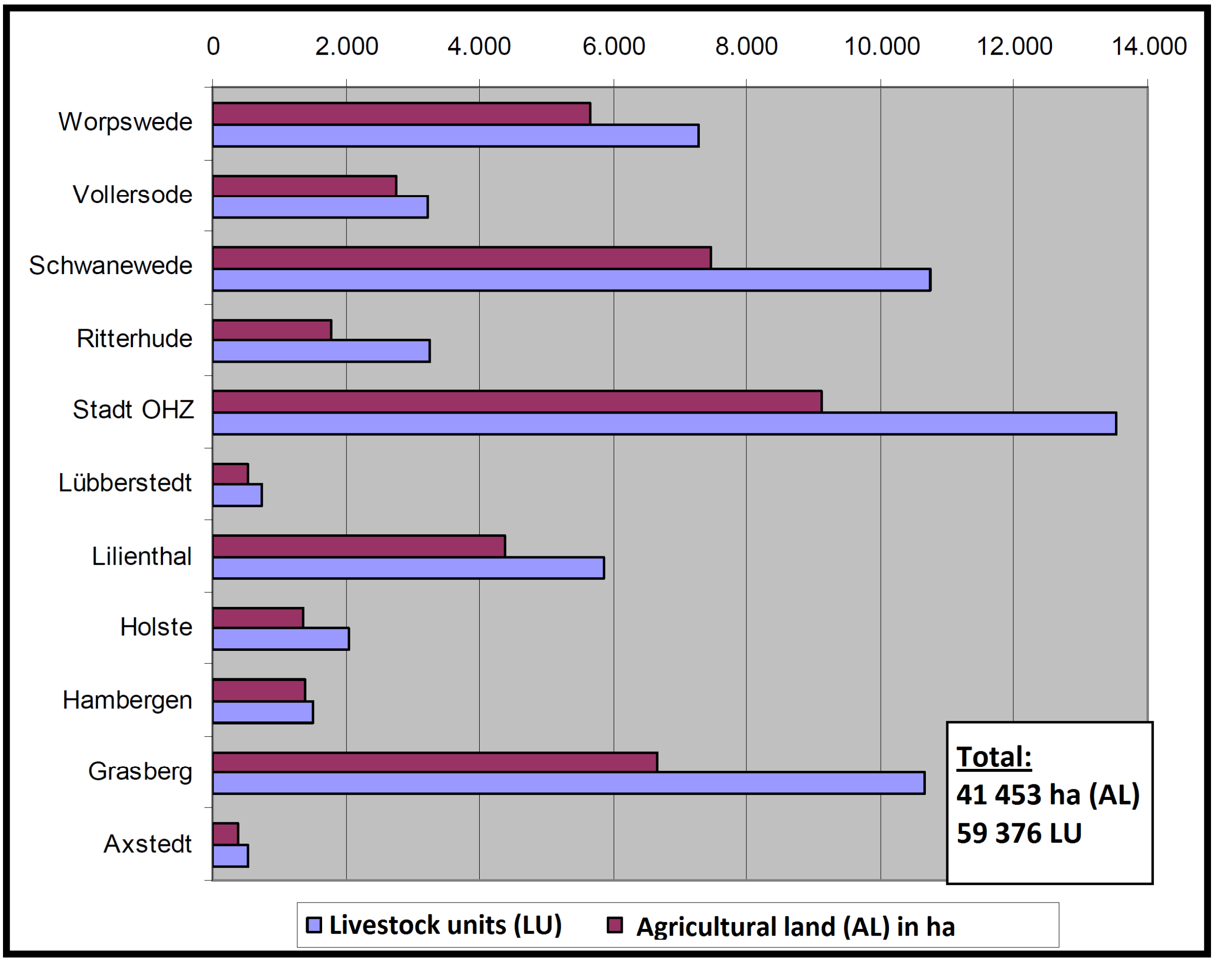
Source: Own presentation from [NLS 2006]

Figure 13: Breakdown of the land area in Osterholz



Source: Own presentation from [NLS 2006]

Figure 14: Use of agricultural land in Osterholz



Source: Own presentation from [NLS 2006]

Figure 15: Agricultural area and livestock units in Osterholz

Municipality	Deciduous Forest	Coniferous Forest	Mixed Forest	Total
Axstedt	33	256	76	367
Grasberg	3	30	13	50
Hambergen	38	217	114	389
Holste	121	885	259	1 329
Lilienthal	40	35	43	190
Lübberstedt	27	153	42	232
Osterholz-Scharmbeck	251	521	429	1 272
Ritterhude	48	38	115	216
Schwanewede	304	407	401	1 207
Vollersode	53	549	116	734
Worpswede	56	73	138	300
Osterholz	976	3 170	1 753	6 290

Source: Own presentation from [NLS 2007]

Table 4: woodland acres and forest types per municipality in Osterholz

Determination of the usable potential

In the second step, potential conflicts of use were determined. In particular this included the current use of agricultural land for food and fodder production as well as the current utilization of forest wood.

Studies show that the agricultural land needed for fodder cultivation in Germany is decreasing [Rösch et al. 2007]. Even today the permanent grassland in Osterholz is not used to full capacity. Often only the first two of three harvests are used as fodder, the third grass harvest often being left on the field.

In order to determine the unused biogas potential in Osterholz, it was assumed that in the medium term, 10% of corn acreage and 80% of the manure from the livestock units will be available for energy production. Taking into account the different crop yields per hectare and the average biogas yield per substrate [Wetter and Brügging 2003], the biogas potential shown in Table 5 can be calculated.

	Slurry from Livestock	Fodder Maiz	Grass from Grassland
Source	80% of Slurry from 60000 Livestock units	10% of 4960 ha	80% of third cut from 29170 ha
Biogas yield per unit	400 m^3/LU/a	8550 m^3/ha/a	1620 m^3/ha/a
Total Biogas yield	19.2 Mill. m^3/a	4.2 Mill. m^3/a	37.8 Mill. m^3/a
Total Biogas yield		**61.2 Mill. m^3/a**	

Table 5: Biogas potential in Osterholz

Table 6 shows the different biogas yields per livestock unit. In Osterholz most livestock is dairy cows and therefore an average biogas yield of 400 m³ / livestock unit can be adopted.

		Gülleanfall je Tier				Gülleanfall je GVe					Durchschnittlicher Gasertrag je GVe		
Tierart	**1 Tier entspricht:**	**Tag**	**Monat**	**Jahr**	**1 GVe entspricht:**	**Tag**	**Monat**	**Jahr**	**TS-Gehalt**	**oTS-Gehalt**	**Tag**	**Monat**	**Jahr**
	[GVe]	[m³/d]	[m³/M]	[m³/a]	[Tiere]	[m³/d]	[m³/M]	[m³/a]	[%]	[% TS]	[m³/GVe/d]	[m³/GVe/m]	[m³/GVe/a]
Milchkuh	1,2000	0,0550	1,650	19,80	0,83	0,0460	1,380	16,50	7-17	44-86	0,56-1,50 **∅ 1,10**	16,8-45 **∅ 33,0**	204-548 **∅ 402**
Rindermast	0,7000	0,0230	0,690	8,30	1,43	0,0330	0,990	11,80					
Jungvieh	0,6000	0,0250	0,750	9,00	1,67	0,0420	1,250	15,00					
Kälberaufzucht	0,2000	0,0080	0,240	2,90	5,00	0,0400	1,200	14,40					
Kälbermast	0,2000	0,0040	0,120	1,40	5,00	0,0200	0,600	7,20					
Schweinemast	0,1200	0,0045	0,140	1,60	8,33	0,0380	1,130	13,50	2,5-13	52-84	0,60-1,25 **∅ 0,88**	18-37,5 **∅ 26,4**	219-456 **∅ 321**
Zuchtsau	0,3400	0,0045	0,140	1,60	2,94	0,0130	0,400	4,80					
Ferkel	0,0400	0,0020	0,060	0,70	25,00	0,0500	1,500	18,00					
Masthähnchen	0,0015	0,0001	0,003	0,035	667	0,0295	0,885	10,60	20-34	70-80	3,50-4,00 **∅ 3,75**	105-120 **∅ 114**	1.278 - 1.460 **∅ 1.368**
Truthahnmast	0,0222	0,0010	0,030	0,35	45	0,0250	0,750	9,00					
Legehennen	0,0033	0,0002	0,006	0,07	300,00	0,0590	1,770	21,20					

Source: [Wetter and Brügging 2003 p.4]

Table 6: Average biogas yield per livestock unit

The current average wood use in Lower Saxony is only 3.0 cubic meters of wood per hectare (Fm / ha) forest [NMlR 2002 p.37-39]. In Osterholz this corresponds to a timber volume of 18 870 Fm / a (6290 ha forest area). The untapped potential lies at about 5 Fm / ha [NMlR 2002 p.37-39]. Under the assumption that long-term 80% of this unused forest wood potential can be tapped, Osterholz has a biomass potential of 25 160 Fm of timber per year. If 50% thereof can be utilised for the production of energy with an average efficiency of heat generation technologies of 90% and an assumed average calorific value of 2,800 kWhth / Fm, 31 700 MWhth of heat energy can be produced per year. This represents approximately 5.4% of the current heat demand in Osterholz.

Bio fuel potential

To meet the estimated current fuel requirements of the county an energy volume of about 980 060 MWh / a or 86.2 million litres of diesel equivalent per year would be necessary. Assuming that these needs should be met with fuels derived from biomass crop with in Osterholz, would require, depending on the fuel, substrate and production process, between 90,000 ha (biodiesel made from rapeseed) and 24,500 ha (hydrogen from Miscanthus by thermo chemical gasification) [Specht et al. 2004 p.247].

The already established biogas potential of 61.2 million m³ / a, would at an energy content of 6kWh / m³ [Weather and Brügging 2003 p.10], cover around 38% of fuel needs. Taking into account the energy required for the production and processing of biogas [Specht et al. 2004 p.247] the potential supply could cover only 34%.

A third possible source of energy to meet the fuel needs is hydrogen from renewable electricity. With an efficiency of 74% [DLR / IFEU / WI 2004 p.60] 1.3244 million MWh / a electricity would be needed. The determined wind energy potential (see below) of up to 337 278 MWh would cover only 26% of the fuel needed, without taking into account the energy necessary for the storage and transportation of the hydrogen.

Since the county has a total of only 41 453 ha of agricultural area and these areas also serve other uses at present, covering a big part of the fuel demand based on local biomass seems unrealistic. The identified biogas and wind energy potentials are needed to cover other energy demands (heat and electricity). Thus, a significant portion of the county's fuel demand can only covered by renewable energies, if this demand is reduced significantly.

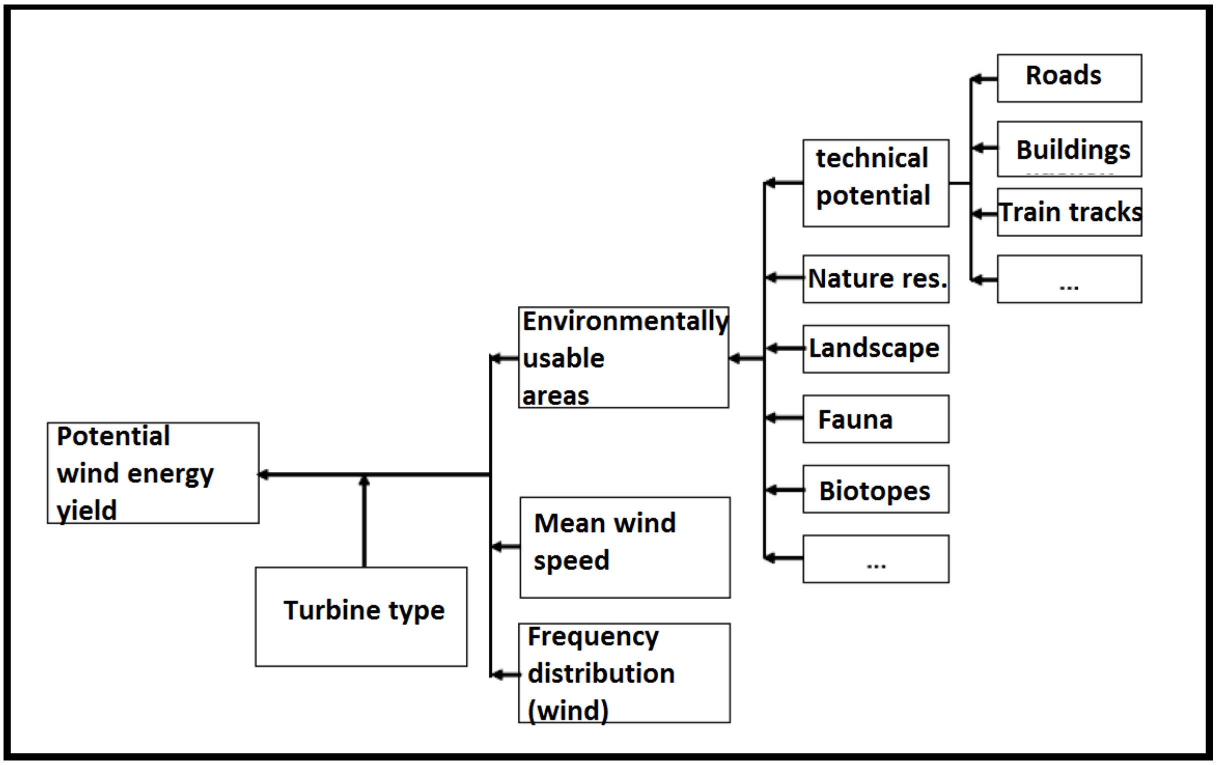
3.2 Wind power potential

Method

The wind power potential of an area is typically influenced by three main factors:

- the mean wind speed in the area,
- the exclusion areas and
- the selected plant sizes and hub heights.

A study commissioned by the BMU takes account of these factors using the following procedure:



Source: [DLR / IFEU / WI 2004 p.123]

Figure 16: Procedure for determining the usable wind energy potential

This approach (in the picture from right to left) does take into account all relevant factors, but is very laborious. For Osterholz the following methodology has been developed (Figure 17). In this approach the steps, which require the least effort and exclude the largest surface areas, were made first.

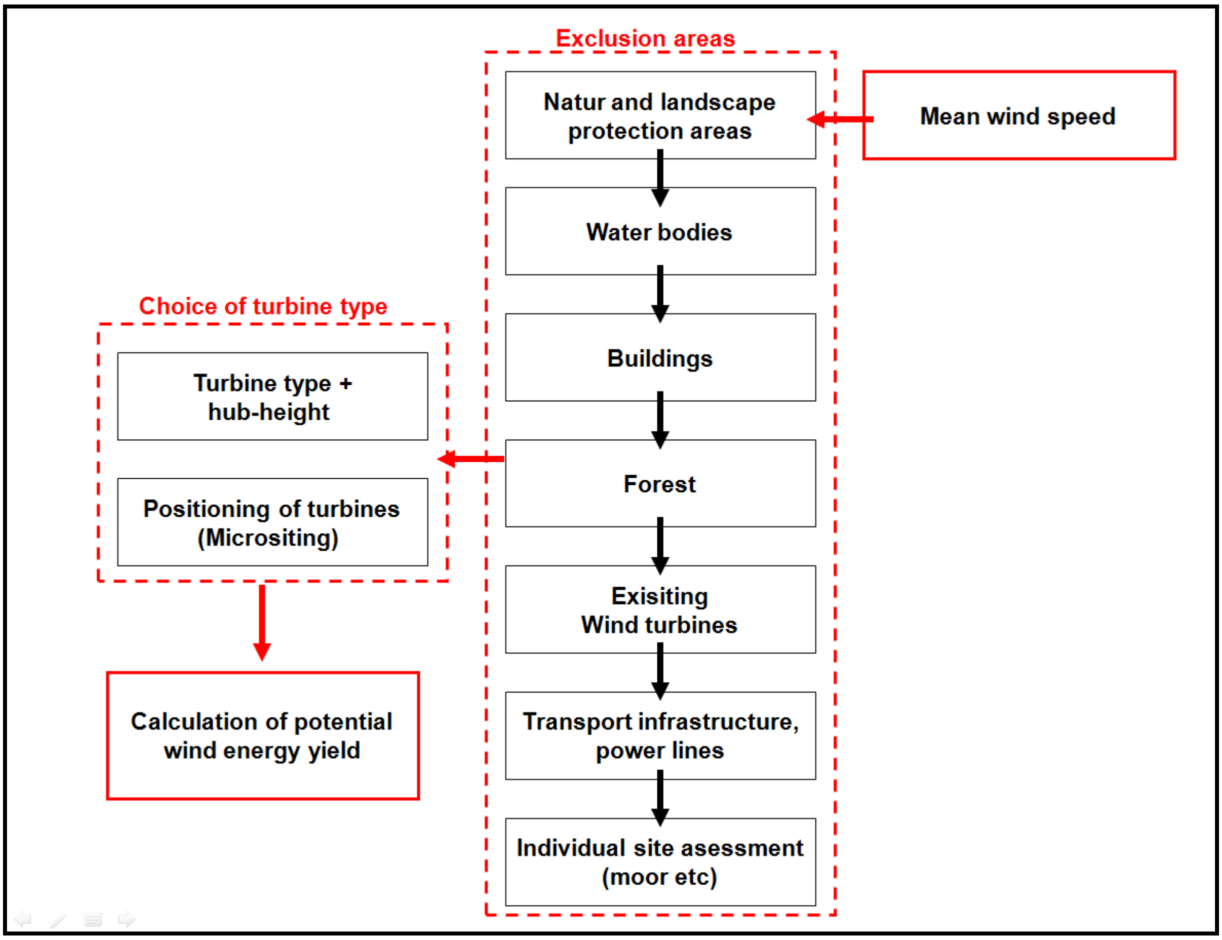
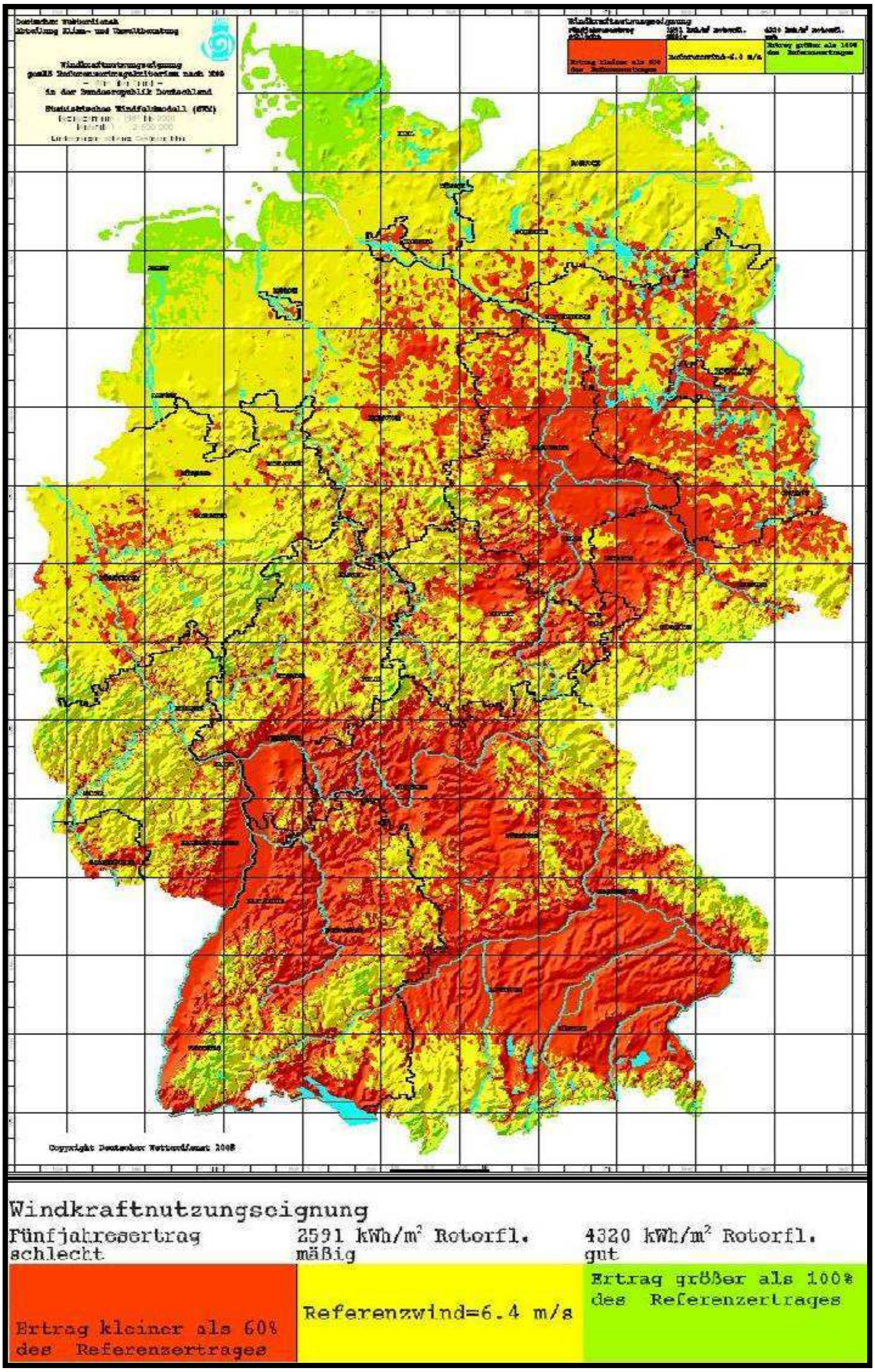


Figure 17: Procedure for determining wind power potential in Osterholz

Estimation of wind speed

As explained above (see Section 3.2), the wind speed is critical for the yield of a wind turbine. As a guideline for yield calculations for different areas the mean annual wind speeds are used. In Germany this data is available from the German weather service. As the wind speed is influenced by the nature of the landscape surface, it differs depending on the height. Therefore, the wind speed estimate at hub height is most significant. Figure 18 shows the annual average wind speeds in Germany, at a height of 80 m above the ground surface. The location of the Osterholz is marked with a blue arrow. With an estimated average wind speed of 6.4 m / s at 80 m height, the general suitability of the site for the use of wind power is given.

Since Osterholz has a very flat geography, it is expected that the mean wind speed in the district is largely constant. In areas with large differences in altitude the wind speed is highly dependent on the terrain height. The influence of terrain height on the wind speed is usually calculated with the help of Geographic Information Systems (GIS).



Source: German Meteorological Service (2002) (Home)

Figure 18: Germany in wind speeds in 80 m

Determination of exclusion areas

To avoid potential conflicts of use and or public concerns in a first step all forms of nature protection and landscape conservation areas were excluded. These excluded areas included:

- Nature reserves and conservation areas
- Biotopes
- valuable areas for breeding birds
- valuable areas for visiting birds
- European bird sanctuaries
- valuable areas for wildlife
- areas of wet-grassland protection program in Lower Saxony
- Reported Fauna-Flora-Habitat (FFH) areas
- moor and swamp areas
- specially protected nature conservation areas (nature and landscape)

These areas were determined using interactive online maps of the Lower Saxony Ministry of Environment and Climate Change.
The maps of every nature and landscape area were overlaid with the help of the software Google Earth ®. The total so determined exclusion areas are shown in red in Figure 19.

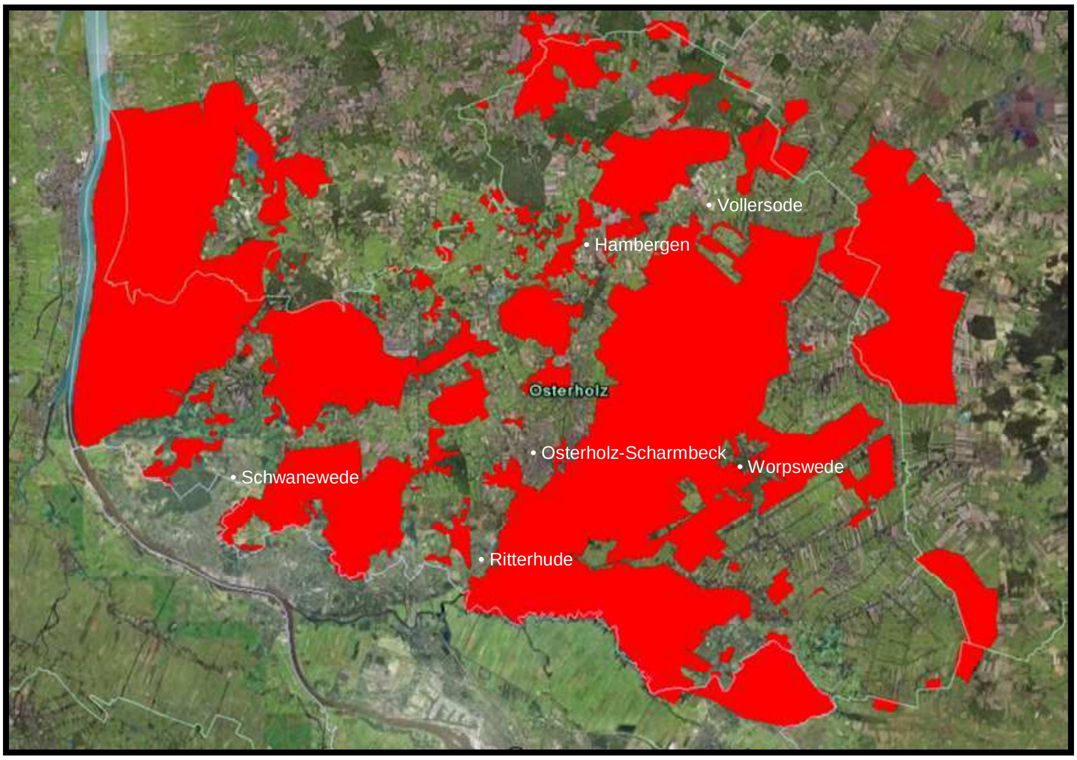


Figure 19: Nature and landscape protection areas in Osterholz

In the next step, the individual settlements and inhabited buildings plus a distance of 500 m were excluded. This step is often very labour intensive, because digital records of settlements and buildings are rare and also not up to date. Therefore, the settlements and buildings in general must be determined according to various maps and aerial images. To mark the building and generate the 500m puffer WindPRO ® software was used. The settlements and inhabited buildings plus a distance of 500 m are shown in Figure 20.

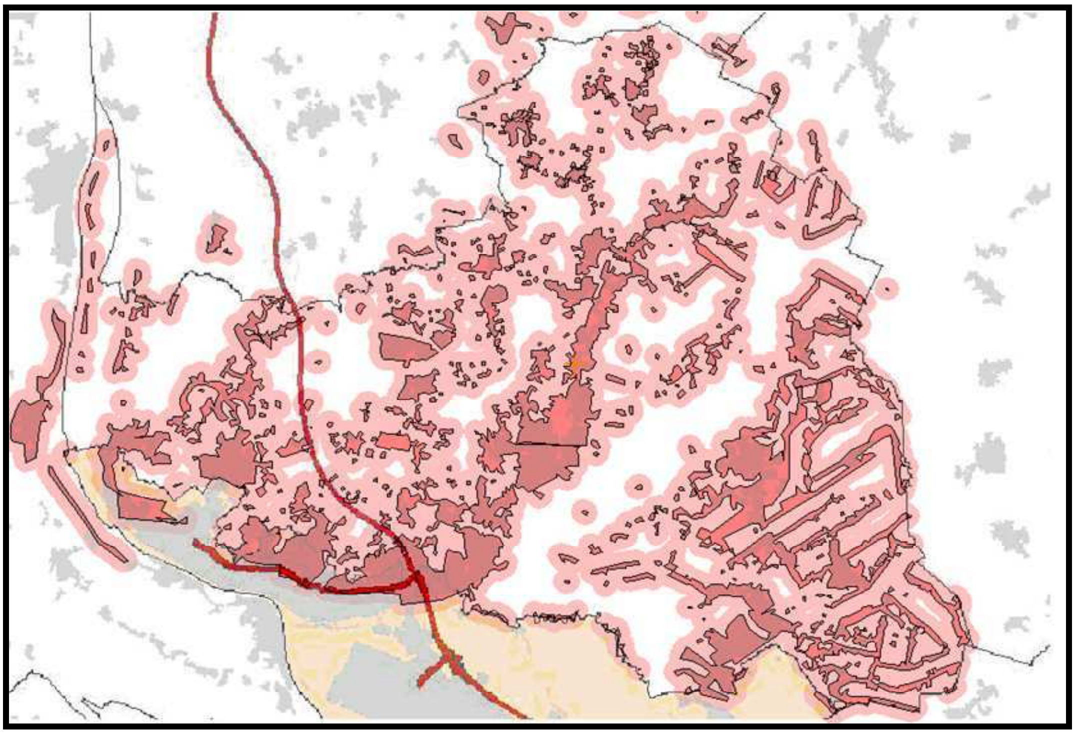


Figure 20: settlements and inhabited buildings in Osterholz plus a distance of 500 m

After overlaying the nature and landscape protection areas with settlements and inhabited buildings plus a distance of 500 m, the blue areas in Figure 21 remained.

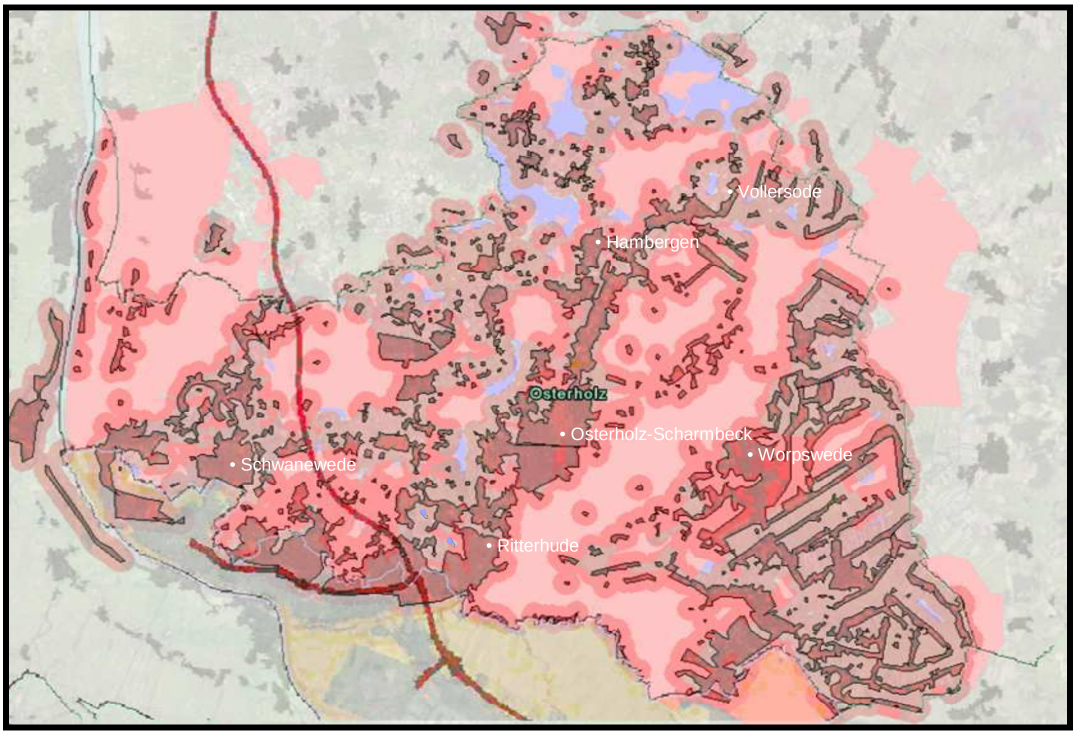


Figure 21: Remaining potential after deduction of nature and landscape conservation and settlement areas.

After deduction of the forest areas the areas shown in Figure 22 remained

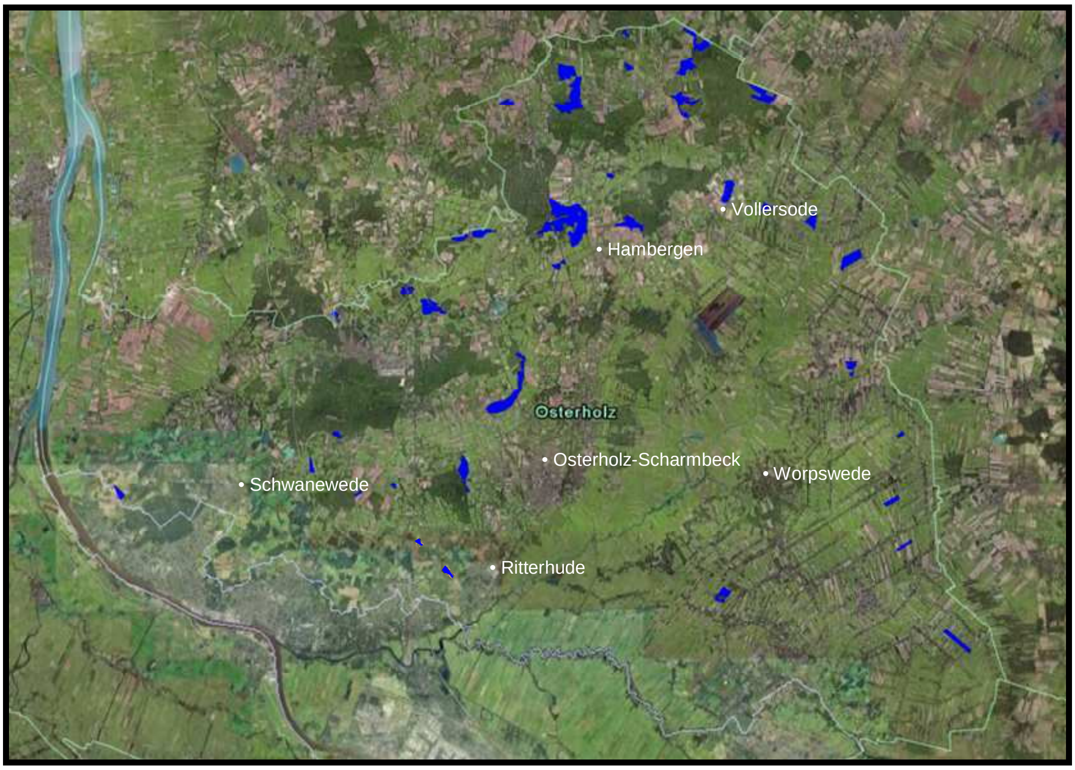


Figure 22: Potential land for the use of wind power after deduction of forested areas

These few remaining areas were examined on site. During this process, the current wind turbines stock was documented. It was noted that many of the existing turbines are not optimally placed in view of protection of nature and local residents. During the investigation of the potential wind areas on site, further land proved unsuitable. In addition to the already existing plants, this was due to: power lines, swampy ground and necessary clearances to smaller, previously unidentified streets and waters. These locations are marked in Figure 23 as problematic.

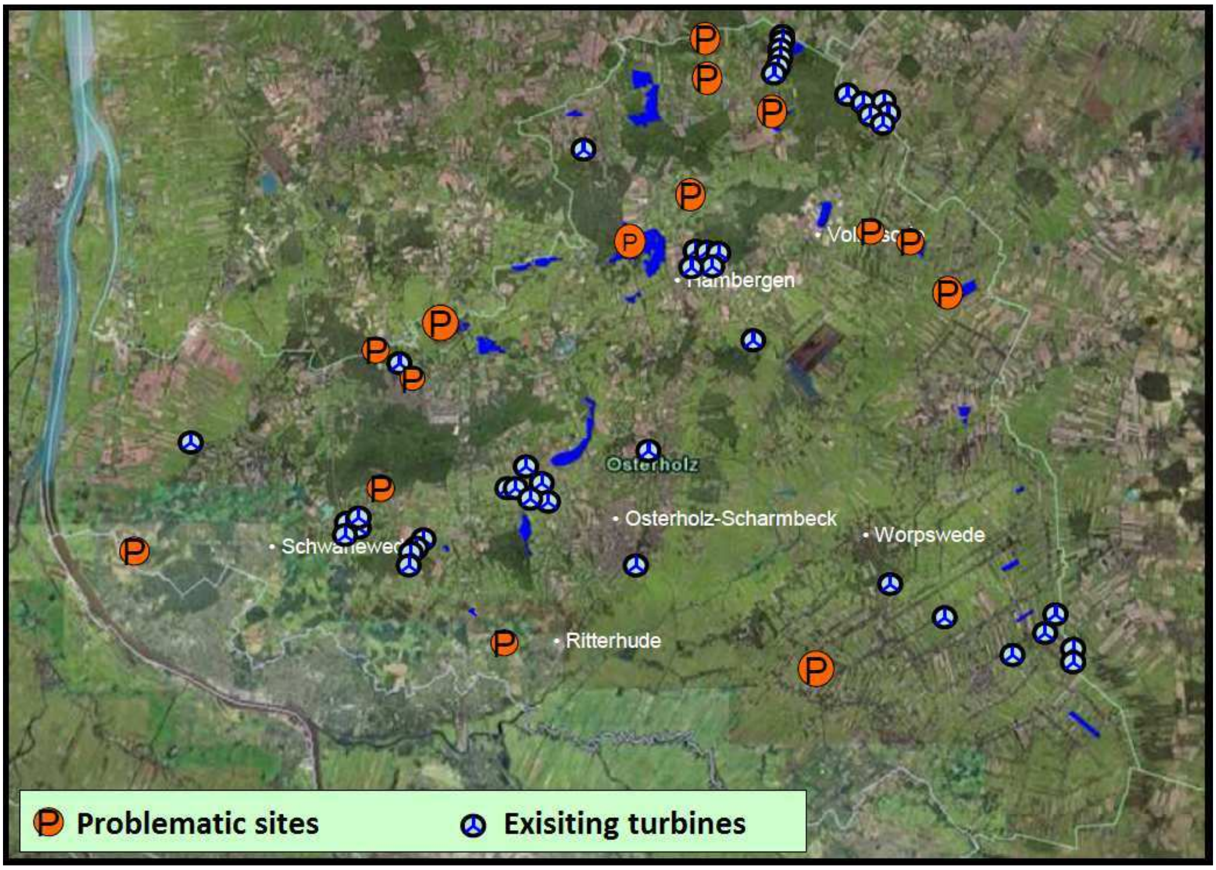


Figure 23: Potential areas for the use of wind power as well as existing facilities

Choice of turbine type

For the remaing potential wind areas a plant location planning (Micrositing) for two different turbine types was carried out. To do this it was necessary to know the prevailing wind direction. As the wind must regenerate once it has flowed through a turbine, certain clearances between turbines must be adhered to. These distances are usually five to seven times rotor diameter in the main wind direction and three to five times adjacent to the main wind direction. The prevailing wind direction is southwest in Osterholz. The first Micrositing was created for the Siemens 2.3 MW wind turbine (rotor diameter 93 m). Overall, 54 wind turbines of this type could be situated on the formally derived potential wind areas in Osterholz. This equals a total capacity of 124.2 MW.

An overview of the potential plant locations is given in Figure 24. Figure 25 shows a portion of the Micrositing for an area in the north of the count near the village of Axstedt. The circles around the plants show the necessary distance in the main and adjacent wind directions.

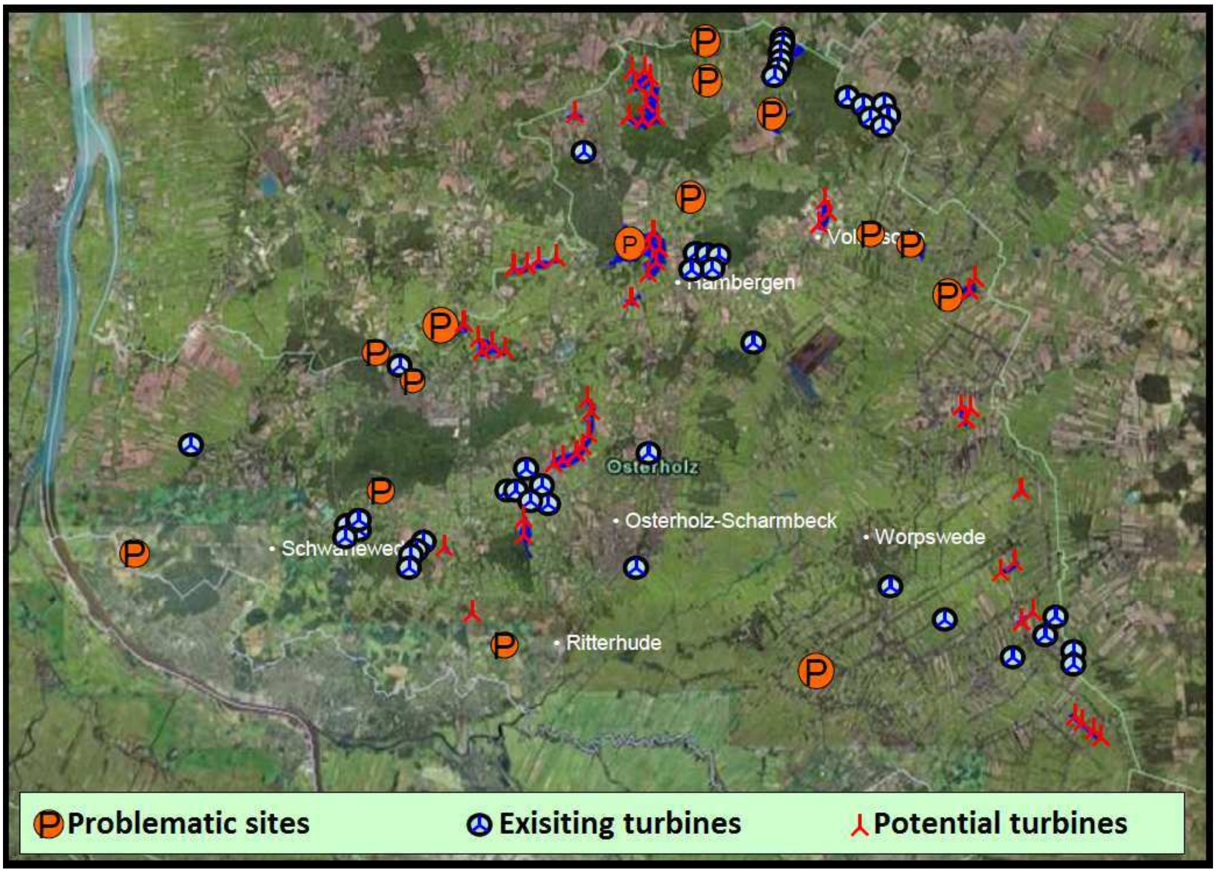


Figure 24: Potential 2.3 MW wind turbines in Osterholz

Figure 25: Detail of micrositing with the Siemens 2.3 MW turbine

The second Micrositing was conducted for a 1.5 MW turbine from GE Wind Energy (77 m rotor diameter). Overall, 72 wind turbines of this type could be situated on the formally derived potential wind areas in Osterholz. This equals a total capacity of 108 MW. Figure 26 shows an example of the second micrositing for the area near Axstedt.

Figure 26: Detail of micrositing with the GE 1.5 MW turbine

Choice of hub height and calculation of the energy yield

As explained in section 3.2, the hub height of a wind turbine has a significant impact on the energy yield; however, in some parts of Germany there are different height restrictions for wind turbines with the aim of reducing the visual impact on the landscape. Two typical height restrictions are 100m and 150m (total height of turbine). The 1.5 MW plant can be supplied to meet the 100m total height requirement, with a hub height of 61 meters. The 2.3 MW turbine is typically erected at a total height of 150 m.

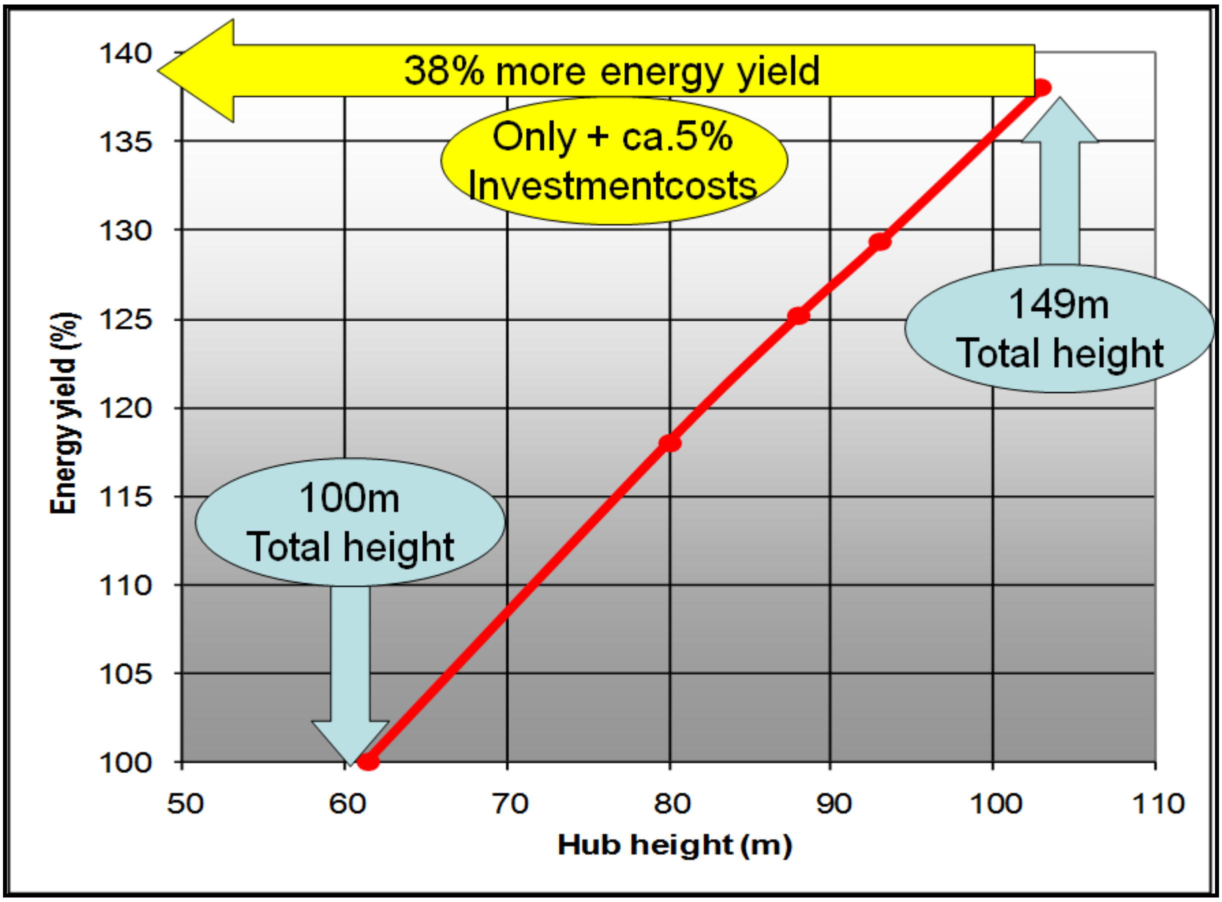
Using wind data from a nearby wind farm and the software WindPRO ®, the potential energy yield for different hub heights and turbine types was calculated. Table 11 shows the results of the calculation.

Depending on turbine type and hub height a potential annual energy yield between 208 138 MWh and 337 278 MWh could be won from the potential wind energy areas in Osterholz. This represents 35.6% and 57.7% of the current energy demand, respectively.

	Scenarios			
	1	2	3	4
Turbine typ	GE 1,5MW	GE 1,5MW	SWT 2,3MW	SWT 2,3MW
Rotor diameter [m]	77	77	93	93
Hub-height [m]	61	80	80	103
Total height [m]	99,5	118,5	126,5	149,5
Turbine capacity [MW_{el}]	1,5	1,5	2,3	2,3
Number of turbines	72	72	54	54
Total capacity [MWel]	108	108	124,2	124,2
Mean wind speed at hub-height [m/s]	5,9	6,4	6,4	6,9
Capacity factor at hub-height [%]	22	24	24	31
Full load hours [h]	1.927	2.102	2.102	2.716
Energy yield per turbine [MWh/a]	2.891	3.154	4.836	6.246
Total energy yield [MWh/a]	**208.138**	**227.059**	**261.118**	**337.278**
Percentage of electricity demand [%]	**35,6%**	**38,9%**	**44,7%**	**57,7%**

Table 7: Additional wind power potential, depending on turbine type and the hub height

The effect of the hub height on the energy yield in Osterholz is illustrated in Figure 27. The additional investment costs caused by the larger tower, are estimated at around 5%



Source: Results from our own calculations with the software WindPRO ®

Figure 27: Influence hub height of wind turbines on the energy yield in Osterholz

3.3 Photovoltaic and solar thermal potential

Due to its geographical position and the corresponding number of hours of sunshine per year, Osterholz is currently not suitable for large photovoltaic plants. In addition, different studies of the potential of suitable areas for the use of photovoltaic and solar thermal systems in existing residential areas judge the unused roof and facade potential to be so great as to offer enough potential for the next 40 years. For these reasons the analysis of solar potential was limited to the usable roof and fascade surfaces.

A study commissioned by the Department for Urban Development Berlin characterized 17 different types of urban space in Berlin and identified the corresponding roof and facade solar potential [SenStadt 2008]. The results of the study are an average usable roof area of 10.40 and façade area of 3.38 square meters per inhabitant. Usable surfaces were defined as those which face south ± 45 and no shade on December 21. The urban space type (Stadtraumtyp 11 - single-family houses of the post-war era) that best compares with the building types in Osterholz, has an estimated solar potential about 3.75 times as high as the Berlin average. This corresponds to a roof and facade area of about 39m ² and 12.7 m² per inhabitant.

For Osterholz a usable roof area of 20m ² per capita was assumed. According to calculations using the online software PVGIS and taking into account the current photovoltaic and solar thermal system efficiencies, the following potential was calculated: 107 520 MWhel / a and 728 000 MWhth / a. This represents 18.4% of the electricity and 56.7% of the heat demand in Osterholz.

3.4 Hydropower

The county of Osterholz has two main rivers, the Hamme and the Wümme, however due to a low gradient and relatively low flow rates the hydro potential is very limited. In the 16th and 17th Century there were several small water mills in the county, of which today only a few are still intact. The conversion of these mills for power generation can be excluded as these buildings are und national heritage protection. The rivers in Osterholz are also integral to the tourism and nature conservation in the county, therefore, their hydropower potential was not considered in more detail in this work.

3.5 Summary of renewable energy potential in Osterholz

In this section, the renewable energy potential that was identified for the county is summarized. Subsequently based on the assumptions on energy efficiency and estimated development of energy demand the feasibility of an energy supply scenario based on these potentials is determined.

The calculated potential for the generation of electricity and heat from renewable energies is collected in Table 8. The results are based on two different scenarios. In the first scenario (max. electricity) the power generation is maximized. For this, the biogas potential is used for combined to electricity and heat generation. The forest wood is also used in thermal power plants using CHP to generate electricity and heat. In the second scenario (maximum heat), the biogas is treated and fed into the existing natural gas grid and used exclusively for heat generation. The forest timber is also utilised for exclusive heat generation in the form of wood pellets and wood chips in decentralized systems. In the scenario max. electricity approximately 100% of the electricity demand and 70% of the county's heat demand is covered. In the scenario max. heat electricity approximately 70% of the electricity demand and 82% of the county's heat demand is covered. The scenarios and the different renewable energy technologies are shown in Figures 28 and 29.

	Electricity generation [MWh_{el}]	Heat generation [MWh_{th}]
Wind energy		
100 m total height	208.138	
150 m total height	**337.278**	
Biogas		
CHP*	**131.788**	**132.192**
Heating only**	**-36.720**	**297.432**
Forest timber		
CHP***	**4.931**	**26.066**
Heatin only*****	**-1.057**	**31.702**
Photovoltaic		
	107.520	
Solar thermal		
		728.000
Total (max. electricity)	**581.517**	**886.258**
Total (max. heat)	**407.021**	**1.057.134**
% of demand (max. electricity)	**99,56%**	**69,00%**
% of demand (max. heat)	**69,69%**	**82,30%**
*20%heat for process ,3% electricity for process, electrical efficiency 37% , thermal efficiency 45% , energy content 6kWh/m³ Biogas		
**20%heat for process ,10% electricity for process, thermal efficiency 90% , energy content 6kWh/m³ Biogas		
***3% electricity for process, electrical efficiency 17% , thermal efficiency 74% , energy content 2.800 kWh/Fm		
****20%heat for process ,3% electricity for process, thermal efficiency 90% , energy content 2.800 kWh/Fm		

Table 8: Renewable energy potential in Osterholz

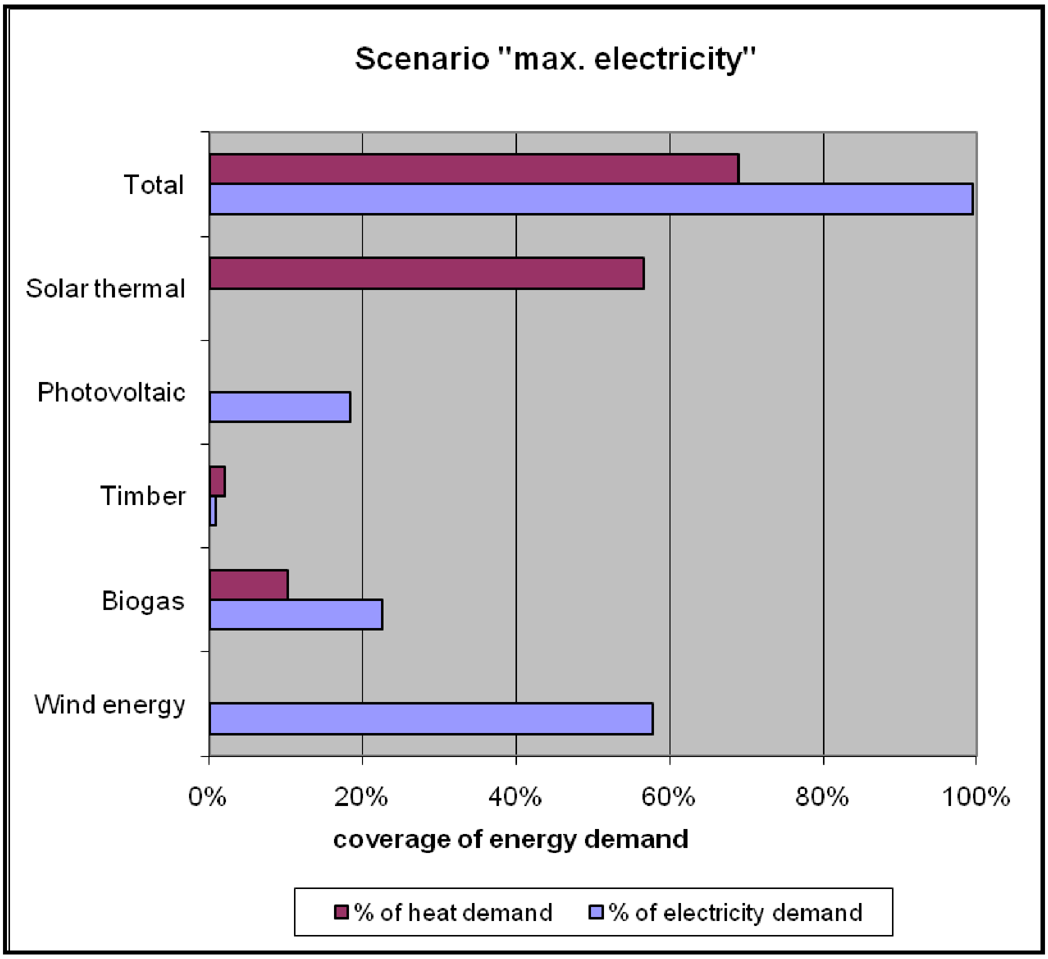


Figure 28: Electricity and heat generation and the renewable energy technologies used in the scenario "max. electricity "

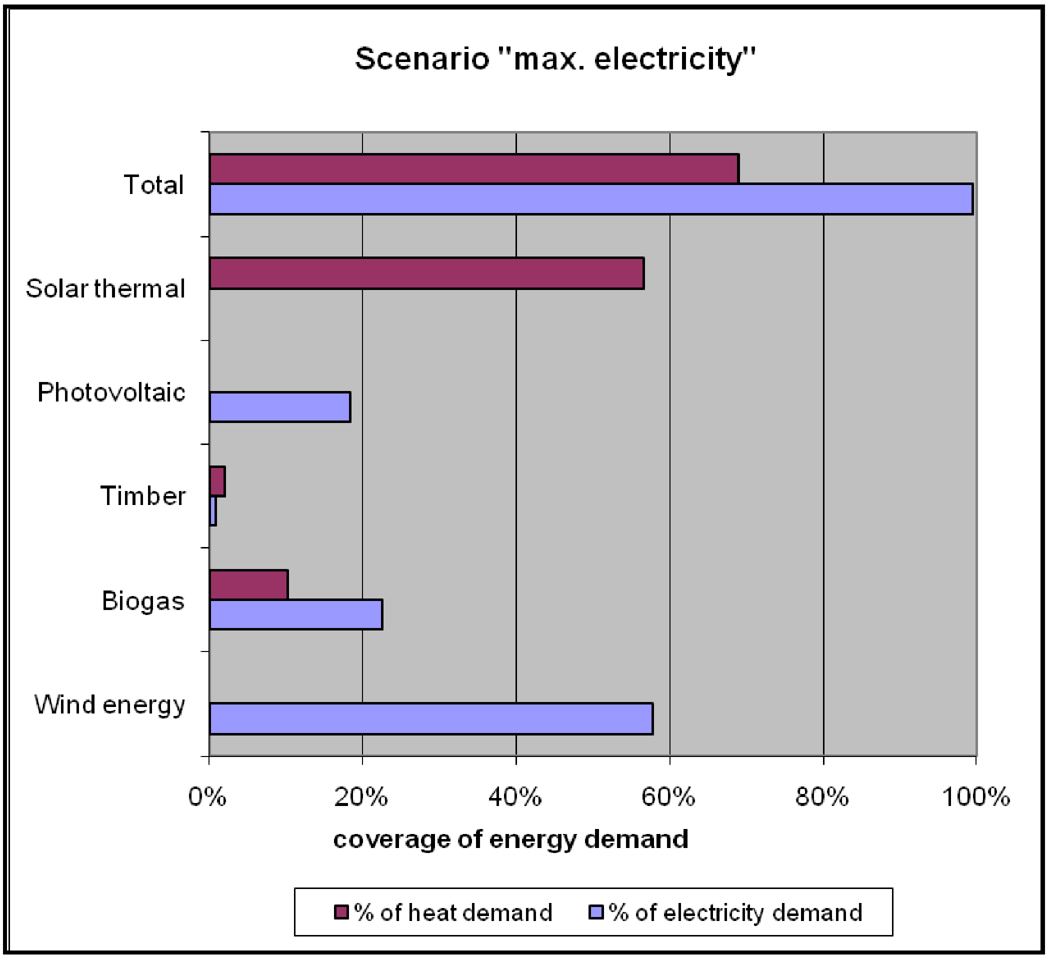


Figure 29: Electricity and heat generation and the renewable energy technologies used in the scenario "max. heat "

Consideration of assumptions on energy saving potential, energy efficiency and fuel requirements

Taking into account the assumptions on possible energy savings and energy efficiency (see above), over time it would be possible to cover the electricity and heat requirements of the county completely using local renewable resources. The remaining unused potentials would be available to cover a portion of the county's fuel needs. Table 9 shows a possible use of renewable energy potential, taking into account possible energy saving potentials and fuel requirements.

	Electricity generation [MWh$_{el}$]	Heat generation [MWh$_{th}$]	Fuel production [MWh$_{th}$]
Energy saving and energy efficiency			
30% electricity savings, 40% heat savings	175.221	524.699	
Wind energy			
100 m total height	302.370		
150 m total height			33.694
Biogas			
CHP*	0	0	
Heating only**	0	0	
BioMethan			330.480
Forest timber			
CHP***	0	0	
Heatin only*****	-1.057	31.702	
Photovoltaic			
	107.520		
Solar thermal			
		728.000	
Total	584.054	1.284.400	364.174
% of demand	100,00%	100,00%	37,16%

*20%heat for process ,3% electricity for process, electrical efficiency 37% , thermal efficiency 45% , energy content 6kWh/m³ Biogas

**20%heat for process ,10% electricity for process, thermal efficiency 90% , energy content 6kWh/m³ Biogas

***3% electricity for process, electrical efficiency 17% , thermal efficiency 74% , energy content 2.800 kWh/Fm

****20%heat for process ,3% electricity for process, thermal efficiency 90% , energy content 2.800 kWh/Fm

Table 9: Use of renewable energy potential, taking energy saving and fuel requirements into account

Table 9 shows that with a future reduction in the electricity and heat demand through energy savings and energy efficiency measures, it would be possible to cover about 37% of current fuel needs, while covering 100% of electricity and heat requirements. The average fuel consumption in Germany in 2006 was almost 8 litres per 100 km for passenger cars. Assuming that in the future the number of motor vehicles and distances travelled remain constant; the average fuel consumption per vehicle would have to be reduced to 3L/100km, in order to cover the fuel demand with the local renewable energy potential.

Dynamic potential of technological advances

It is expected that both the efficiency of technologies for using renewable energy as well as the amount of exploitable energy resources will increase further in the future. The aim of this work, however, was an estimate of the potential in the light of the present state of technology.

4 Summery

The aim of this study was to examine the feasibility of a sustainable energy supply based on renewable energies.

The county of Osterholz was investigated as to whether a specific location has adequate, sustainable potential to cover its own energy needs. For this, the current electricity, heat and fuel requirements were ascertained. The determination of the renewable energy potential was based on the methodology of exisitng studies and carried out through the analysis of maps, aerial photos, statistical surveys and site visits. The results of the analysis of renewable energy potential for the county Osterholz show that even with strict conservation law restrictions, conflicts of use and low solar radiation would be possible to meet 100% of the current electricity and 70% of the current heat demand. In an alternative scenario over 80% of the current heat demand and about 70% of the electricity demand could be covered.

To cover a significant portion of the fuel needs of the county a significant reduction in fuel consumption is necessary. Under the assumption that long term energy savings and efficiency measures are successful, the electricity needs of the district could be reduced by 30% and the heating demand by 40%. To cover the fuel needs for a constant number of vehicls and distance traveled, the average fuel consumption of about 8 L/100km would have to be reduced to 3L/100km.

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