OEVERSEE

Foundations of Sustainable Energy Systems

Report Submitted

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1. INTRODUCTION

1.1. Oeversee (Area under Research)

Oeversee is a municipality in the district of Schleswig-Flensburg, in Schleswig-Holstein, Germany. It is situated approximately 10 km south of Flensburg. The Oeversee municipality was merged with Sankelmark on March 1, 2008. The new municipality is, however, still called Oeversee.

Oeversee is part of the Amt ("collective municipality") Oeversee. The seat of the Amt is located in Tarp, which is close to Idstedt and Stolk, among other smaller towns in the area.

The area was the place of many battles between the Germans and the Danes. There are still annual memorial services held for this event and celebrating the helpfulness of the citizens of Flensburg.

The Austrian city of Graz named an alley and a school after Oeversee in recognition of this event, as the Austrian troops had been based in Graz. Returning the favour, Oeversee named a public square after Graz (Grazer Place).

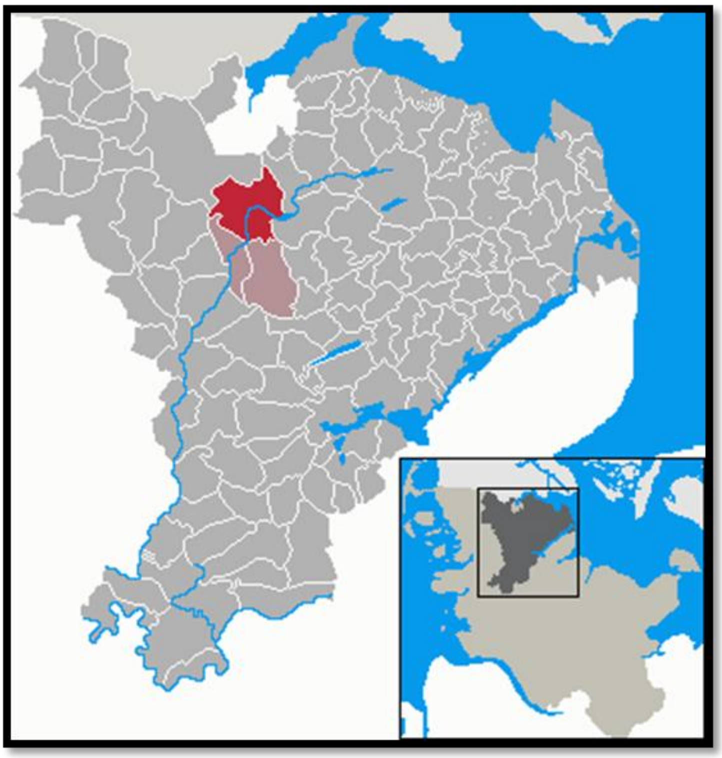


Figure 1.1: Location of Oeversee: 54°42′23″North and 9°26′10″East

Basic Statistics of Oeversee are

- ➢ Area of 36.35 km^2
- ➢ Elevation of 31 meters
- ➢ Population of about 3,369 according to 31 December 2010.

1.2. Aim and Scope

In this project we measure the Sustainability in the context of energy consumption in the region of Oeversee and draw the results for the sustainable development. We analyse the drivers for energy supply and demand which leads to the future development of Oeversee energy system.

Here we will consider different aspects like to achieve solid predictions, first of all, a review of the status quo is made. By assuming a set of driving factors and a specific policy deployment, finally a business as usual scenario are elaborated. The business as usual scenario reflects a development with no regard to climate change. To obtain tangible results, a set of Boundary conditions and Indicators are defined. The data acquisition for the status quo is very much used according to the year and these scenarios depicting the possible development until 2050. Finally, this project will develop the proposals for necessary changes for the development of the energy system to make it sustainable for long run.

Figure 1.2: Solar, Wind and Bio Energy – Sustainable Energies

Also, the aim is to analyse why present energy systems and its likely future development are not sustainable and to develop first ideas to convert the energy system towards a sustainable systems by 2050.

The scope of the project is to use the energy demand data obtained from different sectors and in the coming future by considering the demand of energy, develop the proposals and projects for the transition to sustainability in the region of Oeversee. Considering the present and past data obtained, we can strictly say that there is a drastic raise in the energy demand also rise in sustainable energy production. This is good sign of progress and we should develop the projects for more sustainable energy production by 2050.

1.3. System Boundaries

The consumption and per capita emission of every citizen or company that is registered in the research region is only being considered. This principle has to be applied for the energy carriers (heat, electricity and fuel) used in the region. All other goods cannot be considered due to the non-availability of regional data and to make life easier.

These are the system boundaries derived with respect to the region "Oeversee" according to the following sectors.

Agriculture:

- Onshore and offshore farming
- Fuel, heat and electricity needed to run farm
- Energy needed for the production of fertiliser that is used in the farm
- Ships and tractors that are used in the agriculture belongs to this sector, but not transport sector

Figure 1.3: Agricultural Lands

Commercial and Industry:

- Energy demand for the commercial and Industry
- All public buildings are under this category except schools and kindergartens
- Taxis used for public transport
- Hotels and Restaurants are under commercial

Energy Supply:

- The whole energy produced in Oeversee comes in this sector

Households:

- Consumption of heat and electricity for households and the area has to be taken into account
- Holiday flats are part of this sector as they are used as normal households except unreserved day and nights.

Public buildings:

- Public buildings like Town halls, hospitals, schools, libraries and so on
- Private schools and private kindergartens are under this sector
- Military buildings are neglected

Transport:

- Private vehicles such as cars, motorbikes and so on are to be considered under this sector by their registration in the Oeversee.
- By using the average kilometre/year and average CO_2 emissions/kilometre the total CO_2 emissions are calculated.
- In the case of public transport such as buses, taxis, trains and ships, which were used by atleast two different regions like Oeversee and Flensburg, we should calculate the passengers travelling according to their own region approximately. For example, in our case the people from Oeversee.
- Determine the CO_2 emissions accordingly (per person of the region Oeversee) for all public transport

Figure 1.4: Public transport

- Public vehicles like ambulances, garbage trucks, cleaning vehicles and so on comes under this sector
- Cargo trains, Military vehicles, Police vehicles, Aeroplanes, Cargo ships, Tourism ships and so on are not under this sector and CO_2 emissions are calculated accordingly

1.4. Input for the Research

To proceed with the research we need lot of data from year to year of the above sectors in a respective order. For that we are working with Driving factors, Sustainability Indicators, Status Quo and Business As Usual (BAU) Scenario.

In the case of driving factors, we should consider technological development, Economic growth and also Energy price development like crude oil and natural gas. Calculation of CO_2 emissions plays a vital role.

Sustainability Indicators should consider Energy productivity, Green house gas emissions, share of Renewable energy percentage in the total energy consumption and finally with waste streams.

Under Status Quo, we get the data from different sectors like Energy demands, supply and the emissions. The same in the case of Business As Usual (BAU) Scenario also includes with costs of energy and measures.

2. INDICATORS

2.1. Introduction

Sustainable development is development that meets the needs of current generations without compromising the ability of future generations to meet their needs. It contains within it two key concepts: the concept of needs, in particular the essential needs of the world's poor to which overriding priority should be given; and the idea of limitations imposed by the state of technology and social organization on the environment's ability to meet present and future needs. Achieving sustainable economic development on a global scale will require the judicious use of resources, technology, appropriate economic incentives and strategic policy planning at the local and national levels. It will also require regular monitoring of the impacts of selected policies and strategies to see if they are furthering sustainable development or if they should be adjusted. It is important to be able to measure a country's state of development and to monitor its progress or lack of progress towards sustainability.

The indicators are not merely data; rather, they extend beyond basic statistics to provide a deeper understanding of the main issues and to highlight important relations that are not evident using basic statistics. They are essential tools for communicating energy issues related to sustainable development to policymakers and to the public, and for promoting institutional dialogue. Each set of indicators expresses aspects or consequences of the production and use of energy. Taken together, the indicators give a clear picture of the whole system, including inter-linkages and trade-offs among various dimensions of sustainable development, as well as the longer-term implications of current decisions and behavior. Changes in the indicator values over time mark progress or lack of progress towards sustainable development.

Indicators are useful for monitoring progress towards specific country goals. For example, to reach an annual limit on a set of emissions from the energy sector, it would be sensible to identify the values of appropriate indicators that would be necessary to meet this goal. With knowledge of the energy sector, policymakers can identify the indicators over which they have the most control. Progress is then more easily monitored and policy is often more easily implemented by using these indicators rather than focusing solely on the goal.

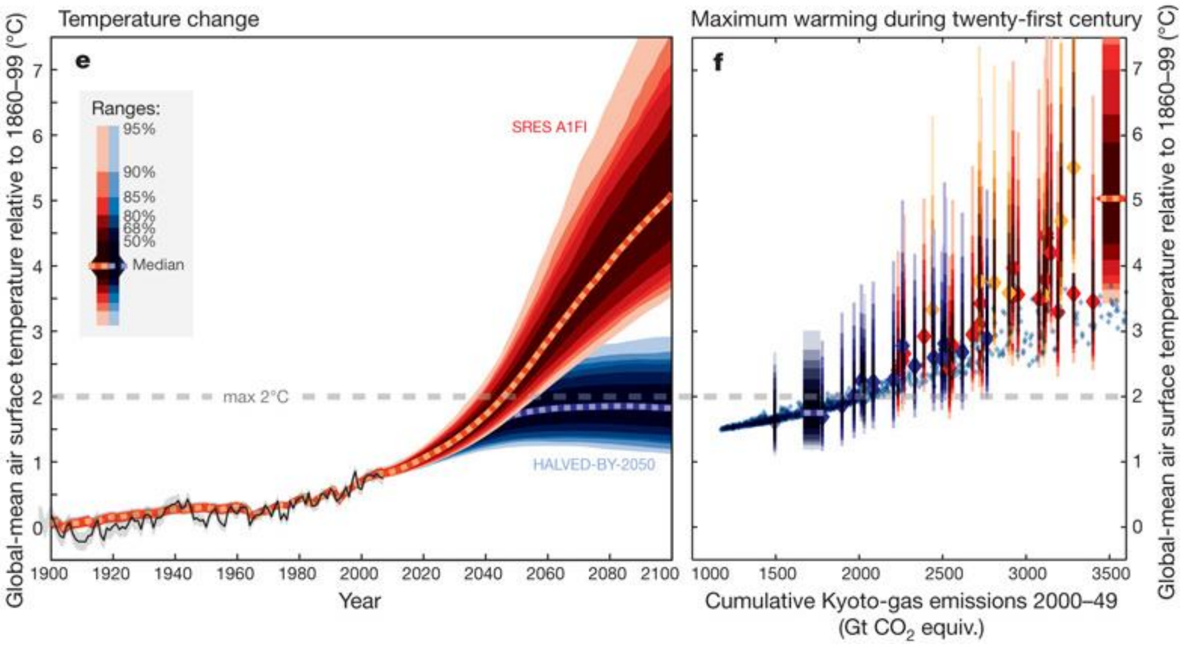
Energy Indicators of Sustainability:

- Bio-energy
- Ratio of Public Transportation
- Energy Consumption Per Capita
- Energy Intensity
- Ratio of Renewable Energy
- GHG emissions per capita

2.2. Sustainability Benchmarks

This is not a process that will lead us from "bad to good" but from "bad to better" in an ongoing improvement development. A partially self regulating and self adjusting procedure to match the evolving nature of a community, leading to the best possible outcome given resources, place and time. Benchmarking can be a difficult and time consuming exercise.

It is estimated that by 2050, the total energy supply is produced from almost 50% of renewable energy sources and the greenhouse gas emissions are of 20% of the 1990 estimated value. Roughly 2.5 tons of CO_2 per person per year (1,000 Gt CO_2 total globally from 2000-2050), as defined by the Intergovernmental Panel on Climate Change 2007 report benchmarks.



Source: Nature International Weekly Journal of Science
http://www.nature.com/nature/journal/v458/n7Nature242/fig_tab/nature08017_F2.html

2.3. Sustainability calculation

For making the calculations some assumptions are made, so that the calculations are somewhat accurate. The assumptions are made because of the non availability of data and for some cases, the possibility of gathering data is impossible.

- Benchmark for comparison
- Methods of Calculation
- Factors of Sustainability and results contained for respective sections in the report

1. Energy Consumption per Capita

The global warming emissions resulting from energy production are a serious global environmental problem. The primary energy supply may reflect the fuel consumption, significant for production and environmental evaluation. Energy losses are not constant but depend on the energy source and technology. From the analytical and statistical point of view one should be aware of these differences that have large significance in the energy ratios, comparisons and evaluation.

Energy Consumption per Capita indicator gives the Energy use in terms of Total Primary Energy Supply (TPES) that measured in TOE per year (Tons Oil Equivalent), total final consumption and final electricity use per capita (Kwh/y). This can be calculated from the below formula.

Energy Consumption = Demand / Population

- Population is nothing but the total number of people present at the region of consideration. But, here only the Households of the region are taken into account.
- Demand is the total energy that is consumed by the people in that region of consideration. Only Electricity consumption and Heat consumptions are taken into account for the Energy consumption

2. Energy Intensity

The ratio of energy use to GDP indicates the total energy being used to support economic and social activity. It represents an aggregate of energy consumption resulting from a wide range of production and consumption activities. In specific economic sectors and sub-sectors, the ratio of energy use to output or activity is the “energy intensity” (if the output is measured in economic units) or the “specific energy requirement” (if the output is measured in physical units such as tons or passenger-kilometers).

Total and sectoral energy consumption is obtained from national energy balances. Household and services/commercial consumption should be carefully separated, and manufacturing should be separated from other industrial uses and agriculture. The aggregate ratio depends as much on the structure of the economy as on the energy intensities of sectors or activities, and changes in the ratio over time are influenced almost as much by changes in the structure of the economy as by changes in sectoral energy intensities.

2.1. Industrial or commercial Sector:

Energy intensity = Energy consumed / Floor area in square meters (OR)

Energy intensity = Energy consumed / GDP

2.2. Agriculture:

Energy intensity = Energy consumed / Area of the Farmland.

- Agricultural energy consumed in KWh
- Total area of farmland in Square meters

2.3. Public Buildings:

Energy intensity = Energy consumed / Floor area

- Energy consumed in KWh
- Floor area in Square meters

3. Ratio of Public Transportation

This Indicator gives the ratio Share of use of the bicycle and public transportation (Number of public passengers per day, year per capita , amount of bicycles per capita). Walking, cycling, passenger cars, motorcycles and mopeds, buses and coaches, train, ship, and plane are considered as the modes of transportation.

Total passenger-kilometers travelled per year divided by the total population, according to the different modes of transport.

Ratio = Public Transport use / Privet transport use

- Public Transport = Distance x passengers
- Private Transport = Distance x passengers

Amount of Bicycle Lanes in kilometers

Amount of Public Transport lines in kilometers

Criteria followed for Calculation:

Basic mathematics are used for calculating the distance as shown below

- 1 person x 1 km = 1P.km
- 60 persons x 1 km = 60P.km = Load Factor (Where the P denotes the people / Persons)

The Load Factors can be used to calculate the kilometers for cars and bus-lines. (OR)

- XY P.km for both buses and cars

If X persons travel for Y kilometers, then the total kilometers can be found by multiplying

- X persons for Y kilometers

4. Ratio of Renewable Energy

It gives the share of Renewable energies on the overall Energy Demand. The overall energy demand includes Electricity, Heat supply and the fuel used for the transportation. It is determined by the following equation.

Renewable Ratio = Renewable Supply / Total Energy Supply

It is estimated that 50% of share could be possible for renewable by 2050 benchmark.

For Electric Supply, the two components are

- Renewable Energy Electric Supply (Energy Supply)
- Total Energy Electric Supply (Energy Supply)

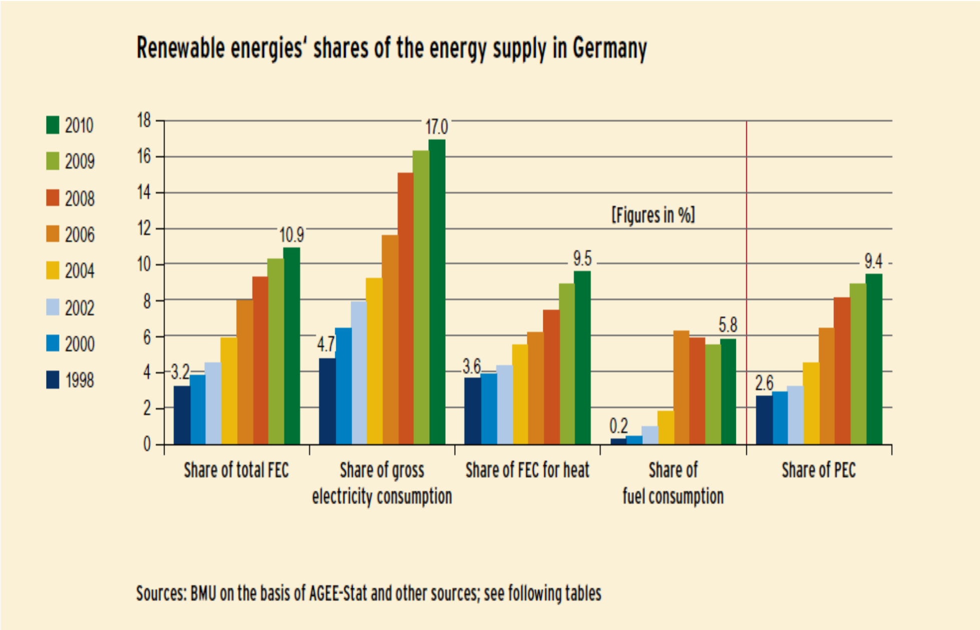
For Heat Supply

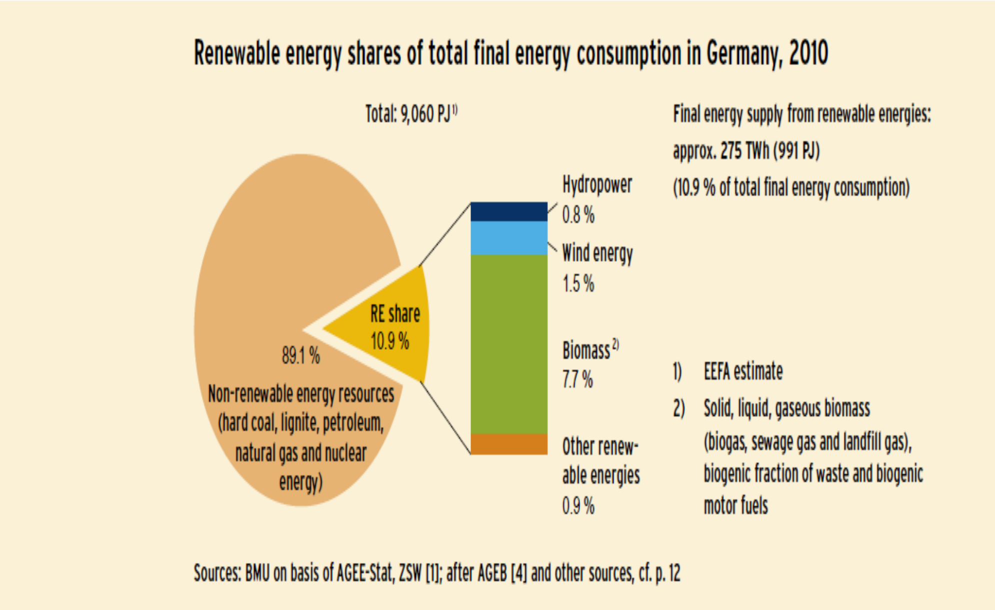
- Renewable Energy Heat Supply (Energy Supply)
- Total Energy Heat Supply (Energy Supply)

For Energy for Transportation

- Renewable Energy Transport Supply (Transportation)
- Total Energy Transport Supply (Transportation)

Renewable Energy Sources in Figures, July, 2011





5. Greenhouse Gas Emissions

A greenhouse gas (sometimes abbreviated **GHG**) is a gas in an atmosphere that absorbs and emits radiation within the thermal infrared range. This process is the fundamental cause of the greenhouse effect. The primary greenhouse gases in the Earth's atmosphere are water vapour, carbon dioxide, methane, nitrous oxide, and ozone. Greenhouse gases greatly affect the temperature of the Earth. Without them, Earth's surface would be on colder than at present.

The primary sources of greenhouse gas emissions from man-made sources include; fossil-fueled power plants such as natural gas power plants and coal fired power plants. Other sources of greenhouse gas emissions linked to man-made causes include internal combustion engines (fueled by gasoline and petroleum diesel) and deforestation.

For the estimation of Greenhouse gas emission, all we need to have are overall sum heat demand, electricity demand and overall sum of fuels. Then the CO_2 emission is calculated for the different kinds.

The following data is considered for the Green House Gas emission calculation.

- Agricultural CO_2 output
- Household CO_2 output
- Industrial and Commercial CO_2 output
- Transportation CO_2 output
- Public Buildings CO_2 output

EXCERPT FROM THE *INVENTORY OF U.S. GREENHOUSE EMISSIONS AND SINKS: 1990-2010*

Gas	Global Warming Potential
Carbon Dioxide (CO2)	1
Methane (CH4)	21
Nitrous Oxide (N2O)	310
HFC-23	11,700
HFC-125	2,800
HFC-134a	1,300
HFC-143a	3,800
HFC-152a	140
HFC-227ea	2,900
HFC-236fa	6,300
HFC-4310mee	1,300
CF4	6,500
C2F6	9,200
C4F10	7,000
C6F14	7,400
SF6	23,900

Source: http://www.epa.gov/climatechange/ghgemissions/usinventoryreport.html

The above table is the latest information on U.S. anthropogenic greenhouse gas emission trends from 1990 through 2010. To ensure that the U.S. emissions inventory is comparable to those of other UNFCCC Parties, the estimates presented here were calculated using methodologies consistent with those recommended in the Revised 1996 Intergovernmental Panel on Climate Change (IPCC) Guidelines for National Greenhouse Gas Inventories (IPCC/UNEP/OECD/IEA 1997), the IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories (IPCC 2000), and the IPCC Good Practice Guidance for Land Use, Land-Use Change, and Forestry (IPCC 2003).

3. STATUS QUO

3.1. Agriculture

1. Introduction

When you think of agriculture in terms of energy balance, the first things that might come to your mind are methane emissions of cows or bio-gas sites. But to put up a decent energy balance one has to take a closer view on the processes of agriculture.

Cultivating fields is one of the main points of it. Farmers have to drive to hand over their fields with tractors and heavy machinery that need fuel. On the other hand cattle’s breeding is a huge consumer of energy as well: Barns have to be heated and milking machines need electricity, too. For this reasons it is necessary to consider agriculture as an important factor in terms of energy balance.

2. Data Research

Detailed data is obligatory for a good research. The cross sectional group dealing with agriculture had troubles with the availability of data. There were very few or even no data available in the internet that satisfied us, because none of them where in details for our personal regions. After some weeks we received very detailed data concerning the live stock and the cultivation of fields from the municipalities. The numbers were put up for every community (German: Gemeinde). In conclusion the communities of each region had to be looked up and the corresponding data extracted. Finally we had numbers for the cultivated area of our communities including the planted crops and the amount of cattle, pigs, etc. for each of them (see Fig. 2).

These data are the basic information one needs for putting up an sophisticated energy balance. Nevertheless these raw data had to be calculated and transferred into CO_2 emissions. How this has been done will be described later. Mandatory for it were data that provided information concerning the energy demand, e.g.: How much energy does the breeding of a certain amount of cattle per year require? (Or) How many liters of fuel are needed for cultivating 10 hectare of rye? Luckily the research regarding that was successful, as well (see Fig.3). We found useful numbers providing the information how many liters of fuel are required for plowing, mowing, etc. 1 hectare of land. Also we found information regarding the energy demand of different livestock per year.

	Flächennutzung in den landwirtschaftlichen Betrieben											
Land ---- Regierungsbezirk ---------------- Kreis ----- Gemeinde ---------- Gemeindeteil	Kulturarten				Anbaufläche auf dem Ackerland							
	Dauerkulturen		Dauergrünland		Getreide zu-sammen	darunter						
						Weizen		Roggen	Triticale	Winter-gerste	Sommer-gerste	Hafer
						zu-sammen	Winter-Weizen					
	Betriebe	ha	Betriebe	ha	ha							
	10	11	12	13	14	15	16	17	18	19	20	21
Oeversee	-	-	16	355	37	-	-	25	·	-	-	-
Sieverstedt	-	-	29	561	456	189	189	87	19	128	-	32
Tarp	-	-	20	393	176	·	·	49	·	47	-	-
	0	0	65	1.309	669	189	189	161	19	175	0	32

Figure 1: Extract of cultivated area data

Categories	Unit	Operations (S)	Heating Housing (H)	Farm bldg Housing (B)	Summe Heat
		electricity	heat	heat	
For dairy cows	GJ/cow	8	0	2,5	2,5
For other cattle Small	GJ/30 small cattle	1,7	0	2,5	2,5
For other cattle Big	GJ/one no. Of big ca	1,7	0	2,5	2,5
For conventional sows	GJ/ 30 sows	6	3,1	2,5	5,6
For organic sows	GJ/ 30 sows	3,2	2	2,5	4,5
For conventional slaughter pigs	GJ/ 30 pigs	0,9	0,6	2,5	3,1
For organic slaughter pigs	GJ/ 30 pigs	0,4	0,4	2,5	2,9

Figure 2: Extract of livestock energy calculation

3. Calculation Of Status Quo

At this point we knew all the details of available livestock and cultivated area. We now had to figure out how to translate this in terms of energy consumption.

3.1. Fields

For the fields we found a list of the fuel consumption for standart farming steps like plowing, mowing, etc. We prepared a list for each of the grown plants in our regions. In this list every plant is connected to the farming step it requires (see Fig. 4).

	Fuel Consumption	Roggen	Fuel Consumption	Triticale	Fuel Consumption	Winter barley / Winter Gerste	Fuel Consumption	Summer barley / Sommer Gerste	Fuel Consumption	Oat / Hafer
					ha					
Tilling and sowing										
Ploughing (21 cm)	21,5	1	21,5	1	21,5	1	21,5	1	21,5	1
Soil compaction I	2	1	2	1	2	1	2	1	2	1
Seedbed harrowing	5	1	5	1	5	1	5	1	5	1
Rolling I	1	0,5	1	0,5	1	0,5	1	0,5	1	0,5
Sowing I	3	1	3	1	3	1	3	1	3	1
Stubble cultivation I	14	2	14	2	14	2	14	2	14	2
Fertilising and liming										
Spreading and loading manure / Mist	1,2	2	1,2	2	1,2	2	1,2	2	1,2	2
Spreading slurry / Gülle	9	30	9	30	9	30	9	30	9	30
Spreading fertiliser	4	2	4	2	4	2	4	2	4	2
Liming I	0,75	0,5	0,75	0,5	0,75	0,5	0,75	0,5	0,75	0,5
Plant protection										
Pesticide spraying I	3	2	3	2	3	2	3	2	3	2
Weed harrowing I	0		0		0		0		0	
Row listing I	0		0		0		0		0	

In conclusion we received the amount of fuel per year and hectare for each crop. We excluded seed production, drying and fertilizer production from the calculation, because this would have made our calculations too complex.

3.2. Livestock

Regarding the livestock we found a satisfying list of energy consumption per cattle per year in a study (see Fig.3), in which values for electricity and heat demand were given. Of course we had to simplify some aspects in this matter, as well so we assume the following:

- The imported fodder norm has been selected as zero
- Sheep, chicken and other fowl are considered as "small cattle"
- Horses are considered to have the same energy demand as cows

- Ratio of organic to conventional pigs 1:10
- Ratio of sows to slaughter pigs 1:4

Sheep

Since detailed numbers about sheep were not provided by the municipality due to data protection, we had to estimate something. Due to another research the number of sheep in the whole region Schleswig-Flensburg was available. Since we had absolutely no clue, we decided to assume that the number of sheep behaves like the area of green land. We assumed the following formula:

$S_{Oeversee}$: = Amount of sheep in Oeversee

$S_{Schleswig-Flensburg}$: = Amount of sheep in Schleswig-Flensburg

$G_{Oeversee}$: = Area of green land in Oeversee

$G_{Schleswig-Flensburg}$: = Area of green land in Schleswig-Flensburg

$$S_{Oeversee} = S_{Schleswig-Flensburg} \cdot \frac{G_{Oeversee}}{G_{Schleswig-Flensburg}}$$

In conclusion we had factors for every cattle and every crop that provided the amount of energy demanded per year and per hectare or animal, so we could calculate our status quo energy demand.

4. Status Quo Energy demand

With the previously described methods and data it was possible to calculate the energy demand for the agriculture of the region Oeversee.

Fields

- Fuel: 377623 l Diesel

Livestock

- Heat: 15590 MWh
- Electricity: 5207 MWh

3.2. Commertial and Industry

1. Introduction

Firstly, this chapter will show how data of the energy demand in the region Oeversee were collected. Secondly, you will find an overview about the energy demand in Oeversee at status quo (nowadays). At the end the energy demand is calculated for the year 2050 by a business as usual scenario.

2. Data evaluation

For the data collection at status quo, commerce and industry are handled equally as it makes no difference towards their nowadays energy consumption if the examined company belongs to commerce or industry; by definition a business counts to industry if it employs more than 20 people. Otherwise, if it employs less than 20 or exactly 20 people, the business belongs to commerce. Furthermore, the production side of business activity is referred to industry (European Comission, 2008). To evaluate the energy demand of the industry and commercial sector different approaches were tried. First of all, the energy suppliers were asked to give us information about the energy demand of the industry and commercial sector of the region Oeversee. After conversation with Mr. Tiessen of the Eon Hanse AG it came out that it is not possible to forward any information about individual energy consumption of companies in this region due to lack of information and data protection laws. The next approach was to contact each of the firms separately to ask them about their energy demand. During the contact search it came out, that around seventy companies provide work in Oeversee. Besides the time period of this project and due the agreement with the groups, which were responsible for other regions around Flensburg, it was not held on the approach to contact each of the company separately.

3. Calculation of the energy demand of industry

To get a more visible result, the bigger companies were asked personally to provide us information about their energy consumption. Therefore, a survey was carried out, which design is imaged by **Error! Reference source not found.**

Foundations of Sustainable Energy Systems – Summer Term 2012
Projekt: Energie und Co2 Bilanz Kreis Schleswig-Flensburg

Datenerhebung:

Sektor: Gewerbe und Industrie

Region: Amt Oeversee (Tarp, Sieverstedt)

Unternehmen(optional):

Ansprechpartner:

Anzahl Mitarbeiter:

2009	2010	2011

Verbrauch Elektrizität (kwh):

2009	2010	2011

Heiz-Art (z.B. Ölheizung, Gas, Fernwärme, Pellets, usw.):

Verbrauch Heizung (in Liter oder kwh):

2009	2010	2011

Anzahl Firmenfahrzeuge:

PKW (Typ)

2009	2010	2011

LKW (Typ)

2009	2010	2011

Verbrauch Kraftsoff (in Liter und Art [z.B. Diesel, Benzin])

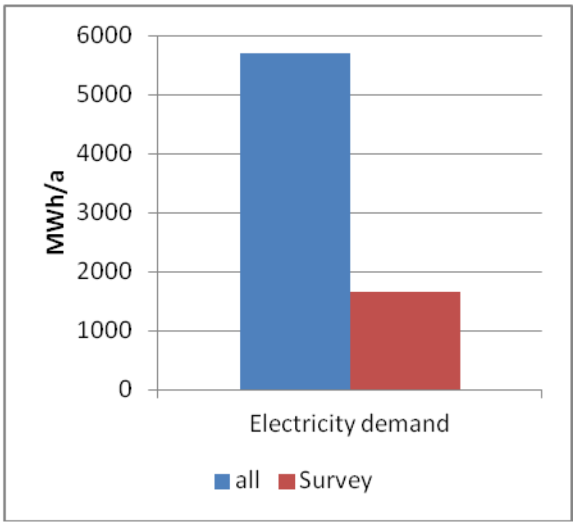
2009	2010	2011

Figure 3: Survey to the companies to receive information about their energy consumption

Three out of five companies that were contacted replied within one week. Thereunder was:

- Trennetaler (beverage company – manufacturer)
- Trixi (pet supplies – whole sale)
- Clausen Kies- und Betonwerke (others)

In Figure 4 you see that these companies cause about one third of the electricity demand as well as heat demand.



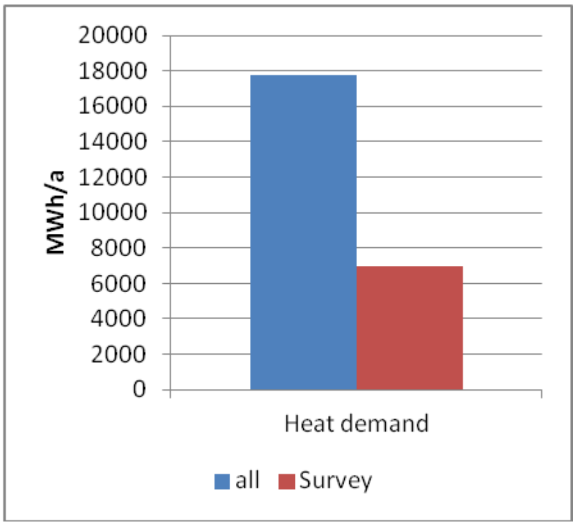


Figure 4: Allocation of energy demand of polled companies and calculated companies

The approach to calculate the energy demand of smaller enterprises is explained in chapter 4.

4. Calculation of the energy demand of commerce

Firstly, the numbers of employees for each company were determined by use of the *Unternehmensdatenbank Norddeutschland* (Unternehmensdatenbank Norddeutschland, 2006). The companies were distinguished in their size class of local units:

1. 1 to 3 employees
2. 4 to 6 employees
3. 7 to 9 employees
4. 10 to 19 employees
5. 20 to 49 employees
6. 50 to 99 employees
7. 100 to 199 employees
8. 200 to 499 employees
9. 500 to 999 employees
10. 1000 to 4999 employees
11. 5000 to 9999 employees
12. 10000 and more employees

Most companies were registered in the *Unternehmensdatenbank Norddeutschland*. The number of employees of companies not registered in the *Unternehmensdatenbank Norddeutschland*, were obtained on the basic of in the internet researchable enterprises (homepage of the company) and personal contacts to businesses (Crosssection group

Industry and Commerce, 2012). These data give an average number of employees for companies which could not be valued by internet research. The estimations are shown in Table 1:

Industry sector	**Employees**	**Source**
Construction industry	7	report "Flensburg 2050", (Prof. Dr. Hohmeyer O., 2008/2009)
Office like enterprises	3	average of yet known companies
Manufacturing enterprises	6	average of yet known companies
Retail trade	3	average of yet known companies
Hotel	20	average of yet known companies
Restaurants	5	average of yet known companies
Homes	11	average of yet known companies
Bakers	5	average of yet known companies
Butchers	5	average of yet known companies
Other food	5	average of yet known companies
Laundries	3	average of yet known companies
Horticulture	3	average of yet known companies
Textile, clothing, leather	2	average of yet known companies
Truck company	15	average of yet known companies

Table 1: Estimation of employees of companies that were not listed in the *Unternehmensdatenbank Norddeutschland*

With these numbers, the energy demand of each company in Oeversee could be calculated by the following equation:

$$Numbers\ of\ Employees \cdot \left(\frac{Energy\ Demand}{Employee}\right) = Energy\ Demand\ of\ the\ Company$$

Equation 1: Calculation of the Energy Demand of a Company

In Equation 1 the value of $\left(\frac{\text{Energy Demand}}{\text{Employee}}\right)$ is given by the report of the *Bundesministerium für Wirtschaft und Technologie* (Bundesministerium für Wirtschaft und Technologie, 2011). In their report the individual energy demand of different industry sectors is distinguished. Therefore, the report lists fourteen different groups of businesses and their electricity as well as heat/fuel consumption in the year 2006, 2007, 2008, 2009 and 2010.

To achieve a comparable result with other regions, the energy demand of the year 2010 is taken.

For the sector of industry and commerce the following groups with its subgroups are important and shown in Table 2:

Name of industry sector	Electricity demand 2010 [kWh/Employee]	Heat demand 2010 [kWh/Employee]
1. Construction industry	1552	5429
2. Office-like enterprises	2474	6082
2.1. Publishing companies	2256	6702
2.2. Other services	6402	5358
2.3. Administrative unit	2138	5533
2.4. Post office	1141	3329
2.5. Telecommunication	24670	5148
2.6. Deutsche Bahn	6917	14923
3. Manufacturing enterprises	3848	8663
3.1. Metal working	4156	6703
3.2. Car workshop	3318	11499
3.3. Carpenter	3163	9582
3.4. Paper manufacture, Printing	5084	8653
3.5. Others	3848	8663
4. Retail trade	4292	7591
4.1. Retail trade – food	7321	6764
4.2. Retail trade – non food	3520	8250
4.3. Whole trade – food	3457	6276
4.4. Whole trade – non food	4411	7455
4.5. Others	1666	6360
6. Hotels, restaurants, homes	4143	12715

6.1. Hotels 6.2. Restaurants 6.3. Organisations without profit, homes	7704 5233 2318	23419 10689 10907
7. Food production 7.1. Bakers 7.2. Butchers 7.3. Other food	8000 6491 8552 8745	12224 16504 9492 10677
8. Laundries	Non-resident in Oeversee	Non-resident in Oeversee
11. Airports	Non-resident in Oeversee	Non-resident in Oeversee
12. Textile, clothing, leather, freight 12.1. Textile, clothing, leather 12.2. Freight	1815 Non-resident in Oeversee 1746	3659 Non-resident in Oeversee 3208
14. Others	Non-resident in Oeversee	Non-resident in Oeversee

Table 2: Industry sectors and their electricity/heat demand per employee (Bundesministerium für Wirtschaft und Technologie, 2011)

5. Results of the data evaluation

Taking the preconditions of chapter 1 and 2 into consideration it is possible to calculate the energy demand of the different industry sectors. The allocation of the electricity demand as well as the heat demand to the industry sectors and respectively the commerce sector show the following figures. Figure 5 stands for the electricity demand and Figure 6 displays the heat demand:

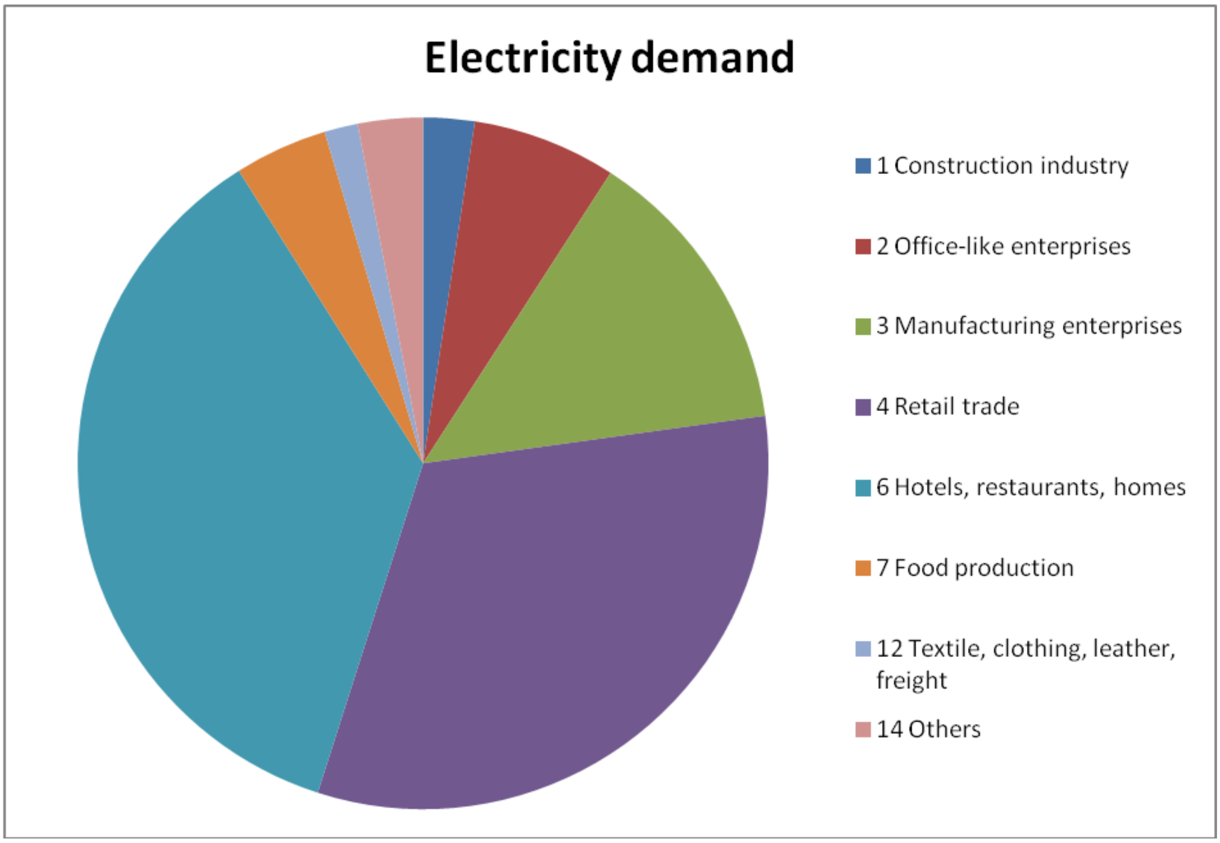


Figure 5: Electricity demand of industry sectors in Oeversee

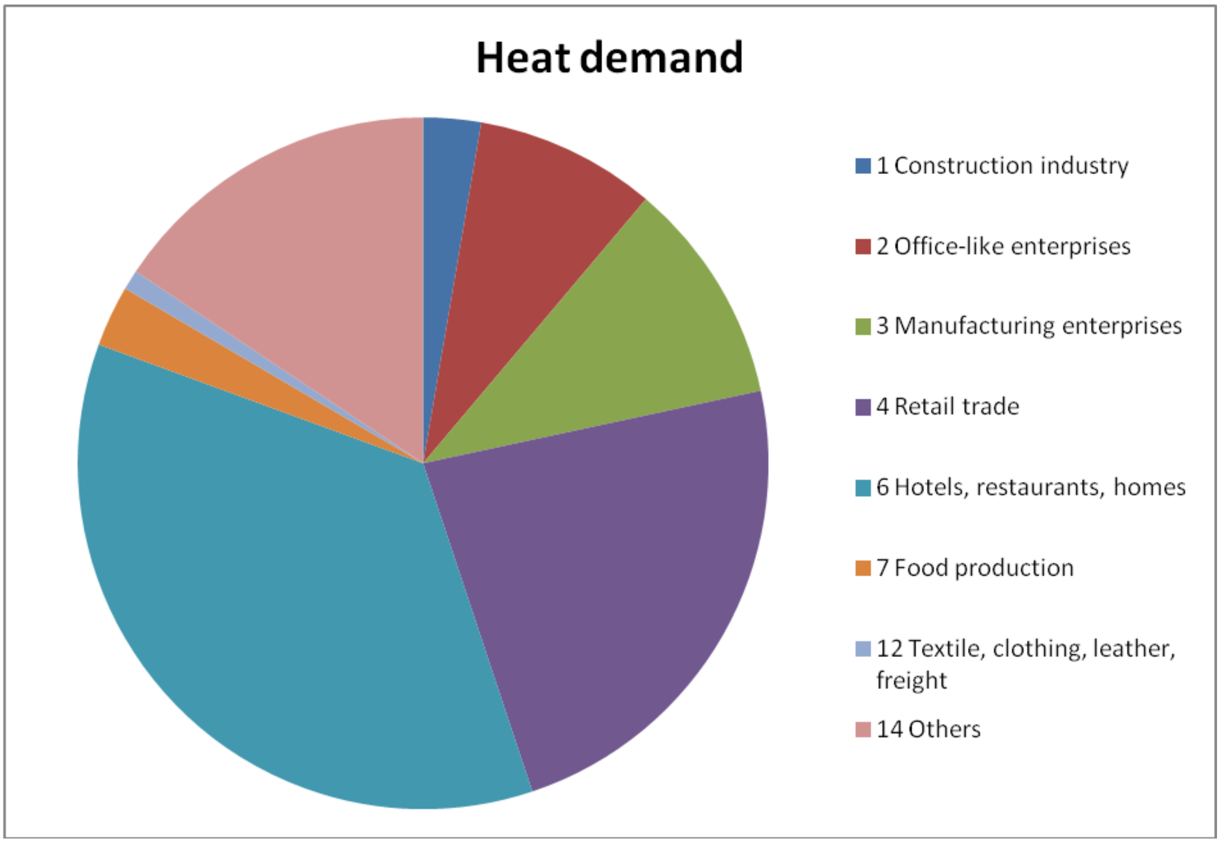


Figure 6: Heat demand of industry sectors in Oeversee

The retail trade as well as “Hotels, Restaurants and Homes” consume electricity the most. The second highest electricity consumption is up to “Manufacturing enterprises”.

Also the hotels, restaurants and homes need the most heat. Followed by “Retail trade” and “Manufacturing enterprises”.

How the electricity demand relates to the heat demand, Figure 7 shows:

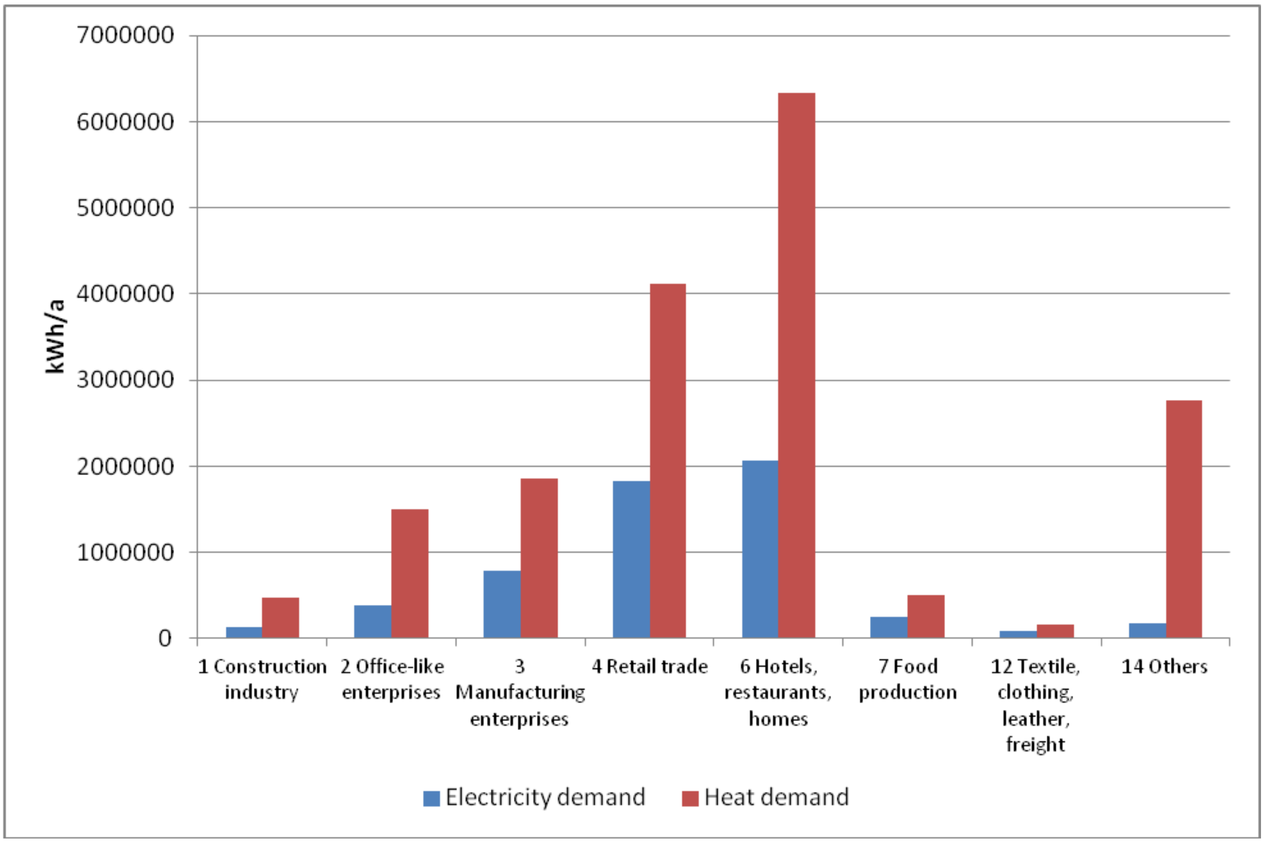


Figure 7: Relation of the electricity demand to the heat demand of the industry sectors

The sector “Others”, which represent Clausen Kies- und Betonwerke, needing a lot of fuel for their machinery, show the biggest gap between electricity and heat demand. The heat demand is about 16 times higher than the electricity demand. The second biggest gap occurs in the “offices like enterprises”. Here the heat demand is about 4 times higher. The most equal electricity demand to heat demand shows the group “Textile, Clothing, Leather and Freight” with a nearly two times higher heat demand than electricity demand. An overview about the coefficients gives Figure 8.

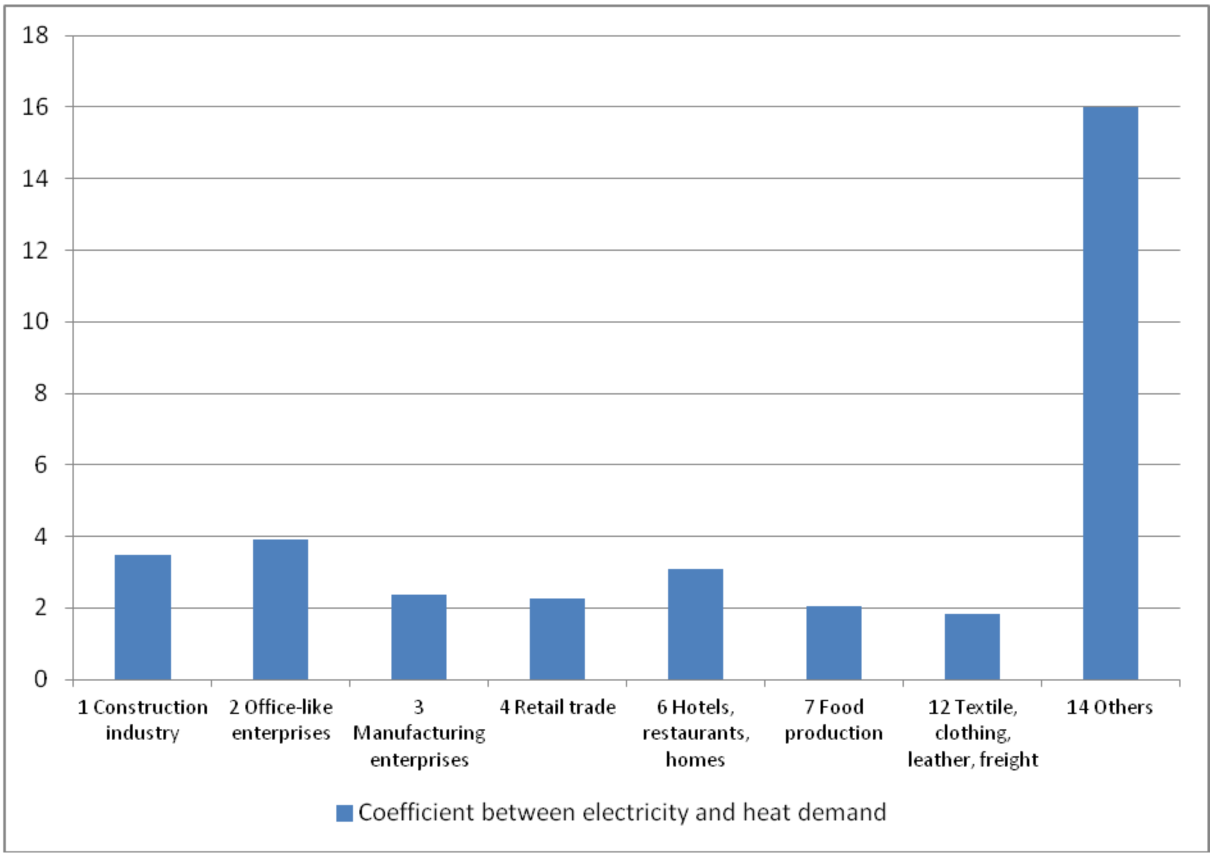


Figure 8: Coefficient between electricity and heat demand of the industry sectors

3.3. Energy Supply

1. Elecrticity

The overall objective of the energy supply is to meet the demand determined by the different sectorial groups. In principal there are two different ways to fulfil the demand:

1. Importing energy into the municipality
2. Producing energy in the municipality.

As the demand for as well as the supply of electricity is subject to strong fluctuations during the day and over the year, the only reasonable solution is to allow the import and export of electricity. This is being done by the grid. The analysis will show later, that the maximum power of import and export exceed significantly the current status, but still remain at a very low level. Hence, one can assume that the grid capacity is sufficient to handle the transport of electricity into and out of the region and does not need further investigation. Furthermore it is assumed, that the remainder of Germany can always supply the region with additional electricity and all surplus production can be exported to the remainder of Germany.

As stated above, the electricity demand and supply is fluctuating. This leads to a need of specifying their values at least on an hourly level. The main drivers for the fluctuations are:

1. Monthly fluctuations:
    a. Demand side: seasonal changes in electricity demand for heating and light
    b. Supply side: seasonal changes in wind and solar radiation
2. Daily fluctuations:
    a. Demand side: depending on the sector evaluated, e.g. office hours for public administration and their electricity demand by electrical devices
    b. Supply side: changes of global radiation during the day for solar power

As the fluctuations mentioned above are of greater importance than the weekly ones, the author decided to treat every day of a particular month being equal. This leads to a loss of information in the demand side calculations. However, regarding the inherent uncertainty in the energy supply prediction, this seems to be a reasonable assumption to keep the model simple. The general approach is shown in Figure 9. A detailed discussion of the used parameters is done in the following chapters.

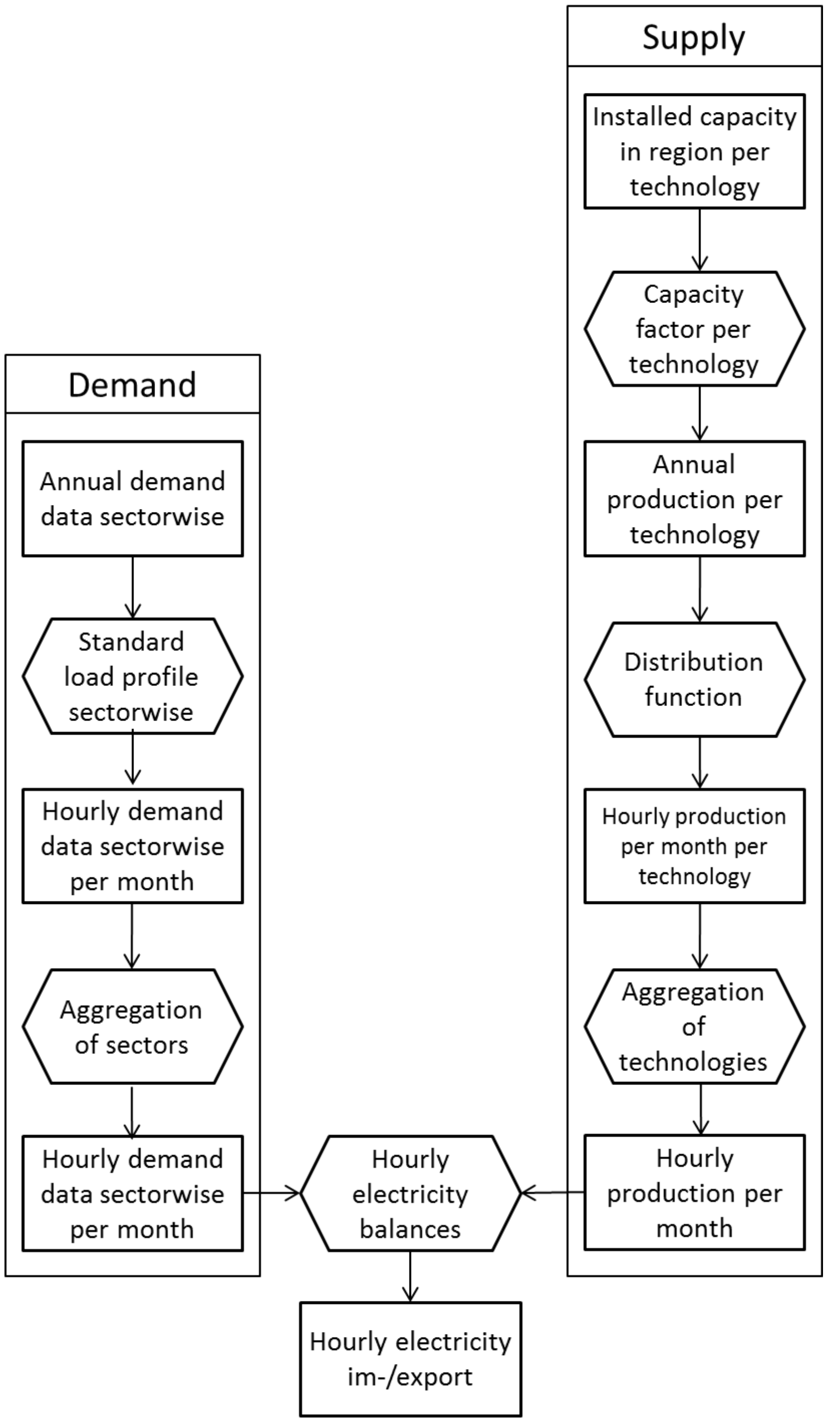


Figure 9: Calculation of hourly electricity balances

1.1. Data acquisition status quo

As already stated above the demand for electricity will be delivered by the different sectorial groups. To specify the electricity supply in the municipality, the installed capacity has to be determined. One can split the capacity into two groups, depending on the time horizon they need to regenerate:

1. Renewable electricity production
2. Non-renewable electricity production

To quantify the installed capacity for renewables, the website energymap.info (Deutsche Gesellschaft für Sonnenenergie e.V. (DGS), 2012) is used. This website collects data for installed renewable power plants on a municipality level. The region of Oeversee consists of the three municipalities Oeversee, Tarp and Sieverstedt, whose installed capacities are being aggregated to a total capacity for the region.

To access the capacity for non-renewables we used two methods:

1. Enquiry for data at the Stadtwerke Flensburg
2. Extensive web search

The base year for the status quo analysis is the year 2010 to be in line with the energy demand calculations.

1.2. Prognosis of electricity supply

A business-as-usual scenario is used for the prognosis of the electricity supply. Most of the methodology mentioned above is time-invariant. Therefore, only a prognosis of the installed capacity is needed to determine the electricity supply in the region. As above renewable and non-renewable power plants are investigated separately.

The major assumption for the renewables – following the lecturers' argumentation – is the immediate determination of the Erneuerbare Energien Gesetz and of all feed-in tariffs. Hence, new plants will only be installed, if it is economical. Furthermore, the lifetime of all renewable power plants (see Wissel et al., 2010) is assumed to be 20 years (wind turbines), 25 years (solar) and 30 years (biomass). Other specific assumption for the different energy carrier is described in the following paragraphs. An overview is given in Table 3.

Technology	Year of profitability	Lifetime	Upper limit
Wind Energy	2012	20 years	Available areas
Photovoltaic	2030	25 years	Available roof area
Biomass	2030	30 years	Available biomass
Hydro	2012	40 years	Hydro potential

Table 3: Overview influence factors prognosis electricity supply

1.2.1. Wind Energy

As stated is above new power plants will only installed, if their operation is economically feasible. This means their cost per kWh electricity is comparable to fossil power plants. A study of the Fraunhofer Institut (Kost et al., 2012) leads to the conclusion that this criterion is fulfilled for wind energy. The upper limit of the wind turbines is given by the available land. At the moment new areas for wind turbines are assigned by the government (Innenministerium SH, 2012). From that map new areas in the region are identified. The area needed for a wind turbine is calculated by Equation II. All new turbines will be installed in 2015.

$$A = 2 * n^2 D^2$$

n: number of wind turbines

D: rotor diameter in [m]

Equation II: Area demand for wind turbine; Dietrich (2008).

Furthermore the capacity can be increased by the repowering of old turbines. During the repowering process the capacity has to be increased between two and five times the old capacity by the law (§30 EEG, 2009). Although the law is assumed to be determined, these numbers shall be used as a reference for the repowering. Hence, each repowering instance will increase the installed capacity of that wind park by 350%. Repowering is assumed to happen at the end of the lifetime of a wind turbine. The increasing capacity at the same area is reasonable due to a likely increase in technology (e.g. higher towers, better power coefficients).

1.2.2. Photovoltaic

Most of the photovoltaic plants in the region are small plants with a size of less than 100 kWp. According to Kost et al. (2012, P. 18) these plants will reach competitive cost of energy produced in Northern Germany by 2030. Hence, there will be no further installation of PV between 2012 and 2030. The available roof area largely determines the upper limit for the installation of photovoltaic modules.

During the last two years the price for PV modules dropped dramatically, so it became economically – as the EEG guaranteed a high feed-in tariff – to install PV module on one's roof. It shall be assumed, that by 2012 all house owner, who have a positive attitude towards the technology, already installed a PV power plant on their roof. Therefore, the installed capacity in 2012 will be regarded as an upper border for the installed capacity. Due to low level of global radiation in the region and the comparable low electricity demand (unlike Southern Germany) it is assumed that no further free field PV power plants will be built. All installed plants will be replaced after 25 years, or as soon as it is economical feasible. The decrease of production due to wear of the solar panel is assumed to be 0.2% per year following usual values in the industry.

1.2.3. Biomass

Assessing the profitability of biomass plants is not easy. Their cost of energy is mainly driven by the cost of the biomass itself. Hence, one needs a solid prognosis of the biomass market price. Vahrenholt and Gassner (2012) state that in the best case the cost of energy for biomass reaching competitive prices at about 2025 following the criteria of Kost et al. (2012). Wissel et al. (2010) give a projection for the cost of energy of biomass in 2015. Comparing that value with the cost of energy of non-renewables (Kost et al., 2012), leads to a competitiveness from 2030 onwards. However, the price for the biomass itself has a huge influence. Therefore, the world market price of biomass has a huge, but almost unpredictable influence.

To use a conservative approach, it is assumed that only the biomass produced in the region can be constantly provided at stable prices. According to the cross-sectional group agriculture biomass production in the region has reached a maximum. As a consequence the current installed capacity will act as an upper limit for the installation of biomass power plants. Existing plants will be after their lifetime, if it is economically feasible.

1.2.4. Hydro and other technologies

One hydro power plant is operational in the region. As it has only a small capacity and therefore a minor influence on the power production. For simplification hydro is assumed to be profitable. The plant will be replaced after 30 year lifetime. There is no potential for a noticeable increase of hydro capacity in the region.

Power plants of technologies, namely non-renewables, are expected to be maintained at the same capacity. However, there are no non-renewable power plants in the region.

1.3. Calculation hourly data: demand side

As stated above the yearly electricity demand of the sectors have to be broken down into at least monthly values. For that purpose standard load profiles by the Bundesverband der Energie- und Wasserwirtschaft e.V. (BDEW) are being used. The load profiles are calculated for 2011. However, as all days of the week are treated equally the only change to 2050 is a change in the public holidays over the month as long as the consumers do not change their behaviour for the use of electricity. Further changes will occur, if the efficiency ratios of electrical devises to each other change over time (e.g. change from light bulbs to LED will save electricity for lighting but the efficiency of computers change less). The change in total demand is being implied by the sectorial groups, but the corresponding change in the load profile cannot be predicted with reasonable effort. However, it is most likely, that the load profiles remain useable.

The used load profiles are listed in Table 4. As there is little industry in the region compared to commerce, the load profile for commerce was chosen. The electrical demand of public buildings however, is better represented by the special load profile for commerce with opening hours during the day. The original profile is only valid for working days, but as the differences between working days and weekend are being neglected (see above), this profile is suitable.

Sector	Used profile
Households	„BDEW-Lastprofil Haushalt H0“
Industry and Commerce	„BDEW-Lastprofil Gewerbe allgemein G0“
Public buildings	„BDEW-Lastprofil Gewerbebetrieb mit Geschäftszeiten von 8 bis 18 Uhr an Werktagen G1“
Agriculture	„BDEW-Lastprofil Landwirtschaftsbetriebe L0“

Table 4: Load profiles used to calculate hourly data; Source: BDEW (2011).

The original data specify the load profile of each sector in 15 min steps for each day of the year. Out of these values, hourly averages for every single month were calculated; see Table 5 for an example.

Original time stamp	Value H0	Hour	Month
01.01.2011 01:00:00	0,086	1	January
01.01.2011 01:15:00	0,079	1	January
01.01.2011 01:30:00	0,072	1	January
01.01.2011 01:45:00	0,067	1	January
...	...		
31.01.2011 01:00:00	0,062	1	January
31.01.2011 01:15:00	0,058	1	January
31.01.2011 01:30:00	0,054	1	January
31.01.2011 01:45:00	0,052	1	January
Average value	**0,063**	**1**	**January**

Table 5: Calculation of hourly demand data households

The demand values are for a total annual consumption of 997.85 kWh. Hence, the percentage values were calculated out of the hourly average values.

1.4. Calculation hourly data: supply side

Similar to the demand data the annual electricity production has to be broken down into hourly production data. Full load hours and operational hours are used to calculate the annual production from the installed capacity. The following paragraphs describe the methodology used for the different technologies. An overview of the underlying assumptions for each calculation is given in Table 6.

Technology	Assumption	Appraisal	Estimated error
Wind	Monthly distribution like 10 year average in similar wind park	Reasonable	Max production difference within standard deviation 43%
Wind	Production in month equally distributed	Critical	Max difference estimated to rated production 82.5%
Wind	Stable annual full load hours	Reasonable	Max difference in production data 14% from mean
Photovoltaic	Stable annual production	Reasonable	Annual differences from long term mean ≈ 15% (KLIWA, 2008).
Photovoltaic	Distribution of global radiation comparable to 2010 data	Reasonable	Seasonal changes large undetermined
Biomass/ Other	Stable annual production	Reasonable	Not affected by environmental effects
Biomass	Production equally distributed over year	Reasonable	Max difference estimated to rated production 14%
Other	Production equally distributed over year	Reasonable	Max difference estimated to rated production 2,5%

Table 6: Assumptions for calculation of hourly supply data

1.4.1. Wind Energy

Figure 10 shows the general methodology used to determine the hourly production of wind energy in the region.

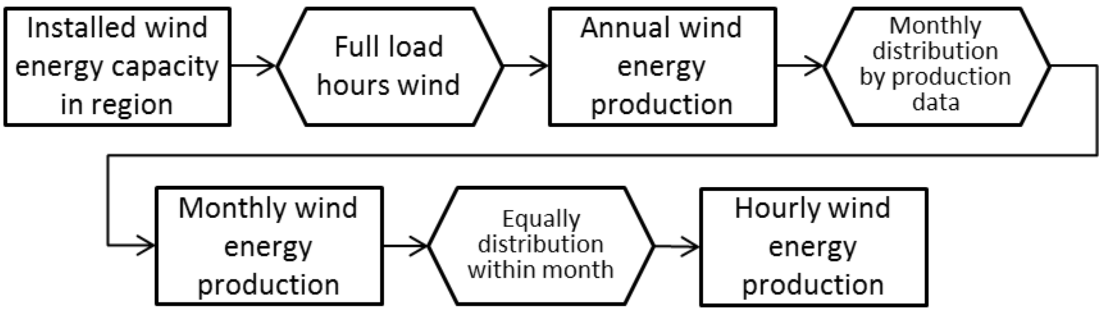


Figure 10: Methodology for determination of hourly data wind energy

All sites in the region are regarded as good wind sites:

1. Full load hours used: 2500h
2. Compare with data from wind farm

In Schleswig-Holstein seasonal fluctuations are of much higher importance than daily fluctuations. Unlike in mountainous regions or at sites with high thermal effects, the daily fluctuations can be neglected. Hence, the annual production has to be broken down into monthly production. Within the months no characteristic production pattern can be observed. Therefore, it is assumed, that the monthly production is equally distributed over the different hours in the month.

The monthly production was determined by the production data of a wind farm in Schuby over the last ten years. The site is in close enough to the region and the shows a similar topography, so that the wind regime can be regarded as being similar.

However, the author is aware, that this methodology to break down an annual to monthly data and assume an equally distributed production in the month inherits a great uncertainty. Another method like generating random production data from the wind regime would not show an inherent advantage in the author's opinion. In the following the uncertainty in the prediction should be accessed:

1. Monthly distribution constantly over the years: Comparing the mean value with the standard distribution, one finds a maximum difference of 43.1% (January average value 11.7%, standard deviation 5%). However, the main patter of having high wind production in winter and lower in summer remained constant throughout all years. So the seasonal distribution remains mainly unchanged and therefore the assumption seems to be uncritical (See

2. Figure 11: Monthly distribution wind energy production (average value and standard deviation)

3. Figure 11).

4. Production in month equally distributed: The monthly production is assumed to be equally distributed over the month. Hence, the wind turbine is assumed to be running at below rated power over the whole month. This however, is not likely to happen. It will rather run at various powers for some time and standing still for other. This lead to maximum difference between the rated and the averaged power in August of 82.4% (1-2500h*5.23%/744h). As this difference is considered to be major, it must be regarded as being critical. However, its' impact is reduced by the time a high wind system needs to pass the region. Therefore, the high production will spread over several hours and does not change the average hourly production that much.

5. Stable annual wind production: As the data show only a difference of 14% deviation from average production over the last years, this assumption seems to be reasonable.

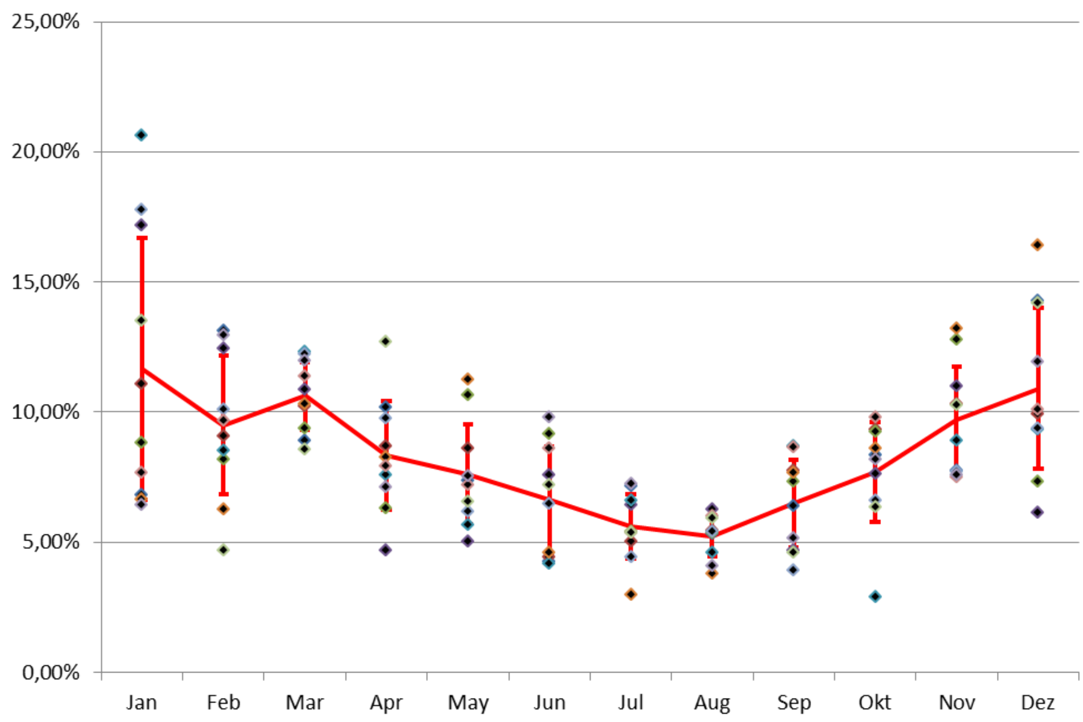


Figure 11: Monthly distribution wind energy production (average value and standard deviation)

1.4.2. Photovoltaic

Figure 12 shows the methodology used to determine the hourly production of solar energy in the region.

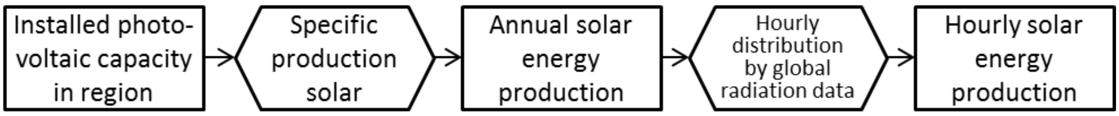


Figure 12: Methodology for determination of hourly data solar energy

The typical specific production in the region is assumed to be 850 kWh/kWpeak. This seems reasonable compared to the values published by Fraunhofer ISE (Burger, 2012; 780kWh/kWp) and energymap data (943kWh/kWp) for 2011. As a large share of the capacity is being installed towards the end of the year, a specific production derived from the Fraunhofer report underestimates the real production, while energymap overestimates the typical values due to the exceptional high global radiation in 2011. Therefore, a weighted average as stated above was chosen.

By means of global radiation data from 2010 the annual production was broken down to hourly data. The 10min-averaged data were supplied by the IfM Geomar, Kiel. Out of these dataset hourly averages for each hour of each month were calculated as a percentage of the annual global radiation. These hourly data account for the seasonal as well as daily fluctuations of the solar energy production. As Kiel is in close proximity to the region the global radiation is similar enough to use these values. The absolute value of radiation was compared to long-term observations by the DWD (2011) are can be regarded as being reliable. However, as the dataset consisted only of 2010, the distribution over the months is not as accurate as it would be using long-term observations. These data were not available free of charge.

1.4.3. Biomass and other technologies

Figure 13 shows the methodology used to determine the hourly electricity production of biomass plants and power plants driven by other technologies in the region.

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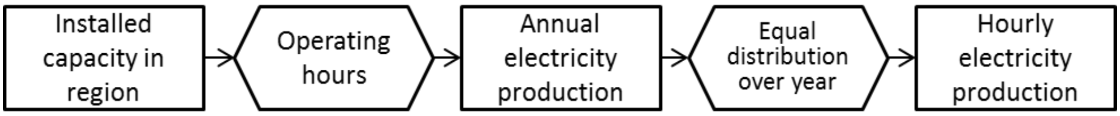


Figure 13: Methodology for determination of hourly data biomass and other technologies

Biomass power plants are often used for combined heat and power production. Although biomass plants are usual regarded to be controllable (see e.g. Vahrenholt and Gassner, 2012), this assumption is only partly valid, when used in combined production. This is also questioned by looking at the annual production of biomass plants on energymap (Deutsche Gesellschaft für Sonnenenergie e.V., 2012). These values and the estimated values for the district heating biogas plant in Tarp (Stadtwerke Flensburg, 2012) show an operation under full load of approximately 7500h per year and should be used for the operating hours of biomass power plants. Due to the high number of full load hours the production is assumed to be equally distributed over the year. The maximum prediction error due to this assumption can be derived from comparing the full load operation with zero production and hence be calculated to $\varepsilon = 1 - 7500h/8760h = 14\%$.

Other plants can almost be neglected due to their small capacities. To keep the model simple it shall be assumed that they have an availability of 97.5%, which results in 8541 annual operational hours. The production is assumed to be equally distributed over the year. As calculated above the maximum error is equal to 2.5%.

1.4.4. Greenhouse gas emissions

The greenhouse gas emissions are being calculated as CO_2 equivalent emissions. In the following it will be called CO_2 emissions.

As a first step to calculate the CO_2 emissions from the electricity supply, the hourly electricity balances were calculated. One has to differentiate two situations:

1. Supply > Demand: All demand can be fulfilled by the production in the region. Hence, electricity is exported from the region to the remainder of Germany. Only the part of the electricity production, which is consumed in

the region counts for the CO_2 emissions. The emissions are being calculated with the specific CO_2 emission factor of the region, depending on the installed capacity of the different technologies.

2. Supply < Demand: All electricity production is consumed in the region. Hence, the total production is accounted for during the CO_2 emission calculations. The electricity import from the remainder of Germany is multiplied with the CO_2 emission factor of Germany, which is depending on the installed capacities of the different technologies in Germany.

The CO_2 emission factors of the different technologies are stated in Table 7. The values are taken from Schlesinger et al. (2010). The renewables are not emission free as indirect emissions are also taken into account. The emissions for biomass are negative as the plants bind more CO_2 growing than it is released during the burning process.

Technology	CO_2 emissions (g/kWh)	Technology	CO_2 emissions (g/kWh)
Bituminous coal	949	Solar	101
Lignite	1153	Wind onshore	24
Nuclear power	32	Wind offshore	23
Natural gas	428	Hydro	40
Oil	890	Biomass	-403

Table 7: CO_2 emission factors power production technologies

For the electricity imported from the remainder of Germany the CO_2 emission factors are subject to the way the electricity is produced and hence change over time. The values were calculated based on a prognosis for different energy carrier by Schlesinger et al. (2010) and are shown in Table 8.

Year	2010	2020	2030	2040	2050
CO_2 emission factor [g/kWh]	562	538	423	386	432

Table 8: CO_2 emission factors Germany

1.5. Status quo electricity supply 2010

Applying the methodology mentioned above one finds the following values for the installed capacity in the region for the end of 2010. Furthermore, there is a small combined heat and power production plant in Tarp (Stadtwerke Flensburg, 2012). It is assumed to be operational from 2011 onwards, so it will be added to the projection of installed capacity.

Technology	Installed capacity	Operation	Electricity production	Source
Solar	9688 kW	840h	8,138 MWh	energymap
Wind	1000 kW	2500h	2,500 MWh	energymap
Biomass	1360 kW	7500h	10,200 MWh	energymap
Hydro	20 kW	8541h	171 MWh	energymap
Sum			21,009 MWh	

Table 9: Installed capacity and calculated electricity production 2010; Source: Deutsche Gesellschaft für Sonnenenergie e.V., 2012, own calculations.

Furthermore, the energy demand as stated by the sectorial groups is shown in Table 10.

Sector	Households	Industry & Commerce	Public buildings	Agriculture	Aggregate
Demand	13,859 MWh	10,565 MWh	603 MWh	5,207 MWh	30,234 MWh

Table 10: Sectorial and total electricity demand 2010

By calculating hourly data out of the annual electricity demand and supply it can fairly easily be seen, that the imbalance is not constant over the year. Figure 6 shows the seasonal fluctuations of production for the different technologies and the fluctuation of the demand. As one would expect the production from wind energy peaks in the winter months.

However, the difference is relatively small compared to the volatility of solar production, which changes by a factor of ten and more. As also the demand is lower in the summer months, the region is much more likely to be self-supplied during these months. However, a further investigation considering the daily fluctuations shows, that even during the summer months, the region is most of the time depending on importing electricity.

Figure 15 shows for how many days of the year the region was importing and exporting electricity for certain daytimes.

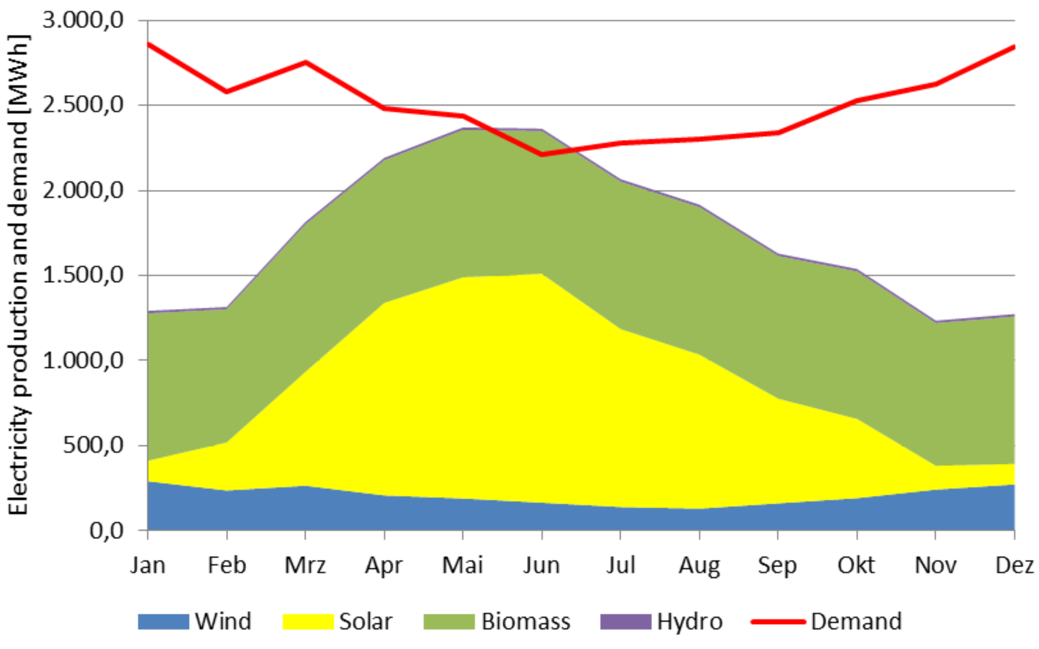


Figure 14: Status quo electricity production by technology and electricity demand 2010

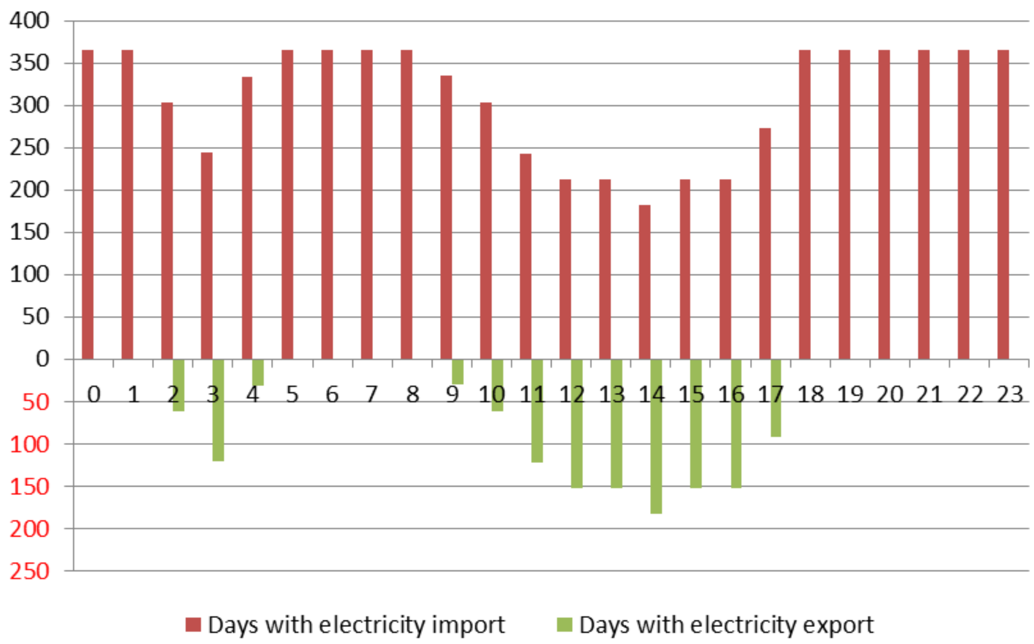


Figure 15: Number of days with electricity import and export by daytime 2010

The import and export can be further investigated. In fact by just comparing the annual data for supply and demand, one would assume a too small value for the imported power and hence underestimate the needed capacity of a power line.

Figure 16 shows the differences, which arise from the import and export balances being calculate for different time horizons:

- Yearly data: The annual aggregated data of electricity consumption and production are compared and equally distributed over the months.
- Monthly data: The hourly electricity balances are being calculated, but the resulting hourly data are aggregated over month, balancing import and export.
- Monthly import/export: These values state the total monthly import and export. Aggregated they are equal to the monthly data mentioned above.

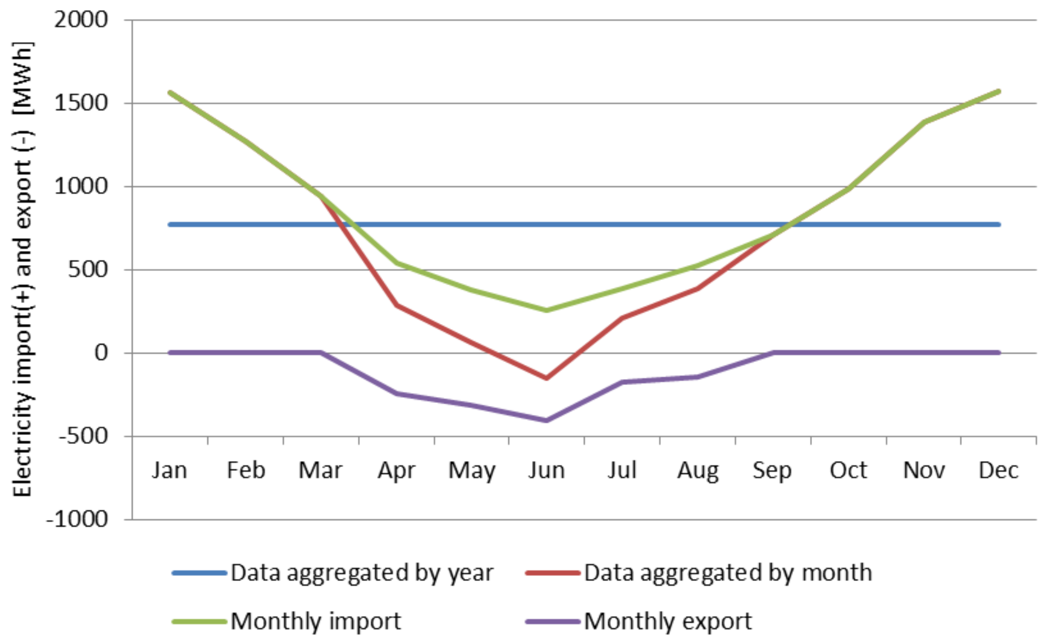


Figure 16: Electricity import and export depending upon examined time horizon 2010

The calculation of the CO_2 emissions is being done as with hourly data and with the values stated above. The total CO_2 emissions are 2755t to account for an electricity consumption of 30.234 MWh. Hence, the average emissions per MWh electricity used in the region comes down to 91,12kg. Due to the high share of renewable energy and the absence of conventional power plants in the region, this value is considerably lower than for Germany as a whole (562kg/MWh). But this comes at the price of a high dependency on electricity import of 34.8%, which is not reasonable for Germany as a whole.

Error! Reference source not found. shows the change of CO_2 emissions over the year for the different technologies. It can be clearly seen, that the change of the year is driven by two main factors, which cause a higher electricity import in the winter months:

1. Lower electricity production from solar in winter
2. Higher demand for electricity

Technology	January	April	July	October	Year
Solar	12,14t	101,3t	96,75t	47,02t	752,67t
Wind	6,98t	4,43t	3,08t	4,62t	57,6t
Biomass	-353,7t	-304,06t	-324,73t	-354,32t	-3.969,88t
Hydro	0,58t	0,5t	0,53t	0,58t	6,5t
Import	879,02t	301,86t	215,75t	555,83t	5.908,16t
Total	545,02t	104,03t	-8,62t	253,74t	2.755,06t

Table 11 sums up the key values for the status quo of the electricity supply in 2010.

Peak import	Peak export	Total import	Total export	Demand supplied by renewables	CO_2 emissions
4.13 MW	2.14 MW	10,513 MWh	1,285 MWh	65.2%	2755 t

Table 11: Key values electricity supply status quo

2. Heat Supply

The current state of Oeversee's heat supply levels is heavily dominated by residential housing heat demand. Consumption of energy to supply heat for living spaces and hot water outweighs that of Public Buildings, Agricultural, and Industrial sectors combined. This section will identify the total heat load of the Oeversee area and address how the region satisfies this overall demand as well as defining these varying fuels.

With no information provided by the Stadtwerke Flensburg about the typical fuel breakdown for the use of heating, the source of specific fuels becomes more generalized and less defined for use in pricing. Fortunately, the Statistisches Bundesamt recently release an in depth Bauen und Wohnen census on the heat energy fuel use for all regions in Germany, including that of Schleswig-Holstein. As this data was gathered and applied to the local area with similar climate, fuel supply, housing construction, and regional density, it can be reasonably assumed accurate for the energy spread of the Oeversee region with only minor errors on a household to household basis.

While the Statistische Bundesamt study focused on household fuel use, the size and structure of the Oeversee region is such that an assumption can be made for this break down in fuel use to reasonably be applied to the other sectors. As such, the types of fuels and their percentages can be directly used for all heat energy demand. Unless otherwise noted, this fuel spread was applied to the heat energy demand defined by the household, Industrial & Commercial, Public Buildings, and Agricultural sectors. Data about the rate of consumption for heating use was gathered from their respective groups with the exception of the Industrial sector. Since no data was available from the Oeversee Industrial sector at the time of this writing, a lump assumption of 8000 MWh for 2010 and 5000 MWh for the projected 2050 BAU was made based on the industrial sectors similarity to Public Building amounts in the region and the small size of the region.

While quite similar to Germany as a whole, the Bauen und Wohnen census identifies some differences in the heating fuels used in Schleswig-Holstein. The study identified four primary sources of heat energy in the region. As can be seen in Figure 2.1.1, these fuels currently break down into natural gas, heating oil, electricity, and wood/wood pellets. The majority of this status quo production for Oeversee relies on natural gas and heating oil to supply the regions demand. This status quo is out of a total heat consumption of 83,331 MWh for the region as defined by the combination of sectors contained in this report.

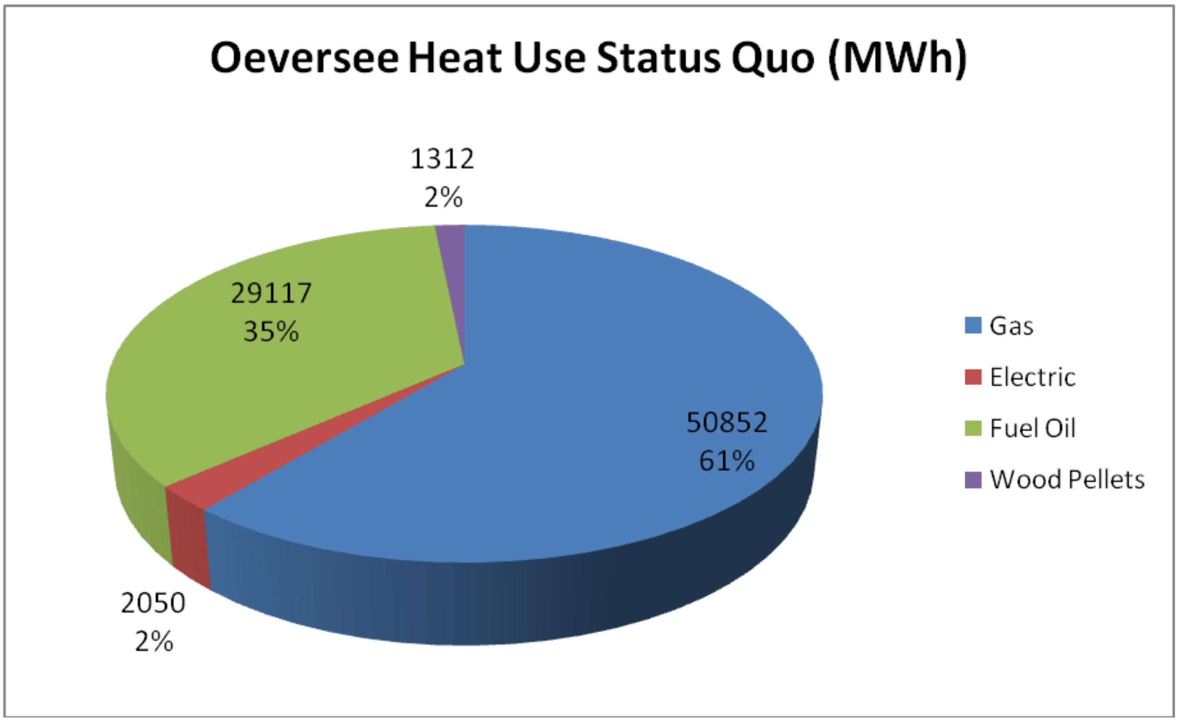


Figure 2.1.1: Status Quo Heat Production in Oeversee

When applying the CO2 equivalent values to the fuels as defined by the UK's DECC and Defra department report on Greenhouse Gas conversion factors, the impact of this type of fuel use becomes apparent. The report values, seen in Table 2.1.1, result in an overall emission in the region of 20,519 metric tons of CO2 equivalent greenhouse gases. Taking into account the current population leads to an emission of 1.94 tons of CO2 per person for just heating use alone. Of note from the report is the value assigned to biofuels- under sustainable use, the total CO2 emission from the use of biomass and biogas is a net of 0 kg CO2 emissions since what is burned countered by the CO2 going into new fuel production[DEFRA2011].

Heating Fuel Type	CO2 Equivalent (kg/MWh)
Natural Gas	202
Electric	562
Fuel Oil	313
Wood	40
Biomass, Biogas	0

Table 2.1.1: Heating Fuel CO2 Equivalent GHG Emission [DEFRA2011]

2.1. Natural Gas

Currently producing 61% of the regions heat, natural gas holds by far the highest percentage of heat fuel used in the Oeversee area. With a higher and more stable supply than oil as well as lower operating costs and typically higher efficiencies for gas fueled boilers, this fuel has become the fuel of choice in more recent years [Scheer2011]. Consisting of light hydrocarbon gases, natural gas is found underground often among other petroleum stores and used to actually be a burned off by-product of crude oil drilling [Naturalgas.org2011]. It is primarily a mixture of methane and ethane with some propane, butane and other hydrocarbons found in varying percentages depending on the global source region the gas was harvested from. Table 2.1.2 gives a general breakdown of the hydrocarbons found in natural gas. While gas does produce slightly less carbon emissions than heating oil, it still produces about 0.20 kg of CO2 per KWh (heating oil producing about 0.31 and coal 0.37).

Another downside is the controversial practice of hydraulic fracturing, or fracking, with which the gas is extracted by. This method is extremely detrimental to the surrounding environment and water supply because of its use of hazardous chemicals and high pressure to fracture the surrounding rock to obtain the gas. While this method has been effectively banned in some countries, many countries still allow it and the import of gas obtained in this method has not followed the same banning trend.

Methane	CH_4	70-90%
Ethane	C_2H_6	0-20%
Propane	C_3H_8	
Butane	C_4H_{10}	
Carbon Dioxide	CO_2	0-8%
Oxygen	O_2	0-0.2%
Nitrogen	N_2	0-5%
Hydrogen sulphide	H_2S	0-5%
Rare gases	A, He, Ne, Xe	trace

Table 2.1.2: Typical Composition of Natural Gas (Naturalgas.org2011)

2.2. Domestic Heating Oil

Producing roughly one third of the heat supply in Oeversee, fuel oil is the second most used fuel for heating in the region. Heating oil came into prominence during the phase out of coal for use in home heating. Readily available, easily contained in small storage tanks and with a relatively high efficiency for when it was widely implimented, it adapted well for use in home heating. Also known as number 2 fuel oil, it is very similar to diesel fuel and kerosene as they are all light distillates derived from refining crude oil with roughly the same composition. Heating oil produces about 10 kWh/liter and weighs .85 kg/liter- about the same energy per mass as diesel [Reed1985]. The fuel has a flash point of 52°C and consists of a mix of hydrocarbons ranging from 14 to 20 carbon atoms.

Accounting for approximately 25% of crude oil yield, the price of heating oil is as volatile as other petroleum based fuels such as gasoline and diesel resulting from unrest in high producing countries and the uncertainty of long-term supply. While this has had a factor in its reduced prominence of use, another factor has been the growing supply and stable availability of natural gas. Another issue with fuel oil has been the environmental toll. Burning oil produces higher carbon emissions than gas for one. Another concern is classified as hazardous waste and as such, leaks in individual home storage tanks do provide some level of contamination to the soil.

2.3. Wood, Electric, and Other Heat Sources

Currently, both wood boiler and electric produced heat make up a small part of the overall heat fuel use in Oeversee. While small, the impact of wood heat in the region is rising, as will be shown in later sections addressing the future Tarp district heating system. The sustainability of wood as a heating fuel is still up for debate as either good for the environment or bad. The UK's DECC and Defra departments do not list the CO2 output of wood, it being theoretically purely sustainable and therefore emitting 0 kg of CO2 when the full ideal cycle is taken into account. However, some sources that refuse to take these into account put the emissions of burning wood at 0.39 kg CO2/kWh at worst case and when the source is clear cut forests. This is higher than even coal! However, when realistic new growth and sustainable practice is taken into consideration the output falls to 0.04 kg CO2/kWh according to Defra, lower than most other heat sources. Wood gets very complicated fast- with factors from deforestation, to source location and shipping of the fuel, to the amount of processing that goes into the wood chips or pellets changing the CO2 and sustainability greatly.

Electricity produced heat is also a greatly varying source. Obviously, if the source of the electricity is a renewable source such as wind or mass solar power, it is a clean source of heat energy. On the other hand, if the source of electricity is from a coal power plant, it is not only less clean, but wasting energy from the conversion from combustive heat energy, to electricity, only to go back to heat energy. Taking into account losses, the overall grid average is around .562 kg CO2 per kWh.

As part of their survey, the Statistisches Bundesamt included a 2.4% non-stated heat source. This can be contributed to sources of error in the survey including those in individual residences that did not answer or did not reveal the heat source for their household. Along with containing an extrapolated portion of the majority heat fuel breakdown, this can also contain a small portion of solar heat or geothermal heat pumps. These sources, such as the use of solar heat collectors for water heating or heat pumps as an extension of electrically produced heat, are currently only on a small house by house basis, and is negligible when extrapolating out for the region of Oeversee.

2.4. Status Quo and the District Heating System in Tarp

With construction of the district heating system in Tarp starting in 2011, these values will soon be shifting towards the more renewable end of the fuel spectrum. Even with some of this system currently online, as this status quo analysis takes only up to the 2010 values for the community they cannot be added to this analysis. It will be a significant heat source though in the future and more details about this system can be found in the business as usual scenario.

3.4. Households

1. Introduction

In this part of the report the heat and electricity demand of the household sector in the region of Oeversee will be calculated. As shown in

Figure 17 the household sector is normally responsible for approximately 28 % of the energy demand. This is not valid for the region of Oeversee.

As the industry and commercial sectors are comparatively small, the household and the transport sector in the region of Oeversee are responsible for the majority of the energy demand and therefore it is even more important to make sure that the calculations for these sectors are as exact as possible.

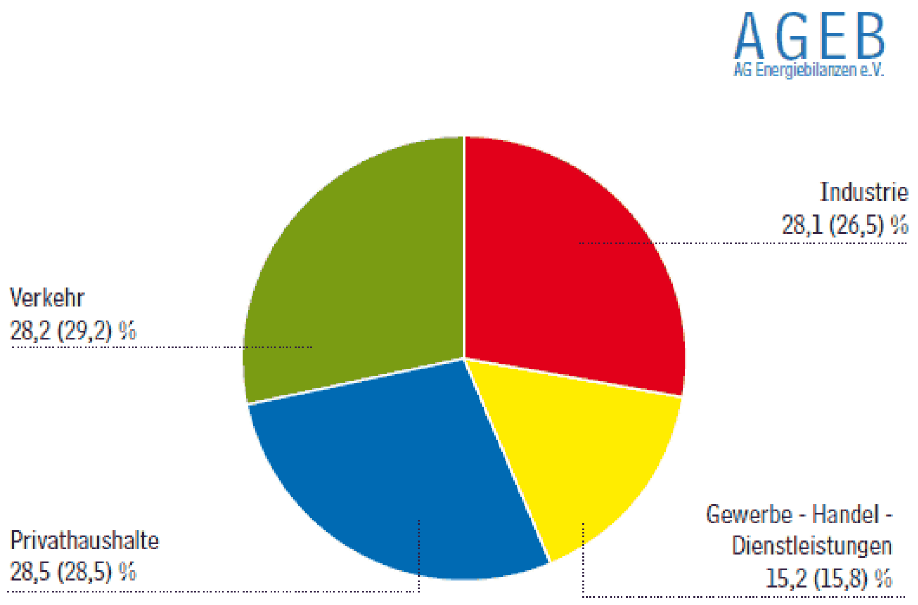


Figure 17: End Energy demand per sector, Germany 2010 (windkraft-journa, 2012)

The energy demand in the Household sector consists of the heat and electricity demand consumed by the private households in the region.

2. Methodology

2.1. Boundary Conditions

For the calculation of the heat and electricity demand only the private households in the region of Oeversee were taken into account. As the needed numbers for the calculations were available for each region it was not necessary to discuss about actual boundaries to other sectors or regions.

The CO2 emissions were not calculated by the household sector but by the energy supply sector.

2.2. Data Research

As no data was available from the municipalities, the whole data research was based on internet research. The cross section group for households also tried to call the big energy suppliers in the region of Flensburg but it was not possible to get helpful data from these. All sources are published in the bibliography at the end of this chapter.

3. Data and Assumptions

To calculate the actual energy demand of the region it was first important to identify the drivers which drive the heat and electricity demand of household sector.

The following drivers for the Status Quo were identified by the household cross section group.

3.1. Number of population (heat and electricity demand)

First of all the numbers for the population in the regions were acquired. These numbers are one important part of the heat and electricity calculation of the region. Only the total number of persons was used for the calculations, as the effect age or gender of the population is very difficult to estimate properly and the effect was considered as small. The following numbers for the regions of Oeversee was provided.

Number of population	Oeversee	Tarp	Sieverstedt	**Total**
2010	3369	5510	1660	**10539**

Table 12: Population of Oeversee (Regional Statistik, 2012)

3.2. Number of households and total living space (heat demand)

The second important driver is the number of houses/apartments in the region and the total living space. These numbers and the average heat demand per m² which is stated in the next chapter, is the main information needed for the calculation of the heat and energy demand in the region.The following numbers were used.

	Total	Houses with one apartment	Houses with two apartments
Oeversee	1129	935	159
Tarp	1316	1034	158
Sieverstedt	521	406	98

Table 13: Number of households and total living space (Regional Statistik, 2012)

From the information of Table 13 the number of houses with more than one apartment could be extracted.

	Houses with more than two apartments
Oeversee	35
Tarp	124
Sievensted	17

Table 14: Number of houses with more than two apartments

In addition the total number of apartments (including apartments in single and two family houses) was used:

	Total number of apartments
Oeversee	1407
Tarp	2142
Sievenstedt	678

Table 15: Total number of apartments in Oeversee (Regional Statistik, 2012)

From Table 13 and Table 15 the total number of apartments in houses with more than two apartments can be extracted. This is important because no information about the total living space in these apartments was available. As an assumption the “Energiemodell der Wohngebäude” was used. There the following number was given.

Average living space per apartment in houses with more than two apartments
78,12 m²

Table 16: Average living space per apartment in houses with more than two apartments (Energiemodell der Wohngebäude)

The following table shows the total living space in Oeversee.

Living space in one and two family houses	Living space in houses with more apartments
434000 m²	79389 m²

Table 17: Total living space in Oeversee (Regional Statistik, 2012)

3.3. Average building standard (heat demand)

The third factor for the calculation was identified as the average building standard and this factor is one of the most important and most difficult drivers. As no information about the age structure and the type structure of buildings was available in the municipalities, data for the region of Kreis Schleswig-Flensburg was used.

The specific heat demand per m² for each building type and age was taken from the TABULA database for Germany (http://www.building-typology.eu/).

The type, age structure and the specific heat demand of the region Oeversee is shown on the next two figures.

		vor 1918	1918-1948	1949-1957	1958-1968	1969-1978
Einfamilienhäuser (EFH)	m² per living unit (=household)*	117	106	101	109	119
	% of total houses	21,5%	12,3%	7,7%	13,2%	12,9%
	heat demand in kWh/m²a	180,5	164,8	181,3	146,5	155,6
Zweifamilienhäuser (ZFH)	m² per living unit (=household)*	85	71	70	83	87
	% of total houses	21,5%	12,3%	7,7%	13,2%	12,9%
	heat demand in kWh/m²a	153,7	137,1	156,6	106,3	127,9
MFH	m² per living unit (=household)*	89,5	70	63	69	78,5
	% of total houses	31,0%	5,5%	10,7%	13,1%	10,5%
	heat demand in kWh/m²a	143,8	168,1	156,2	129,7	134,0

Figure 18: Type, age structure and specific heat demand of the buildings in Oeversee part I

		1979-1987	1988-1993	1994-2001	2002-2009
Einfamilienhäuser (EFH)	m² per living unit (=household)*	117	109	111	111
	% of total houses	11,2%	5,3%	9,0%	6,8%
	heat demand in kWh/m²a	118,4	132,7	110,1	88,8
Zweifamilienhäuser (ZFH)	m² per living unit (=household)*	89	82	86	86
	% of total houses	11,2%	5,3%	9,0%	6,8%
	heat demand in kWh/m²a	127,5	98,8	78,1	86,8
MFH	m² per living unit (=household)*	83,5	69	67	67
	% of total houses	17,8%	3,4%	5,6%	2,3%
	heat demand in kWh/m²a	118,3	122,9	92,8	79,9

Figure 19: Type, age structure and specific heat demand of the buildings in Oeversee part II

From Figure 18 and Figure 19 the average specific heat demand of the building types could be calculated.

Single family houses	148,7 kWh/m²a
Two family houses	122,9 kWh/m²a
Houses with more than 2 apartments	133,9 kWh/m²a

Table 18: Average specific heat demand of the building types

3.4. Electricity demand per household

For the calculation of the electricity demand of the household sector in the region of Oeversee the average number of inhabitants per household and the average electricity demand per capita and household were needed. As the average number of inhabitants per household could be extracted from the data provided by regional statistic, the average electricity demand had to be found out.

Again no specific data for the region of Oeversee was available, so average values for Germany were taken.

Size of household	1 person	2 persons	3 persons	4 persons	5 persons	6 persons
Annual energy Ø (kWh)	2.000	3.100	3.908	4.503	5.257	5.764

Table 19: Electric energy consumption of different household sizes (Energieagentur NRW 03/2006 "Prozentuale Anteile der 12 Stromverbrauchsbereiche in den verschiedenen Haushaltsgrößen")

As the average household in Oeversee consists of 2.5 persons, a trend function was used to calculate the average electrical energy consumption per household in Oeversee.

The result is shown in the following table.

Average size of household	2,5 persons
Annual energyØ (kWh)	3708

Table 20: Electric energy consumption of a 2.5 person household

4. Results

In this chapter only the results of the calculations are presented. The complete calculation can be found in the appendix of this report

4.1. Heat demand

The following results were calculated for the total heat demand of the region of Oeversee in 2010.

Single family houses	41734 MWh/a
Two family houses	9181 MWh/a
Houses with more than 2 apartments	10687 MWh/a
Total	**61603 MWh/a**

Table 21: Total heat demand in Oeversee

According to the total number of households and inhabitants the following indicators can be extracted:

Heat demand per household	14,57 MWh/a capita
Heat demand per capita	5,84 MWh/a capita

Table 22: Results for indicators (heat)

4.2. Electricity demand

The following results were calculated for the total electricity demand of the region of Oeversee in 2010.

Total electricity demand in Oeversee	13859 MWh/a

Table 23: Total electricity demand in Oeversee 2010

According to the total number of households and inhabitants the following indicators can be extracted:

Electricity demand per household	5,84 MWh/a capita
Electricity demand per capita	1,48 MWh/a capita

Table 24: Results for indicators (electricity)

4.3. Total energy demand

According to the numbers stated in chapter 4.1 and 4.2 the following indicators for the total energy demand can be calculated.

Total energy demand per household	20,41 MWh/a capita
Total electricity demand per capita	7,32 MWh/a capita

Table 25: Results for indicators (total energy)

3.5. Public Buildings

1. Introduction

Looking at other climate protection papers there is often no sector like public buildings. Therefore an own definition had to be found for this study. As one thinks about public buildings, things like the town hall, schools, libraries, hospitals and so on come to one’s mind. Looking at these examples in some cases it is clear that they are public buildings because they are operated by the municipalities or the government. When it comes to hospitals and retirement homes the classification of the sector becomes more difficult, because a lot of these facilities are privatized or are operated by non-profit organizations in nowadays, like church related organizations. Furthermore there is the Danish minority in the project region that has their own churches, schools and kindergartens. Caused by these circumstances the study had to have its own definition.

In this study public buildings are defined as facilities that are operated by a non-profit organization and additionally create welfare for the society.

Out of this definition the following list of buildings was arranged. These are the types of buildings that are taken into account in the public building analysis:

- Town halls (municipality/administration offices)
- Fire departments
- Police offices
- Buildings for water treatment and supply
- Buildings for waste management
- Kindergartens
- Schools
- Sport facilities (including swimming pools)
- Adult education centers
- Libraries
- Cultural institutions (museums and theaters)
- Health services
- Retirement homes
- Churches
- Forestry offices

Facilities that are not taken into account are:

- Military buildings
- Street lights
- Train and bus stations

These exceptions were made due to the following facts. Military buildings do not create a real welfare for the society in times when there is no danger of war in Europe anymore. On the other hand it would be quiet hard to get actual data about these military bases for security reasons and they are operated by the government while the research project is only working together with the local municipalities and other local based organizations. The study should show these regional players their potential for environmental protection improvements. Further, street lights are no buildings and belong to the infrastructure of transportation. Just like the street lights are the train and the bus stations part of the transportation sector.

Based on this definition and preliminary consideration the data acquisition was started.

2. Data acquisition of status-Quo

This chapter will describe the way the data acquisition was done and what difficulties arisen. The status-quo of energy consumption will only give us a rough estimation of the real energy consumption of the public buildings. This is based on the fact that the way of data acquisition is limited to the amount of actual input data given by the municipality, on what buildings could be found on the internet and the estimations for their energy consumption. Different types of data sources were available and different ways of assuming the energy demand were used.

The team of the responsible persons for the public buildings sections of all regions thought it would be a better way to use the limited amount of time to start with a very general list of buildings and let it grow with more accurate data over time. So first of all it was tried to set up a list of all public buildings that could be found on the internet. The web page of the “Amt Oeversee” municipality has an extra tab for public facilities (Amt Oeversee, 200?). It gave a lot of information of the existing public buildings. Unfortunately not all facilities that would be count as public buildings where listed in this section of the website. That’s why the other types of facilities where randomly searched on the internet, for example the buildings like the police stations. This research gave us a list of public buildings and their addresses. As they were listed by the municipality of Oeversee the administration office should have hold information on the energy consumption of these buildings. In case of Oeversee there was a new employee of the municipality responsible to find information about the demanded data in their archives. As mentioned above the investigation should come from a rough estimation to a more and more accurate data pool. Being aware of the fact that sometimes it would not be possible to get the actual energy demand, the responsible person at the municipality was asked for the following data:

- List of all buildings operated by the municipality
- Energy consumption (electricity, heat by/with energy performance certificate)
- Source of energy (std. electricity mix, renewables, gas, oil, etc.)
- Year of construction
- Gross floor space of the Building
- Energetic upgrades like PV, solar thermal, insulation
- Planed insulation and plans for construction of new buildings

For the first three points it is obvious why these data is needed. The other information was demanded to be able to make better assumptions, by being able to have as much accurate information about the building.

Knowing the gross floor space is the basis to calculate the energy demand per m² und to be able to translate it to other buildings with unknown energy consumption. The year of construction and the last renovations/insulations were needed to compare and assume the energy consumption only of buildings of the same age and efficiency. Further, solar thermal systems are decreasing the fuel demand for heat per m². As it was not possible to communicate with this employee directly, the data was not available until June 11th. Unfortunately there seemed to be a misunderstanding the data was sent. The municipality provided their energy consumption for the year 2011 and not for 2010 as asked. Because of this and the limited amount of time it is assumed that 2010 had the same consumption. The communication was held with the administrative officer Mr. Ploog. To use the time wisely preparations for the date that the data would be handed in were undertaken. Other ways of data acquisition were discussed in the public building team meetings.

For the buildings that are operated by the Protestant church the Flensburg University could provide data from a study they've made for a climate protection study with this church (Flensburg University, 2012). Every regional group-member of public buildings asked for these numbers for his region separately to maintain secrecy. This study contained a detailed separation of heat and electricity demand by sources. The data processing was done by a former EUM Student who did this as his master thesis.

In case that only the gross floor space was known, an additional source for the energy demand per m² was needed, especially in cases where no comparable building in the area with known consumption could be found. Therefor a study of the Wirtschaftsministerium Baden-Württemberg was used which worked with data from a company called ages GmbH (see Wirtschaftsministerium Baden-Württemberg, 2004). The ages GmbH that is based in Münster had a research project on the characteristic energy consumption of buildings based on their type of usage. For the categorization of buildings they used the VDI 3807 guideline. Ages came up with a paper that contains a detailed categorization of types of buildings by their average heat and electricity consumption per m² gross floor space.

The gross floor space would be given by the municipality in many cases, so that the study of the Wirtschaftsministerium Baden-Württemberg or the compassion with buildings of the same type and age and the given area of the building could be used to assume the heat and electricity demand. In other cases this number could be missing. To call all responsible persons of the buildings would have cost too much time so it was planned to use Google maps, an address list from the internet research and photos from the internet to assume the gross floor space. With the address list and the satellite pictures of Google maps one could make a rough estimation of the size of the building. The pictures were used to know the number of floors, to have a better estimation of the total gross floor space of the building.

3. Data processing of status-Quo

As described before, first a general excel worksheet was set up to fill it with the incoming data. Starting with general information to coming to a more and more detailed reflection of the real energy demand. The sheet contained information about the name of the building, the location, the year of construction with the years of renovation, gross floor space, the electricity consumption from standard fuel mix for electricity of the German energy supply, the electricity consumption from renewables which was in most cases from the supplier “Lichtblick GmbH” and the energy consumption for heating. To have a better overview there was also an extra column with the method used for the assumptions. In addition, four building classes were introduced which were needed for the business-as-usual-scenario calculation and are discussed in the next chapter.

The worksheet from the municipality, the worksheet from the church study and the worksheet from the internet research had to be merged. Further the lists had to be checked for doublings or missing buildings from other lists. Due to lack of time resulting in the late response of the municipality it was sometime not quite clear what institution the named buildings contained, especially in the case of the school campus of Tarp. In this case the school with its gym, a kindergarten and the adult education center were assumed to be one campus-unit. In the end the list contained 46 buildings (-complexes).

The municipality provided certain data for the electricity of 26 buildings and the heat demand of 20 buildings. The study from the Flensburg University gave information about the electricity of 15 buildings and the heat demand of six buildings belonging to the Protestant church. The internet research gave five additional buildings of which no additional information was available at all. In the end the electricity demand for five buildings and the heat consumption of 20 buildings was unknown. In six cases the gross floor space had to be assumed with the Google method. For four buildings the method of using the same consumption per m³ of buildings of the same type and same age were used. For all the other buildings the assumptions for energy consumption for heat and electricity were made with the study from ages GmbH. Summing all of these numbers up gives the following table.

Status-quo of energy demand of public buildings in Oeversee region	Electricity from German fuel mix in kWh	Electricity from renewables in kWh	Heat from fossil fuels in kWh
Churches	16597	31533	157191

Schools and Kindergartens	55096	104889	394315
Retirement Homes	3968	10065	71566
Rest	320982	70629	7663208
Total	396643	217116	8286280

Table 1.1 Status-quo of energy demand of public buildings in Oeversee region

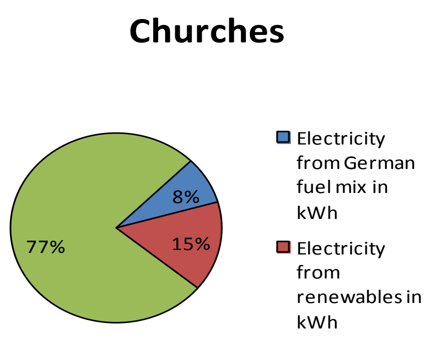


Figure 1.1 Share of different energy sources on the churches

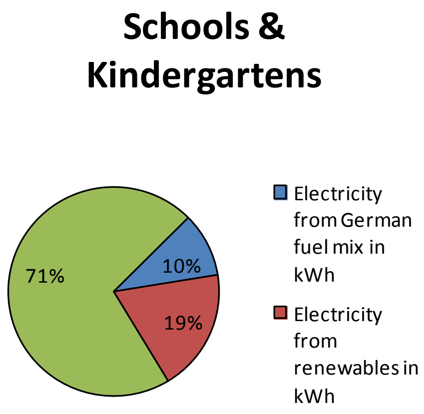


Figure 1.2 Share of different energy sources on schools and kindergartens

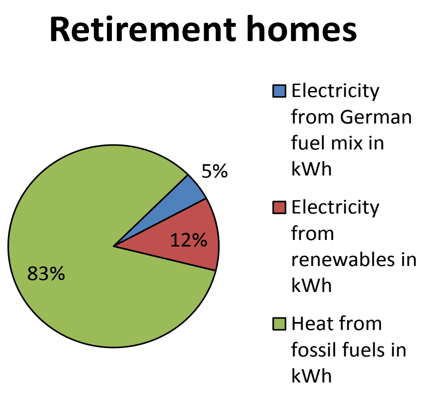


Figure 1.3 Share of different energy sources on the retirement homes

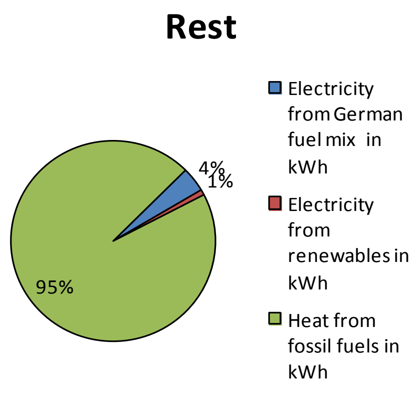


Figure 1.4 Share of different energy sources on the rest of the buildings

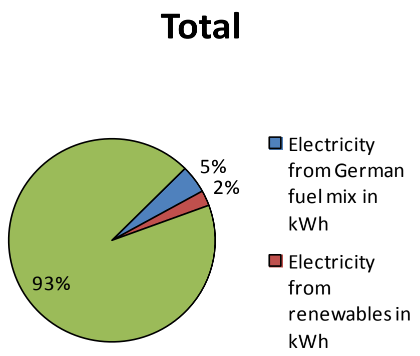


Figure 1.5 Share of different energy sources on total energy consumption of Oeversee

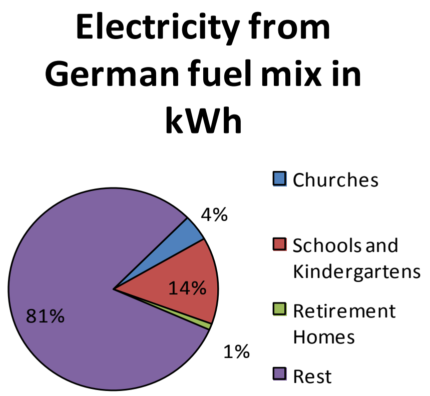


Figure 1.6 Share of different building classes on the electricity from German fuel mix

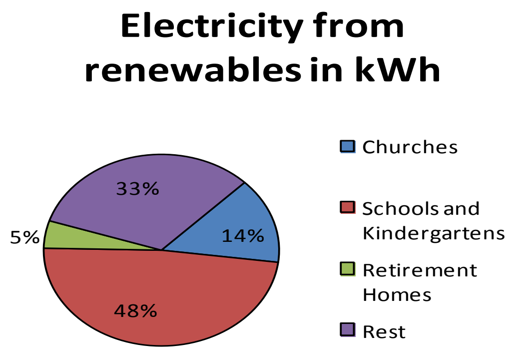


Figure 1.7 Share of different building classes on the electricity from renewables

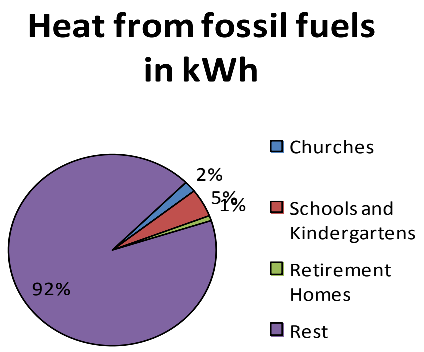


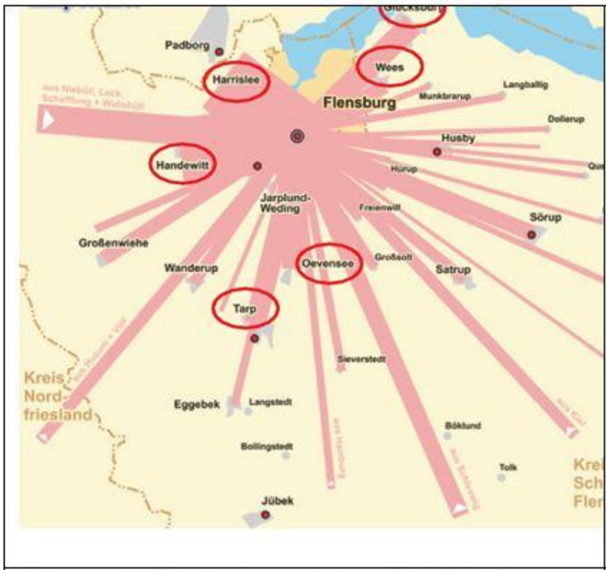
Figure 1.8 Share of different building classes on the heat from fossil fuels

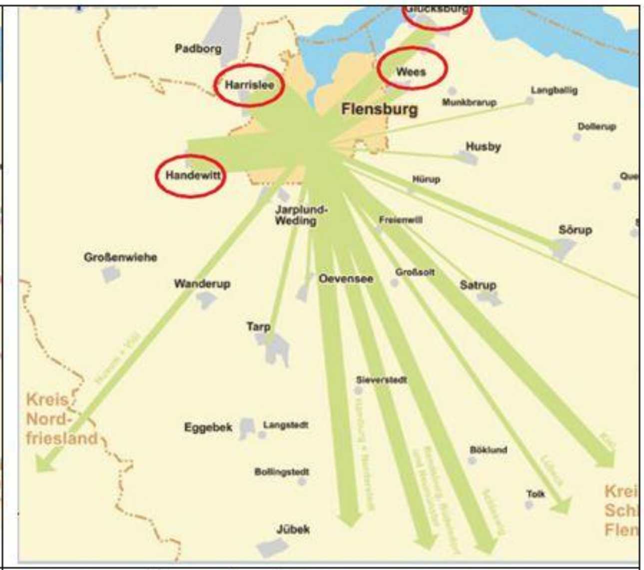
In figure 1.1 to figure 1.5 you can see the share of the different energy sources on the different building classes. The distribution in the church, the schools and kindergartens and the retirement homes is quiet even. In the Rest class there is a big difference. In this class the heat demand has by far the biggest share with 95 %. This result comes mainly from the swimming pool of Tarp which is in that class. The swimming pool alone has a heat consumption of 5557579 kWh. This value is about 10 times higher than most of the other values. Additionally there is the waterworks for the water supply which also needs 1176395 kWh. Both of these are the biggest consumers of heat in the public building sector of Oeversee. This has also a big impact on the total results that you can see in figure 1.5. Another conclusion of this figures is, that there is a big potential in energy savings in heat demand. The public buildings already uses a lot of renewable energy sources for their electricity demand but this could be widen as well of course. In the further figures you can see the shares of the different classes on the different energy sources. This is just additional information.

3.6. Transport

1. Introduction

Flensburg has a comparably high numbers of commuters travelling to Flensburg city from the surroundings and vice versa which is shown in the figures below:





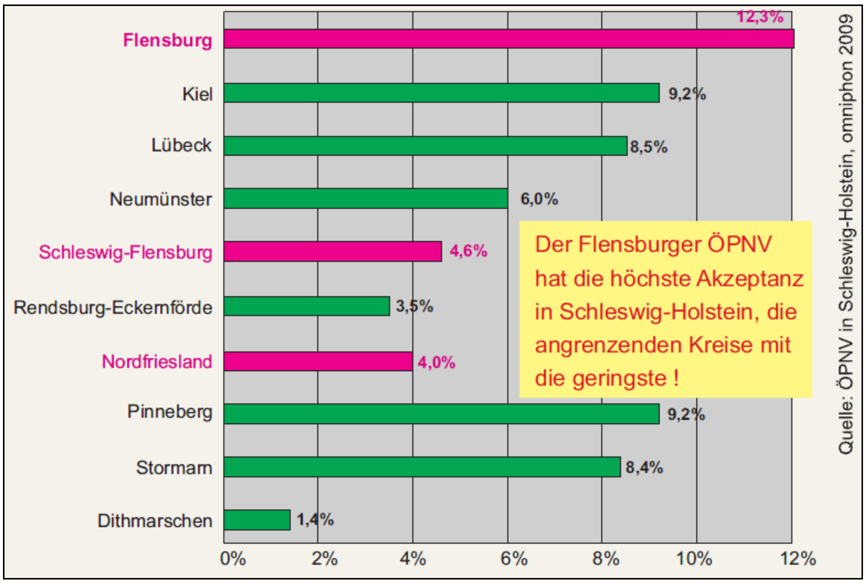
Commuter from communities into Flensburg	Commuter from Flensburg to communities

Villages	Number	Village	Number
Handewitt	1874	Handewitt	1172
Harrislee	1721	Harrislee	905
Glücksburg	619	Glücksburg	436
Tarp	556	Kiel	402
Oeversee	543	Hamburg	387

2. Public Transport

The city of Flensburg has the highest acceptance of public transport in Schleswig-Holstein with 12.3%, compared to 9.2% in Kiel and even lower 4.6% in Schleswig Flensburg. In fact, the acceptance of the public transport in the neighboring regions of Flensburg is the lowest in Schleswig-Holstein.

Following a survey [xx], reasons for this result mainly in a poor public transport network with unfavorable departure times, low flexibility, long distances to the stations and the omnipresent rainy weather due to maritime climate. Although there is a high number of people commuting to work from the Flensburger surroundings to Flensburg and vice versa, the usage of the public transport is very low and commuting is usually done by car. Oeversee is located in a rural area with low infrastructure; therefore the usual means of transport is the car.



From Flensburg to Oeversee and vice versa, the following bus services are offered:

Bus service #	Shuttles per day
1550	42
4810	34

For the status quo data, the bus companies and the Verkehrsbetriebe Schleswig-Flensburg were contacted. However, no specific data regarding the relevant bus services in Oeversee was available. Surveys were done by Verkehrsbetriebe Schleswig-Flensburg for Flensburg city, but not for the surroundings. As no comparable data that could have been mapped on Oeversee was available, and as the usage of public transport is among others a question of political motivation which is hard to put in numbers, no Business-As-Usual-Scenario was developed for the Public Transport.

3. Individual Transport

Due to the small size of the region of interest, the data acquisition of the status quo in Oeversee, Tarp and Sieverstedt was difficult. In fact, no specific numbers of the quantities and qualities of cars was available, only a general number for Flensburg was given. As this number is non-representative for the surroundings, when the city is also taken into account, the status quo was calculated using the Oeversee average [xx] of 597 cars per 1000 inhabitants was used.

4. BUSINESS AS USUAL

4.1. Agriculture

1. Drivers

Very important for forecast the development of energy demand is the determination of drivers. Drivers are the factors that influence your demand of energy. The agriculture group created the following list of drivers:

Drivers	Production efficiency
Technology (lifestock)	0,99
Climate change (livestock)	1,002
Technological development (field)	0,995
Climate change (field)	1,015
Decrease of agriculture used land by	0,9985
Extensification	1

The values for each driver were research by different members of the agriculture cross sectional group. Most of them were found in scientific papers or studies in the internet.

Like before the BAU – calculation will be subdivided into livestock and field.

1.1. Driver for livestock data

The driver for the livestock data is the arithmetical average of the first two drivers.

$$d_{livestock} = \frac{(0.99+1.002)}{2} = 0{,}996$$

1.2. Driver for field data

The driver for the field data is the arithmetical average of the last for drivers in the list.

$$d_{fields} = \frac{(0.995+1.015+0.9985+1)}{4} = 1.002125$$

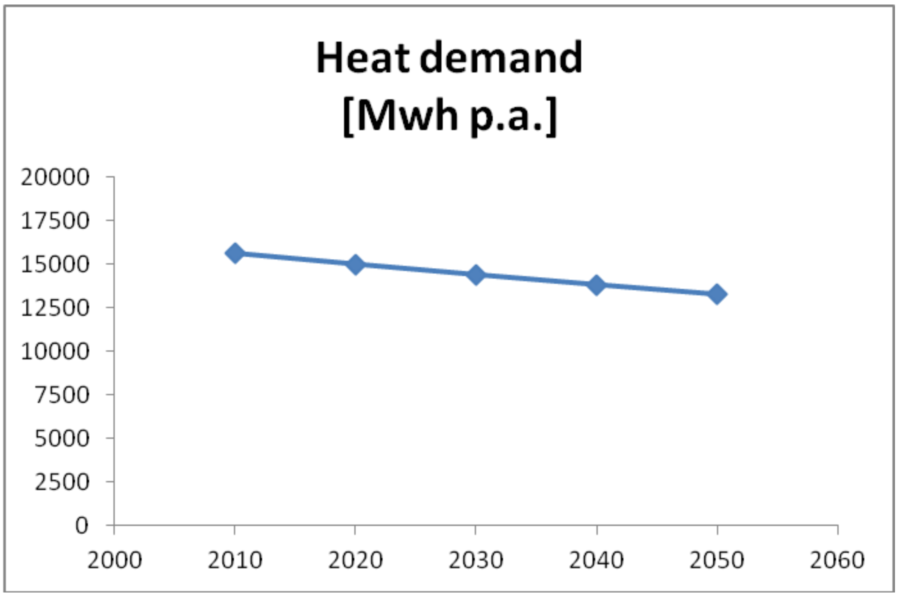
2. Results

With the researched data introduced in the previous chapters and the drivers, the following energy demands for the agriculture of the region of Oeversee were predicted:

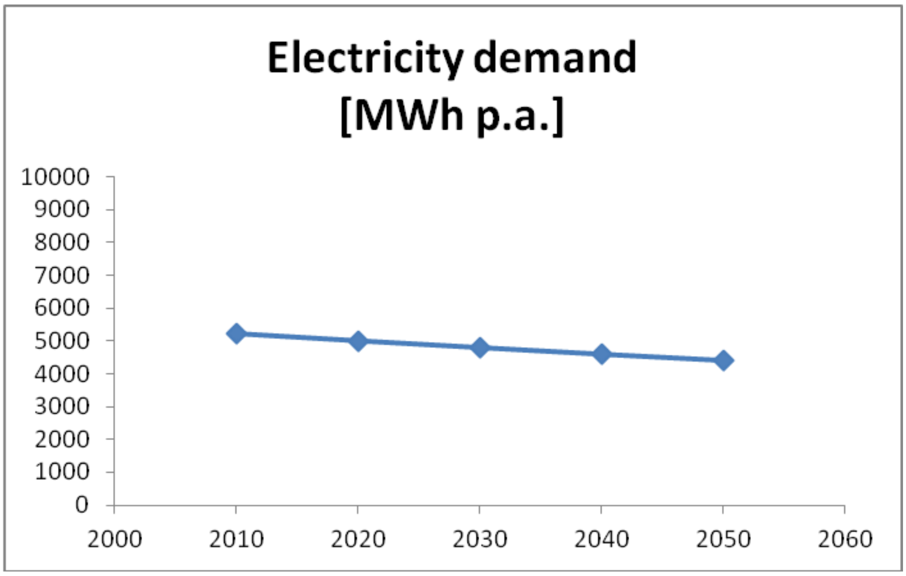
2.1. Total development

	2010	2020	2030	2040	2050
Heat demand [Mwh p.a.]	15590	14966	14368	13793	13241
Electricity demand [MWh p.a.]	5207	4999	4799	4607	4423
Fuel demand [l Diesel p.a.]	377623	385647	393842	402212	410759

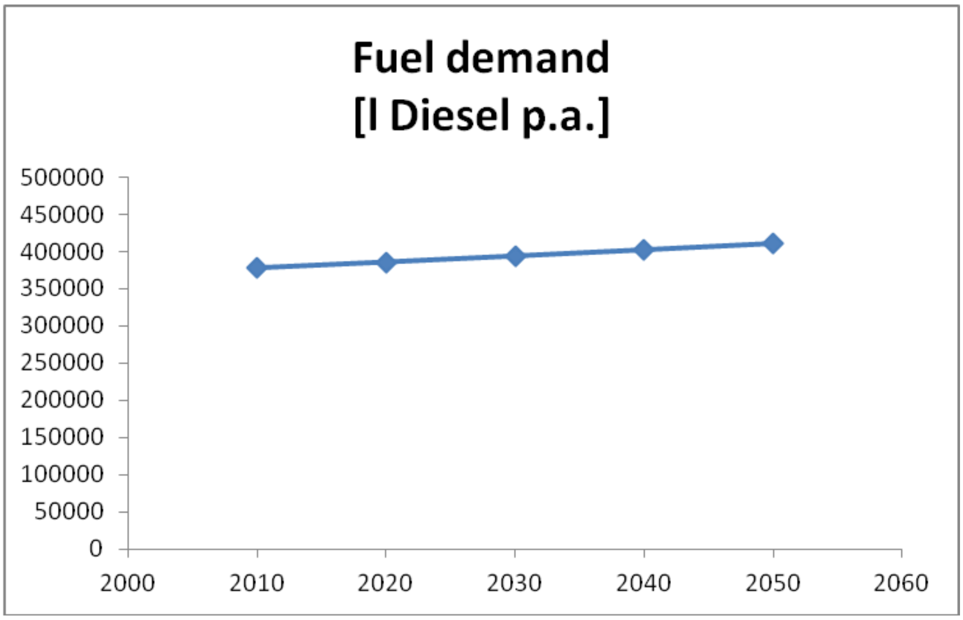
2.2. Heat demand development



2.3. Electricity demand development



2.4. Fuel demand development



3. CO_2 – Emission

One can see that the energy demand for livestock farming is decreasing and increasing for field farming. To give a prognosis how this will affect the energy balance, these three demands have to be compared and translated into CO_2 – emissions.

The values for the different energy demands can be multiplied with the following factors:

Emission district Electricity [kg/MWh]:	0,562
Emission district Heating [kg/GJ]:	0,622
Emission district Diesel [kg/l]:	2,65

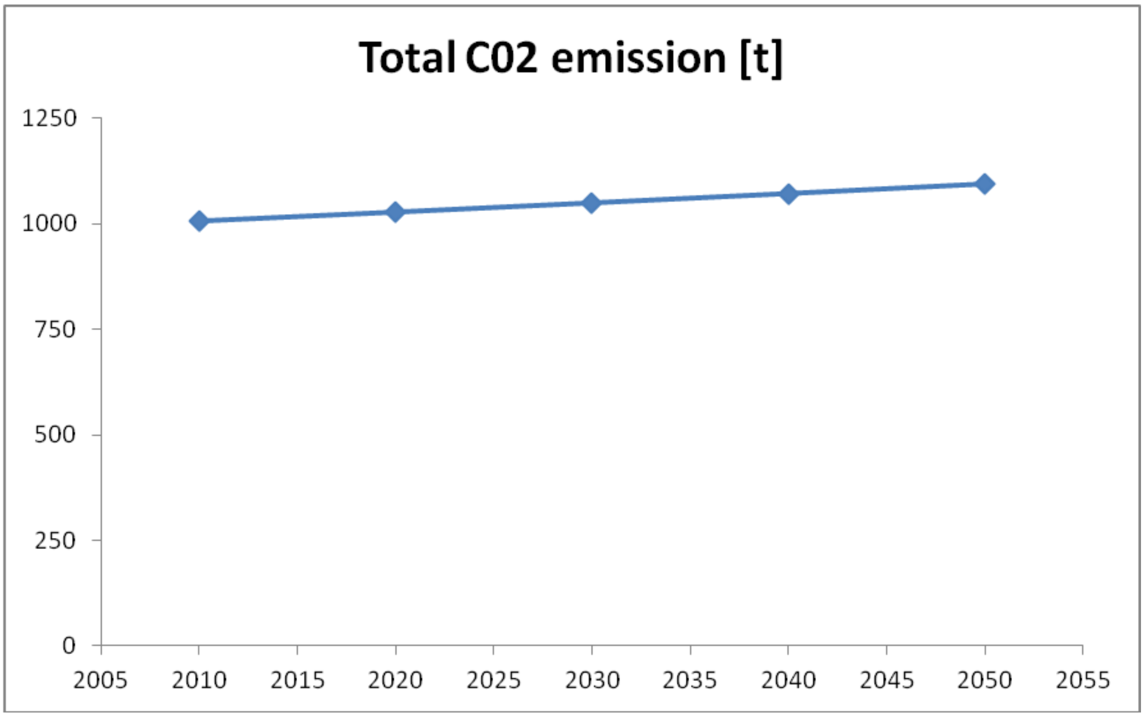
If you do so, you get the following table of results:

	2010	2020	2030	2040	2050
Heat $C0_2$ emission [t]	2,69	2,59	2,48	2,38	2,29
Electricity CO_2 emission [t]	2,93	2,81	2,70	2,59	2,49
Fuel $C0_2$ emission [t]	1001	1022	1044	1066	1089
Total $C0_2$ emission [t]	**1006**	**1027**	**1049**	**1071**	**1093**

One can see the high influence of the fuel emission. The fuel emission is caused by the field farming, only. In contrast to that the livestock farming has a very low energy demand. It shall be stated that methane emission by cattle is not considered in this scenario, because it is no demand.

In the following graph, one can see the prognosis of CO_2-emission for the agriculture of Oeversee from 2010 to 2050. It will increase from 1006t to 1093, which equals an increase of approximately 8.6%. It has to be stated that this report can only give an estimated trend, based on data research and should be reconsidered for further use.

3.1. Total CO_2 – emission



4.2. Commercial and Industry

1. Introduction

For the business as usual scenario (BAU) the gross domestic product (GDP) and the increasing efficiency of processes, such as production lines as well as energy production, are taken into account. The development of the business as usual scenario is calculated till the year 2050.

The GDP is taken from the *Business Development and Technology Transfer Corporation of Schleswig-Holstein,* which refers to the Schleswig-Holstein state government and gives an GDP-growth of about 0,8% per year (Business Development and Technology Transfer Corporation of Schleswig-Holstein, 2010).

The report of *Greenpeace* gives an estimation of the efficiency in heat and electricity production till the year 2050 (Dr. Barzantny K., Achner S., Vomberg S., 2007). Additionally, the report of the *AG-Energiebilanzen* was included (AG-Energiebilanzen, 2012).

For this scenario it is distinguished between commerce and industry by the definition given above.[1] Unlike the forecast of energy demand of households, the prediction of the

[1] In the region Oeversee are three companies that are defined as industry, that is: Trennetaler Getränke Verwaltungs-GmbH, Gonde Clausen Kieswerk Betonwaren as well as TRIXIE Heimtierbedarf.

sector industry and commerce does not deal with population growth in the considered region. As previous examples show, in the case of economic growth workforce will always be due to immigration. That is to say the population growth is not the bottlenecked on the energy demand, that is calculated by $\frac{\text{Energy Demand}}{\text{Employee}}$, but economic growth. However, it is hard to get specific information about Oeversee. The *Statistikamt Nord* gives statements about Schleswig Holstein and cities like Flensburg, Kiel, or Lübeck but gives no numbers about Oeversee. They estimate a decrease of about 4% in population in the whole region of Schleswig Holstein till 2050 with big differences of population growth or decline inside Schleswig Holstein (Statistikamt Nord, 2010). To get a visible result the population growth was not taken into account.

The figures are summarized in Table 26 and Table 27.

	2015	**2020**	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
Industry Sector:								
GDP-Growth	1,008	1,008	1,008	1,008	1,008	1,008	1,008	1,008
Electricity-Efficiency	0,996	0,996	0,991	0,991	0,991	0,991	0,991	0,991
Heat/Fuel-Efficiency	0,986	0,988	0,991	0,991	0,991	0,991	0,991	0,991

Table 26: GDP-Growth, energy production efficiency of the industry sector

	2015	**2020**	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
Commercial Sector:								
GDP-Growth	1,008	1,008	1,008	1,008	1,008	1,008	1,008	1,008
Electricity-Efficiency	0,986	0,986	0,988	0,9875	0,980	0,980	0,980	0,980
Heat/Fuel-Efficiency	0,967	0,967	0,987	0,987	0,984	0,984	0,984	0,984

Table 27: GDP-Growth, energy production efficiency of the commerce sector

By the GDP-growth and the changed efficiency in energy use, the energy demand of each year can be calculated with the following equations:

$$electricity\ demand\ \text{"}status\ quo\text{"} \cdot (GDPgrowth)^n \cdot electricity\ efficiency^n = electricity\ demand\ in\ n\ years$$

Equation 3: Electricity demand in n years

$$heat\ demand\ \text{"}status\ quo\text{"} \cdot (GDPgrowth)^n \cdot heat\ efficiency^n = heat\ demand\ in\ n\ years$$

Equation 4: Heat demand in n years

The BAU scenario is shown in Figure 20 for the industry and Figure 21 for the commerce.

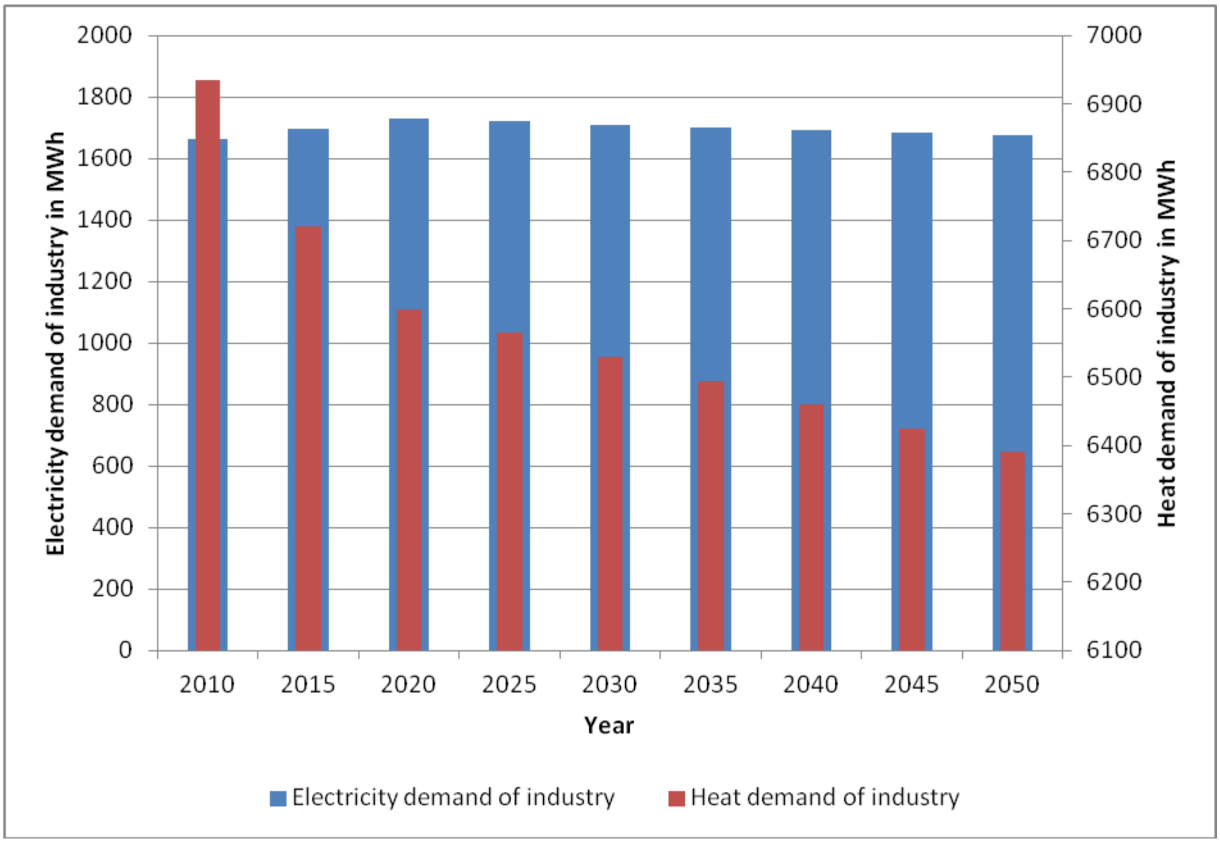


Figure 20: Heat and electricity demand of the industry sector in the business as usual scenario

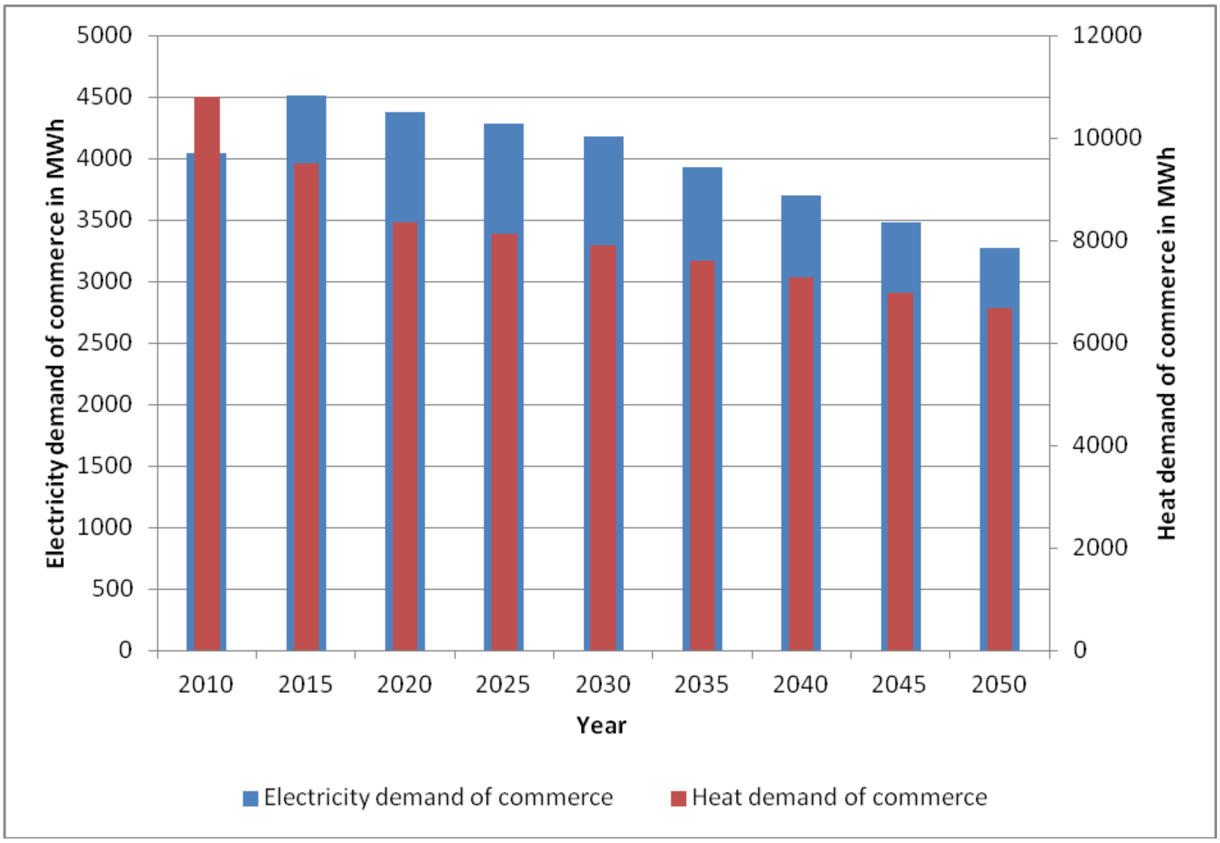


Figure 21: Heat and electricity demand of the commerce sector in the business as usual scenario

Although the GDP is positive, the energy demand decreases until the year 2050. The heat demand of the commerce will go down about 38%. In the industry it will lower about 8%. High potential in conservation of energy shows the commercial sector. In contrast to the industry, whose electricity demand will go up about 1%, the electricity demand of the commercial sector is calculated to go down about 19%. Table 28 shows the BAU in numbers.

Electricity demand forecast	**2010**	**20 15**	**20 20**	**20 25**	**20 30**	**20 35**	**20 40**	**20 45**	**20 50**
Electricity demand commerce in MWh	4043	45 15	43 79	42 79	41 81	39 33	37 00	34 80	32 74
Electricity demand industry in MWh	1661	16 95	17 29	17 19	17 10	17 01	16 92	16 83	16 74
Heat demand forecast	**2010**	**20 15**	**20 20**	**20 25**	**20 30**	**20 35**	**20 40**	**20 45**	**20 50**
Heat demand commerce in MWh	10794	94 97	83 57	81 29	79 08	75 92	72 88	69 79	66 83
Heat demand industry in MWh	6934	67 21	66 00	65 64	65 29	64 94	64 60	64 25	63 91

Table 28: Energy demand until 2050

4.3. Energy Supply

1. Electricity

With the values from the status quo and the methodology mentioned above one can project the installed capacity and hence the electricity production in the region over the years. The values will be calculated in 10 year steps. The projection derives from the methodology above in two points to account for recent changes and therefore makes it more realistic:

1. Renewables capacity installed between 2011 and 22/02/2012 (date for energymap database) will be assumed to be installed in the period between 2010 and 2020, although they might not be profitable
2. The combined heat and power plant in Tarp will be installed as stated on the website (Stadtwerke Flensburg, 2012)

At a first step the capacities for the different technologies are projected (see Table 29 to Table 31). All solar panel installed before 2007 are assumed to be installed in 2007 as their total share is very low. The hydro capacity is assumed to remain in the region. The capacities for the different years are summed up in Table 32, while the production is stated in Table 33.

Installation year	2007	2008	2009	2010	2011
Installed capacity	322 kW	314 kW	575 kW	8477 kW	971 kW
Replacement year	2032	2033	2034	2035	2036
Capacity 2020	314 kW	307 kW	562 kW	8309 kW	954 kW
Capacity 2030	308 kW	300 kW	551 kW	8144 kW	935 kW
Capacity 2040	317 kW	310 kW	568 kW	8393 kW	963 kW
Capacity 2050	311 kW	303 kW	557 kW	8226 kW	944 kW

Table 29: Projection PV capacity by installation year

Installation year	Installed capacity	Repowering year	Repowering capacity	2nd Repowering year	2nd Repowering capacity
1995	1,000 kW	2015	3,500 kW	2035	12,250 kW
2015	6,300 kW	2035	22,050 kW		

Table 30: Projection wind capacity by installation year

Installation year	2007	2011	2012
Installed capacity	1,360 kW	400 kW	2,000 kW
Replacement year	2037	2041	2042

Table 31: Projection biomass capacity by installation year

Technology	2010	2020	2030	2040	2050
Solar	9,688 kW	10,659 kW	10,238 kW	10,551 kW	10,341 kW
Wind	1,000 kW	9,800 kW	9,800 kW	34,300 kW	34,300 kW
Biomass	1,360 kW	3,760 kW	3,760 kW	3,760 kW	3,760 kW
Hydro	20 kW	20 kW	20 kW	20 kW	20 kW

Table 32: Installed capacity 2010-2050 by technology

Technology	2010	2020	2030	2040	2050
Solar	8,137 MWh	8,775 MWh	8,600 MWh	8,863 MWh	8,686 MWh
Wind	2,500 MWh	24,500 MWh	24,500 MWh	85,750 MWh	85,750 MWh
Biomass	10,200 MWh	28,200 MWh	28,200 MWh	28,200 MWh	28,200 MWh
Hydro	171 MWh	171 MWh	171 MWh	171 MWh	171 MWh
Sum	21,009 MWh	61,646 MWh	61,471 MWh	122,983 MWh	122,807MWh

Table 33: Electricity production 2010-2050 by technology

Furthermore, the projection energy demand as stated by the sectorial groups is shown in Table 34. As the industry and commerce group was not able to provide sufficient data in time, its' demand is assumed to decrease by 5% over each decade.

Sector	Households	Industry& Commerce	Public buildings	Agriculture	Aggregate
2010	13,859 MWh	10,565 MWh	603 MWh	5,207 MWh	30,234 MWh
2020	11,670 MWh	10,037 MWh	539 MWh	4,999 MWh	27,245 MWh
2030	9,481 MWh	9,535 MWh	485 MWh	4,799 MWh	24,300 MWh
2040	7,292 MWh	9,058 MWh	433 MWh	4,607 MWh	21,390 MWh
2050	5,103 MWh	8,605 MWh	390 MWh	4,423 MWh	18,521 MWh

Table 34: Sectorial and total electricity demand 2010-2050

Figure 22 shows the development of the electricity production by the different technologies and the demand over the investigated time.

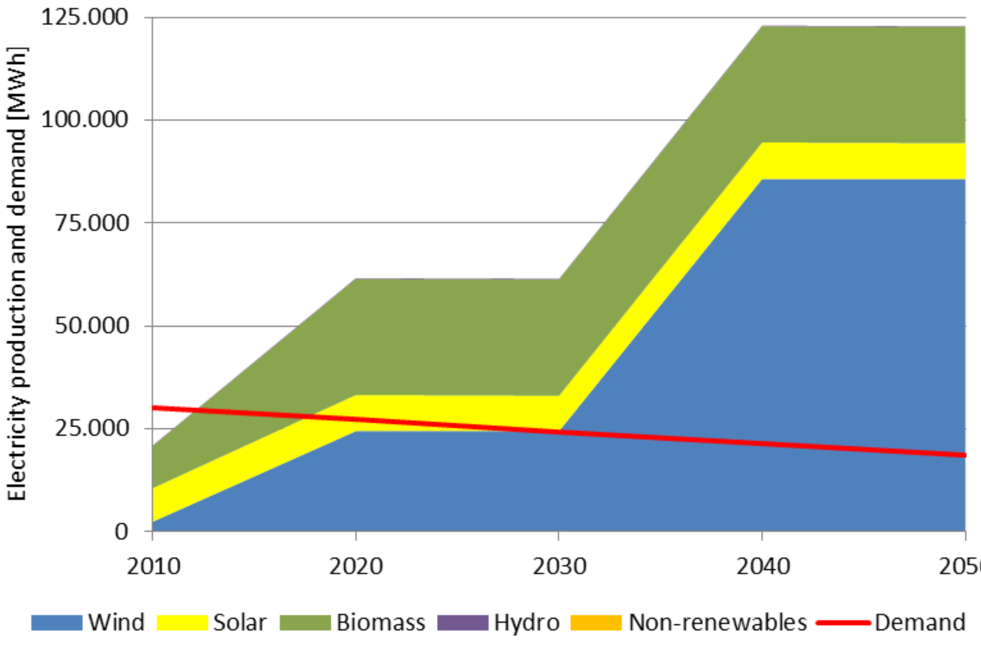


Figure 22: Development of electricity production and demand between 2010 and 2050

As in the status quo by calculating hourly data out of the annual electricity demand and supply it can fairly easily be seen, that the imbalance is not constant over the year. Figure 23 shows the seasonal fluctuations of production for the different technologies and the fluctuation of the demand in 2050.The values show the same general pattern as in 2010. However, due to high production of biomass and especially wind energy over the whole year, the demand is easily covered in every hour of the year (see Figure 24). This is insofar not only a theoretical value as the constant production from biomass and hydro covers the demand in every hour. This means that even in times of high consumption all production from solar and wind energy can be exported. The region can be supplied by 100% from renewables. This is not surprising as it is a rural area with little industry, and especially none with high energy demand.

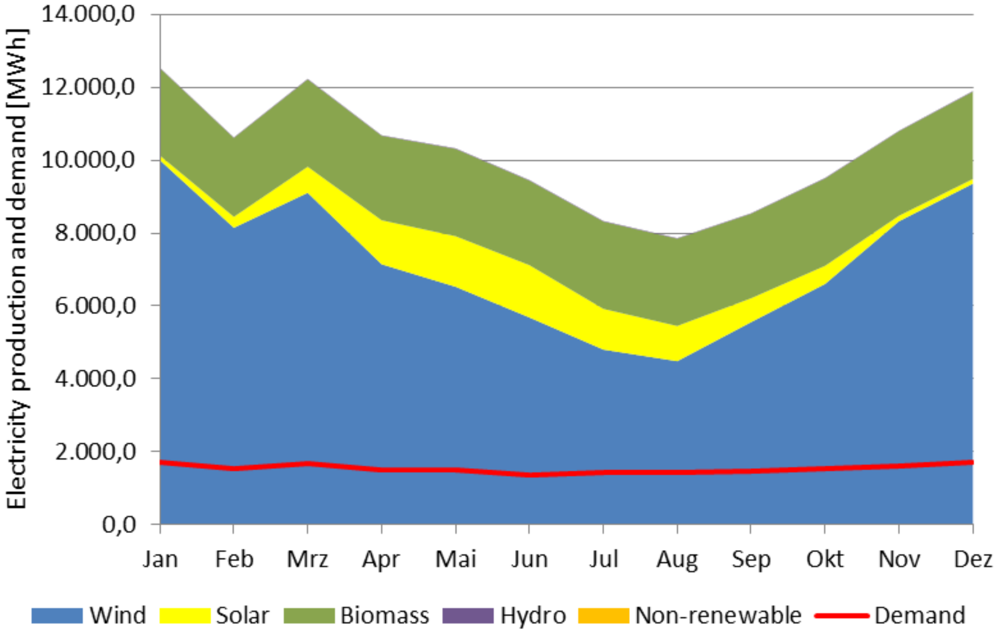


Figure 23: Status quo electricity production by technology and electricity demand 2050

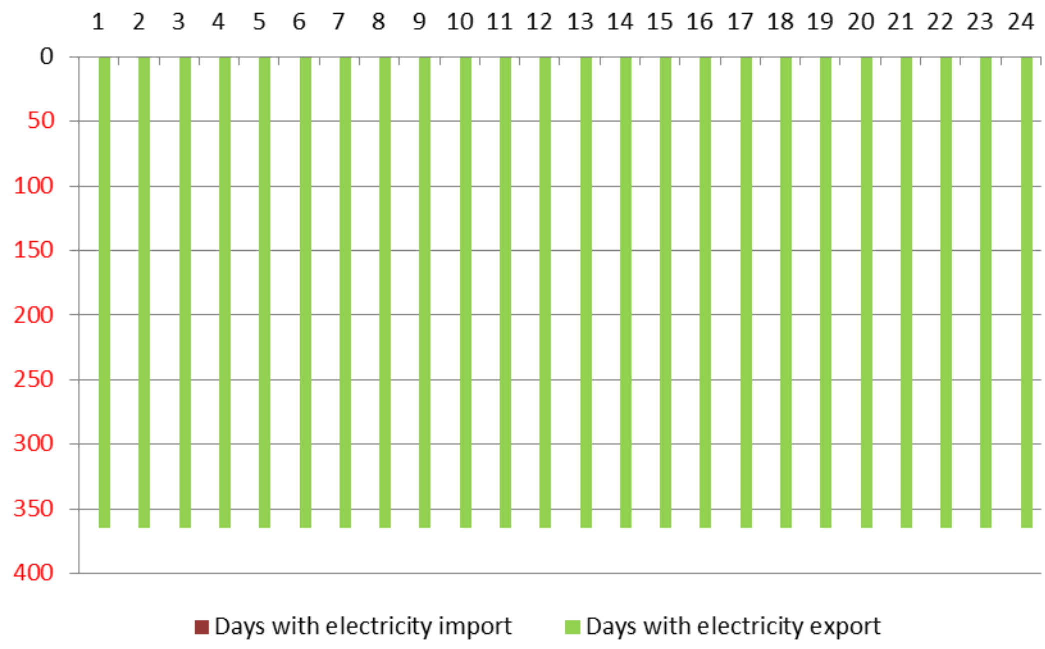


Figure 24: Number of days with electricity import and export by daytime 2050

Figure 25 shows again the differences, which arise from the import and export balances being calculated for different time horizons. As electricity is exported in every hour of the year, there is no difference between monthly aggregated data and the monthly export.

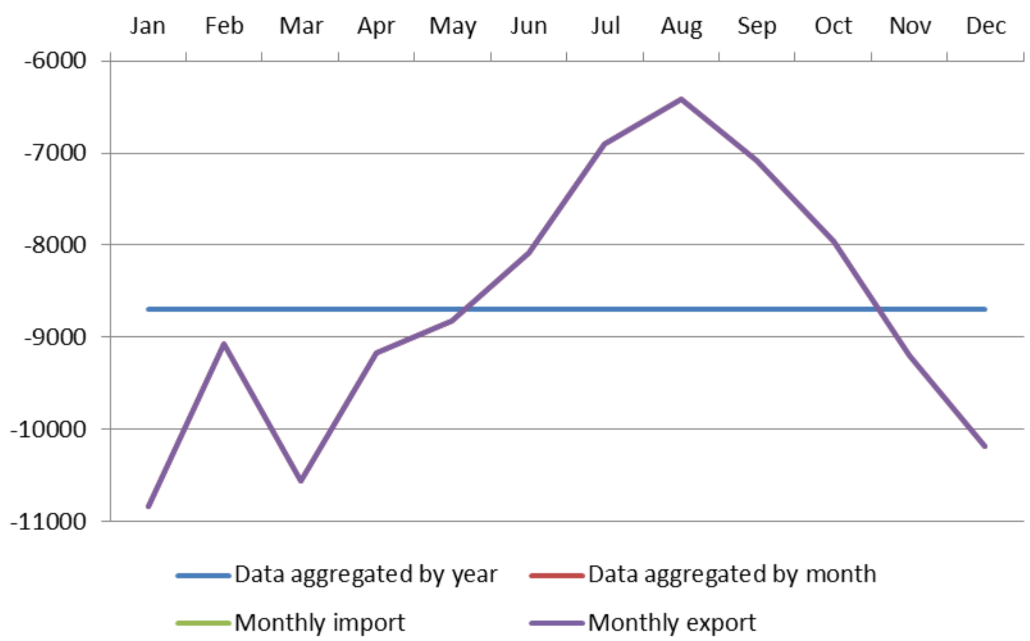


Figure 25: Electricity import and export depending upon examined time horizon 2050

Following the same methodology for the calculation of the CO_2 emissions as in 2010, one achieves the values in Table 35. It is remarkable, that the CO_2 emissions increase after 2030. This is due to the increased use of wind energy instead of biomass in the region.

Hence, a smaller share of the biomass energy is used in the region, while a greater share is being exported and does not affect the CO_2 emissions in the region any more.

Year	2010	2020	2030	2040	2050
Electricity consumption [MWh]	30,234	27,245	24,300	21,390	18,521
CO_2 emissions [t]	2.755	-4,478	-4,011	-1,515	-1,318
Average CO_2 emissions [kg/MWh]	91.12	-164.36	-165.06	-70.83	-71.16

Table 35: CO_2 emission key figures

Table 36 shows the change of CO_2 emissions over the year for the different technologies for 2050. It can be clearly seen, that the change of the year is driven by two main factors, which cause a higher electricity import in the winter months:

1. Lower electricity production from solar in winter
2. Higher demand for electricity

Technology	January	April	July	October	Year
Solar	1.76t	17.23t	19.33t	8.17t	135.68t
Wind	32.56t	24.23t	19.79t	25.82t	308.22t
Biomass	-132.9t	-133.98t	-168.07t	-159.52t	-1,762.45t
Hydro	0.08t	0.08t	0.10t	0.09t	1.04t
Import	0t	0t	0t	0t	0t
Total	-98.51t	-92.43t	-128.85t	-125.43t	-1,317.51t

Table 36: CO2 emissions by technology over the year 2050

Peak import	Peak export	Total import	Total export	Demand supplied by renewables	CO_2 emissions
0 MW	15.93 MW	0 MWh	104,286 MWh	100%	-1,318 t

Table 19 sums up the key values for the status quo of the electricity supply in 2050. As stated above the energy demand in the rural area is low. Due to negative CO_2 emissions from biomass, which balance the indirect emissions from other renewables, the electricity supply of the region can become a CO_2 sink by 2050.

Peak import	Peak export	Total import	Total export	Demand supplied by renewables	CO_2 emissions
0 MW	15.93 MW	0 MWh	104,286 MWh	100%	-1,318 t

Table 37: Key values electricity supply business as usual 2050.

2. Heat Supply

For the Oeversee region, there are several factors in heat supply that will be affecting not only the overall heat demand, but also the source of fuels to satisfy that demand. Taken as a whole, the population of the region is expected to remain somewhat stable. As documented in the household’s chapter, the population is actually predicted to slightly drop in Oeversee from 10540 down to 10117 residents. When combining this drop in energy consumers with the generally expected rise in household efficiency, the demand in heat energy drops from the status quo of 83331 MWh to 68895 MWh- a projected drop of over 17% by 2050. The projected heat energy use and fuel breakdown is shown in Figure 2.2.1.

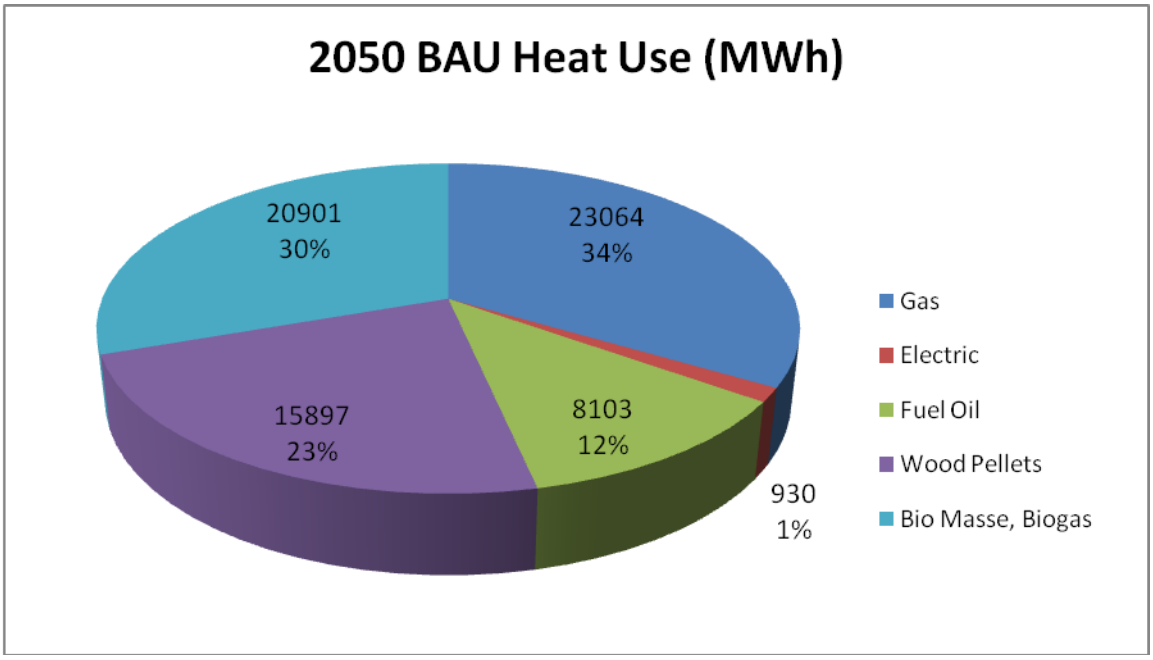


Figure 2.2.1: 2050 BAU projected Heat Energy Consumption

The most immediate fact of the BAU scenario is the introduction and increased use of renewable fuels. Many of these changes are already starting to go into effect now from the introduction of district heating in the Tarp area. The projection's assumptions and major factors of change are described below. First, the drop in residents and rise in efficiency also translates into less heat demand from the Industrial and Public Buildings sectors as well- with a projected drop of 37% (from 8308 MWh to 5280 MWh) in public building heat use. This reduction is slightly countered however by a small projected increase in heat demand from the areas agricultural sector. More details on these values can be found in their respective section reports.

2.1. Fuel Oil to Bio-fuel Phase-out

Another factor to consider in the BAU scenario is the likelihood of individuals changing their heating systems to more sustainable fuels. While there are several options and limitless possibilities to look into for the future projection out to 2050, the most reasonable is the change from older fuel oil heating systems in the region. This change is most easily and cost efficiently made when converting from fuel oil to a wood pellet or bio mass boiler heating system. Considering the current rising costs of heating a home by fuel oil as a result of growing and highly fluctuating costs of oil, this changeover trend is bound to happen. In a regional case study of Germany by the

Energy Research Centre of the Netherlands, this changeover from fossil fuels to biomass for heat was confirmed in three of the four future BAU scenarios they studied, the only case not changing over being the absolute worst case scenario projected status quo [SUSPLAN 2010].

We can assume from this report that at least for the short term, there will be a changeover to wood and biomass systems when a household or small business's boiler system reaches its life expectancy. Considering an average life expectancy of 20 years, that would result in a five percent per year changeover rate. Making a broad assumption on the bases that at rate of growth, wood and biomass prices can predictably remain below that of oil for approximately 10 years before leveling out, thereby not making it cost efficient for those who have not already made the change from fuel oil. This means that we can most likely see about half of all current remaining fuel oil users convert over to wood and biomass for heating use. Which of the two fuels home and business owners will change to is more or less up for grabs at this point, and as such will be divided 50/50 for this analysis.

2.2. BAU Scenario and the Tarp District Heating System

One of the largest changes in the Oeversee region from the Status Quo to the Business as Usual scenario is the introduction of the distributed combined heat and power generation plant (CHP) in Tarp. To be completed in 2014, this power production plant could not be considered in the status quo scenario. Designed with the goal of providing environmentally friendly district heat supply, the system is based on the use of renewable raw materials to provide heat as well as some CO2-free electrical energy [Stadtwerk 2012]. Upon completion, the CHP will have a total heat energy output of 31000 MWh, satisfying the heat demand for basically all residents of Tarp and nearly half of the current heat demand from Oeversee.

The Tarp CHP will utilize three different fuels to satisfy the varying load situations of heat and power production. This breakdown is represented in Figure 2.2.2. To satisfy the initial base load, renewable biomass produced bio-methane will be used to produce 2,200 kW of usable heat at an annual operating time of 8,000 hours. This translates into a total of 17,600 MWh of biofuel produced heat. The second stage, central heat load of the plant is produced with a wood boiler that is claimed to utilize wood chips and wood from the local countryside. This central load stage produces 3,000 kW going into the Tarp heating network for an average load time of 4000 hours. The boiler will produce 12,000 MWh of heat per year from wood. The final, peak heat load generation is covered by a hot water boiler fueled by heating oil. This stage will satisfy short duration peak heat demand with a production of 3,000 kW for an annual load time of only 500 hours. It will supply around 1,500 MWh of heat per year from fuel oil.

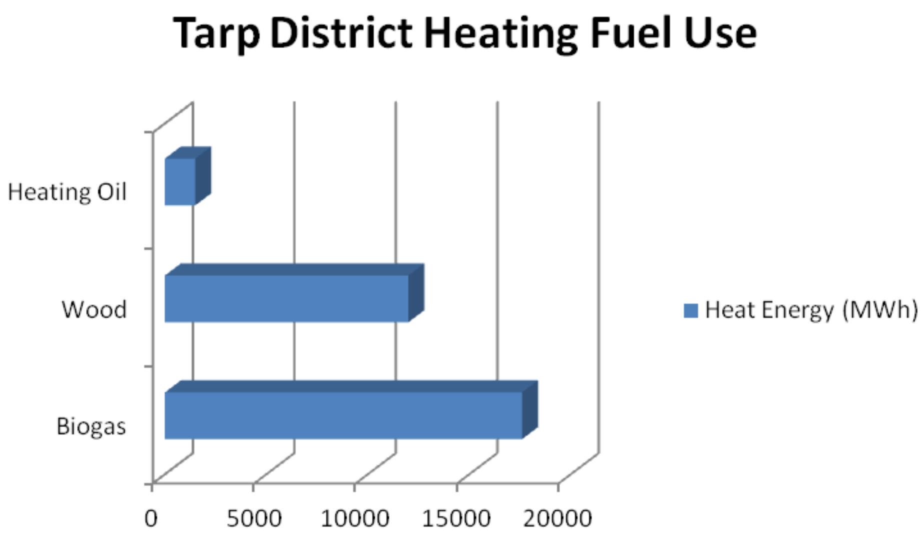


Figure 2.2.2: Tarp District Heating Fuel Input [Stadtwerk 2012]

2.3. BAU Heating Fuel Use

When taking the above assumptions and the Tarp district heating plan into account, the change to the diversification of heating fuels in the region is enormous. As seen in Figure 2.2.3, this change is greatest on the reduction of the use of Natural Gas, dropping from 61% of the total heat supply down to 34% with just the introduction of the Tarp heating plant. This reduction, along with the resulting reduction in total fuel oil use, is compensated by the dramatic increase in wood and biomass use. Also surprising by the introduction of the Tarp CHP is the overall decrease in fuel oil consumption. By replacing Tarp's fuel oil users with the distributed heating system, the use of the fuel dramatically decreases, even though the plant is run part time on fuel oil. This is because the fuel is only run in short durations to cover high load periods. The effect of these changes is a massive decrease in green house gas emissions for the Oeversee region.

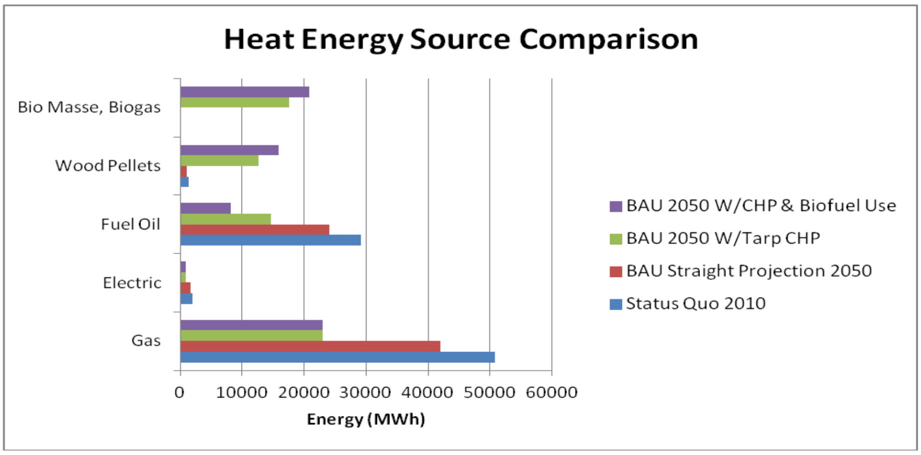


Figure 2.2.3: Heat energy use with respect to different BAU projections.

2.4. Equivalent CO2 Emissions of Oeversee

So what effect do all of these changes in Oeversee's heat source have on the regions sustainability? As wood and biofuels have a low overall carbon output, the introduction of district heating in the region will result in a massive decrease in the emission of greenhouse gasses. Seen in Figure 2.2.4, a comparison of the CO2 outputs shows the dramatic results of this systems introduction. When compared to the current status quo, the introduction of the Tarp CHP system will result in half of the overall CO2 output for the entire Oeversee region, bringing the output per person from nearly 2 tons of CO2 per person currently, down to about 1 ton per person. This drop is also apparent when comparing to a straight projection of current status quo practices. When adding in the anticipated changeover to wood and biomass heating, the projected CO2 output per person drops down to 0.826 tons of CO2 per person- less than half that of the area under current practices!

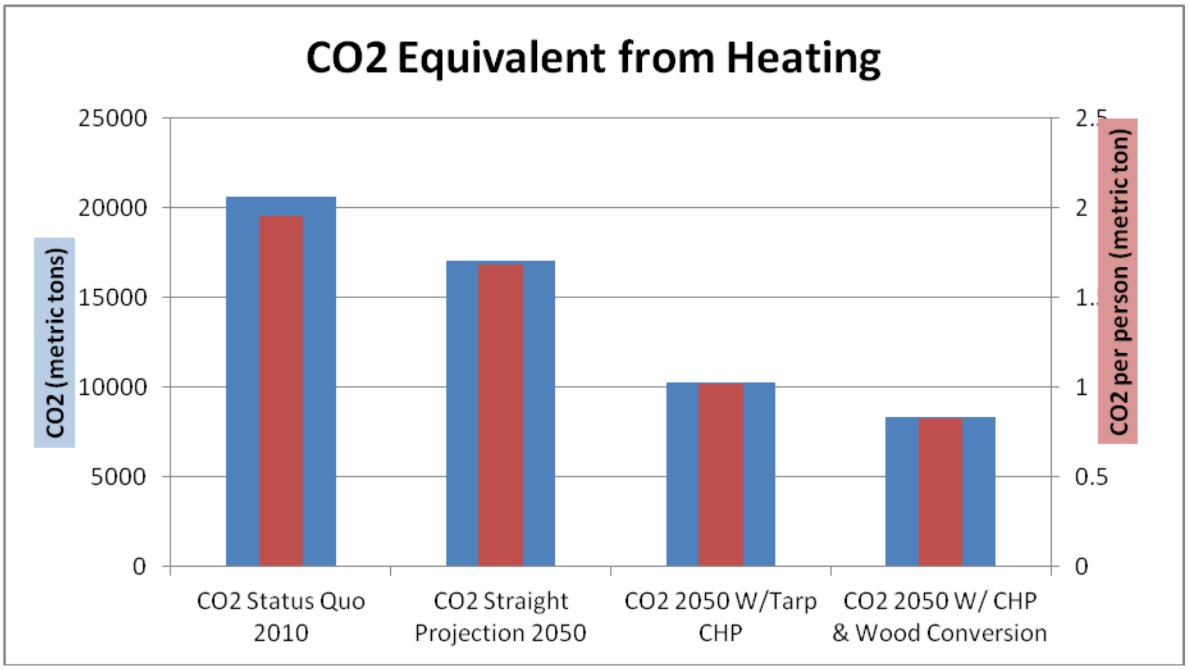


Figure 2.2.4: Heat Fuels CO2 Equivalent Emissions for Different Energy Scenarios

This dramatic decrease in greenhouse gas emissions is already in motion for the area. It can be somewhat attributable to both the slight drop in population for the region as well as an anticipated rise in overall efficiency of households in the future. However the greatest decrease is a direct result of the use of renewable fuels, as can be seen in the graph in Figure 2.2.5. Taken from the CO2 weightings given by the UK's DEFRA report in Table 2.1.1, the contrast is stark when comparing how much CO2 is produced versus how much energy is produced by the same fuels shown back in Figure 2.2.4.

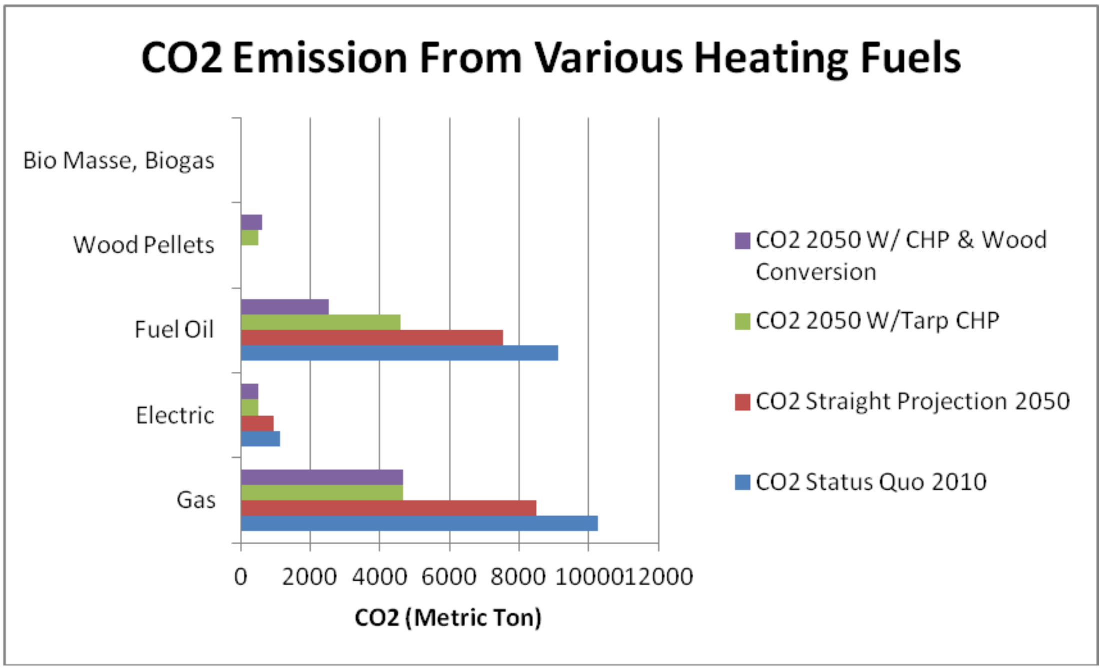


Figure 2.2.5: GHG Equivalent Emissions Based on Fuel and Scenario Type

2.5. Sustainability of Heating in Oeversee

So where does this projection put Oeversee with respect to sustainability? In 2007, the Intergovernmental Panel on Climate Change put a goal for the reduction down to 20% of 1990 greenhouse gas emissions by 2050 and 50% renewables for the entire energy supply [IPCC2007]. What this translates to is an estimated 2.5 tons of CO2 annually per person globally (assuming global population growth consistent with projections). With a projected output of 0.826 tons of CO2 per person annually in Oeversee for heat production, the region looks to be on track towards the IPCC's definition of sustainability very soon. However, this heavily depends on if the region can perform the same reductions in its electricity and transportation fuels consumption.

To give more breathing room for areas difficult to change, such as transportation, the region can still continue to adapt its heating methods for sustainability. For one, the expansion of the Tarp CHP to the entirety of the Oeversee region would bring CO2 emissions to very nearly approach a net zero output. This expansion (or creation of a separate one to cover the village of Oeversee itself), however, would be highly dependent on the future availability of wood and biomass/biogas supplies to fuel this increase. As the local available agricultural land is already close to maximized, this growth would most likely rely on imports in the fuels from other areas- often coming from large distances and therefore increasing the impact of shipping the fuels.

Another possible venue is the use of solar heating systems. While the region, like all of northern Germany, is not comparatively rich in solar energy, with the right system households are able to achieve massive decreases in dependence on heating from fossil fuels. Along the same lines is the increased use of heat pumps and geothermal heat energy storage which also decreases the need for fossil fuel heating. As technologies develop, these solutions become more and more viable for households as a solution. However, no matter how environmentally beneficial they are, these systems won't be utilized if the costs of installation and continued use do not come down and become economically viable for the individuals and small businesses in the region.

4.4. Households

1. Introduction

Business as usual scenario definitions

1. Scenario that examines the consequences of continuing current trends in population, economy, technology and human behavior.

2. A projected level of future emissions against which reductions by project activities might be determined, or the emissions that would occur without policy intervention.

To keep global warming within a mean global temperature increase of no more than 2ºC, which is considered still manageable and to which it will presumably still be possible to adapt, worldwide greenhouse gas emissions must be reduced and stabilized. The target time frame generally mentioned for the change is 2050. Today the emission levels of all industrialized countries are many times this figure. Mean emissions in Germany are currently about 11-12 metric tons per capita per year.

2. Methodology

Energy demand in the household sector is analysed and extrapolated into the future on the basis of a differentiation among uses for space heating, hot water, cooking and consumption by different household appliances like light, refrigerator, washing machine etc.
For the calculation of the heat and the electricity demand the houses are differentiated into three types (Single family houses, duplexes, Multi unit dwellings) and heating structures broken down by energy source. The lead variables for the extrapolation of living space are population and assumptions about the development of average living space per capita.

- The following influencing factors were taken into account in calculating energy consumption for space heating:
- The quantity of housing and apartments and heated living space,
- The energy performance standards of residential buildings, expressed as demand in heat capacity (in watts/m2) or specific energy consumption (in kWh/m2/yr), Residents' behaviour,
- The performance standard of heating systems, expressed as the ratio of useful energy to final energy (technical efficiency in percent)

The main drivers for the calculation assumption of the business as usual scenario are

- Population development (demographic change) form 2010 to 2050

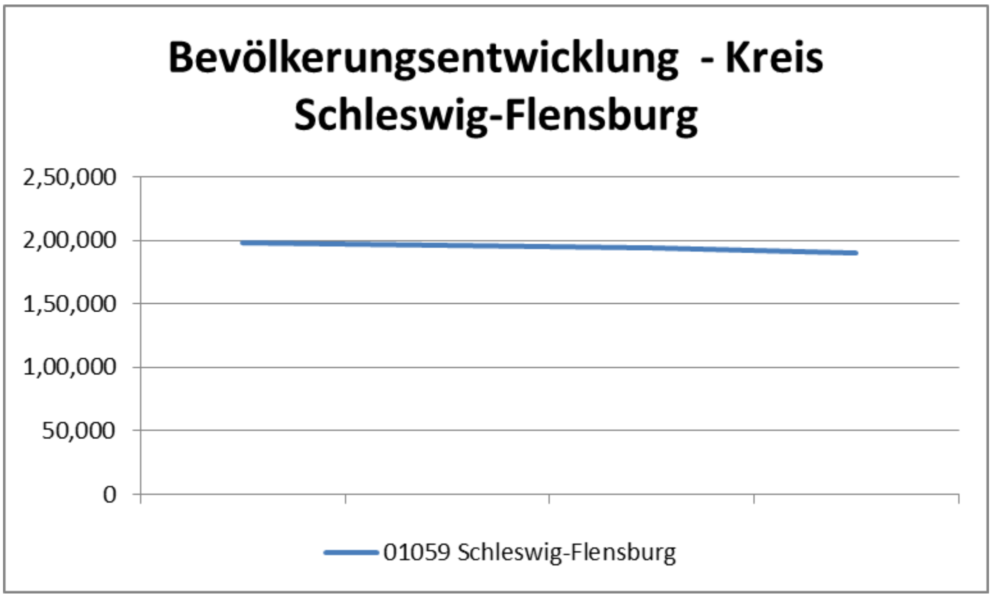
- House hold development from 2010 to 2050
- Development of private households till 2050
- Energy efficiency of the electrical devices
- Development of building standards

3. Population development (Demographic change)

Based on the status quo the inhabitants in oversee are 2010 in 10539 inhabitants. According to the population projection of Kreis-Schleswig Flensburg it is seen that the population of the region will decrease by approximately 4.03% from year 2010 to 2025 where as it is seen to be 9.28% from year 2025 to 2050.This is given in the following table

Alter von…bis Unter....Jahren	2010	2015	2020	2025
0 - under 5	8,192	7,776	7,699	7,623
5 - under 10	9,304	8,663	8,256	8,163
10 - under 15	11,831	9,576	8,939	8,522
15 - under 20	12,498	11,940	9,691	9,046
20 - under 25	10,040	10,572	10,022	7,770
25 - under 30	8,452	8,803	9,337	8,785
30 - under 35	9,852	8,727	9,081	9,603
35 - under 40	11,409	10,398	9,288	9,620
40 - under 45	17,289	11,774	10,781	9,659
45 - under 50	17,253	17,451	11,999	11,007
50 - under 55	14,291	17,235	17,451	12,076
55 - under 60	12,617	14,317	17,225	17,448
60 - under 65	12,266	12,624	14,307	17,152
65 - under 70	11,816	12,040	12,432	14,090
70 - under 75	13,242	11,134	11,435	11,867

75 - under 80	7,632	11,657	9,869	10,269
80 - under 85	5,338	6,102	9,418	8,047
85 - under 90	3,287	3,591	4,202	6,560
90 - under 95	1,043	1,613	1,817	2,197
95 – and older	500	390	553	667
Total	1,98,153	1,96,383	1,93,802	1,90,172
Delta		-0.89%	-1.31%	-1.87%
Oversee	**10539**	**10445**	**10308**	**10115**



Year	Schleswig-Holstein	difference before Period	Oversee
2010	2 827		
2015	2 824	-0.11%	10115
2020	2 824	0.00%	9974
2025	2 812	-0.42%	9794
2030	2 773	-1.39%	9607
2035	2 723	-1.80%	9406
2040	2 671	-1.91%	9176
2045	2 615	-2.10%	10115
2050	2 551	-2.45%	9974
2051	2 537	-0.11%	9794

Thus it is seen that buy extrapolating the population for the region in 2010 the population is **10539** which will decrease to **10115** till the year 2025 and **9176** till the year 2050.

4. Household development from 2010 to 2050

4.1. Development of households till 2030

Based on the assumptions by "Population in private households by age group in Germany from 2010 to 2030" the development of single family households from 2010 to 2030 is as follows

Year	Single family households
2010	16134
2011	16274
2012	16389
2013	16504
2014	16611
2015	16687
2016	16771
2017	16865
2018	16950
2019	17036
2020	17193
2021	17272
2022	17347
2023	17419
2024	17486
2025	17546
2026	17608
2027	17608
2028	17672
2029	17735
2030	17799

From the above table it can be calculated that the development of single family households will increased by 10.32%.In case of two family house holds the development is as follows

Year	Two family households
2010	13776
2011	13898
2012	14027
2013	14157
2014	14286
2015	14419
2016	14549
2017	14672
2018	14786
2019	14893

2020	14991
2021	15082
2022	15155
2023	15221
2024	15284
2025	15337
2026	15387
2027	15429
2028	15462
2029	15481
2030	15487

For two family households the development is 12.42%.Whereas for multifamily households

Year	Multifamily households
2010	5139
2011	5064
2012	4963
2013	4877
2014	4819
2015	4765
2016	4709
2017	4651
2018	4593
2019	4531
2020	4468
2021	4403
2022	4339
2023	4274
2024	4208
2025	4143
2026	4077
2027	4012
2028	3948
2029	3886
2030	3827

For multifamily households there is a decrease of 25.53%.
In order to get the development till 2050 for single, two and multifamily households the above values of percentage are multiplied by a factor of two. Thus the development of households till 2050 is

Type of household	Percentage
Single family households	20.62
Two family house holds	24.84
Multifamily households	51.06 (Decrease)

5. Development of living space

The living space is differentiated and calculated by building type (single-family homes, duplexes, multi-unit dwellings), building age group, and heating structure broken down by energy source. For this purpose specific assumptions are made about additions of living space and their heating structure, and disposals of living space (broken down by type of building and building age group). In a substitution matrix, additional assumptions are made about replacing one heating system with another. The lead variables for the extrapolation of living space are population and assumptions about the development of average living space per capita. The energy performance standard of living space is modeled using thermal output demand specific to the class of building and building age group, and those needs in turn change due to additions, disposals, and energy-saving refurbishment of existing living space. Based on the physically existing living space in 2010 and the assumed change in socio-economic base conditions (population, residential, age structure, income ;), living space is projected to expand by a total of 33.33% from 2010 to 2050.This is shown in the following table

Year	Living space per person [m^2]
2010	48
2015	50
2020	52
2025	54
2030	56
2035	58
2040	60
2045	62
2050	64

The development of single family houses is assumed to increase from 2375 in 2010 to 2865 in 2050. Thus we can see that there is an increase of 20.5%.Whereas the development of apartments will reduce form 1000 apartments to 500 apartments. Thus there is a reduction of 50% in the next 50 years.

6. Modernization rate (renovation rate and insulation rate)

The electrical appliances used in households includes what are known as “white goods” (large appliances like refrigerators, washing machines, dryers, dishwashers), entertainment equipment, information and communication (ICT) equipment, lighting, air conditioners, and other small appliances. Almost all devices have substantial potential for increasing their technical energy efficiency.

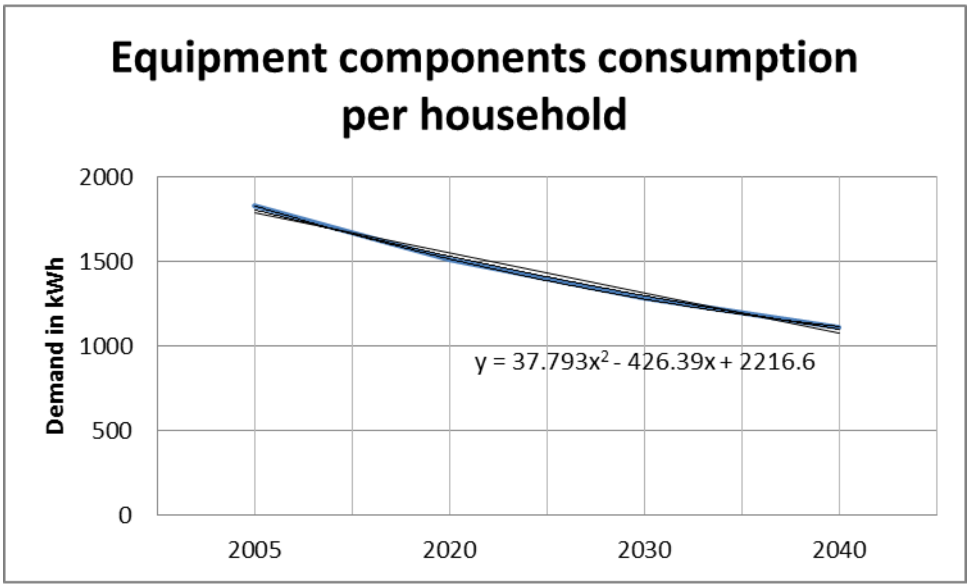
During the period under consideration, the inventory of electrical appliances – whose service life as a rule is between 10 and 20 years – will be replaced several times. To take due account of the market penetration of new technologies, high-consumption large appliances like refrigerators, freezers, washing machines, dishwashers and televisions are projected using cohort models. In refrigerators, an ongoing spread of magnetic refrigerators is assumed. Additionally, a limited amount of “waterless” washing machines will be introduced, thus eliminating the need for dryers and washer-dryers. The sharp decline in specific consumption for lighting is explained primarily by the ban on conventional incandescent bulbs. Consequently more efficient lighting will be used across the board. The trend towards multifunctional ICT devices will continue. Since these devices see more intensive use than single-function devices, the influence of this structural change on energy consumption will remain small.

	2005	2020	2030	2040	2050
	[kWh/appl.]1)	[kWh/appl.]	[kWh/appl.]	[kWh/appl.]	[kWh/appl.]
Light	281	125	105	42	33
Refrigerator	256	199	145	122	114
Referigerator-freezer	329	237	156	114	95
Freezer	299	225	170	141	127
Washing machine	223	171	143	128	117
Washer-Dryer	613	495	422	379	348
dryer	298	235	204	183	166
Dishwasher	243	202	184	169	156
Colour TV	162	207	150	97	83
radio/sound system	51	48	46	44	42
Video/DVD player	40	8	8	8	8
Electric iron	25	24	23	22	20
vacuum Cleaner	24	23	22	21	20
Coffee maker	85	85	68	68	68
Toaster	25	24	23	22	20
Hair dryer	25	24	23	22	20
Extraction Hood(Cooker)	45	43	41	39	37
Microwave	35	33	32	30	29
PC(incl.peripherals)	196	84	62	62	62
Communal area lighting.etc	28	21	20	17	17

In addition to technical progress, the number of electric devices in operation is also of critical importance for power consumption of the residential sector. This quantity component is determined by the number of households and what electrical equipment they have, also taking second units into account. Generally the scenario assumes that households will have increasing amounts of electrical equipment.

	2005	2020	2030	2040	2050
	[kWh / Household]	[kWh / Household]	[kWh / Household]	[kWh / Household]	[kWh / Household]
Light	281	125	105	105	33
Refrigerator	174.08	123.38	87	87	53.58
Refrigerator-freezer	105.28	90.06	62.4	62.4	50.35
Freezer	176.41	144	112.2	112.2	91.44
Washing machine	196.24	138.51	102.96	102.96	44.46
Washer-Dryer	49.04	79.2	113.94	113.94	215.76
dryer	113.24	96.35	81.6	81.6	41.5
Dishwasher	143.37	151.5	147.2	147.2	132.6
Colour TV	152.28	194.58	141	141	78.02
radio/sound system	51	48	46	46	42
Video/DVD player	33.2	7.36	7.68	7.68	8
Electric iron	24.5	23.76	22.77	22.77	19.8
vacuum Cleaner	23.76	22.77	21.78	21.78	19.8
Coffee maker	80.75	83.3	68	68	68
Toaster	22.5	22.56	22.08	22.08	19.8
Hair dryer	20.25	20.16	20.01	20.01	18.6
Extraction Hood(Cooker)	26.55	28.38	28.29	28.29	27.01
Microwave	22.75	27.72	30.08	30.08	29
PC(incl. peripherals)	133.28	84	62	62	62
Communal area lighting. Etc.	0	0	0	0	0
SUM	1829.48	1510.59	1281.99	1281.99	1054.72

From the above table the decrease in the consumption of electric energy per household is **42.35**%.



With insulation, the installation of modern windows, an efficient system, building automation and the use of renewable energy, the heat and cooling energy consumption in buildings can be reduced by 80 %. The energy concept of the federal government is in this context, a doubling of the rate to 2 per cent for energy efficiency. The rehabilitation of existing buildings causes economic benefits, economic growth and positive effects on the labour market. To guarantee the development of energy consumption and CO2 emissions of new buildings shown in the innovation scenario, regulatory provisions – like those currently laid down in the German Energy Saving Ordinance (Energieeinsparverordnung, EnEV) – are necessary. Based on the revision of the EnEv, which was decided upon in 2007 and entered into force on 1 October 2009, the requirements for the maximum permitted annual primary energy demand and the maximum permitted U-values (also referred to as the overall heat transfer coefficients) for existing and new buildings has been reduced by 30 % to increase energy efficiency. For existing buildings it was also provided for that rehabilitation encompassing more than 10 % of the component area has to fulfil component requirements. For 2012 an additional reduction of the U-values by 30 % is planned.

Numerous analyses show that newly built passive houses are already profitable. With rising energy prices, it is likely that the extra costs will increasingly remain within acceptable parameters in the longer term, also in the case of buildings with a zero energy standard or even a plus energy standard (in this context, it should be required that the remaining (low) heat demand is met – or even a surplus be generated – by renewable energies). The goal has to be to tighten the standards for room heating in new buildings to a maximum final energy consumption level of 20 kWh/m2 from 2015, 10 kWh/m2 from 2020 and to the zero energy or plus energy standard from 2025 onwards. Compliance with these efficiency standards should be guaranteed without any compensation from the volume of energy production from renewable energies as it is laid down in § 5 of the German EnEV of 2009; exceptions should only be allowed when a plus energy standard has been reached.

7. Calculation of heat demand in 2050

7.1. Calculation for single family houses

From the status quo the number of single family houses in the region of Oversee is 2375 and the average area /house will increase by 33.33% from year 2010 to 2050 and the Average Heat demand for single family houses will decrease by 30 % as is given by German Energy Saving Ordinance (Energieeinsparverordnung, EnEV) form 2010 to 2050.Thus by taking the values from the status quo the average area per house hold becomes 118.18×33.33% =157.57 kwh/a and the average heat demand decreases from 148.68 to 104.08 kWh/m^{2}a.The Heat demand can be calculated by multiplying the number of households with the area and the average heat demand .

Average heat demand (Kwh/m^{2}a)	104.0827
Number of houses	2375
Average area per household (m^2)	157.57
Total Heat demand for single family household (kWh/a)	38958442.1

Calculation for two family households, similarly for two family households

Average heat demand (Kwh/m^{2}a)	87.46185
Number of houses	396
Average area per household (m^2)	236.09
Total Heat demand for two family household (kWh/a)	8171511.703

7.2. Calculation for multifamily households

Average heat demand (Kwh/m2a)	93.70767
Number of houses	500
Average area per household (m2)	104.16
Total Heat demand for multifamily household (kWh/a)	4881840.641

The total heat demand for the all the types of households is **52011.79 mWh/a.**

7.3. Calculation for Electricity Demand in 2050

According to the population development in the year 2050 the total population is 9175 and the total number of households is 2375+(2×396)+500 = 3667.Thus we get 2.50 persons per household. The electricity demand for each household can be calculated as 2082.8×ln(2.50)×(- 0.4235) = 1573 kWh/a and the total electricity demand for all the households with warm water is 1573×3667 = 5769 mWh/a. Whereas the total electricity demand without warm water is 5103 mWh/a.

4.5. Public Buildings

The business-as-usual-scenario (BAU-scenario) should describe how the energy consumption could develop if no additional environmental protection measure would be taken into account. In case of public buildings this study used the following indicators that were considered as the main drivers of energy consumption for the years 2010 to 2050.

As public buildings are operated because they satisfy the needs of the inhabitants of the local area, a strong interrelation between the population and the energy consumed by public buildings could be seen. Therefore three the population forecasts were analyzed. The first one was Statistisches Amt für Hamburg und Schleswig-Holstein, 2011 which contained the growth of population in every administrative district of Schleswig Holstein in one year steps up to the year 2025. For the calculations only five year steps from 2010 to 2025 were used. From that year 2030 another statistic from the German statistical office (DESTATIS, 2011) was the source for the five year steps up to the year of 2050. The study contained the population forecast for all separate states of Germany. The growth rates for Schleswig-Holstein were analyzed and taken into account for all buildings that are not related to the age of its users.

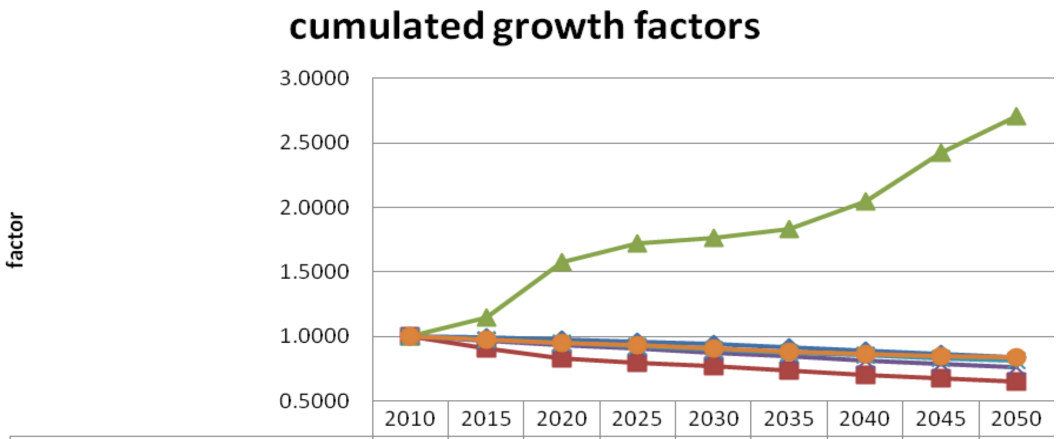
Taking the demographic change into consideration was the next step. The society of Germany becomes older but has a declining number of newborn children. The older people need other buildings than the children. If a population grows older fewer schools and kindergartens but more retirement homes are needed. This step relied on the data of the first study from 2010 to 2025 by summing up the age classes individually to all inhabitants younger than 20 years and older than 80 years in extra classes. For the years 2030 to 2050 the data is based on an online tool of the German statistical office which is based on the data of DESTATIS, 2011 and shows the age structure for each state of Germany until 2060 in five year steps. It already contained the age classes of younger than 20 years and older than 80 years.

Further, the number of the Danish minority was considered to be constant. There couldn't be reliable data found. On the one hand the minority report of Schleswig Holstein from Landtag of Schleswig-Holstein, 2011 (p.37) mentions that there are no statistical investigations on the number of members of the minority. The report assumes a number of 50000 members. On the other hand refers Wikipedia, 2009? to a decreasing number of members of the Sydslesvigsk Forening, the Dansk minority organization, over the last 10 years by 3500 but only to a decrease of 300 pupils in the Danish schools in all of southern Schleswig. As Wikipedia gives no sources for this number or they have had broken links, this numbers were assumed to be invalid. Due to this lack of clarity the share of the Danish minority is assumed to stay constant.

The next considered development is the decreasing number of member of churches. If there aren't so much church members less buildings are needed to satisfy their needs. For this development the assumption of the Nordelbische Kirche and the Flensburg University (Flensburg University, 2012) for the development of the church members were used.

In addition the looked for the renovation rates of public buildings and what kinds of regulations are defined for the future by the government. Renovations also mean insulation of the building which results in lower energy consumption and lower CO_2-emissions. In the MEMO/11/440 of theEuropean Commission, 2011 it is mentioned that the renovation rate of public buildings should be 3% p.a. but only in half of the cases this means an improvement in energy efficiency. The MEMO says further that a cost optimal renovation could save up to 60 % of energy consumption. Therefore this study used an annual renovation rate of 1.5% with an increase of 45 % in energy efficiency. This 45 % improvement is an assumption made by the public building group as the 60 % were seen to be too optimistic.

Further, there is a trend to a broader use of technical devices on the one hand and an increase in energy efficiency. Therefor the forecast from the study “Modell Deutschland” from the Prognos AG, 2009 was used. The Study predicts a total decrease of energy demand of electrical devices of 21% from 2005 to 2050 even with an increase of 18 % in the number of used devices. Calculating in five year steps from 2010 to 2050, the total development of the wider technology use and the increasing efficiency had to be recalculated. The result was a decrease of 18.9 % instead to have an accurate conversion of the trend in the BAU scenario.



	2010	2015	2020	2025	2030	2035	2040	2045	2050
total	1.0000	0.9911	0.9780	0.9597	0.9397	0.9155	0.8906	0.8640	0.8346
younger than 20 years	1.0000	0.9074	0.8269	0.7975	0.7715	0.7381	0.7048	0.6752	0.6522
older than 80 years	1.0000	1.1502	1.5723	1.7181	1.7613	1.8317	2.0444	2.4200	2.7068
insulation/renovation	1.0000	0.9667	0.9345	0.9034	0.8733	0.8442	0.8161	0.7890	0.7627
Increased technology use and efficiency	1.0000	0.9741	0.9490	0.9244	0.9005	0.8773	0.8546	0.8325	0.8110
Churches members	1.0000	0.9749	0.9507	0.9306	0.9035	0.8843	0.8630	0.8510	0.8363

Figure 1.9 Cumulated growth factors in reference to 2010

With this different growth rates in mind four different building classes were created

- Churches
- Schools and kindergartens
- Retirement homes
- Rest

Looking at the number of buildings that are in the classes, the church class contained 14 buildings, the schools and kindergartens class contained 11 building(s) (-complexes), the retirement homes contained 2 building(s) (-complexes) and the rest class had 19 building(s) (-complexes). The increase in technology use and efficiency for the electricity and the insulation rate of public buildings for the heat demand were used for all classes. Further the growth rate of church membership and the general population rate were used for the church class. For the schools and kindergartens the population rate of inhabitant younger than 20 years was used and for the retirement homes the population rate of people older than 80 year was used. The rest class had no additional development rate beside the ones used for all classes. It contained buildings like the waterworks for water supply, the swimming pool of Tarp, the police station, fire department and other such buildings.

After calculating the development of energy consumption of each class for every five years these values were summed up to have the development of energy demand in total.

Total in kWh	2010	2015	2020	2025	2030	2035	2040	2045	2050
Electricity German fuel mix	396643	378662	361711	345399	328881	311618	295308	279982	264490
Electricity renewables	217116	201866	190700	182011	172717	163203	155225	149332	143223
Heating	8286280	7914166	7550571	7166080	6780976	6386497	6014628	5661265	5305290

Development compared to 2010 in percent	2010	2015	2020	2025	2030	2035	2040	2045	2050
Electricity German fuel mix	100	95,47	91,19	87,08	82,92	78,56	74,45	70,59	66,68
Electricity renewables	100	92,98	87,83	83,83	79,55	75,17	71,49	68,78	65,97
Heating	100	95,51	91,12	86,48	81,83	77,07	72,59	68,32	64,02

5-year development in percent	2010	2015	2020	2025	2030	2035	2040	2045	2050
Electricity German fuel mix	100	95,47	95,52	95,49	95,22	94,75	94,77	94,81	94,47
Electricity renewables	100	92,98	94,47	95,44	94,89	94,49	95,11	96,20	95,91
Heating	100	95,51	95,41	94,91	94,63	94,18	94,18	94,12	93,71

Table 1.2 BAU-Scenario in total number, percent compared to 2010 and 5 year development in percent

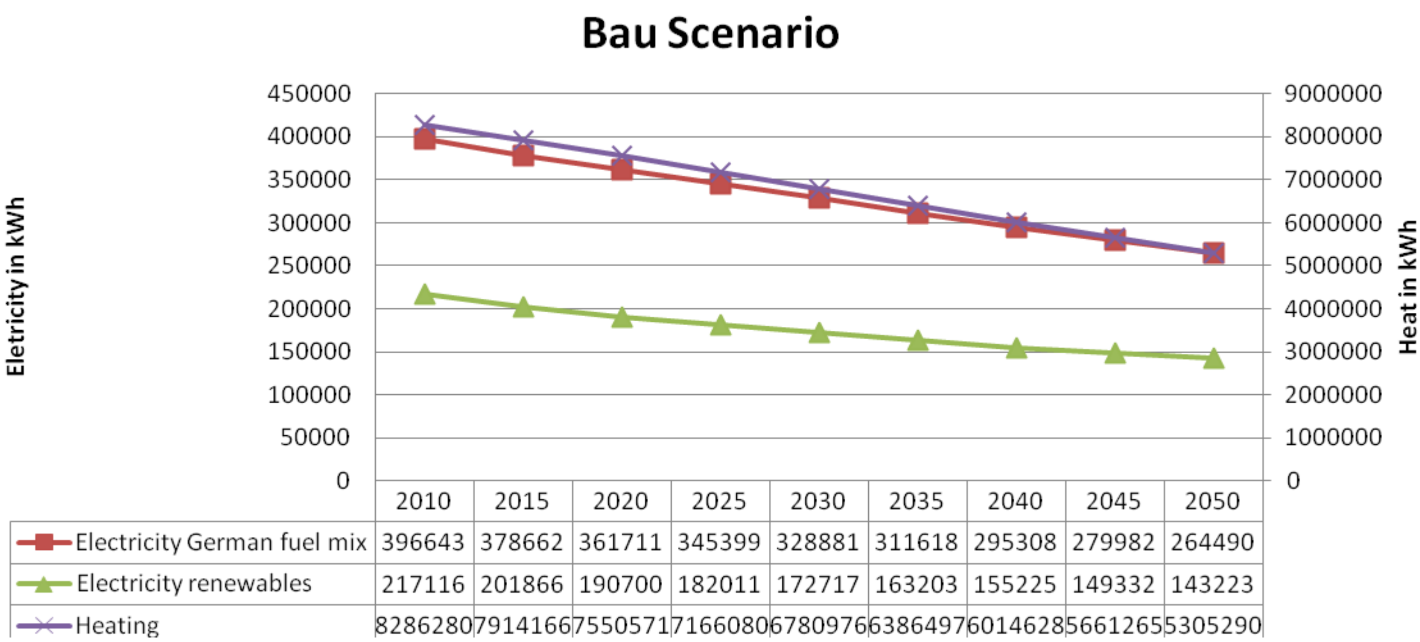


Figure 1.10 BAU-Scenario results in total numbers from year 2010 to year 2050 in 5 year steps

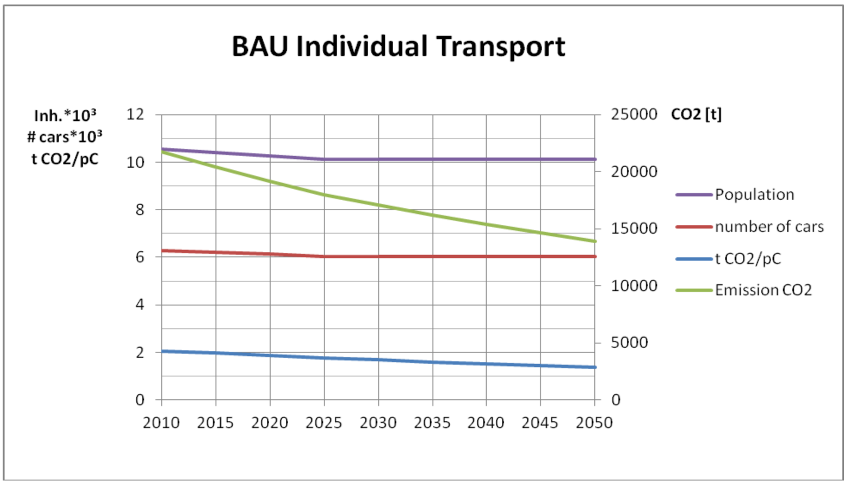
The results of the BAU-scenario calculation show a decrease of the energy demand of 33.32 % for the electricity demand from German fuel mix, 34.03 % for the electricity demand from renewables and 35.98 % for the heat demand comparing the year 2010 with 2050. Maybe one wonders about the different development of the electricity consumption. The first guess would be no matter from what source it is produced in a scenario with the same assumption for both they would develop in the same way. But by calculating different trends for different building classes and summing their results up, the electricity will not develop in the same way as the shares of renewables and the growth rates are different in every class. That is the reason for different developments in both the electricity columns. Comparing these numbers with the 34% overall decrease of energy consumption used in the reference scenario for the year 2050 in Prognos AG 2009, the other growth rate assumptions that did't came from these study seems quit realistic. The report stated further in its innovation scenario that a decrease of 58 % of the overall energy demands would be possible. Their reference scenario ends with a decrease of 52 % of CO_2 equivalent while the innovation scenario would lead to a decrease of 96 % of CO_2 equivalent. So for a further study on the development for such an innovation scenario in the case of Oeversee are a lot possible measures for improvements.

4.6. Transport

For the calculation of the Business-As-Usual-Scenario, the population change rate and the efficiency increase of combustion engines where used as drivers, the annual mileage and the number of cars per capita where assumed to be constant.

Drivers	
Population growth	2010-2025: -1,05% p.a. 2025-2050: stagnation
Efficiency increase	2010-2050: 1% p.a.
Constants	
Cars per capita [xx]	0,597
Mileage per capita [x2]	18693

Using these factors for the Business-As-Usual-Scenario, the calculation shows that the region Oeversee will not be sustainable in the transport sector, as the CO2-Emissions would only decrease from 2,06 t CO2 in 2010 to 1,4 t CO2 in 2050.



In order to achieve a sustainable system, the public transport needs to be improved in order to increase the acceptance of the people. In terms of individual transport, electro mobility might be a possible solution for a more sustainable system.

1. CO2 Emission For Fuels For Transport

In Germany the transport sector accounts for a big portion of the CO2 produced accounting for nearly 18 percent.

Here when we talk about C02 emissions we talk not only about CO2 but also CO2 equivalent emissions, such as, CH4, N20 etc.

Further more we subdivide this further in to two parts i.e. agriculture (transport in agriculture sector) and transport (private cars, buses etc).

1.1. CO2 Emissions In Agriculture

Here we take in to account the fuel used for agricultural purposes. This includes fuels used while ploughing, mowing etc.

	2010	2020	2030	2040	2050
Fuel Demand (diesel/ year)	377623	385647	393842	402212	410759
Fuel CO2 Emission (t)	1001	1022	1044	1066	1089

Average CO2 emission / litter = ?

From the above given values

We get 1001(t) CO2 for 377623l so
1(t) we get for 377.2 litters of fuel

Also we know 1(t) = 1000Kg
so we can calculate that for **every 1 litter we get 2.65 Kg CO2**

1.2. CO2 Emissions In Transport

We further divide Transport sector in to two groups i.e.

1) Private Transport
2) Public Transport

Here as already discussed, because the region is small no accurate data is available, so we have made some assumptions.

1. Private Transport:

Here we take in to account all vehicles privately owned e.g cars, motor bikes etc. As no exact number is available we use the Oeversee average of 597 cars/ 1000 inhabitants

Now we match this data up with the total population of the region so as to get an idea of the fuel consumed and from that we may extrapolate the amount of CO_2 produced.

	2010	2015	2020	2025	2050
Population	3414	3239	3072	2914	2914
Cars	2038	1933	1834	1739	1739

Here as already discussed the population decreases up to 2025 by a factor of 1.05%, until it reaches stagnation.

Also the mileage/person we took as a constant is 18693. Multiplying this with number of cars we get total mileage. .

	2010	2015	2020	2025	2050
Distance(miles)	3809 9287	3614 0640	3428 2685	3252 0246	3252 0246
Distance (km)	6133 9852	5818 6431	5519 5124	5235 7597	5235 7597

From the distance traveled we are able to extrapolate the fuel consumed and thus find the CO_2 emission. As we know on average a car travels 100 km with 8 litters so we get fuel consumption to be 0.079l/km

	2010	2015	2020	2025	2050
Fuel consu med	4858 116	4608 365	4371 453	4146 721	4146 721
CO_2	1150 2	1091 0	1035 9	9817	9817

Average CO_2 emission / litter = ?

From the above given values

We get 11502(t) CO_2 for 4858116 so
1(t) we get for 422 litters of fuel

Also we know 1(t) = 1000Kg
so we can calculate that for **every 1 litter we get 2.4 Kg CO_2**

2. Public Transport

As discussed earlier no comparable data that could have been mapped on Oeversee was available, therefore no Business-As-Usual-Scenario was developed for the Public Transport

5. IDEAS AND CONCLUSION

In the world today a common problem being discussed is CO2 emissions and how these emissions adversely affect the delicate environmental balance around us. The situation in Flensburg in general and Oeversee in Particular is no different.

A number of ideas are being discussed, and implemented, all over the world in order to reduce these emissions. We will discuss these ideas with relevance to Oeversee.

5.1. Make climate conscious Political decisions

Firstly and most importantly, it is important that we realize climate change caused due to CO2 emissions is not a thing of the future. It is here now and if not tackled can and will increase many folds.

It is obvious that strong action is needed to combat this problem and for this strong political will is required. Maybe even some tough decisions have to be taken. This willpower comes from the voters, who demand real action and are not satisfied by half measures.

Some of the actions that can be taken up and have enforced by political authorities are

1. Fines for emissions
2. Fuel taxes
3. Better planning of roads to avoid traffic jams and congestion
4. Give subsidy to people buying electric/ fuel cell vehicles in order to promote it.

5.2. Changing Lifestyle

Some people believe that the biggest difference to climate change can be made if we make small changes to our way of living.

Some basic changes we can make in an effort to use less fuel and electricity (as these both directly contribute to CO2 emissions) are

1. Bike more.
2. Car pooling.
3. Use public transport.
4. Plug appliances out if not in use.
5. Wash dishes/ clothes only when machine full
6. When cold, wear more clothes thus use less heating.
7. Use sun and wind to dry clothes.
8. Insulating houses.

These are just a handful of things we can do, which can collectively make a big difference to the emission of green house gases.

5.3. Solar energy

In most cases solar energy is thought to be one of the best answers as far as CO2 emissions go, but for our region with a fairly limited availability of sun is not necessarily the best solution. In fact by around 2030 the region will have reached the saturation level for solar power.

5.4. Wind energy

For the Flensburg region, power production using wind energy is a good option. The region because of its close proximity to the sea has a high wind availability, which if harnessed fully can lead to a lot of green energy production.

This way we not only do not produce no CO2 while generating the electricity, we also require less electricity from other sources which also indirectly leads to reduction of green house gas emissions.

The region of Flensburg has a number of sites for the setting up of wind farms, and all these sites are considered to be good for setting these farms up. Yet these farms can have a number of advantages and disadvantages some of which are as follows

Advantages:

1. Wind is naturally available (especially in our area of discussion) and with modern technology can and should be harnessed.
2. Once operational the energy produced is clean.
3. Unlike solar power, this is available all day long.
4. Although wind turbines can be very tall each takes up only a small plot of land. This means that the land below can still be used. This is especially the case in agricultural areas (such as oeversee) as farming can still continue.
5. Size of wind farm can be increased to meet requirments

Disadvantages:

1. Many people feel that the country side should be left untouched and in natural form for every one to enjoy
2. Wind turbines are noisy, with each one producing nearly the same noise as a car traveling at 70mph
3. Turbulence is created by these turbines.
4. Normally one turbine does not produce enough power so we generally need farms with multiple turbines.

5.5. Bio-mass

Bio mass is a renewable energy source and is carbon, hydrogen and oxygen based. In our study we have discussed of a bio mass plant in Tarp, but in an effort to have a sustainable future this is another option that can be looked in to.

Using biomass has a number of positives which are discussed below:

Advantages:

1. Bio mass reduces the need for fossil fuels for the production of heat, steam and electricity for residential and agricultural purposes
2. Always available and can be used as a renewable source
3. Agricultural waste can be used as a fuel (especially with relevance to Oeversee as it basically is agriculture based) adding secondary value to the crop
4. The use of waste material reduces landfills etc.
5. It also leads to using less money on foreign fuels

It is important to note here that a big problem with such plants is that because we burn a lot of waste material it can in some cases lead to air pollution.

5.6. Transport

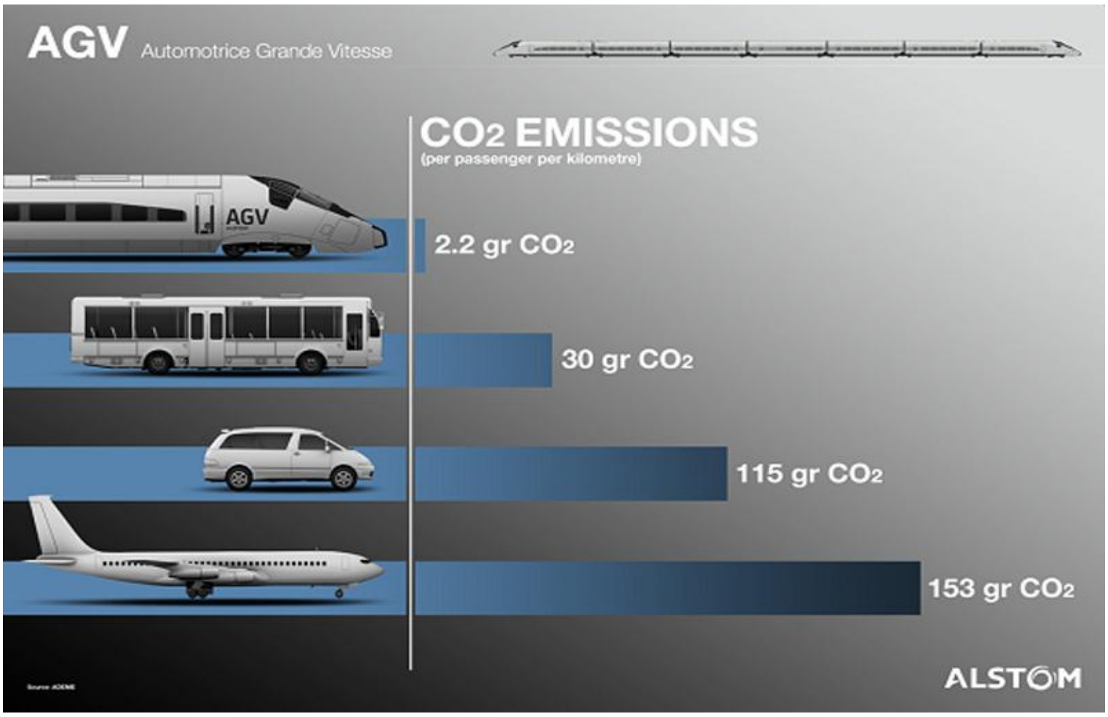
Burning of fossil fuels is one of the primary sources for the producing of CO2 which is a major hurdle faced by us in achieving sustainability.

As of today the primary source of fuel for our transport comes from fossil fuels upon burning which we emit huge amounts of CO2. As the public becomes more aware of these hazards and in an effort to reach sustainability by 2050, new and more efficient engines are being engineered. Every year we get vehicles which are traveling more distance while burning the same amount of fuel. Simultaneously the introduction of electric and hybrid vehicles is a blessing as we now have vehicles with virtually no CO2 emission,

By 2050 nearly all busses in public transport will be hydrogen powered fuel cell busses, while nearly 80% of all registered cars will be electric. But for now to make immediate changes we have to make more use of biofuels.

A good example for the use of bio fuels is Brazil, where nearly 25% more ethanol is added to fossil fuels. This has a couple of advantages

1. The ethanol comes from crop (in Brazils case sugarcane), so import of fossil fuel is reduced.
2. Bio diesels emit less CO2 when used



Keeping the enhancements aside in an effort to attain sustainability a conscious effort has to be made to shift from using private to public transport. Even within public transport we should try more to travel in trains rather than in airplanes.

6. FURTHER WORK AND RESEARCH (SHORT SUMMERY)

CO2 emissions are naturally occurring phenomena. In fact compared to natural emissions man made emissions are very small. So where does the problem lie?

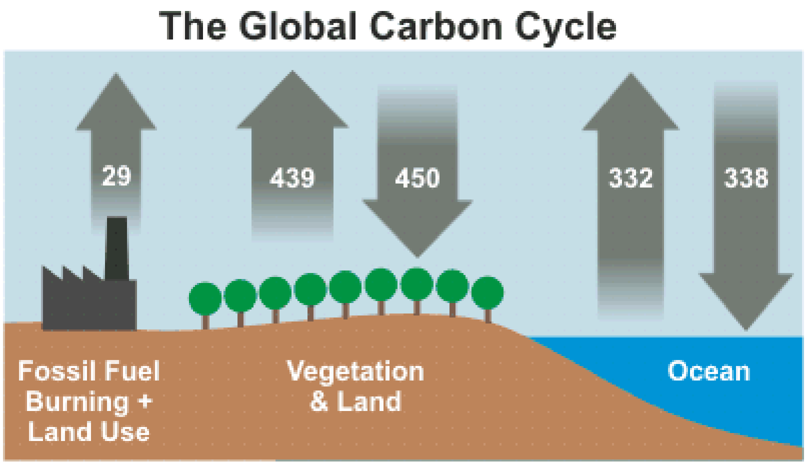


Figure 1: Global carbon cycle. Numbers represent flux of carbon dioxide in gigatonnes (source intergovernmental panel on climate change IPCC)

Here The problem is that even though massive amounts of CO2 is emitted naturally, more is absorbed and thus we have neutrality for CO2 in our environment, but this absorption is only bale to cover about 40% of the man made CO2 emitted. Due to this the CO2 is at its highest in 15 to 20 million years.

The recent increase of 100 ppm has taken about 120 years as opposed to 5000 to 20,000 years it would take under normal circumstances. Because of this humans have started feeling the effects of this imbalance.

The purpose of this study was to check how the region of Flensburg in general and Oeversee in particular will fare in terms of sustainability between the base years of 2010 to the target year of 2050.

In this study we tried to measure the current trends which we termed as "statue quo" fixed some drivers ie some assumptions to help us predict how things are going to shape up in the future. With the help of this study we were able to give a rough estimate as to how things are going to look like by the year 2050. This should help all those who are working on making the region more sustainable and prosperous.

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(* All the cross-sectional groups are included with *Status Quo* and *Business As Usual Scenario* and are written by the Writer itself.)