



# Master plan for Renewable Energy 2030



## MASTER PLAN ON RENEWABLE ENERGY 2030

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### **This plan is approved by:**

- *The municipal Plan- and Environmental Committee in November 2014*
- *The municipal Economic Committee in November 2014*
- *By Frederikshavn City Council in December 2014*

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- *Electricity supply companies in Municipality of Frederikshavn*
- *Heat- and district heat companies in Municipality of Frederikshavn*
- *Public housing associations in Municipality of Frederikshavn*
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# 1. Preface

The MUNICIPALITY OF FREDERIKSHAVN has prepared a strategy plan on renewable energy 2030. The strategy plan follows the Municipality action plan on the EU Covenant of Mayors agreement prepared in December 2012. The strategy plan is prepared to implement the energy policy of FREDERIKSHAVN MUNICIPALITY for the entire Municipality as geographical boundary and aims towards a 100% renewable energy supply and optimum energy consumption by year 2030.

In this way, the strategy plan is a continuation of the visions for the Energy city Frederikshavn, where a limited geographical area in the previous Frederikshavn Municipality was to be converted into 100% renewable energy by year 2015.

The current strategy plan includes the entire Municipality of Frederikshavn. Therefore, the objectives in the strategy plan are a further development of the business plan for Energy city Frederikshavn and replace this. Some of the most important reasons for the transfer from Energy city to Energy Municipality are:

- The Energy city-project with its original content included the city Frederikshavn and the towns of Strandby and Elling. The plan was to use the experiences from Energy city Frederikshavn for further integration in the remaining part of the Municipality later on. The limited geographical area in the Energy city Frederikshavn makes it difficult for the citizens and companies in the remaining part of the Municipality to identify with the project and to take owner-

ship. Today Frederikshavn Municipality is a new Municipality, consisting of the three previous communities Skagen, Sæby and Frederikshavn. As the new Municipality is the initiator and the owner of the Energy city, it was decided during fall 2013 to make the assets of the project available to all citizens and companies in the Municipality. Therefore, it is the most natural action to extend the geographical border of the project to include the entire Municipality.

- Practical experiences in connection with the fulfilment of the vision of Energy city Frederikshavn to make a 100% conversion into renewable energy show that the vision of the project is up-scalable, so that it includes the entire Municipality. Furthermore, the geographical border of the energy city does not include sufficient energy resources converting the entire Energy city Frederikshavn into 100% renewable energy by 2015. A considerable part of the activities of the Energy city concerning renewable energy, such as planning of wind power turbines, planning of biomass based energy production; continuous conversion of transport and energy efficiency improvements of houses is already taking place outside the geographical area of the Energy city. Therefore, the most appropriate thing to do is to prepare a plan, which will deal with energy efforts in the entire Municipality. Furthermore, the most rational thing to do concerning planning, is to prepare a coherent plan on renewable energy for the entire Municipality compared to

doing the planning for a limited area. In other words, through the demonstration projects of the Energy city, through networks and through cooperation Frederikshavn Municipality has created a solid basis for extension of the project including the complete geographical area of the Municipality.

- Apart from the vision of 100% renewable energy supply in the Municipality in 2030, the plan will help creating development, growth and increased employment within the growth track "Energy" in the Municipality of Frederikshavn. Companies and energy supply companies in the Municipality are the leading element and play an important role concerning the growth track energy. These companies are located all over the Municipality from Skagen far north to Voerså far south. With the Municipality border as effort area, the Energy City will have the possibility of including all citizens, companies and educational institutions of the Municipality in a development process. In this process, we create dynamic and synergy in a way, where all involved parties work together to fulfil the visions behind the Energy growth track for the benefit and growth and increased employment of the local area.

The vision of the strategy plan to have 100% renewable energy supply and optimum energy use in Frederikshavn Municipality as geographical border 2030 means that FREDERIKSHAVN MUNICIPALITY must work targeted with following subjective:

- Increase the basis of resources by further development and promotion of local, renewable energy resources.
- Continuous promotion of efficient utilization of energy resources i.e. by supporting energy savings in buildings.
- Support the effort of the energy supply companies to convert to renewable energy production.
- Promote the use of renewable fuels in the transport sector including public transport.
- Maintain focus on the growth track Energy as a promising growth and development strategy for all citizens and companies in Frederikshavn Municipality.
- Support innovation, development and demonstration projects in preparation for promotion of renewable industrial development

FREDERIKSHAVN MUNICIPALITY would like to collaborate with the industry, including energy supply companies and public transportation companies, citizens, universities and vocational education institutions, public and private institutions, associations, other communities and other regional players. This to implement the strategy plan as it leads the road to making the citizens and businesses of the Municipality making the growth track "Energy" their new way of living.

Frederikshavn Municipality we will let ourselves in Frederikshavn get inspired and we wish to make use of the experiences and opportunities that are present in the world outside the Municipality's border.

Best regards



Birgit Stenbak Hansen  
Mayor  
September 2014

# Definitions and assumptions

## **Renewable energy**

Definition of renewable energy, used in this plan, is defined as energy, that have no limited resources, but are limited in their immediate prevalence.

The mention of renewable energy resources in this plan includes the energy resources sun, wind, hydro power, firm biomass, waste of non-fossil origin, liquid biofuels, biogas, ambient heat, geothermal Energy and solar heat.

## **Renewable energy supply**

Renewable energy supply means long-lasting, minimum strain to the environment, minimum strain to the local environment and that the solution is advantageous to the society and the consumers.

## **Energy consumption without the influence of the municipality**

### *Train, sea and flight carriage*

The Municipality's share of fossil energy consumption for flight carriage, train carriage and sea carriage is estimated to 144.48 GWh/year. Basis for the estimation is the country average of fossil fuel consumption for train, sea and flight carriage and allocated according to number of citizens – including municipalities without ports and airports (energy statistics 2010). Emission of CO<sub>2</sub> because of train and flight carriage is still included in the overall CO<sub>2</sub> statement of the municipality.

We realize that the conversion of the municipality's share of fossil energy consumption for train service and flight carriage is outside the influence of the municipality. Therefore, it is unrealistic to prepare action plans on these areas.

### *Import of electrical power*

The concept includes import of electrical power, not manufactured within the geographical border of the municipality, but imported from outside the border of the municipality through the national electricity grid. The share of import of electrical power in the municipality of Frederikshavn is the sum of electrical power production within the municipality minus all consumption of electrical power in the municipality plus loss by distribution. The municipality has no influence on the conversion of the import of electrical power in the municipality into renewable energy.

## **The share of renewable energy in import of electrical power**

The estimation of the share of renewable energy in import of electrical power in this plan is 33.1% of the total production of electrical power, which is a national average on production of renewable energy in Denmark in 2010.

In 2013, the share of renewable energy for production of electrical power has increased to 41.8%, source, Energinet.dk, August 2014.

## 2. Summary

The present strategy plan is an attempt to create a reliable basis for the effort of Frederikshavn municipality for transition to renewable energy. The primary intention of the plan is to make an proposal on how the transition of the municipality to renewable energy can be organized and planned in the most appropriate and systematic way. Therefore, the plan must be considered as a template for the continuous work of the municipality with strategic energy planning and further development of this.

The aim of the strategy plan is to visualize the contribution of Frederikshavn municipality to the national vision of making Denmark a society without any consumption of fossil fuels in 2050, which means without using coal, oil or natural gas. Furthermore, the strategy plan will contribute to structure of the municipality growth track "Energy".

By preparation of the strategy plan on renewable energy 2030 the socio-economic parameters have been included in the various individual action plans, so that FREDERIKSHAVN MUNICIPALITY will be able to comply with the vision of the strategy plan in a financially sustainable way. In this way, the strategy plan will mark Frederikshavn municipality as a pioneer municipality within sustainable energy and furthermore, supports a contemporary development of the society.

The strategy plan on renewable energy 2030 for Frederikshavn Municipality is also a dynamic catalogue of ideas containing recommendations and actions known in 2014. Therefore, it is important to relate to the parameters, which continuously influence the assumptions within the individual effort areas of this plan.

It is of crucial importance to the applicability of this plan, that any changes to the parameters of this plan are regularly ana-

lyzed and integrated into the overall strategy plan. Therefore, the use of this plan depends directly on the maintenance of the "wholeness and the balance" of the plan. Likewise, it is important that the municipality as an organization takes on the responsibility for maintaining and development of the plan. Furthermore, it is recommended that an annual status on the progress of the plan is prepared, see paragraph 8.

In compliance with the guidelines of the Danish Energy Agency on strategic Energy planning, the total energy consumption of Frederikshavn municipality in 2010 is surveyed at 2,593.63 GWh. Likewise; the total CO<sub>2</sub>-emission of the municipality in 2010 is surveyed at 547,000 ton/year corresponding to 8.8 ton CO<sub>2</sub> per citizen.

A summary of the renewable energy action plans shows that it is realistic for the municipality of Frederikshavn to produce 1,838.93 GWh renewable energy, corresponding to 102.7% of the total fossil energy consumption of the municipality in 2010. This, when the impact of implemented savings and the share of fossil energy consumption out of the influence of the municipality (fossil energy consumption for train services and aviation) has been deducted.

Likewise, the survey shows that the CO<sub>2</sub>-emission of the municipality is reducible by 97% compared to the CO<sub>2</sub>-emission of the municipality in 2010.

Furthermore, the survey indicates that the impact of the strategy plan on the growth track "Energy" when it comes to growth by companies, competence development and increased employment in the local societies, looks promising. However, quantification of the employment potential by each single action is difficult, due to lack of reliable data and ambiguity in the statements available today. See table 1 and 2.

The survey also shows that with the feasible action plans we know in 2014, 54.8% of the necessary renewable energy must come from wind power turbines. The high share and sustainable energy coming from wind power turbines can make the strategy plan vulnerable.

It is important to ensure balance and interaction in the mentioned renewable energy resources, as it is a condition for the realization of the municipal vision of transfer to 100% renewable energy.

To establish a balanced energy system and to maintain the energy supply security in the future it is important to work continuously with the integration of necessary energy storing technologies in the complete energy system.

Likewise, it is important to make sure that the production of renewable energy at any time is performed at market terms and in a compatible way.

Bahram Dehghan  
September 2014

### FACTS

#### Status 2030

Renewable energy production equivalent to 102% compared to the energy consumption in 2010.

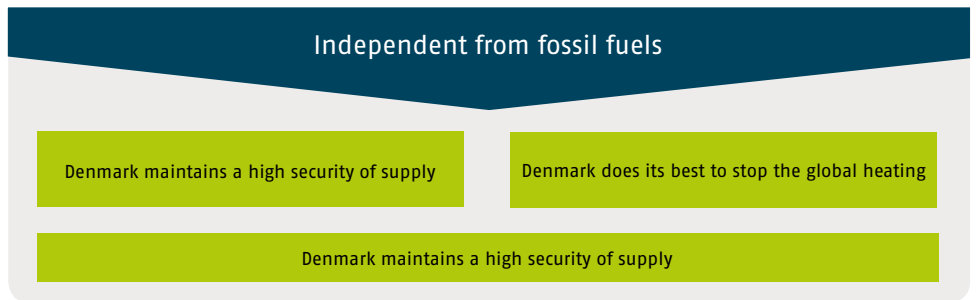
- Total fixed asset Investment equivalent to 7.5 billion DKK.
- CO<sub>2</sub> reduction equivalent to 97% compared to 2010.
- 55% renewable energy will come from wind.
- Reorganization of road transport to renewable energies is a challenge.

### 3. Background

In March 2012 the Danish government negotiated an energy agreement. The energy agreement was made between the government (the Social Democratic Party, the Social-Radical party and the Socialist Peoples party) and the Liberals, the Danish People's party, the Red-Green Alliance and the Conservative party and covers the period from 2012 – 2020. By the approval of the Energy agreement the Ministry of Energy, Climate and Housing set new objectives for the Danish energy policy 2012–2020 to promote the green conversion of Denmark and to support the common EU objectives.

The energy agreement includes overall objectives for energy savings, development of wind power and other renewable technologies, promotion of CHP-plants, district heating and biomass, smart energy infrastructure, integration of electrical power and biomass in the transport sector and increased research, development and demonstration projects. The energy agreement also includes proposals on financing of the energy political actions of the agreement, see enclosure 1.

In February 2011 the Ministry of Energy, Climate and Housing launched the "Energy strategy 2050, from coal, oil and gas to green energy". With the "Energy strategy 2050" the government aims to fulfil the promise of the government work program "Denmark 2020" to present an objective on when Denmark can become independent from fossil fuels and a strategy on how to achieve the goal in the current election period. Following indicates an extract from the main messages of the government energy strategy 2050.



**Objectives in the government work program**

- Denmark will be a green, sustainable society
- Denmark will be among the three countries in the world, which lifts its sustainable energy share the most towards 2030.
- In 2030 Denmark will be among the three most energy efficient countries in OECD.

**Danish objectives related yo the EU climate and energy package**

- The share of renewable energy must be increased to 30% of the total energy consumption in 2030 as a part of a total EU-objective of 20% renewable energy in 2020.
- The share of renewable energy in the transport sector must be 10% in 2020.

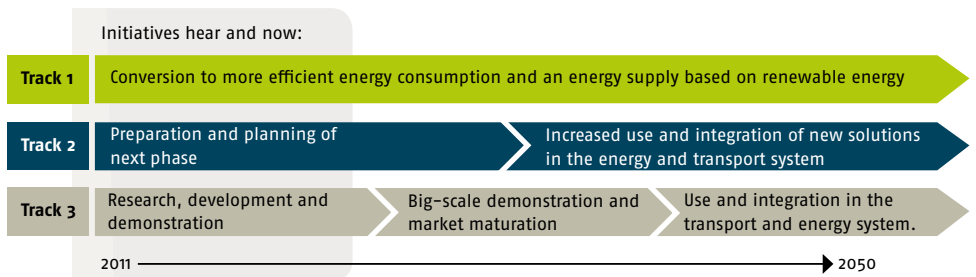
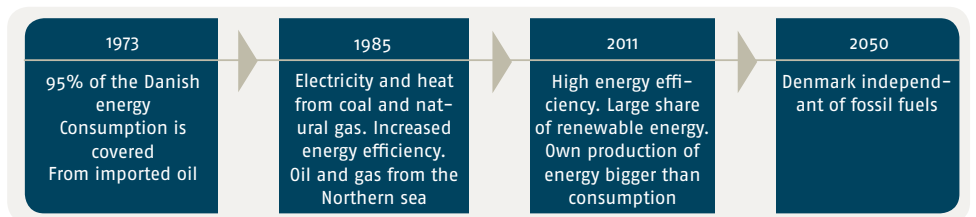
- The emissions in the quota-regulated sectors must gradually be reduced in 2013–2020 and with 20% in 2020 compared to 2005 as a part of a complete EU objective to reduce the emissions by 20% in 2020 compared to 1990.

**Objectives of the Energy agreement for the period 2008–2011.**

- In 2020, the gross energy consumption must be 4% less than in 2008.

**Danish objectives for the EU climate and energy policy**

- The government cooperates to make EU take on the obligation to reduce its total emission of greenhouse gas by 30% in 2020 compared to 1990 level.



Source: Energy strategy 2050 edited by the ministry of Climate, Energy and Housing, February 2011.



Furthermore, the Ministry of Commerce and Growth launched its growth plan for Energy and Climate in October 2013.

The growth plan must contribute to the creation of growth and employment and improved export opportunities for Danish companies in Energy technology and solutions. The growth plan includes 30 initiatives divided between 5 effort areas:

1. Green conversion of the energy system – a more flexible and coherent energy system
2. Promotion of export – in the global markets.
3. Buildings – an energy efficient and sustainable building stock.
4. Research, development, market maturation and education – Denmark as green test and demonstration country
5. Utilization of resources – efficient extraction of the fossil energy resources in the North Sea.

From the above effort areas 1-4, launched by the Ministry of Commerce and Growth it is visible that, the intentions of the government growth plan are completely consistent with the intentions of the Frederikshavn municipality for the Energy city.

By the preparation of the strategy plan for renewable energy weight is put on the specification of action plans and effort areas based in the government's tracks and initiatives that can be launched immediately. The reason for this priority is that energy planning for the other effort areas calls for an overall national planning and regulation where the state makes the guidelines, defines the objectives and facilitates the means. An audit of the strategy plan must be done every year.

**The purpose of municipal strategic planning**

The purpose of municipal strategic energy planning is to promote a conversion to a more flexible energy system with less energy consumption and more renewable energy. The strategic energy plan provides the municipality of Frederikshavn with the opportunity of determining the local energy matters to a more flexible and energy efficient energy system in a way, so the potential for implementation of energy savings and conversion to more renewable energy is utilized in the socially most energy efficient way.

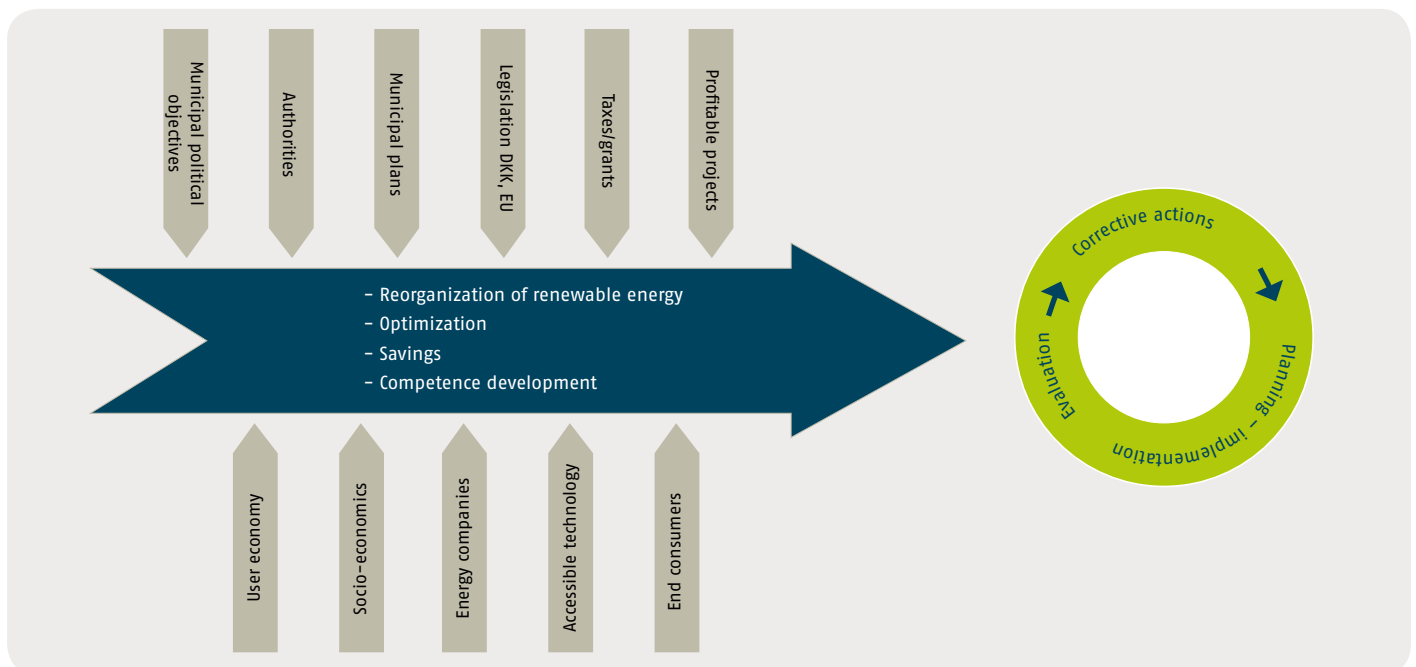
The current strategy plan for conversion to renewable energy is equitable to a strategic energy plan for conversion to renewable energy, which is made as a white paper with a number of directions and means that the municipality intends to use to achieve the sustainable energy measures of the municipality in a socio-economic way.

**The strategy plan includes three overall main elements:**

1. Conversion from oil and natural gas (fossil fuels) for renewable and sustainable energy for electricity and heat production and for coverage of the transport sector.
2. More efficient utilization of the energy.
3. Energy savings.

In practice these are complex dispositions that might include savings, efficiency improvements, conversions, development of new technologies and energy resources together with a better utilization of renewable and sustainable energy in the complete municipal energy system.

Below illustration shows the parameters influencing the strategy plan.



### Renewable energy planning and CO<sub>2</sub>-neutral community development

When FREDERIKSHAVN MUNICIPALITY determines its objective for conversion to renewable energy and reduction of CO<sub>2</sub>-emission by implementation of energy savings, it needs to differ between what the municipality has directly influence on and the development from the outside.

The illustration on page 9 indicates that some of the effort areas are influenced by several factors during planning and realization. As it is not possible to predict the future development of these factors, it is not possible to define certain strategies and guide lines to comply with the long-term sustainable energy objectives.

On the contrary, it is possible to define a strategic way to access the energy planning, which is flexible enough for FREDERIKSHAVN MUNICIPALITY to create the framework of making the optimum decisions to fulfil its objective of creating growth in a renewable energy-municipality.

By continuous updating of this strategy plan FREDERIKSHAVN MUNICIPALITY aims to ensure an optimum and balanced interaction between the energy need and the energy supply in the municipality. In the strategy plan, all sorts of energy for electricity, heat and transport in Frederikshavn municipality are included. Here the heat supply planning together with the municipal

waste planning, where the future of the heat supply is determined, is an important energy supply strategy for the municipality. The municipal heat planning authority is the central key party and the role of this function is determining, whether the municipality can fulfil its objectives of becoming a renewable energy municipality.

The strategy plan of FREDERIKSHAVN MUNICIPALITY on renewable energy is a holistic sustainable action plan with the intention of gathering, coordinating and uniting the municipal effort in the energy area and in the growth track energy in consideration of other municipalities, regional, national and European plans and strategies.

At national level, Denmark has specific climate objectives until 2020 as a part of the EU 2020 objective. It is the vision of the government that Denmark will be free of fossil fuels in 2050, which means liberated from the dependency of the fossil fuels such as coal, oils and natural gas. In the strategy plan for Frederikshavn Municipality on renewable energy 2030 the objective is conversion of the consumption of the municipality of electrical power, heat and transport into renewable energy, equivalent of at least 100% in 2030 compared to the consumption in 2010.

The municipal objective on reduction of CO<sub>2</sub>-emission is also compared to the CO<sub>2</sub>-emission of the municipality in the reference year 2010.



Proces



## 4. Key figures for Frederikshavn Municipality

### Key figures for 2013

Area of the municipality: 648.6 km<sup>2</sup>

Number of households: 20,292

Number of citizens: (2012): 61,158

Distribution of the citizens of the municipality in towns 70% and in rural districts 30%

Total housing area: 4,306,079 mill. M<sup>2</sup>

Total heated business area: 2,248,938 mill. M<sup>2</sup>

Population density: 94.3 citizen per km<sup>2</sup>

Total heat consumption in the municipality: approx. 1,214,000 MWh a year

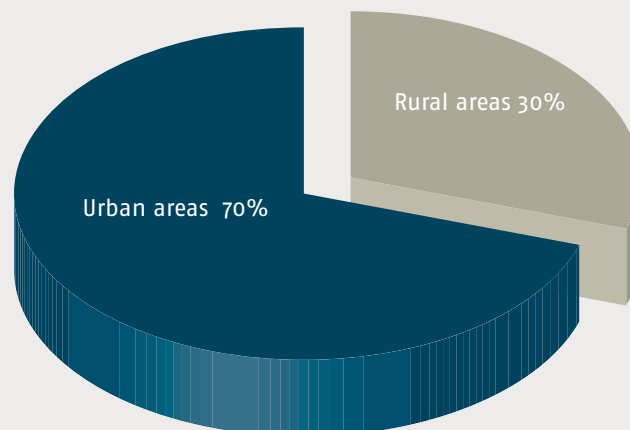
Total power consumption in the municipality: approx. 432,470 MWh a year

Number of cars per citizen: approx. 0.4

Total CO<sub>2</sub>-emissions in the municipality (2010): approx. 554,660 ton per year (8.8 ton per citizen)

Below figure illustrates the division of the population in urban and rural districts.

Figure 1.



## 5. Climate and environmental impact of the energy consumption

When climate related impacts of energy consumption is evaluated, it is the use of fossil fuels that causes climate problems as the combustion of fossil fuels increase the outlet of greenhouse gasses into the atmosphere. Greenhouse gasses include CO<sub>2</sub> (carbon dioxide), CH<sub>4</sub> (methane) and N<sub>2</sub>O (laughing gas). The total climate impact of CO<sub>2</sub>, CH<sub>4</sub> and N<sub>2</sub>O is converted into so called CO<sub>2</sub> equivalents. International scientists estimate that to high amounts of greenhouse gasses in the atmosphere contribute to changes in the climate i.e. in the shape of a global temperature increase consequently.

The emission of the biofuels by combustion including the CO<sub>2</sub>-emission is set at zero. Therefore, it is decided that biofuels are CO<sub>2</sub> neutral, which means that CO<sub>2</sub> equivalent to the amount of CO<sub>2</sub> absorbed by plants during growth is emitted by combustion of biomass. Therefore, the replanting is important when wood is cut down for energy purpose.

### Other polluting materials

SO<sub>2</sub> (sulphur dioxide) and NO<sub>x</sub> (nitrogen) are not greenhouse gasses, but are important environmental polluting gasses. They contribute at the creation of air pollution and acidification of the surface water and the green areas. PM<sub>2.5</sub> particles (fine particles less than 2.5 Gm=0.0025 mm) might origin from combustion or be formed by chemical reactions in the atmosphere (i.e. by oxidation of NO<sub>2</sub> and SO<sub>2</sub>). They are considered dangerous to health.

Emission of polluting materials from collective heat and power plants is however, declining. The decline is primarily due to

better cleaning of the smoke in the plants and a better combustion technology and a more efficient energy exploitation. In smaller plants burning biomass the polluting materials in smaller local areas might be high. This mainly comes from wood stoves and small wood pellet boilers.

### 5.1 Calculation of CO<sub>2</sub>-emission

#### CO<sub>2</sub>-emissions for fossil fuels

In the following energy accounts tables you see the CO<sub>2</sub>-emission for a number of fossil fuels stated as ton per GWh. We have taken the data on the fuels from the Energy statistics 2010 of the Danish Energy Agency. As mentioned, according to the law on CO<sub>2</sub> quotas, waste is considered CO<sub>2</sub> neutral. However, waste contains high amounts of plastic made from fossil oil. The Danish Energy Agency prepared a special statement on the CO<sub>2</sub>-emission from combustion of non-biodegradable waste in Energy Statistics 2010. The reason for the special statement i.e. appears from "note concerning CO<sub>2</sub>-emissions from waste combustion" from DMU 2008. The energy account is divided in non-biodegradable and biodegradable waste on respectively 41.2% and 58.8% according to energy statistics 2010.

With regards to calculations this equals the use of a emission factor of 32.5 ton/277.78 MWh for CO<sub>2</sub> from waste and therefore the emission facto is set at 78.9

ton/277.78 MWh for the non-biodegradable part of the waste and 0 ton/MWh for the biodegradable part.

#### Key figures for emission for power in Denmark

The CO<sub>2</sub>-emission for power import is from the environmental report for 2010 from Energynet.dk. Emission data is used on power consumption by the use of the 125% method. The emission factor on power is excluding transmission and distribution loss as the actual energy consumption from power import in the energy accounts has factored in the loss of energy from transmission and distribution loss.

#### RE % (share of renewable energy consumption)

Renewable energy is calculated as the share of the local consumption of renewable energy supply (% RE used). RE % is calculated as the energy amount used for heating for RE sources (non-surplus heat) divided by the total consumption of fuel for the municipality. Power import is calculated as average with a RE share of 33.1% for 2010 according to Energy statistics 2010.

#### Power import

The purpose of including power import/export is to correct for import and export of power in and out of the municipality. By correcting for the exchange of power, it is taken into consideration that municipalities with

Emission for power consumption i Denmark 2012			
Emissions factor (g/kWh)	CO <sub>2</sub>	SO <sub>2</sub>	NO <sub>x</sub>
Power in Denmark	303	0.06	0.25

a small production of power have to import power from plants outside the municipality (average for Denmark, while municipalities with a high power production are net-exporters of power. We assume that imported/exported power has an average CO<sub>2</sub>-emission as the average emission for Denmark according to Energinet.dk's Environmental declaration 2010. Before 2010 Energinet.dk divided the CO<sub>2</sub>-emission in respectively Western part of Denmark and Eastern part of Denmark, but from 2010 the CO<sub>2</sub>-emission covers all Denmark, because of the newly

established direct current cable under the Storebælt. Power import is calculated as the sum of power production in the municipality minus the entire power consumption plus distribution loss.

The power production figures for 2013 from Energinet.dk show that 41.8% of the total power in Denmark was produced on renewable energy sources of which wind energy was 33% and biomass, hydropower and solar was 11.8% – a total of 41.8%.

### Net loss on the power grid

The total net loss consists partly of a distribution loss and partly of a transmission loss. According to the Energy Declaration 2010 from Energinet.dk the distribution loss for the power grid is set at 5%. The net loss in the transmission grid is calculated based on the environmental declaration for Western Denmark as: Grid loss in the transmission grid/sale of transmission and makes up 2.63%. According to the above stated the total loss in the power grid makes up 7.63% equivalent to an efficiency for the power grid of 92.37%.

### Key figures for emission of district heat consumption, CHP plant

Emission key figures for district heating is an average for Denmark in 2008.

Emission key figures on district heating consumption, CHP plant in Denmark 2008			
Emission factor (g/kWh)	CO <sub>2</sub>	SO <sub>2</sub>	NO <sub>x</sub>
Power in Denmark	122	0.10	0.35

Source: Danish Energy Agency, September 2009.

### Key figures for emission on natural gas

Emission key figures for district heating is an average for Denmark in 2008.

Emission key figures for natural gas in Denmark								
Natural gas	CO <sub>2</sub> g/kWh	CO <sub>2</sub> g/m <sup>3</sup>	CO g/kWh	UHC * g/kWh	SO <sub>2</sub> g/kWh	SO <sub>2</sub> g/m <sup>3</sup>	NO <sub>x</sub> g/kWh	NO <sub>x</sub> g/m <sup>3</sup>
Gas boilers > 30 kW	204,32	2185	0,011	0,011	0,0011	0,012	0,15	1,68
Gas boilers < 30 kW (trad.)	204,32	2185	0,79	-	0,0011	0,012	0,15	1,68
Gas boilers < 30 kW (cond.)	204,32	2185	0,029	-	0,0011		0,068	0,76
Gas motors	204,32	2185	0,66	1,91	0,0011	0,012	0,65	7,23
Gas motors	204,32	2185	0,022	0,011	0,0011	0,012	0,46	5015

\* VOC (fleeting organically connections) are total carbon dioxide emission (THC) or not combusted hydrocarbon (UHC) with the exception of methane and ethane. For the natural gas combustions, a VOC emission of 20% of the HUC emission is estimated and for distilled oil for combustion, the VOC emissions have been set at 50% of the HUC emission. Source: Energy and environmental data, DGC project report, November 2009.

### Key figures for heating oil, bottled gas, auto gas, wood and straw

Below table states the emissions for heating oil, bottled gas, auto gas, wood and straw.

Emissions for heating oil, bottled gas, auto gas, wood and straw in Denmark						
Emissions in kg per delivered fuel unit	CO <sub>2</sub> kg/MWh	CO <sub>2</sub> kg/l	SO <sub>2</sub> kg/MWh	SO <sub>2</sub> g/l <sub>3</sub>	NO <sub>x</sub> kg/MWh	NO <sub>x</sub> g/l
Heating oil type 1 (SO <sub>2</sub> :10ppm)	266,4	2,65	0,002	0,02	0,18	1,80
Heating oil type 2 (SO <sub>2</sub> :50ppm)	266,4	2,65	0,008	0,08	0,18	1,80
Heating oil type 3 (SO <sub>2</sub> :500ppm)	266,4	2,65	0,08	0,82	0,18	1,80
Fuel oil	288	3,2	1,08	11,9	0,54	5,94
Bottled gas (LPG)	234	-	0,008	-	0,36	-
Auto gas	234	-	0,008	-	0,36	-
Wood, wooden pellets, wooden briquettes	0*	-	0,09	-	0,32	-
Straw	0*	-	0,47	-	0,32	-

\* Wood, Wooden pellets, wooden briquettes and straw are CO<sub>2</sub> neutral fuels and therefore the CO<sub>2</sub>-emission equals zero.

Source: Technological Institute.

# 6. Status on the energy consumption and emission of Frederikshavn Municipality (2010)

## 6.1 The total energy consumption and CO<sub>2</sub>-emission of the municipality

As climate municipality, it is important for FREDERIKSHAVN MUNICIPALITY to have an overview of the energy consumption in the municipality and the types of development that lies ahead in the future, so that the municipality in cooperation with citizens and businesses can act strategically optimal concerning the climate objectives of the municipality. The table to the right shows the total energy consumption of Frederikshavn municipality.

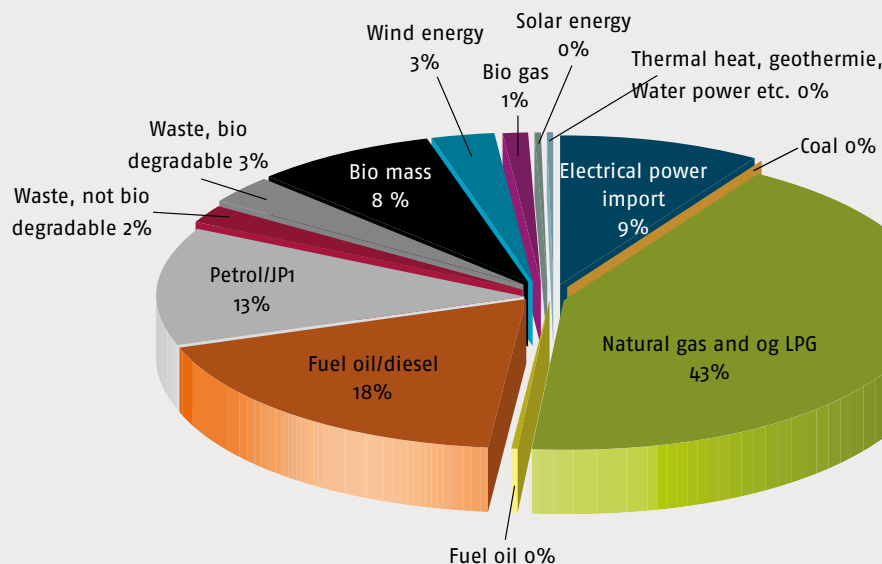
With a total CO<sub>2</sub>-emission in 2010 of 547,000 ton and a population of 62,007 in the same year, the key figure of Frederikshavn Municipality for CO<sub>2</sub>-emission is calculable to 8.8 ton per citizen.

Gross energy consumption divided in fuels	GWh/year	1,000 ton	Local biomass potential GWh/year
Electrical power import	218,6	91	0
Coal	0,2778	0	0
Natural gas and LPG	1.121,95	229	0
Fuel oil	6,39	2	0
Fuel oil/diesel	468,9	125	0
Petrol/JP1	323,9	85	0
Waste, not bio degradable	53,05	15	0
Waste, bio degradable	75,83	0	0
Biomass	213,9	0	1.516
Wind energy	84,16	0	0
Bio gas	20,83	0	306
Solar energy	5,28	0	0
Thermal heat, geothermie, Water power etc.	0,55	0	0
<b>Total:</b>	<b>2.593,62</b>	<b>547</b>	<b>1.822</b>

Source: PlanEnergi, Energivision 2010.

Below figure illustrates the division of the gross consumption in 2010 divided on fuels.

Figure 2



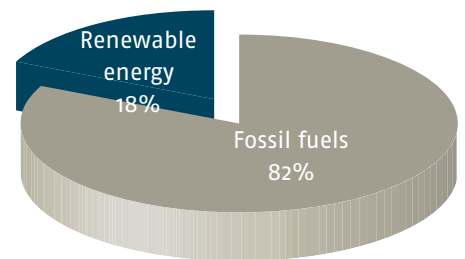
### Division of gross energy production

Below table indicates the division of energy production in Frederikshavn Municipality

Energy source	GWh
Fossil fuels	2.120,29
Renewable energy	473,059
Total fuel consumption	2.593,35
Percent-wise share of renewable energy	18,2

Below figure illustrates the division of the gross energy consumption in 2010 divided on renewable and fossil fuels.

Figure 3



### Division of renewable gross energy production divided on types of resources

From figure 3 you can see that 18% of the total energy consumption in the municipality comes from renewable energy production (the contribution from industrial excess heat is not included).

In 2010 the share of renewable energy production in the municipality was estimated to 573,059 GWh divided in following types of resources.

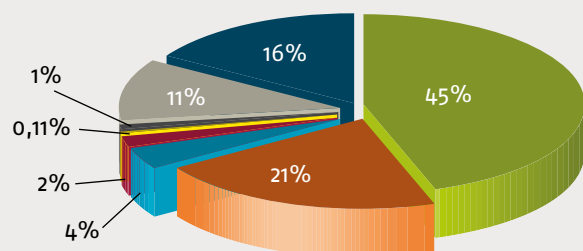
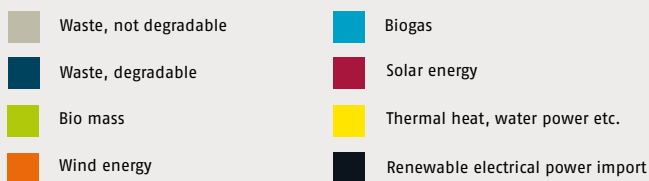
Renewable energy resources	GWh
Waste, not biodegradable	53,056
Waste, biodegradable	75,83
Biomass*	213,89
Wind energy	98,61
Biogas	20,83
Solar energy**	11,68
Thermal heat, geothermie, water power etc.	0,55
Renewable electrical power import	5,0
<b>Total:</b>	<b>479,45</b>

\*The consumption of the municipality of biomass is mapped to 213.89 GWh and includes energy production based on straw on 38.33 GWh, bio fuels and energy crops of 3.61 GWh, firewood, wood chips of 107.5 GWh and wood pellets of 64.45 GWh.

\*\* Production based on solar energy is based on production data from 2010 and 2011.

Below figure illustrates the division in percentage of renewable energy production in Frederikshavn Municipality in 2010.

Figure 4



**Division of renewable gross energy production divided on resource types**

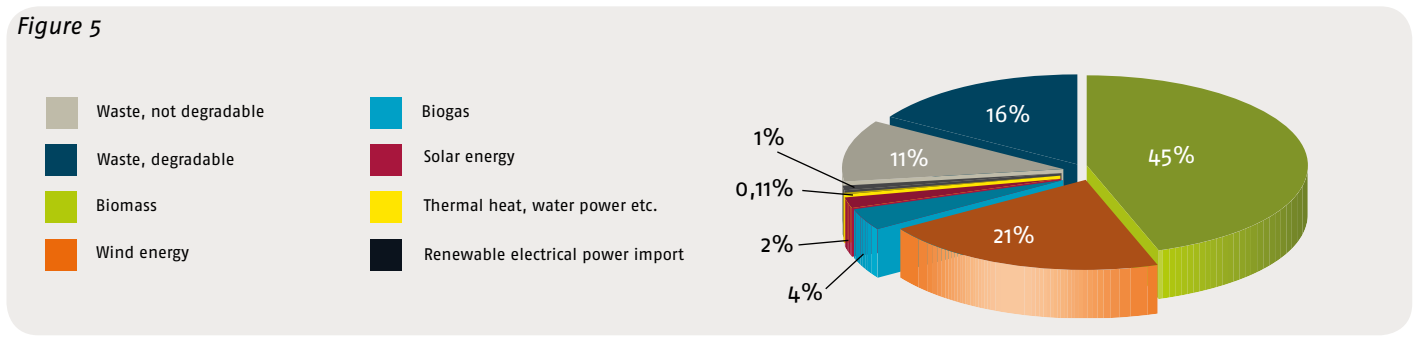
From figure 3 it appears that 18% of the total energy consumption in the municipality originates from renewable energy production (the contribution from industrial surplus heat is not included).

In 2010, the share of renewable energy production in the municipality was calculated to 473.059 GWh divided on following resource types:

Renewable energy resource	GWh
Waste, non-biodegradable	53,056
Waste, biodegradable	75,83
Biomass	213,89
Wind energy	98,61
Biogas	20,83
Solar energy *	11,68
Geothermal, hydropower, etc.	0,55
Renewable power import	5,0
<b>Total</b>	<b>479,45</b>

\* Production based on solar energy is estimated based on production data from 2010 and 2011.

Below figure illustrates the percentage wise division of renewable energy production in Frederikshavn municipality in 2010.



**Division of gross energy consumption in the field of applications**

The table on the right states the division of gross energy consumption in Frederikshavn Municipality in 2010.

Field of application	GWh
Individual heating	381,66
Collective power and heat supply	744,72
Industry	507,50
Transport	656,67
Renewable power consumption	84,44
Power import	218,60
<b>Total</b>	<b>2.593,35</b>

Below figure illustrates the percentage wise division of gross energy consumption divided on field of application areas in 2010.





The composition of the energy consumption in Frederikshavn Municipality compared to the rest of the country is necessarily connected with the special conditions that characterize the municipality. E.g. concerning collective power and heat supplies that accounts for 29% of the total gross energy consumption in the municipality, is due to the fact, that the connection intensity to the collective district heat supplies in the municipality is high.

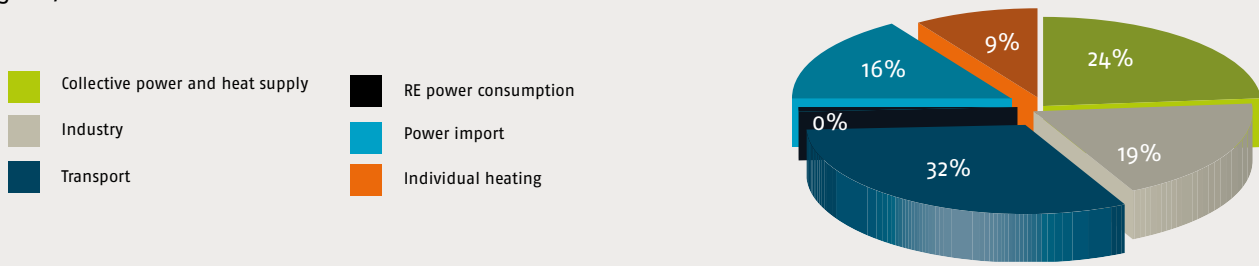
**The total CO<sub>2</sub>-emission of the municipality on fields of application**

The total CO<sub>2</sub>-emission of Frederikshavn municipality in 2010 is made up to 547,000 ton per year. With a population of 62,007 the same year the key figures of Frederikshavn municipality on CO<sub>2</sub>-emission per citizen will be set at 8.8 ton per citizen per year.

From figure 7, it appears that, the largest share of the CO<sub>2</sub>-emission of the municipality originates from the transport sector with 32%. There after the production of collective power and heat is the second highest contribution to the CO<sub>2</sub>-emission of the municipality by 24% followed by the industry by 19%. Imported power for Frederikshavn municipality accounts for 16% of the total CO<sub>2</sub>-emission of the municipality.

Below figure illustrates the total CO<sub>2</sub>-emission of the municipality divided on fields of application in Frederikshavn municipality in 2010.

Figure 7



**6.1.1 Power supply and power consumption in Frederikshavn municipality**

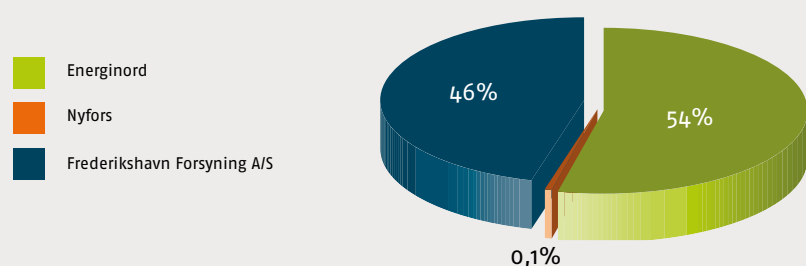
Delivery of power to Frederikshavn municipality takes place through three utility companies; Frederikshavn Forsyning A/S, Energinord and Nyfors. In 2010, these utility companies delivered a total of 432.4 GWh electric power to Frederikshavn municipality. The amount and the share of the power supply is seen in the table to the right.

Utility company	kWh (2010)	Percentage wise division
Frederikshavn Forsyning A/S	198.655.804	45,9%
Energinord	233.659.792	54,0%
Nyfors	156.982	0,1%
Total	432.472.578	100 %

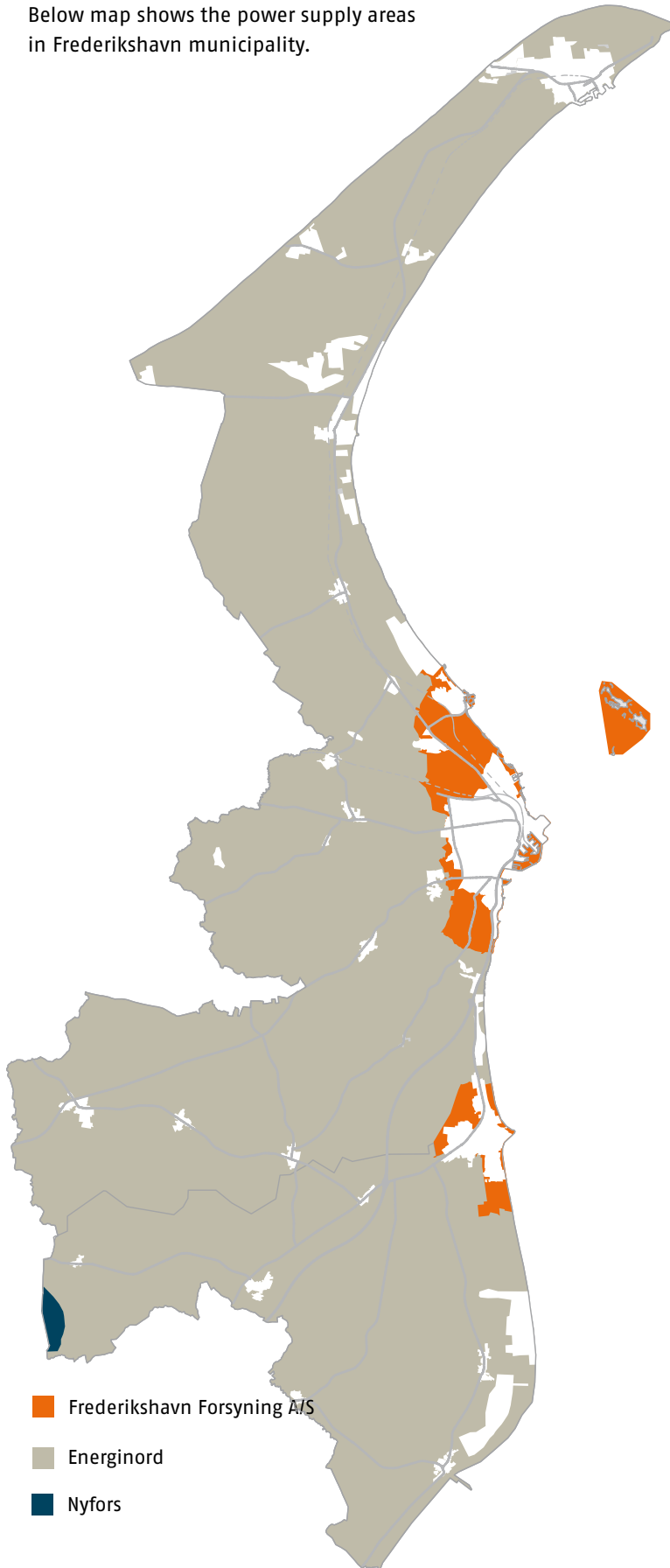
From the above table it is visible that Energinord is the biggest supplier of power for Frederikshavn municipality followed by Frederikshavn Forsyning A/S.

Below figure illustrates the division of power supplies for Frederikshavn municipality.

Figure 8



Below map shows the power supply areas in Frederikshavn municipality.



**Power production in Frederikshavn municipality**

Power in the municipality is produced by CHP plants, wind power turbines and to a smaller degree by solar cells. Power production on hydropower is available at a very low level equivalent to 0.1 GWh/year. The remaining part of the power consumption of the municipality comes from outside the municipality from the national power transmission grid and is called power import.

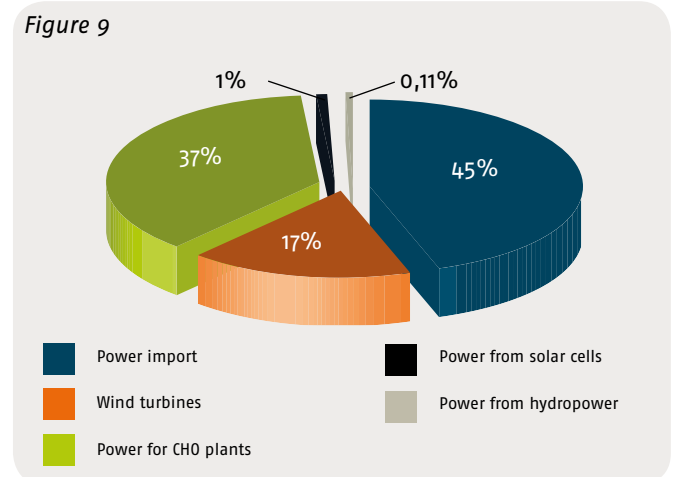
Below table states the gross power production in the municipality in 2010. In 2010, no considerable solar cell plans were installed in the municipality and therefore the figure for power production from solar cells is taken from the statement of Energinet.dk from 8<sup>th</sup> of April 2013.

Production source	GWh/year	Percentage wise division
Power import	218,6	45,34 %
Wind turbines	84,15	17,45 %
Power produced by The CHP plants	179,2	37,17 %
Solar cell plants*	5,36*	1,10 %
Hydropower	0,11	0,02 %
<b>Total</b>	<b>487,42</b>	<b>100 %</b>

\* Figure for power production through solar cells originates from the statement of Energinet.dk per 8<sup>th</sup> April 2013 and therefore, it is not included in the total power production for 2010.

From figure 9 it appears that the largest part of the power consumption of the municipality of 45% is covered by produced power outside the border of the municipality through the national/European transmission grid.

Below figure illustrates the power production in Frederikshavn municipality measured on production source.



**The total power consumption of the municipality divided on main categories**

The table on the right indicates the power consumption of the municipality on main categories (incl. power heating).

Sector	Consumption in GWh/year	Percentage wise division
Households		30,8%
Farms	32,7	7,6%
Garden centers	0,2778	0,06%
Trade (detail and wholesale)	43,3	10,0%
Private service	33,6	7,7%
Public service	83,0	19,2%
Construction industry	2,5	0,58%
Production company	104,4	24,1%
Transport	0	0%
<b>Total</b>	<b>432,47</b>	<b>100%</b>

By comparing the power production and the power consumption of the municipality, the result shows that gross power production is 50.13% higher than the net

power consumption. This partly because a power grid distribution loss of 5% and a power grid transmission loss of 2.63%, a total of 7.63% equivalent to 36.8 GWh/

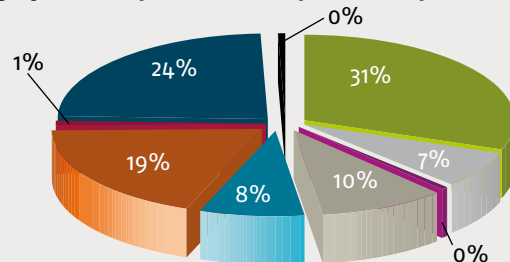
year must be taken into account. The second reason for the deviation is that the power consumption of the energy manufacturer is included in the gross power production, which in this case equals 13.34 GWh/year.

Below figure illustrates the category divided power consumption incl. power heat.

Figure 10



Category divided power consumption incl. power heat.



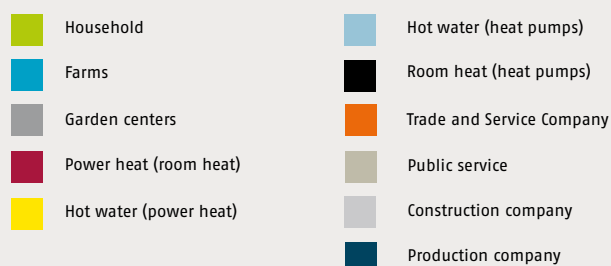
Above figure indicates that private households with 31% of the total power consumption, when ascribing the consumption for heat power to this category is the largest consumer of power

in Frederikshavn Municipality followed by production industries by 24% of the total power consumption. From figure 10 it is ascertained, that the power savings potentials are biggest by private house-

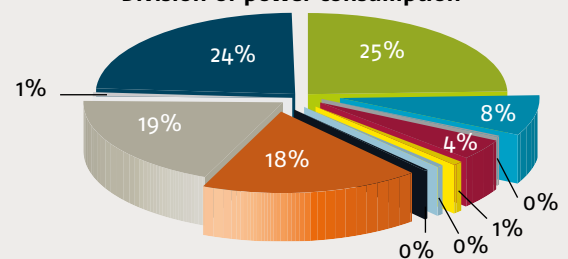
holds. Likewise, there is a prevailing possibility that power savings can be found by production companies, public service companies and trade and service companies.

Below figure illustrates the total division of power consumption with the use of power for heat production in Frederikshavn municipality.

Figure 11



Division of power consumption



### 6.1.2 Natural gas in Frederikshavn municipality

By the end of the 1980's the natural gas arrived in the 3 previous municipalities (Sæby, Frederikshavn and Skagen) that forms the municipality of Frederikshavn today. The overall natural gas pipeline north of the Limfjord Distribution grid – were laid in 1987 together with the distribution grid in the areas where satisfactory connection shares – and the established grids were launched during fall 1987.

Originally, the natural gas grid in Northern and Central Jutland was limited to the central part of central Jutland and part of Himmerland. However, in connection with the entry of agreements concerning the construction of natural gas fired CHP-plants in Frederikshavn and Hirtshals together with an agreement with the Fishing industry on conversion to natural gas, the natural gas project in Central and Northern Jutland was extended to include Vendsyssel as well.

The interest of being connected to the natural gas grid was surprisingly high, why in some areas distribution grids were established and supplied from a large gas plant until the natural gas got to the areas. The rather large surrounding towns that became connected to the natural gas grid were natural gas were Ålbæk, Jerup, Elling, Kilden and Gærum.

*The total natural gas consumption in 2010 is calculated to 95,076,600 m<sup>3</sup> or 1041.8 GWh equivalent to 40.2% of the total energy consumption in Frederikshavn municipality.*

Below map shows the prevalence of the natural gas in Frederikshavn municipality.



Below table indicates the sector divided natural gas consumption in Frederikshavn municipality in 2010

Field of application	M <sup>3</sup> natural gas per year	GWh/year	Percentage wise distribution
Household	6.570.830	71,94	6,92 %
Business	36.088.629	395,55	37,95 %
CHP-plants	52.156.983	574,44	55,13 %
Others	260.160	2,85	0,27 %
Total	95.076.602	1.041,8	100 %

1 m<sup>3</sup> natural gas contains 11 kWh energy.

The gas consumption for household is assessed by HMN Natural Gas Ltd. 3,713 natural gas billing meters are registered in the municipality, where a customer can have several meters in the same address.

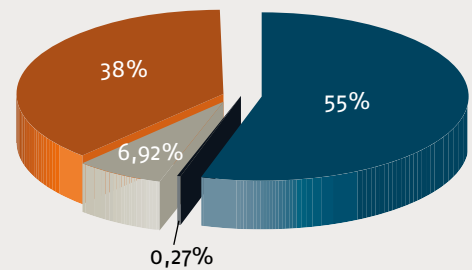
The consumption in the categories business and other is assessed by deducting the natural gas consumption in the energy producer counting in 2010 equivalent to 52,156,983 m<sup>3</sup> 574.44 GWh) from the total sale of gas.

Figure 12 indicates that the energy producing CHP-plants stand for 55% of the total natural gas consumption of the municipality. The consumption of natural gas of CHP-plants is quite natural as the bigger towns in Frederikshavn municipality such as Frederikshavn, Sæby, Skagen, Østervrå etc. are supplied with collective natural gas driven CHPs and approx. 90% of the citizens in collective heat supply areas are connected to district heating. The share of natural gas consumption for

businesses goes to the brickwork, industry, meat and fish processing in food processing companies and institutions with decentralize heating units in the form of boiler centrals. The natural gas consumption of the housing sector of 7% of the total gas consumption is outside the collective heat supply areas and mainly in the towns located in the rural areas such as Gærum, Jerup and Ålbæk and in the rural districts.

Figure 12

- CHP plants
- Business
- Household
- Other



### 6.1.3 Heat supply and heat production in Frederikshavn municipality

Collective district heating plants mainly handle the district heat production in Frederikshavn municipality. In the town of Skagen parts of the waste heat from the fishing industry is used for district heating supply. Some of the households in the

municipality are supplied with natural gas, where the heat is produced decentralized by each individual consumer.

Electric power is used for room heating and production of hot water in summer-house areas and there are still oil boilers in towns and rural districts both within and outside collective heat supply areas of the municipality.

### District heat production and district heat supply in Frederikshavn municipality

The total district heat consumption for Frederikshavn municipality is assessed from collected data in 2010 from 10 district heating companies in the municipality.

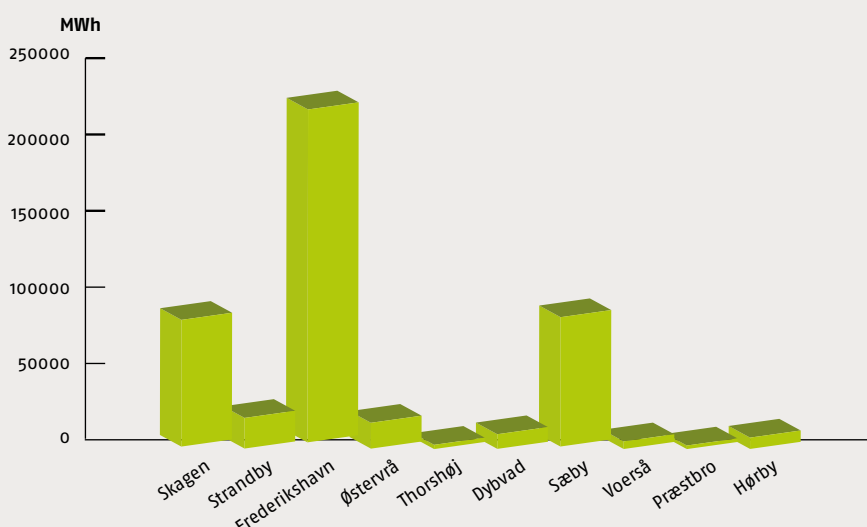
Below table states the heat production and the sale of heat by each of the district heat plants in Frederikshavn municipality in 2010.

District heating plant	Production (MWh)	Sale of heat (MWh)	Net loss (MWh)	Net loss (%)	CHP-plants/ heat types of fuel
Skagen	86.394	66.653	19.741	23%	CHP-plants, Waste, natural gas, Waste heat
Strandby	20.900	17.116	3.784	18%	CHP-plants, Natural gas, solar
Frederikshavn	255.579	207.298	48.281	19%	CHP-plants, Waste, Natural gas
Østervrå	17.643	14.694	2.949	17%	CHP-plants, Natural gas
Thorshøj	2.906	1.931	975	34%	CHP-plants, Natural gas
Dybvad	10.000	8.000	2.000	20%	Heat, wooden pellets
Sæby	88.212	64.581	23.631	27%	CHP-plants, Natural gas, solar
Voerså	5.200	3.600	1.600	31%	CHP-plants, Natural gas
Præstbro	2.450	1.600	850	35%	CHP-plants, Natural gas
Hørby	7.716	5.445	2.271	29%	Heat, straw
Total:	497.000	390.918	106.082	21,3%	

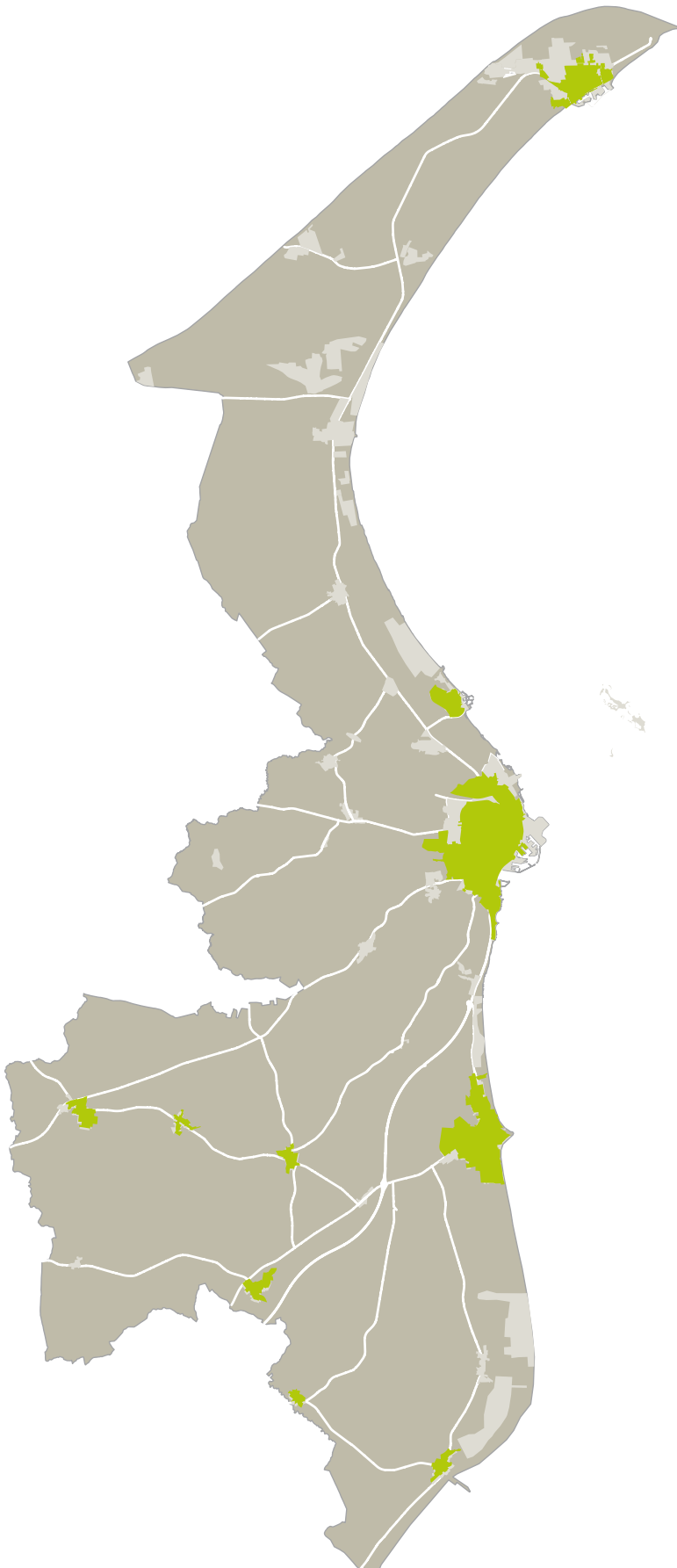
The naval base in Frederikshavn has its own CHP-plant based on natural gas consisting of a gas combustion motor for heat supply of the buildings of the naval base. In 2010 the plant produced 55.5 MWh heat and 27.8 MWh power.

The figure on the right shows the district heating production in Frederikshavn municipality divided on district heating plants.

Figure 13



Below map illustrates the spread of the district heating in Frederikshavn municipality.



### The heating plant in Skagen

The heating plant in Skagen is a natural gas based CHP-plant that purchases and produces district heating to 2,450 consumers. The plant covers the deliveries from waste heat, industrial surplus heat, surplus power from wind power turbines with electrical boilers and three natural gas fired gas motors with an effect of 104%.

41.5% of the natural gas consumption is transformed into power and 62.5% is transformed into heat. Absorption heat pumps driven by flue gas achieve this high effect. Before the installation of absorption heat pumps, the plant has an effect of 92%.

Therefore, the consumers in Skagen are supplied by heat, which is 50% CO<sub>2</sub> neutral heat, produced on waste replacing the purchase of natural gas by approx. 30%. Furthermore, they have better utilization of industrial surplus heat replacing the natural gas consumption of the plant by approx. 20% and surplus power from wind power turbines for district heating production by the mean of an electrical boiler.

In 2007 the plant launched the preparation of a strategic action plan, where the objective i.e. was to reduce the natural gas consumption of the plant by 50% compared to 2006. The objective was achievable, if the delivery of waste would increase and if the utilization of the surplus heat from the industry would improve. Since 2007 the delivery of district heating from waste combustion in Skagen has increased by 8 GWh per year and the industrial surplus heat has increased by 10 GWh per year. The electrical boiler has contributed with 3–8 GWh/year. After installing the heat pumps the energy content of the natural gas is utilized by 104%, which contributes with 8–10 GWh heat per year with the same consumption of natural gas as in 2006.

In 2006 the CHP-plant used approx. 10 mill m<sup>3</sup> natural gas per year. The consumption has been reduced to 5–6 mill m<sup>3</sup> per year.

All objectives from the first strategy plan have been obtained and now the heating plant has prepared a new plan in 2013. The main

points from the new plan are extension of the district heating supply areas and reduction of loss from the pipelines and, in case the authorities approve the plan, installation of bio boilers on wood chips or other biofuel sources for production of district heating. In the new action plan of the heating plant it is assessed that the last-mentioned will lead to more jobs and support of the economy of Skagen harbor by receipt of e.g. wood chips.



#### Strandby heating plant

Strandby heating plant is a natural gas driven CHP-plant. The district heating is manufactured on gas motor (3.66 MW power and 4.2 Mw heat), gas driven capacity load boiler (10 Mw boiler), electrical boiler (10 Mw), absorptions heat pump (0.5 MW) and 8019 m<sup>2</sup> solar heat. The total energy consumption of the district heating plant in 2011 was 2.8 mill. m<sup>3</sup> natural gas.

The electrical boiler was taken into use in September 2012 and the expected annual consumption is 2,000 MWh power per year for the heat production of the electrical boiler. The electrical boiler is installed to utilize cheap surplus power from the wind turbine production.

In 2011 the CHP-plant sold 17,725.6 MWh heat and 7,665.3 MWh power. Strandby heating plant has 857 connected consumers.

In 2010 the heating plant established an 8,019 m<sup>2</sup>, 6 MW solar heating system with an annual heat production of 3,760 MWh. The heating plant is working on establishing further 4,500 m<sup>2</sup> solar heating system in the next future.

Furthermore, heat is produced through 10 natural gas driven capacity load boilers.



#### Frederikshavn Varme A/S

Frederikshavn Varme A/S is originally founded

in 1965, but since 2006 it changed its status to a municipal private-limited company. The production plants consist of 1 gas turbine that delivers 17 MW power and 30 MW heat plus 10 natural gas capacity load boilers of a total of 80 MW. The production of district heating is mainly based on natural gas through the gas turbine. Furthermore, the district heating plant purchases 75,000 MWh heat per year from Frederikshavn waste CHP plant. Apart from this, heat is produced through 10 natural gas driven capacity load boilers. Frederikshavn Varme A/S produces and delivers district heating to 6,050 consumers. The waste CHP plant delivers 40% of this total amount of heat to the district heating grid.



#### Østervrå district heating plant

Østervrå district heating plant was founded in 1959 and is a natural gas driven CHP-plant. A gas motor, two gas driven capacity load boilers and one electrical boiler produce the district heating. Production plant: 1 motor of 3.047 MW power and 3.65 MW heat. The gas motor consumes 1,110,000 m<sup>3</sup> natural gas per year and the two gas boilers use a total of 600,000 m<sup>3</sup> natural gas per year. The power consumption of the electrical boiler is assessed to 4,000 MWh/year. The district heating plant has 650 connected consumers.



#### Thorshøj heating plant

Thorshøj heating plant was founded in 1997 and is a natural gas driven CHP plant. A gas motor and an electrical boiler produces the district heating.

The production plant: one motor of 0.922 MW power and 1.36 MW heat. The gas motor uses 450,000 m<sup>3</sup> natural gas per year. The gas boiler

produces 1.6 MW heat and has a consumption of 50,000 m<sup>3</sup> natural gas per year. The district heating plant has 102 connected users.



#### Dybvad heating plant

Dybvad heating plant was founded in 1959 and is a heating plant that mainly uses bio-fuel in the form of wood pellets for heat production and fuel oil in capacity load periods.

The heating plant has two heat producing boilers, one wood pellet fired boiler with an annual fuel consumption of 2,100 ton wood pellets and an oil fired boiler with an annual fuel consumption of approx. 8,000 liter fuel oil. The heating plant has 350 connected users.



#### Sæby heating plant

Sæby heating plant was founded in 1961 as an oil driven heating central with approx. 50 connected users. In 1988 the heating plant moved to Energivej in Sæby, where the oil-driven heat producing plants were replaced by a 4.1 MW gas turbine owned by NEFO for CHP-plants. In 2001 the cooperation with NEFO stopped. This caused Sæby Heating plant to replace the gas turbine with two gas driven motors for CHP-plants. The gas motors each delivers 6 MW power and 7 MW heat. In 2009 the heating plant was given the permission to install an electrical boiler of 12 MW for heat production, which meant that the heating plant could install an additional accumulation tank of 2700 m<sup>3</sup>. Today the plant has two accumulation tanks of each 2,700 m<sup>3</sup>. In 2011 the heating plant installed an 11,870 m<sup>2</sup>, 8.2 MW solar heating system with an annual heat production of approx. 6,000 MWh.

During the period from 2012–2013 Frederiks-



havn housing association build 84 apartments in Sæby Strand and in connection with the construction, a 500 m<sup>2</sup> solar heating system was installed to handle the heat supply to the apartments. The solar heating system is connected to the transmission system of Sæby heating plant so the surplus heat production from Sæby Strand Heating plant is transferred to the collective district heating supply in Sæby. According to Sæby Heating plant Sæby Strand will deliver between 60-70 MWh solar heating per year to Sæby Heating system.



**Præstbro CHP plant**

Præstbro CHP plant was founded in 1994 with basis, that the plant should supply at least 100 consumers with a heat consumption of 2,200 MWh. The plant is a natural gas driven CHP plant. The district heat is produced on a gas motor, where the motor heat and heat from exhaust gas is delivered to the district heating grid.



**Voerså CHP plant**

Voerså CHP plant was founded in 1992. The district heating is produced on a gas motor and a gas boiler as reserve. The plant has a natural gas consumption of approx. 800,000 m<sup>3</sup> per year. Voerså CHP plant has 195 connected users.



**Hørby Heating plant.**

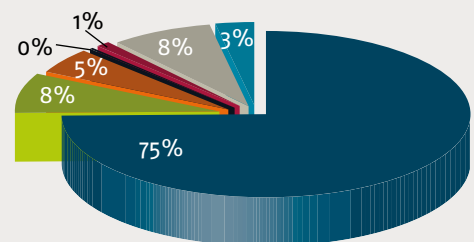
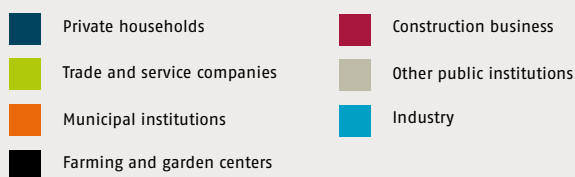
Hørby heating plant was founded in 1964. Originally, the plant was an oil-driven heating plant, where the heat was produced by 2

oil-driven boilers on Hybenvej. In 1985, the heating plant purchased the farm Rigsgård, which was rebuilt into a straw-fired heating plant.

In 2001, the plant build a new straw-fired heating plant and in connection with this, the plant build a new house of 525 m<sup>2</sup> together with the existing warehouse. The new house made it possible to use other types of CO<sub>2</sub> neutral fuels as the heating plant also installed a stoker on the new boiler. In 2003, the plant had a new accumulation tank with a capacity of 905 M<sup>3</sup>. In 2010, the old warehouse was struck by a high snow pressure and had to be torn down. Therefore, the plant built a bigger storehouse with a capacity for straw that was 4 times the size of the old one. Today Hørby heating plant supplies approx. 202 consumers. The heating plant produces approx. 7,360 MWh on straw and approx. 117 MWh on other bio fuels. The total consumption of bio fuels of the plant equals approx. 1900 ton of straw. The heating plant also has 2 oil boilers on standby.

Below figure illustrates the sector division of district heating consumption in Frederikshavn municipality.

Figure 14



From the above figure, it is clear that by planning of the energy saving effort in the municipality private households must have a high priority as they stand for ¾ of the total consumption of district heating in the municipality, which means that the bigger energy savings potential lies with this group of consumers.

### 6.1.4 Biomass and biogas in Frederikshavn municipality

The consumption of biomass in the municipality is rather limited for the time being. Many households supply their traditional heat supply with heat from a wood stove. Buildings only using biomass are rare in the municipality and are usually only placed in the rural areas. The share of energy production on biomass in the municipality is assessed to 2.4 GWh/year equivalent to 2.3% of the total gross energy consumption of the municipality.

The total biogas production on the municipal biogas plant is stated both in the Energy manufacturer counting of the Danish Energy Agency and in the statistics on biogas from the Danish Energy agency.

**Biogas production** is partly based on manure and partly on organic waste from the industry. The Biogas production is divided between gas production from biomass and from manure in the energy accounts. This division is based on figures from 2005 from the plants in Region Central Jutland. According to these figures gas and manure stands for an average of 46% in the joint biogas plant, while the gas production from organic industrial waste stands for an average of 54%. This division is used for joint biogas plants and farm biogas plants in Region Northern Jutland.

The share of biogas production is assessed to 21.0 GWh/year equivalent to 0.8% of the total gross energy consumption of the municipality.

Below table states the biogas production units in Frederikshavn municipality.

Production units	GWh/year
Nordjysk Minkfoder	8,70
Skagen Sewage plant	4,77
Frederikshavn Sewage plant	2,41
2b Biogas A/S	5,11
Total	21

### 6.1.5 Handling of waste and incineration of waste in Frederikshavn municipality

Today the waste in Frederikshavn municipality is managed by Frederikshavn Forsyning A/S. In January 2011, the merger process between the waste deposit companies "Affaldsselskabet Vendsyssel Øst, AVØ A/S", Frederikshavn waste CHP plant and Frederikshavn Forsyning A/S. In 2011, the company form was determined by Frederikshavn Forsyning A/S holding company and the waste incineration as subsidiary. Today AVØ is organizational integrated in the other supply companies in Frederikshavn Forsyning

A/S. This means that AVØ share domicile, secretariat, customer service and book keeping with the other subsidiaries. The board of AVØ was closed down in January 2014, which means that the board of the Forsyning A/S works as one board for AVØ as well.

AVØ still handles the waste separation and combustion in Frederikshavn municipality. AVØ is environmental certificated according to the Norwegian EMAS- environment management system.

The incineration of waste for energy production is handled in two waste combustion plants in Frederikshavn municipality.

#### I. Frederikshavn Waste CHP-plant

Frederikshavn Waste CHP-plant consists of a waste combustion boiler, a steam turbine, a generator, voltage transformers and various heat exchangers and pumps for district heating production. In 2012 the plant produced 19,101 MWh power equivalent to 20% powers and 76,522 MWh district heating equivalent to 80% heat. For power and heat production in 2012 the waste CHP-plant used 34,152 ton waste, 2,762 ton biofuel and 31.31 ton fuel oil.

#### II. Skagen Waste Incineration Plant

Skagen waste incineration Plant consists of one waste incineration boiler and various heat exchangers and pump systems for production of district heating. The plant is only a heating plant without any production of power. In 2012, the plant produced 29,463 MWh heating, of which 28,841 MWh was district heating and the remaining 622 MWh was cooled down. For heat production in 2012, the plant used 10,869 ton waste and 1,715 ton biomass.

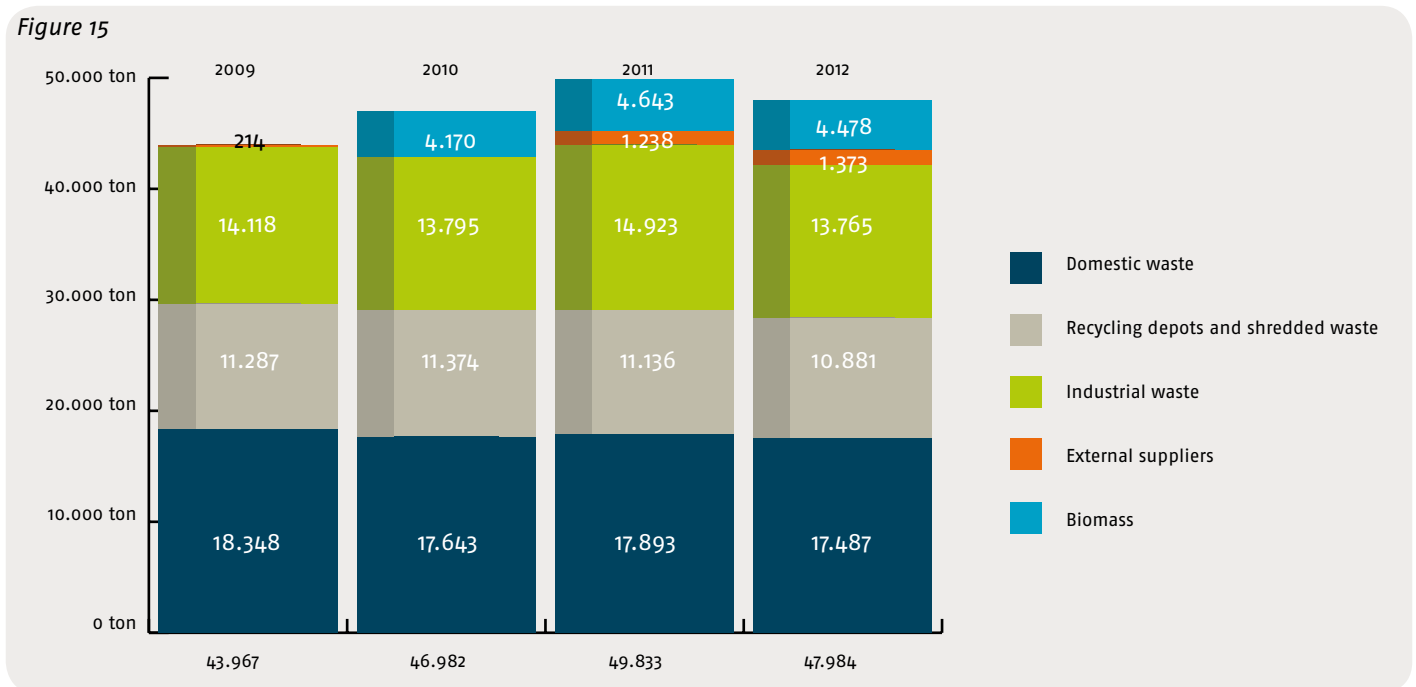
**Status on waste incineration year 2012**

The amount of waste for incineration and hereby power production has been decreasing lately. This goes for all three main waste groups, refuse collection, recycling depots and industry waste. The fact that the production of waste has been decreasing is positive, as it is connected to less resource consumption and environmental strain plus an increasing tendency of recycling. The decrease of waste is also caused by the low economic activity and decreasing population in the municipality.

In order to compensate the decreasing waste production to secure stable energy production AVØ has on trial basis started collecting clean, whole loads of branches (biofuels) from summerhouse areas. The primary purpose of this action is to obtain supplementary fuel for the combustions plants. The reception of this scheme has been positive; the financial side of it has not yet been calculated. Biofuel is exempted from taxes and therefore it is interesting to use this to ensure stable operations in the current situation where the waste amounts are decreasing.

Furthermore, it has shown to be possible to receive waste from abroad. There are very few places in Europe, that has a system as extensive as the waste incineration and associated district heating system as in Denmark and that makes Danish waste incineration plants competitive. In December 2012 AVØ therefore received 2,900 ton "refined waste fuel" from England and the first experiences are positive – both with regards to operation and economy.

Below diagram states the variation in waste amounts through the last 4 years.



Waste Management Company East Vendsyssel, Annual report 2012

*The diagram shows that the incineration amounts have also decreased from 49,833 ton in 2011 to 47,984 ton in 2012. A smaller resource consumption and the fact that a higher share of the waste is disposed of for recycling means that the incineration amounts decreases.*

In 2013 a further decrease in the incineration amounts may be expected. However, this is compensated for by the fact, that AVØ has entered agreements on import of combustion suitable waste, so the total incineration amount equals the amounts in 2012.

Expectations are that the government will

present its resource strategy in fall 2013, so the guidelines in this can be included in the future municipal waste plans. One of the guidelines is that recycling of waste must be increased. Therefore, it is expected that recycling of waste will increase considerably during the coming years, which means that the amount of suitable waste for incineration will decrease.

## 6.1.6 Solar heat in Frederikshavn municipality

### Household solar heat units

Mapping of the solar thermal systems and heat production is provided by the Danish Energy Agency in 2011 and Energy statistics in 2010 and is divided on number of houses with individual supply in the municipality. According to the Danish Energy Agency there are 7,628 solar heating systems in the municipality with a total heat production of 1.8 GWh heat per year.

### Business related solar heat production

Larger commercial solar related solar heat production takes place in two of the district heating plants in the municipality in

Sæby and Strandby. Sæby District Heating Plant has a solar heating system of 11,870 m<sup>2</sup>, 8.2 MW with an annual heat production of 6.35 GWh.

Likewise, Strandby District Heating Plant has a solar heating system of 8,019 m<sup>2</sup>, 6.0 MW with an annual heat production of 3.53 GWh. Furthermore, there are a number of companies and institutions using solar heat energy for heating and utility water in their buildings. Frederikshavn municipality as a company (a total of 310 MWh/year), Frederikshavn public swimming pool (100 MWh/year), Sæby swimming pool (300 MWh/year), the Frederikshavn Housing Association, the police station in Frederikshavn and Trigon are examples of this.

The total solar heat production in the municipality is seen from below table.

Solar heat production unit	Number	GWh/year
Household and buildings	7,628	1,8
Sæby District heating Plant	1	6,35
Strandby District Heating Plant	1	3,53
Total solar heat production	7,630	11,68

## 6.1.7 PV plants (solar cells) in Frederikshavn municipality

### Household solar cell units

The installation of household solar cell units got its ubiquity in 2011 and 2012, as the national grid calculation system made it financially attractive for households to invest in solar cell unit.

In 2012 and 2013, Energinet.dk published a new database for individual solar cell plants. According to Energinet.dk a total of 280 solar cell units were installed in September 2012 with a total effect of 1,437 kW in the municipality. Until 8<sup>th</sup> of April the number of installed units increased to 1,061 and a total capacity of 5,961 kW equivalent to an increase of 380% in 8 months. Since the government removed the subsidy for establishing household solar cell units in November 2012, the interest of installing solar cell plants has dropped significantly.

### Commercial PV plants

So far there have been no commercial solar cell plants installed in Frederikshavn municipality.



**Larger solar cell plants in public housing organizations**

The total installed solar cell capacity in Frederikshavn municipality as a company is set at 347 kWp equivalent to an annual power production of 150 MWh in 2012. Likewise, the public housing association Vesterport has invested massively in a rather large solar cell plant. In 2012 and until May 2013 the public housing association Vesterport installed 173 kW solar cell plant in its departments.

Based on information from Energinet.dk on 8<sup>th</sup> April 2013, the total solar cell capacity in the municipality as geographical area is set at 5,961 kWp equivalent to a production of approx. 5,360 MWh electricity per year (900 kWh/KW installed solar cell).

**6.1.8 Others (Chimneysweeper data)**

Following information comes from gathered data from 2010, delivered by 3 chimney sweepers, who has Frederikshavn municipality as action area and includes

the energy consumption of the wood stoves, solid fuel, straw boiler, oil boiler, pellet and automatic stoker and wood.

Calculation of the energy consumption and unit consumption of the above heat sources is carried out by using key figures from the research "consumption of firewood in Denmark" made by Technological institute and Force Technology.

With reference to the research, following average unit consumption is set:

- Wood stoves in occupied houses: 25.6 GJ
- Wood stoves in summerhouses: 15.2 GJ
- Wood boilers: 148.8 GJ

The unit consumption for straw boilers is made, based on data from Technological

Institute. Technological Institute estimate, that we have 7-8,000 straw boilers in Denmark with a total straw consumption of approx. 330,000 ton. The heating value of straw at 14.5 GJ/ton, according to Energistatistik 2020. The average unit consumption for straw boilers is calculated as: 330,000 ton/7,500 x 14.5 GJ/ton = 638 GJ.

The unit consumption for pellet boilers is set with basis in the fact that Technological Institute estimates, that pellet boilers on average use 10-12 ton wood pellets per year. The heating value for wood pellets is according to Energistatistik at 2007 17.5 GJ/ton. The unit consumption for pellet boilers is calculated as: 11 ton x 17.5 GJ/ton = 193 GJ.

Heating source	Number	Energy consumption GWh/year
Wood stoves, permanent residence	9.536	67,78
Wood stoves, summer houses	863	3,61
Boiler with solid fuel	719	29,72
Straw boiler	176	31,11
Pellet boiler and automatic stoker	879	47,22
Oil-driven boiler	3831	127,78

Figure 15

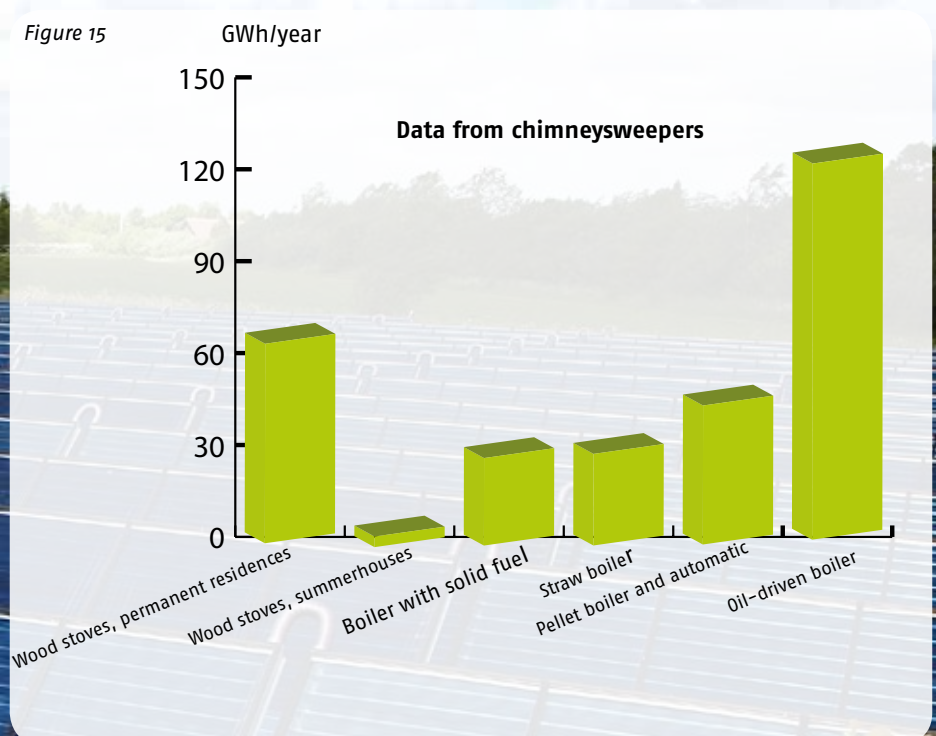


Figure 15 illustrates that the energy consumption for oil driven boilers in the municipality (127.8 GWh/year) is far bigger than the other sustainable fuels both within and outside the collective heat supply area. This is due to oil-driven boilers are used as main heat producing source in permanent residences, where wood stoves are used as supplementary heat source. Pellet boilers and automatic stokers are also used as main heat producing source, but these are not very widespread as there are still 3,831 oil-driven boilers in the municipality.

## 6.2 Transport

The consumption of diesel and petrol for road transport is based on statements on the stock of vehicles in the municipality. The energy consumption is calculated as a share of the total consumption for road transport calculated in Energistatistik 2010. The calculation is based on national

data for driven kilometers per type of vehicle (The National Road Directorate 2011) and the average standard consumption per vehicle (DMU 2012). In the calculation the consumption of diesel is divided on cars, busses and trucks etc. In Denmark 1.67% of the consumption of petrol

consists of bioethanol and 0.02% of the consumption of diesel is bio-diesel. Therefore, 1.67% of the individual fuel consumption for road transport is allocated to bioethanol and 0.02% is allocated to bio-diesel in the energy accounts.

According to the statement of the National Road Directorate from 2010 following Vehicles are present in Frederikshavn municipality:

Type of vehicle	Number	Petrol consumption liter/year	Diesel consumption liter/year	Energy consumption, petrol GWh/year	Energy consumption, diesel GWh/year	Energy consumption total GWh/year
Cars, incl. 54 taxies	23.847	22.916.275	5.373.013	209,16	53,61	262,78
Busses total	16		459.097			4,45
Delivery vans	4.854		9.829.225			98,05
286 trucks and 150 semi-trailer haulages	436		9.674.708			96,39
Motor bikes total	2.437	431.839				3,89
Moped 45	964	37.830				
Tractors	1.131					29,72
Total	33.685	23.385.944	25.336.043	209,16	53,61	495,28

### Diesel, petrol, fuel oil for flight carriage, ships and train carriage

Fuel oil is used for shipping transport. The country average for the use of fuel oil for sea transport is found in Energistatistik 2010 and divided according to population in municipalities, including municipalities without any harbors.

The calculation of diesel consumption for flight carriage, ships and train carriage is made by dividing the country figures for the fuel consumption from Energistatistik 2010, according to population in the individual municipalities. The consumption of petrol (flight petrol) for flights is calculated by dividing the country figures on fuel consumption from Energistatistik 2010, according to population in the individual municipalities.

Use (the municipal share)	Type of fuel	Energy consumption GWh/year
Train service	Diesel	10,19
Shipping trade	Diesel	17,64
Shipping trade	Fuel oil	2,69
Flight	Flight petrol	114,16
Total		144,68

Figure 17 illustrates the share of energy consumption for trains, ships and flights in Frederikshavn municipality.

**Non-road diesel consumption in the agriculture sector 2010**

The consumption of diesel fuel in the agriculture for tractors etc. is calculated through standard consumption on various types of crops, according to "Energy consumption and input-output relations of fields operations" (Nielsen, 1989). The crop division for the municipality in Region Northern Jutland for 2010 is present in Statistics Denmark 2012.

In Denmark 0.02% of the diesel consumption consists of bio-diesel. Therefore 0.02% of the diesel consumption of the agriculture sector is allocated to bio-diesel in the energy accounts. Based on information concerning cultivated agricultural areas and types of crop it is stated, there is a total of 1,131 tractors and agricultural machines in Frederikshavn municipality with a total diesel consumption equivalent to 29.72 GWh/year.

**Non-road petrol consumption in gardens and households.**

According to the CO<sub>2</sub> mapping of Frederikshavn municipality in 2008 the consumption of petrol in gardens and households (lawn mowers, motor saws etc.) is set at 1,016,362 liter equivalent to 10.16 GWh/year.

**The total energy consumption of the means of transport**

Based on the statements in the previous paragraph the total energy consumption of the transport sector can be set at 656 GWh/year. The division of the energy consumption of the transport sector is illustrated in figure 18. Percentage wise division of the energy consumption of the transport sector is visible in figure 19 on the next page.

Figure 17

**The municipal share of national energy consumption for air, trains and shipping transport**

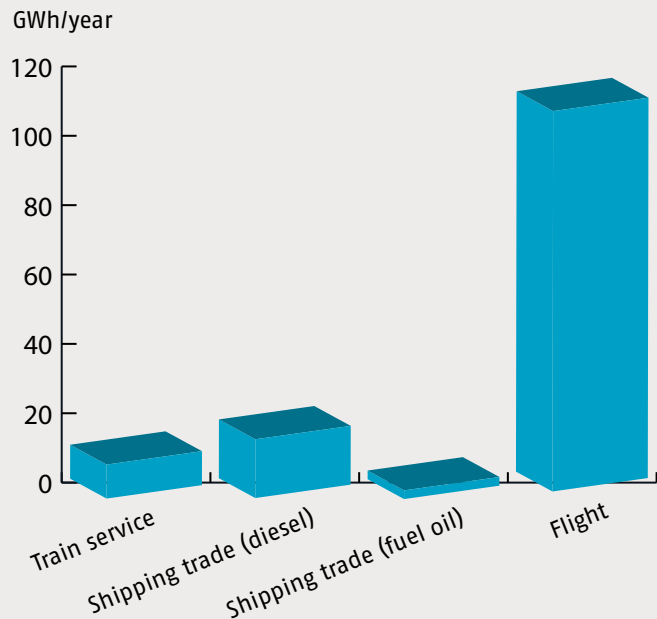


Figure 18

**Division of the energy consumption of the transport sector**

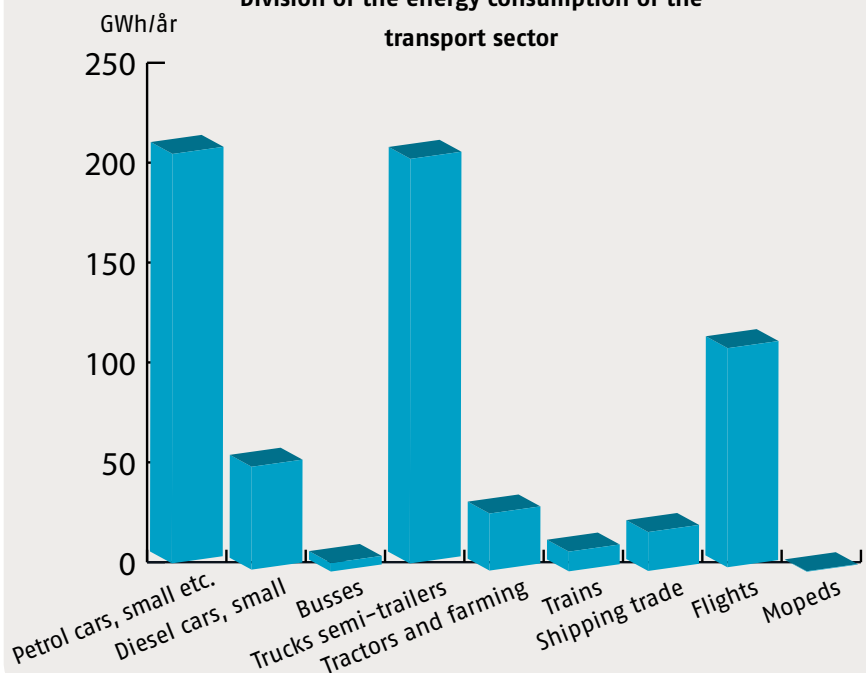
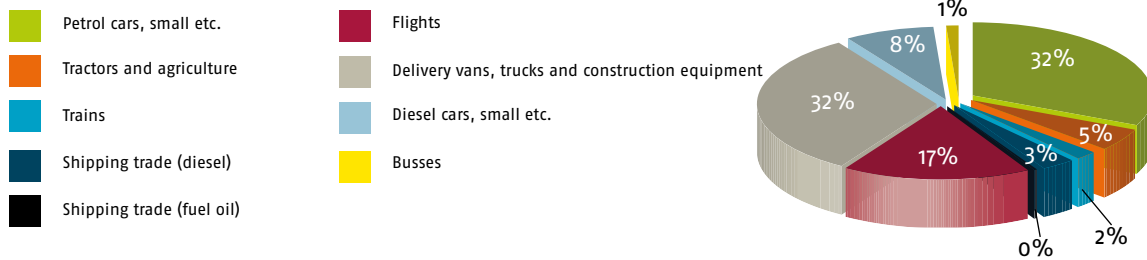


Figure 19

Percentage wise division of the fuel consumption for transport



From figure 18 and 19 the conclusion is, that petrol cars and diesel cars jointly stand for 40% of the total energy consumption for the transport sector in the municipality. According to the mapping material – see figure 6 – the transport sector stands for 25% of the total gross energy consumption and 32% of the total CO<sub>2</sub>- emission in Frederikshavn municipality. This compared to the share of cars in the total energy consumption of the transport sector (40%) indicates that private cars have a big share of the energy consumption and environmental strain in the municipality.

### LPG (bottled gas) and petroleum

The consumption of LPG (bottled gas) and petroleum is relatively limited nationwide, according to Energistatistik 2010. LPG stands for the far biggest energy consumption of the two fuels, where LPG is used in consumed in i.e. production companies, houses and private services.

The consumption of LPG and petroleum in the energy accounts is calculated by weighting the national consumption with the population in the municipalities. For Frederikshavn municipality the consumption of LPG and petroleum is set at 7.66 GWh/year equivalent to 0.29% of the total energy consumption.



## 7. The existing agreements on reduction of the CO<sub>2</sub>-emission in the Municipality



### Climate municipality agreement

As the first municipality in Denmark, Frederikshavn municipality signed an

agreement with The Danish Society for Nature Conservation in 2007 on an annual 3% reduction of the municipality's own CO<sub>2</sub>-emission as an organization. A reduction of CO<sub>2</sub>-emission is achieved through the initiatives of the municipality set in the climate municipality action plan. With the climate municipality agreement Frederikshavn municipality is obligated to reduce the CO<sub>2</sub>- emission in the own businesses of the municipality by 3% per

year. In 2007, which is the reference year, the emission of the municipality was on 14,042 ton CO<sub>2</sub>, where this has been reduced to an emission of 11,409 ton CO<sub>2</sub> in 2012. This means that since Frederikshavn municipality entered the climate municipality agreement with the The Danish Society for Nature Conservation the CO<sub>2</sub>- emission of the municipality as an organization is reduced by 2,633 ton equivalent to a total of 18,7%.



### The Covenant of Mayors

As the first municipality in Region North Jutland, the Municipality of Frederikshavn joined the Covenant of Mayors in April 2011. The Covenant of Mayors is a voluntary European Union initiative, where the task is about municipalities in EU wanting to go further than the 20% reduction of CO<sub>2</sub>-emission that EU has committed to by 2020. As co-signatory of the Covenant of mayors in 2011, the municipality of Frederikshavn is committed to reduce the CO<sub>2</sub>-emission in the municipality

as a geographical area by more than 20% in 2020. See the action plan for the Covenant of Mayors. An annual follow-up on each of the individual action plans is annually conducted – first time in November 2013.

In November 2012, the financial committee of the Municipality of Frederikshavn adopted the objective of the Covenant of Mayors of reducing the CO<sub>2</sub>- emission by more than 20% in the municipality as a geographical area by the end of 2020.

A statement of the action plan of the Covenant of Mayors shows, that the municipality of Frederikshavn can reduce its total CO<sub>2</sub>- emission by 53% by 2020, compared to the CO<sub>2</sub>- emission of the municipality in 2010 by

implementing the short-term action plans specified in the in the Covenant of Mayors action plan. Likewise, the same statement indicates, that the share of renewable energy production in the municipality will be 70% of the total energy consumption of the municipality by 2020 under the assumption, that the action plans for production of renewable energy specified in the action plan will be realized. Furthermore, the municipality, as an organization, will continue reducing its CO<sub>2</sub>- emission by at least 3% according to the agreement with the municipality and the Danish Society for Nature preservation about CO<sub>2</sub>- reduction. Both the short-term and the long-term action plans in the Covenant of Mayors action plan 2020 for the municipality of Frederikshavn are presented in this strategy plan.

## 8. Frederikshavn Municipality's strategic energy planning

The aim of Frederikshavn municipality is to prepare a long-term climate plan, which includes all the strategies of the municipality concerning energy and climate in the municipality. The intention of the municipality is to prepare special strategy plans on other plan areas such as climate adjustment plan, waste deposit plan, heating plan, water plan etc., so that earlier mentioned plans provides a complete climate plan of the municipality.

Please notice that the other plans of the municipality i.e. the water plan is prepared as independent plans but together they will form the overall climate plan of the municipality.

In 2013, the Ministry of the Environment launched a national resource plan. The aim of the ministry is, that the national resource plan together with the new municipal waste deposit plan will help complying with the Danish obligations according to the waste directive, why the plan will focus on a better utilization of the resources, a higher quality in the recycling and better possibilities for waste separation by the citizens.

The strategy plan for renewable energy 2030 must reflect the climate and energy policy of the municipality and point out realistic and realizable actions that are needed to comply with the vision of the municipality concerning changing into renewable energy and create growth within the municipal growth track En-

ergy until 2030. Therefore, the actions mentioned in the plan must be seen as a continuous process as the influences from the outside can change the justification of the effort areas concerning actuality, finances, political decisions etc. We are talking long-term energy strategies in a number of basic areas with considerably political interest and attention both locally and nationally and therefore implementation of the individual effort areas require a political handling in the concerned committee in the municipality, before the implementation of the action plans is possible.

To achieve a holistic continuous energy planning of the total energy system in the municipality it is necessary to include the local planning authorities, who work with planning within following areas:

- Sustainable urban planning in the in the municipality
- Sustainable construction and energy renovation
- Sustainable transport planning
- Operations on optimizing the energy of the energy consumption of buildings in towns and in the country
- Sustainable energy planning for renewable energy supply
- Sustainable heat planning
- Wind Power turbine
- Waste planning
- Biomass planning
- Rural districts and their potential for producing and consuming renewable energy
- Local political objective for involvement of citizens and communication to promote sustainable development and growth
- The sustainable purchase policy of Frederikshavn municipality

*FREDERIKSHAVN MUNICIPALITY ought to include above mentioned effort areas and other initiatives as described in this strategy plan in all relevant municipal planning.*

## 8.1 Organization

To ensure a continuous follow-up on initiatives mentioned in the following chapter 10 "effort areas", the municipality of Frederikshavn should establish a

transverse local cooperation and a project organization that also cooperates with external partners and sectors such

as supply companies, energy manufacturers, businesses, common housing associations etc.

*The cooperation should be between individual municipal employees or groups with each individual area of responsibility working in various centers. In the municipal system, following sub organizations should be involved in a continuous updating of the current strategy plan:*

- Environment and energy planning, Center for Technic and Environment
- Wind turbine planning, Center for Technic and Environment
- Municipal properties, Real estate Center
- Traffic planning, Center for Technic and Environment
- Biogas planning, Center for Technic and Environment
- Purchase office, The Finance center
- Waste disposal company Vendsyssel Øst, AVØ
- Urban and rural planning/development, Center for Technic and Environment
- Municipal center for Development and Business
- Data/analysis – collection, summary and follow-up on development in energy consumption and CO<sub>2</sub>- emission for the municipality as geographical limit and overall coordination, The Energy city.

*Following external collaborators have already been involved in the preparation of specific actions plans, which will be incorporated in the current energy plan:*

*Following external partners will continue to be part of the overall project organization, so that both public and private parties are actively involved in maintaining and developing the strategy plan of the municipality together.*

- All heat and combined heat and power plants in the municipality of Frederikshavn
- Power and district heating supply plants and the public road lighting.
- The collective traffic companies
- Housing organizations
- Banks and investment bodies
- Organizations, who promote business development in and outside the municipality
- Businesses, constructors, landowners and private investors
- Agricultural organizations
- The citizens of the municipality

Above mentioned groups should work together to determine time schedules for the specific actions and to point out relevant resource persons and collaborators, etc. To achieve the best possible results from the work of the project groups, **creating a joint vision and objective for the future energy in the municipality is essential.** Likewise, it is important to the citizens of the municipality and to the business community to ensure a joint understanding, support to and participation in the work of the municipality with the reorganization for transmission to renewable energy. The objective is that the strategic energy planning will create a joint understanding of sustainable development of the society, so that all involved parties show interest and are able to take on a role to fulfil the intonation of the municipality, which is to create growth on the municipal track En-

ergy, while the municipality transfers to 100% renewable energy supply.

Therefore it is determining that the current strategy plan for renewable energy defines the framework of the effort areas of the entire municipality as one joint energy system, but also that the framework is determined in a way, so the individual action plans and effort areas can be implemented in a socio-economic, most energy efficient and financially cost effective manner.

The specific implementation of the strategic energy plan must take place through realization of the action plans that are mentioned in schedule 1, where specific CO<sub>2</sub>- reduction objectives and actions for fulfilment of the objectives have been determined.

## 8.2 Evaluation and review of the plan

Since the strategy plan is prepared for a period from 2014 to 2030, a review of the plan must be carried out every year in December. The necessity of reviewing is due to maintaining focus on the choice of priority in connection with the realization of the effort areas, fast development in renewable energy technology and continuous adjustment of the legislation in the energy sector.

The evaluation process includes the preparation of new appendixes describing possible necessary changes in the individual effort areas, the reasons for the changes and what corrective actions should be taken in order to ensure that the effort of the municipality within renewable energy as a growth area can be maintained continuously and reflected in this strategy plan.

## 9. The energy scenarios of the future

Following diagnosis origin from the Danish Energy projection 2012 published by the Danish Energy Agency in September 2012.

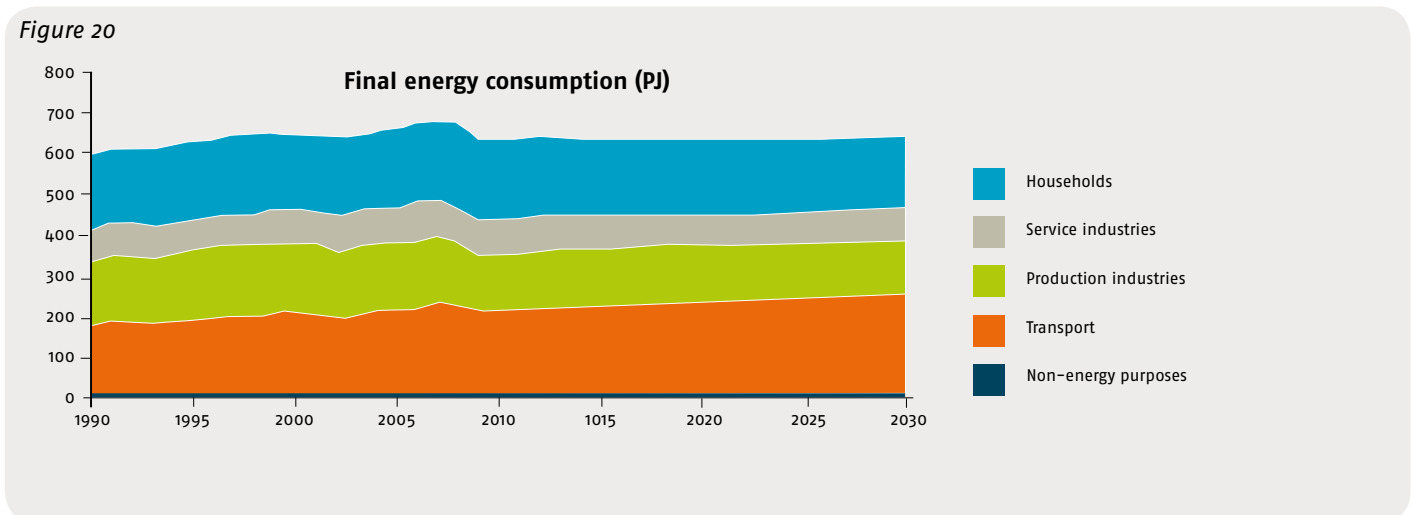
The purpose of the basic projection is to have an evaluation of how the energy consumption will develop in the future in case no new political steps are taken often referred to as "frozen policy"-scenario. The actual development will be influenced when new political steps are introduced and therefore the projection is not considered a long-term prognosis,

but rather a course that defines the challenges of the future energy policy based on some given assumptions.

### 9.1 Final energy consumption

The final energy consumption in Denmark decreases from 640 PJ in 2011 to 632 PJ in 2020. This covers a fall in the energy consumption of the businesses and the households while the energy consumption of the transport sector is expected to increase. The energy consumption will decrease in spite of the expected financial growth in the period.

The energy consumption in the industry stagnated in 2008 and dropped significantly from 2008 to 2010 because of the lower activity especially in the production businesses. The projection shows a small decrease in the energy consumption in the industry towards 2020 from 221 PJ in 2011 to 214 in 2010. Savings not least cause the decrease in the energy agreement from March 2012. After 2020 there will be another small decrease in the energy consumption in the industry to 211 PJ in 2030. The projection of final energy consumption is seen in the figure below.



Today the energy consumption of the transport sector makes up approx. 1/3 of the final energy consumption and mainly consists of fossil fuels.

### 9.2 The power and district heat production of the future in Denmark

Power and district heat production represent almost 45% of the national gross energy consumption. Denmark is part of the Nordic and Northern European electricity market. This is of great importance for the

price formation on electricity, the production pattern and the fuel consumption in Denmark. Therefore, the production systems are modelled in all Nordic countries (Denmark, Norway, Sweden and Finland) and the exchange of electricity between the Nordic countries and Germany, Poland, Holland, Russia and the Baltic States is included. Inventory of

the production is based on projections of electricity and district heat consumption from the EMMA model for Denmark and the latest official projections from the authorities in the other countries.

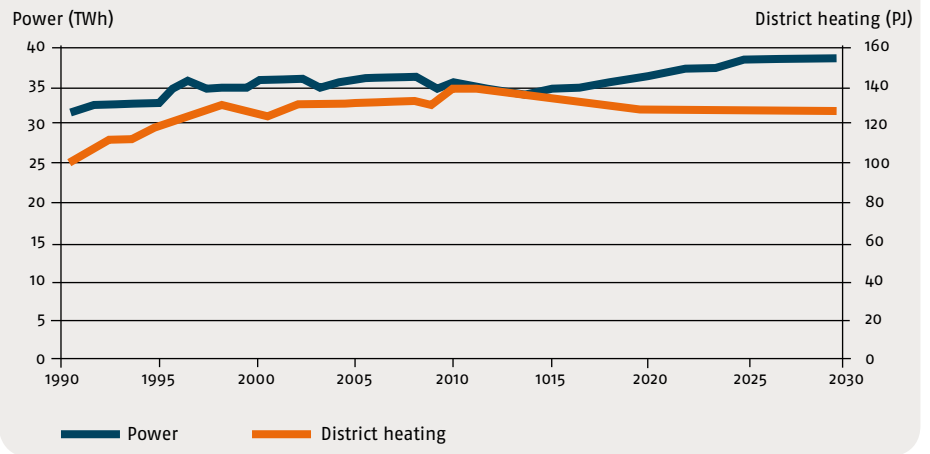
The demand for power in Denmark has increased continuously during the period from 1990 to 2008. Hereafter, there was

a decrease because of the financial crisis. This decline is expected first obtained around or just before 2020. Hereafter, the demand is expected to increase further according to the figure on the right. The consumption of power has also decreased in the other Nordic countries during the financial crisis.

The demand for district heating has increased since 1996, where after it stabilized according to the figure on the right.

Figure 21

**Power and district heat production ex works.**



The consumption of power and district heating ex works in the basic projection – i.e. incl. net loss.

**The future power production in Denmark**

In 2000, wind power covered approx. 12% of the Danish power supply, increasing to approx. 21% in 2010 and approx. 28% in 2011. The large increase from 2010 to 2011 is partly because of a new offshore wind park and partly because the year 2010 was

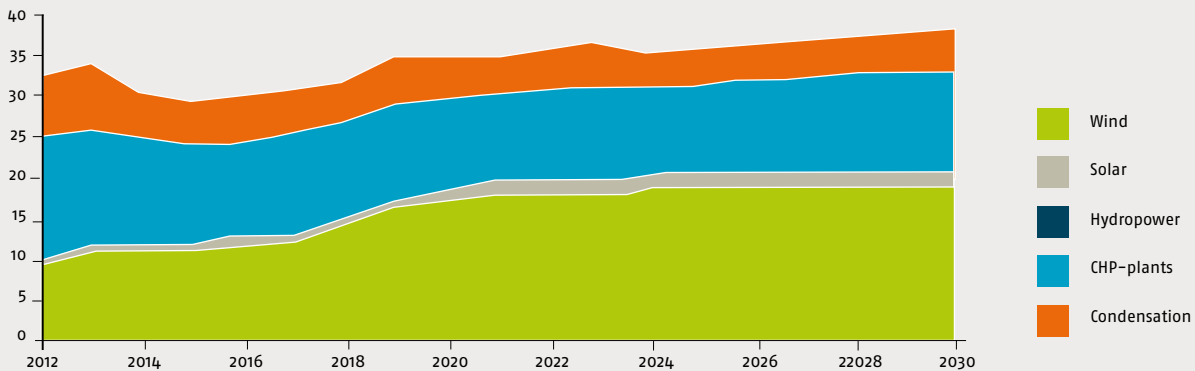
a bad wind year while 2011 was normal. The share of wind will expectedly increase to approx. 34% in 2013 and approx. 50% in 2020.

This development reflects the extension of wind power turbines onshore, coastal

turbines and the initialization of offshore wind parks by Anholt, Horns Rev 3 and Kriegers Flak. The share will expectedly be almost normal during the rest of the period. In the below figure the projected Danish power production is split on types.

Figure 22

**Power production in Denmark (TWh)**



### 9.2.1 Status on power production in Frederikshavn municipality

From paragraph 6.1.1 in this plan it is stated, that the total amount of power production in the municipality is assessed at 482.06 GWh divided with 45% on power import from outside the municipality, 37% from CHP-plants, 17% from wind power turbines and 1.1% from solar cell plants\* installed in the municipality

\* Production figures for produced power on solar cell plants come from Energinet.dk for 2013.

Since 31.3% of the total power production in Denmark comes from wind power turbines it can be estimated, that 31.3% of the municipal power import is also produced by wind power turbines. The share of produced power from wind power turbines in the municipality in imported power from outside the municipality is then set at 61.2 GWh/year. The remaining share of imported power in the municipality equivalent to 157.4 GWh/year is produced on fossil fuels.

**Thus, the share of renewable power production in Frederikshavn municipality is estimated at 31.3% of the total power consumption in the municipality.**

### The future district heating production in Denmark

Historically the share of district heating production from CHP-plants until 2000 has been increasing, due to the development of CHP-plants in the eighties and nineties. After the introduction of the natural gas driven decentralized CHP-plants in the power market in 2005 and 2007 the share of CHP-plants has decreased because the CHP-plants is not running as much, when the price on electricity is low. In the projection, the share of CHP-heat decreases further until 2015, where after it is fairly stable until 2030. See below table.

(%)	1980	1990	2000	2005	2011	2015	2020	3030
Share of CHP-plants of the district heating production.	39,1	58,8	81,6	82,4	79,4	65,7	66,1	66,3

The decrease in district heating production from CHP-plants is mainly caused by an increasing price on natural gas, which makes the CHP-heat production on natural gas less attractive\*. The large share of power from wind power turbines also

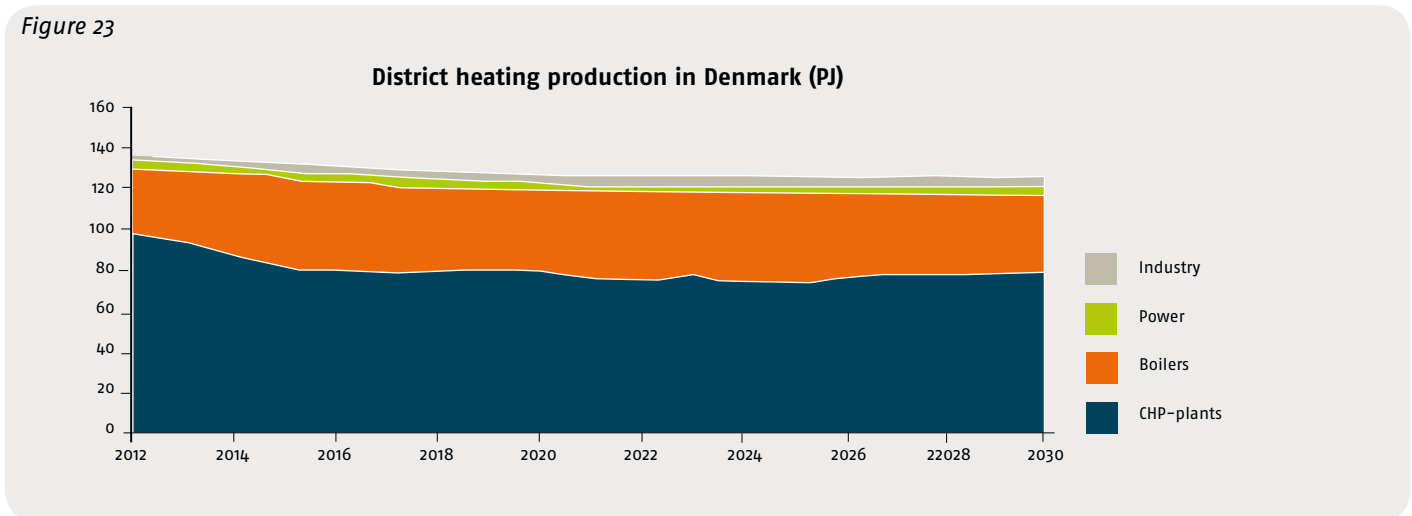
contributes to displacing the CHP-heat production, as periods with high wind production pressures the power price down, whereby it is more attractive to produce heat on a boiler than in a CHP-

plant.

\* The short-term increase in the share of CHP-heat production in 2010 was due to low operation time in the Swedish nuclear plants that means increased production on the fuel-fired plants in the Nordic countries including Danish CHP-plants.

In below figure see the projected district heating production in Denmark

Figure 23



### 9.2.2 Status on district heating production in Frederikshavn municipality

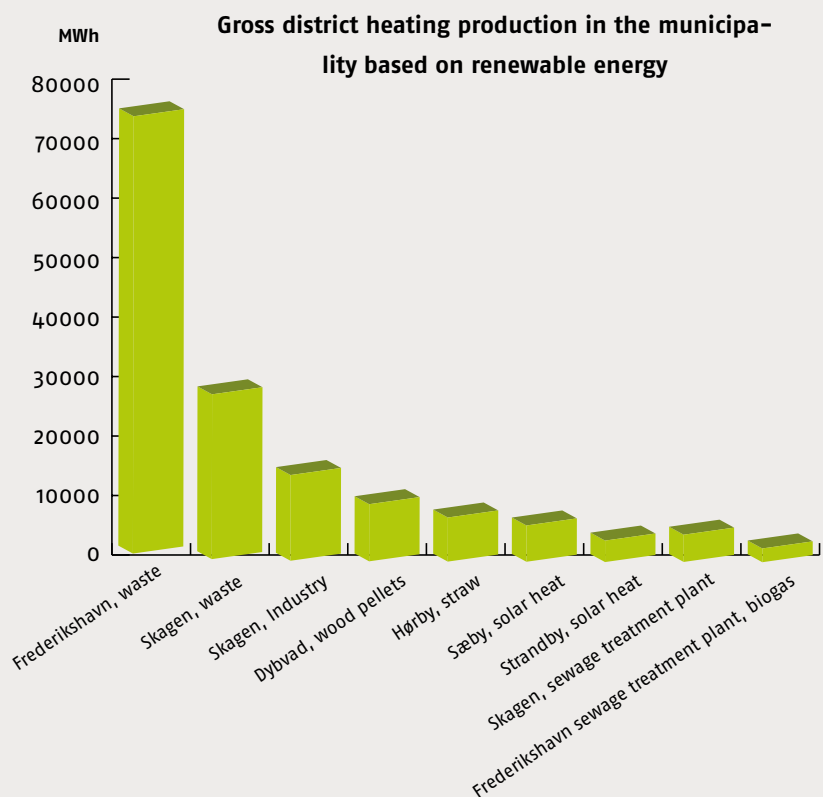
From paragraph 6.1.3 of this plan it is seen, that the 10 district heating plants in the municipality in 2010 together produced 468,421 MWh (1.751 PJ) heat, where the sale of heat is calculated at 256,620 MWh. This equals a total heat loss of 102,801 MWh, which gives a total transmission loss of 22%.

The share of renewable energy for district heating production in the municipality is 155,370 MWh, which equals 33.1% of the total district heating production. The figure on the right shows the district heating production based on renewable energy in Frederikshavn municipality in 2013.

In this strategy plan the aim is that in the future the district heating production in Frederikshavn municipality will be produced on more biomass and other renewable energy than the fossil energy sources such as natural gas in the future.

The government wants a better waste separation, as waste is considered as an important raw material resource and no longer only a fuel. In paragraph 8.6 of this plan the most important elements of the government resource plan are mentioned. In case the resource strategy of the Ministry of Environment could be approved, it would be able to reduce the fossil share in the waste that is incinerated in waste power plants today. This means, that waste driven CHP-plants must look for other types of fuels than waste in order to be able to produce and deliver the same amount of heat as today. More about this in paragraph 9.6.

Figure 24



It is expected that the energy saving actions and the higher requirements for heat consumption of houses can partly compensate for the lack of heat production to a limited extent. On the contrary, the government wish of phasing-out oil-driven boilers by 2017 will increase the need for heat production in collective supply areas.

#### District heating interaction with the overall energy system

There is no doubt that it is quite a challenge to transfer the entire energy sector of a municipality into renewable energy,

so that it becomes independent from fossil fuels especially when renewable energy system must be kept in a continuous balance at the same time, as the energy supply safety must be ensured continuously.

To become independent from fossil fuels in the most socio-economic manner without deteriorated quality of life, it is necessary for the municipality to work together across all sectors. Especially, it is important to focus on the interaction of the heat sector with the rest of the energy sector. As heat authority, Frederikshavn municipality influences the sustainable development of the district heating.

### 9.3 The consumption of renewable energy in Denmark

Renewable energy covers types of energy that do not have limited resources, but are limited in their immediate prevalence. In the statement of the consumption of renewable energy solar, wind and hydropower, solid biomass, waste of non-fossil origin, fluent bio-fuel, bi-

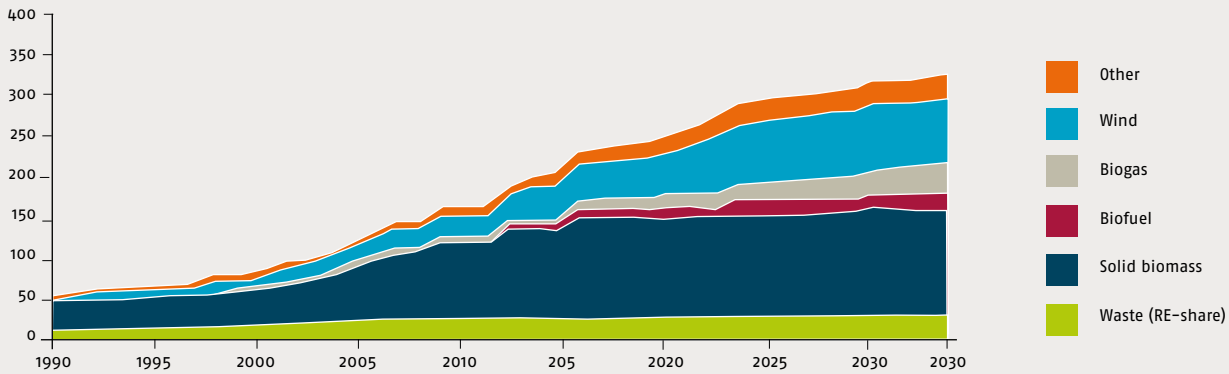
ogas, ambient heat, geothermal and solar heat are included. From 1990 to 2011, the consumption of renewable energy in the Danish energy system has more than tripled and the consumption is now approx. 175 PJ per year. Of this the main part is biomass, but also wind power contributes considerable, especially when it is taken into consideration that the included wind power is transformed directly to

electricity without any conversion loss, while the use of biomass is connected with a conversion loss.

Until 2020, the consumption of renewable energy will increase by approx. 45% compared to 2011 while the increase until 2030 will increase by almost 70%. See below figure.

Figure 25

Renewable energy in gross energy consumption (PJ)



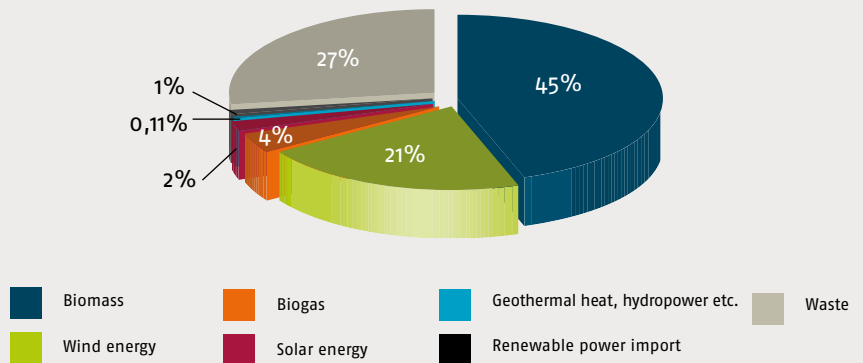
#### 9.3.1 Status on renewable energy production in Frederikshavn municipality

From paragraph 6 of this plan it appears that in 2010 Frederikshavn municipality had a total production of renewable energy at 473 GWh, corresponding to 18,2% of the total energy production in the municipality.

The figure on the right shows the production of renewable energy in the municipality in 2010.

Figure 26

Renewable energy production in Frederikshavn municipality





## 9.4 The consumption of fossil fuels in Denmark

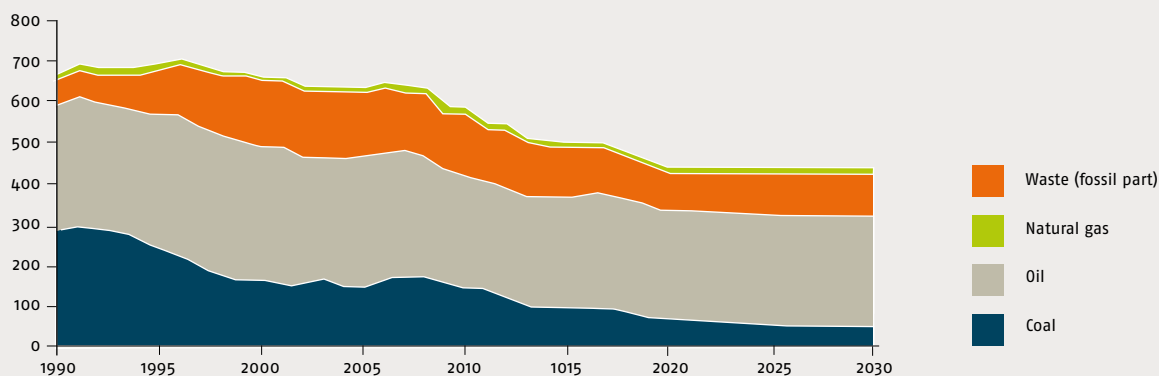
The government has set up objectives on the phasing-out of the use of fossil fuels. The consumption of coal for power production and district heating must be phased-out by 2030, while the consump-

tion of fossil fuels for the entire production of power and heat must be phased-out by 2035. In the long-term in 2050, the entire energy consumption must be covered by renewable energy. **Therefore, it is relevant to look at the development of the fossil part of the energy consumption.** Especially the consumption of

coal and gas varies a lot from year to year because of the difference in the exchange of power with the neighboring countries. To evaluate a trend in the development, these "random" variations are ignored and in the following, we are looking at the corrected consumption of fossil fuels. See below figure.

Figure 27

Fossil fuels in the gross energy consumption (PJ)



From above figure, it is evident that the consumption of fossil fuels is decreasing during the projection period. In the period until 2020 the consumption decreases by approx. 20% compared to 2011, while it in the period until 2030 decreases by approx. 21%. In the period until 2020, the consumption of fossil fuels is reduced by approx. 125 PJ. The highest contributions come from coal and natural gas that will be reduced by respectively 53% and 28%. This is due to a high extend because of substitution with biomass and a higher share of wind power in the production of power and district heating. In the period after 2020 the consumption of coal will decrease further, so that this is reduced to approx. 45 PJ in 2030 and thereby reduced by approx. 69% compared to 2011.

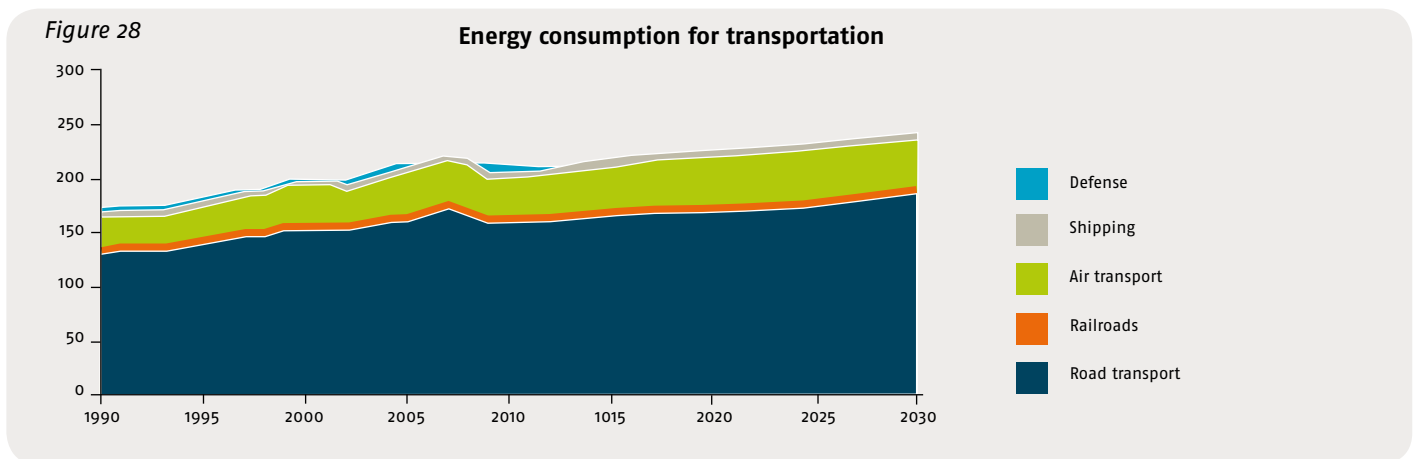


## 9.5 The energy consumption of the transport sector in Denmark

Today the energy consumption of the transport sector represents approx. 1/3 of the total energy consumption in Denmark and mainly consists of fossil fuels. The transport sector includes road transport, rail transport, air transport, domestic

shipping and the consumption of energy transport purposes in Defense. The road transport represents the largest part of the energy consumption of the transport sector (76%) followed by air transport (17%). The main part of this is international air transport. The projection of the energy consumption of the transport divided on transport means is seen in figure 28 be-

low. The energy consumption has been increasing until 2008 where the financial crisis led to a decrease in consumption. A further decrease in consumption took place in 2009 and after that it has been quite constant in 2010 and 2011. Below figure shows the energy consumption of the transport sector until 2030.



### 9.5.1 Status on the energy consumption in the transport sector in Frederikshavn municipality

In paragraph 6.2 the share of energy consumption for the transport sector is set at 656 GWh/year. According to the mapping material (see figure 6 in this plan), the transport sector stands for 25% of the total gross energy consumption and 32% of the total CO<sub>2</sub>-emission in Frederikshavn municipality. This compared with the share from cars in the total energy consumption of the transport sector (40%) indicates that private motoring has a high share of the energy consumption and environmental strain of the municipality.

### 9.6 The future of waste and waste incineration in the municipality

In the beginning of October 2013, the government launched its resource plan. Among others, this resource plan states that recycling of waste will be doubled in

10 years. The government has following other important objectives for the waste strategy:

- In 2012 Denmark will recycle 50% of the household waste. That is more than a doubling of the recycling of household waste in Denmark in less than 10 years. Today the Danes recycle 22%.
- In 2018 25% of the garden waste must be used for energy production. Today the energy utilization of garden waste equals 4%.
- Recycling of paper, cardboard, glass, metal and plastic wrapping from the service sector must be increased by 25%. Today approx. 53% is recycled. The cycling level of 2018 is expectedly 70%.
- Almost 4 times as much organic waste from restaurants, grocery shopping etc. must be collected and used for biogas. The expected recycling level in 2018 is 60%.

The government's resource plan further-

more says that the municipalities have the primary responsibility of the waste separation while private industries have the competence and knowledge to refine the technological solutions.

From the above-mentioned objectives of the government's resource plan it is ascertained that in the near future:

1. The amount of waste for combustion will minimize
2. Household waste and garden waste will more than previously be included in the production of energy.

The total amount of waste for combustion in Frederikshavn municipality is constantly influenced by the different parameters.

In 2012, the amounts of waste for combustion has been decreasing compared to previous years. The reason is, that more waste will be recycled and the low so-

cio-economic activity and the fact that the population falls within the municipality has influence on the production of waste.

In the future, the amounts of waste for combustion will expectedly decrease slightly in the municipality.

Furthermore, the amounts of waste are to a high extend depending of the dynamics of the society, in other words the socio-economics, and it is difficult to predict the future financial development. It is not expected that the socio-economy will reach the same level as before 2009 in the next years, so the waste amounts will probably not increase significantly due to high level of activities.

A third fact that speaks against increasing waste amounts for combustion in Frederikshavn municipality is a slightly decreasing population. Population prognosis for Frederikshavn municipality shows that in the future there will be fewer citizens in Frederikshavn municipality.

Whether the decreasing amounts of waste leads to a reduction of the number of incineration plants in Frederikshavn municipality from two to one is uncertain.

During the last years, the incineration plants have supplemented with biofuel because the amount of waste for combustion is decreasing. This means higher prices on biofuel and also that suddenly waste as a fuel from other European countries has become environmentally and financially attractive to combust in Danish incineration plants.

Therefore, Frederikshavn municipality has entered an agreement on combustion of waste from England. Environmentally this is a profit, as the coefficient of utilization in the two plants in Frederikshavn municipality is more than 90% of the energy, whereas the English plants only uses 25% of the energy. The difference is caused by the fact that the combustion plants in Frederikshavn municipality are utilized for district heating supply. There is still not overall economy on combustion of waste from England, but it looks positive.

If the current duty system in England and Denmark is maintained, it must be expected that more agreements on combustion of English waste in the incineration plants in Frederikshavn municipality will be entered.

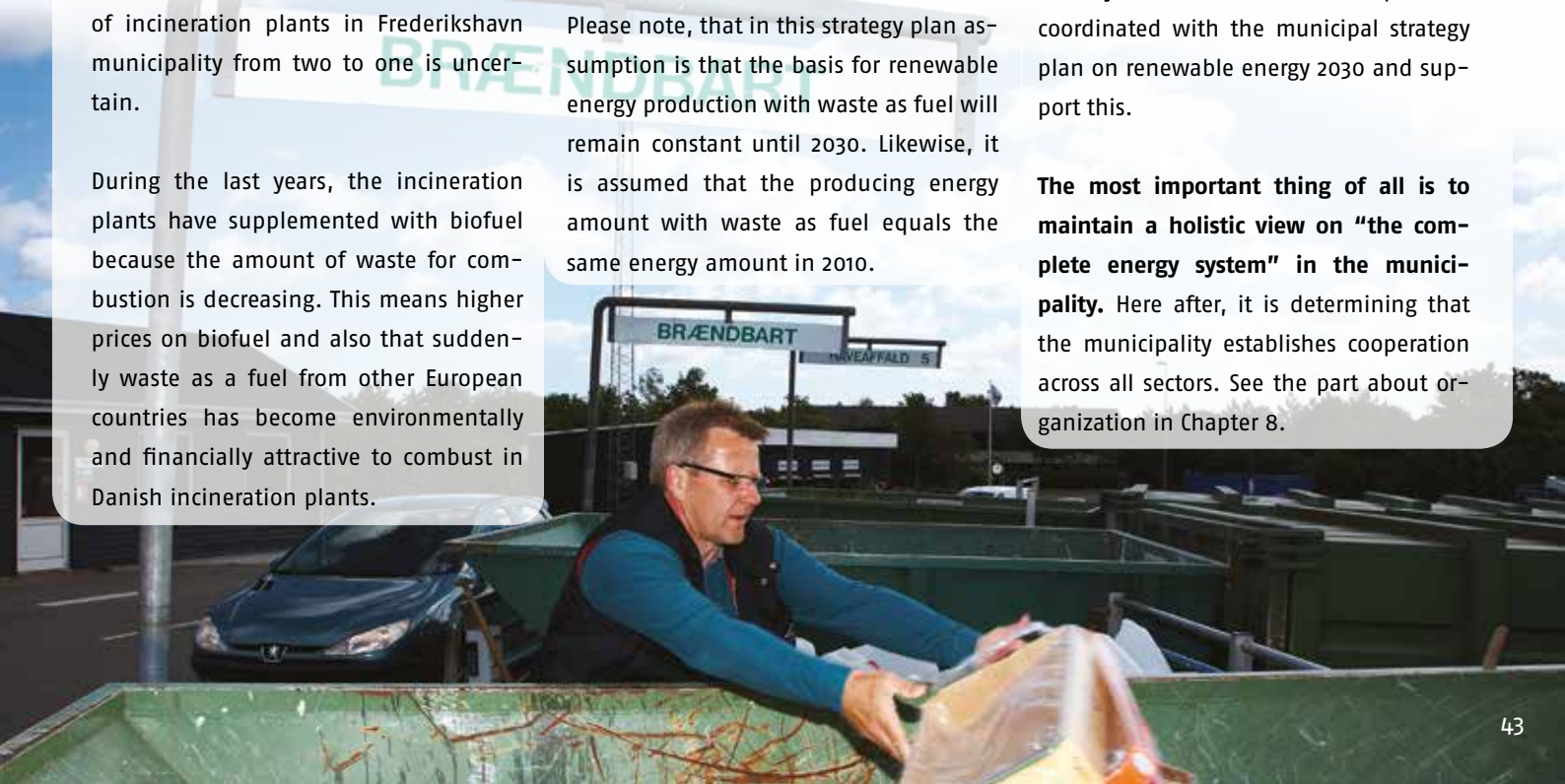
The government's resource plan does not take a stand on imported waste, but on page, 29 in the plan it is stated that "the government will present a model for a changed organization of the waste combustion sector" quote.

Please note, that in this strategy plan assumption is the basis for renewable energy production with waste as fuel will remain constant until 2030. Likewise, it is assumed that the producing energy amount with waste as fuel equals the same energy amount in 2010.

## 9.7 Other means

The above-described future scenarios on power-, district heating- waste combustion- and fossil fuels sectors must continuously be compared with other external factors to maintain a realistic and marketable strategic energy plan in the municipality especially when it comes to choice of effort areas. Likewise, it is important to keep updated with development of new energy technologies and cost efficient energy solutions within renewable energy and the development in energy prices, taxes and duties and Furthermore subsidy capabilities within the energy and climate political areas, prioritized by the Danish government and in the EU. These external factors should continuously be integrated and included in the work with strategic energy planning in the municipality. In the strategy plan, which in this sense can be considered a strategic energy plan, the municipality must also involve all relevant planning functions, so that the most important effort areas mentioned in this plan are integrated in the other municipal planning work. This, so the visions and the objectives in each individual plan are coordinated with the municipal strategy plan on renewable energy 2030 and support this.

**The most important thing of all is to maintain a holistic view on "the complete energy system" in the municipality.** Here after, it is determining that the municipality establishes cooperation across all sectors. See the part about organization in Chapter 8.



# 10. Effort areas

The strategy plan for Frederikshavn municipality on renewable energy include following three main elements:

1. *Conversion of oil and natural gas (fossil fuels) to renewable and sustainable energy for power and heat production and coverage of the transport sector*
2. *More efficient utilization of the energy*
3. *Energy savings*

With this strategy plan on renewable energy the municipality of Frederikshavn puts focus on following 11 effort areas. The efforts will result in more renewable energy, less energy consumption and less CO<sub>2</sub>- emission.

A possible implementation of the effort areas stated in this paragraph must help supporting Development of the local competencies and strengthen the effort in the growth track energy in the municipality in a socio-economic and financial cost effective way.

Please note that the effort plans within the transport sector only include the segment in the sector, where the municipality has real influence. **Conversion of fossil fuels for flight carriage, train carriage and ships to renewable energy is therefore not subject to the actions of this strategic plan.**

1. *Integration of renewable energy in all municipal planning including climate planning, energy planning, urban planning, municipal planning and district planning in urban and rural areas.*
2. *Reduction of energy consumption in municipal buildings, reduction of the environmental strain of the transport and introduction of sustainable purchase policy in the municipality as an organization.*
3. *Reduction of the energy consumption in private houses in urban and rural districts.*
4. *Reduction of the energy consumption and production of renewable energy in Housing Associations.*
5. *Increased use of renewable energy in existing energy infrastructure and displacement of fossil fuels by collective energy supply.*
6. *Increased production of renewable energy by establishing new renewable energy plants.*
7. *Establishment of infrastructure to promote sustainable transportation in the municipality and in the region.*
8. *Establishment of infrastructure for sustainable transport based on renewable energy.*
9. *Improvement of infrastructure for sustainable transportation including promotion of cycling and more sustainable transport behavior.*
10. *Promotions of demonstration projects for renewable energy plants including smart grid, wave energy and intelligent lighting.*
11. *Promotion of district heating in the urban areas.*

The 11 effort areas mentioned in the last page must contribute to the fact that Frederikshavn municipality fulfils the vision of becoming a renewable energy municipality and of reducing the CO<sub>2</sub>-emission of the municipality by at least 97% until 2030 through a financial sustainable development.

To meet the intentions in this strategy plan and conversion of the effort areas into specific projects and initiatives it is necessary for the municipality to prepare and realize specific action plans. It will be necessary to strengthen the cooperation with the other players within the energy sector, agriculture and the industry, e.g. the energy companies to prepare and implement specific renewable energy project. **It is important to keep a constant focus on "the complete energy system"**, so that the conversion of the system into renewable energy is carried out in a financially sustainable manner, while ensuring the balance of the total renewable energy system. At the same time, the security of energy supply must be maintained.

The realization process on each individual effort area will be a continuous process, where the assumption conditions and incentives for realization will change constantly. This e.g. means that some of the projects that are not immediate socio-economic, industrial-economic or consumer-economic and thereby unfavorable today might become attractive projects in a year or two. The same goes for projects that right now does not receive a lot of support among the citizens and companies e.g. the building of on-shore wind power turbines or investment in vehicles using alternative sustainable fuels. Therefore, it is important to keep updated on the technological development and the legislation and duty regulation in the energy sector.

## 10.1 Effort area 1a

### Integration of renewable energy in all municipal climate and energy planning including urban planning, municipal planning and district planning

FREDERIKSHAVN MUNICIPALITY is willing to implement renewable energy in all municipal climate and energy planning including urban development, district planning in urban and rural districts.

The objective in the long-term is to create a model on a fossil fuel-free society within the geographical area of the municipality. This, due to limiting the CO<sub>2</sub>-emission of the municipality, to take on the responsibility of implementing the energy strategy "Energiplan 2050" of the state and as a minimum to comply with the climate goals for 2020 of the Danish government as well as The European Union.

The municipal council announced that by the preparation of municipal plans, district plans, traffic plans, other municipal planning and in connection with the preparation of these, energy efficiency, reduction of CO<sub>2</sub>-emission and integration of renewable energy must be part of the plans. The same goes for preparation or revising of municipal construction and renovation projects, purchase policy, transport policy etc., where reduction of CO<sub>2</sub>-emission, energy savings and integration of renewable energy will become a natural part of the municipal activities. The action plans should be part of a larger whole, where focus will be on the interaction with the nearby society for the benefit of the whole. by selection of specific areas of action, the municipality must take into account the requirements of national economy, the local economy and consumer economy.

### 10.1.1a Action plan 1

#### Establishment of organization and cross-disciplinary cooperation

In paragraph 8.1 and 9.5 in this strategy plan the importance of establishing a cross-disciplinary organization to promote cooperation between the municipal authorities, developers, energy suppliers, property owners and the citizens of the municipality is explained. **It is essential to create a joint understanding of the vision and objective of the municipality within the energy area to obtain the best possible results.**

Based on the reasons explained in paragraph 8.1 and 9.5 it is recommended, that Frederikshavn municipality establishes an organization for cross-disciplinary cooperation.

### 10.1.1a Action plan 2

#### Implementation of the action plan from European Covenant of Mayors

The action plan of Frederikshavn municipality on the Covenant of Mayors includes a number of actions, on which specific action plans have been prepared, see enclosure 3. Implementation of the short-term actions specified in the action plans can reduce the total CO<sub>2</sub>- emission of the municipality by 53% in 2020 compared to municipality's CO<sub>2</sub>- emission in 2007. The implementation of the actions stated in the action plan for the Covenant of Mayors will furthermore increase the share of renewable energy production in the municipality to 70% of the total energy consumption in 2007. For comparison the production of renewable energy today is 473 GWh (1,703 Tj) equivalent to 18.2% of the total energy consumption in the municipality.

## 10.1 Effort area 1b

### Promotion of the municipal heat planning based on renewable energy

The choice of the right heat supply for buildings in urban and rural areas is a considerate factor when it comes to promotion of renewable energy and sustainability. Sustainable energy supply is a long-life, minimum strain of the environment, minimum strain of the local environment and the fact that the solu-

tion is advantageous in terms of socio- and consumer-economy.

Heat supply for room heating and production of hot utility water is an important element in the heat planning of the municipality when it comes to choice of the most sustainable heat supply. The heat supply is regulated through the heat supply legislation, where requirements are made so that the municipality as heat supply authority must ensure the

most optimum socio-economic heat supply solutions.

To give a general picture of status on the heat planning in Denmark please read the Varmeplan Denmark 2010 prepared by Rambøll Danmark in cooperation with Aalborg University in September 2010. Apart from a lot of good advices and guidelines, Varmeplan Denmark 2010 i.e. focuses on following problems as important barriers for preparation of strategic heat planning in Denmark:

*The existing division in the old municipal heat plans is not up-to-date in terms of e.g. extensions of district heating, low-energy houses or conversion from natural gas. There is a need for strategic energy planning, if the entire energy system is to be future-proof, including if the development plan is to be realizable. However, the municipalities currently have very limited funds for this assignment.*

*A determining barrier in relation to i.e. the replacement of natural gas with district heating and heat pumps is the existing division in heat plan zones that were created by the extension with district heating and natural gas. There is a large need for revising of this division. The future energy system will however, be more diverse and complex and therefore it is not expedient only to repeat the previous heat planning.*

*On the contrary there is a need for a holistic planning of the complete energy system both in the municipalities and nationwide and with coordination compared to savings, the power-sector and the transport sector.*

*If the heat supply and the energy system as a whole are to be future-proof, it is necessary with financing of the planning – including strategic energy planning.*

Source: Varmeplan Danmark 2010

Together with the Energy city, the heat authority of the municipality has established a constructive cooperation with all district heat supply companies in Frederikshavn municipality. Through the established cooperation, the heat authorities have succeeded in creating a joint understanding of the municipal intentions with the future heat supply, where the heat authority and heat supply companies work together on developing the district heating supply areas and promoting renewable energy in the local district heating sector.

### 10.1.1b Action plan 1

#### Extension of the district heating grid in urban areas

Compared to natural gas supply areas and individual heat supply areas the district heating is still the best-fitted heat supply solution when it comes to high-density housing and by larger blocks of flats in towns and surrounding villages. Decisions in the Environmental Board of Appeal show that socio-, business- and consumer-economic turn out to the advantage of district heating. In Frederikshavn municipality the district heating is wide spread, where there are a total of 10 district heating plants in the municipality and with a few exceptions the big-

gest cities and towns in the municipality have established district heating with the highest-possible number of connected houses.

As part of the municipal strategy plan on renewable energy the municipality will focus on spreading the district heating supply areas in towns and villages where there is already an existing district heating grid. In connection with the preparation of the municipal plans and district plans on new industry and settlement areas in or close to existing district heating grid, the district heating supply of the mentioned areas should be prioritized in case the socio-economy, the business-economy and the consumer-economy speaks for it.

From paragraph 6.1.8 of this plan it appears that there is a certain number of houses in the district heating supply areas, which still have oil-driven boilers as main heat supply source and therefore are not connected to the district heating, even though they are close to existing district heat grid. In cooperation with i.e. district heating companies and heat fitters Frederikshavn municipality can prepare an action plan on phasing out oil-driven boilers in the municipality during the period from 2013 – 2017 in accordance with the objectives for phasing-out oil-driven boilers by 2017 from the Danish Ministry of Climate, Energy and Buildings.

### 10.1.1b Action plan 2

#### Change of the plan area for natural gas into plan areas for district heating or renewable energy supply

The government has announced that the use of fossil fuels (including natural gas) for power and heat production must be phased out by 2035 and the energy consumption in Denmark must be covered by renewable energy in 2050.

Concerning the government objectives on phasing out of fossil fuels including natural gas the municipality should focus on changing the existing division of heating plan zones in the municipality so that natural gas supply areas, where the heat are produced individually in towns and villages can be supplied with district heating and alternative renewable energy sources including heat pumps.

Concerning promotion of renewable energy supply in the municipality there are large potentials for renewable energy supply in residential areas in the municipality. These settlement areas such as Kilden and towns like Gærum, Haldbjerg, Elling, Jerupp and Ålbæk are interesting in

this context, if the socio-, business- and consumer-economy suggest changing the heating plan zones and where there is the highest-possible support among the citizens of the mentioned residential areas. It is obvious that in the long-term such planning will become essential. In case district heating will become the focus area as substitute for natural gas, the preparation of such project might become complex as you will hit the barrier suggesting that the Investment costs for putting down a new district heating grid would generally be high compared to the expected sale of heat. Therefore, a fast pace of connection and a high degree of connection are important parameters to make the district heating financially attractive.

In the Government Energy strategy 2050 it is stated, that electricity will become the dominating energy carrier in the future energy system with a heavy increase in the consumption of power, where the wind power share of the power production will be bigger. Based in the government strategy it will be relevant to focus on wind turbine power as a sustainable alternative to heat production by the means of heat pumps with high COP-value instead of natural gas in natural gas areas, where each individual consumer produces the heat individually. This solution should be considered seriously especially for heat supply in areas, where district heating cannot become financially justifiable.

Above considerations call for the initiation of a strategic cooperation between municipality, district heating companies and possible investors about a joint effort towards potential district heating customers both individually and through homeowners associations, civic associations and housing associations. By cooperating, the municipality will ask the district heating companies to identify pri-

oritized areas for district heating conversion and the municipality will assist with support by e.g. dialogue with the homeowners. Likewise, Frederikshavn municipality will assist the homeowners, who are willing to use district heating in starting cooperation with the district heating companies.

The City Council in Frederikshavn has the opportunity to command various types of obligations in order to connect to district heating, if a district heating project is socio-economical reasonable. As the connection deadline must not be below 9 years for existing houses this will practically rarely save the economy in a district heating conversion project.

Therefore, Frederikshavn municipality should determine by each single project proposal, if the obligation to utilizing district heating will be of benefit to the social-economic objectives.

### 10.1.1b Action plan 3

#### Gradually phasing out of natural gas consumption and production of renewable energy

The government has stated that the consumption of fossil fuels (including natural gas) for power and heat production must be phased-out by 2035 and the entire energy consumption in Denmark must be covered by renewable energy in 2050.

Heat and CHP-plants in Frederikshavn municipality together use 52,156,983 m<sup>3</sup> natural gas (574.5 GWh) equivalent to 55.13% of the total natural gas consumption in the municipality. Based in the above it is recommended that the municipal heat authority in dialogue with heat and CHP-plants prepare specific projects for gradual phasing out of the natural gas consumption for district heating production in favor of production, based on renewable energy resources until 2030.

## 10.1.1b Action plan 4

### Extension of the municipal wind power plan in land and in sea

#### Wind turbines onshore

From paragraph, 7.1.2 in the action plan for Covenant of Mayors it appears that Frederikshavn municipality has prepared a theme subject plan for putting up wind power turbines onshore. In paragraph 7.1.2 a statement is made on the short-term action plans on wind power turbines in the municipality showing that there is a predominantly likelihood of producing wind power equivalent to at least 250 GWh per year by putting up wind power turbines in the 10 chosen areas in the municipality. On March 4 2014, the municipal Planning and Environment Committee decided to leave out 3 of the 10 areas (Kvissel Brænding, Tamholt and Donsted). From the short-term action plan (duration 3–5 years) it is mentioned that the reason for this probably is, that parts of the chosen wind power areas meet resistance from the citizens living nearby or close to these areas. Possible construction of wind power turbines onshore must therefore be done in close dialogue with the concerned citizens, where there is an opportunity of finding a satisfactory solution to all parties is present. It is Furthermore recommended to investigate the opportunities of compensating purchase of land in and around the wind turbine areas and to involve the concerned citizens in the financial profit that construction of wind power turbines onshore will give by offering shares in the wind power turbines. The co-ownership of the concerned citizens and the shared financial profit by sale of green electricity will probably influence the attitude towards wind power turbines by some of citizens.

Generally, the construction of wind power turbines onshore is connected with some uncertainty as this partly depends

on the expected profitability and partly of the planning related matters concerning placement of new wind power turbines. Until 2020 the expected extension of the energy agreement from March 2012 is included. The extension after 2020 is far more uncertain and therefore estimations are that the capacity will be constant. This however, means that the production will still increase, as old wind power turbines will be replaced by new and more efficient turbines.

#### Offshore wind power turbines

The Danish state handles the planning of wind power turbines with a total height of more than 150 meter onshore and the planning of offshore turbines, where the municipality is part of the hearing.

#### Coastal wind power turbines by Hirsholmene

In 2012 DONG chose not to put up 6 planned coastal test wind power turbines by Hirsholmene in spite of the fact that a EIA statement prepared for the purpose followed by a public hearing did not speak against the construction of the wind power turbines. According to the plan, 48 MW wind power turbines with a total power production of 171,000 MWh per year were to be installed. Based on the preceding work a local work group has initiated an investigation concerning, whether other stakeholders than DONG could take over the construction of the wind power turbines by Hirsholmene. Currently discussions are ongoing with the Danish Energy Agency concerning transfer of the project from DONG to another stakeholder. Furthermore, the Danish Energy Agency has asked the local work group to prepare a business plan on the project. In case the work group succeeds in gathering stakeholders for the project, changes will be carried out both in the number of wind power turbines and in the installed effect. The local work group intends to involve the two largest power supply companies in the municipi-

pality as stakeholders in the continuous work.

#### Coastal wind power turbines 4 km from the coast of Sæby

Until 2020, Denmark will extend its power supply from wind power by 1,500 MW. This means that Denmark achieves a share of approx. 50% wind power in the power consumption by 2020.

The Danish state, by the Danish Energy Agency has planned the establishment of 6 offshore wind parks in the Danish water territory with a total installed capacity of 450 MW, where the water territory outside Sæby is appointed as a potential offshore wind power park. The extension of offshore wind power parks of 450 MW is put out to tender in one total tender and the 6 offshore wind parks will compete with each other. The maximum installed capacity in each appointed area is 200 MW and the coastal offshore wind power parks must be at least 4 km from the coast. Furthermore, an area can include several smaller projects. Frederikshavn municipality is working on making the offshore wind power park by Sæby coast as a part of a total tender.

#### Coastal wind power turbines in connection with the extension of the Frederikshavn harbor

Frederikshavn Harbor wishes to investigate, whether it would be possible to put up 5 near-shore wind power turbines with the capacity of 3.6 MW each in continuation of an extension plan for Frederikshavn harbor. The vision of establishing the near-shore wind power turbines must be considered a future scenario as Frederikshavn Harbor is focusing completely on the work with the extension of the harbor, which has the absolute first priority.



## 10.2 Effort area

### **Reduction of energy consumption in municipal properties and reduction of the environmental strain from transport sector in the municipality as company**

The overall objective of the municipal Property Center is to reduce the CO<sub>2</sub>-emission from municipal properties by 20% in 2020, to integrate renewable energy sources in the energy supply of municipal properties equivalent to 20% and to achieve an energy saving in municipal

properties of 20% compared to the energy consumption in 2007. Furthermore, Frederikshavn municipality has set the goal of reducing the energy consumption and integrating as much renewable energy as possible in municipal properties in connection with the construction of new buildings, building renovations and maintenance.

In the transport area the municipal emergency center has prepared an action plan for fleet management of the municipal Vehicles.



## 10.2 Action plan 1

### Continuous reduction of energy consumption in municipal buildings

In 2007 Frederikshavn municipal entered a climate agreement for municipalities with the Danish Society for Nature conservation. The criteria for this agreement is that Frederikshavn municipality must lower the annual CO<sub>2</sub>-emission by 3% and where the effort is made based in Frederikshavn municipality as a company. The agreement is valid until 2025. The reference year for the Climate agreement for municipalities is 2007, which is therefore indexed as 100.

#### Vision

FREDERIKSHAVN MUNICIPALITY has a vision of continuous reduction of the energy consumption of municipal properties and of integrating most possible renewable energy in connection with new build, renovation and maintenance

#### Objective

The municipal agreement with the Danish Society for Nature Conservation means that with a CO<sub>2</sub> saving of 3% per year during the period from 2007 to 2025 the municipality as company will be able to reduce its own CO<sub>2</sub>-emission by 54%.

#### Effort areas in the municipal properties

- Focus on energy control in municipal properties.
- Investment in actions with short payback time, typically under 5 years
- Investment in energy renovation actions, payback time up to 25 years.
- Investment in energy producing plans/actions.

Effort year	Heat consumption MWh/year	Index	Power consumption MWh/year	Index	CO <sub>2</sub> -emission ton CO <sub>2</sub> /year	Index
2007 (reference)	29.473	100	9.779	100	13.036	100
2012	25.041	85	9.129	93	9.279	71
2030	17.684	60	6.845	70	3.911	30

## 10.2 Action plan 2

### Continuous integration of renewable energy in connection with new build, renovation and maintenance of municipal properties

Since 2007, the property center Frederikshavn municipality has been working on phasing-in renewable energy in the municipal buildings. Since 2007 where the municipality entered the agreement with the Danish Society for Nature Conservation, the property center has established following properties:

- 2007: 165 m<sup>2</sup> solar heating system is installed at Frederikshavn Swimming center
- 2007: 36 m<sup>2</sup> solar heating system, is installed at Store Tofetlund
- 2008/09: 160 m<sup>2</sup> solar cell plant is installed at Frederikshavn City Hall
- 2008/09: 40 m<sup>2</sup> solar cell plant is in-

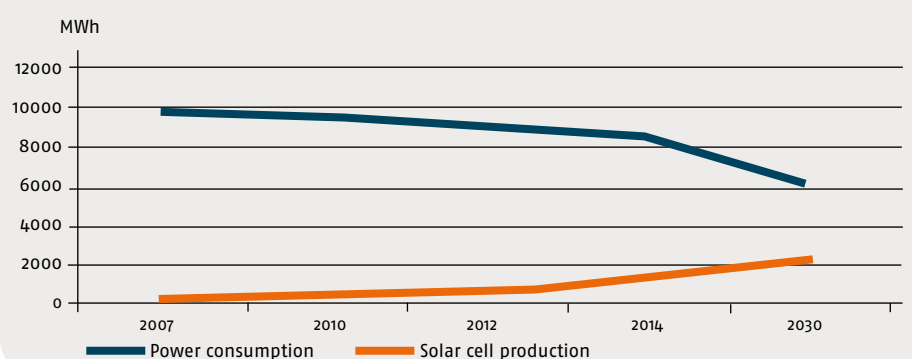
stalled at Knivholt Hovedgård

- 2009: 65 m<sup>2</sup> solar cell plant is installed at Ålbæk school
- 2010-2012: approx. 1,000 m<sup>2</sup> solar cell units equivalent to 200 kWp is installed on municipal properties
- 2013: expected installation of solar cell plants with a capacity of approx. 400 kWp, which means that there is a total of 4,000 m<sup>2</sup> solar cell by the end of 2013

In 2014 the municipal Property Center has a goal of installing solar cell plants with a capacity of approx. 400 kWp, so by the end of 2014 the installed amount equals a total area of approx. 7,000 m<sup>2</sup> solar cells.

The municipal Property Center predicts following development of the energy production compared to the consumption on municipal buildings until 2030.

Figure 29



## 10.2 Action plan 3

### Implementation of municipal fleet management

FREDERIKSHAVN MUNICIPALITY is working on delegating the operational responsibility for all municipal vehicles to the Emergency Center, Frederikshavn.

In June 2010, the Energy City made a detailed mapping of the total fleet of cars of the municipality. The mapping was carried out as a necessary introductory maneuver for establishing municipal fleet management.

According to wish from the Emergency Center Frederikshavn the municipal Center for Finance and Personnel in Jan-

uary 2014 prepared a statement, which i.e. describes an important financial rationale by introducing fleet management as there is a political decision of reducing the annual net costs for the mileage of the municipality of 1.5 mill DKK.

In November 2013 The Center for Municipal Parks and Roads prepared below statement of its fleet of cars.

Department	Trucks etc.	Delivery vans	Busses	Cars	Total
Emergency	11	11		12	34
Materials Center	12	55		2	69(1)
Social residences		4	5	11	20
Property Center		12		4	16
Elderly care		4	1	66	71
Other areas	1	13	9	10	33
<b>Total</b>	<b>24</b>	<b>99</b>	<b>15</b>	<b>105</b>	<b>243</b>

(1): See below table.

Type of car	Number
Tractor	18
Excavator	7
Loader	3
Delivery vans 1.5-3.5 ton	55
Delivery vans 3.5-8 ton	3
Trucks 8-16 ton	2
Trucks 16-32 ton	5
<b>Total</b>	<b>93</b>

The statement of 2014 from the municipality Center for Finance and Personnel contains a lot of factual arguments for establishment of fleet management in the municipality of Frederikshavn with considerable financial advantages. The environmental impacts because of establishing fleet management are not quantified, but there is no doubt that the establishment of a demand adjusted fleet man-

agement will reduce the consumption of fuel and thereby reduce the CO<sub>2</sub>-emission. Likewise, the demand adjustment as a consequence of establishing fleet management will open up possibilities of integrating renewable energy Vehicles e.g. electrical cars in the existing fleet.

Based in the above it is recommended, that FREDERIKSHAVN MUNICIPALITY establishes fleet management of its vehicles.

The total fuel consumption of Center for Parks and Roads in 2012 is set as follows:

Type of fuel	Consumption in Liter	CO <sub>2</sub> - emission in ton/year
Diesel	368.000	976,8
Petroleum	47.000	113

Source: The key figures of the Danish Energy Agency on heating value and CO<sub>2</sub>- emission, note of January 13, 2014.

## 10.2 Action plan 4

### Implementation of holistic sustainable purchase policy in the municipality as organization

In February 2013, Frederikshavn City Council approved a purchase and tender policy. Apart from the legislative requirements such as the EU tender directive and the Tender law and other relevant guidelines for the purchase and tender of the municipality the purchase and tender policy of the municipality also includes statements that support both the overall business and growth policy of the municipality and the municipal consideration for environment and climate. From the purchase and tender policy of the municipality it appears:

*“Frederikshavn City Council wants to use social clauses and partnership agreements as a mean of achieving the objectives within education, the more inclusive labor mar-*

*ket and development of the growth tracks” (A).*

*From the paragraph on environment and climate in the purchase and tender policy it appears:*

*“Frederikshavn City Council works to lower the environmental strain. This i.e. by promoting the use of less environmentally straining products and services and by targeted working according to the objectives of the Energy City Frederikshavn municipality. (B).*

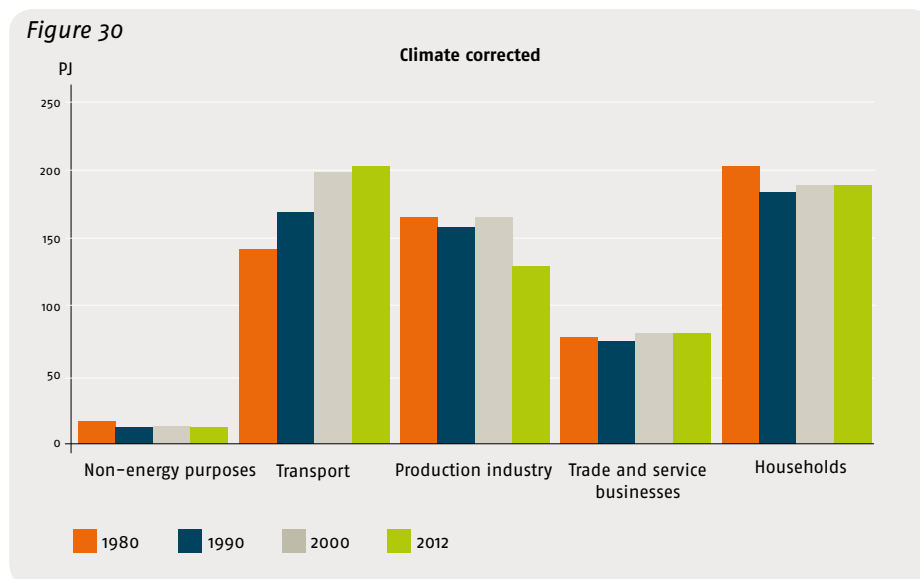
*Therefore, Frederikshavn City Council wants to deal with suppliers, who take environmental and climate considerations.*

*Depending on the specific assignment, the municipality can put up some requirements on the used products, energy labelling of machines or handling of waste.*

*In the allocation period, the energy and environmental considerations can also be included where relevant. A parameter could*

*be that the supplier works on minimizing the environmental strain by production, distribution and removal or environmental use of the product and the possibilities of recycling. By tender of operational assignments, framework agreements and larger construction assignments Frederikshavn Municipality can make demands for the environment, climate and energy policy of the supplier.*

Sustainability includes a broad perspective that e.g. includes environmental, health related, social, ethical and financial matters. Even though the purchase and tender policy of Frederikshavn municipality contains elements of energy and climate considerations, it is recommended to evaluate the policy so that the policy complies with the declared statements marked in the points (A) and (B) e.g. by defining specific objectives for reduction of the environmental strain. This could e.g. be goals for integration of renewable energy for vehicles in the municipal fleet of vehicles.



Source: The Danish Energy Agency, Statistics and key figures 2012.

*From above figure it is i.e. seen that the final energy consumption of Danish households is the second highest energy consumption area only exceeded by the transport sector from 2000 to 2012. Compared to 2011 the climate corrected energy consumption for households increased by 2.5%.*



### 10.3 Effort area

#### Reduction of energy consumption in private households in towns and rural districts

From the mapping material in paragraph 6 of this plan it appears that private households in 2010 stood for 31% of the total power consumption equivalent to 133 GWh, corresponding to 75% of the total district heating consumption and 7% of the total natural gas consumption in Frederikshavn municipality.

Key figures from the Danish Energy Agency on the energy consumption shows that the Danish households (one-family homes and blocks of flats) in 2012 stood for 30.52% of the total Danish energy consumption.

The below figure 52 illustrates the final energy consumption of households compared to the other fields of application.



### 10.3 Action plan 1

#### Energy renovations and energy savings in private houses

In cooperation with Frederikshavn Utility Ltd., Energy City launched a campaign for energy counselling targeted energy renovation of private houses all over the municipality. The statement of the effort for reduction of energy consumption in private houses for 2012 shows that 310 private houses received cost-free and neutral energy counselling, whereby 1,482.5 MWh energy savings were assigned. The implemented savings actions in the same year are registered to 969.9 MWh equivalent to 65% of the assigned savings in 2012. Implemented savings potentials by private houses have given a CO<sub>2</sub>- emission saving of approx. 485 ton. Furthermore, the statement shows that implemented energy actions, due to the counselling effort in Frederikshavn municipality, has generated jobs to local craftsmen equivalent to 10.3 mill DKK 1): *We are counting on a CO<sub>2</sub>- emission equivalent to 0.5 kg/ implemented kWh power and heat savings.*

From the action plan on the Covenant of Mayors it appears that Frederikshavn Municipality wants a continuous effort for reduction of energy consumption in private houses until 2020.

#### Better Housing Scheme

Frederikshavn municipality contributes in the Better Housing Scheme initiated by the Danish Energy Agency together with 8 other chosen municipalities.

Better housing is the new scheme of the Danish energy Agency to make it simpler and cleaver to Danish homeowners to energy renovate. The purpose is to motivate homeowners to energy renovate by giving

them the possibility of a total qualified solution to energy improve their home.

The scheme is established as a part of the " Government Growth Plan DK" and has been approved by a broad political back up. It is plan of the government effort to create growth and green conversion.

The aim of the specially educated Better Housing counsellors is to make it easier for owners of private houses to thing energy when they are renovating their houses. When energy improvement becomes a part of the renovation, the house owner achieves many advantages and makes their homes future-proof in several areas such as reduced energy bill, increased property value, more healthy comfort and indoor climate and a better utilization of the area of the house.

In cooperation with the Energy Agency Frederikshavn Municipality facilitated additional education of 4 housing advisors for the special Better Housing counsellor education. The advisors advise homeowners in the municipality about energy savings.

Likewise, Landbo-Nord offers special energy counselling for the agricultural business in Frederikshavn Municipality.

Based in the above it is recommended that Frederikshavn Municipality has established cooperation with the parties who offer and give energy counselling in the municipality. The cooperation must i.e. include a method for improve quantification of the implemented savings proposals by the target groups private houses and agricultural properties. The quantification must be part of the evaluation of the efficiency of the effort

are and launching of possible corrective action to achieve optimum utilization of the large energy savings potentials that still are present in the private housing sector until 2030.



#### 10.4 Effort areas

##### **Reduction of energy consumption and production of renewable energy in common housing associations**

Frederikshavn Housing association and the Housing Association Vesterport manage 5,766 dwellings in Frederikshavn municipality and thereby they are important actors when it comes to efficient use of energy in public dwellings, cluster energy renovations and energy efficient new builds. Both housing associations con-

tribute to the action plan for Covenant of Mayors of Frederikshavn Municipality with important energy savings actions and integration of renewable energy in houses. The short-term energy action plans of these housing associations are mentioned in the Action plan for Covenant of Mayors of Frederikshavn municipality.



## 10.4 Action plan 1

### Energy efficiency improvement by Frederikshavn Housing Association

The Central board of the Housing association has approved an energy policy in which the vision, objective, action plans, priority of effort areas and organization of the energy saving activities of the housing association have been defined thoroughly, see enclosure 3.

The objective of the housing association for reducing the energy consumption and limiting the CO<sub>2</sub>- emission is defined as follows:

#### **Frederikshavn Housing association in 2013:**

From the municipal action plan for the Covenant of Mayors it appears that the Housing association of Frederikshavn municipality planned energy savings activities equivalent to 1,736 MWh power and 3,584 MWh heat within the next 5 years.

In the first of November 2013 the housing association has implemented savings of 392.947 MWh of electricity and 355.62 MWh heat.

#### **The heat consumption of Frederikshavn Housing association in 2020:**

The objective for 2020 is that the heat consumption of the 3,500 dwellings of the housing association must be reduced by 75% compared to the heat consumption in 2010.

#### **The power consumption of Frederikshavn Housing association in 2030:**

The objective for 2030 is that the power consumption in the same 3500 houses of the housing association will be equally reduced by 75% compared to the consumption in 2010.

#### **The energy consumption of Frederikshavn Housing Association in 2050**

Frederikshavn Housing Association has a vision of becoming 100% self-sufficient with renewable energy in 2050.

## 10.4 Action plan 2

### Energy efficiency improvement the Housing Association Vesterport

With its approx. 2,500 houses, the Housing Association Vesterport is the second largest public housing association in the municipality. Likewise, the housing association Vesterport has a vision of reducing its CO<sub>2</sub>- emission as much as possible through a targeted energy saving efforts by initiating housing renovations, construction of new buildings with a minimum of energy consumption and integration of renewable energy producing plants in its buildings.

In principle Vesterport chose solutions based on both green and overall economic considerations. The solutions must be sustainable in the long term and therefore the necessary Investments are provided even though they might be a more expensive solution in the short term. Both tenants-democracy and the personnel have high focus on the possibility of energy optimizing and therefore Vesterport had much success with not only talking about green policy, but also to live up to it.

#### **New buildings**

All construction launched in 2010 and later is build according to requirements expected to be valid in 2020 as well. Therefore, low energy buildings are constructed where the heat consumption is

minimal. As heat source air-to- hot water pumps driven by electricity produced by own solar cells are used. The only energy that is led to the houses from outside is the electricity that the residents use for own consumption.

Also in the future Vesterport will make houses according to future standards and the objective for future houses is that they must be energy neutral, which will include own production of electricity must also cover own consumption of the residents. Vesterport aims to be first-mover within green initiatives and is glad to enter communities and cooperations where these are tested.

#### **Renovations**

A large number of the 2,500 dwelling administrated by Vesterport consist of buildings are constructed before the focus on the energy consumption of the housing stock. Therefore, it is due to the continuous renovation of this part of the housing stock, that Vesterport can and will achieve high reductions in the CO<sub>2</sub>- emission and resource consumption.

As mentioned, it is determining for Vesterport that they can offer attractive houses that are both cheap and up-to-date. Therefore, there must be balance between the result of the energy optimizations that are implemented and the overall economic costs connected to this. It is possible to have a green profile and through proactive actions to reduce the CO<sub>2</sub>- emission and the resource consumption without having the net rent increase significantly because of that.

Therefore Vesterport will, in connection with current and future renovations, implement the energy related renovation actions, where it is possible to reduce the CO<sub>2</sub>- emission significantly at the same



time as the rent does not increase significantly for the residents. In renovation cases, Vesterport will therefore especially focus on the possibility of renovating facades and end walls where additional insulation will be put in. Likewise, focus will be on additional insulation of attics. By exchange of windows, the change will be into low-energy windows. Establishment of ventilation with heat recovery is also an efficient initiative.

The result of such initiatives will be visible through lower heat consumption and it is therefore possible to finance these initiatives through a rent increase that is counterbalanced by a decrease in the on-account heat bill whereby the individual residents experience an apartment, where the energy level is up-to-date with the requirements of the time without influencing the rent.

#### **Other energy related actions**

Additional to new builds and renovation cases there is also high focus on the ener-

gy consumption in connection with daily operations. Vesterport has implemented energy labelling of all its dwellings that are not facing an immediate thorough energy renovation and in that aspect Vesterport has a number of recommendations on how the energy consumption can be reduced in this part of the housing stock – recommendations, that Vesterport intends to comply with.

Furthermore, the housing association has invested in a number of solar cell plants that cover the power consumption in joint facility buildings (e.g. launderettes, outdoor and indoor lighting on common areas. The total production of the solar cell of Vesterport is approx. 280,000 kWh per year, which equals a smaller emission of CO<sub>2</sub>-emission of 500 ton per year. Vesterport intends to establish further solar cell plants based on overall economic considerations.

Even though it in the short-term seems to be a more expensive investment, all out-

door lighting will be converted into LED lighting – a technology that only uses a fraction of ordinary lighting

#### **The Housing association Vesterport in 2030:**

From the municipal action plan for the Covenant of Mayors it appears that the housing association Vesterport has planned installation of solar cell plants at a total annual power production equivalent to 240 MWh. From the same plan it appears that the housing association has planned energy renovation of its departments with a total heat savings potential of 2,820 MWh per year for the period 2013–2020.

The housing association Vesterport has since November 2013 integrated solar cell plants in 5 of its departments with a total power production of 240 MWh per year. Likewise, the housing association has reduced its heat consumption by 22.18 MWh per year by energy renovating a facility building in one of the departments.



## 10.5 Effort area

### Increased use of renewable energy in existing energy infrastructure and displacement of fossil fuels by collective energy supplies

According to the government, the use of coal for production of power and district heating must be phased-out by 2030, while the use of fossil fuels (including natural gas) for the entire production of power and heat must be phased-out in 2035. The entire energy consumption must be covered by renewable energy in 2050.

In paragraph 6.1.2 in this plan the total natural gas consumption of the municipality in 2010 is set at 95 mill m<sup>3</sup> equivalent to approx. 1,042 GWh. The natural gas consumption hereby reaches 40% of the total gross energy consumption of the municipality. From paragraph 6.1.2 in the plan it appears in 2010 that heat and CHP-plants used 52 mill m<sup>3</sup> natural gas which equals to 55% of the total natural gas consumption in the municipality.

From paragraph 9.1.2 of this plan it likewise appears that the share of renewable energy incl. waste for district heating production is on 155.4 GWh, which equals 33% of the total district heating produc-

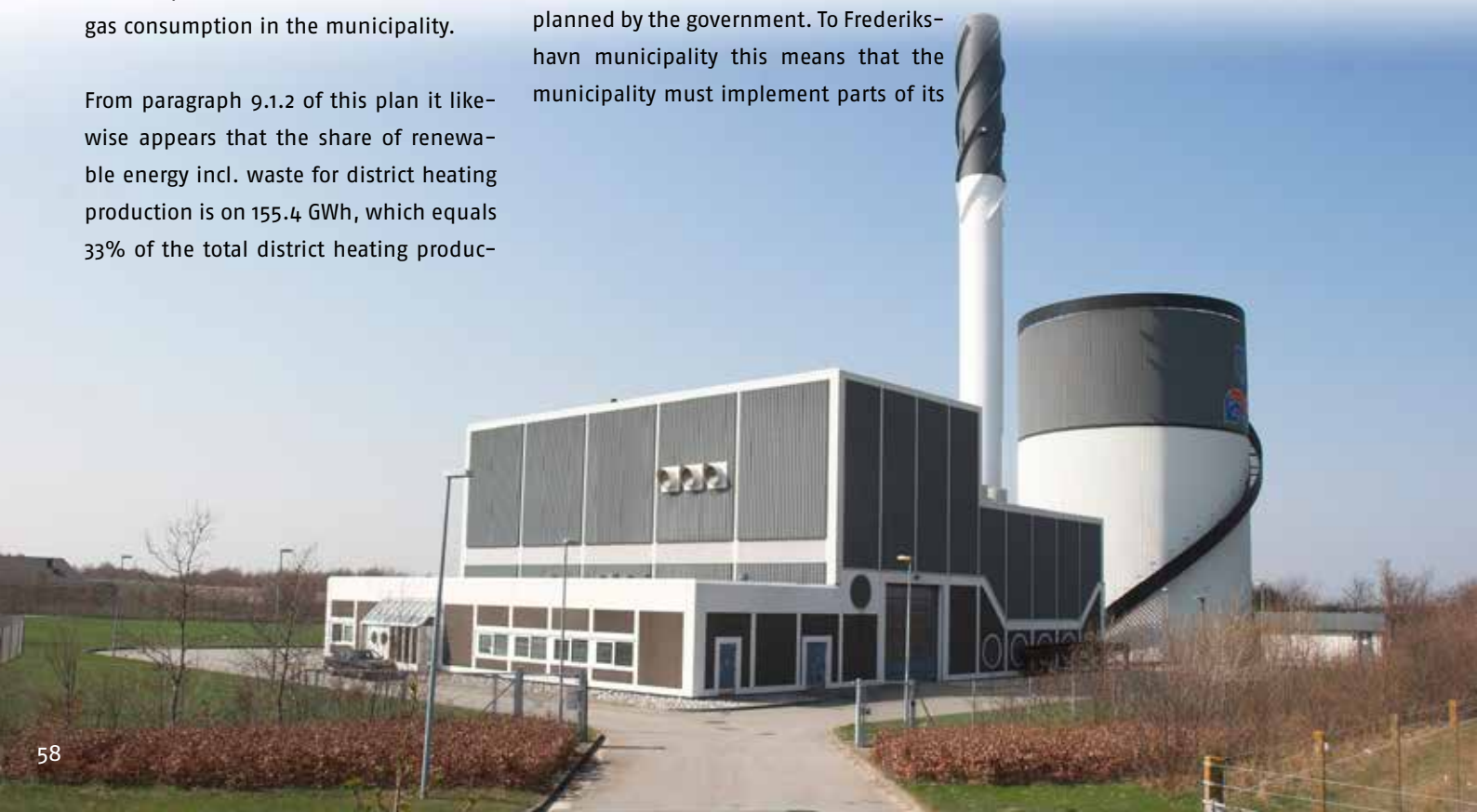
tion in Frederikshavn municipality. The remaining 77% of the district heating is produced on natural gas.

As the government is preparing the ground for phasing-out natural gas for power and heat production by 2035, the share of renewable energy sources for heat production should be gradually increased so natural gas consumption of 155.4 GWh can be out-phased by 2035. Furthermore, it is important for the municipal heat planner to follow the government resource plan thoroughly as any implementation of the government's resource plan might change the terms for future incineration of combustible waste in the municipality.

This plan must enlighten the municipal possibilities of 100% renewable energy supply in 2030, while the energy plan of the government says that Denmark must be free of fossil fuels by 2050. In other words Frederikshavn municipality must comply with the government objectives in the energy area 20 years earlier than planned by the government. To Frederikshavn municipality this means that the municipality must implement parts of its

renewable energy plans under consideration to valid laws, rules and especially the duty mechanisms that will not be adjusted until 20 years after the municipality achieved its renewable energy goal. To meet this challenge in the district heating sector, it is recommended that the municipal planning authority considers whether it is possible to grant permission to set up individual wind power turbines by district heat supplies situated outside urban areas and in industrial areas. This so they can produce heat on wind turbine power without having to pay the current transmission fee for the collective power grid. The transmission fee makes the heat supply Investments in wind power turbines outside own property uneconomic.

Furthermore it is recommended that all district heating supplies in the municipality prepare specific action plans on reduction of transmission loss, exchange of old pumps, heat recovery in the production devices, optimum district heating cooling by the end users and intelligent control of the district heating grid.



## 10.5 Action plan 1

### Increased use of renewable energy in district heating production

#### **Sæby Heating Plant:**

A: Sæby heating plant considers a possible extension of its existing solar heat system of 8.2 MW installed capacity. The new plant will be producing 6,350 MWh solar heating per year, which equals a doubling of existing solar heat production.

The implementation of this initiative will result in a natural gas savings of 1.35 mill m<sup>3</sup> per year. By implementation of this initiative, Sæby district heating plant will achieve a CO<sub>2</sub>-emission of 2,950 ton/year. (CO<sub>2</sub>-emission key figure for gas motors 2,185 g/m<sup>3</sup>).

B: Sæby district heating plant is investigating whether it is possible to utilize industrial surplus heat from Sæby Fish industry.

#### **Strandby Heating Plant:**

Like Sæby Heating plant, Strandby heating plant considers to extend the existing solar heat system with 4,000 m<sup>2</sup> with an installed effect of approx. 3MW. The plant will be producing 1,790 MWh solar heat per year.

The implementation of this initiative will result in a natural gas savings of 165,695 m<sup>3</sup>. By implementation of this initiation Strandby Heating plant will achieve a reduction of CO<sub>2</sub>-emission of 362 ton per year. (CO<sub>2</sub>-emission key figure for gas motors 2,185 g/m<sup>3</sup>).

#### **Hørby, Thorshøj and Østervrå District heating plants:**

Description of these three district heating

plants is to be found in paragraph 6.1.3.

To promote the use of renewable energy, optimal utilization of the produced district heating and to achieve economy of scale these district heating plants have decided to establish a district heating transmission line from Hørby to Thorshøj and on to Østervrå. The aim of this connection of the three district heating plants is that the surplus heat produced on straw in Hørby can supply all three towns with sustainable district heating in the periods of spring, summer and fall. In the winter Østervrå district heating plant will supplement with district heating production according to the actual need and Thorshøj district heating plan will have a stand-by function.

The connection of the district heating pipeline between these three district heating plants is ongoing at the moment. Calculations show that 97% of the heat demand in Thorshøj and 46% of the heat demand in Østervrå can be delivered as district heating produced on straw in Hørby. The implementation of the project means, that the CO<sub>2</sub>-emission from the supply areas of these heat supplies will be reduced from existing 9,000 ton per year to 4,000 ton per year, which equals a CO<sub>2</sub> reduction of 53%.

#### **Dybvad Heating Plant**

Dybvad Heating Plant is a heating plant that mainly uses wood pellets and in capacity load periods fuel oil for district heating production, see paragraph 6.1.3. The heating plant has recently bought approx. 1 hectare neighboring land to establish a heat accumulation container, extension of the storage capacity for wood pellets and construction of a solar heating system.

After building the heat accumulation container, Dybvad heating plant intends to deliver district heating to three industries in Dybvad, namely Dybvad Stål industry, Nilles Busrejser and Neptun Vaskeri. The two industries mentioned first uses fuel oil and the third bottled gas for room heating and water heating purposes. Furthermore, the heating plant wants to investigate the opportunity of a consolidation of Dybvad and Flauenskjold district heating transmission system to optimize the district heating plants in these two towns.

#### **Præstbro CHP-plant**

Præstbro CHP-plant was founded in 1994 to supply at least 100 consumers with a heat consumption of 2,200 MWh. The plant is a natural gas driven CHP-plant, see paragraph 6.1.3. Right now, the board of the CHP-plant considers if the plant can be taken over by other energy supply companies or it should continue the district heating supply of Præstbro. The CHP-plant will be free of debt in 2014 and in connection with that the board considers to invest in new sustainable district heating production based on straw under the assumption that Præstbro has a future as a viable village.

#### **Voerså CHP-plant**

Voerså CHP-plant was founded in 1992. The district heating is produced on a gas motor and a gas boiler as spare. The plant has an annual natural gas consumption of approx. 800,000 m<sup>3</sup>. Voerså CHP-plant has 195 connected consumers and is situated in urban area. Voerså CHP-plant has a transmission loss of 31%, which is the biggest transmission loss among the existing district heating supplies in the municipality.

As in 1st of July 2013 the CHP-plant is free of debt and in connection with this the plant intends to lower the district heating price for the end consumers. In the future, Voerså CHP-plant wishes to produce CHP-produced district heat based on renewable energy. Likewise, the plant intends to establish a solar heating system for heat production. The solar heating system will be established close to the plant property.

#### **Frederikshavn Utility Ltd.**

In connection with the municipal preparation of Strategy plan on renewable energy 2030, Frederikshavn Utility Ltd. has stated following action plans:

- Establishing a wood chip-fired heat or CHP-plant for district heating supply in Elling town and possibly of connecting with Strandby district heating.
- Establishing seawater based heating pump.
- Delivery of district heating for the naval base in city of Frederikshavn.
- Delivery of district heating for Ravnsbøj
- Utilization of industrial surplus heat from MAN Frederikshavn.

#### **Skagen Heating plant**

In the third quarter of 2013, Skagen Heating plant prepared a strategy roadmap. The strategy roadmap is based on preceding investigations and analysis, and a strategy seminar held in September 2013. The roadmap describes The Vision 2020, which contains:

- Skagen Heating plant is a user owned co-operative society, which wants to be the preferred supplier of heat in Skagen.

- Skagen heating plant delivers district heating at competitive prices in consideration of security in supply, environment and energy policy.
- Skagen heating plant wants to be a contemporary company developing both financially, energy related and technologically.

In accordance with The Vision 2020, Skagen heating plant has prepared specific objectives on how to realize the vision of the plant. The objectives of the plant are as follows:

- Extension of the district heating supply area (today the plant supplies 70% of the city of Skagen with district heat).
- Conversion of natural gas supplied harbor area into district heating
- Inclusion of wind power for district heating supply (security of supply compared to the future waste incineration in Skagen town)
- Further inclusion of the industrial surplus heat in the district heating system.
- Operational optimization of production plant, transmission plant and distribution plant.
- Optimization of district heat consumption at end users.
- Settlement of the future waste combustion and district heating production based on waste combustion in Skagen town.
- Continuous reduction of the natural gas consumption of the plant equivalent to 50% compared to the consumption in 2006. The natural gas consumption of the plant in 2006 was 10 mill. m<sup>3</sup>. The natural gas consumption is in 2013 reduced by 40%. The remaining reduction of 10% will be reached continuously until 2017.

## 10.5 Action plan 2

### **Phasing-out oil-driven heating plants in collective district heat supply areas and the construction of RE-based individual heating**

In the government's energy agreement it is stated that oil-driven boilers must be phased-out in existing buildings. This will be initiated by introducing a stop for installation of oil and natural gas fired boilers in 2013 in new houses and by making it impossible to install oil-driven boilers in existing houses in areas with district heating or natural gas as alternative by 2016.

From paragraph 6.1.8 of this plan it appears that in 2010, 3,831 oil-driven boilers were installed in and outside collective energy supply areas in the municipality. These oil-driven boilers has a total annual fossil energy consumption of 127.78 GWh equivalent to a consumption of fuel-oil of approx. 11,000 ton/year, corresponding to a CO<sub>2</sub>- emission of approx. 34,000 ton per year.

It is recommended that all collective heat supplies launch campaigns towards owners of properties that use oil-driven boilers in areas with collected heat supply, to convert to district heating supply. Outside collective districts heating supply areas and other localities, it is recommended that the property transfers to another type of RE-based heat supply e.g. heating pumps, solar heat or a combination of both.

## 10.6 Effort area

**Increased production of renewable energy by establishing new renewable energy plant**



## 10.6 Action plan 1

### Establishment of a new biogas plant in the municipality

This action is described in the action plan for Covenant of Mayors, see enclosure 3, paragraph 7.

The plans of building a biogas plant is carried out under the auspices of Northern Jutland Bio energy models. To Frederikshavn municipality the construction of a biogas plant is part of a total development strategy with three purposes. These are production of renewable energy in the form of biogas as a sustainable fuel for the heavy transport sector including local collective transport, local development of the agricultural business by creating basis for production of more fattened pigs in order to maintain 1,200 employees at the local slaughterhouse factory.

The biogas plant is dimensioned to deliv-

er 10 mill. m<sup>3</sup> upgraded biogas at natural gas quality, which is then led in to the national natural gas transmission grid and transmitted to locations, where it's needed. If the biogas will only go to fuel supply of heavy on-road transport, the biogas production equals 30 mill km drive of truck and bus.

The biogas plant is planned as a biogas joint plant. The joint plants are known as larger plants with a number of suppliers.

The cooperation between the municipalities, agriculture and the industry the project partners are working on a possible placement of the plant in Frederikshavn municipality. The technical data of the biogas plant are as follows:

- Manure: 300,000 ton/year
- Industrial waste: 30,000 ton/year
- Energy crops: 25,000 ton/year

- Biogas production: 42,000 m<sup>3</sup>/day
- Annual methane production approx. 10 mill m<sup>3</sup>

The biogas can be converted into:

- Power production equivalent to 42 GWh/year together with district heating production of 210,000 GJ/year
- Or approx. 30 mill km drive of truck and bus
- Or another use in the natural gas grid or industry

The biogas plant consists of:

- Storing and gasification tanks
- Closed unloading hall
- Technical room
- Gas cleaning facilities
- Motor or upgrading plant (for removal of CO<sub>2</sub>)

## 10.6 Action plan 2

### Establishment of a new biofuel refinery plant together with the extension of Frederikshavn harbor for supplying sustainable fuel of the maritime sector

From paragraph 6.2 in this plan it appears that the share of the municipal energy consumption for shipping is mapped at 20.15 GWh/year divided on consumption of diesel of 17.64 GWh/year and fuel oil of 2.69 GWh/year. The municipal energy consumption for shipping is calculated by dividing the total Danish consumption for shipping from the energy statistics of the Danish Energy Agency 2010 and then divided to the consumption in the individual municipalities according to population. This is not considered accurate for Frederikshavn municipality as there are 14 large and small harbors in the municipality, including Sæby Harbor, Frederikshavn Harbor, The Naval Station in Frederikshavn and Skagen Harbor.



Based on the above consumption calculation the total municipal CO<sub>2</sub>-emission for shipping is 5,455 ton CO<sub>2</sub>/year.

Frederikshavn Harbor has begun cooperating with foreign partners and Aalborg University on establishing a biofuel refinery in the new extended harbor area in Frederikshavn harbor. In the preliminary project phase the plant will not be able to cover the entire need of the harbor, but the biofuel refinery is planned, so it can produce 50,000–150,000 ton of sustainable fuel per year equivalent to a sustainable energy production of 520–1560 GWh/year.

The reason for this project is, that from January 2015 on, a new EU law steps into force and forces naval ships that sail in the so-called SECA areas in the Baltic Sea, in the North Sea and along the Californian coast must either clean the fuel for sulphur and or change to sulphur free fuel. Frederikshavn Harbor estimates that there is a market for approx. 900,000 ton navy fuel annual in Skagerak and the Northern Kattegat alone. As raw material the bio-

gas refinery plant will be using imported bio waste from the wood industry and forestry from e.g. Russia, the Baltic States, Sweden, Finland or Canada.

With an annual production of biofuel of 50,000–150,000 ton, given that the production displaces an equal amount of fossil fuel oil, the implementation of this initiative will save the environment for CO<sub>2</sub>-emission equivalent to respectively 162,600 ton and 478,800 ton per year. The emission of SO<sub>2</sub> will also be reduced by respectively 610 ton and 1,830 ton per year. The reduction of NO<sub>x</sub> emission is estimated at respectively 305 tons and 915 ton per year. The total CO<sub>2</sub>-emission of Frederikshavn municipality for shipping is set at 5,455 tons CO<sub>2</sub>/year, which means that the implementation of the project will give a reduction of the CO<sub>2</sub>-emission that lies between 29 and 87 times bigger than the annual CO<sub>2</sub>-emission of the municipality according to the statement of the Danish Energy Agency.

Furthermore, Frederikshavn municipality is aware that the shipping company Ste-

na Line is considering use of methanol as fuel for their ships. Due to stronger requirements for emission, many shipping companies are working on finding alternative fuels for their ships. Many shipping companies invest in liquid natural gas, LNG, but Stena Line might choose methanol for their ships. At first Stena will try to convert the ferry Stena Germanica to methanol in 2014. If the test is a success, Stena Line will convert further 24 ships to methanol before 2018 or 2020.

As Ships from Stena Line enters the Frederikshavn harbor, the transition of the shipping company to methanol will affect the CO<sub>2</sub> accounts of the municipality in a positive way. This because the CO<sub>2</sub>-emission figures of the methanol compared to the CO<sub>2</sub>-emission figures for fuel oil for the same energy amount is 11% lower\* and furthermore methanol is free of sulphur.

*\*source: Key figures for CO<sub>2</sub>-emissions, Danish Energy Agency, January 13, 2014.*





10.7 Effort area

Establishing infrastructure to promote sustainable transport in the municipality and in the region



## 10.7 Action plan 1

### Infrastructure for supply of biogas to transport sector

In 2012 Frederikshavn municipality initiated the establishment of a gas for transport-group consisting of representatives from Aalborg and Frederikshavn municipalities, Region Northern Jutland, HMN Natural gas and Northern Jutland traffic company, NT see enclose 6.

The project is divided in two phases and has the following specific objectives:

- To achieve environmental and supply security related profits by exchanging the existing busses in the routes in the cities and in the surrounding area in Frederikshavn municipality (6 busses) with busses driven by alternative sustainable fuel (biogas).
- To achieve environmental and supply security related profits by inserting regional busses on biogas in the corridor Frederikshavn – Aalborg (5 busses). (step 1).
- To make sure that the busses from the beginning have the same operational stability and better environmental output than the current diesel vehicles.
- To contribute to growth and increased employment through competence boost in the education centers of the motor business in Northern Jutland so they can build up know how concerning maintenance and care for gas driven Vehicles.
- That the project attracts more users of the public transport.
- That the partners in this project appear as innovative actors in terms of the spread and use of renewable energy for transport and reduction of environmental strains.

The first phase of the project is about the use of biogas in busses in Frederikshavn

municipality and in the corridor Frederikshavn – Aalborg and establishment of two gas stations in Aalborg and Frederikshavn with the possibility of public access. Phase 2 includes conversion of further public vehicles fleets such as other regional bus routes, city busses in Aalborg or in the other large cities of the region, waste disposal trucks by AVØ in Frederikshavn and in Aalborg municipalities or municipal car and delivery vans from fossil to biogas fuel.

The objective of the project is to establish the first part of a public accessible gas tank network along the Jutlandic Highway (E45) from north to south. Such a network will create a connection to the Swedish and Norwegian gas network and from Aalborg the gas tank network can be extended by establishing more ramifications of gas stations in the North Jutland region and further south to Aarhus.

The first operational phase will be on natural gas or on buying certificated bio gas, until the local biogas plant is commercially in operation.

## 10.7 Action pan 2

### Infrastructure for electrical cars

Since 2008, the municipality has been working on establishing infrastructure and promotion of the use of electrical cars in the municipality. As the first company, the municipal Property Center chose to invest in 5 electrical cars as replacement for an equal number of petrol cars. Likewise, charging stations were established in Frederikshavn and Skagen and installation of charging stations in Sæby is on the way.

Recommendations are that Frederikshavn municipality continues the integration of electrical cars in its fleet. Likewise, it is recommended to increase the number of charging stations in the public room in the

municipality as the need occurs. This paragraph is further described in paragraph 9.7.4 concerning the municipal fleet management.

## 10.7 Action plan 3

### Continuous development of infrastructure to promote bicycling in the municipality

The Municipality of Frederikshavn has prepared a bicycling policy to promote bicycling. That the bicycling policy of Frederikshavn municipality is mentioned in the strategy plan is primarily because promotion of bicycling is considered as an integrated part of the overall transport policy of the municipality and because bicycling has a positive influence on the environmental strain of the municipality, due to the fact that bicycles replace the cars in short city tours. The bicycling policy of the municipality also has the purpose of counteracting the decreasing number of bicycle tours in the cities. Furthermore, the promotion of bicycling has a positive impact on public health and promotes the tourism in the municipality.

The proposal is an addendum (addendum no. 09–23) to the district plan 2009–2020, which has been out to public hearing. The proposal on the municipal bicycling policy includes a declared objective, where specific effort areas have been defined to reach this objective.

It is recommended that the municipal bicycle policy is presented to the Planning and Environment Committee and then the local council for accession, so that the Committee can start the practical implementation of the plan, including budget planning and prioritization of certain effort areas.

10.8 Effort area

Promotion of demonstration projects on renewable energy, Smart grid, wave energy and intelligent lighting



## 10.8. Action plan 1

### Promotion of demonstration projects on renewable energy

One of the conditions to comply with the intentions behind the transition to fossil free municipality and to create competency development and growth during this process is to create a showroom for renewable energy technologies, where the various sustainable technologies can be experienced in the local area. The show room will also be the forum, where the innovative players will gather to get sparring, think innovative, construct and test new technologies for production and distribution of renewable energy.

Innovative players consist of innovative local businesses, business developers, universities, persons from the scientific environment and local education institution, inventors, visionary project makers, energy utility companies, the finance sector and other interested parties, who work in renewable energy technology as a potential business area.

Establishing the innovative forum can support specific renewable energy projects from idea phase to the production of proto types, company foundations, financing and specific business plans. Models for existing effort areas such as wave energy and intelligent lighting can develop their business in the auspices of "the innovative forum".

Paragraph 8.1 of this plan contains recommendations to establishment of an organization that can develop and maintain the strategy plan for renewable energy until 2030. Recommendations are that a representative from the above-mentioned innovative forum takes part in this organization.

## 10.8 Action plan 2

### Initiation and development of smart grid

An interconnected renewable energy system cannot exist without an overall system (smart grid) that is able to coordinate the complete system consisting of many different production plants and various energy products on the one side and just as different energy consumers on the other side. This must be initiated in an intelligent way so that the total system is always in balance and that the security of supply is secured optimally.

Development of operational systems for handling of Smart Grid is complex and therefore, it requires a close cooperation among parties in the energy sector and the scientific environment. Furthermore, Smart Grid contains considerable potentials for growth and competency development. There is no doubt that the operational systems for Smart Grid will be requested in the near future.

A possible effort within development of Smart Grid must be launched based on the existing infrastructure of the energy systems and further developed, as more and more renewable energy systems are continuously integrated in the existing Grid. The utilization of the national electricity grid as it is carried out today, is a good example of establishment of a Smart Grid in the electricity grid in the introductory phase<sup>1)</sup>, as the electricity is produced on CHP-plants, Power heated plants, wind power turbines, hydro plants and solar cell plants in all sizes all over Europe. This is distributed in a way, so there is access to electricity 24 hours a day all year round no matter how much electricity is produced and how much is consumed.

<sup>1)</sup> Why Smart Grid on the electricity grid is considered in the introductory phase is i.e. because there are still challenges with the utilization of surplus power from wind power turbines in an operational optimum way. Furthermore, the integration of power driven Vehicles in the electricity grid is not yet complete and with the rate settlement and utilization of surplus heat by each consumer is not finally developed. On top of this comes that the Smart Grid of the electricity grid must be integrated in an overall Energy Smart Grid so all other types of energy than power can be handled in the same system.

With its heat and CHP-plants, power supply companies, wind power turbines, solar cell and solar heating systems, a possible bio gas plant and the existing innovative energy network in cooperation with the other parties working in the growth track Energy, Frederikshavn municipality as geographical limit has the right conditions to be part of a cooperation. This cooperation should develop holistic systems for energy Smart Grid in favor of growth and competency development for the local society as a bonus.

## 11. Expected results in 2030

With the strategy plan Frederikshavn Municipality has set up a number of objectives for transition to renewable energy and reduction of environmental strain including CO<sub>2</sub> until 2030. Likewise, the expected 2030 results for conversion to renewable energy are quantified in this paragraph.

Apart from the environmental impact this paragraph will also try to make the effect of growth and increased employment potential in the municipal energy growth track probable by implementing the action plans described in paragraph 10.

### 10.1 Effort area 1a

**Integration of renewable energy in all municipal climate and energy planning including town planning, municipal planning, district plans in urban and rural districts**

Integration of renewable energy in the municipal climate and energy planning including heat planning, sustainable urban development, municipal plans, district plans in rural and urban areas will include solutions with less CO<sub>2</sub> strain than conventional municipal planning.

#### Environmental impact:

The statement of the environmental effect is connected with a high degree of uncertainty. It is however, estimated that the municipal requirements on less CO<sub>2</sub> strain in connection with e.g. new con-

struction and renovation and traffic planning will contribute to reduction of the total CO<sub>2</sub>-emission in Frederikshavn municipality by 1%, which equals an annual CO<sub>2</sub> saving in the municipality of 5,470 ton per year.

#### The impact on growth and employment related potential:

This action plan does not have a direct growth and employment related potential as the plan suggests, that the organization for maintenance of the municipal strategy plan will be established with participation from employees in the existing organization.

### 10.1.1a Action plan 1

**Establishment of organization and cross-disciplinary cooperation**

#### Environmental impact:

This action plan has no direct quantifiable environmental impact. Establishment of municipal organization and cross-disciplinary cooperation is considered necessary for the further municipal work on creating a joint understanding of the vision and the objectives for strategic energy planning and conversion from fossil to renewable energy in the municipality. It is important that the municipality allocates the necessary resources in the area.

#### The impact on growth and employment related potential:

This action plan does not have a direct growth and employment related potential, as the plan suggests that the organ-

ization for maintenance of the municipal strategy plan will be established with participation from employees in the existing organization.

### 10.1.1a Action plan 2

**Implementation of Covenant of Mayors Action plan**

#### Environmental impact:

According to agreement with the EU mayor secretariat Frederikshavn municipality's action plan will be updated once every year in December, see enclosure 3, the Covenant of Mayors Action plan revised, November 2013. By the end of November 2013 the Covenant of mayors action plan represented an energy saving of 96,351 MWh, integration of renewable energy in existing energy supply of 770,609 MWh and an CO<sub>2</sub> saving of 287,334 ton until 2020. The CO<sub>2</sub> saving equals a reduction of 48% of the total CO<sub>2</sub>-emission of the municipality in 2007.

The result of the follow-up on the Covenant of Mayors action plan in November appears in enclosed addendum 3.

In March 2014, the municipal Planning and Environment Committee chose to leave out three onshore wind power turbines in the new draft for the municipal plan, which means that the above values with the exception of objective for energy savings must be revised at the end of 2015.

The environmental effect of the imple-

mentation of the Covenant of Mayors action plan is not included in this plan, as the action plans in the Covenant of Mayors

Action plan have been up-scaled to the 2030 objectives of the municipality and therefore the environmental effects are calculated separately.

#### The effect of growth and employment related potential:

The effect of growth and employment related potential by implementation of the Covenant of Mayors Action plan has not been included in this plan, as the action plans in the Covenant of Mayors have been up-scaled to the 2030 objectives of the municipality and therefore they will be calculated separately.

#### 10.1.1b Action plan 1

##### Extension of district heating grid in urban area

The Danish Ministry of Climate, Energy and Building launched an objective for phasing out oil-driven boilers by 2017. From paragraph 6.1.8 in the plan it appears that in the municipality there are 3,831 oil-driven boilers with a total energy consumption of 127.78 GWh/year. In paragraph 5, page 13 of the plan the CO<sub>2</sub>-emission of fuel oil is stated as 266.4 kg/MWh. Existing oil-driven boilers in the municipality contributes with emission equivalent to 34,040 ton CO<sub>2</sub> per year.

#### Environmental impact:

In the following it is estimated that 40% of the mapped oil-driven boilers (approx. 1,530 pcs.) are used in district heating areas and that, the remaining 60% (2,300 pcs.) are used in the peripheral region outside public heat supply.

If we estimate that 60% of the existing oil-driven boilers in the peripheral areas are Converted into district heating and the remaining 40% are Converted to heat pumps (COP-value =3.5) it will result in a CO<sub>2</sub> saving of approx. 8,100 ton per year.

To existing oil-driven boilers in the peripheral areas it is estimated that 70% will be converted to boiler with biomass as fuel and 30% to heat pumps. This gives a CO<sub>2</sub> saving of 21,170 ton per year.

With the above conditions the total CO<sub>2</sub> saving in this action plan will be assessed to approx. 29,170 ton per year equivalent to a reduction of 85.7%.

The share of renewable energy by the use of biomass is assessed to 53.67 GWh/year. The share of renewable energy by the use of 28% renewable power for operation of heat pumps is calculated to 8.8 GWh per year.

#### The effect on growth and employment related potential:

No increase in employment is expected by the implementation of this initiative, as the existing heat contractors will handle the work with their current staff.

#### 10.1.1b Action plan 2

##### Change of natural gas supply areas to district heating or renewable energy supply areas

From paragraph 6.2.1 in the report it appears that private households annually consume 6,570,830 m<sup>3</sup> natural gas for house heating purposes. Examples are the towns in the settlement areas such as Gærum, Elling, Jerup, Hulsig, Ålbæk and the local settlement peripheral areas such as Kilden, Haldbjerg, Vangen and the area

vest of Suderbovej and Knivholtvej in the city of Frederikshavn, where the areas are supplied with natural gas based on individual gas boiler units.

The total natural gas consumption in private households contributes with a CO<sub>2</sub>-emission equivalent to 14,777 ton/year.<sup>1)</sup>

1) Standard values for heating values and CO<sub>2</sub>-emissions – reporting of CO<sub>2</sub>-emission for 2013. The Danish Energy Agency, January 13th 2014. (Heating value for natural gas: 0.0396 GJ/Nm<sup>3</sup>. Emission factor for natural gas: 56.79 ton/TJ must be used).

#### Environmental impact:

By transition to 100% renewable energy the CO<sub>2</sub> saving will be at 14,777 ton/year.

#### The effect on growth and employment related potential:

There are no reliable data for statement of the employment related potential.

#### 10.1.1b Action plan 3

##### Gradual phasing-out of natural gas consumption in favor of producing renewable energy

The government has launched, that the use of fossil fuels (including natural gas) for power and heat production must be phased out by 2035 and the entire energy consumption in Denmark must be covered by renewable energy in 2050.

The total natural gas consumption in the municipality is calculated to 95,076,600 m<sup>3</sup> equivalent to 1,041.8 GWh. The natural gas consumption stands for 40.2% of the total energy consumption in the municipality. Heat and CHP-plants uses 52,156,983 m<sup>3</sup> (574.5 GWh) equivalent to 55.13% of the total natural gas consumption

**Environmental impact:**

By transition to 100% renewable energy the CO<sub>2</sub> saving will be 14,777 ton/year.

**The effect on growth and employment related potential:**

There are no reliable data for statement of the employment related potential.

10.1.1b Action plan 4

**Extension of the plan for wind power on shore and offshore in the municipality**

**Plan for wind power turbines onshore**

According to the Covenant of Mayors action plan the municipality has prepared a short-term (3-5 year) strategy plan for putting up wind power turbines onshore indicating that installation of wind power turbines equivalent to an annual power production of 247,900 MWh per year was planned. (Plan for 23,700 MWh/year in Højstrup has been implemented). In March 2014, the municipal Planning and Environment Committee revised the plan with the result that three onshore wind turbine areas were taken out the plan.

The revised strategy plan of the municipality on installation of wind power turbines onshore shows that the potential for putting up wind power turbines in the municipality equals 247,900 <sup>1)</sup> MWh per year see the Covenant of Mayors page 13. After 2020 the expected extension far more uncertain and therefore it has been calculation technically estimated that the capacity of putting up wind power turbines onshore will be kept constant. This however, means that the production will continue to increase because old wind power turbines are replaced by new and more efficient.

<sup>1)</sup> In the original wind turbine plan of the municipality the expected production of power was set at 247,900 MWh per year even though

*the assessment does not include power production from three planned wind turbine areas (the East coast road, Kærskov and Faurholt). On the contrary, since the publishing of the plan, three areas for wind power turbines have been appointed (Kvissel brænding, Tamholt and Donsted). This together with an expected increase of the efficiency of the new wind power turbines is the reason why this plan is still working with the original production figures in the wind turbine plan of the municipality of 247,900 MWh per year.*

**Coastal wind power turbines by Hirsholmene**

A local work group is working on realizing the installation of 6 coastal offshore wind power turbines by Hirsholmene. (4 pcs. 8 MW + 2 pcs. 3.3 MW). The implementation of the plan will contribute with a total power production of 136,100 MWh/year.

**Coastal wind power turbines 4 km from the coast of Sæby**

The sea outside Sæby is appointed as potential offshore wind park. Maximum capacity of the construction in the area is set to 200 MW. A local working group is working on realizing the construction of a 150 MW offshore wind park 4 km outside the coast of Sæby. Preliminary calculations show that the construction of the wind power park in the sea outside Sæby can contribute with an annual power production of 528,900 MWh

**Coastal wind power turbines in connection with the extension of Frederikshavn harbor**

In connection with the extension of Frederikshavn Harbor, it will be possible to put up 5 pcs. 3.6 MW coastal wind power turbines in continuation of the extension plan for Frederikshavn Harbor. The construction of wind power in Frederikshavn harbor area can contribute with an annual power production of 64,000 MWh.

**Environmental impact:**

Based on the short-term plans for construction of wind power turbines in the municipality mentioned in this action

plan (10.1.b.4), the total power production of the wind power turbines is assessed at 976.9 GWh/year, which equals 41.7% of the fossil energy consumed in the municipality in 2010:

**CO<sub>2</sub>-savings:**

$$(976.9 \text{ GWh} \times 303 \text{ ton CO}_2/\text{GWh}^*) = 296,000 \text{ ton CO}_2/\text{year}$$

**SO<sub>2</sub>-savings:**

$$(976.9 \text{ GWh} \times 60 \text{ ton SO}_2/\text{GWh}^{**}) = 58,614 \text{ ton SO}_2/\text{year}$$

**NO<sub>x</sub>-savings:**

$$(976.9 \text{ GWh} \times 250 \text{ ton NO}_x/\text{GWh}^{**}) = 244,225 \text{ ton NO}_x/\text{year}$$

<sup>\*</sup>See the paragraph for emission for power consumption in paragraph 5 page 12 of this plan.

<sup>\*\*</sup>SO<sub>2</sub> (sulphur dioxide) and NO<sub>x</sub> (nitrogen oxide) are not greenhouse gasses, but are important environmental pollution gasses.

**The effect on growth and employment related potential:**

Currently there are no official estimations of the socio-economic impacts by putting up wind power parks. In June 2013 the trade council of the labor movement prepared the report (employment effect) of the new coastal wind power parks, in which calculations have been made through the ADAM method combined with interview with DONG Energy, international experiences from European Wind Energy Associations. The report concludes that set up of 400 MW coastal wind power turbines will generate almost 8,000 jobs, accumulated in the period from 2015 to 2020.

Given, that 150 MW coastal wind power turbines will be established in Frederikshavn municipality during the same period (2015-2020) and based on the estimations in the report from the trade council of the labor movement, it will generate work for 3,000 full time employees for 5 years.

The service life for the two near shore is estimated 25 years. The employment po-

tential in the operational phase of 25 years will give employment to between 26 and 37 (average 31) full time employees.

#### 10.2 Action plan 1

##### Continuous reduction of energy consumption in municipal building mass

According to paragraph 10.2 in this plan Frederikshavn municipality as company has prepared an energy efficiency plan for municipal properties until 2030, that shows that the implementation of the plan will contribute with a reduction of heat consumption equivalent to 7,357 MWh per year and a reduction of power consumption equivalent to 2,284 MWh per year.

##### Environmental impact:

Implementation of the municipal energy efficiency plan for the municipal properties until 2030 will reduce the municipal CO<sub>2</sub>-emission by 5,368 ton per year.

##### The effect on growth and employment related potential:

The municipal Property Center informs that the center counts on investing an average of 13 mill DKK per year for maintenance of the municipal properties. Based on this information there will be a total investment of 221 mill DKK until 2030.

The implementation of the action 10.2.1 will generate new jobs equivalent to 24.3 full time employees per year. The total employment related potential for the planning period (2014-2030) thereby amounts to 413 full time employees.<sup>1)</sup>

<sup>1)</sup> Source: According to key figures from Danish Construction Association the potential for increased employment will amount to 1,500 new jobs for each billion DKK investment in new build and 1,870 jobs for each billion DKK invested in renovation.

#### 10.2 Action plan 2

##### Continuous integration of renewable energy in connection with new build, renovations and maintenance of municipal properties

##### Environmental impact:

Is included in the statement of the action plan 10.2.1

##### The effect on growth and employment related potential:

The municipal Property Center informs that the center is counting on investing an average of 6 mill DKK for energy initiatives in connection with renovation in the plan period (2014-2030).

The implementation of action plan 10.2.2 will generate new jobs equivalent to 10.8 full time employees per year. The total employment related potential for the plan period (2014-2030) thereby amounts 413 full time employees.<sup>2)</sup>

<sup>1)</sup> Source: According to the employment multiplier of the Danish Construction Association based on the latest employment multiplier from Statistics Denmark the potential for increased employment equivalent to 1,450 new jobs divided in 850 jobs directly in construction and 600 in sideline businesses for each billion DKK investment in new build. According to the same source renovations will generate 1,860 new jobs divided on 1,430 direct in construction and 430 in sideline businesses for each billion DKK invested in renovation.

#### 10.2 Action plan 3

##### Implementation of fleet management of the municipal fleet of cars

The municipal Financial Committee and the executive board decided to introduce fleet management in Frederikshavn Municipality, which is very appropriate, knowing that the municipality has a fleet of 256 vehicles including 116 cars and also

knowing that the municipality paid 12.2 mill DKK in mileage allowance in 2013 of these 8.6 mill DKK at high rate.

The fleet of municipal consumes 368,000 liters diesel and 47,000 liters petrol. The consumption of diesel and petrol gives a total CO<sub>2</sub>-emission of 1,090 ton CO<sub>2</sub>/year.

##### Environmental impact:

Currently there are no national figures on CO<sub>2</sub> savings by establishing fleet management, but English surveys\* show that establishing fleet management has contributed to a reduction in CO<sub>2</sub> of at least 15%. Apart from this there will be a reduction of NO<sub>x</sub> and particles, but these are not included in the equivalent CO<sub>2</sub> savings. According to the survey from United Kingdom, the reduction of CO<sub>2</sub> occurred by the introduction of systematic service maintenance, ECO driving courses and route planning as the bearing elements in fleet management.

\*Source: Energy Saving Trust, Fleet management September 2012 UK

Based in the above the Establishment of fleet management for municipal vehicles will contribute to a reduction of CO<sub>2</sub>-emission from the municipal car fleet of 163.5 ton per year.

##### The effect on growth and employment related potential

The necessary resources are already found in existing organization.

#### 10.2 Action plan 4

##### Implementation of holistic, sustainable purchase policy in the municipality as company

##### Environmental impact:

Currently there are no reliable statements of the environmental effect by sustainable purchase apart from the field of application transport.

### The effect on growth and employment related potential:

The resources are found in already existing organization.

#### 10.3 Action plan 1

##### Energy renovations and energy savings in private houses

Private houses stand for 31% of the total power consumption of the municipality, 75% of the total district heating consumption and 7% of the total natural gas consumption.

The statements of the Energy City on the energy saving efforts in the municipality in private houses for 2012 show that there is still potential for heat savings in existing houses, corresponding to 2,100 MWh heat per year and 3.6 MWh power per year in the period 2014–2020.

##### Environmental impact:

###### By reduced district heating consumption:

CO<sub>2</sub>-savings:

$$(2100 \text{ MWh/år} \times 0.122 \text{ ton CO}_2/\text{MWh}^*) = 256.2 \text{ ton CO}_2/\text{year}$$

SO<sub>2</sub>-savings:

$$(2100 \text{ MWh} \times 0.1 \text{ ton SO}_2/\text{MWh}^{**}) = 210.0 \text{ ton SO}_2/\text{year}$$

NO<sub>x</sub>-savings:

$$(2100 \text{ MWh} \times 0.35 \text{ ton NO}_x/\text{MWh}^{**}) = 735 \text{ ton NO}_x/\text{year}$$

###### By reduced power consumption:

CO<sub>2</sub>-savings:

$$(3.6 \text{ MWh} \times 0.303 \text{ ton CO}_2/\text{MWh}^*) = 1.09 \text{ ton CO}_2/\text{year}$$

SO<sub>2</sub>-savings:

$$(3.6 \text{ MWh} \times 0.06 \text{ ton SO}_2/\text{MWh}^{**}) = 0.216 \text{ ton SO}_2/\text{year}$$

NO<sub>x</sub>-savings:

$$(3.6 \text{ MWh} \times 0.25 \text{ ton NO}_x/\text{MWh}^{**}) = 0.90 \text{ ton NO}_x/\text{year}$$

<sup>\*)</sup> See paragraph for emission on power consumption in paragraph 5 page 12 of this plan.

<sup>\*\*)</sup> SO<sub>2</sub> (sulphur dioxide) and NO<sub>x</sub> (nitrogen oxide) are not greenhouse gasses, but important environmental pollution gasses.

### The impact on growth and employment related potential:

From the statement of the Energy City on energy saving efforts performed by private property owners it appears, that in 2012 energy savings initiatives equivalent to 969 MWh were implemented and investments at 10,044,134 DKK were made to achieve these energy savings. From the above experience figures, estimation is that in order to achieve energy savings of 700 MWh per year in the private housing sector, investments must be made for 7,250,000 DKK per year (the annual investment amount is not index-regulated for the years up till 2020)<sup>1)</sup>.

The employment related potential is estimated to 14 full time employees per year.<sup>1)</sup>

<sup>1)</sup> Source: According to the employment multiplier of the Danish Construction Association based on the latest employment multiplier from Statistics Denmark the potential for increased employment equivalent to 1,450 new jobs divided in 850 jobs directly in construction and 600 in sideline businesses for each billion DKK Investment in new build. According to the same source renovations will generate 1,860 new jobs divided on 1,430 direct in construction and 430 in sideline businesses for each billion DKK invested in renovation.

#### 10.4 Action plan 1

##### Energy renovation of common houses by Frederikshavn Housing Association

From the energy policy of the Housing association it appears that the housing association has an objective of reducing its heat consumption by 75% in 2020, compared to the consumption in 2010 and of reducing its power consumption by 75% in 2030, compared to the power consumption in 2010. As many of the tenants of the housing association settle their energy consumption with the energy supply companies, a quantification of the energy measures of the association will be executable when energy consumption data for all housing units in the association

are available. This will be realized in 3rd quarter of 2013.

##### Environmental impact:

Frederikshavn Housing Association is working on introducing energy management in all its departments. If the short-term heat and power saving effort according to the Covenant of Mayors Action plan for the period 2013–2015 is used, the short-term environmental impact will be assessed at:

###### By reduced district heating consumption:

CO<sub>2</sub>-savings:

$$(1,194 \text{ MWh/år} \times 0.122 \text{ ton CO}_2/\text{MWh}^*) = 145.7 \text{ ton CO}_2/\text{year}$$

SO<sub>2</sub>-savings:

$$(1,194 \text{ MWh} \times 0.1 \text{ ton SO}_2/\text{MWh}^{**}) = 119.4 \text{ ton SO}_2/\text{year}$$

NO<sub>x</sub>-savings:

$$(1,194 \text{ MWh} \times 0.35 \text{ ton NO}_x/\text{MWh}^{**}) = 418 \text{ ton NO}_x/\text{year}$$

###### By reduced power consumption:

CO<sub>2</sub>-savings:

$$(578 \text{ MWh} \times 0.303 \text{ ton CO}_2/\text{MWh}^*) = 175 \text{ ton CO}_2/\text{year}$$

SO<sub>2</sub>-savings:

$$(578 \text{ MWh} \times 0.06 \text{ ton SO}_2/\text{MWh}^{**}) = 34.7 \text{ ton SO}_2/\text{year}$$

NO<sub>x</sub>-savings:

$$(578 \text{ MWh} \times 0.25 \text{ ton NO}_x/\text{MWh}^{**}) = 144.5 \text{ ton NO}_x/\text{year}$$

<sup>\*)</sup> See paragraph for emission on power consumption in paragraph 5 page 12 of this plan.

<sup>\*\*)</sup> SO<sub>2</sub> (sulphur dioxide) and NO<sub>x</sub> (nitrogen oxide) are not greenhouse gasses, but important environmental pollution gasses.

For the period 2014–2020 the housing association has planned housing renovation projects including energy renovation for 1 billion DKK. Currently there are no key figures that show the energy savings potential per DKK Investment by energy renovations, but energy renovation have been performed in 2 of the departments (Vinkelgården and Bakkegården), where specific calculations of the Investment amount and achieved energy savings<sup>\*\*\*)</sup> have been assessed.



\*\*\*) Please note that there are many factors that influence the impact of energy savings by renovation projects in the various departments of the associations, depending on what specific department it is. The preparation of key figures on specific renovation projects is therefore most credible in each specific department. The preparation of key figures based on this are therefore connected with high uncertainty and only have the purpose of making the size of the environmental impact visible.

Based on the two mentioned projects following key figures have been prepared:

**A: Vinkelgården** (energy renovation of 66 house units for 88 mill DKK)

*Heat saving:*

2.58 MWh/mill DKK Investment

*Power saving:*

0.307 MWh/mill DKK Investment

**B: Bakkegården** (energy renovation of 100 house units for 150 mill DKK).

*Heat saving:*

1.02 MWh/mill DKK Investment

*Power saving:*

0.78 MWh/mill DKK Investment

- Average key figure for heat savings is assessed at 1.8 MWh/mill DKK Investment
- Average key figure for power savings is assessed at 0.54 MWh/mill DKK Investment

With an Investment of 1 billion DKK until 2020 the environmental effect is assessed as follows:

*Varmebesparelse:*

**CO<sub>2</sub>-savings:**

$(1.8 \text{ MWh/mill DKK} \times 103 \times 0.122 \text{ ton CO}_2/\text{MWh}) = 219.6 \text{ ton CO}_2/\text{year}$

**SO<sub>2</sub>-savings:**

$(1.8 \text{ MWh/mill DKK} \times 103 \times 0.1 \text{ ton SO}_2/\text{MWh}^{**}) = 180.0 \text{ ton SO}_2/\text{year}$

**NO<sub>x</sub>-savings:**

$(1.8 \text{ MWh/mill DKK} \times 103 \times 0.35 \text{ ton NO}_x/\text{MWh}^{**}) = 630 \text{ ton NO}_x/\text{year}$

**By reduced power consumption:**

**CO<sub>2</sub>-savings:**

$(0.54 \text{ MWh/mill} \times 103 \times 0.303 \text{ ton CO}_2/\text{MWh}^*) = 163.6 \text{ ton CO}_2/\text{year}$

**SO<sub>2</sub>-savings:**

$(0.54 \text{ MWh/mill} \times 103 \times 0.06 \text{ ton SO}_2/\text{MWh}^{**}) = 32.4 \text{ ton SO}_2/\text{year}$

**NO<sub>x</sub>-savings:**

$(0.54 \text{ MWh/mill} \times 103 \times 0.25 \text{ ton NO}_x/\text{MWh}^{**}) = 135.0 \text{ ton NO}_x/\text{year}$

<sup>\*)</sup> See paragraph for emission on power consumption in paragraph 5 page 12 of this plan.

<sup>\*\*)</sup> SO<sub>2</sub> (sulphur dioxide) and NO<sub>x</sub> (nitrogen oxide) are not greenhouse gasses, but important environmental pollution gasses.

**The impact on growth and employment related potential:**

From the action plan of Covenant of Mayors it appears that Frederikshavn Housing Association has a budget for heat and power saving efforts for the period 2013–2015 equivalent to 430,150,000 DKK.

In an approved review for the year 2013–2014 the board of the housing association has prepared renovation projects for 1 billion DKK probable until 2020. Currently the housing association has no plans of constructing new builds, it but expects an upcoming demand for new builds within a couple of years.

Based in the plan for renovation of the housing association until 2020 the employment related potential is assessed to 1,860 full time employees in 6 years <sup>1)</sup>.

<sup>1)</sup>Source: According to the employment, multiplier of the Danish Construction Association based on the latest employment multiplier from Statistics Denmark the potential for increased employment equivalent to 1,450 new jobs divided in 850 jobs directly in construction and 600 in sideline businesses for each billion DKK Investment in new build. According to the same source renovations will generate 1,860 new jobs divided on 1,430 direct in construction and 430 in sideline businesses for each billion DKK invested in renovation.

10.4 Action plan 2

**Energy renovation of public houses by the housing association Vesterport**

From the Covenant of Mayors action plan it appears that the housing association Vesterport has specific action plans for the period 2013–2020 with a total investment need of 794,000,000 DKK.

The total district heating savings are assessed at 2,820 MWh/year.

The use of heating pumps generated additional consumption of power equivalent to 185.84 MWh per year.

**By 280 MWh power production via solar cells:**

**CO<sub>2</sub>-savings:**

$(280 \text{ MWh} \times 0.303 \text{ ton CO}_2/\text{MWh}^*) = 84.8 \text{ ton CO}_2/\text{year}$

**SO<sub>2</sub>-savings:**

$(280 \text{ MWh} \times 0.06 \text{ ton SO}_2/\text{MWh}^{**}) = 16.8 \text{ ton SO}_2/\text{year}$

**NO<sub>x</sub>-savings:**

$(280 \text{ MWh} \times 0.25 \text{ ton NO}_x/\text{MWh}^{**}) = 70.0 \text{ ton NO}_x/\text{year}$

**Additional consumption of power for heat production through heat pumps:**

**CO<sub>2</sub>-savings:**

$(185.8 \text{ MWh} \times 0.303 \text{ ton CO}_2/\text{MWh}^*) = 56.3 \text{ ton CO}_2/\text{year}$

**SO<sub>2</sub>-savings:**

$(185.8 \text{ MWh} \times 0.06 \text{ ton SO}_2/\text{MWh}^{**}) = 11.1 \text{ ton SO}_2/\text{year}$

**NO<sub>x</sub>-savings:**

$(185.8 \text{ MWh} \times 0.25 \text{ ton NO}_x/\text{MWh}^{**}) = 46.4 \text{ ton NO}_x/\text{year}$

**By reduced district heating consumption:**

**CO<sub>2</sub>-savings:**

$(2,820 \text{ MWh}/\text{år} \times 0.122 \text{ ton CO}_2/\text{MWh}^*) = 334 \text{ ton CO}_2/\text{year}$

**SO<sub>2</sub>-savings:**

$(2,820 \text{ MWh} \times 0.1 \text{ ton SO}_2/\text{MWh}^{**}) = 282 \text{ ton SO}_2/\text{year}$

**NO<sub>x</sub>-savings:**

$(2,820 \text{ MWh} \times 0.35 \text{ ton NO}_x/\text{MWh}^{**}) = 987 \text{ ton NO}_x/\text{year}$

<sup>\*)</sup> See paragraph for emission on power consumption in paragraph 5 page 12 of this plan.

<sup>\*\*)</sup> SO<sub>2</sub> (sulphur dioxide) and NO<sub>x</sub> (nitrogen oxide) are not greenhouse gasses, but important environmental pollution gasses.

**Environmental impact:**

CO<sub>2</sub>-savings:  
 ((334+84.4) – 56.3) = 362 ton CO<sub>2</sub>/year

SO<sub>2</sub>-savings:  
 ((282+16.8) – 11,1) = 288 ton SO<sub>2</sub>/year

NO<sub>x</sub>-savings:  
 ((987+70) – 46.6) = 1.010 ton NO<sub>x</sub>/year

**The effect for growth and employment related potential:**

Based on Investment for 794 mill. DKK until 2020 the employment related potential is assessed to 1,448 full time employees in the period 2013–2020.<sup>1)</sup>

<sup>1)</sup>Source: According to the employment, multiplier of the Danish Construction Association based on the latest employment multiplier from Statistics Denmark the potential for increased employment equivalent to 1,450 new jobs divided in 850 jobs directly in construction and 600 in sideline businesses for each billion DKK Investment in new build. According to the same source renovations will generate 1,860 new jobs divided on 1,430 direct in construction and 430 in sideline businesses for each billion DKK invested in renovation.

10.5 Action plan 1

**Increased use of renewable energy in the district heating production**

**Environmental impact:**

**A: Sæby heating plant:**

Establishment of 6,350 MWh solar heat, replaces 1.35 mill. m<sup>3</sup> natural gas consumption.

CO<sub>2</sub> savings: 2,950 ton/year

RE-contribution: 6,350 MWh/year

**B: Strandby heating plant:**

Establishment of 1,790 MWh solar heat, replaces 165.670 m<sup>3</sup> natural gas consumption.

CO<sub>2</sub> savings: 362 ton/year

RE-contribution: 1,790 MWh/year

**C: Voerså district heating:**

Reduction of transmission loss from 33% to 22% gives an annual natural gas saving of 88,000 m<sup>3</sup>/year

CO<sub>2</sub> savings: 175 ton/year

**D: Frederikshavn Supply:**

**D1:** Utilization of surplus heat from MANequivalent to a saving of natural gas consumption of 7,000 MWh/year.

CO<sub>2</sub> displacement: 110.42 ton/year.

Investment need: 6 mill. DKK <sup>1)</sup>

<sup>1)</sup> The standard values of the Danish Energy Agency for heating values and CO<sub>2</sub>-emissions, Danish Energy Agency January 13, 2013.

**D2:** Establishment of seawater based heat pump, energy savings: 56,000 MWh,

CO<sub>2</sub> savings: 12,475 ton/year.

Investment need: 85 mill DKK <sup>2)</sup>

**D3:** D3: Delivery of district heating to the naval station Frederikshavn, energy savings: 3,750 MWh,

CO<sub>2</sub> savings: 487 ton/year

Investment need: 1 mill. DKK <sup>2)</sup>

**D4:** Construction of wood chip fired central heating plant for district heating supply of the Elling, energy savings: 26,000 MWh/year of which 12% integrated renewable energy in the project equivalent to 3,120 MWh/year.

CO<sub>2</sub> savings: 6,000 ton/year

Investment need: 40 mill. DKK <sup>2)</sup>

<sup>2)</sup>Calculations are made by Frederikshavn supply A/S

**E: Skagen heating plant**

**E1:** Extension of the supply areas of the plant <sup>3)</sup>.

<sup>3)</sup>Today Skagen District heating plant supplies 70% of Skagen with district heating.

**E2:** Conversion of natural gas supplied harbor area to district heating supply.

**E3:** Inclusion of wind turbine power for production of district heating.

**E4:** Further utilization of industrial surplus heat for district heating supply.

**E5 :**Operation optimization of production plant, transmission plant and distribution plant.

**E6 :**Operation optimization by the end users of the district heating.

**E7 :**Continuous reduction of the natural gas consumption of the plant equivalent to 10% of the natural gas consumption in 2006 equivalent to 1 mill. m<sup>3</sup> until 2017.

CO<sub>2</sub> savings: 2,249 ton/year. <sup>4)</sup>

<sup>4)</sup>The standard values of the Danish Energy Agency on the heating value and CO<sub>2</sub>-emissions, the Danish Energy Agency January 13, 2014.

**F: Interoperation of district heating plants Hørby, Thorshøj and Østervrå:**

Interoperation of the transmission grid of these three district heating plants caused that 97% of the need for heat in Thorshøj and 46% of the need for heat in Østervrå can be delivered as district heating produced on straw by Hørby heating plant.

The implementation of the project means that the CO<sub>2</sub>-emission from Thorshøj and Østervrå heating plants will be reduced from existing 9000 ton per year to 4000 ton per year.

**The impact on growth and employment related potentials:**

16 full time employees in three months.

10.5 Action plan 2

**Phasing out oil-driven heating plant in public heat supply areas and construction of RE based individual heating.**

See the action plan of this paragraph 10.1.1b.

**Environmental impact:**

See the action plan of this paragraph 10.1.1b

**The impact on growth and employment related potential.**

## 10.6 Action 1

**Construction of a new biogas plant in the municipality**

Production capacity of 10 mill. upgraded biogas.

**Environmental impact:**

Production of biogas is estimated to displace an equivalent amount of natural gas consumption in the municipality.

CO<sub>2</sub> savings: 22,488 ton/year.

Renewable energy production: 110,000 MWh per year<sup>4)</sup>

<sup>4)</sup>The standard values of the Danish Energy Agency on heating values and CO<sub>2</sub>-emissions. The Danish Energy Agency January 13, 2014.

**The impact on growth and employment related potential:**

*Construction phase:* 11 full time employees in one year.

*Operational phase:* : 10 full time employees, incl. transport of organic fertilizer + 5 indirectly employed – a total of 15 persons.

## 10.6 Action plan 2

**Construction of a new bio refinery in connection with the extension of Frederikshavn Harbor for fuel supplying of the maritime sector****Environmental impact:**

By an annual production of 50,000 tons biofuel oil per year:

CO<sub>2</sub> savings: 157,315 ton/year<sup>1)</sup>

By an annual production of 150,000 ton biofuel oil per year:

CO<sub>2</sub> savings: 471,950 ton/year<sup>1)</sup>

<sup>1)</sup>The standard values of the Danish Energy Agency on heating values and CO<sub>2</sub>-emissions. "Fuel-oil used in other sectors than CHP-plants", heating value: 40.65 GJ/ton, CO<sub>2</sub>-emission: 77.4 ton/TJ, the Danish Energy Agency January 13, 2014.

**The impact on growth and employment related potential:**

*The construction phase (estimated):* 10 full time employees for a year

*The operational phase (estimated):* 10 persons + 5 indirectly employed – a total of 15 persons

## 10.7 Action plan 1

**Development of infrastructure for biogas to the transportation sector****Environmental effect:**

*Phase 1: CO<sub>2</sub> savings: 158.5 ton/year*

*Phase 1+2: CO<sub>2</sub> savings: 2,889.7 ton/year<sup>2)</sup>*

<sup>2)</sup>Calculation of the energy consumption and emission of CO<sub>2</sub> is based on results from "Alternative fuels", Danish Energy Agency, May 2013. See the gas for transport project "Analysis on financial and environmental matter by the implementation of the project", the Energy city.

**The impact on growth and employment related potential:**

So far, the actor is stalling unmanned filling stations.

## 10.7 Action plan 2

**Development of infrastructure for electrical cars**

In Frederikshavn municipality, the transport sector stands for 25% of the total energy consumption and 32% of the total CO<sub>2</sub>-emission in the municipality as geographical border. From the government's energy agreement, it appears that the

share of renewable energy in the transport sector should be increased to 10% in 2020.

It is recommended, that Frederikshavn municipality integrates the establishment of infrastructure for electrical vehicles in municipal planning.

**Environmental impact:**

Currently is not measurable.

**The impact on growth and employment related potential:**

There will be no considerable impact on growth and employment related potential.

## 10.7 Action plan 3

**Further development of infrastructure and promotion of cycling****Environmental impact:**

Currently is not measurable.

**Impact on growth and employment related potential:**

There will be no considerable impact on growth and employment related potential.

## 10.8 Action plan 1 and 2

**Promotion of demonstration projects for renewable energy, Smart Grid, wave energy and intelligent lighting.**

Energy cities are also characterized by demonstrating innovative renewable energy technologies that make the energy cities capable of participating in development or further development of the future energy technologies and business models for later commercialization and marketing.

Without initiation of demonstration projects, local energy companies will have difficulties taking part in the technology development that will help generate competency development and create growth for these companies and therefore it is important to make the local companies interested in these demonstration projects by initiating demonstration projects.

Today, not all types of energy companies, that are represented in the local community and therefore it will always be possible cooperate across municipal, regional and even country borders. The main agenda is, that the cross-disciplinary cooperation brings new value to the companies, educational institutions etc. of the local community. Demonstration projects such as wave energy plants, implementation of intelligent lighting in the public space are examples of municipality's effort within innovative demonstration projects.

A coherent and well-balanced energy system cannot exist without an opera-



tional management system, better known as Smart Grid. Smart Grid is a specific field especially for the energy supply companies. Establishment of Smart Grid as a demonstration project will create a forum for the companies, who deliver energy to the municipality, where the energy com-

panies can work together to develop customized Smart Grid systems. Hereafter, the product can be further developed to sellable products with the opportunity of commercialization and resale across the municipal border.



Table 1: Implemented actions according to follow-up on the EU Covenant of Mayors action plan in the period 2010 – November 2013, see enclosure 3:

Action	Energy savings (MWh/year)	VE-production (MWh/year)	CO <sub>2</sub> savings (ton/year)	CO <sub>2</sub> savings (%)	Investment (TKR)	Confirmation	Project period
Land turbines, Højstrup		23.700	7.181 <sup>1)</sup>				2013
Exchange of 5 cars to electrical cars			8				2012
Energy advising private houses	701,2 (heat)		85,7		6.279		2012–2013
Frederikshavn supply, lighting	412,0 (power)		124,83				2012–2013
Frederikshavn supply, district heating	2.200 (heat)		268,4				2012–2013
Frederikshavn supply, district heating	3,6		0,44				2012–2013
Frederikshavn supply, district heating	1.570		191,54				2012–2013
Skagen district heating, exceed heat 1)	5.000		610,0				2008–2011
Skagen district heating, exceed heat 2)	10.000		1.220				2010–2012
Skagen district heating, exchange of pumps	50 (el)		15,1				2008–2011
Skagen district heating, heat recovery	10.000 <sup>2)</sup>		2.044,44				2011–2013
Strandby district heating, solar heat 3)	3.579 <sup>2)</sup>	3.579	782,74		14.500		2008–2011
Strandby district heating, power boiler, wind turbine power			408,88 <sup>3)</sup>		16.500		2012–2013
Sæby district heating solar heat	6.350 <sup>2)</sup>	6.350	3.035				2010–2012
Sæby district heating, reduced pipeline loss	1.750 (heat)		213,5				1011–2017
Sæby district heating, district heating/oil-driven boiler			30,7		40		2012–2013
Housing associations Frederikshavn, renovation Højbo	197 (heat)		24,03		20.000		2014–2015
Housing associations Frederikshavn, Solar heating, Sæbystrand	400 (heat)	400	48,8				2011–2013
Vesterport, Solar cells step 1, Koktvedstien	12 (power)	12	3,63		245		2012–2013
Vesterport, solar cells step 2, Koktvedstien	24 (power)	24	7,27		491		2012–2014
Vesterport, heating pumps	248	434	362		470		2013–2014
Vesterport, Solar cells, Gl. Skagensvej 4)	96 (power)	96	29,08		<sup>4)</sup>		2013–2015
Vesterport, Solar cells, Ravnshøj	24 (power)	24	7,27		500		2012–2013
Vesterport, Solar cells, Fælledbo	24 (power)	24	7,27		369		2012–2013
Vesterport, Solar cells, Lindegårdsvej	60 (power)	60	18,18		1.150		Ikke oplyst
Vesterport, Engparken, Multi house.	22,18 (heat)		2,7		3.000		2012–2013
<b>Total</b>	<b>42.723</b>	<b>34.703</b>	<b>16.731</b>				

1): See the paragraph for emission for power consumption in the paragraph 5, page 12 of this plan

2): Standard values for five values and CO<sub>2</sub>-emissions – reporting of CO<sub>2</sub>-emission for 2013, the Danish Energy Agency January 13th 2013 (Five value for natural gas: 0.0396 GJ/Nm<sup>3</sup>. Emission key factor for natural gas 56.79 ton/TJ must be used)

3): The heat supply uses 2.000 MWh exceed power from wind power turbines for production of district heating. The alternative was that the plant used an equal amount of natural gas for production of district heating, therefore the CO<sub>2</sub> saving is calculated as the reduced natural gas consumption of the plant and thereby reduced CO<sub>2</sub>- emission from natural gas

4): The amount included in the total construction budget.

Table 2: Action plans per August 2014:

Effort area	Headline of the plan	Energy saving (MWh/year)	Renewable production (MWh/year)
10.1	Integration of Renewable energy in all municipal energy and climate planning		
10.1b.1	Development of district heating in the urban areas	0	
10.1.b.2	Change of natural gas supply areas to district heating areas	0	
10.1b.3	Gradually phasing-out of natural gas consumption and production of renewable energy	0	
10.1b.4	Development of the municipality wind turbine plan on land and at sea	0	
10.2.2	Integration of renewable energy in municipal buildings by renovation of buildings		
10.5.1.A	Increased use of Renewable energy for production of district heating, Sæby heating plant	0	
10.5.1.B	Increased use of Renewable energy for production of district heating, Strandby heating plant		
10.5.1.D	Increased use of Renewable energy for utilization of surplus heating for production of district heating, Frederikshavn heating plant	66,750	
10.5.1.E3	Use of surplus power from wind power turbines for production of district heating, Skagen heating plant	7,581	
10.5.1.F	Connection of the heating plants in Hørby, Thorshøj and Østervrå	24,456,6	
10.5.2	Phasing out of oil heated heating plant in collective heat supply areas	See 10.1.b.1	
10.6.1	Construction of new biogas plant in Frederikshavn municipality	0	
10.7.1	Establishing infrastructure for biogas for the transport sector	0	
10.8.1	Promote demonstration project for renewable energy		
10.8.2	Initiation and development of smart grid	Not estimated	
10.2.1	Continuous reduction of energy consumption in municipal buildings	9,641	
10.2.3	Implementation of control of the municipal fleet of cars		
10.2.4	Implementation of sustainable purchase policy in the municipality of Frederikshavn	Not estimated	
10.3.1	Energy renovation and energy savings on private houses and farms	2.103,6	
10.4.1	Energy renovation of council flats, Frederikshavn housing association	1.198	
10.4.2	Energy renovated council flats, Housing association Vesterport	4.239	
10.5.1.E1	Expansion of the district heating supply area, Skagen heating plant	Not estimated	
10.5.1.E2	Conversion of natural gas supply areas for district heating, Skagen heating plant	Not estimated	
10.5.1.E7	Continuous reduction of natural gas consumption, Skagen heating plant	11,000	
10.5.1.C	Voerså heating plant, reduction of power line loss	9,680	
10.5.1.E4	Further utilization of the surplus heat from the industry for the production of district heating, Skagen heating plant	9,780	
10.5.1.E5	Operational optimization of production, transmission and distribution plant, Skagen heating plant	1,516	
10.5.1.E6	Operational optimization of the district heating plants of the end users, Skagen heating plant	6,579	
10.1a.2 <sup>1)</sup>	Implementation of the EU-Mayor agreement	51,507 <sup>2)</sup>	
10.7.2	Establishment of infrastructure for electrical cars	0	
10.7.3	Further development of infrastructure to promote bicycling in the municipality	Not estimated	
<b>I alt:</b>		<b>206.231</b>	

1): See paragraph 6

2): Concerning the EU Covenant of Mayors action plan, evaluated edition, November 2013. The values occur by deduction, implemented actions from proposed actions. The CO<sub>2</sub> saving is included in the table of implemented actions during the period from 2010 – 2014.

energy pro- MWh/year)	CO <sub>2</sub> saving (Ton/year)	CO <sub>2</sub> -ssaving (%) <sup>1)</sup>	Investment need (Mio. DKK)	Employment	Project period
	5.470	1	Not estimated		2015-2030
62.470	29.270	5,3	Not estimated		
72.279	14.777	2,7	41		
573.272	117.295	21,4	85		
976.900	296.000	54,1	5.091	3.031 in 5 years	
	Included in 10.2.1		Included in 10.2.1	11 per year	
6.350	2.950	0,54	24		2014-2016
1.790	362	0,07	14,5		
3.120	19.072,4	3,6	6		
7.581	1.550	0,29	20		2015
24.456,6	5.000	0,94	16,5	16 in 0.25 year	2013-2014
See 10.1.b.1	See 10.1.b.1		134		
110.000	22.488	4,1	150	15	2012-2016
Dele af 10.6.1	2889,7	0,53	10		
Not estimated	Not estimated		Not estimated		
Not estimated	Not estimated		10.000		
	5.368	1,0	221	24 per year	2013-2030
	163,5	0,03	2	0	2014-2017
0	Not estimated	Not estimated	Not estimated	0	Not decided
0	257,29	0,04	420	14 per year	
Not estimated	703,9	0,13	430,15	1,680 in 6 year	2014-2020
714	362	0,06	794	1,448 in 6 year	2014-2020
Not estimated	Not estimated		15		212-
Not estimated	Not estimated		20		2015
	2.249	0,4	Not estimated		
0	175	0,03	15		
	2.000	0,37	20		
	310	0,06	0,4		
	1.345	0,25	15		
736,340 <sup>2)</sup>	261.002 <sup>2)</sup>	49,2 <sup>2)</sup>			2011-2020
0	Not estimated		Not estimated		
0	Not estimated		Not estimated		
1.838.932	530.058	97	7.554.631		

## 12. Summary

From paragraph 6 in this plan it appears that the total energy consumption of the municipality as geographical border in 2010 is assessed to 2,593.63 GWh, of which 473.059 GWh is based on renewable energy equivalent to 18.3% of the entire energy consumption. The share of energy consumption based on fossil fuels thereby amounts to 2,120.57 GWh/year<sup>1)</sup>

<sup>1)</sup>Energy production based on combustion of waste is considered renewable energy production. Furthermore, 33.1% of the municipal power import of 218.6 GWh/year comes from renewable energy production based on power from wind power turbines. In 2013, the share of renewable energy for power production in Denmark has increased from 33.1% to 41.8% (source Energinet.dk, August 2014).

With the new distribution ratios for 2013 from Energinet.dk the share of renewable energy for power import in Frederikshavn municipality is assessed at 91.37 GWh/year. Constructed renewable energy producing plants in the municipality during the period 2010–2013 is assessed at 34.703 GWh (see table 2). The total renewable energy production in the municipality is therefore set at 526.89 GWh in 2013 equivalent to 20.3% of the total energy consumption in the municipality.

In paragraph 11, table 1 a statement of implemented energy initiatives in the period from 2010–2013 has been prepared, showing that during this period energy initiatives with following results have been implemented:

1. Energy savings equivalent to 42.723 GWh
2. Renewable energy production equivalent to 34.703 GWh
3. CO<sub>2</sub> savings equivalent to 16,731 ton

### Status on energy and emission in Frederikshavn municipality as of June 2014:

Based in the above the total energy consumption, CO<sub>2</sub>-emission and renewable energy production of the municipality in Jun 2014 is assessed as follows:

*Total energy consumption of the municipality:*

$(2,593.63 - 42.723) \text{ GWh/year} = 2,551 \text{ GWh/year}$

*Total CO<sub>2</sub>-emission of the municipality:*

$(547,000 - 16,730) \text{ ton/year} = 530,270 \text{ ton/year}$

*Total energy production of the municipality:*

$(492.19 + 34.703) = 526.89 \text{ GWh/year}$

*Fossil energy consumption in the municipality:*

$(2,551 - 526.89) = 2,024.11 \text{ GWh/year}$

From paragraph 6.2 in this plan, it furthermore appears that the municipal share of fossil energy consumption for transport by airplanes, rail transport and shipping was mapped at 144.48 GWh/year. Please note that the statement is based on the national average for fossil fuel consumption for rail, shipping and transport by airplanes and is divided according to population, also applied for municipalities without harbors and airports, (Energistatistik 2010). Emission of CO<sub>2</sub> caused by rail and air transport is therefore still a part of the total CO<sub>2</sub> statement of the municipality.

Paragraph 10.6 Action plan 2 mentions a possible statement on bio fuel refinery. In the preliminary project outline, stakeholders are working on a plant, which is capable of producing 50,000–150,000 ton sustainable fuel per year for the maritime sector equivalent to a sustainable fuel production of 520–1560 GWh/year. According to Energistatistik 2010 the share of fossil fuel consumption for Frederikshavn municipality is assessed at 20.33 GWh/year.

The construction of a bio fuel refinery in Frederikshavn opens up the possibility of annual production of 50,000 – 150,000 ton of sustainable fuel equivalent to a renewable energy amount of 520–1560 GWh/year. According to the project plan, the produced bio fuel will replace the consumption of the maritime sectors fossil fuels. This is the reason why the future production of bio

fuel does not figure in the renewable energy accounts of this plan, even though the production of bio fuel will take place in the municipality.

We acknowledge that the conversion of the municipal share of fossil energy consumption for rail and transport by air is out of the influence of the municipality and therefore, it is considered unrealistic to prepare action plans concerning these areas. If the municipal share of fossil energy consumption for rail transport (10.19 GWh/year) and transport by air (114.16) is extracted, the municipal share of fossil energy consumption for which practicable action plans can be prepared will assess:

$$2,024.11 (10.19 + 114.16) \text{ GWh/year} = 1,996.22 \text{ GWh/year}$$

### Status on energy and emission in Frederikshavn municipality 2030

In paragraph 11, table 2 a statement of the future action plans is prepared as we know them today for the period 2014–2030. The table 2 shows following potential:

- Energy savings equivalent to 206,231 MWh
- Renewable energy production equivalent to 1,739,932 MWh
- CO<sub>2</sub> savings equivalent to 530,058 ton

The amount of fossil fuel, as presented by the planned energy saving efforts in this plan, will not need to be converted into renewable energy and therefore the total energy consumption of the municipality that will be converted amounts to:

$$1,996.22 - 206.23 \text{ GWh/year} = 1,790 \text{ GWh/year}$$



# Conclusion

Referring to the statements in paragraph 12 and based in the impact of the action plans mentioned in this plan currently following is concluded:

- It is important to ensure balance and interaction in the mentioned renewable energy resources as it is a condition for the realization of the municipal vision of transferring to 100% renewable energy.
- To establish a balanced energy system and to maintain the energy supply security in the future it is important to work continuously with the integration of necessary energy storing technologies in the complete energy system.
- Likewise, it is important to make sure that the production of renewable energy at any time is carried out at market terms and in a compatible way.
- Production of renewable energy in 2030 will quantitative corresponds to 102.7% of the total municipal fossil energy consumption (level 2010)
- Implementation of the mentioned action plans requires a fixed asset investment of 7.5 billion DKK.
- 97% of the total CO<sub>2</sub>-emission of the municipality (level 2010) is reducible in 2030.
- 54.8% of the necessary renewable energy must origin from wind power turbines. This can make the strategy plan relatively vulnerable. The relatively large share of renewable energy from wind power turbines is due to the fact, that the prevalence of the other renewable energy resources such as bio mass and solar energy is limited both in the municipality as geographical area and in the country.
- Currently there are no specific plans for conversion of the fossil energy consumption of the road transport (210 GWh/year) into renewable energy (private cars and trucks). Reorganization of city busses in the municipality of Frederikshavn from diesel to biogas displaces fossil energy equivalent to 1.3 GWh/year.

## 13. Litterature list

1. Energifaftalen 2020, Klima- og Energiministeriet, marts 2012
2. Energistrategi 2050, Klima- og Energiministeriet, februar 2012
3. Danmarks Energifremskrivning, Energistyrelsen, april 2011
4. Danmark uden affald (Ressourceplan), Miljøministeriet, oktober 2013
5. En moderniseret affaldssektor, Kommunernes Landsforening, KL, 2013
6. Strategisk Energiplanlægning i kommunerne, Energistyrelsen, april 2012
7. Energistatistik 2010, 2011 og 2012, Energistyrelsen
8. AVØ. Årsberetning 2012, EMAS Miljøreddegørelse, 2012
9. Strategi for intelligent, offentligt indkøb, Miljøministeriet, oktober 2013
10. Indførelse af Fleet Management i Frederikshavn Kommune, Frederikshavn Kommune, januar 2014
11. Frederikshavn Kommunes Cykelpolitik, august 2011
12. Baggrundsnotat for energiregnskab 2010, PlanEnergi, juni 2012
13. Demonstrationsprojekt Gas til transport, Frederikshavn Kommune, december 2013
14. Handlingsplan for EU-Borgmesteraftalen, evalueret udgave, november 2013.

## 14. Enclosures

- Enclosure 1: Energy agreement
- Enclosure 2: Energy strategy 2050
- Enclosure 3: The action plan for the Covenant of Mayors of Frederikshavn municipality, revised November 2013
- Enclosure 4: Holistic and centralized Fleet management
- Enclosure 5: LGDK and Danish waste association suggestion for a modernized waste sector



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