Danish Energy Agency

DANISH ENERGY AND CLIMATE OUTLOOK 2015

Denmark's Energy and Climate Outlook 2015
Published December 2015 by the Danish Energy Agency, Amaliegade 44, 1256 Copenhagen K, Denmark
Tel: +45 33 92 67 00, Fax +45 33 11 47 43, E-mail: ens@ens.dk, Website http://www.ens.dk
Design and production: Danish Energy Agency
ISBN: 978-87-93180-12-3
Queries concerning methods and calculations should be addressed to the Danish Energy Agency

Contents

Annexes

Background reports

A: Model setup
B: Fuel and carbon-dioxide prices
C: Households and the corporate sector
D: Transport
E: Electricity and district heating
F: Projection of electricity prices
G: Emissions of greenhouse gases
H: Oil and gas extraction in the North Sea
I: Tables
Background reports are available on the Danish Energy Agency's website (Projections) (Only in Danish).

1 Introduction

1.1 What is Denmark's Energy and Climate Outlook 2015?

Denmark's Energy and Climate Outlook 2015, better known as the Baseline Projection 2015, assesses how energy consumption, energy production and greenhouse-gas emissions will develop up to 2025, if no new political initiatives within energy and climate policy are introduced; often referred to as a 'frozen policy' projection for energy and climate. This means that the projection only takes into account adopted policies and measures and does not include overall quantitative targets. This is why targets are not necessarily met in the projection.

Actual developments will be influenced when new political initiatives are introduced, and the projection should therefore not be considered as a prognosis, but rather as a scenario, which defines the challenges faced by future energy and climate policy. The projection creates a solid foundation for political decision-making and debate on energy and climate.

The projection is based on a number of overall economic assumptions (corporate-sector production, private consumption, fuel prices etc.), a number of technology-specific assumptions, as well as assumptions regarding prices and the efficiency of different types of technologies deployed. The projection also makes assumptions regarding how energy-market players will act on the market, as well as qualitative estimates, for instance concerning planning aspects.

Projections of this nature will always be subject to many uncertain assumptions, and developments which differ from those assumed could therefore cause the results to move in another direction than the one presented.

1.2 Who is the target group?

This publication consists of a main report and a number of background reports (in Danish only).

The main report focuses on the most important trends and themes of the projection and is directed towards readers interested in overall policy frameworks, and readers interested in the overall picture. The report describes different types of energy consumption, e.g. gross energy consumption and final energy consumption. There is a more detailed description of this at the end of the report.

The background reports examine more deeply the assumptions and results from each main area of the projection: households, the corporate sector, transport, production of electricity and district heating (including developments in electricity prices), as well as greenhouse-gas emissions. This part of the publication is directed towards readers interested specifically in the individual areas, and readers who are interested the methodologies behind the projection.

1.3 What are the assumptions behind the projection?

The impacts of already adopted, but not necessarily implemented, initiatives are factored in. All elements in the 2012 Energy Agreement, the finance acts up to and including the Finance Act 2016, "Growth Plan DK" as well as the "Growth Package 2014", including the "Agreement to Cancel the Security of Supply Tax etc.

and Deregulation of the PSO Scheme" for the corporate sector have therefore been included in the projection.

In the days up to completion of the projection, proposals were made regarding an agricultural and food growth package. The climate-change impacts of the package are closely linked to specific implementation of a number of the instruments in the package, and therefore it is not possible to estimate the impact until the final package has been conclusively negotiated. The impact has therefore not been factored in.

The assumptions regarding economic growth are based on Denmark's Convergence Programme from April 2015, whilst developments in prices of fossil fuels are calculated on the basis of assumptions in the International Energy Agency (IEA) World Energy Outlook 2015 from November 2015, from which developments and assumptions in the "New Policy Scenario" have been used. Read more about the assumptions regarding prices of fossil fuels in the "B: Fuel and carbon-dioxide prices" background report.

1.4 The projection has three scenarios

The carbon-dioxide price has significance for the projection of e.g. fuel consumption and CO_2 emissions. As considerable uncertainty surrounds the level of future carbon prices, the projection has been prepared with three scenarios for the carbon price. The three scenarios for the carbon price are combined with assumptions about developments in the energy sector abroad, which are very important for calculations of electricity prices and cross-border exchange of electricity, and the scenarios have been combined with the expansion of wind power in Denmark:

- **Scenario A:** The carbon price remains at the current level of about DKK 55 per tonne. This is combined with a lower green transition abroad and a lower estimate for wind power expansion in Denmark.
- **Scenario B:** The carbon price follows developments in the IEA's World Energy Outlook 2015 and increases to about DKK 100 per tonne by 2020 and about DKK 170 per tonne by 2025. This is combined with substantial green transition abroad and an upper estimate for wind power expansion in Denmark.
- **Scenario FM:** The allowance price follows estimates from the Danish Ministry of Finance and increases to about DKK 65 per tonne by 2020 and about DKK 85 per tonne by 2025[1]. This is combined with a lower green transition abroad and a medium estimate for wind power expansion in Denmark (not medium of lower and upper estimates, as the electricity price and, with it, the profitability of wind turbines in this scenario is closer to "Scenario A" than to "Scenario B").

Together, the three scenarios provide a likely range for the results of the projection.

1.5 How we did it

To reflect the energy system in the best way possible, we chose to work with a number of different models:

- **EMMA** models energy consumption of households and the corporate sector.
- On the basis of input from EMMA, the **Heating Model** manages shifts between types of heating in households.

[1] Moreover, the oil price applied has been estimated by the Danish Ministry of Finance. However, this is more or less at the same level as the oil price based on the IEA, World Energy Outlook 2015.

- **RAMSES** models electricity and district heating production as well as electricity prices on the basis of consumption figures from EMMA, the Heating Model and the Transport Model.
- **The Transport Model** models energy consumption by the transport sector.
- Data from the models is collected in the **Summary Model**, which ensures an output that can be used directly in the report and submissions.

In addition to our own model setup, the projection also includes external inputs. Read more about the models used in the "A: Model setup" background report.

1.6 Why do results change from one projection to the other?

The results of the projection change will always differ from the previous projection, partly, because of new statistics, and thereby new points of departure, and partly because central assumptions for future developments change. Moreover, the models used are continuously developed and improved, and this in itself may cause changes in results.

For instance, the 2015 projection shows a higher increase in consumption of biomass for the production of electricity and district heating up until 2020 than in the 2014 projection. One of the reasons is a reassessment in the model setup of the assumptions of existing and future production capacity, as well as revised assessments of the development in fuel and carbon prices, both of which have significant impact on the competitiveness of biomass compared with other fuels.

Correspondingly, new statistics for Danish wind turbine capacity are available, and a reassessment of future development has been carried out. This means that the expected electricity production from wind power differs from the 2014 projection. As the 2015 projection also anticipates lower electricity consumption, the share of wind in electricity consumption changes correspondingly.

The higher increase in biomass consumption contributes to a greater fall in ETS greenhouse-gas emissions up to 2020 than in the 2014 projection. Even though non-ETS emissions are actually higher in the 2015 projection, total emissions will be lower than in the 2014 projection. This also means that total greenhouse-gas emissions are likely to be lower in 2020 compared with the 2014 projection, if the Danish climate efforts are calculated according to the same method as in the 2013 Climate Policy Plan.

2 The full picture

2.1 Main points

- Consumption of renewable energy increases significantly up to 2020, but there are huge differences in developments within different sectors. The EU target of 30% renewable energy in energy consumption by 2020 is exceeded by a large margin, as the share is expected to be around 40%.
- The most important transition to renewable energy is carried out in the electricity and district heating sector, where additional transition to biomass use and wind energy is expected.
- The total share of renewable energy in electricity consumption is expected to be about 80-85% by 2020 and 65% for district heating consumption. Wind power alone is expected to cover up to 53-59% of electricity consumption by 2020 compared with about 40% today. However, the share of wind power is sensitive towards changes in deployment of wind production capacity and changes in electricity consumption.
- The transport sector continues to be almost exclusively based on fossil fuels, hence fulfilment of the transport sector's targets for renewable energy will require increased use of second generation biofuels or alternative efforts.
- Consumption of coal and natural gas will drop up to 2020, while consumption of oil will remain at the current level. Overall, consumption of coal, oil and natural gas will decrease by slightly more than 30% compared with 2010.
- Overall Danish greenhouse-gas emissions will fall up to 2020 and then remain stable in the remaining part of the projection period. The most profound fall will be in electricity and district heating production. If the Danish climate efforts are calculated using the same method as in the 2013 Climate Policy Plan, which includes a contribution from carbon sequestration in soil and forests, overall greenhouse-gas emissions are expected to be reduced by about 40% by 2020 compared with 1990.
- However, there are significant uncertainties linked to the projection, and therefore the reduction is expected to be within a spread of about 35-44%.
- Denmark is expected to reach its accumulated non-ETS obligation in relation to the EU for the period 2013-2020. It is expected that the target for 2020 as a single year will not quite be met. However, overall, Denmark is likely to go beyond its EU obligation, as reductions beyond the target in previous years more than compensate for the single-year non-compliance in 2020.

2.2 Development in energy consumption and renewable shares up to 2020 and 2025

Total Danish gross energy consumption[2] has decreased since 2000, primarily during the financial crisis. Future gross energy consumption is expected to remain at the current level, which in 2014 was 755 PJ.

The same applies to final energy consumption, which describes energy consumption in households, the corporate sector and transport. Future total final energy consumption is expected to remain at the current level of around 610 PJ.

[2] Total energy consumption adjusted for energy consumption linked to trading with electricity and fluctuations in relation to a normal weather year.

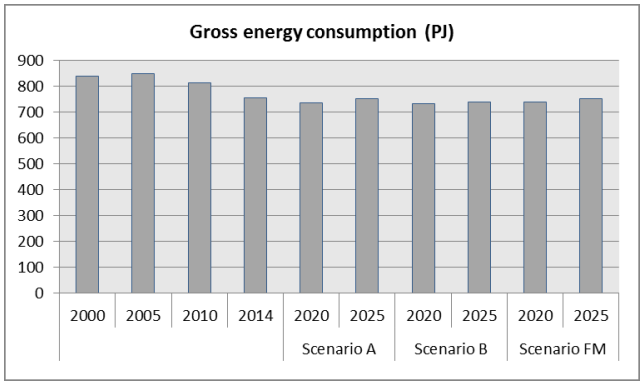

Figure 1: Gross energy consumption has decreased since 2000, primarily during the financial crisis. In the future, gross energy consumption is expected to remain at more or less the current level.

2.2.1 Consumption of renewable energy will increase rapidly up to 2020

Renewable energy consumption has been increasing steadily since 2000, primarily due to biomass conversion and wind power deployment, and is likely to increase additionally up to 2020. An increase of just under 50% up to 2020 compared with today is expected.

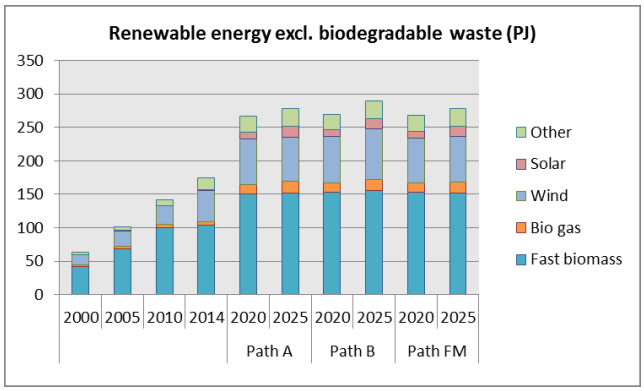

Figure 2: Consumption of renewable energy will increase rapidly up to 2020. This is particularly due to biomass conversion and wind power expansion in the electricity and district heating sector.

However, the extent to which the different sectors convert to renewable energy varies greatly in the projection. Households will convert part of their energy consumption for heating to biomass and heat pumps, whilst the corporate sector will convert part of its energy consumption for heating and process purposes to biomass. In contrast, there is almost no conversion in the transport sector; only a small increase in biofuel blending in petrol and diesel. This means that the greatest transition is in the electricity and district heating sector, where further conversion to biomass and more wind power expansion is expected. However, consumption of biomass by the electricity and district heating sector is sensitive

towards developments in biomass prices relative to coal prices (including carbon prices).

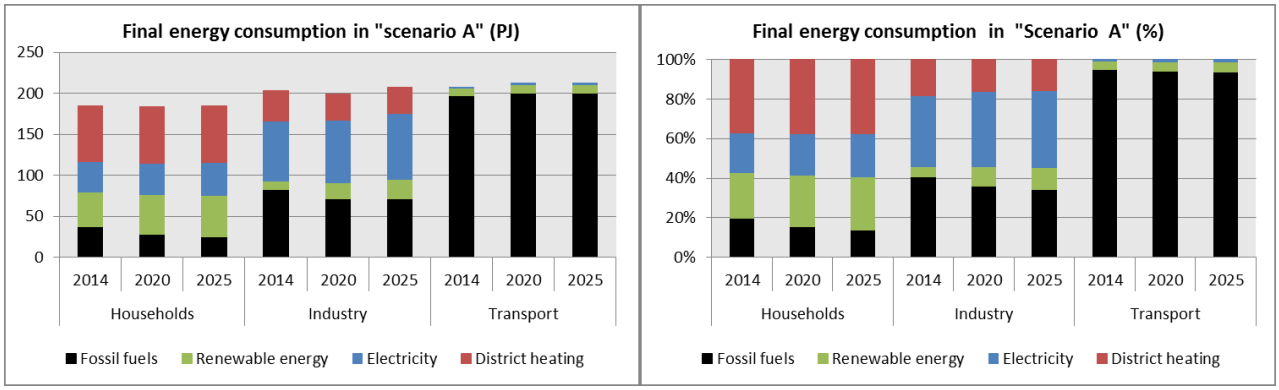

Figure 3: In households and the corporate sector, part of energy consumption for heating and process purposes will be converted to renewable energy (primarily biomass and heat pumps), whilst almost no transition will take place in the transport sector. Energy consumption is only shown for Scenario A as there are only small differences between the scenarios A, B and FM.

2.2.2 The renewable energy target for extended final energy consumption will be exceeded by a large margin

In the EU climate and energy package, Denmark is obligated to reach a renewable share of its extended final energy consumption[3] of at least 30% in 2020, and to achieve sub-targets on the way to meeting this 2020 target. With a renewable share of slightly more than 40% by 2020, this target will be exceeded by a large margin. Annual targets up to 2020 will also be reached by a large margin. However, consumption of biomass by the electricity and district heating sector is sensitive towards developments in biomass prices relative to coal prices (including carbon prices). Even in sensitivity calculations where several central assumptions vary, the renewable share is expected to reach 35% as a minimum by 2020.

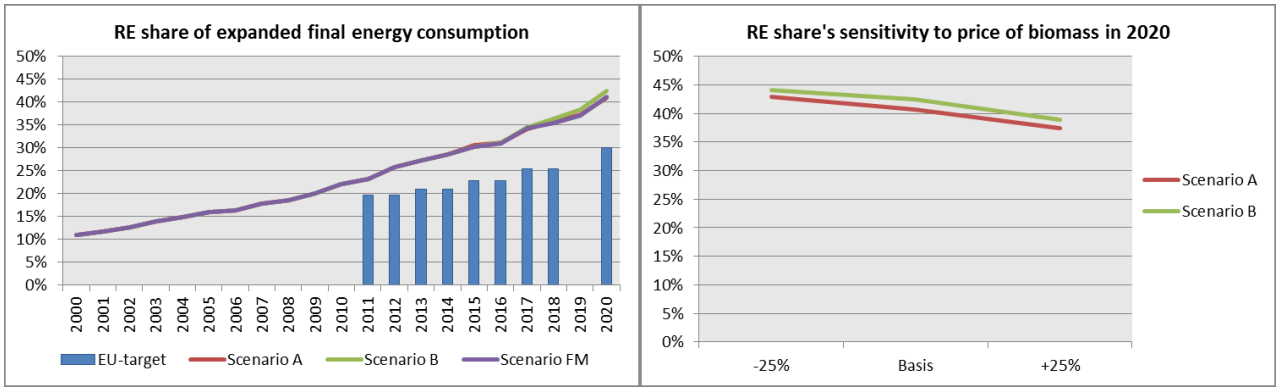

Figure 4: Renewable share of extended final energy consumption will be above the EU goals set for the entire period.

2.2.3 Uncertainty about compliance with renewable energy goals for the transport sector

The EU Climate and Energy Package also includes a separate renewable share target for the transport sector, by which Denmark is obliged to reach a renewable share in land-based transport of at least 10% by 2020. This target only applies in 2020, and therefore there are no sub-targets towards 2020.

[3] Extended final energy consumption is calculated by adding final energy consumption, excluding consumption for non-energy purposes, to cross-border trade, electricity and district heating losses, as well as own consumption of electricity and district heating in production of the same.

In the 2012 Energy Agreement, it was decided to amend the Biofuel Act to ensure a mix that includes 10% biofuels by 2020. However, the decision is pending analysis of alternatives which can help Denmark meet the renewable energy target. Since the Energy Agreement was made, the expectations to which biofuel standards will be applicable by 2020 have changed, and similarly, a number of changes have been made to the Renewable Energy Directive which influence the actual quantity of biofuels which can be added to petrol and diesel.

Against this background, it is probably unrealistic that a mix of 10% will be achieved by 2020. In contrast, a shift in standards is expected as a consequence of higher biofuel blending requirements. Therefore, a mix of around 6.6% by 2020 is expected. With regard to meeting the renewable energy target, this can be fulfilled by a mix of renewable electricity for road and rail transport, as well as increased use of second-generation biofuels which count double in target compliance. However, currently, the market for second-generation biofuels is limited in size, and has high prices in relation to other biofuels. This may be a significant barrier.

2.2.4 Consumption of coal and natural gas will decrease up to 2020

Consumption of fossil fuels has decreased steadily since 2000 and a further drop is expected up to 2020, after which it will stagnate. Compared with today, a decrease of around 20% up to 2020 is expected, corresponding to a fall in coal consumption of about 80-90 PJ and a fall in natural gas consumption of about 20-25 PJ[4]. Only consumption of coal and natural gas will fall, while consumption of oil will remain at the current level. Around 70% of oil consumption is in the transport sector, where there is nothing to suggest that a green transition will make a break through this side of 2025. Coal consumption will fall because large-scale power plants will convert to biomass. With regard to natural gas, there will be a drop in consumption in all sectors. Compared with 2010, consumption of coal, oil and natural gas will decrease by slightly more than 30% compared with 2020.

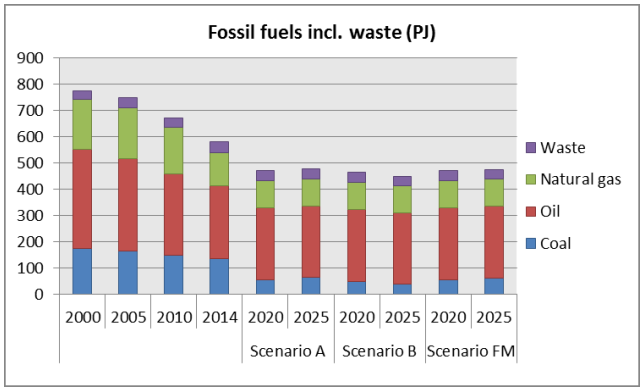

Figure 5: Consumption of coal and natural gas will continue to drop up to 2020, while consumption of oil will remain at the current level.

[4] Consumption of coal and natural gas in particular may fluctuate considerably from year to year as a consequence of electricity trade with other countries. To assess a trend in the development, such 'random' fluctuations have to be disregarded, and therefore consumption has been adjusted for energy consumption linked to electricity trade with other countries.

2.3 Developments in greenhouse-gas emissions up to 2020 and 2025

Total Danish greenhouse-gas emissions have been falling since the start of the 1990s and are expected to continue falling up to 2020 and then remain stable in the remaining part of the projection period. The most pronounced fall will be in electricity and district heating production. If the trend of falling total emissions is to continue up to 2030 and 2050, new initiatives are needed.

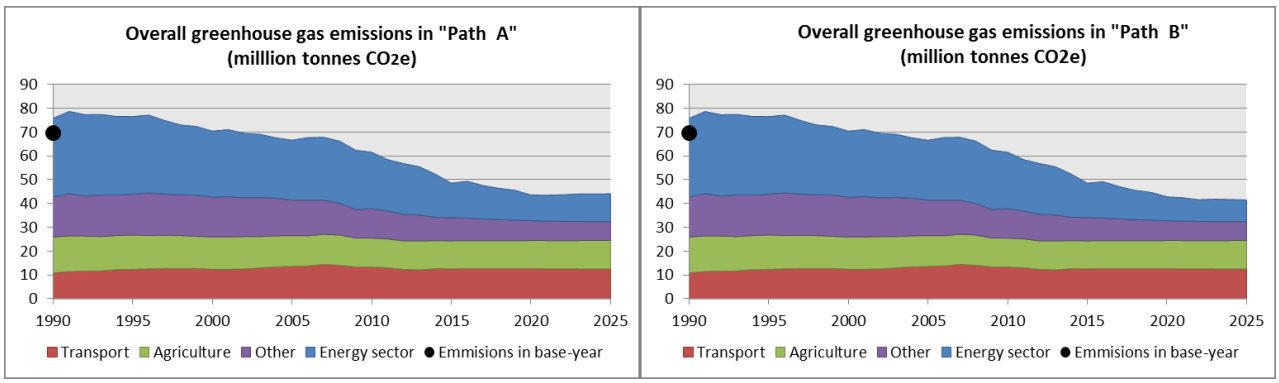

Figure 6: Total **Danish greenhouse-gas emissions will fall up to 2020 and then remain stable. The most pronounced fall will be in electricity and district heating production. Emissions have been adjusted for electricity trade with other countries. Note that the baseline year is defined by observed emissions in 1990, which were particularly low due to considerable levels of electricity imports.**

Total emissions by 2020 are expected to be around 37-38% below the 1990 level. If emissions are calculated according to the method used to prepare the 2013 Climate Policy Plan, emissions will be about 40-41% below the 1990 level. The difference is due to the fact that contributions from carbon sequestration in soil and forests, the so-called LULUCF contributions, are included in the calculations in the Climate Policy Plan. However, there are significant uncertainties linked to the projection, and the reduction, including LULUCF, is therefore likely to be within a spread of about 35-44%.

2.3.1 The target for non-ETS greenhouse-gas emissions in 2013-2020 will be reached

In the EU Climate and Energy Package, Denmark is obliged to reduce non-ETS greenhouse-gas emissions by 20% by 2020 compared with the 2005 level, as well as to achieve sub-goals towards 2020. However, not complying with the target in one year is allowed, if the target is exceeded correspondingly in another year. The target for accumulated non-ETS greenhouse-gas emissions in the period 2013-2020 is likely to be met, despite an expectation of a minor gap in 2020. This means that, in overall terms, the EU obligation will be met.

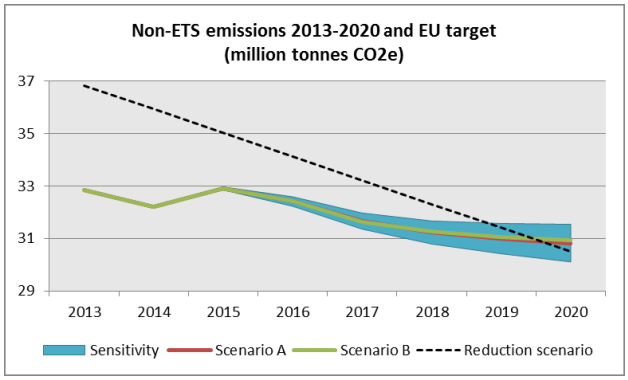

Figure 7: The target for accumulated greenhouse-gas emissions will be met despite an expectation of a minor gap in 2020. Note that the y axis does not go down to 0.

3 Energy consumption by the household sector

3.1 Main points

- Up to 2025, energy consumption by households is expected to remain at more or less the same level as today. This is because future growth in private consumption is expected to be compensated by increased energy efficiency.
- Energy consumption from the existing building stock will continue to dominate, while energy consumption in new buildings will be an insignificant part of the overall picture.
- In areas without the option to be connected to district heating, only a small transition from oil and natural gas to renewable energy sources is expected, even if, in a number of cases, it may be economically attractive to replace old oil and natural gas boilers with either wood pellet boilers or heat pumps.
- Despite more appliances in households, continued efficiency improvements made possible through regulation at national and EU level ensure a more or less constant future electricity consumption in households.

3.2 Introduction

Energy consumption by households today amounts to about 30% of total Danish final energy consumption. 83% of the final energy consumption of households is spent on space heating and hot water, and the remaining 17% is for electrical appliances. These figures do not take into account transformation losses in electricity and district heating production.

Energy consumption for heating has been fairly stable throughout a number of years, but there have been significant changes in the sources of the energy. For the past 15 years, there has been a pronounced phasing-out of oil-fired boilers, which, among other things, have been replaced by district heating, wood pellet boilers, wood-burning stoves and heat pumps.

Despite an increasing number of electrical appliances, the accompanying electricity consumption has been more or less constant for the past 15 years, as there has been increased energy efficiency in the various appliances.

3.3 Developments up to 2020 and 2025

Future growth in private consumption is also expected to develop in line with increased energy efficiency. This means that total energy consumption is expected to remain at approximately the current level. However, this covers a small fall in energy consumption for heating and a small increase in electricity consumption for appliances.

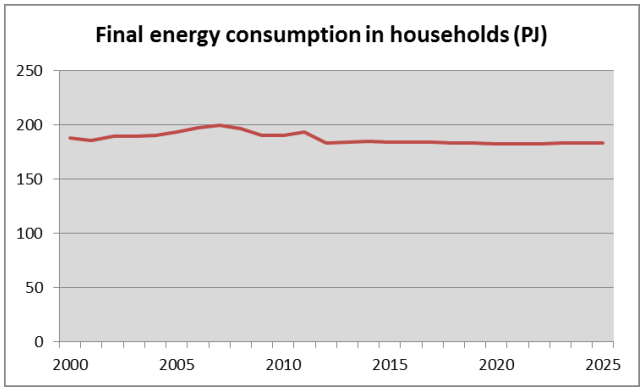

Figure 8: The future total final energy consumption of households for heating and electricity for appliances is expected to remain at the current level.

3.3.1 The transition to renewable energy for heating is happening at a slow pace

Up to 2025, only a small transition from oil and natural gas to renewable energy sources is expected, and the transition is primarily to heat pumps. Oil consumption will drop by more than 40% and natural gas consumption will fall by more than 20% up to 2025, compared with today, corresponding to a decrease in oil consumption of 4 PJ and a drop in natural gas consumption of 6 PJ. The fall in oil and natural gas consumption is also due to conversion to district heating.

District heating covers a significant part of heating, and as this production is being converted into more renewable energy, the energy consumption of households will also be converted indirectly.

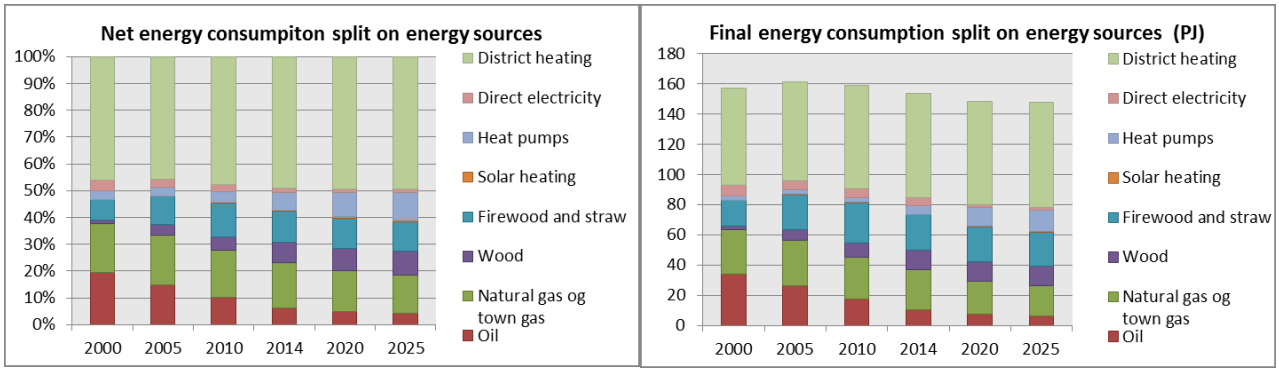

Figure 9: Up to 2025, there will be only a small transition to renewable energy for heating. Note that in figure 2 the historical electricity consumption is not broken down between electricity for heat pumps and direct electricity.

Even though, in a number of cases, there seems to be an economic incentive to replace old oil and natural gas boilers with either wood pellet boilers or heat pumps in areas without the option to be connected to district heating, according to the projection, this will only take place to a lesser extent. Even if transition to heat pumps would add flexibility to the energy system, and thereby contribute positively to the integration of increasing quantities of electricity from wind power, and even if heat pumps are socio-economically more attractive than boilers fired by oil, gas or wood pellets, barriers prevent this change from taking place. One such barrier is the relatively large investment needed for a heat pump compared to other types of heating. Another barrier is the relatively high tax on the electricity required to drive the heat pump. As regards the former barrier, for households, making an investment of about DKK 100,000 for a heating system based on heat pumps may seem extremely costly, particularly in parts of Denmark where housing prices are generally low. In such areas, particularly wood-pellet boilers and wood-burning stoves are

economically attractive alternatives to heat pumps, as the installation price is lower, fuel is less expensive, and there is usually storage room for fuel.

It may also seem easier to choose a familiar type of heating rather than a new one, such as a heat pump. Moreover, in some cases there may also be technical barriers which impede the installation of a heat pump. This applies if a house has to change radiator system, if a house has to be re-insulated, or if installations require huge outdoor excavations for ground-source heat pumps. Such technical barriers may seem like extra complications and may also generate higher investment costs.

There is uncertainty about future developments in efficiency rates for the different types of heating, and about future developments in total heating needs. In relation to total heating needs, the uncertainty is in development of standards for insulation in the existing building stock (as there are well-defined requirements for the future building stock), as well as uncertainty about indoor comfort temperatures and hot water demands. This may depend more on the general growth in private consumption than assumed in the projection. In relation to the distribution between types of heating, it is difficult to assess whether the economic advantage of biomass installations for private households is of such magnitude that it matches the extra effort connected with choosing this type of heating. If so, the increase in biomass use may be higher than anticipated.

3.3.2 More, but more efficient electrical appliances in Danish homes

The growth in future private consumption means that people will invest in more electrical appliances. At the same time, a number of efficiency improvements are expected, as regulations have been issued for a large number of electrical appliances in the form of ecodesign (EU requirement) [5] and the energy labelling scheme (Danish legislation). The effects of legislation were analysed in 2013[6]. In 2025, efficiency improvements will amount to almost 20% of total electricity consumption for electrical appliances in households, compared with a scenario without regulation. Electricity consumption by households is also sensitive to overall developments in private consumption. For example, if total private consumption is 10% lower than expected in 2025, electricity consumption will be correspondingly 5% lower.

3.4 How we did it

The projection of energy consumption by households was partly completed in the EMMA consumption model, and partly in the Danish Energy Agency's own tool for calculating energy for household heating. EMMA is a macro-economic tool which describes corporate and household energy demand on the basis of production, energy prices and developments in energy technology. EMMA is linked to the ADAM macro-economic model, which provides assumptions about economic growth. The Danish Energy Agency uses growth assumptions from the Danish Ministry of Finance. The Danish Energy Agency has developed a tool to project household heating consumption. The tool is based on developments in net energy consumption

[5] In order to reduce the energy consumption of various products, the EU has imposed requirements (e.g. ecodesign) so that the least energy-efficient products are removed from the market. The Ecodesign Directive is the legislative basis for implementing ecodesign requirements for products and appliances. Ecodesign requirements can be imposed on energy-related products that either use energy themselves, or that have an effect on energy consumption when they are used (e.g. windows). The regulations for individual products are implemented through EU regulations.

[6] "*Effektvurdering af ecodesign og energimærkning*" (Impact Assessment of Ecodesign and Energy Labelling), drawn up by IT-Energy and Viegand Maagøe for the Danish Energy Agency in 2013.

estimated in EMMA as well as assumptions about developments in the efficiency of various types of heating.

More information is available here:

- The “A: Model setup” background report contains information about the EMMA model and about the Danish Energy Agency’s model for household energy consumption for heating.
- The “C: Households and the corporate sector” background report contains more information about the assumptions and methods of calculation applied in the projection of household energy consumption.

4 Energy consumption by the corporate sector

4.1 Main points

- Up to 2020, energy consumption by the corporate sector is expected to remain at more or less the same level as today. This is because future economic growth is expected to develop in line with increased energy efficiency.
- A slight increase is expected after 2020 because of the proposed construction of the ”Apple datacenter” outside the town of Viborg.
- Increased efficiency improvements are primarily due to the energy savings energy companies have to realise in the period 2013-2020.
- The transition to more renewable energy will primarily be in industry, and the increase in consumption of renewable energy is primarily due to the expected effect of the “RE for production processes” subsidy scheme.

4.2 Introduction

Energy consumption by the corporate sector today amounts to about 35% of total Danish final energy consumption. Historically, industry has accounted for almost half of energy consumption by the corporate sector, but since 2000 energy consumption by this sector has fallen and today it accounts for about 40%. In addition to this, the service sector accounts for about 40%, while agriculture and construction account for the remaining 20% of energy consumption.

The corporate sector has been converting from oil and gas to renewable energy and district heating for many years. Consumption of natural gas has remained relatively constant for a long period. Energy consumption by industry has been falling due to the general decline in industry, which was hit especially hard by the economic crisis between 2007 and 2010. In this period there was a drop in economic growth in industry of almost 6% annually, and this led to a more or less corresponding drop in energy consumption. In the period 2000-2014, energy consumption by agriculture fell by about one-third. This is mainly due to a drop in oil consumption. Energy consumption by the service sector was almost constant in the period 2000-2014.

Parts of the business sector, primarily industry, are covered by the EU CO_2 Emissions Trading System (ETS). However, with the current low carbon prices, the ETS has relatively little significance for energy consumption by the business sector, since the carbon price only accounts for a very small share of total energy costs for businesses.

4.3 Developments up to 2020 and 2025[7]

Future economic growth is expected to be accompanied by increased energy efficiency. This means that total energy consumption is expected to remain at approximately the current level up to 2020, after which it will rise a little. This slight increase after 2020 is primarily due to plans to build the ”Apple datacenter” outside the town of Viborg. When it is completed in 2023, it is estimated that the datacenter will have an

[7] This section only presents results for “Scenario A”, as the three scenarios are more or less identical.

electricity consumption of 2.2 TWh[8]. Electricity consumption by the Apple datacenter will therefore account for almost 20% of total electricity consumption by the service sector.

Increased efficiency improvements in the corporate sector in the projection are primarily due to the energy savings which energy companies are obliged to realise in the period 2013-2020. Energy-efficiency improvements realised by energy companies will mostly consist of reductions in heating consumption in buildings and energy-efficiency improvements in industrial processes.

Consumption of natural gas will fall as consumption of renewable energy from biomass, biogas and heat pumps increases. Consumption of coal, oil and district heating will only drop slightly up to 2025.

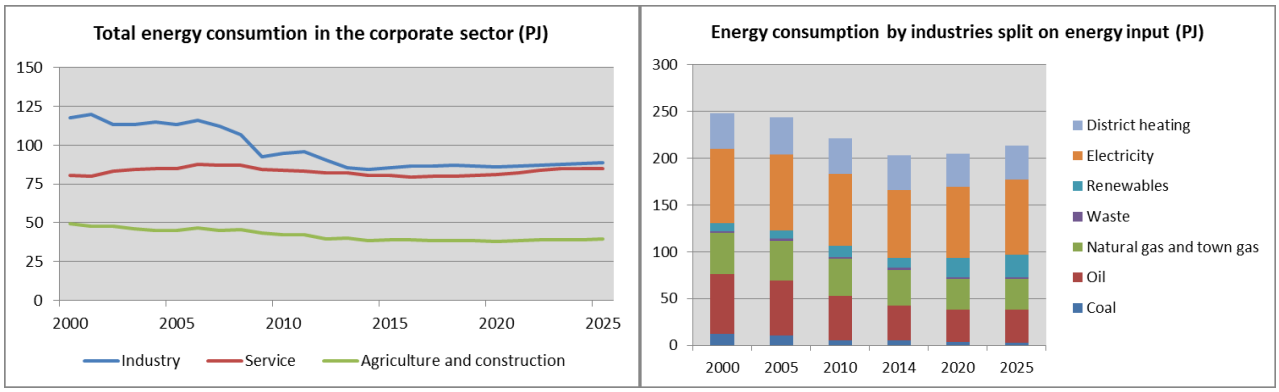

Figure 10: Total energy consumption by the business sector is expected to remain at approximately the current level up to 2020, after which it will rise a little up 2025. Consumption of natural gas will fall in the future as consumption of renewable energy (RE) and electricity increases.

As mentioned above, economic growth is very significant for changes in energy consumption. Up to 2025 it is expected that average annual growth will be 1.7%. This is considerably higher than in the period 2000-2014, when average annual economic growth was around 0.6%. Sensitivity calculations show that average annual growth of 3% for all businesses up to 2025 will increase total energy consumption by the corporate sector by about 7%. In contrast, if annual growth is just 1% for all businesses up to 2025, total energy consumption by businesses will be reduced by about 9%. Another factor which will also have a large impact on energy consumption by the business sector is how growth is distributed between individual business sectors. The sensitivity analyses assume equal growth in all business sectors, but it may well be the case that there will be a structural shift within or between sectors or that there may be a different growth rate in high-energy consuming businesses compared with the rest of the economy.

4.3.1 The "RE for production processes scheme" promotes the transition to more renewable energy

The transition to more renewable energy will primarily take place in industry, where consumption of renewables will triple up to 2025, corresponding to an increase of 12 PJ. The increase is mainly due to the expected effect of the "RE for production processes" subsidy scheme. The scheme provides enterprises with an opportunity to receive construction subsidies to convert their energy consumption to renewables. For example, this could be replacing an oil and natural gas boiler with a boiler using biomass. The effect of

[8]The projection does not usually address individual installations on the consumption side, but in this case there is a relatively large consumption. Ongoing development of the datacenter has been assumed from 2017-2023, when total electricity consumption will be 2.2 TWh.

the “RE for production processes scheme” in the projection has been assessed on the basis of the effect the scheme has had up to now, based on the pledges for subsidies. With a few adjustments, the effect has been assumed to continue as the subsidies are granted (DKK 400 mill./year up to and including 2020, as well as DKK 500 mill. in 2021). Subsidies used to convert CHP plants have not been included under the corporate sector, but have been included under electricity and district heating.

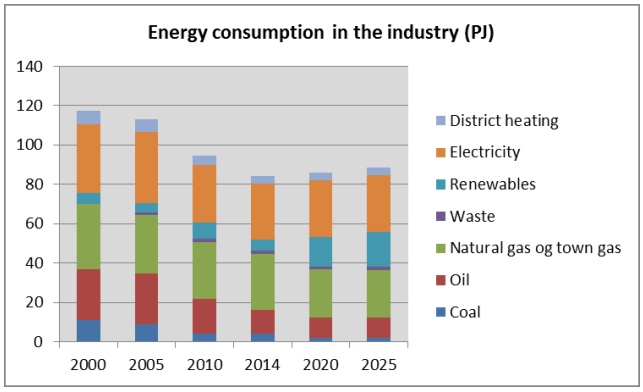

Figure 11: The composition of energy consumption by industry shows increased use of renewable energy (RE) up to 2025, with a simultaneous drop in natural gas consumption.

4.4 How we did it

The projection of energy consumption by the corporate sector has been completed in the EMMA consumption model. EMMA is a macro-economic tool which describes corporate and household energy demand on the basis of production, energy prices and developments in energy technology. EMMA is linked to the ADAM macro-economic model, which provides assumptions about economic growth. The Danish Energy Agency has used growth assumptions from the Danish Ministry of Finance in the projection.

More information is available here:

- The “A: Modelsetup” background report contains information about the EMMA model.
- The “C: Households and the corporate sector” background report contains more information about the assumptions and methods of calculation applied in the projection of energy consumption.

5 Energy consumption by the transport sector

5.1 Main points

- Up to 2025, energy consumption for transport is expected to remain at more or less the same level as today.
- The number of kilometres driven will increase by 20% up to 2025, but continued efficiency improvements in new vehicles means that energy consumption will be kept stable.
- Fossil fuels are likely to continue to dominate energy consumption and will account for 94% of energy consumption in 2020 and 2025 compared with 95% today.
- It is still not expected that vehicles powered by electricity, natural gas and hydrogen will gain any considerable ground.
- Railway electrification will continue, but this will not affect the overall picture very much.

5.2 Introduction

Energy consumption by the transport sector today amounts to about 30% of total Danish final energy consumption, and is almost entirely composed of fossil fuels. The sector includes road transport, rail transport, aviation, domestic shipping as well as energy consumption by the military for transport purposes. Road transport today accounts for 75% of energy consumption, followed by aviation (20%), of which most is for international air travel. With regard to road transport, cars account for more than 60% of energy consumption, vans and lorries each account for about 15%, while busses and motorcycles account for the remaining 10%.

Historically, the number of kilometres driven and energy consumption increased steadily until the 2008 economic crisis, which came at the same time as greater focus on energy-efficient cars. Increases in energy efficiency are due to an EU Regulation under which car manufacturers must reduce carbon emissions. This led to a greater range of small, energy-efficient cars and in Denmark these have been further promoted by changes in vehicle registration tax introduced in 2007, which favour fuel-efficient cars.

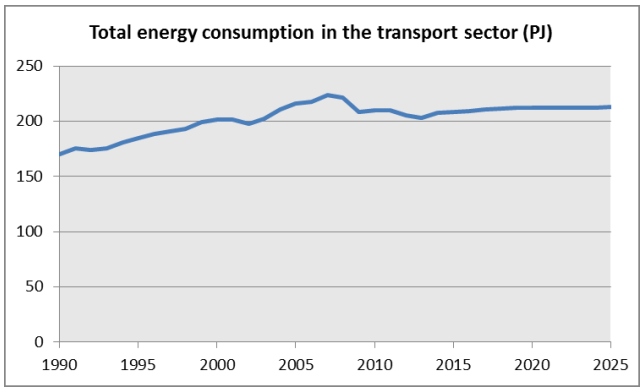

Figure 12: Historically, energy consumption for transport has steadily increased, but greater efficiency is expected to keep consumption stable in future.

So far, the green transition of the transport sector has been very limited. A small percentage of rail transport is powered by electricity, and since 2006 biofuels have been mixed in petrol and diesel for road transport, but otherwise almost all other energy consumption is from fossil oil products (about 95%).

5.3 Developments up to 2020 and 2025

Total energy consumption by the transport sector is expected to increase by slightly more than 2% up to 2020 compared with the current level. After this, energy consumption will rise slightly in the period 2020-2025 The rise will primarily be due to an increase in international air travel of 12% up to 2025, and a small drop in energy consumption for road transport. Consumption of diesel will continue to rise, with a corresponding drop in petrol consumption, and from 2020 it is expected that a greater percentage of biofuels will be used. It is currently unclear whether, and to what extent, there will be requirements to increase the level of biofuel blending. However, it is unlikely that a mix of up to 10% will be realistic, as has previously been assumed. On the other hand an increased biofuel blending in petrol has been assumed from 2020, bringing the total biofuel blending in petrol and diesel to about 6.6% (in relation to the energy content).

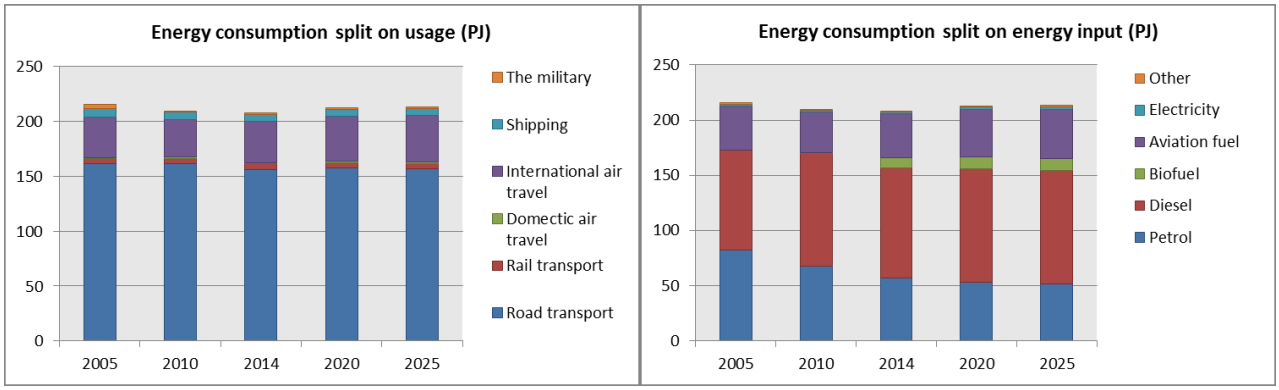

Figure 13. Developments in the transport sector are relatively stable. There will be an increase in air travel and a slight drop in road transport, while other types of transport are expected to remain at more or less the same level as today. Fossil fuels will account for 94% of energy consumption in 2020 and 2025 compared with 95% today. There is no difference between the different scenarios for the projection for transport.

5.3.1 More kilometres on the roads for the same energy consumption

It is expected that the number of kilometres driven on the roads will increase in the future, so that in 2020 11% more kilometres will be driven than in 2014, and in 2025 20% more kilometres will be driven than in 2014. Both passenger and freight transport will increase. The increase is due to economic growth combined with expansion of the infrastructure, which will lead to greater mobility for society.

At the same time, new cars are expected to be more energy efficient, although not to the same degree as the efficiency improvements seen between 2007 and 2012. If the trend of recent years continues, new sales will meet the standard EU requirement of 95 gCO_2/km, which will apply from and including 2021. Overall the vehicles on the roads will be more efficient as older vehicles are scrapped and new, more efficient vehicles take their place. This increased efficiency balances out the increases in the number of

kilometres driven so that total energy consumption will remain more or less stable. This assessment takes into account the changes in vehicle registration tax adopted in the 2016 Finance Act[9].

However, there is great uncertainty regarding changes in efficiency and number of kilometres driven. This uncertainty is particularly because developments depend on consumer behaviour, including the type of car consumers buy, how often they replace their car, and how much they use it. The "D: Transport" background report contains a number of sensitivity calculations to illustrate the significance of changes in assumptions on efficiency and number of kilometres driven.

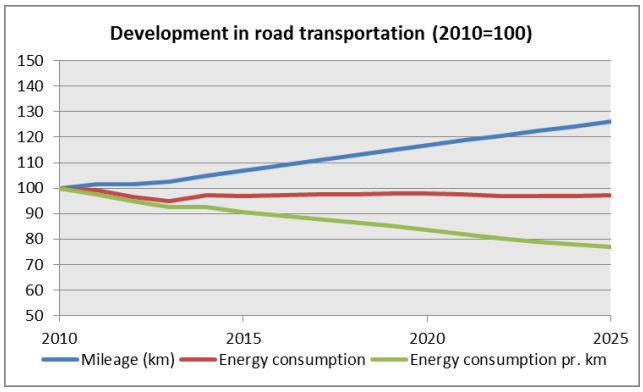

Figure 14. More efficient vehicles ensure that total energy consumption is kept more or less constant, despite an increasing number of kilometres driven. Developments are shown for total road transport, but there will be differences between the different types of transport.

5.3.2 New technologies still have yet to break through

Nothing indicates that cars, busses and lorries will move away significantly from petrol and diesel power to electricity, natural gas and hydrogen before 2025. These alternatives are still expensive compared with conventional fuels, and there is a lack of infrastructure (primarily for gas and hydrogen). No significant technological breakthroughs are expected up to 2025 under the current conditions to enable these alternative vehicles to become more widespread, and therefore there will be only limited increases, see the table below. The alternative vehicles account for less than 0.4% of energy consumption by road transport in 2025.

Vehicle type	Fuel	2016	2020	2025
Cars (number)	Electricity	4,000	6,000	10,000
	Natural gas/biogas	~0	~0	~0
	Hydrogen	~0	200	400
Busses and lorries	Electricity	5	100	300
	Natural gas/biogas	10	300	750

Table 1. Limited increases in the number of alternative vehicles running on electricity, natural gas and hydrogen are expected, and together these are also likely to have a very small effect on energy consumption. There are possibly a few cars in Denmark running on gas and hydrogen, but how much these cars are used in practice is unclear, and therefore the figure has been rounded to 0 in the projection.

[9] The effects of the specific changes in vehicle registration tax are uncertain, but it is expected that, all else being equal, there will be higher sales of larger cars. This will mean that fuel consumption for the average new sale will be slightly greater than otherwise. The historical trend, e.g. from 2007-2012 has been, however, a higher development than required to meet the EU requirement for 2021. Therefore, it has been assessed that, realistically, Denmark will just meet the 2021 requirement.

5.3.3 Increase in rail transport goes hand on hand with electrification

Growth in rail transport is also expected up to 2025, and the number of kilometres covered is expected to rise by almost 15% compared with the current level. The increase is primarily due to the effects of the planned light railways and extension of the Metro in Copenhagen. There will also be a slight increase in long-distance and regional routes and well as freight transport.

Electrification of the existing railway network has also been planned at the same time as this increased activity. This transition will secure significant efficiency improvements in rail transport, as electrically powered trains are much more efficient than diesel trains. Overall, energy consumption for rail transport is expected to go up by almost 5% up to 2025.

5.4 How we did it

The projection of energy consumption for transport has been drawn up by the Danish Energy Agency with considerable input from the Danish Transport and Construction Agency, in particular. The projection has been prepared on the basis of a frozen-policy approach for the parameters regulating energy consumption, e.g. requirements for fuel-efficient for cars. On the other hand, developments in the amount of traffic have been projected on the basis of an assessment of the most realistic scenario, and therefore they also include expected future expansion of the infrastructure, even though specific projects have yet to be decided.

The projection has been prepared using the Danish Energy Agency's own Transport Model, which is a simple model to describe total energy consumption by the transport sector. The model describes road transport in most detail, and the other sectors more simply. The model projects energy consumption by road transport on the basis of total annual growth from the current level. The change in the number of kilometres driven is based on model simulations from the *Landstrafikmodellen* (national traffic model) which projects total traffic in all of Denmark.[10] After including expected efficiency improvements for new cars and the rate of replacement, total growth is calculated.

Trends in rail transport are based on expectations from the Danish Transport and Construction Agency, and these are based on known projects and their expected effects.

Simpler projections have been used for the other sectors, based on expected developments in total consumption.

More information about the projection for the transport area is available in the "D: Transport" background report.

[10] The *Landstrafikmodellen* was developed by DTU Transport at the Technical University of Denmark for the Ministry of Transport and Building and it is used in analyses and projections of traffic throughout Denmark. For more information (in Danish) see: www.landstrafikmodellen.dk

6 Production of electricity and district heating

6.1 Main points

- The green transition of the energy sector, including conversion of electricity and district heating production to renewable sources, will continue up to 2025, primarily through increased use of biomass and wind power expansion.
- Consumption of solid biomass will increase dramatically, almost doubling up to 2025 compared with current consumption. Particularly consumption of wood pellets and wood chips at large-scale plants will rise. However, consumption is sensitive to changes in biomass prices.
- Renewable energy is expected to cover about 80-85% of electricity consumption and up to 65% of district heating in 2020, compared with 55% and 50%, respectively, today. Up to 2025, the share will increase further up to 80-95% and 70%, respectively.
- Wind power alone is expected to be able to cover 53-59% of electricity consumption in 2020 and up to 53-65% of electricity consumption by 2025, compared with about 40% today. The share of wind power is sensitive towards the rate of deployment and changes in electricity consumption.
- The rising amount of electricity from wind power increases the value of the interplay with neighbouring countries through stronger interconnectors. It is expected that Danish interconnectors will be enhanced up to 2020 and 2025, with both new connections and upgrades to existing connections. This will help increase operational hours for the large-scale power plants in the period after 2020.
- Increased use of electricity to produce district heating could be a positive factor in incorporating wind power. However, significant expansion with large electrically powered heat pumps is unlikely in the near future.

6.2 Introduction

Energy consumption to produce electricity and district heating accounts for almost 45% of total Danish gross energy consumption, and therefore it is an important element in the overall green transition towards fossil-fuel independence and reducing emissions of greenhouse gases. Electricity will increasingly be generated by wind power and biomass, with corresponding reductions in production from coal, oil and natural gas. District heating production has also undergone a transition, primarily from coal and natural gas to biomass.

Today, almost 55% of electricity consumption and almost 50% of district heating consumption is covered by renewables, compared with 15% and 20%, respectively, in 2000. The large expansion of wind power has meant that wind power has risen from covering 10% of electricity consumption in 2000 to around 40% today.

The transition has also changed the way in which electricity and district heating are produced. For many years there has been a large percentage of simultaneous production of electricity and district heating at thermal CHP plants, securing high exploitation of the fuel, but this percentage is starting to fall. Among other things, this is because expansion of wind power, combined with low electricity prices, has meant that district heating is increasingly being produced from boilers that only produce heat. More efficient energy exploitation in a system with a high proportion of wind power (and in the long term perhaps with

photovoltaic solar modules and wave power) would be by producing district heating from large, electrically powered heat pumps, but this development has not yet been seen in Denmark.

Electricity production is increasingly taking place through an interplay with countries neighbouring Denmark, because electricity is exchanged through interconnectors. If it is very windy in Denmark, it is possible to sell electricity abroad. On the other hand, if there has been a lot of rain, Norway will have a surplus of hydropower-based electricity which it can sell to Denmark. Exchange is important, as it means good exploitation of electric power generating plants and it provides high security of electricity supply. The interplay with other countries is also important, as wind power cannot be adjusted like conventional thermal plants.

6.3 Developments up to 2020 and 2025

Continued development of the sector has already been planned for the years leading up to 2020, and many power plants have decided or are already in progress with converting from coal or natural gas to biomass. At the same time, continued deployment of wind power is expected, among other things as a result of the offshore wind farm projects in the 2012 Energy Agreement. However, after 2020 more modest transition to biomass and wind power expansion is expected.

Renewables are expected to cover about 80-85% of electricity consumption and up to 65% of district heating in 2020, compared with 55% and 50%, respectively, today. Up to 2025, the share will increase further up to 80-95% and 70%, respectively.[11] The renewable percentage of electricity consumption has been calculated on the assumption that exported electricity is ***not*** generated from renewables. In reality some of the electricity exported will be generated from wind power, for example, and this is already happening today.

%	2000	2005	2010	2014	2020	2025
Renewable energy in electricity consumption	16	27	35	53	78-85 (79)	80-95 (84)
- of this, wind power	12	18	22	39	53-59 (54)	53-65 (57)
- of this, other renewables	4	9	13	15	24-26 (25)	28-29 (28)
Renewable energy in district heating consumption	19	27	34	48	64-66	68-70

Table 2: Large increase in consumption of electricity and district heating covered by renewables over the past 15 years. Renewable waste is included in renewable energy. The percentage will grow further up to 2020 and 2025. Figures in brackets are for Scenario FM.

The percentage of electricity generated by wind power and in the longer term by solar photovoltaics (PV) will increase significantly at the cost of smaller CHP production and especially condensating power from large-scale power plants. The recent years' deployment of solar PV is expected to continue. Up to 2020, the deployment will primarily be in private households, but after 2020, deployment of large, commercial installations which only produce electricity for the grid, is expected to become commercially viable. Therefore, capacity is expected to more than double up to 2020, and more than quadruple up to 2025 compared with the current level, provided the expected technological developments are realised.

[11] Note that the contribution from upgraded biogas in the natural gas grid has not been included in the renewable shares.

Electricity production from solar PV modules will thereby account for about 5% of electricity consumption in 2020, rising to about 8% in 2025.

District heating from CHP plants will be about 70% in 2020 and 2025, corresponding to approximately the same level as today. In the short term, however, a lower percentage of CHP than today is expected, as the expected continuing low electricity prices make production at natural-gas-fired small-scale CHP plants more expensive than heat production from boilers. A small amount of district heating production from boilers is expected to be replaced by solar heating and electricity.

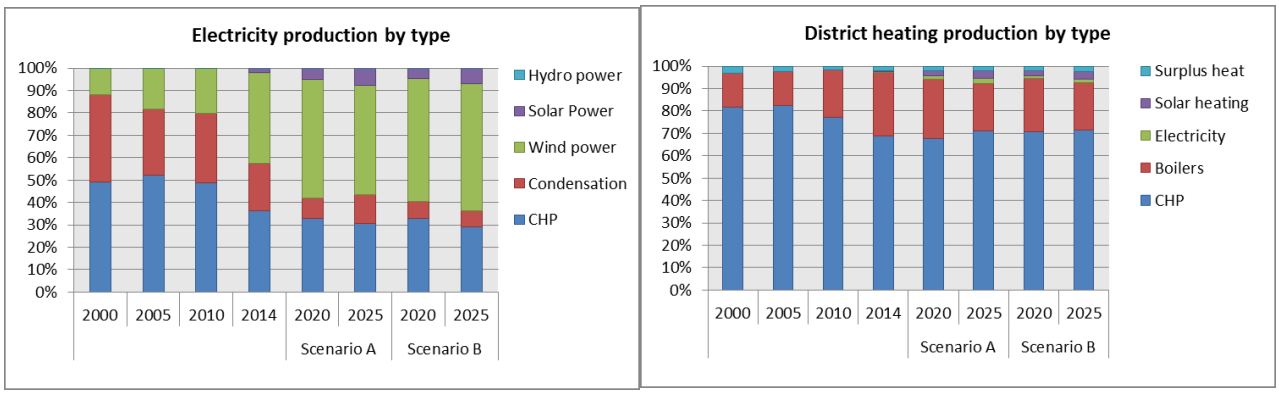

Figure 15: The percentage of electricity and district heating generated through CHP production has started to fall. The percentage of electricity generated by wind power and in the longer term by photovoltaic solar modules will increase significantly up to 2020 and 2025, primarily at the cost of production from capacitors at large-scale power plants. The composition of district heating production will not change very much, but a small part of production from boilers is expected to be replaced by solar heating and electricity.

6.3.1 Conversion to biomass will continue apace

Up to 2020, in particular, transition to biomass will continue, both through converting existing coal and natural-gas fired CHP plants and through construction of new CHP plants and heating plants. Several conversions and new builds are already in progress and are expected to be completed within the next couple of years. However, the amount of electricity and heat the new and converted plants then produce, and therefore the amount of biomass they burn, depends on what is otherwise available on the market, and at what price.

Consumption of solid biomass for electricity and district heating is expected to increase from just under 58 PJ in 2014 to 102-108 PJ in 2020 and 106-113 PJ in 2025. This means that biomass consumption will have almost doubled by 2025, and consumption of wood pellets and wood chips at large-scale plants in particular will increase. However, consumption of biomass is sensitive to developments in the biomass price relative to coal prices (including carbon prices).

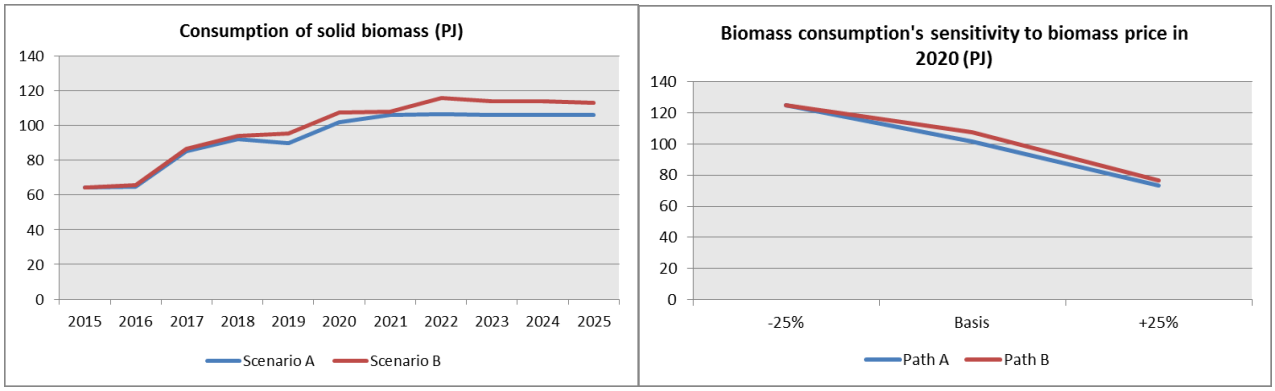

Figure 16: Consumption of solid biomass will increase dramatically up to 2020, but it is sensitive to changes in biomass prices.

A large percentage of biomass is used at large-scale plants which can be fired by either biomass or fossil fuels such as coal or natural gas. Fuel prices, carbon prices , subsidies and taxes, all determine that biomass is primarily used for CHP production, while coal or natural gas is used for separate electricity production.

6.3.2 Electricity from wind power increases and raises the value of the interplay with neighbouring countries

Electricity from wind power already covers about 40% of Danish electricity consumption, and this percentage is expected to increase considerably up to 2020, and perhaps even more up to 2025. The deployment of wind power up to 2020 is primarily due to the tendering procedures for offshore wind farms agreed in the 2012 Energy Agreement. This deployment is reasonably certain, although there may be delays in the dates the wind farms come into operation. Deployment of onshore wind power and offshore wind power under the so-called open-door scheme is more uncertain, partly because of the current very low electricity prices on the spot market, which create some uncertainty about the future revenue base for investors. Therefore deployment is likely to be more diverse. Planning aspects, such as municipal administration of the distance requirements for onshore turbines and public concerns, also contribute to uncertainty regarding future deployment. What exactly will happen regarding onshore expansion after 2020 and up to 2025 is even more uncertain, as many existing turbines are expected to reach the end of their operational life in this period. With the estimated deployment, electricity from wind power is expected to cover 53-59% of electricity consumption in 2020 and up to 53-65% of electricity consumption in 2025[12]. The percentage of wind power will also be affected by changes in electricity consumption.

[12] Electricity consumption includes grid losses and includes electricity consumption for district heating production.

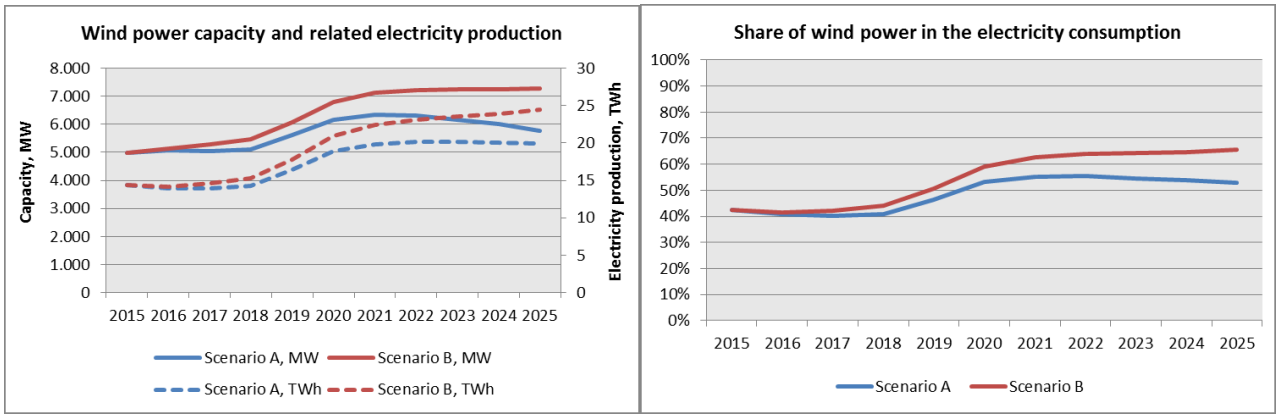

Figure 17: The expansion of wind power will intensify up to 2020, after which will bottom out or drop slightly. However, production is not expected to drop after 2020, as new turbines will produce more than the old turbines they will be replacing. The share of electricity consumption to be covered by wind power will increase vigorously up to 2020, then bottom out.

This amount of wind power increases the value of the interaction with neighbouring countries in the form of strong interconnectors so that the intermittent production from wind power can be allocated cost-efficiently, whilst also minimising the need for national reserves and maintaining a high security of electricity supply.

Denmark is already electrically connected to Norway, Sweden and Germany, although the capacity in the connection between Jutland and Germany is not being fully exploited due to internal bottlenecks in Germany. The connection to Norway has recently been improved with the establishment of Skagerrak 4, and before 2020, Denmark will be electrically connected to the Netherlands, and similarly, a new connection to Germany from the future offshore wind farm at Kriegers Flak will be developed. Up to 2020 the connection between Jutland and Germany is expected to open up more, and additional upgrading after 2020 is anticipated. This is an important prerequisite for incorporation of increasing quantities of electricity from wind power. In addition, the strengthening of interconnectors will help increase operational hours for large-scale power plants in the period after 2020.

Increased use of electricity for production of district heating may also help incorporate the increasing quantities of electricity from wind power, and at the same time, Danish district heating consumers will benefit from low-priced electricity from wind power. However, there is little information to suggest that vigorous deployment of large electrically powered heat pumps is imminent, and therefore electricity is merely expected to cover up to 2% of district heating consumption up to 2020 and 2025.

6.3.3 Denmark is a net exporter of electricity

Circumstances indicate that Denmark will go from being a net importer of electricity in the short term to being a net exporter of electricity from about 2020, see the figure below. Whether or not Denmark will then be a net importer or net exporter of electricity in a given year is, however, uncertain, as cross-border electricity depends largely on a number of factors in the electricity market; among other things, the water flow into the Norwegian hydropower system has immense importance.

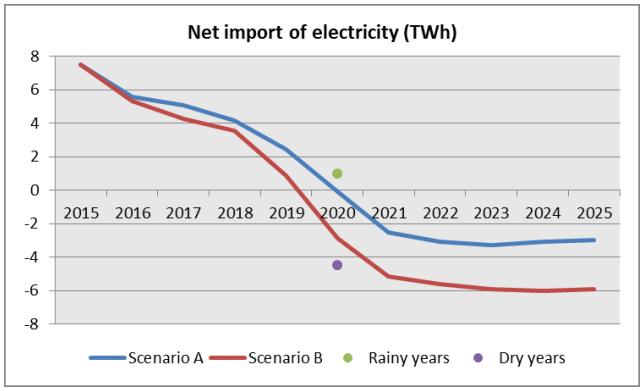

Figure 18: Denmark will go from being a net importer of electricity in the short term to being a net exporter of electricity in the long term.

Cross-border electricity is also important for electricity prices, as are strong interconnectors towards the south, which are typically high-price areas. This may help increase Danish electricity prices and thus improve the revenue base of Danish electricity generators. For more information about the development and sensitivity of electricity prices to changed assumptions, see the background report "F: Projection of electricity prices".

6.4 How we did it

Electricity and district heating production have been calculated on the basis of the RAMSES model of the Danish Energy Agency. RAMSES is a simulation model, which calculates electricity and district heating production by an installation in time intervals down to one hour. Also fuel consumption, environmental impacts and financial aspects are calculated for the individual installations, as well as electricity prices for, and cross-border electricity between, the countries included. Denmark, Norway, Sweden, Finland, Germany and the Netherlands are part of RAMSES. Countries outside the model, to which there are electrical connections, are modelled using cross-border electricity given exogenously.

More information is available here:

- For more information on RAMSES, see the "A: Model Setup" background report and the Danish Energy Agency's website[13].
- For more information about assumptions for developments in consumption, production capacity, etc., see the "E: Electricity and district heating" background report.
- For more information about assumptions for developments in fuel and allowance prices, see the "B: Fuel and allowance prices" background report.

[13] http://www.ens.dk/info/tal-kort/fremskrivninger-analyser-modeller/modeller/ramses

7 Greenhouse gas emissions

7.1 Main points

- Total Danish greenhouse-gas emissions are expected to continue to fall up to 2020, after which they will remain stable up to 2025. The most substantial fall is within production of electricity and district heating sectors.
- If the Danish climate efforts are calculated using the same method as in the 2013 Climate Policy Plan, which includes a contribution from carbon sequestration in soil and forests, total greenhouse-gas emissions are expected to be reduced by about 40% by 2020 compared with 1990.
- Emissions without contributions from carbon sequestration in forests and soil are expected to be 37-38% below the 1990 level by 2020.
- However, there are significant uncertainties associated with the projection of greenhouse-gas emissions, and with variations of different parameters, sensitivity analyses show a reduction in the interval 35-44% in 2020 compared with 1990, including contributions from carbon sequestration in forests and soil.
- Denmark is expected to reach its accumulated non-ETS obligation in relation to the EU for the period 2013-2020. However, it is likely that the single-year goal in 2020 will not quite be met. Overall, however, Denmark is likely to go beyond its EU obligation, as meeting below target one year is allowed, if the obligation is exceeded correspondingly in another year.

7.2 Introduction

Total Danish greenhouse-gas emissions have exhibited a downward trend since the mid-1990s. In 2013, total emissions had dropped by about 20% compared with 1990. Emissions from the energy sector - which include emissions from electricity and district heating production, as well as oil and gas extraction and refineries - have traditionally been the major share of emissions, but have also fallen significantly, due to Danish efforts in the green transition of the energy system. In 1990, the transport sector was a less important category in the calculation of greenhouse gases, but the sector has grown steadily as a consequence of the increasing transport needs following in the wake of economic development. However, there has been a drop in the energy consumption of the transport sector and thus greenhouse-gas emissions since 2008 due to the financial downturn and increasing focus on energy efficiency in cars. Emissions from agriculture, including energy consumption for this sector, have been falling since 1990, primarily due to increased efficiency of agricultural production and stricter environmental regulation. Other emissions, which are from heating of households, energy consumption by businesses as well as waste and wastewater, have seen the same falling trend in emissions as the energy sector, and they are driven by the same mechanisms - transition to renewable energy and increased energy efficiency.

Greenhouse-gas emissions and CO_2eq explained
Greenhouse gases include: • CO_2 (carbon dioxide): Derives primarily from burning fossil fuels such as coal, oil and natural gas. • CH_4 (methane): Derives primarily from organic processes such as the digestion system of animals and waste composting. • N_2O (nitrous oxide): Derives primarily from nitrogen conversion. • F-gases: Derive primarily from chemical processes.

CO_2 is the greenhouse gas that dominates. In order to compare the climate impact of emissions of various gases, their climate impact is translated into CO_2 equivalents or CO_2eq. The result is a figure that shows the amount of tonnes of CO_2 corresponding to one tonne of methane, nitrous oxide or F-gas.

The greenhouse gases derive from many different activities and sources, but emissions are only measured in very few cases. Therefore emissions are decided by means of emissions factors which are established on the basis of scientific surveys. For activities such as burning fossil fuels, the calculation is simple, but for many other activities, the calculation of the emissions factor is more complex. Emissions from animal production depend on the ability of the animals to exploit animal feed, whilst methane evaporation from landfills is linked to the amount and composition of waste.

Science regularly assesses whether emissions factors are appropriate, or need to be adjusted in the light of new knowledge. When this happens, the projections and also historical figures are adjusted to produce a more correct presentation of the historical emissions. Adjustments in emissions factors are made to a greater or lesser extent between each projection, and the 2015 projection is no exception. Therefore it is important to emphasize that the projection shows a snapshot of the historical greenhouse-gas emissions, and what such emissions will be in the future, based on assumptions applying today's best knowledge.

7.3 Developments up to 2020 and 2025

Total Danish greenhouse-gas emissions are expected to fall up to 2020, after which they will remain stable for the remaining part of the projection period[14]. In 2020, total emissions without contributions from carbon sequestration in forests and soil are expected to be around 37-38% under the 1990 level, but the development by sector varies.

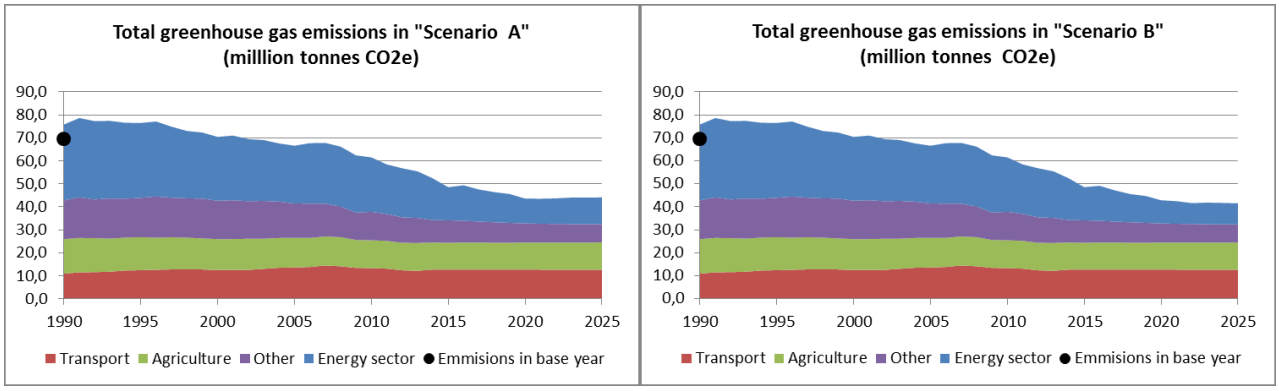

Figure 19: Total **Danish greenhouse-gas emissions will fall up to 2020 and then bottom out. The most pronounced fall will be in electricity and district heating production. Emissions have been adjusted for electricity trade with other countries. Note that the baseline year is defined by observed emissions in 1990, which were particularly low due to considerable levels of electricity imports.**

Most of the fall in projected emissions will be in the energy sector, and it is linked to increasing energy efficiency and the conversion to renewable energy for production of electricity and district heating. The current Energy Agreement from 2012 and previous energy agreements, have had great importance for

[14] In the projection, energy consumption (and associated greenhouse-gas emissions) for electricity production has been adjusted for electricity trade with other countries. This illustrates the greenhouse gas footprint of Danish energy consumption, regardless of whether the energy has been produced inside or outside Denmark.

developments in emissions. Policy initiatives in the current agreement contribute to reducing emissions from the production of electricity and district heating up to 2021[15]. The expiry of the agreement thus causes emissions to remain stable after 2020.

For the transport sector, emissions in 2020 are expected to be at a higher level than in 1990. This covers a fall since 2005 and up to today, after which a slight increase is expected up to 2020. However, emissions are still below the 2005 level.

Emissions from the agricultural sector are expected to drop by about 22% in 2020 compared with 1990, but the rate is expected to be lower in the coming years than it has been in the past.

Emissions from the other sectors are expected to be reduced by about 69% in 2020 compared with 1990. This is primarily due to continued transition to renewable energy and increasing energy efficiency in households and the corporate sector.

	1990	2005	Reduction in relative to 1990	2013	Reduction in relative to 1990	2020	Reduction in relative to 1990
Total emissions	69.6	66.6	4%	55.5	20%	43-43½	37-38%
Energy sector	33.0	25.2	24%	20.3	39%	10-11	67-69%
Transport sector	10.9	13.6	-25%	12.2	-12%	12.7	-16%
Agricultural sector	15.0	12.8	15%	12.1	20%	11.8	22%
Other sectors	16.6	14.9	10%	10.9	34%	8.3	50%

Table 3: Total emissions analysed by sector in 1990, 2005, 2013 and 2020. Note: Negative figures mean increased emissions. Except for the baseline year 1990, emissions from the energy sector have been adjusted for emissions linked to electricity trade with other countries. Note that in the baseline year 1990, there were extensive electricity imports, and that the adjusted emissions this year are therefore considerably higher than shown in the table.

7.3.1 Distribution between sectors changes over time

In 1990, the energy sector accounted for just under 45% of total emissions, but is expected to only account for about 25% in 2020. This means that the transport sector and the agricultural sector, where emissions in 2020 are expected to be more or less at the current level, will be relatively more dominant overall.

It should be noted that, as the reduction potential in the energy sector drops, it will be increasingly more necessary to increase reduction efforts in the other sectors, if the total downward trend is to continue.

[15] The agreement runs until 2020, but the most recent planned date of commencement of the offshore wind farm at Kriegers Flak was delayed with Growth Agreement 2014, to the affect that the wind farm is now not expected to be fully running until at the end of 2021, and similarly, part of the RE for production processes scheme pool was delayed until 2021.

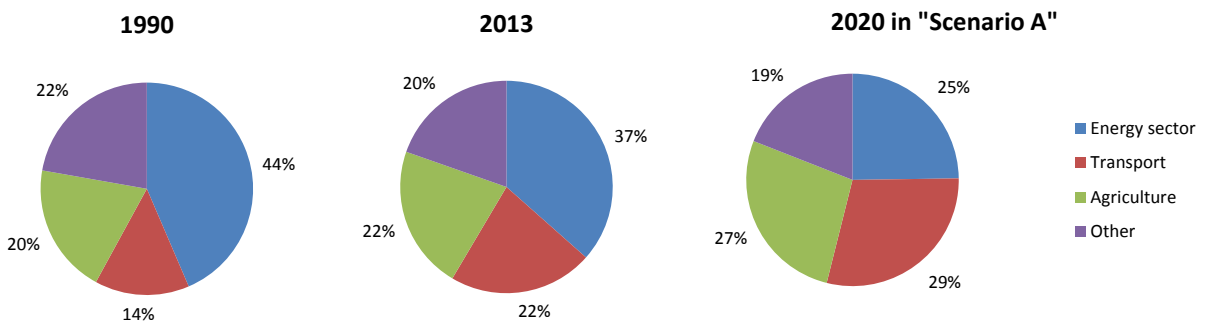

Figure 20: Distribution of emissions between sectors changes over time. Except for the baseline year 1990, emissions from the energy sector have been adjusted for emissions linked to electricity trade with other countries. For 2020 this distribution is only shown for "Scenario A" as the distribution is more or less identical to the other scenarios.

7.3.2 The emissions are sensitive to changes in assumptions

In addition to the general uncertainty associated with a projection, a number of specific parameters are important for the emissions, and these may develop differently than assumed. Sensitivity analyses have been made for a number of significant parameters, adding together the parameter changes pulling in the same direction. The sensitivity analyses reflect adjustments of general assumptions and not changes in regulation. The impact of any new regulation will therefore go beyond the sensitivity analyses.

Emissions in 2020 (million tonnes of CO_2eq)	Energy sector	Transport	Agriculture
Higher emissions	+2.7	+0.4	+0.3
Lower emissions	-1.6	-0.4	-0.3

Table 4: Significance of sensitivity analyses on emissions by 2020. Emissions have been adjusted for electricity trade with other countries.

7.3.3 Greater reductions in total emissions in 2020 than in the 2014 projection

In connection with drawing up the 2013 Climate Policy Plan, an expected contribution of 1.9 million tonnes of CO_2eq from sequestration of carbon in soil and forests, the so-called LULUCF contribution was included in the calculation. If the emissions in the 2015 projection are calculated according to the method used for the 2013 Climate Policy Plan, the emissions are about 40-41% lower than the 1990 level compared with 37% in the 2014 projection. However, as mentioned, results are sensitive to changes in central assumptions. When taking into account the result of the sensitivity analyses, the total range will be considerably greater, and with the parameter variants used, emissions in 2020 are expected to be about 35-44% below the 1990 level.

Million tonnes of CO_2eq	Emissions in baseline year 1990	LULUCF contribution	Expected emissions in 2020	Reduction relative to 1990, %	Expected emissions in 2020, including LULUCF contribution	Reduction relative to 1990, including LULUCF contribution, %
The 2014 projection	68.9	-1.9	45.2	34%	43.3	37%
Scenario A	69.6	-1.9	43.6	37%	41.7	40%
Scenario B:	69.6	-1.9	42.9	38%	41.0	41%
Scenario FM:	69.6	-1.9	43.5	38%	41.6	40%
Scenarios A, B, FM, including sensitivities	69.6	-1.9	40.6-47.1	32-42%	38.7-45.2	35-44%

***Based on the scenario with estimated mean allowance price.**
Table 5: Emissions and reductions in 2020, including LULUCF contribution and compared with the 2014 projection. Except for the baseline year 1990, emissions from the energy sector have been adjusted for emissions linked to electricity trade with other countries.

7.3.4 Why will the reduction in 2020 be higher in the 2015 projection?

Generally, it is difficult to isolate the individual assumptions that generate the differences between different year's projections. Compared with the 2014 projections, emissions in the base year 1990 will be adjusted upwards, as a consequence of new knowledge about the emissions factor associated with dairy cattle. This in itself has increased the expected reduction by about ½ percentage point.

The greatest change is in the energy sector, due to expectations for greater use of biomass for the production of electricity and district heating. Also, a significant downwards adjustment in the expectations for electricity consumption causes the picture to change. Overall, this will result in considerably lower emissions. The increased reduction in this sector has contributed to increasing the expected total reduction by 3 percentage points. In the agricultural sector, lower expectations for the number of animals also reduce emissions, whereas in contrast, expectations for the transport sector lead to increased emissions compared with the last projection. The transport sector contributes to reducing the expected total reduction by 1 percentage points. This is partly due to recent statistics showing that more cars are expected, but also lower use of biofuels than in the last projection.

Overall the adjustments mean that the expected, total emissions in 2020 are about 2½ percentage points lower than in the 2014 projection. Behind this are two opposite trends: Emissions covered by the EU Emissions Trading System ETS are expected to be 2-3 million tonnes of CO_2eq lower in 2020 than at the last projection, whilst non-ETS emissions are expected to be about 1 million tonnes CO_2eq higher in 2020 compared with the 2014 projections.

7.3.5 The goal for non-ETS greenhouse-gas emissions in 2013-2020 will be reached

In the EU climate and energy package from 2009, Denmark is obliged to reduce emissions from non-ETS sectors by 20% by 2020 in relation to the 2005 level, as well as to achieve sub-targets towards 2020. The sub-targets are tightened gradually up to the end-target in 2020. Because of natural fluctuations in emissions, it is possible, however, to carry forward over-compliance from one year and set this off against under-compliance in another year.

The projection shows over-compliance throughout the period 2013-2019, whilst a shortfall of about ½ million tonnes CO_2eq is expected in 2020. As the preceding years' over-compliance may be carried forward and used for target performance in 2020, Denmark is expected to comply with the reduction obligations. In

total, accumulated over-compliance of about 14 million tonnes CO_2eq is expected for the entire commitment period.

When taking into account the sensitivities, the result may go from coming below the target in 2020 of slightly above 1 million tonnes CO_2eq to over-compliance for the entire period. Overall, including sensitivities, accumulated over-compliance is expected for the entire period of between 11½ and 16½ million tonnes CO_2eq.

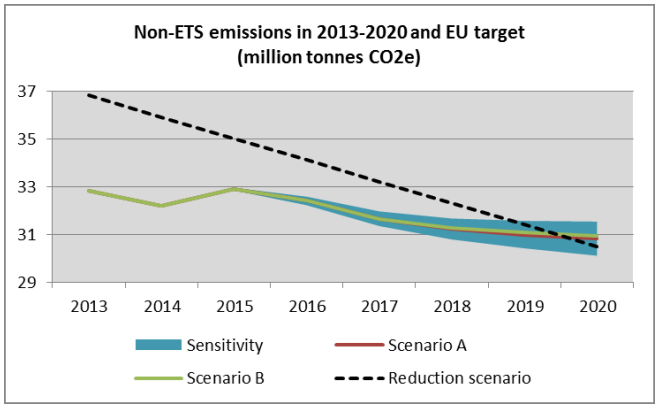

Figure 21: It is likely that the target will be exceeded up to 2019 and go slightly below the target in 2020. Note that the y axis does not go down to 0.

7.4 How we did it

Danish fuel consumption, including the breakdown into ETS/non-ETS, has been projected by the Danish Energy Agency. The Danish Centre for Environment and Energy (DCE) at Aarhus University has subsequently converted this fuel consumption into greenhouse-gas emissions. Furthermore, the Danish Centre for Environment and Energy (DCE) has projected the other non-energy-related activities such as agriculture, waste and wastewater as well as industrial processes. The Danish Centre for Environment and Energy (DCE) has converted these activity data into greenhouse-gas emissions, broken down by gases and sources.

The projection of agricultural activities is with input from relevant authorities and research organisations. A new model for the projection of livestock numbers is being developed, but has not been used in the 2015 projection. Instead, the same growth assumptions have been used as in the last projection, based on updated statistics. Lower statistics have resulted in a lower level in emissions from livestock.

More information about the projection for greenhouse-gas emissions is available in the “D: Greenhouse gas emissions" background report.

Definitions regarding energy consumption

Final energy consumption: The final energy consumption expresses energy consumption delivered to end users, i.e. private and public enterprises as well as households. The purpose of this energy use is manufacture of goods and services, space heating, lighting and other appliance consumption as well as transport. To this should be added consumption for non-energy purposes, i.e. lubrication, cleaning and bitumen (asphalt) for paving roads. Energy consumption in connection with extraction of energy, refining and production of electricity and district heating is not included in final energy consumption. Moreover, final energy consumption excludes cross-border trading with oil products defined as the quantity of petrol, gas/diesel fuel and pet-coke, which due to differences in price is purchased (net) by private individuals and transport operators etc. on one side of the border and consumed on the other side of the border.

Gross final energy consumption: The gross final energy consumption is calculated by adding final energy consumption, excluding consumption for non-energy purposes, to cross-border trade, electricity and district heating losses, as well as consumption of electricity and heat by the energy branch for electricity and district heating. The gross final energy consumption is used in connection with the EU's renewable energy targets.

Actual energy consumption: The actual energy consumption is found by adding final energy consumption distribution losses and energy consumption in connection with extraction of energy and refining. Furthermore, energy consumption applied (fuel consumption, wind energy, etc.) by production of electricity and district heating is added.

Gross energy consumption: Gross energy consumption is found by adjusting observed energy consumption for fuel consumption linked to foreign trade in electricity. The gross energy consumption describes the total input of primary energy to the energy system. The primary energy input to the Danish energy system is a mix of fuels and fuel-free energy in the form of wind power, solar energy and geothermal energy.

Gross energy consumption (adjusted): Adjusted gross energy consumption is found by adjusting observed energy consumption for fluctuations in climate with respect to a normal weather year. In practice, the final energy consumption is climate-adjusted. In connection with projections, a normal weather year is assumed, and therefore the adjusted gross energy consumption equals the gross energy consumption and the projection only mentions the gross energy consumption. The adjusted gross energy consumption is used in connection with national targets.