REPORT

2017

Energinet's analysis assumptions

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CONTENTS

1. Introduction

Energinet is tasked with infrastructure development in the energy system based on long-term and comprehensive planning. It is therefore important to have a central set of assumptions about the future development of the energy system for use in Energinet's analyses, business cases, budget and international cooperation.

Due to the conversion of the energy system to accommodate increasing volumes of renewable energy and the rapid technological developments observed in this field, it is also important that these assumptions are updated on a regular basis.

Energinet therefore prepares annual analysis assumptions, and this report describes the assumptions and data used in Energinet in 2017. Tables and data underpinning the figures in this report can be found in the associated spreadsheet [1].

Energinet's analysis assumptions are prepared for internal use only, but are published to give stakeholders insight into Energinet's assumptions about the future energy system. Energinet accepts no responsibility for how these assumptions are used outside Energinet.

1.1 Delimitation

Energinet's analysis assumptions 2017 describe assumptions about prices, consumption, and production and transmission capacity in the electricity and gas systems, chiefly for Denmark but to some extent also for Denmark's neighbouring countries.

In addition to this, the use of the analysis assumptions for grid planning is described.

Some assumptions are not covered in this report. Reference is made to the Danish Energy Agency's macroeconomic calculation assumptions [2] for data on, for example, heat prices, emissions and tax rates.

1.2 Important changes from last year's analysis assumptions

The following sections detail significant changes from last year's analysis assumptions. Changes relate to revised political or technological framework conditions or methods, or new analysis results.

1.2.1 Electricity consumption

Substantial upward adjustment of electricity and gas consumption for road and sea transport based on a new, long-term analysis prepared by Energinet. The analysis will be published in mid-2017.

1.2.2 Combined heat and power (CHP)

Minor adjustments of short and long-term capacity for the central CHP plants based on Energinet's latest information and own calculations. The projection also factors in the possibility of combining, or completely replacing, electricity generation with electricity consumption for heat generation.

Significantly reduced long-term electricity capacity for local electric heat pumps based on a changed analysis approach in which lifetime analyses for investments in the heating sector in the medium term will have an impact on new investments after 2030.

1.2.3 Solar cells

The expected capacity for solar cells in the short and medium terms is reduced, while a rapid increase in the rate of expansion is expected in the long term. The adjustment is based on significant changes in the framework conditions for investments in solar cells.

1.2.4 Wind turbines

Expectations for new capacity have been lowered for land-based wind turbines, but adjusted upward for offshore and near-shore wind turbines. These changes are based on a reassessment of the framework conditions for the installation of wind turbines. The shift from land to sea owes partly to a significant price reduction on offshore installation, and partly to land-based wind turbines encountering steadily increasing local opposition.

1.2.5 Gas

Data on gas production from the North Sea has been reduced in the period 2020-2022 due to the shutdown and renovation of the Tyra gas field during these years. The years 2024-2027 show an increase in gas production from the North Sea, following the renovation of Tyra. Gas consumption data has been updated to match the results from the new analysis of electricity and gas for transport.

1.3 Energinet's approach to long-term projections

Energinet's analysis assumptions are prepared on the basis of detailed analyses of the energy system (both internal and external) and on Energinet's professional input, and they represent Energinet's best estimates for a possible future development among many probabilities.

Combined with announced but not yet launched initiatives, the assumptions are based on current political framework conditions and expectations of a long-term and socio-economically viable transition. Thus, these assumptions are not subject to a 'frozen policy' and have not been projected with the aim of achieving political objectives – but the political objectives are, of course, taken into account as Energinet is responsible for developing infrastructure which meets national and international energy and environmental policy objectives at all times.

Energinet uses two general approaches to estimating the future dissemination of technologies in the Danish energy system:

1) Projection of large plants, e.g. wind turbines, power stations and data centres.
2) Projection of small units, e.g. solar cells, electric vehicles and heat pumps.

Technologies under item 1 generally require a longer process for planning, obtaining regulatory approvals etc. This makes it possible for Energinet, through dialogue with stakeholders and industry players, to keep an updated pipeline estimate of future projects, using this to estimate long-term development.

Technologies under item 2 require more of a prediction of the behaviour of large groups of stakeholders. Examples include businesses' purchase of solar cells and households' replacement of heating sources or transport modes. For these, Energinet estimates the expected phase-in curve based on a general S-curve approach[1] that takes account of the fact that the market players are not a homogeneous group and that they make investments based on a number of differing parameters.

A generic example of an S-curve for technology phase-in is shown in Figure 1. The form and slope of the S-curve will vary from technology to technology. An elasticity assessment where changes in consumer behaviour are estimated on the basis of historical data may be used to determine the form and slope of the S-curve. For a number of technologies, such as electric vehicles, household battery plants and heat pumps in district heating, the historical basis for estimating elasticity is sparse, as the dissemination of these technologies in the sector is limited. Here, Energinet uses professional assessments of the maturity of the technology, its ability to meet consumer demands, economic aspects etc. to determine the form and slope of the S-curve.

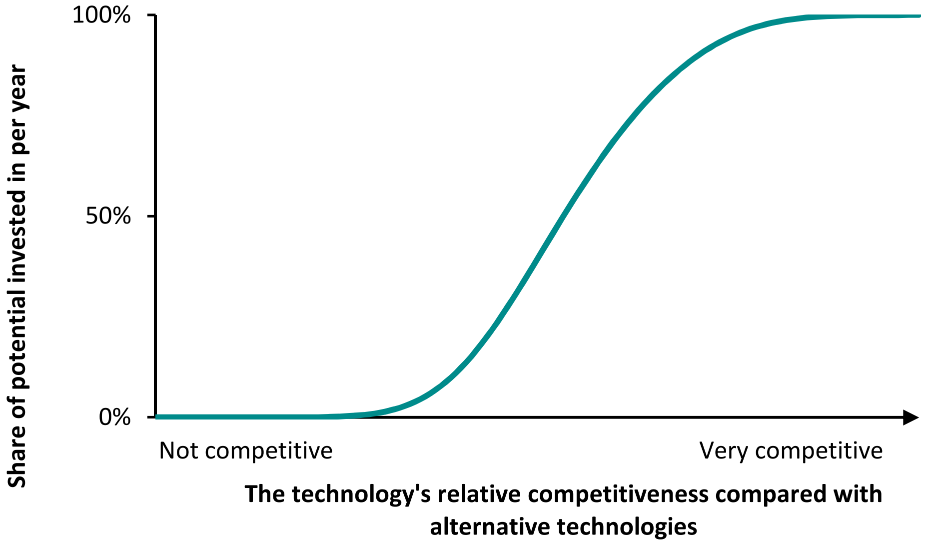

Figure 1 Generic example of an S-curve for phase-in of a given technology.

Energinet uses the S-curve to perform analyses to determine the number of investments to expect in a given sector (the potential) as a function of competitiveness. Individual calculations are made for each year within the planning period under two scenarios – one with current taxes and subsidies and one without. The latter calculation means to take into account the long-term development of the framework conditions which, with a certain degree of approximation, may be expected to become less fiscally distorted.

Energinet's expected development is found by coupling the two expansion scenarios. Short-term, business economy is weighted the highest, while socio-economics takes top place in the long term. Figure 2 shows the principle behind the weighting between the business economic and socio-economic scenarios as well as an example of how these processes can be combined into an expected scenario which is used in the analysis assumptions.

1 The S-curve approach is, among others, described by Brian C. Twiss in the publication *Forecasting for Technologists and Engineers: A Practical Guide for Better Decisions* [37].

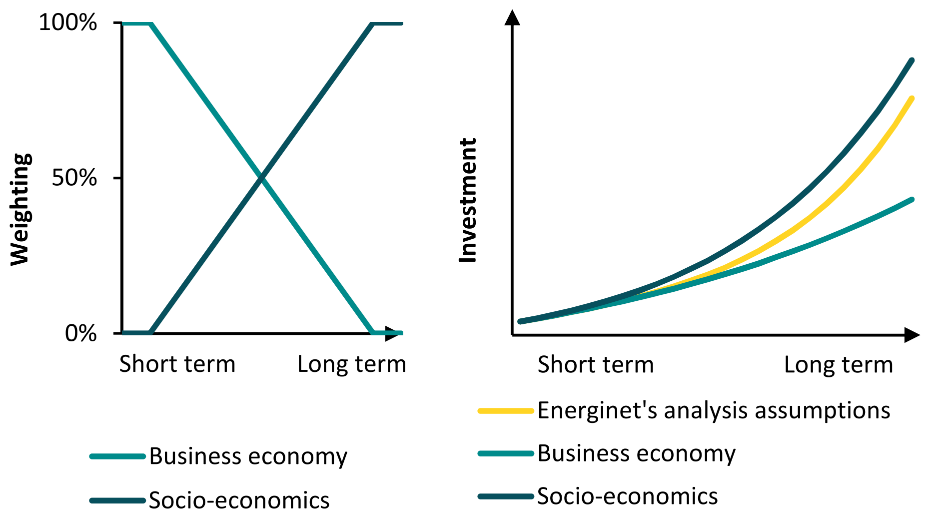

Figure 2 Principle behind the weighting of business economy and socio-economics in the short and long term (left) and a sample expansion scenario for a given technology (right).

2. Key economic figures

Energinet uses the Ministry of Economic Affairs and the Interior's economic projections found in Denmark's Convergence Programme 2017 as the source of key economic figures in present analysis assumptions.

The outlook for average real growth in the gross domestic product (GDP), inflation measured by the change in percentages in the net price index and the 10-year Danish government bond yield in the final year is shown in Table 1.

	2017	2018	2019	2020	2025	2030	2040
	Annual change in per cent						
Real GDP	1.5	1.7	1.7	2.0	1.2	1.6	1.5
Net price index	1.3	1.7	1.7	2.0	2.1	2.1	2.1
	Per cent						
10-year Danish government bond yield	0.7	1.1	1.6	2.2	4.4	4.5	4.5

Table 1 Development in real GDP, inflation expressed by the net price index and the 10-year Danish government bond yield from Denmark's Convergence Programme 2017.

For investment projects where the cost-benefit analysis is based on socio-economic calculations, the guidelines in the instructions from the Danish Energy Agency [2] and the Danish Ministry of Finance [3] are used. When evaluating investment alternatives, a socio-economic calculation interest rate [4] (discount rate) is used, which starts at 4 per cent but is gradually reduced for projects with a long duration, as shown in Table 2. The specified socio-economic calculation interest rate is a real interest rate, meaning that it is inflation-adjusted.

Real socio-economic calculation interest rate (per cent)	
Year 0-35	4%
Year 36-70	3%
Year 70 and subsequent years	2%

Table 2 The real socio-economic calculation interest rate in per cent (discount rate).

When calculating construction loan interest rates in connection with Energinet's investment projects, Energinet's effective interest rate is used, which reflects the total finance cost in the fiscal year for Energinet. As a rule, it is based on a mix of 10 and 30-year government bonds. The forecast for the effective interest rate, calculated in early May 2017, is shown in Table 3.

Year	Effective interest rate for construction loan interest rates (per cent)
2017-2018	1.60%
2019-2022	1.75%
2023 and onwards	1.90%

Table 3 Energinet's effective construction loan interest rate forecast in per cent, early May 2017.

In connection with foreign currency translations when projecting fuel prices and CO_2 emission allowance prices in the analysis assumptions, the exchange rates used in the Danish Energy

Agency's socio-economic assumptions for energy prices and emissions are used [5]. Contrary to these assumptions, the dollar exchange rate has been given a small upward adjustment in the short term in Denmark's Convergence Programme 2017, but is still being adjusted to a long-term exchange rate of DKK 6.25 per USD. The exchange rates in Denmark's Convergence Programme 2017 are shown in Table 4.

	2017	2018	2019	2020	2025	2030	2040
DKK/USD	6.93	6.89	6.80	6.70	6.25	6.25	6.25
USD/EUR	1.07	1.08	1.09	1.11	1.19	1.19	1.19
DKK/EUR	7.44	7.44	7.41	7.46	7.44	7.44	7.44

Table 4 USD and EUR exchange rates from Denmark's Convergence Programme 2017.

3. Fuel prices

One important role of the analysis assumptions is to provide Energinet with an insight into the market players' situations and actions. In this context, assumptions concerning future fuel prices at which players buy fuels are a crucial parameter, and they are also a significant factor behind electricity prices in Denmark and Denmark's neighbouring areas [6].

Fuel prices used in the analysis assumptions are calculated based on data from representative consumption sites: for central power stations or central CHP plants (at central plant) and for local CHP plants, district heating plants and industry plants (at local plant). All prices are exclusive of taxes, subsidies and VAT.

All assumptions about refinery costs and costs of transport, storage and profits (including for households and other small-scale consumers) as well as heating values, exchange rates and inflation are from the Danish Energy Agency's socio-economic assumptions published in May 2017 [5].

The resulting prices in Energinet's analysis assumptions are not identical to those in the socio-economic assumptions, due to differences in the way that short-term market prices are combined with long-term modelled equilibrium prices, as described in section 3.1.

The following sections describe the sources of the fossil fuel and biomass prices, respectively, as well as the methods Energinet applies.

3.1 Projections of coal, oil and natural gas prices

The most recent projections from the International Energy Agency (IEA) form the basis of the fossil fuel prices used (coal, oil products and natural gas). The IEA calculates long-term equilibrium fossil fuel prices under conditions set up in a number of cohesive scenarios for trends in the global energy markets, updated in the agency's annual publication *World Energy Outlook*. Prices in the analysis assumptions are based on trends in the main scenario 'New Policies Scenario' in *World Energy Outlook 2016* [7].

The method of using IEA's prices as the basis of projections of fossil fuel prices for Danish consumption sites was developed by Ea Energy Analyses and can be described in three overall steps:

1. Projections of international prices of coal, crude oil and natural gas by combining long-term equilibrium prices from the IEA with current market expectations for short-term price movements.
2. Estimation of Danish import prices by adjusting the international prices in step 1 with the average historical difference between IEA-based prices and Danish import prices.
3. Estimation of extra charges and deductions for the determination of the coupling between the Danish prices in step 2 and Danish prices at the consumption sites.

3.1.1 Step 1: Projections of international prices

As current market prices may have changed significantly since the IEA published its projections, and not least until Energinet begins using them in the analysis assumptions, the long-term prices from the IEA are combined with the market's most recent outlook in the form of the price of forward contracts in the financial markets (forward prices) [8].

In practice, this step is therefore a combination of two price scenarios: a scenario based solely on forward prices (kept constant in fixed prices matching the last available year) and a scenario based solely on IEA prices. Forward prices used by Energinet are spot prices from 29 March 2017, and sources are indicated in Table 5.

Fuel	Power exchange	Product name
Coal	ICE	Rotterdam Coal Futures
Crude oil	ICE	Brent Crude Futures
Natural gas	ICE Endex	German GASPOOL Futures

Table 5 Sources of forward prices in Energinet's analysis assumptions 2017.

The mechanics of the combination of IEA prices and forward prices is as much an assessment of how long the market outlook holds in respect of the equilibrium price between supply and demand which the IEA deems necessary. In any case, both forward prices and IEA's projections are associated with significant uncertainties; historically, forward prices have fluctuated greatly, and IEA prices, as model prices, are subject to simplifications and uncertainties associated with the exogenous assumptions that the IEA makes about global trends in the scenario.

Compared with the original method developed by Ea Energy Analyses, Energinet has chosen to place greater weight on the forward prices in the short and medium terms, as shown in Table 6. This method was also used in last year's analysis assumptions.

2017-2019	2020-2029	2030 and onwards
100 per cent forward prices.	Gradual linear transition	100 per cent IEA prices.

Table 6 Weighting between forward prices and the IEA's long-term equilibrium prices used in the projection of fossil fuel prices.

3.1.2 Step 2: Estimation of Danish import prices

Danish import prices are estimated by adding the average difference between historical Danish prices (calculated on the basis of the Energy Account tables ENE2HA and ENE4HA from Statistics Denmark) and IEA prices (from the IEA's *Energy Prices and Taxes* as well as earlier publications of *World Energy Outlook*) to international prices. This difference has been calculated for each fuel type in the period 2000-2014 and is shown in Table 7.

DKK/GJ (2017 prices)	Price difference to IEA
Coal	0.32
Crude oil	5.67
Natural gas	-13.40

Table 7 Average difference between historical Danish prices and historical IEA prices for coal, crude oil and natural gas in the period 2000-2014.

Historically, Danish natural gas prices have been DKK 13.4 per GJ below the IEA price, which is used as a European average. This can be explained by Denmark historical role as a net exporter of natural gas, often setting prices. Due to the long-term outlook that natural gas production in the North Sea will be reduced[2], it is assessed that Denmark will become a price taker instead. In the natural gas price projections, this is reflected in a gradual reduction of the price difference, bringing the Danish import price of natural gas on a par with international prices in 2035. This is a significant change compared with last year's analysis assumptions and the original method developed by Ea Energy Analyses.

The historical price differences to IEA for coal and crude oil are assumed to be constant in fixed prices for the full projection period.

3.1.3 Step 3: Estimation of prices at Danish consumption site

A number of estimated extra charges are used for refinery costs and costs of transport, storage and profits when converting Danish import prices to the prices that Danish market players must pay for fuel products. The method used to estimate these extra charges was developed and described by Ea Energy Analyses [9]. Extra charges used in the analysis assumptions are found in the Danish Energy Agency's socio-economic assumptions published in May 2017 [5] and shown in Table 8. All extra charges are kept constant in fixed prices for the full projection period.

DKK/GJ (2017 prices)	At central plant	At local plant
Coal	0.4	-
Fuel oil	-15.5	-
Gas oil	22.7	35.2
Natural gas	2.6	9.4
Natural gas (excluding sunk costs)	1.3	2.7

Table 8 Refinery costs and costs of transport, storage and profits for fossil fuels used in Energinet's analysis assumptions 2017.

Resulting prices of fossil fuels utilised at central plant are illustrated in Figure 3, while prices at local plant are shown in Figure 4.

2 See chapter 11 for consumption and production of natural gas.

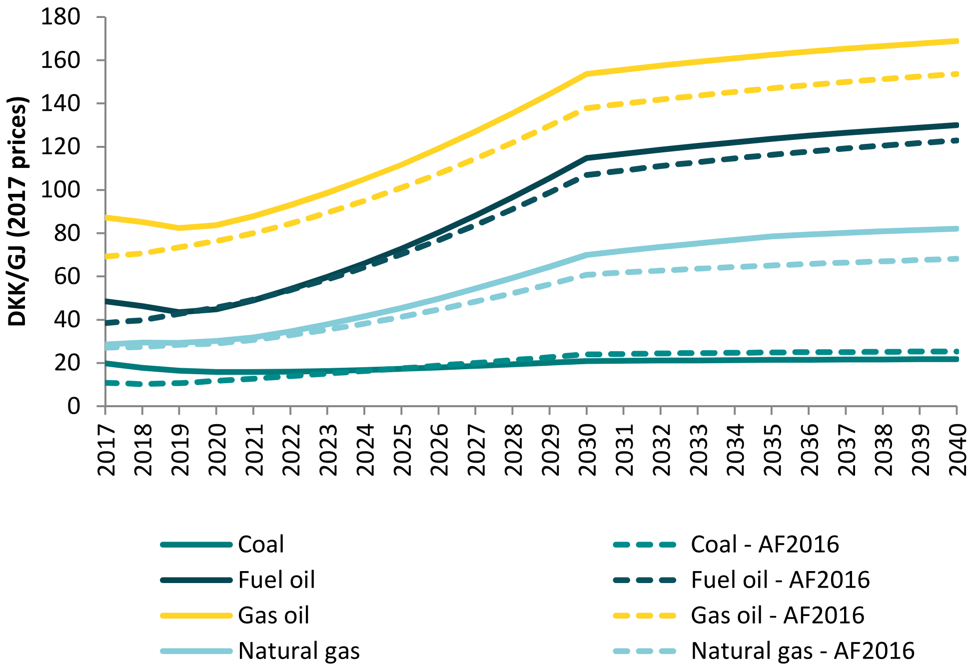

Figure 3 Price projection for used fossil fuels to central plant for the 2017-2040 period. All prices are in DKK/GJ (2017 prices). The natural gas price is inclusive of sunk costs.

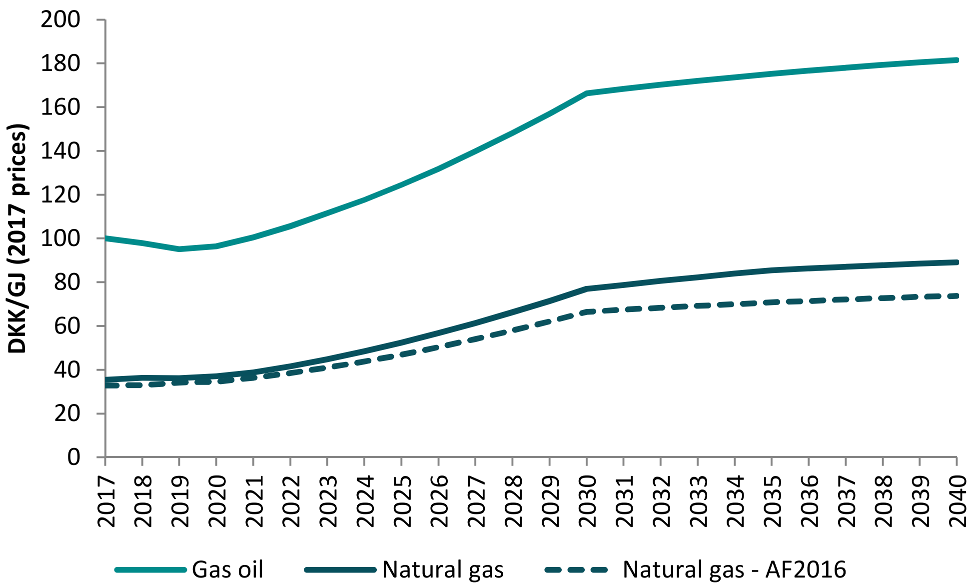

Figure 4 Price projection for used fossil fuels to local plant for the 2017-2040 period. All prices are in DKK/GJ (2017 prices). The natural gas price is inclusive of sunk costs.

3.2 Projection of prices of straw, wood chips and wood pellets

As opposed to the projection of fossil fuel prices, the IEA does not prepare a regularly updated projection of the prices of solid biomass (straw, wood chips and wood pellets). For this reason, Ea Energy Analyses, on behalf of the Danish Energy Agency, has prepared an analysis of the long-term Danish import prices of solid biomass [10] and has developed a method for converting these import prices to prices at Danish consumption site [11]. The method and data basis of the analysis were most recently updated in 2016, when Ea Energy Analyses made it possible to incorporate forward prices of wood pellets [12], among other things,. The result of this work is used in the Danish Energy Agency's socio-economic assumptions and forms the basis of the projection in the analysis assumptions.

Initially, calculations are made of the long-term equilibrium prices for wood chips and wood pellets delivered to Denmark (import prices) and of locally produced straw and wood chips. Estimated costs of primarily transport are added to the prices to work out final prices at central plant and at local plant, respectively. This approach is described in detail in the referenced material from Ea Energy Analyses and in the background report of the Danish Energy Agency's Base Projection 2017 [13].

To ensure agreement with the projection of fossil fuel prices, the crude oil price in the analysis assumptions is used to estimate the cost of producing and transporting biomass.

Energinet has not used forward prices for wood pellets. This owes solely to the fact that Energinet did not have access to forward prices for biomass before prices were frozen for this update of the analysis assumptions. Similar to Ea Energy Analyses and the Danish Energy Agency, Energinet is of the opinion that forward prices are more representative of the short-term price of wood pellets, and they will be included in the analysis assumptions going forward.

Resulting prices of the used biomass fuels at central plant are shown in Figure 5, while prices at local plant are shown in Figure 6.

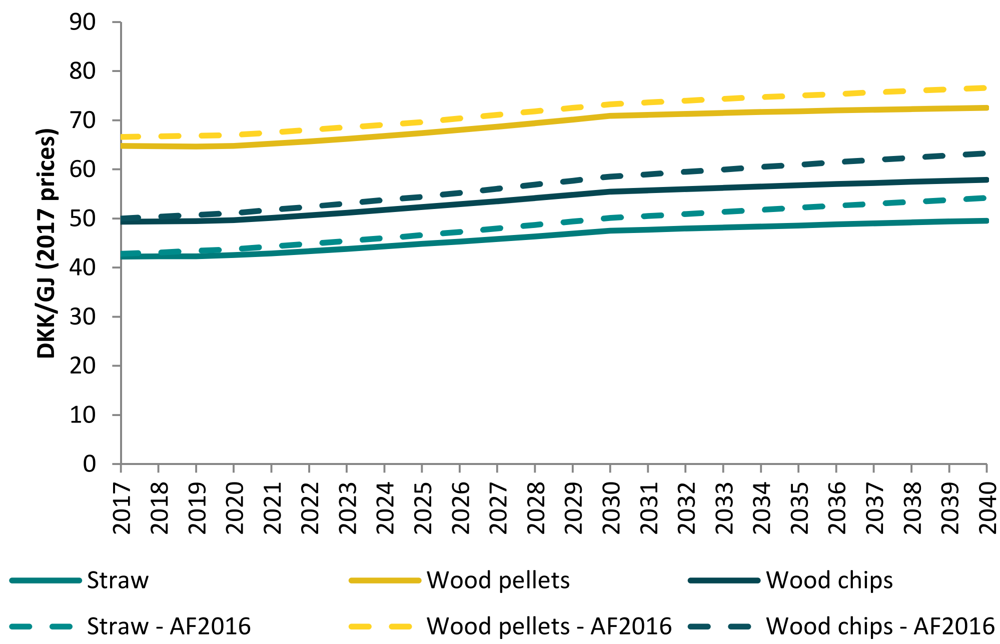

Figure 5 Price projection for used biomass fuels at central plant for the 2017-2040 period. All prices are in DKK/GJ (2017 prices).

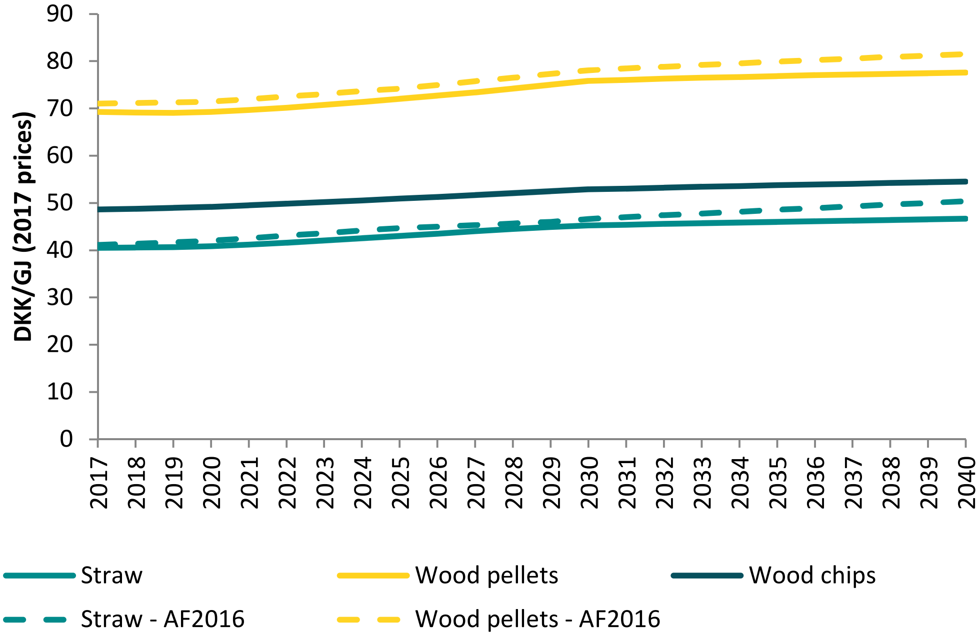

Figure 6 Price projection for used biomass fuels at local plant for the 2017-2040 period. All prices are in DKK/GJ (2017 prices).

4. CO_2 emission allowance prices

In Denmark, the CO_2 emission allowance limit is determined by the EU's Emissions Trading System (EU ETS) (European Union Greenhouse Gas Emission Trading System). The system, which makes it possible to trade CO_2 emission allowances, entered into force in 2005 after the EU undertook to reduce its CO_2 emissions in the international Kyoto Protocol [14]. Historically, the CO_2 emission allowance price has varied considerably, and there is still considerable uncertainty as to what the future price will be. The ETS is in its third period, which runs up to and including 2020, and much therefore hinges on how the system will develop after 2020.

The CO_2 emission allowance prices have a significant impact on the relative costs of using different fuels, giving them a contributory effect on both the market players' actions and the system's electricity price [6].

4.1 Price projection for CO_2 emission allowances

In the IEA's projections of the global energy markets in *World Energy Outlook*, the CO_2 emission allowance price is included as one of the key variables in the structure of the scenarios in the publication. To ensure agreement with the projection of fossil fuel prices, Energinet uses the CO_2 emission allowance prices in the main scenario 'New Policies Scenario' in *World Energy Outlook 2016*. In this scenario, it is assumed that the current systems will continue for the remainder of the projection period, and that they will be supplemented by initiatives announced, but not yet launched [7].

Projection of the CO_2 emission allowance prices combine the IEA's assumptions with the market's expectations for the price of forward contracts in the financial markets. The weighting used between forward prices and the IEA's assumptions is the same as the weighting described in the projection of fossil fuel prices (see chapter 3).

Forward prices are spot prices of European Emission Allowances Futures from EEX collected on 29 March 2017.

Projected CO_2 emission allowance prices are shown in Figure 7.

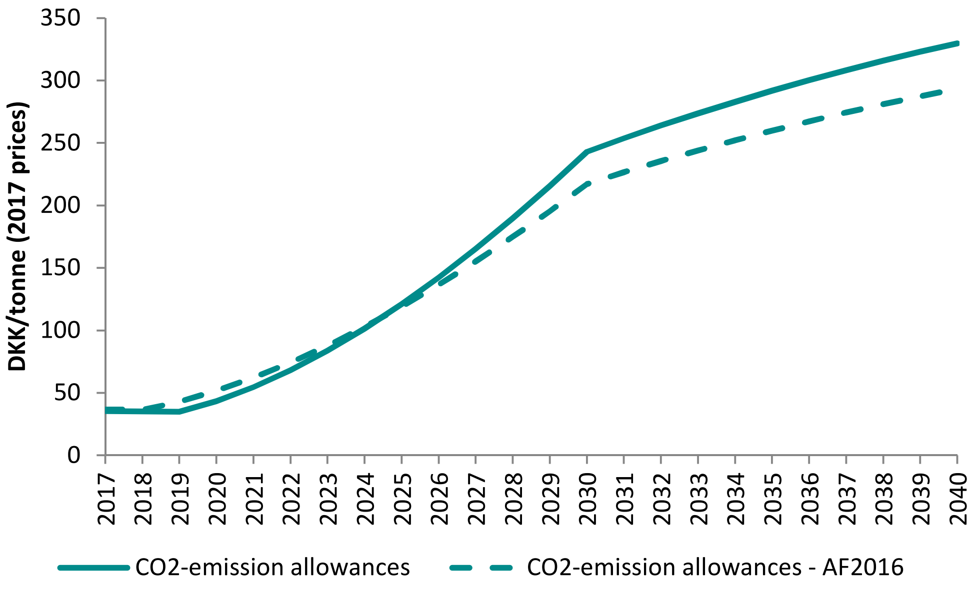

Figure 7 Projections of CO_2 emission allowance prices for the 2017-2040 period. All prices are in DKK/tonne (2017 prices).

5. Electricity prices

Electricity price projections are primarily a result of the other analysis assumptions and must therefore to a large extent be seen as an indicator for the electricity system as a whole.

Projections should be used with caution and must be considered as one possible outcome based on the given assumptions. This is due to the fact that uncertainties in the parameters in the analysis assumptions may be transferred to the electricity price. The electricity price is particularly affected by factors which may be price-setting (international connections, consumption, generation capacity, fuel prices and CO_2 prices). The electricity price is also affected by factors which are not described directly in the analysis assumptions, such as deviations from the meteorological normal year (for example so-called wet years and dry years). The average electricity price stated in the analysis assumptions also includes considerable fluctuations in electricity prices from hour to hour.

Projections of international electricity prices are included as input to the projections of the Danish electricity prices.

5.1 Danish electricity prices

Forward prices from SysPower [15] collected on 29 March 2017 have been used up to and including 2019.

For the period after 2019, prices have been simulated as electricity spot prices in Energinet's Sifre [16] calculation model on the basis of the analysis assumptions. Prices have been simulated hour by hour throughout the period and are shown in the analysis assumptions as annual averages for Western Denmark and Eastern Denmark, respectively.

The average annual electricity prices for Denmark's two price areas are shown in Figure 8.

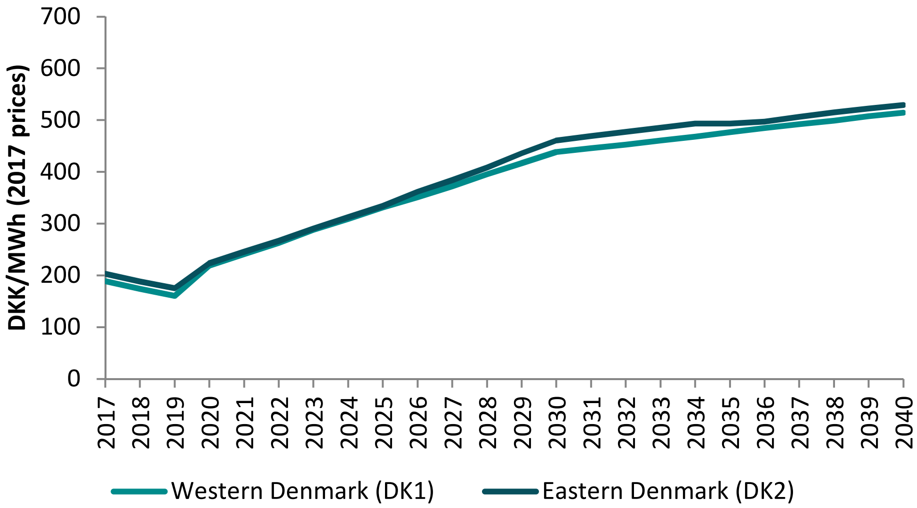

Figure 8 Average annual electricity prices for Western Denmark and Eastern Denmark. All prices are in DKK/MWh (2017 prices).

5.2 International electricity prices

As for Danish electricity prices, forward prices are used in the period up to and including 2019. These forward prices were collected from SysPower [15] on 29 March 2017.

In the period after 2019, prices have been simulated as electricity spot prices in Energinet's BID [16] calculation model on the basis of the analysis assumptions. Prices have been simulated hour by hour in the years 2020, 2030 and 2040. As described in the section on international data, Energinet does not have an international data set for 2040 at its disposal. The simulation of international electricity prices in 2040 is therefore based on a model run in which only fuel prices and CO_2 emission allowance prices are updated relative to 2030.

Linear interpolation has been used in the years between 2020, 2030 and 2040.

Average annual electricity prices for Denmark's closest neighbouring regions are shown in Figure 9.

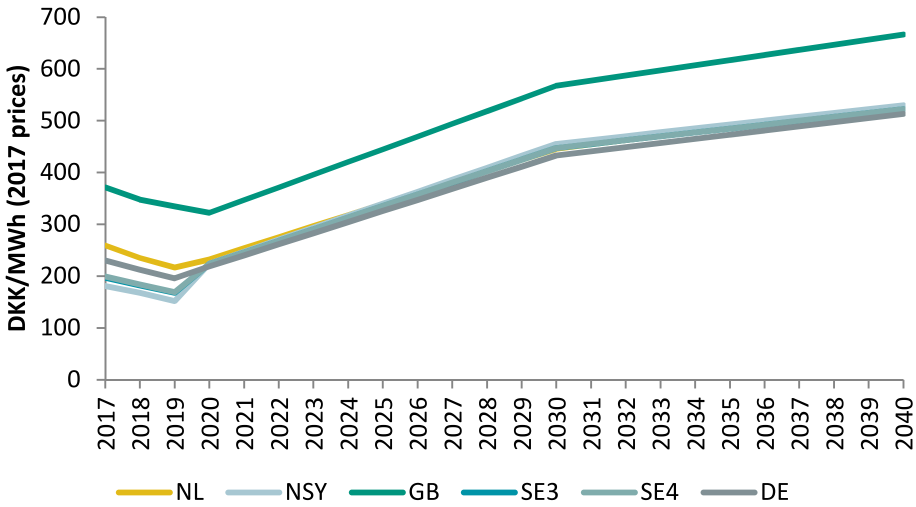

Figure 9 Average annual electricity prices for Denmark's closest neighbouring regions: Norway (NSY), Sweden (SE3, SE4), Germany (DE), the Netherlands (NL) and the United Kingdom (GB). All prices are in DKK/MWh (2017 prices).

6. International data

The effects of trends in both neighbouring areas and their neighbouring areas are important factors in the assumptions. Denmark's dependence on other countries is reflected directly in the electricity prices. On average, Denmark has had its own electricity prices for 10 per cent of the time since 2010. In the remaining hours, electricity prices in Denmark have been identical with electricity prices either in our neighbouring countries to the north (50 per cent), to the south (20 per cent) or in both directions (20 per cent) [6].

In order to counter this, Energinet models the following countries: Austria, Belgium, the Czech Republic, Denmark, Estonia, Finland, France, the United Kingdom, Germany, Ireland, Italy, Latvia, Lithuania, the Netherlands, Northern Ireland, Norway, Poland, Slovakia, Spain, Sweden and Switzerland.

This section accounts for the international data set which Energinet uses in market modelling for the analysis assumptions. The data set contains assumptions for both Denmark and other countries for the years 2020 and 2030. In addition to this, fuel prices and CO_2 emission allowance prices are also used as described in the relevant section in the analysis assumptions.

The data set contains information about electricity consumption, electricity generation capacity as well as electricity transmission capacity for each individual country.

6.1 Electricity consumption and generation capacity

Consumption and generation capacity are based on data from Energinet’s ENTSO-E collaboration, bilateral partnerships and the Nordic-Baltic model collaboration in the Baltic Sea Market Modelling Group (BSMMG).

Generally, technical and economic data for power stations relate to ENTSO-E's Ten-Year Network Development Plan 2016 (TYNDP2016) and are incorporated with a high level of detail based on Energinet's ENTSO-E collaboration. Hydropower in the Nordic region is based solely on detailed data from the Nordic cooperation.

Specifically for 2020, the assessment has been prepared on the basis of the years 2016, 2020 and 2025 in ENTSO-E's Scenario Outlook & Adequacy Forecasts from 2015 [17] as well as Expected Progress for 2020 (EP2020) from TYNDP2016 [18]. In addition, data from bilateral partnerships and BSMMG are incorporated.

Specifically for 2030, the assessment is prepared on the basis of TYNDP2016 [18] as well as data from bilateral partnerships and BSMMG.

6.1.1 Profiles

Consumption profiles are based on EP2020 for 2020, and based on TYNDP2016 for 2030. Renewable energy generation profiles are mainly based on the Pan-European Climate Database 2016 (PECD16), which has been prepared by DTU Risø. To obtain a more detailed representation of wind power for Denmark and the neighbouring countries, wind profiles have been prepared by Energinet based on data from DTU Risø.

6.2 Transmission capacity

Transmission capacity for the continent is based on TYNDP2016 [18], and for the Nordic region, it is based on data from the BSMMG work. Energinet expects full availability on all connections, with the exception of the international connection between Western Denmark and Germany. Together, Energinet and German TenneT TSO GmbH have prepared an in-depth study detailing the two companies' best estimate of the availability of the international connection between Western Denmark and Germany in 2020 and 2030. The result has been used as input to Energinet's market model.

7. Electricity consumption

In the analysis assumptions, total electricity consumption is calculated as the electricity consumption of households and businesses (traditional electricity consumption) and new electricity consumption which is expected to arise primarily as a result of the electrification of the heating and transport sectors and the establishment of data centres in Denmark.

It should be noted that projections of the electricity consumption are subject to many uncertainties, particularly as regards the level of consumption and the distribution of consumption within the day and the year – characteristics which are crucial to Energinet's infrastructure planning. This is especially true due to the fact that new technologies are expected to make up a large part of the electricity consumption increase, and either no or only very limited experience and metered data are available in the system today. Energinet expects to make ongoing adjustments to these projections as and when, for example, data centres are established and new data and information are received about developments in household heating systems and the electrification of the transport sector.

The total expected growth in Denmark's gross electricity consumption is illustrated in Figure 10, which shows a significant increase in electricity consumption of approximately 8 TWh in 2025 relative to 2016 levels, corresponding to an increase of approximately 24 per cent. Energinet expects total data centre electricity consumption to account for close to half of this increase, while the other half is made up of growing electrification of the transport sector and individual household heating system solutions. This corresponds roughly to Energinet's expectations presented in last year's analysis assumptions. This trend is expected to continue after 2025, primarily as a consequence of rising electricity consumption for light road transport, with the increase totalling approx. 19 TWh in 2040 compared with 2016 levels, corresponding to approx. 56 per cent.

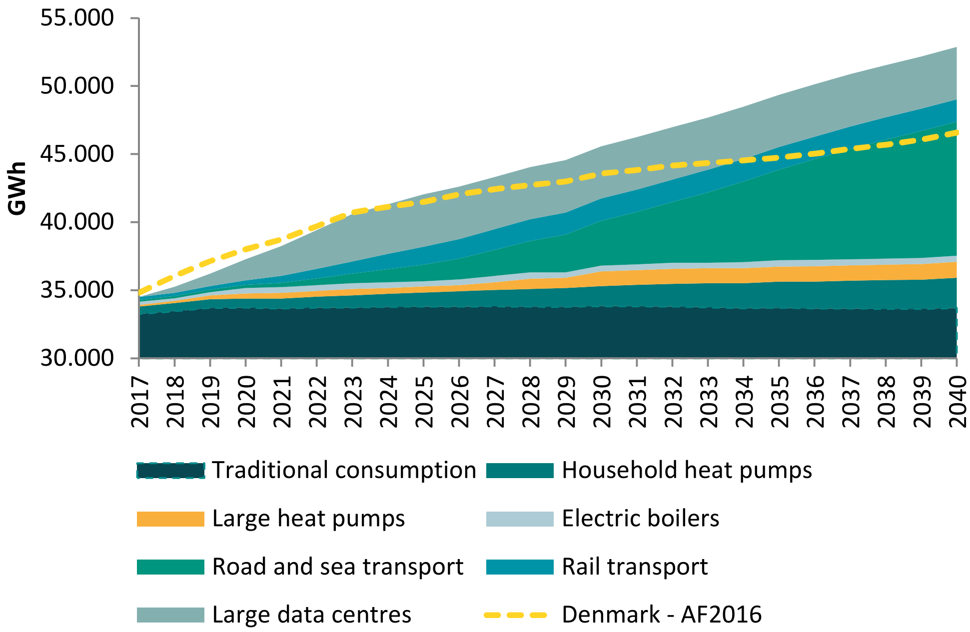

Figure 10 Expected total annual Danish gross electricity consumption in the projection period, compared with last year's analysis assumptions (AF2016). Please note that the axis does not reach zero.

7.1 Traditional electricity consumption

Traditional electricity consumption covers electricity consumption by households and businesses. The projection was prepared in 2016 in cooperation with DTU Management Engineering based on output from the EMMA [19] consumption model. EMMA is a satellite of the ADAM [20] macroeconomic model used by the Danish Ministry of Finance for the projection of Denmark's economy. The projection has not been updated this year, but has been adjusted to the level of consumption realised in 2016.

There are basically three types of input for projecting traditional electricity consumption:

1. Economic trends, i.e. trends in production and private consumption which are projected by the Danish Ministry of Finance using the ADAM model. This is based on the economic trends described in *Denmark's Convergence Programme 2015*.
2. Trends in energy prices. The energy prices used in the analysis are from *Energinet's analysis assumptions 2015*.
3. The historical efficiency trend and future saving/streamlining initiatives. The period until 2020 is based on the energy saving agreement's objective of a total energy saving of 12.2 PJ per year [21]. No political targets have been set after 2020. Estimated annual savings of 8 PJ per year has been used instead, based on the expected trends in the years 2000-2020. Twenty per cent of the savings have been allocated to electricity and 80 per cent to other energy, based on the historical savings distribution.

The sum of this input means that commercial demand for electricity is expected to grow by an average of 0.10 per cent annually up to and including 2040. For households, average annual growth is approx. 0.05 per cent in the same period.

Figure 11 shows traditional electricity consumption for Western Denmark and Eastern Denmark in the projection period compared with last year's projections. In the period until 2020, total electricity consumption of households and businesses will increase slightly, which can be attributed primarily to economic trends in the businesses combined with the agreed energy savings. In the period after 2020, traditional electricity consumption remains at a fairly constant level. This is attributable to more moderate economic growth during the period, an expectation of increased electricity prices and energy savings.

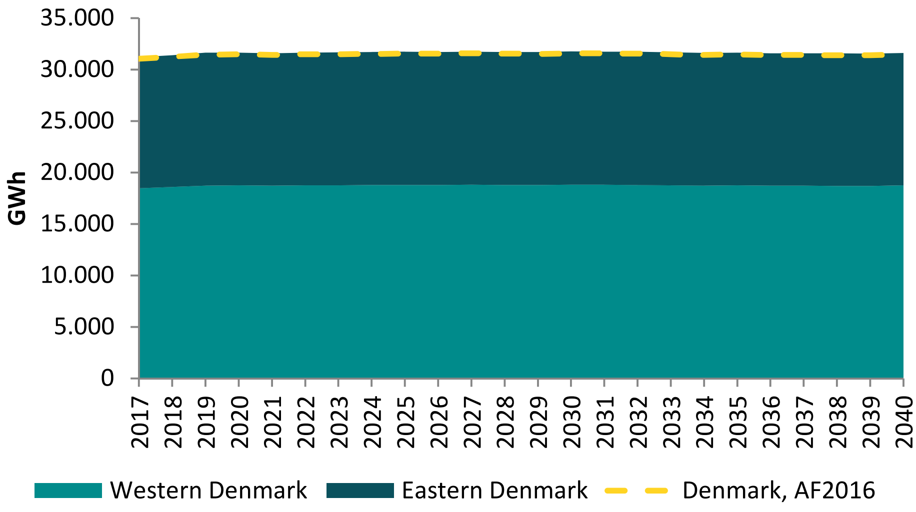

Figure 11 Expected net annual traditional electricity consumption in the projection period, compared with last year's analysis assumptions (AF2016).

7.2 Heat pumps

In an energy system which increasingly needs to integrate electricity from fluctuating renewable energy sources, heat pumps will play a role in relation to heat generation going forward. From a socio-economic perspective, heat pumps are a cost-effective and energy efficient way of generating heat from renewable energy sources, and in their function as flexible electricity-consuming units, they play an important role in Energinet's planning work.

In the analysis assumptions, heat pumps are divided into two overall categories:

1. Large heat pumps installed in large central district heating areas and heat pumps supplying local district heating grids.
2. Household heat pumps.

7.2.1 Large heat pumps

Figure 12 shows the expected capacity expansion for large heat pumps in the district heating sector, distributed on central and local heat pumps. Central heat pumps are large heat pumps which are installed in the large Danish district heating areas: Copenhagen, Kalundborg, Aalborg, Aarhus, Esbjerg, Herning, Odense and TVIS (the Triangle Region). Local heat pumps are the other (smaller) large heat pumps that supply the remaining district heating areas. These are expected to be distributed among the local CHP plants, with approx. twice as much installed capacity in Western Denmark as in Eastern Denmark.

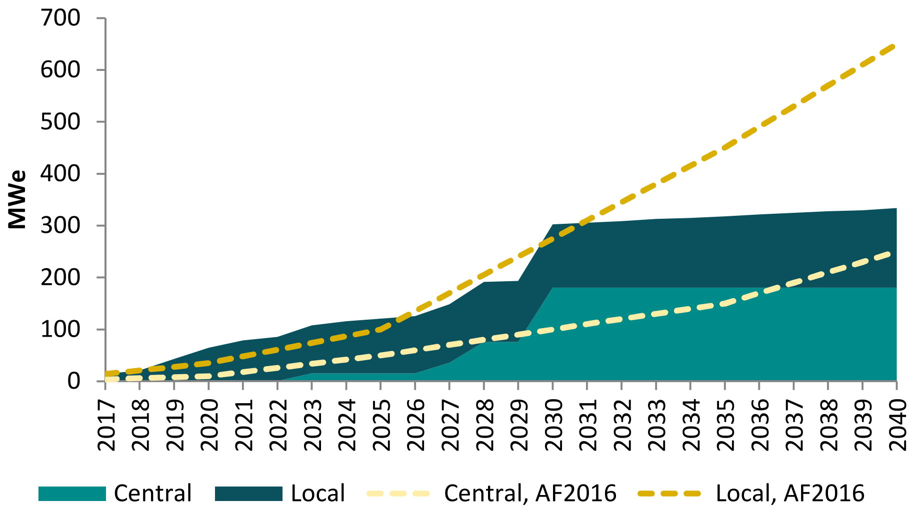

Figure 12 Expected change in electricity capacity for large heat pumps in the heating sector, compared with last year's analysis assumptions (AF2016).

As concerns central power stations, Energinet carried out an independent analysis in spring 2017 of the demand for heating and the expected financial situation. It is assessed, particularly in connection with lifetime extensions of power station units, that there may be possibilities for integrating large heat pumps in major towns and cities. This process will, however, be very sensitive to the applicable framework conditions and technological developments at the time in question.

In autumn 2016, Energinet did an internal analysis of the expected development in local heat generation capacity. The analysis is based on the general methodological approach described in section 1.3. The analysis includes many different technologies for meeting the district heating areas' demand for heating; expectations for hybrid gas/electric heat pumps, among other things, have been included. Only heat pumps driven solely by electricity have been included in the calculation of heat pumps in the analysis assumptions.

For local areas, projections show slightly increased capacity expansion towards 2025 compared with last year's analysis assumptions. This is due primarily to the effect of the phase-out of the PSO tariff as well as marginally higher fuel prices.

In the long term, however, the expansion with heat pumps in local areas is significantly lower. This is primarily the result of a changed methodological approach, where investments in alternative heat sources towards 2030 'bind' a part of the heat generation towards 2040. As the heat pump is a base-load technology, it is found not to be competitive with, for example, biomass boilers, which are expected to be installed in relatively high numbers towards 2030.

Electricity consumption for large heat pumps is calculated in Energinet's Sifre [16] calculation model, as operations are highly dependent on the interaction with the rest of the energy system described in the analysis assumptions. Net electricity consumption is shown in Figure 13. Results indicate that the load factor decreases towards 2025. In Western Denmark, the highest load factor is 8,300 hours in 2018, while the highest load factor in Eastern Denmark is 5,600 hours in 2017. After 2025, the load factor stabilises at about 3,000 hours (approx. 3,500 hours in Western Denmark and 2,700 hours in Eastern Denmark).

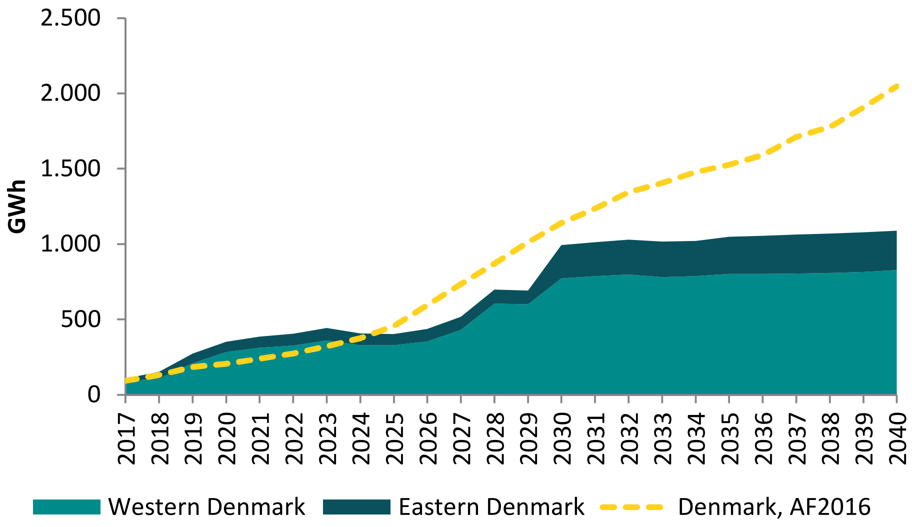

Figure 13 Expected net annual electricity consumption for large heat pumps in the projection period, compared with last year's analysis assumptions (AF2016).

7.2.2 Household heat pumps

Household heat pumps are projected as electricity consumption and not on the basis of capacity, as is the case for large heat pumps. The projection is identical with last year's analysis assumptions.

The projection of electricity consumption for household heat pumps is based on an analysis of the progress of converting household heating from oil-fired boilers to wood pellet boilers or heat pumps, which the Danish Energy Association, DONG Energy and Energinet prepared in 2013 [22]. In 2015, the projection was updated by Energinet to include an estimate for conversion to heat pumps in areas with natural gas [23].

Electricity consumption for household heat pumps is shown in Figure 14 and is approximately equivalent to the numbers stated in Table 9. Please note that the number is an estimate subject to simplified assumptions.

Heat pumps are expected to be a mixture of electric heat pumps, hybrid electric/gas heat pumps and heat pump/boiler hybrids.

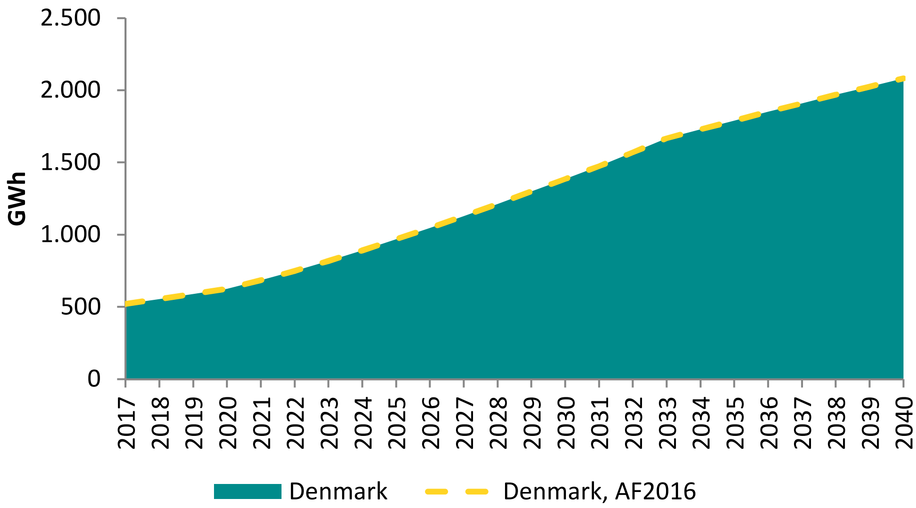

Figure 14 Expected net annual electricity consumption for household heat pumps in the projection period, compared with last year's analysis assumptions (AF2016).

Year	Number (units)
2020	157,000
2030	434,000
2040	723,000

Table 9 Electricity consumption for household heat pumps, converted to number of heat pumps. The number is an estimate subject to simplified assumptions.

7.3 Electric boilers

At the beginning of 2017, Denmark's installed electricity capacity for electric boilers was 590 MW, distributed on 455 MW in Western Denmark and 135 MW in Eastern Denmark. Energinet expects an additional 50 MW in Western Denmark in the course of 2017, and 120 MW in Eastern Denmark in the course of 2018, see Figure 15.

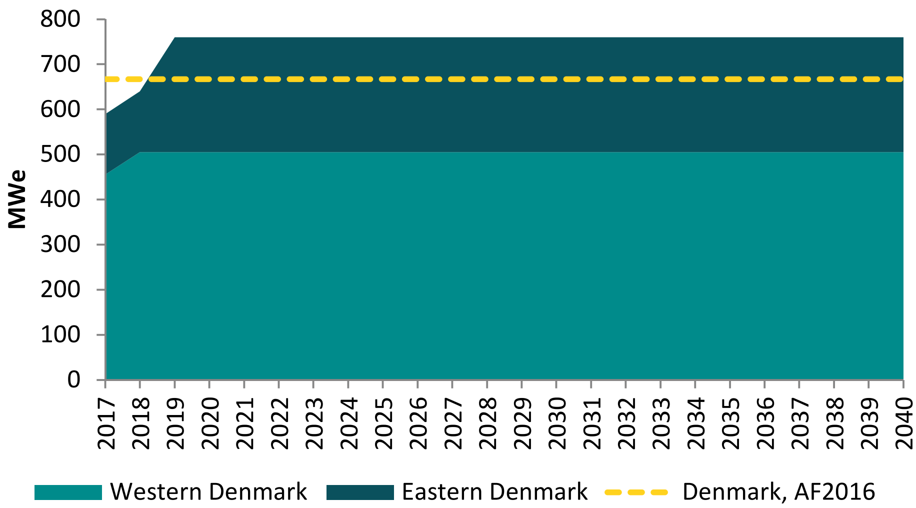

Figure 15 Expected change in electricity capacity for electric boilers, compared with last year's analysis assumptions (AF2016).

Energinet does not prepare a projection of electric boilers, but exclusively bases new capacity on projects in the pipeline. The electricity consumption has been established on the basis of simulations in the Sifre [16] calculation model, where electric boilers are included as part of the overall energy system described in the analysis assumptions. The calculated net electricity consumption is shown in Figure 16. Results indicate that the load factor for electric boilers is somewhat lower in Western Denmark (approx. 100-200 hours) than in Eastern Denmark (approx. 1,200 hours). This may partly be due to the fact that simulations of the energy system do not capture periods in which electric boilers are in fact in operation.

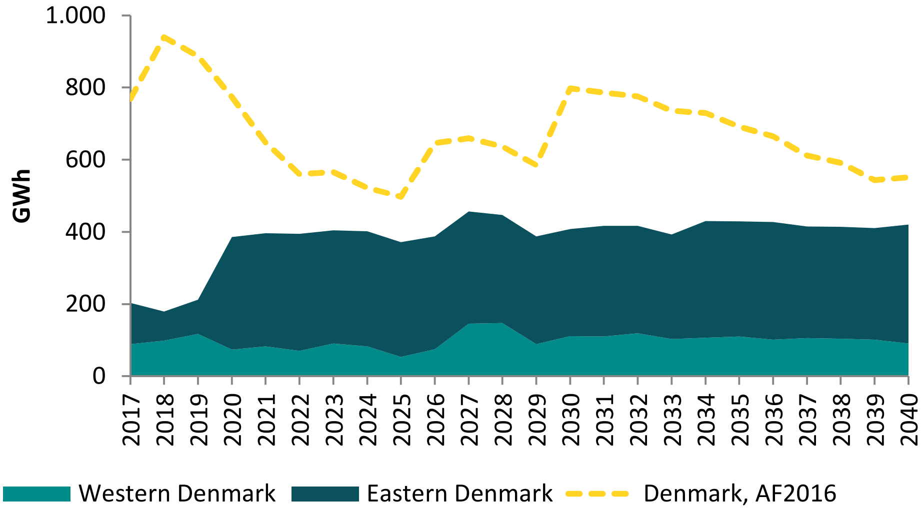

Figure 16 Expected net annual electricity consumption for electric boilers in the projection period, compared with last year's analysis assumptions (AF2016).

7.4 Transport

Today, the Danish transport sector consists predominantly of petrol and diesel vehicles and is potentially facing a major transition to consumption of electricity. This will be realised partly for rail transport in the form of Banedanmark's projects for electrification of the railway network, and partly for road and sea transport on the basis of the expectations for the technological developments in batteries and electric vehicles in general. Projections of electricity consumption for transport are essential, but also subject to great uncertainty as both the technology and the framework conditions are developing rapidly.

7.4.1 Electrification of the railway network and the Fehmarn Belt Fixed Link

Energinet coordinates the commissioning dates for the individual connection points in the transmission grid with Banedanmark on an ongoing basis, and changes to this information are the primary reason for this year's minor adjustments of the electricity consumption for the electrification of the railway network and the Fehmarn Belt Fixed Link. The Fehmarn Belt Fixed Link is not Banedanmark's responsibility, and data in this respect currently represent Energinet's best estimates.

Electricity consumption as shown in Figure 17 contains only existing and new electricity consumption for the railway network (and not electricity consumption for S-trains and the Metro). Electricity consumption is calculated on the basis of an estimated power draw at the individual connection points, an assumption of a linear phase-in period of five years as well as an annual load factor of 2,000 hours.

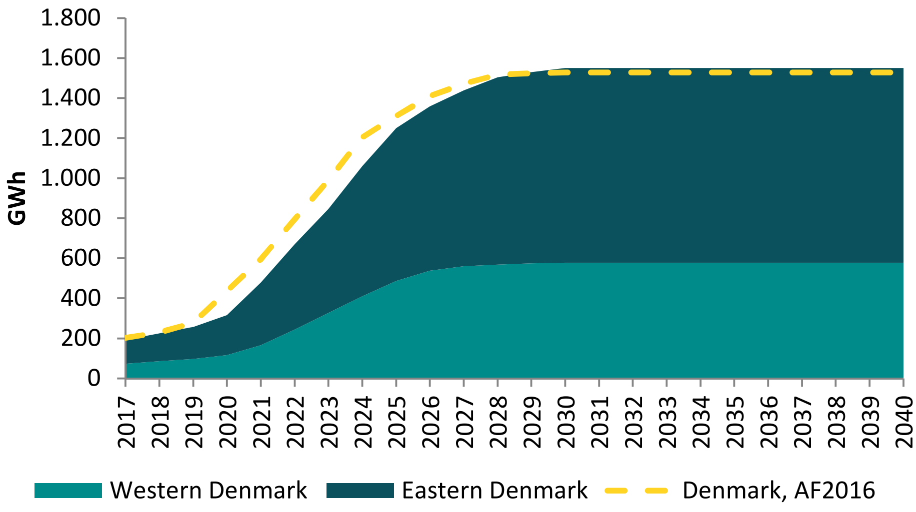

Figure 17 Expected net annual electricity consumption for the railway network and the Fehmarn Belt Fixed Link in the projection period, compared with last year's analysis assumptions (AF2016).

7.4.2 Road and sea transport

Road and sea transport includes electricity for electric cars and charging hybrids, electricity for buses and trucks as well as electricity for domestic sea transport.

The projection of the consumption of electricity for transport is the result of a new analysis prepared by Energinet [24]. The analysis is based on the principles described in section 1.3 and compares electricity and gas-powered transport with conventional petrol and diesel-powered transport. Against this background, the analysis makes a 'best estimate' of the extent to which the transport sector will make use of electricity and gas.

The new analysis shows higher electricity consumption – especially in the period after 2020 – than was the case in previous years' analysis assumptions. The explanation for this is, among other things, that the projection, as something new, factors in electricity for charging hybrids, electricity for heavy transport and charging losses; however, the expectation that increased electrification of, in particular, passenger transport will contribute to increased electricity consumption is also part of the explanation. The projection is very uncertain as it is highly dependent on expectations for future technology and infrastructure developments as well as on the individual's attitude towards the changed transport modes.

Figure 18 shows the annual electricity consumption for transport distributed on three categories: light transport, heavy transport and sea transport. The underlying analysis is based on a transport requirement, but depending on the replacement of the car fleet, the consumption for light transport can be estimated as a number of electric vehicles in the intervals indicated in Table 10. However, the conversion is subject to a range of simplified assumptions, and the number should therefore be used with caution.

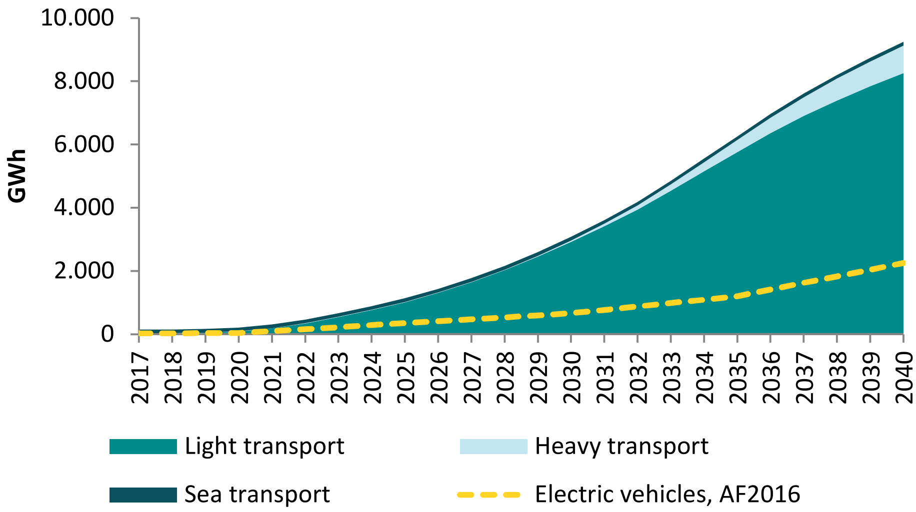

Figure 18 Expected net annual electricity consumption (including charging losses) in the projection period for passenger and goods transport and for domestic sea transport, compared with last year's analysis assumptions (AF2016).

Year	Number (units)
2020	8,500-20,600
2030	417,000-795,000
2040	1,840,000-2,430,000

Table 10 Electricity consumption for transport converted to an estimated number of electric vehicles.

7.5 Large data centres

In 2017, Energinet is fully engaged in completing a number of connection points to the first large data centres in Denmark. Large data centres are a new consumer group which is characterised by having particularly high power requirements for the operation of IT equipment. The availability and the securing of this power in the electricity system have a clear impact on Energinet's planning and are therefore accounted for separately in Energinet's analysis assumptions.

The projection of the data centres' electricity consumption is subject to great uncertainty, which should be seen in light of the fact that there are no statistics available as yet for this consumer group in Denmark. The projection therefore reflects Energinet's best estimates and has been prepared on the basis of a series of conservative estimates and assumptions:

- Only projects for which connection and establishment contracts exist are included in the analysis assumptions. Additional projects are in the pipeline, but details such as location (including which country) and size make them too uncertain to include in current planning.
- It is assumed that all data centres will be built in Western Denmark, due to the data centres' high security of electricity supply requirements and the historically lower electricity price.
- The data centres are expected to be developed in stages, resulting in gradually increasing power requirements. Energinet has estimated a linear development period of five years for all data centres.

- The electricity consumption profile is assumed to be constant with a load factor of 8,760 hours. Thus, no account is taken of fluctuations in electricity consumption as a consequence of variations in, for example, data demand or daily and seasonal patterns.

Energinet expects to adjust the above assumptions as and when the data centres go into operation in the coming years. Furthermore, Energinet is engaged in ongoing dialogue with the individual consumers and is in the process of determining a method for estimating the collective future electricity consumption for this particular consumer group.

Due to Energinet's approach to the projection of the electricity consumption of large data centres, the projection shows a gradual development until 2025, after which the consumption is kept constant in the remaining part of the projection period. This does not mean that Energinet expects the development to stop after 2025, but owes to the fact that Energinet does not have a sufficient basis for estimating any development in addition to the projects currently deemed probable.

Net electricity consumption for large data centres is estimated at approx. 3.6 TWh in total in Western Denmark in 2025 and is shown in Figure 19. This is approximately 0.2 TWh lower than stated in last year's analysis assumptions, where electricity consumption was approx. 3.8 TWh in 2023, and is primarily attributable to adjustments to the project portfolio. However, Energinet considers this difference to be marginal in relation to the uncertainty associated with the projection.

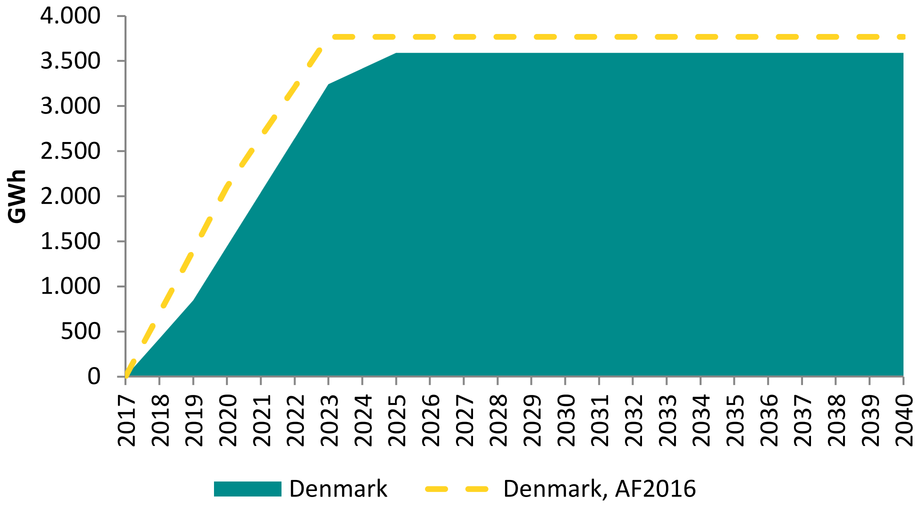

Figure 19 Expected net annual electricity consumption for large data centres in the projection period, compared with last year's analysis assumptions (AF2016).

8. District heating consumption

Energinet does not prepare projections of the district heating consumption, but uses the Danish Energy Agency's projection of Denmark's district heating consumption in their Base Projection 2017 [13].

The development in district heating is important for Energinet's planning, partly because CHP generation constitutes a large part of both Danish electricity generation and Danish gas consumption and partly because of the ongoing electrification of the heating sector. It is therefore necessary to represent the district heating areas' demand for heating in order to provide a realistic reflection of the energy system in Energinet's calculation models.

District heating consumption is projected by the Danish Energy Agency until 2030, after which Energinet has assumed a steady consumption until 2040. The distribution of district heating consumption between Eastern Denmark and Western Denmark, respectively, and the various heating areas has been assumed to follow the historical distribution in the analysis assumptions.

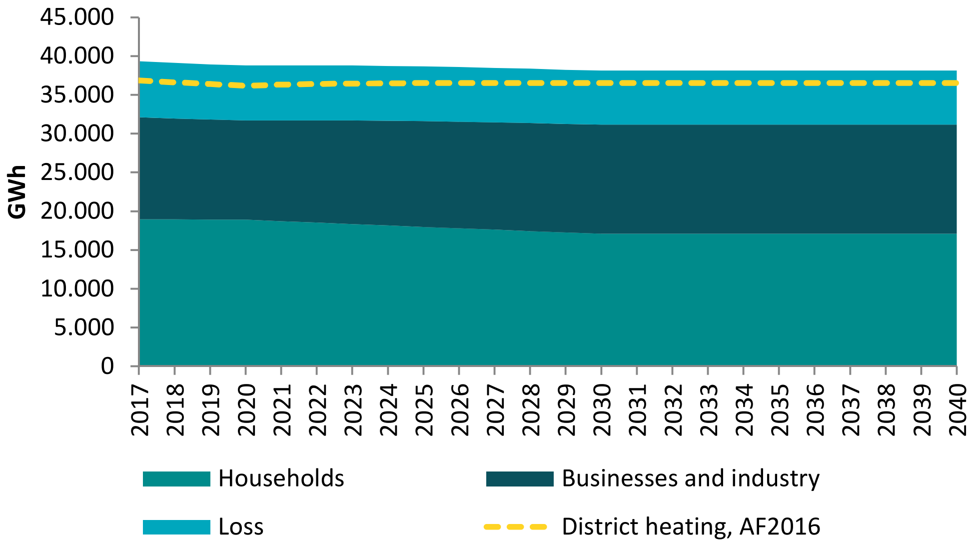

Figure 20 Expected district heating consumption in the period 2017-2040, compared with last year's analysis assumptions (AF2016). Based on the Danish Energy Agency's Base Projection 2017 for 2017-2030. The consumption is assumed to remain constant after 2030.

9. Generation facilities

9.1 Power stations

Energinet's projection of central and local power station capacity is based primarily on the Danish power station owners' own announcements concerning plans for expansion, conversion (including lifetime extension and/or biomass conversion) and closing.

For installations where the future plans are unknown, Energinet has prepared an estimate, which of course means that the projection is subject to quite a few uncertainties.

Figure 21 shows an overview of central and local stand-by power station capacity in the projection period. A detailed overview of the installed generation capacity distributed on Eastern Denmark and Western Denmark can be seen in the spreadsheet [1].

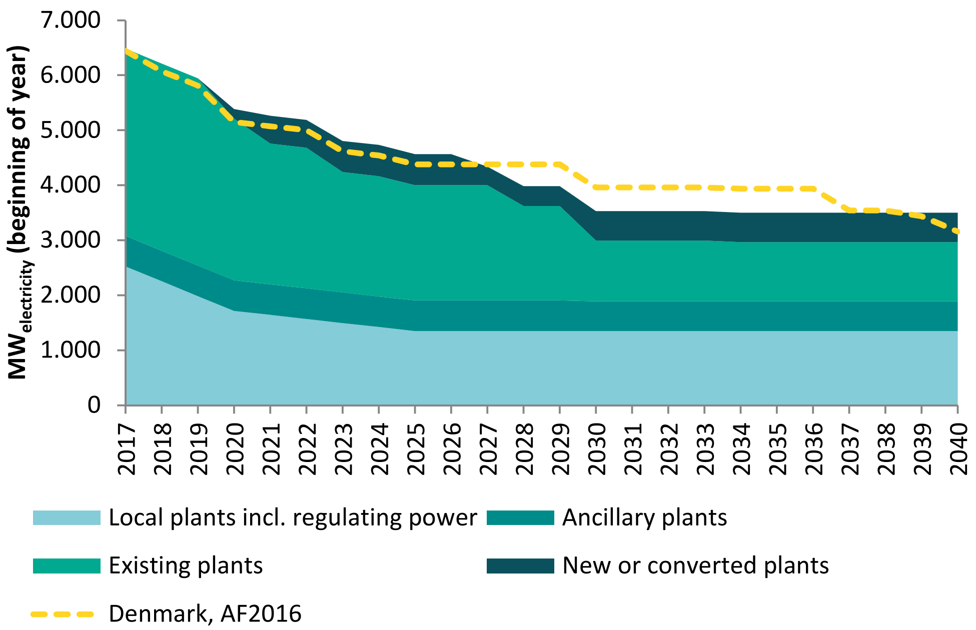

Figure 21 Energinet's expectations for the development in the power stations' nominal electricity capacity in Denmark in the projection period compared with last year's analysis assumptions (AF2016). Capacities are divided according to existing central power stations, new or converted central power stations, central reserves and local plants, including regulating power plants.

The generation capacity included in Energinet's analyses takes into account that, for most of the facilities, there is a difference between nominal capacity and the electricity generation actually available. Among other things, account has been taken of the delivery of combined heat and power by reducing the nominal capacity of plants.

In addition to meeting demand, generation capacity also helps cover the need for ancillary services.

9.1.1 Central power stations

Many central Danish power stations are currently in the process of, or planning, biomass conversions for old fossil-fired units.

In Western Denmark, the conversion of Skærbæk Power Station unit 3 to wood chips is expected to be completed for the next heating season, while Studstrup Power Station unit 3 had its lifetime extended and was converted to use wood pellets as fuel in 2016. Herning Power Station has been converted over several stages to predominantly fire with wood chips, while Fyn Power Station unit 8 is straw-fired.

In Eastern Denmark, new wood chip-fired biomass units are currently being constructed at Amager Power Station and Asnæs Power Station, which are to replace the existing coal-fired units. Avedøre Power Station unit 1 was converted to use wood pellets instead of coal in 2016, while Amager Power Station unit 1 and Avedøre Power Station unit 2 are already biomass-fired. Rønne Power Station on the island of Bornholm has also got the option of firing solely with wood chips in back-pressure operation.

For plants for which future plans are unknown, development has been assessed based on the possibilities to invest in new plants or extend the lifetime on the basis of the individual plants' demand for heating and the expected economy. A detailed description of Energinet's method of assessing central power station capacity can be found in the background memorandum 'Method for Energinet.dk's projected changes in power stations in Denmark' (*Metode for Energinet.dk's forventninger til kraftværksudviklingen i Danmark*) [25].

Energinet updated the assessment in spring 2017 on the basis of results from Energinet's Sifre [16] calculation model based on last year's analysis assumptions. Overall, this led to a reduction in central electricity capacity in the long term compared with previous years, see Figure 21. The assessment also takes account of the possibility of establishing a heat pump to meet the demand for heating, as described in section 7.2.1.

The reduction owes to the fact that many of the plants are expected to convert to biofuel in the period up until 2040, which will result in lower electricity capacity as the focus will be on supplying cheap and CO_2-neutral heating. It is assumed that the lifetime of power stations, as a minimum, is prolonged by 15 years from the time of conversion.

The projection has a high degree of inherent uncertainty, and it does not take into account changes or constraints in the power stations' surroundings which could influence their lifetime, unless a final decision has been made. There is also some capacity where it is uncertain whether the power station will be closed or converted.

9.1.2 Local plants

The total installed capacity at local CHP plants was approx. 2.5 GW in the beginning of 2016, spread across approx. 1,000 plants of various sizes.

The future trend for local CHP plants is very uncertain. Much depends on the current subsidy scheme, which will wind up at the end of 2018, and municipal plans for fossil-free heat generation. Many of the local plants are also nearing the end of their lifetimes, which means that plant owners will have to decide whether to continue the existing CHP generation in the years ahead.

Energinet expects a reduction in local electricity capacity of almost 50 per cent towards 2025.The reduction is due primarily to the closing of many small natural gas-fired plants. Major overhauls are expected to be economically feasible at large natural gas-fired plants, leading to a lifetime extension. It has been assumed that waste-fired capacity will remain fixed, while the change in other local plants is expected to follow the natural gas-fired plants.

9.2 Wind turbines

The Danish electricity system is to a large extent based on electricity generation by wind turbines. Considerable volumes of new capacity are still being installed, concurrently with a part of the already installed capacity reaching the end of its technical life. The projection is therefore a projection of both installation and decommissioning of land-based, near-shore and offshore wind turbines connected to the Danish electricity grid.

The expected decommissioning is maintained from last year's analysis assumptions. The expectations for wind turbine installation, however, have been adjusted so that less land-based capacity is installed, but with more capacity being installed near-shore and offshore. Overall, wind turbine capacity is slightly higher in the long term than the expectation indicated in analysis assumptions 2016.

Figure 22 shows the expected installed capacity for land-based wind turbines, near-shore wind turbines and offshore wind turbines in the projection period, compared with last year's analysis assumptions.

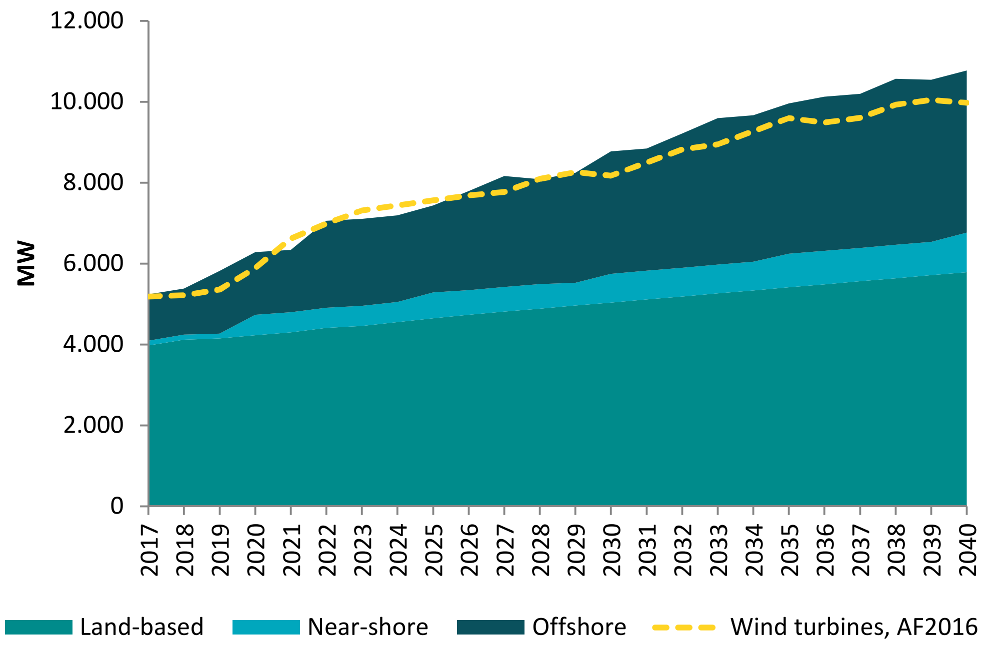

Figure 22 Expected change in capacity for wind turbines, compared with last year's analysis assumptions (AF2016).

9.2.1 Land-based wind turbines

Figure 23 shows the expected installed capacity of land-based wind turbines in relation to installation period. For comparison, the projection in last year's analysis assumptions is also shown.

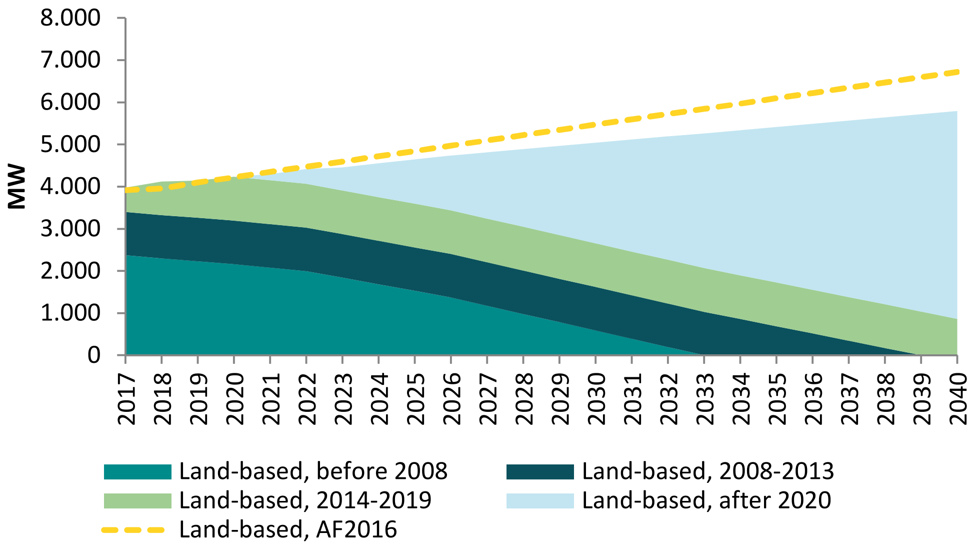

Figure 23 Expected change in capacity for land-based wind turbines in relation to installation period, compared with last year's analysis assumptions (AF2016).

The projection of land-based wind turbines is very uncertain. The current subsidy for land-based wind turbines of DKK 0.25/kWh on top of the market price for approximately seven years expires as of February 2018, and no political decision has been made on a future subsidy model for land-based wind turbines. Energinet expects the future subsidy model to be a form of tender model – possibly with exemptions for small wind farms with six wind turbines or less. It is still uncertain when a final political decision on a new subsidy scheme for land-based wind turbines will be made, and it is therefore not unlikely that there may be a period of time from the expiry of the old model in February 2018 until a new subsidy model, if any, enters into force. This is reflected in the analysis assumptions through a minor expansion of land-based wind turbines in the next few years.

In the long term, the projection has been reduced relative to analysis assumptions 2016. This is due particularly to the significant price reductions for offshore wind turbines, near-shore wind turbines and large-scale solar cell projects that we have seen in Denmark in 2016, which shows that there are economically viable alternatives to a large number of land-based wind turbines going forward.

The decommissioning rate for land-based wind turbines is identical to last year's projection and is based on the main scenario in Energinet's analysis of the decommissioning of old land-based wind turbines from spring 2016 [26]. The actual decommissioning in 2016 matched the expectation in last year's analysis assumptions quite well.

A certain buffer capacity is expected in terms of net installation, which means that lower gross installation than assumed in the analysis assumptions will to some extent be offset by correspondingly lower decommissioning of old wind turbines. The projection of accumulated land-based wind turbine capacity is thus expected to be more robust than the projection of gross installation seen in isolation.

Table 11 shows the expected installation of land-based wind turbines in the years up to and including 2040 with an indication of the most important assumptions and decisive factors.

Period	Capacity (MW/year)	Background
2017	220 (gross)	As many as possible of the adopted projects in the pipeline are assumed to be realised under the old subsidy scheme.
2018	95 (gross)	Only very few projects are commissioned this year after February 2018.
2019-2020	150 (gross)	From 2019, a new subsidy scheme for land-based wind turbines is assumed established. The installation is predominantly covered by calls for tenders and possibly a pool for minor projects (six wind turbines or less).
2021-2022	200 (gross)	Depends on the capacity tendered for in connection with the period for a new energy agreement. The capacity includes a presumption that a number of projects may be financed outside a state subsidy scheme.
2023-2025	250 (gross)	A certain probability of cross-border projects (as a result of the EU's Winter Package) as well as an expectation of cheaper land-based wind turbines (so that more projects are realised without state subsidies) lead to increased wind turbine installation in this period relative to the years before.
2026-2040	75 (net)	Land-based wind turbines are expected to be able to manage completely without subsidies to an increasing extent. Consequently, it will therefore to a larger extent be the degree to which the public will accept land-based wind turbines and the additional price for less landscape-impacting alternatives, such as offshore wind turbines and solar cells, which can be expected to determine the rate of expansion.

Table 11 Expected installation of land-based wind turbines in the projection period, with specification of decisive factors for the installation in the relevant year(s).

9.2.2 Near-shore wind turbines

Figure 24 shows the installed capacity for near-shore wind turbines in the projection period, compared with the projection in last year's analysis assumptions.

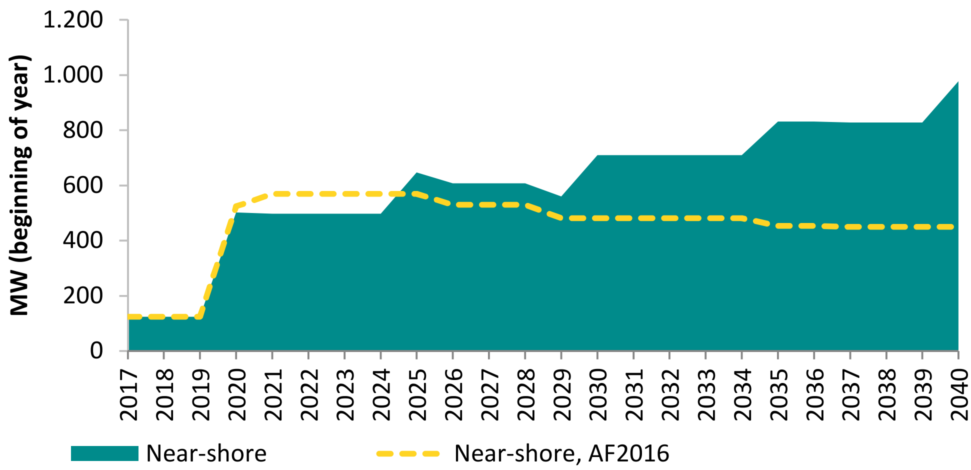

Figure 24 Expected change in total capacity for near-shore wind turbines, compared with last year's analysis assumptions (AF2016).

The distinction between near-shore wind turbines and offshore wind turbines is somewhat arbitrary. Historically, it may make sense that the small 4-40 MW wind farms very close to shore and with direct shore links had their own designation. But as can be seen from the near-shore wind turbine projects tendered by the Danish state and awarded to Vattenfall with Vesterhav South (170 MW) and Vesterhav North (180 MW) in 2016, cost-effective near-shore wind farms are easily capable of generating the same volumes as offshore wind farms. In Denmark, the designation offshore wind farm has also historically meant wind farms tendered by the Danish state with shore links and offshore substations managed by Energinet on behalf of the Danish state.

The historically clear difference between near-shore wind farms and offshore wind farms may be expected to become much less distinct in future. This year's analysis assumptions do not propose any general new terminology for near-shore wind turbines, but the former designation 'Non-tendered near-shore wind turbines' (*Kystnære møller uden for udbud*) has been replaced by 'Near-shore wind turbines (municipally/locally anchored)' (*Kystnære møller (kommunalt/lokalt forankret)*).

Near-shore wind turbines are upward adjusted relative to last year. The upward adjustment concerns 100 MW new wind turbines in Eastern Denmark and 50 MW new wind turbines in Western Denmark in each of the years 2025, 2030, 2035 and 2040. The upward adjustment takes place in the category 'Near-shore wind turbines (municipally/locally anchored)'. In this context, the City of Copenhagen, through HOFOR, is expected to explore the possibilities of large near-shore wind farms in Øresund around Copenhagen. In Western Denmark, Sønderborg Municipality has plans on the drawing board – and with new, reduced prices of offshore wind turbines, other major coastal municipalities might also be interested in local 'near-shore' projects.

On the other hand, it no longer seems realistic to expect that the two 25 MW 'Non-tendered near-shore wind turbines', which were included in the relatively short term in 2021 in last year's analysis assumptions, will be realised, and they are therefore no longer included in the analysis assumptions.

This assessment is subject to significant uncertainties and reflects an average probability-weighted expectation. Commissioning every fifth year in round number years (beginning of year) has been chosen, as it is often in these round years that the municipalities have set green objectives.

9.2.3 Offshore wind turbines

Figure 25 shows the installed capacity for offshore wind turbines in the projection period, compared with the projection in last year's analysis assumptions.

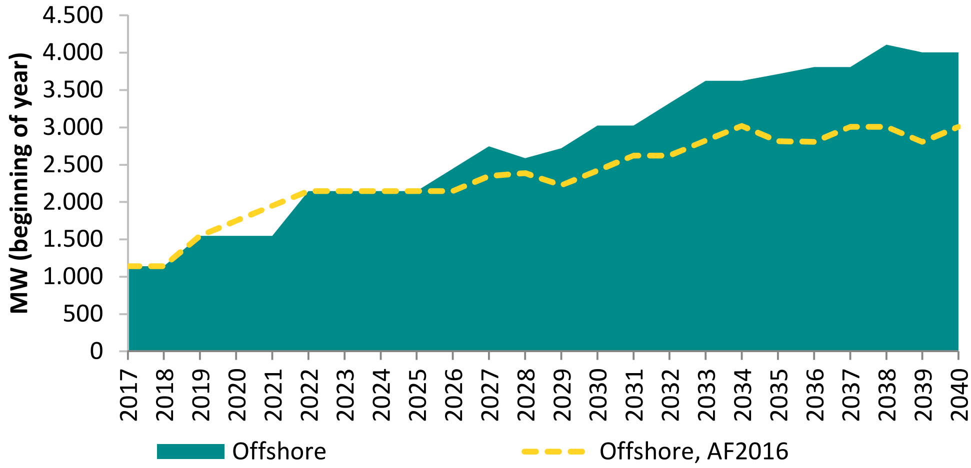

Figure 25 Expected change in total capacity for offshore wind turbines, compared with last year's analysis assumptions (AF2016).

Particularly the significant price reductions for offshore wind turbines (and near-shore wind turbines) observed since analysis assumptions 2016 have resulted in an upward adjustment of the expectations for offshore wind turbines relative to last year's projections.

The observed price reductions for offshore wind turbines in 2016, both in Denmark and neighbouring countries, will also lead to a price reduction for offshore wind turbines in the technology catalogue, where the section concerning offshore wind turbines is being updated in the first half of 2017.

Generally, the number and location of offshore wind farms have not been changed compared with last year's analysis assumptions, but all offshore wind farms after Kriegers Flak have been brought one year forward, which means that, after Kriegers Flak, two offshore wind farms will be fully commissioned up to the beginning of 2030. This acceleration is deemed realistic, as 2030 in the course of 2016 became an important year for energy policy objectives in relation to the expansion of renewable energy. Thus, a new offshore wind farm is expected every third year from the beginning of year 2027 and onwards.

The capacity of future offshore wind farms after Kriegers Flak has also been upward adjusted relative to last year's analysis assumptions, so that all offshore wind farms after Kriegers Flak are assumed to have a size of 600 MW.

The Danish government has announced an updated analysis of future locations of offshore wind farms. Energinet is awaiting this report before any new locations of offshore wind farms are included in the analysis assumptions.

9.2.4 Full-load hours

In order to be able to convert expected capacity into energy output, it is necessary to have an estimate of the number of full-load hours for the different wind turbine categories.

The number of annual full-load hours (or the annual capacity factor) for wind turbines depends mainly on the volumes of wind energy which in a normal year hit the converted area of the wind turbine blades relative to the capacity of the wind turbine generator. Modern wind turbines typically have more full-load hours than older wind turbines at the same location, primarily due to the height (higher wind speeds) and longer blades relative to generator size.

For already installed wind turbines, full-load hours are estimated on the basis of the historical generation adjusted to a normal wind year. For future wind turbines, full-load hours are estimated on the basis of expected location and expected future wind turbine design; see the technology catalogue. The number of full-load hours for the different wind turbine categories matches last year's analysis assumptions, where a major internal analysis was performed of the number of full-load hours used.

Figure 26 shows the development in the analysis assumptions' average annual number of full-load hours for wind turbine categories. It is expected for all wind turbine categories that the average number of full-load hours will increase over the years as the wind turbine fleet is replaced by newer and larger wind turbines.

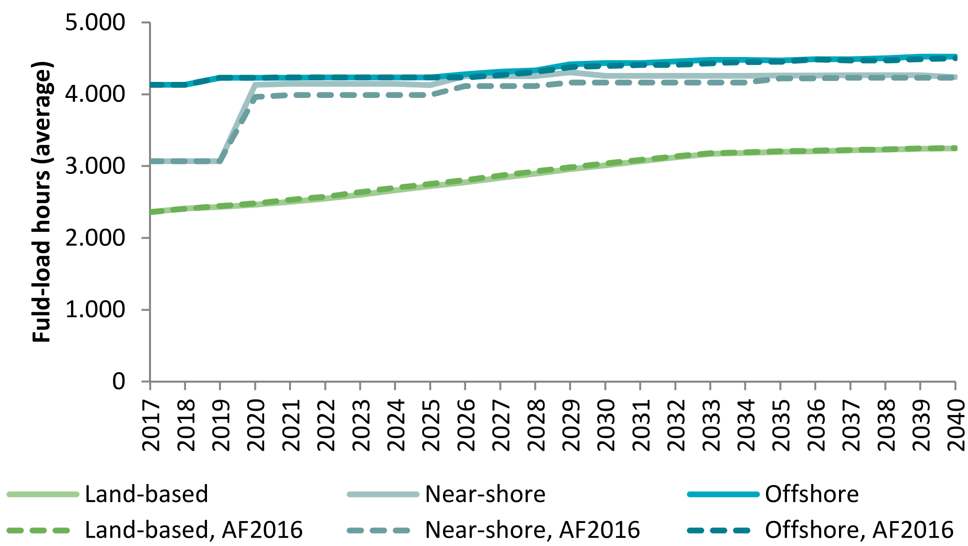

Figure 26 Estimated number of full-load hours for land-based wind turbines, near-shore wind turbines and offshore wind turbines in the projection period, compared with last year's analysis assumptions (AF2016). The number of hours indicates an annual average for a wind turbine in each of the three wind turbine categories.

9.3 Solar cells

As of 1 January 2017, approx. 850 MW of solar cells were installed in Denmark [27]. Many of these solar cells are small household units which were installed in the 2011-2013 period due to a favourable subsidy scheme, with approx. 400 MW installed at the end of 2013. The scheme was changed in December 2012, and in the period up to today, solar cells have seen a modest increase. This includes a relatively large expansion at the end of 2015, where a 140 MW field system was installed in the last quarter of the year alone. In 2016, net installations of approx. 70 MW solar cells were realised. This somewhat moderate growth should be seen in light of the fact that the Danish parliament, Folketinget, adopted a statutory intervention on 3 May 2016, which terminated the so-called 60/40 subsidy scheme for solar cells [28], as well as adopting a new statutory intervention on 19 December 2016 [29], which resulted in the termination of a planned transitional scheme. All in all, applications for subsidies via the two schemes for the construction of a total of approx. 5 GW solar cells had been submitted just before the termination of the schemes.

Solar cells are also seeing a major technology price decline, with an expected reduction in production costs for solar power plants by 2030 of more than 30 per cent [30].

The projection of the expected change in solar cell capacity was updated this year on the basis of a new analysis prepared by Energinet in 2016 to examine the trend for solar cells and batteries up until 2040 [31]. The analysis is based on the principles described in section 1.3. The projection in the analysis assumptions has been updated with various corrections and additions to the analysis.

Figure 27 shows the expected change in solar cell capacity in the projection period, compared with last year's analysis assumptions.

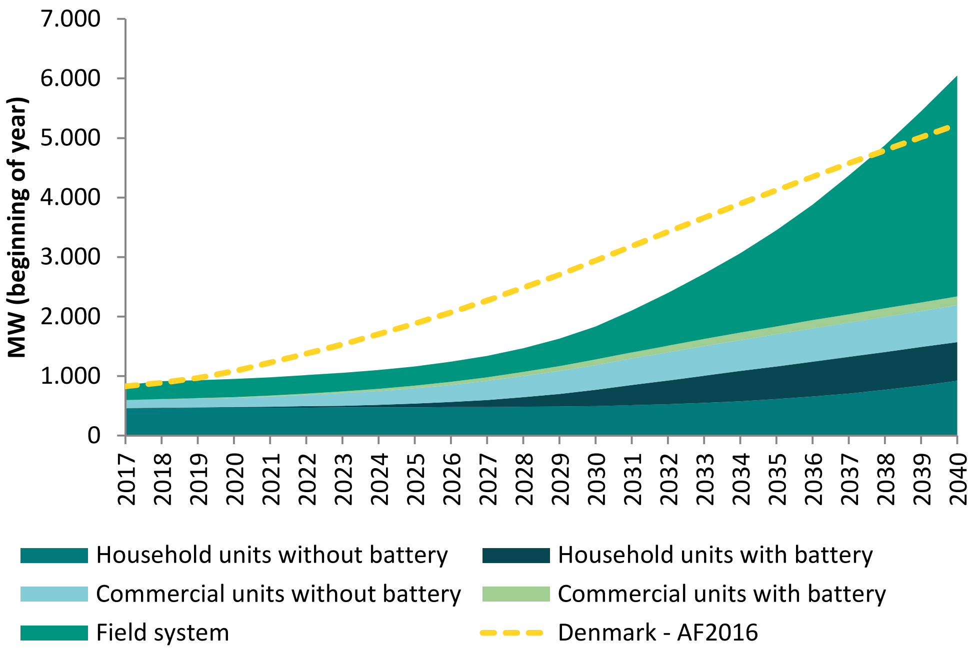

Figure 27 Expected change in total capacity for solar cells in the projection period, compared with last year's analysis assumptions (AF2016).

9.3.1 Full-load hours

As is the case for wind turbines, it is also necessary to have an estimate of the number of full-load hours for the different solar cell categories.

The number of annual full-load hours for solar cells depends primarily on the level of solar radiation expected in a normal year. Modern solar cells typically have more full-load hours than older solar cells at the same location. This is primarily attributable to improved technology, including an increasing ability to use indirect solar radiation. Going forward, it is also expected that the inverter will be designed such that the number of full-load hours for the entire plant is increased. This is done by installing additional solar panels behind the inverter, without increasing the capacity of the inverter. This will contribute to increased annual generation without increasing capacity (as the inverter turns into a 'bottleneck' on a cloudless summer day and thus limits capacity).

For already installed solar cells, the number of full-load hours is estimated on the basis of historical generation. For future solar cells, full-load hours are estimated on the basis of an expected future design; see, among other things, the technology catalogue.

Figure 28 shows the analysis assumptions' average annual number of full-load hours for Danish solar cells. For all plant sizes, the average number of full-load hours is expected to increase over the years along with rising investments in more new solar cells. Conservative estimates of the number of full-load hours have been made for all plant sizes. It can be seen that new household units in particular show a large increase in the number of full-load hours. A similar development may also turn out to be the case for both commercial units and field systems. However, the data basis for these plant sizes is still limited, and the analysis assumptions therefore assume a more conservative development.

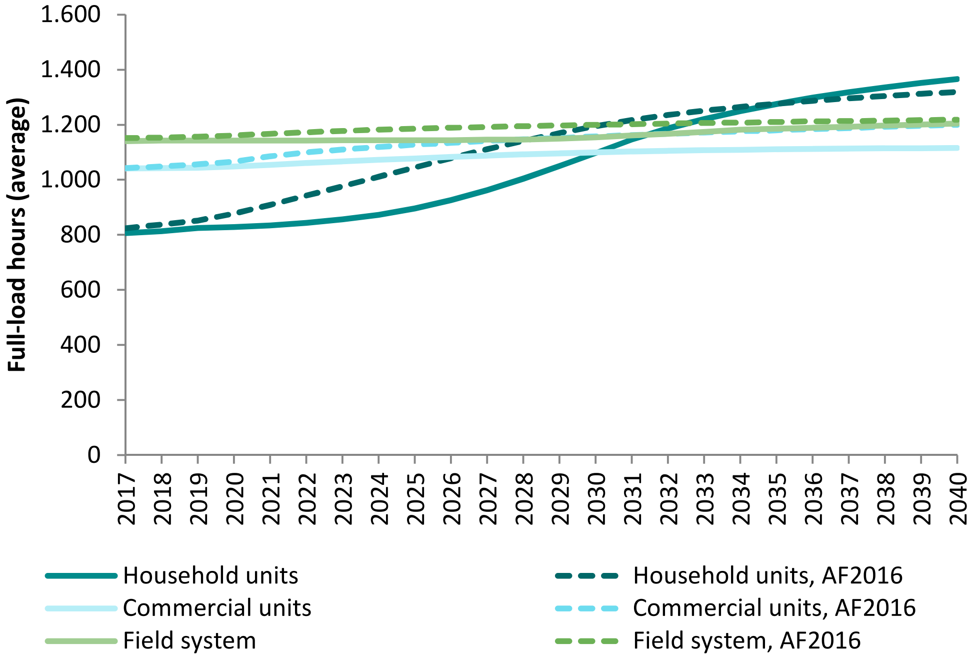

Figure 28 Estimated number of full-load hours for Danish solar cells in the projection period, compared with last year's analysis assumptions (AF2016). The number of hours indicates an annual average for a plant in each of the three categories: household units, commercial units and field systems.

10. International connections

The Danish electricity system is connected to Germany, Sweden and Norway, which allows optimum utilisation of generation capacity across the interconnected regions. These connections have a major impact on the interaction between generation and consumption in the interconnected systems. In future, the Danish electricity grid will be connected to the neighbouring countries to an even greater extent.

The following describes existing and planned international connections between Denmark and Denmark's neighbouring countries included in Energinet's analysis assumptions. The values for import and export capacity indicate the maximum net transfer capacity (NTC) released to the market. The capacities stated therefore take account of transmission losses [32].

Figure 29 shows existing and planned Danish international connections which are included in the analysis assumptions, including the Great Belt Power Link.

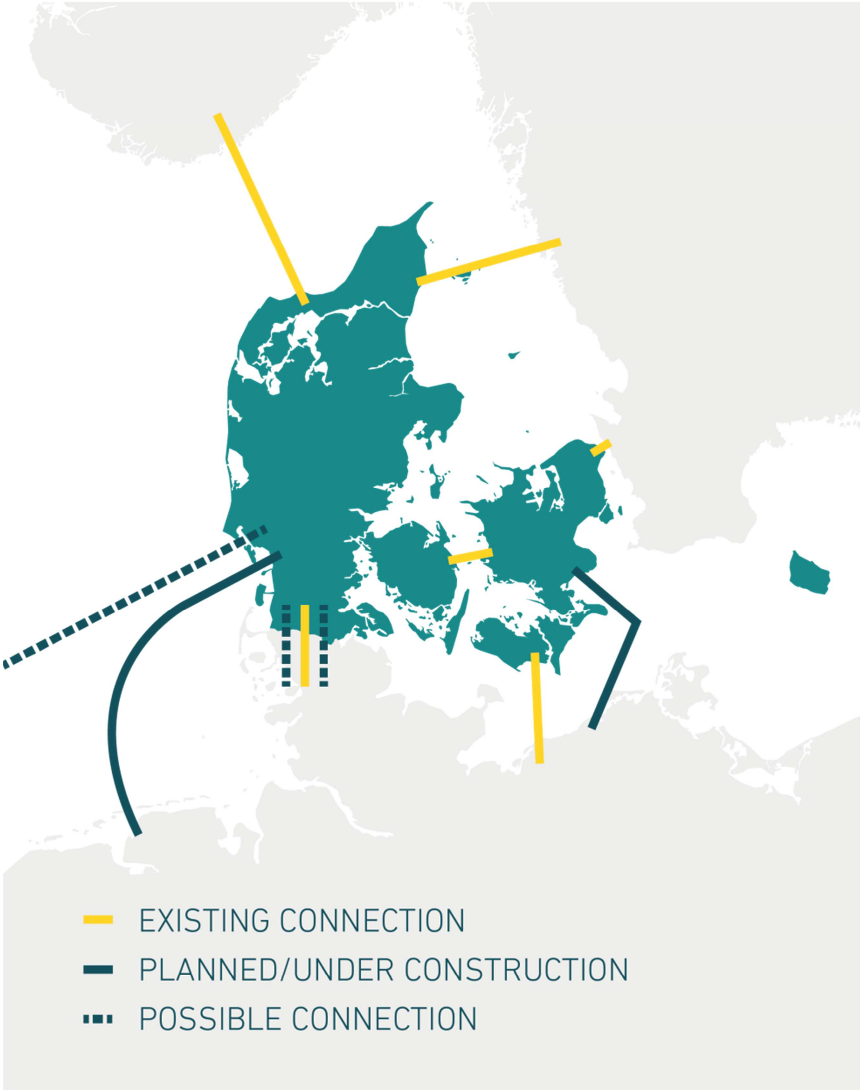

Figure 29 Existing and planned Danish international connections included in Energinet's analysis assumptions. Please note that the connection between Sweden and Bornholm is not included in the analysis assumptions.

10.1 International connections in Western Denmark

The Western Denmark electricity system is connected by a High Voltage Alternating Current (HVAC) connection to the continent, which is operated as one synchronous area with the same frequency. The connection to Germany consists of four HVAC connections. The export capacity is 1,640 MW, and the import capacity is 1,500 MW. The import limitation is due to the fact that part of this capacity is made unavailable to the market in the event that outages occur in other parts of the electricity system and a need therefore arises for importing electricity from Germany. Export capacity is limited by internal congestion in the North German electricity grid [33]. That limit may vary greatly, and Energinet therefore models the congestion over time. This method is described in a background memorandum to the analysis assumptions [34][3].

The Western Denmark electricity system is connected to Sweden and Norway by High Voltage Direct Current (HVDC) connections. The Konti-Skan connection to Sweden consists of two HVDC connections with a total export capacity of 740 MW and an import capacity of 680 MW. In addition to coverage of transmission losses, the difference is due to allowances being made for historical design criteria in respect of security of supply in the event of an outage of the connection [32].

The Skagerrak connection to Norway consists of four HVDC connections. The connection was expanded in 2014, and total capacity is now 1,632 MW in both directions.

In future, the Western Danish electricity system will be interconnected with other countries to an even greater extent.

Energinet and the Dutch TSO, TenneT, are jointly planning the COBRAcable connection to the Netherlands, which will be an HVDC connection with a transmission capacity of 700 MW. Commissioning is expected in 2019, and the first full year of operation will therefore be 2020.

Energinet has entered into cooperation with German TenneT TSO GmbH on an upgrade of the existing connection between Western Denmark and Germany. This is to increase transmission capacity in both directions to 2,500 MW, while at the same time considerably increasing availability in the connection. The expansion is expected to have its first full year of operation in 2021. Limitations in the export direction are expected throughout the entire projection period due to congestion in the German grid.

Energinet is planning to establish a 1,400 MW HVDC connection to the UK jointly with National Grid Interconnector Holdings Ltd. The project is called Viking-Link, and the connection is expected to have its first full year of operation in 2023. Energinet is also planning to establish the 'West Coast Connection' (*Vestkystforbindelsen*) in cooperation with TenneT TSO GmbH – an HVAC connection from Endrup (east of Esbjerg) to the border, which will increase the maximum net transfer capacity across the Danish-German border from 2,500 MW to 3,500 MW. Viking-Link and the West Coast Connection are mutually dependent, so the latter is also expected to have its first full year of operation in 2023.

3 On June 14th 2017, the Danish Ministry of Energy, Utilities and Climate entered into an agreement with the German Federal Ministry for Economic Affairs and Energy on a minimum level for the capacity available for trading on the connection. Energinet is examining how this agreement must be taken into account in the use of the analysis assumptions.

10.2 International connections in Eastern Denmark

The Eastern Denmark electricity system is connected by HVAC connections to the rest of the Nordic electricity system, which is operated as one synchronous area with the same frequency. The Øresund Link to Sweden consists of six HVAC connections with a total export capacity of 1,700 MW and an import capacity of 1,300 MW. The import capacity is limited due to congestion in the Swedish grid. The Øresund Link faces major renovations in the future, as the cables are nearing the end of their lifetimes. This lifetime extension is not expected to have an impact on long-term transmission capacity.

In addition, the Eastern Denmark electricity system is connected to Germany by an HVDC connection, Kontek, which has an export capacity of 585 MW and an import capacity of 600 MW. The difference in capacity is due to the coverage of transmission losses [32].

Eastern Denmark and Germany will be connected in the future via the world's first offshore electricity grid at Kriegers Flak in the Baltic Sea. The Kriegers Flak HVDC connection has a transmission capacity of 400 MW in both directions and is expected to have its first full year of operation in 2019. Export and import capacities of the connection will be limited by the electricity generation of Kriegers Flak offshore wind farm[4].

In addition, Bornholm is connected to southern Sweden via an HVAC connection, which has a capacity of 60 MW in both directions. This connection is not normally included in Energinet's model calculations of Eastern Denmark's electricity system, and the connection is not part of the analysis assumptions.

10.3 Great Belt Power Link

Western Denmark and Eastern Denmark are connected by an HVDC connection, the Great Belt Power Link. The connection is obviously not an actual international connection as it connects two Danish price areas. However, it is operated in the same manner and is also included on the market on the same terms as the other international connections. The Great Belt Power Link was commissioned in August 2010. The capacity from Western Denmark to Eastern Denmark is 590 MW, while capacity is 600 MW in the opposite direction. The difference in capacity is due to the coverage of transmission losses [32].

4 The Danish offshore wind farm at Kriegers Flak is expected to have a capacity of 600 MW, which is also the maximum transmission the shore link can handle. The German offshore wind farms have a capacity of approx. 340 MW, while their shore link allows the transmission of up to 400 MW. The Kriegers Flak international connection allows the transmission of up to 400 MW between Eastern Denmark and Germany. The connection's released net transfer capacity (hour by hour) will be determined by the surplus capacity in the shore links once the expected wind turbine generation has been deducted [38].

11. Gas data

Gas consumption and production are facing radical changes as society undergoes the transition to renewable energy sources. The consumption of fossil gas will decrease, but the production of renewable gas will increase at the same time. A projection of central gas data is a prerequisite for Energinet being able to stay ahead of the challenges that will arise during this transition. Gas data are divided into four parts: consumption, production, imports and exports, and international connections.

Energinet's gas forecast in analysis assumptions 2016 has been updated. One of the most important changes is a consequence of DUC's (Danish Underground Consortium) agreement from 22 March 2017 with the Danish government on the renovation of the Tyra field. The agreement entails that all production from the Tyra field and connected fields ends in December 2019. Gas production is expected to be in operation again in March 2022.

11.1 Consumption

Gas consumption in Denmark towards 2040 comprises consumption for electricity, CHP and district heating generation, individual heating in households and businesses, and transport. Sweden is dependent on Denmark as a gas supplier, as the only gas transmission pipeline to Sweden is from Denmark.

Natural gas consumption and total gas consumption in Denmark are expected to decrease in the period, while consumption of gas based on renewable energy sources (RE gas) will increase. The analysis assumptions indicate the consumption of natural gas and RE gas (gas upgraded to natural gas quality) in the Danish gas system (exit zone). The consumption of natural gas in the North Sea and the consumption of raw biogas (not upgraded) are not included.

The projection of gas consumption for generating electricity, CHP and district heating is based on results from Energinet's Sifre calculation model set up with the analysis assumptions. Gas consumption for households and businesses is based on the Danish Energy Agency's Base Projection 2017 [13] as well as Energinet's analyses of the role of gas in the green transition from 2015 [35]. The transport sector's gas consumption is based on the results of Energinet's new analysis of electricity and gas for transport [24]. Annual consumption in the first year of the projection period has been determined by way of a forecast based on actual consumption in the first months of 2017.

Figure 30 shows gas consumption in Denmark and Sweden in the projection period, compared with the projection in analysis assumptions 2016. The consumption projection is generally very uncertain.

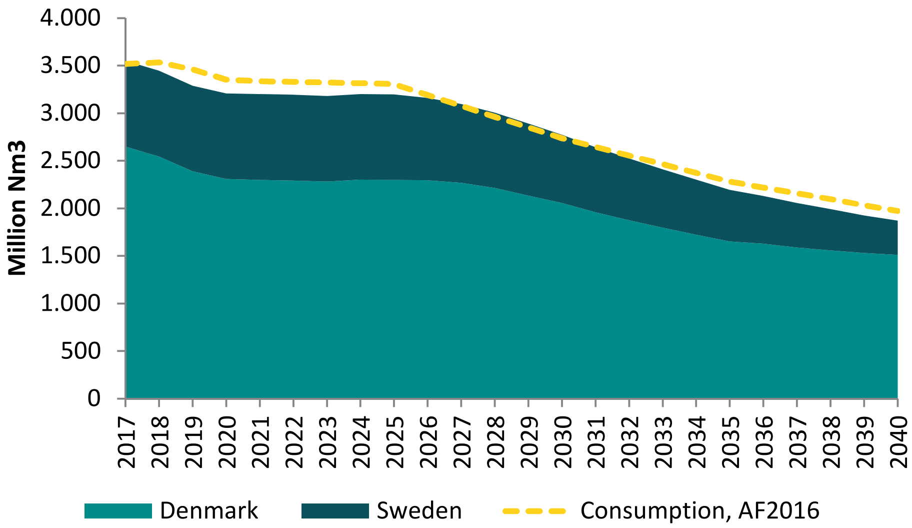

Figure 30 Expected gas consumption in Denmark and Sweden, compared with last year's analysis assumptions (AF2016).

In the short term, gas to the electricity and district heating sector is expected to be reduced as a result of possible closing of local plants. The trend may be counteracted to some extent by low gas prices, but in the long term, the transition to renewable energy in the electricity and district heating sectors is expected to result in considerably lower gas consumption.

Gas consumption by individual heating systems is expected to weakly decline in the short term up until 2025-2030 due to energy savings and conversion to other forms of heating. Subsequently, gas consumption will decline further in step with the transition to renewable energy.

Gas consumption by businesses is expected to remain virtually unchanged for the first 10 years, after which the transition to renewable energy will result in declining consumption in businesses as well. The use of gas in industry is sensitive to market conditions, and may be reduced due to conversions or changes to the number of manufacturing companies.

There is significant uncertainty surrounding the trend in the transport sector. According to Energinet's new analysis of electricity and gas consumption for transport, gas for light and heavy road transport will increase significantly until around 2030-2035. Gas for sea transport will increase during the entire projection period. After 2030-2035, gas for road transport will decline again as electricity becomes more competitive.

Swedish consumption in 2017-2025 is assumed to be slightly higher than the current level. After this time, it is expected to decline, due in part to expectations of increased biogas production in Sweden as in Denmark.

11.2 Production

Expectations of a renovation of the Tyra field installations in 2022 are of vital importance to gas production projections.

The expected supplies from the North Sea are based on the Danish Energy Agency's projection of Denmark's oil and gas production from April 2017 [36]. Here, the total production of natural gas (expected reserves) in the North Sea is expected to be on a par with today until 2019, after which it is expected to decrease significantly in the following years. When the Tyra field's renovations are completed in 2022, production increases once more and is expected to exceed the current level. From 2027 onwards, production will gradually decline.

The outlook for biogas production has been aligned with the outlook for Danish consumption which has been assessed on the basis of the Danish Energy Agency's Base Projection 2017 [13] as well as Energinet's analyses of the role of gas in the green transition from 2015 [35]. Any future production of synthesis gas from thermal gasification and electrolysis gas is not included in the analysis assumptions.

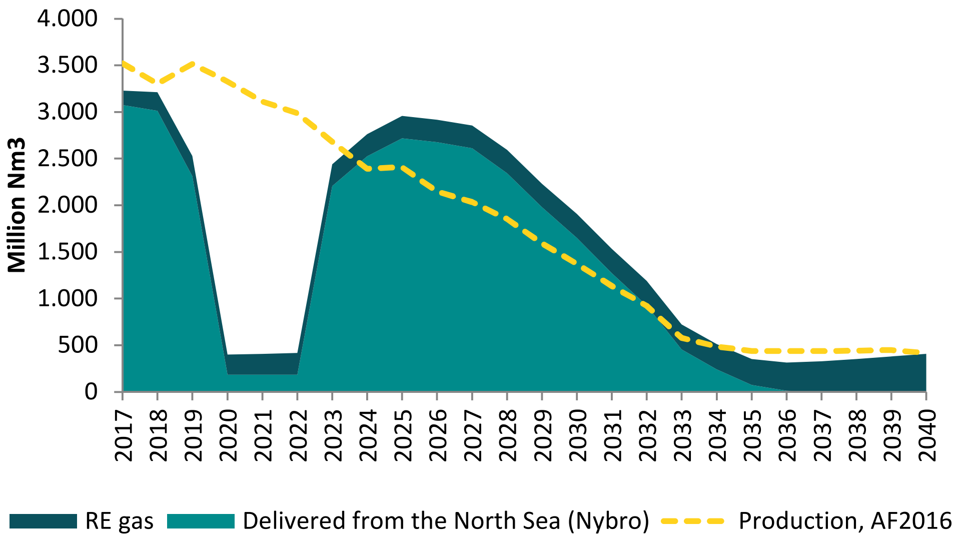

Figure 31 Expected production from the North Sea and RE gases, compared with last year's analysis assumptions (AF2016). The figure only shows the part of the RE gas production (e.g. upgraded biogas) which is sold via the gas system.

11.3 Imports and exports

Historically, Denmark has been a net exporter of gas, and this is expected to continue to be the case. With the current available resources, Denmark is expected to be a net exporter until 2032. However, in the years 2020 and 2021, while renovations of the Tyra field facilities are still ongoing, Denmark is expected to be a net importer of gas.

In years when Denmark is a net exporter of gas overall, there may still be periods when Denmark imports gas. As has been the case historically, all imports in the projection period are expected to come from Germany.

Figure 32 shows the annual balance for the exchange of gas between Denmark and Germany. Positive values indicate that Denmark imports more gas in a given year than it exports to Germany. Exports to the Netherlands are not shown, as gas supplies to the Netherlands do not impact on the Danish transmission grid. It should be noted in this context that it is very uncertain whether the export of natural gas from the North Sea takes place to the Netherlands or to Germany via Denmark.

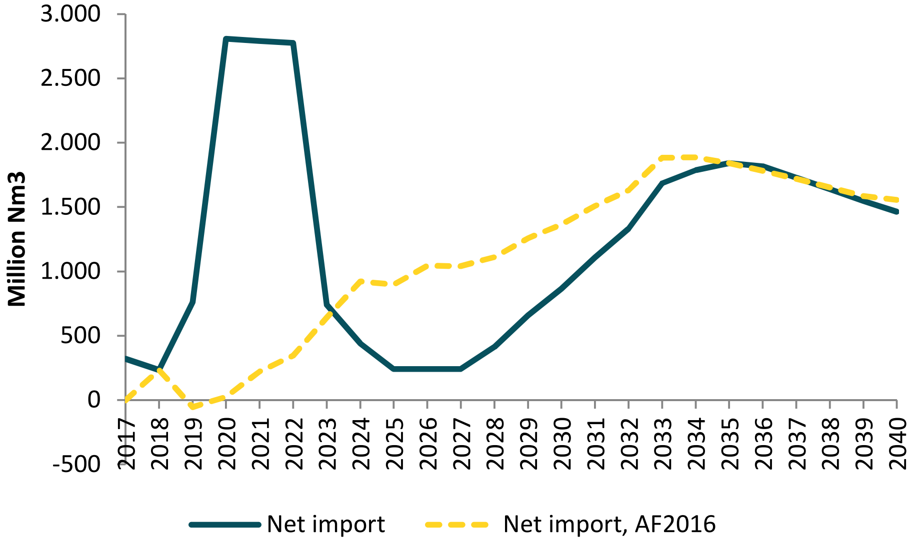

Figure 32 Expected net natural gas imports from Germany in the projection period, compared with last year's analysis assumptions (AF2016). Positive numbers indicate imports.

11.4 Gas connections

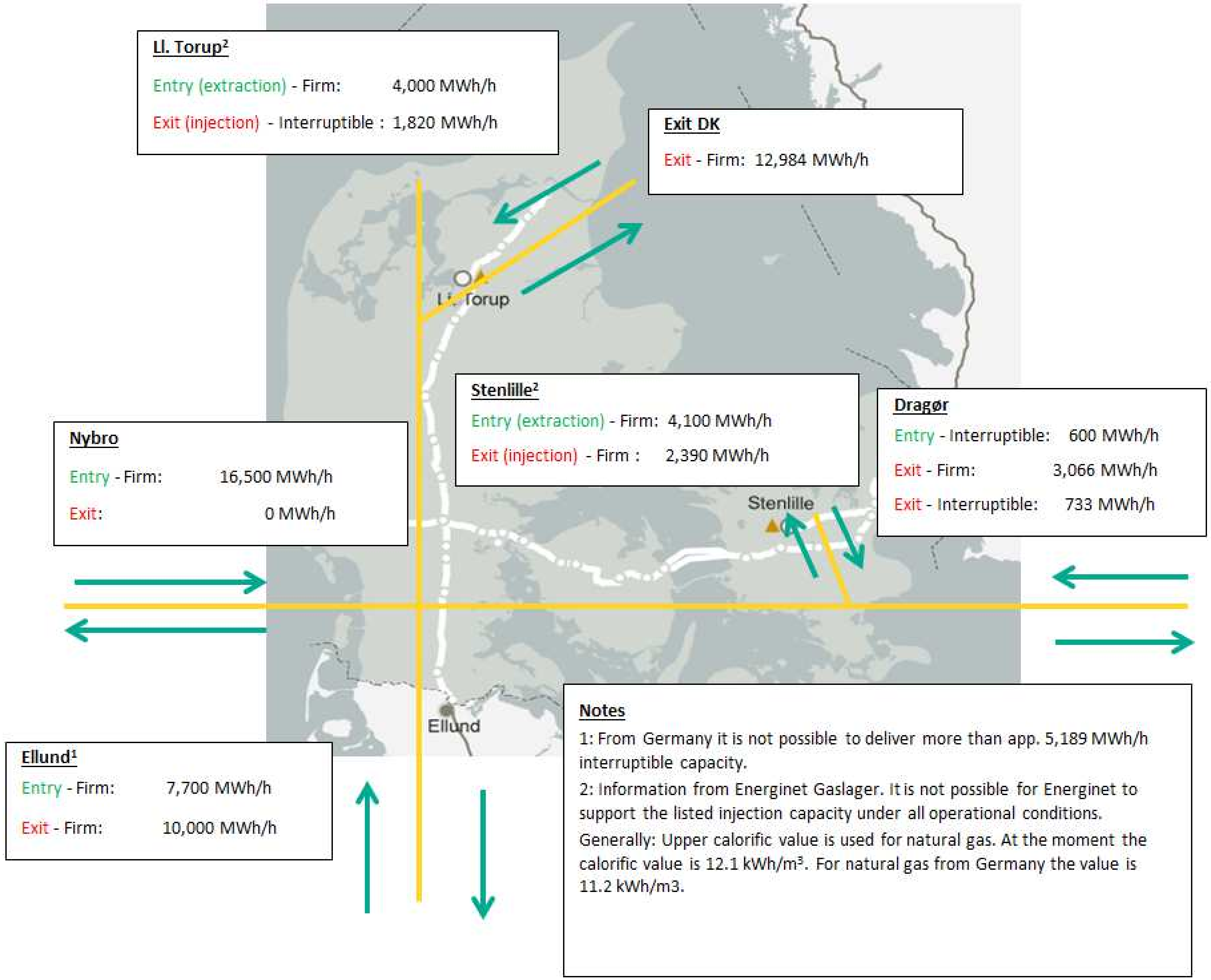

Figure 33 Gas connections in the Danish gas transmission system.

12. Grid planning assumptions

12.1 Grid planning models

Based on the analysis assumptions' projections of consumption, production capacity and capacity to neighbouring areas, more detailed local conditions are defined for use for grid planning. Current and projected infeed and consumption are determined for each individual substation in the transmission grid.

The transmission grid is planned on the basis of power analyses. This means that up-to-the-minute situations with rated maximum and minimum characteristics must be determined.

The analysis assumptions include both specified as unspecified consumption and production capacity. The specified assumptions contain information about power ratings and connection points, while the unspecified assumptions are overall system values.

The specified assumptions include the central CHP plants, offshore wind power and coastal wind power, local CHP, consumption for large data centres, consumption for the electrification of the railway network and international connections. These assumptions are incorporated directly in the grid planning models without further processing.

The unspecified assumptions include:

- On the demand side, basic consumption includes traditional consumption as well as the consumption for household heat pumps and electric vehicles.
- On the supply side, onshore wind power and solar cells.

As regards these assumptions, methods for conversion into power ratings and for allocation to the individual substations have been determined.

12.2 From energy to power

Grid planning is based on power analyses rather than energy analyses in order to get a picture of how the transmission system may be affected at any time. A number of power balances are used in the planning based on assumptions of power consumption, power generation and power transmission via the trade connections. This means that energy projections for consumption must be converted into power ratings. Both a maximum and minimum impact on the system from power consumption is applied in this work.

It is assumed that the basic energy consumption used for calculating power ratings includes traditional consumption as well as consumption for household heat pumps and 25 per cent of the energy consumption for electric cars. Energy consumption on Bornholm has been deducted from the Eastern Denmark energy consumption.

12.2.1 Maximum power consumption

The basic energy consumption is converted into a maximum power rating based on a load factor determined on the basis of historical metered data for energy consumption and the maximum hourly consumption (MWh/h).

The maximum power rating used for grid planning represents a 10-year winter, and the load factor used for the conversion is thus the lowest rating for the last 10 years. The load factor for calculating the maximum power rating is unchanged from last year.

Year	Western Denmark			Eastern Denmark		
	Annual consumption	Max. power	Load factor	Annual consumption	Max. power	Load factor
	TWh	MWh/h	h	TWh	MWh/h	h
2007	21.6	3,767	5,733	14.5	2,669	5,438
2008	21.6	3,748	5,769	14.5	2,660	5,442
2009	20.6	3,677	5,590	14.1	2,614	5,375
2010	21.1	3,743	5,643	14.4	2,615	5,497
2011	20.7	3,665	5,650	13.9	2,556	5,434
2012	20.4	3,677	**5,560**	13.7	2,559	5,354
2013	20.1	3,563	5,643	13.5	2,521	5,341
2014	20.1	3,541	5,683	13.3	2,500	**5,327**
2015	20.3	3,427	5,925	13.3	2,337	5,695
2016	20.5	3,672	5,591	13.4	2,444	5,504
Load factor 2017			**5,560**			**5,327**

Table 12 Metered data for consumption to calculate the load factor for determining the maximum power consumption.

When converting into power, an additional 2 per cent is added to the maximum power rating to accommodate the peak power loads that may occur within the individual hour.

The remaining consumption covers consumption by large data centres, consumption for the railway network and consumption for large heat pumps and electric boilers. Consumption for data centres and the railway network is specified with a maximum power draw and specific connection points. The load factors are 8,760 hours and 2,000 hours, respectively. This maximum power draw is assumed to affect the peak power load by 100 per cent. Consumption for large heat pumps and electric boilers is assumed not to affect the peak power load.

Development in the maximum power rating used when planning the transmission grid is shown in Figure 34 and Figure 35.

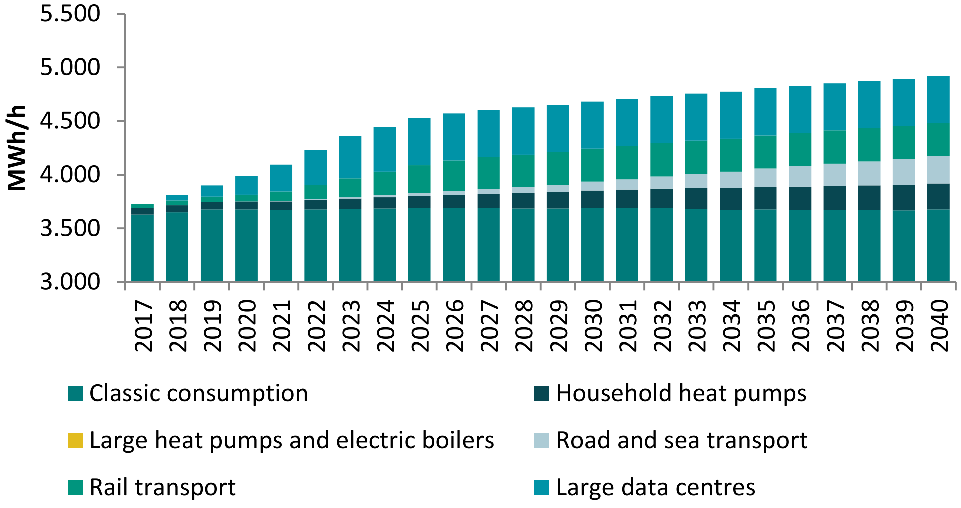

Figure 34 Development in maximum power consumption in Western Denmark. Please note that the axis does not reach zero.

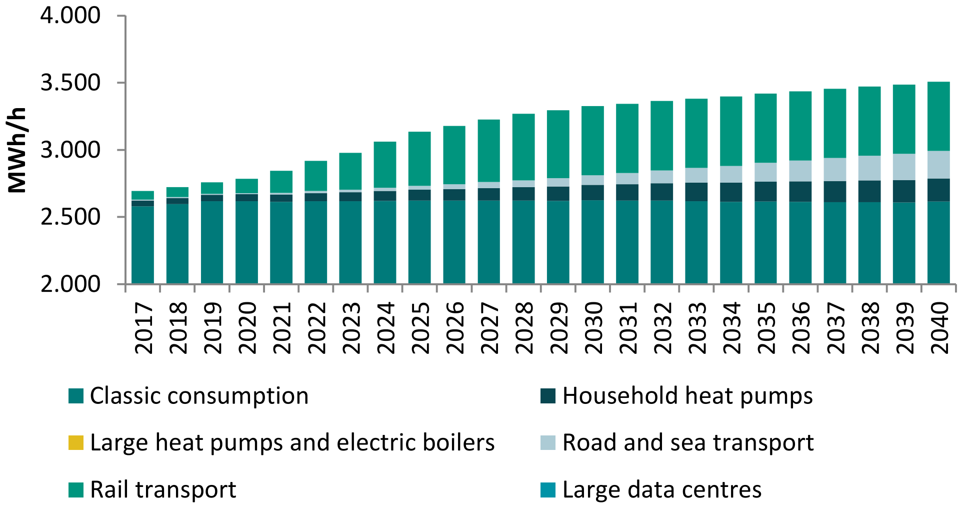

Figure 35 Development in maximum power consumption in Eastern Denmark. Please note that the axis does not reach zero.

12.2.2 Minimum power consumption

The energy projection of the basic consumption is converted into a minimum power impact based on a load factor determined on the basis of historical metered data for energy consumption and the minimum power consumption (MWh/h). The minimum power rating used for grid planning represents a 10-year summer, and the load factor used for the conversion is the highest load factor calculated for the last 10 years.

Year	Western Denmark			Eastern Denmark		
	Annual consumption	Min. power	Load factor	Annual consumption	Min. power	Load factor
	TWh	MWh/h	h	TWh	MWh/h	h
2007	21.6	1,384	15,608	14.5	915	15,857
2008	21.6	1,301	16,621	14.5	922	15,705
2009	20.6	1,266	16,234	14.1	892	15,747
2010	21.1	1,309	16,132	14.4	906	**15,862**
2011	20.7	1,306	15,857	13.9	897	15,490
2012	20.4	1,209	**16,911**	13.7	873	15,691
2013	20.1	1,353	14,857	13.5	898	15,001
2014	20.1	1,373	14,662	13.3	898	14,827
2015	20.3	1,365	14,878	13.3	886	15,021
2016	20.5	1,331	15,430	13.4	883	15,245
Load factor 2017			**16,911**			**15,862**

Table 13 Metered data for consumption for calculation of load factor for determining minimum power consumption.

A load factor for determining minimum power consumption has not previously been calculated. Historically, the minimum power rating makes up approx. 35-40 per cent of the maximum rating.

When converting into power, an additional 2 per cent is deducted from the minimum rating to accommodate the fluctuations that may occur within the individual hour.

The remaining consumption covers consumption by large data centres, consumption for the railway network and consumption for large heat pumps and electric boilers. The maximum power draw from the data centres is always present, while the power draw from the railroad network only has a load factor of approx. 2,000 hours. It is therefore assumed that the maximum consumption by data centres affects the minimum power, while the consumption by the railway network and the Fehmarn Belt Fixed Link does not. Consumption for large heat pumps and electric boilers is also assumed not to affect minimum power.

The development in the minimum power rating is shown in Figure 36 and Figure 37.

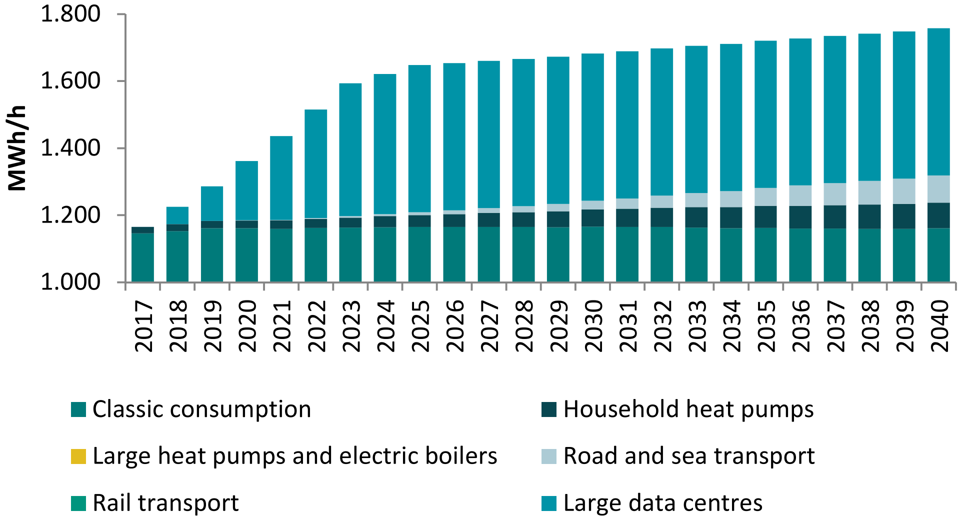

Figure 36 Development in minimum power impact in Western Denmark. Please note that the axis does not reach zero.

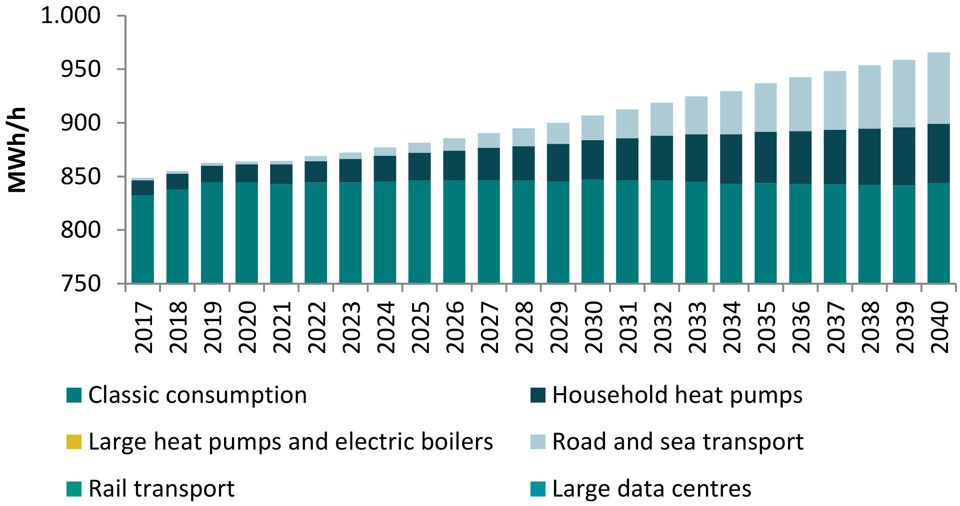

Figure 37 Development in minimum power impact in Eastern Denmark. Please note that the axis does not reach zero.

12.3 Substation area consumption

The determination of unspecified consumption at the individual substations (substation area consumption) for grid planning is done in two steps:

1. Determination of basis
2. Projection

Consumption is calculated in MW and shows the substation area consumption occurring when area consumption in Western Denmark and Eastern Denmark, respectively, reaches its maximum. This means that it is not necessarily the substation's maximum value.

12.3.1 Determination of basis

The methods for determining the basis are currently different in Western Denmark and Eastern Denmark. The primary reason for this is that access to metered data for calculating substation area consumption varies. However, the two methods have the following in common:

- When Energinet has prepared an estimate of substation area consumption, it is submitted to the regional grid companies for a quality check and subsequently adjusted according to any feedback received.
- Substation area consumption has been scaled such that the sum of all consumption is equal to the maximum power consumption in Western Denmark and Eastern Denmark, respectively.

In Western Denmark, the basis for substation area consumption is calculated on the basis of statistical analyses of metered data five years back. In addition, the current combination of consumption types is determined per substation. Consumption types comprise the agricultural, industrial, service and household sectors.

Current substation area consumption in Eastern Denmark is determined on the basis of the values from the most recent grid planning assumptions from 2016.

12.3.2 Projection

Substation area consumption in Western Denmark has been projected with differentiated growth factors determined on the basis of the individual substations' current combination of consumption for households, agriculture, industry and public and private service.

The projection of substation area consumption in Eastern Denmark is divided into a projection for the Copenhagen area and a projection for the rest of Zealand.

In the Copenhagen area, new consumption as a consequence of specific plans for urban development is taken into consideration. For the rest of Zealand, the projection is distributed evenly with a joint growth factor.

12.4 Production capacity

The currently installed wind power is retrieved directly from metered data. The local projection is based on an analysis of the available space for wind turbines compared with the compensation to be paid for the establishment of land-based wind turbines and for the potential wind generation of the location. This means that the development will primarily take place in areas along the west coast of Jutland and on the Lolland-Falster islands.

The installed power on solar cells is distributed and projected on the basis of substation area consumption.

12.5 Computation of planning balances

For use in grid planning, a number of predefined standard planning balances are used which, together with Energinet's grid dimensioning criteria, are necessary when examining the transmission grid's limitations and assessing the adequacy of alternative solutions. Planning balances underpin analyses of grid adequacy subject to given requirements for security of supply, integration of renewable energy (RE) and market functions both in terms of systems and locally.

Planning balances are computed with realistic combinations of consumption, generation and exchange with neighbouring countries which put a load on the system. Combinations are identified on the basis of statistical analyses of our market balances (calculated by means of the Sifre calculation model), which has a balance for each hour of a given year. The standard balances are divided into system balances and area balances:

Basis for system balances	Basis for area balances
- Security of supply, described in situations with high consumption. - Exploitation and integration of renewable energy, described through situations with large production from renewable energy. - Use of international connections, described in situations with maximum transit through the systems. - Securing the Mvar balance, described in a situation with low consumption and large local CHP generation.	- Generally large infeed into the 400 kV grid and thereby large transfers from the transmission grid towards the distribution grid. - Generally large infeed into the distribution grid and thereby large transfers from the distribution grid towards the transmission grid. - Area-specific balances with local generation deficits. - Area-specific balances with local generation surpluses.

List of references

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