DENMARK'S CLIMATE STATUS AND OUTLOOK 2021

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Danish Energy Agency, Carsten Niebuhrs Gade 43, DK-1577 Copenhagen V
Tel: +45 33 92 67 00, E-mail: ens@ens.dk

Internet: http://www.ens.dk

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1 About Denmark's Climate Status and Outlook 2021

Denmark's Climate Status and Outlook 2021 (CSO21) is an account of how Danish greenhouse gas emissions have developed from 1990 to 2019, as well as a technical, expert assessment of how greenhouse gas emissions as well as energy consumption and production will evolve over the period up to 2030 based on a frozen-policy scenario.

A frozen-policy scenario describes a scenario in which no new policy measures are introduced in the climate and energy area other than those decided by the Danish Parliament before 1 January 2021, or arising out of binding agreements. The policy freeze pertains to Danish climate and energy policy only, and it does not reflect the assumption that development in general will come to a halt. For example, economic growth and demographic trends are not part of the freeze.

CSO21 thus serves to examine to what extent Denmark's climate and energy targets and commitments will be met within the framework of current regulation. CSO21 can thus be used as a technical reference when planning new measures in the climate and energy area, and when assessing the impact of such measures.

1.1 What is the basis for CSO21?

According to the Danish Climate Act of 18 June 2020 (the Climate Act) a climate status and outlook report must be drawn up annually. CSO21 is the first in this series of statutory climate status and outlook reports.[1]

The Climate Act stipulates that Denmark is to reduce emissions of greenhouse gases by 70% in 2030 relative to the 1990 level. The Climate Act also sets out an annual cycle to ensure annual follow-up on whether climate efforts are supporting the fulfilment of targets in the Climate Act. According to the annual cycle, every year in April, Denmark's Climate Status and Outlook report is to review Denmark's progress towards meeting its climate targets.

Denmark's Climate Status and Outlook report is a continuation of Denmark's Energy and Climate Outlook reports prepared by the Danish Energy Agency. However, because the new report focuses on both current status and future projections, the report includes more detailed descriptions for agriculture, transport, and building and construction, among other things.[2]

[1] The Climate Act also requires global reporting on the international impacts of Danish climate efforts. Denmark's annual global reporting for 2021 has been prepared in parallel with CSO21 and has been published in a separate publication (Global Reporting 2021). References to CSO21 therefore only pertain to Denmark's national climate status and outlook.
[2] Denmark's Energy and Climate Outlook reports from previous years can be found at https://ens.dk/basisfremskrivning.

1.2 What does CSO21 include and how is the climate projection made?

To understand the results in CSO21, it is important to know what emissions are in focus, what policy measures and similar are included in the climate projection, and how the projection is made.

What emissions are included in CSO21?

The Climate Act sets out targets for greenhouse gas emissions reductions as well as guidelines for how these should be calculated. As a rule, the reduction targets for greenhouse gas emissions should be met within Danish territory, and the greenhouse gas emissions included in the Climate Act's targets should be calculated using the UN IPCC methodology. The targets in the Climate Act include Denmark's overall greenhouse gas emissions, including carbon removals/emissions by soils and forests (LULUCF), negative emissions from technological processes (e.g. underground storage of CO_2) and indirect CO_2 emissions (substances that, at a later stage, are converted to CO_2 in the atmosphere). In accordance with the UN IPCC methodology, the targets do not include emissions from international shipping and aviation, nor do they include direct emissions of CO_2 from burning biomass (wood chips and wood pellets, for example; i.e. biogenic emissions).[3]

What policy measures etc. are included CSO21?

The cut-off date for including policy measures in CSO21's modelling for the period 2020 to 2030 has been defined as 1 January 2021. The cut-off date for including policy measures in Denmark's Energy and Climate Outlook 2020 (DECO20) was 1 May 2020. Since that date, several policy measures have been adopted within the climate and energy area. These new policy measures have been included in CSO21 and include the *climate plan for a green waste sector and circular economy*, the *2020 climate agreement for energy and industry, etc.*, the *green road transport agreement*, the *green tax reform agreement*, the 2021 Finance Act, and more. See the underlying CSO21 memorandum on assumptions 2A (only available in Danish) for the full list of policy measures included in CSO21.

The energy islands decided as part of the *2020 climate agreement for energy and industry, etc.* have not been included in the basic scenario in CSO21. This is because establishment of these islands depends on measures that have yet to be decided, for example measures concerning interconnectors. Because of the assumptions applied in CSO21, the energy islands cannot therefore, at present, be included in the frozen-policy scenario. A few other adopted policy measures have not been included in CSO21, either because they have yet to be sufficiently concretised or because it is (currently) not possible to estimate their impact. See the underlying CSO21 memorandum on assumptions 2C (only available in Danish) for a list of measures adopted that have not been included in CSO21.

In addition to policy measures, CSO21 includes an updated overall assessment of developments based on current market conditions. Amongst other things, this includes actual investment decisions by various players. How CSO21 deals with collaboration

[3] See the underlying CSO21 memorandum on assumptions 2B (only available in Danish) for further explanation of the emissions included in CSO21.

agreements between the government and businesses is described in more detail in the underlying CSO21 memorandum on assumptions 2D (only available in Danish).

How was CSO21 prepared?
CSO21 is a collection of a number of different projections from the Danish Energy Agency and the Danish Centre for Environment and Energy (DCE), which the Danish Energy Agency has combined with statistical data to produce an overall climate status and outlook report for Denmark. How CSO21 was prepared is described in more detail in the underlying CSO21 memorandum on assumptions 0 (only available in Danish), and the specific assumptions, data and models used in the projection of emissions, etc. are described in several other underlying memoranda on assumptions, see Appendix 1.

1.3 *What uncertainty is linked to CSO21?*

CSO21 presents a basic scenario up to 2030. The projections are based on a central set of assumptions which the Danish Energy Agency assesses to reflect the most probable development on the basis of current knowledge and current policies. It is important to bear in mind that sensitive assumptions and uncertainties affect the key results in CSO21. The projections look ten years ahead, and the results may vary from year to year, regardless of measures. The projected results are therefore subject to general methodological uncertainty and to considerable uncertainty due to external variables, including unforeseen developments in behaviour and technologies, external factors such as fluctuations in weather, etc. The uncertainties associated with projected results for the individual sectors are described in the respective chapters about these sectors, as well as in the associated sector memoranda.

1.4 *How is the CSO21 material structured?*

CSO21 consists of a main report, underlying sector memoranda and memoranda of assumptions, as well as a number of data sheets. The documentation behind the projections has therefore been considerably expanded compared to previous years' projections.

For each of the main report's sector chapters (chapters 3-11), one or several sector memoranda have been prepared presenting detailed and thoroughly documented status descriptions and projections for the sector in question. Furthermore, the assumptions underlying projections have been documented in several memoranda on assumptions. These memoranda have been through public consultation. For a list of all written CSO21 material, see Appendix 1.

In addition to the main report and the sector memoranda, just as previous year's baseline projections, CSO21 is supplemented with a series of data sheets, e.g. on CRF tables, energy balance and additional sector data. Data for indicators listed in the 2020 Climate Action Plan is included as part of the data sheet with data behind figures (*"Tal bag figurer"*; only available in Danish).[4] See Appendix 2 for further information on this CSO21 data and a list of CSO21 data sheets.

[4] The 2020 Climate Action Plan presents several indicators which will in future contribute to the assessment of progress in the transition of individual sectors. Section 2.2 in each sector memorandum presents the indicators relevant for the sector in question, and the associated data sheet with results and data behind figures, (*"KF21 resultater – Tal bag figurer"*; only available in Danish) contains links to indicators for the different sectors.

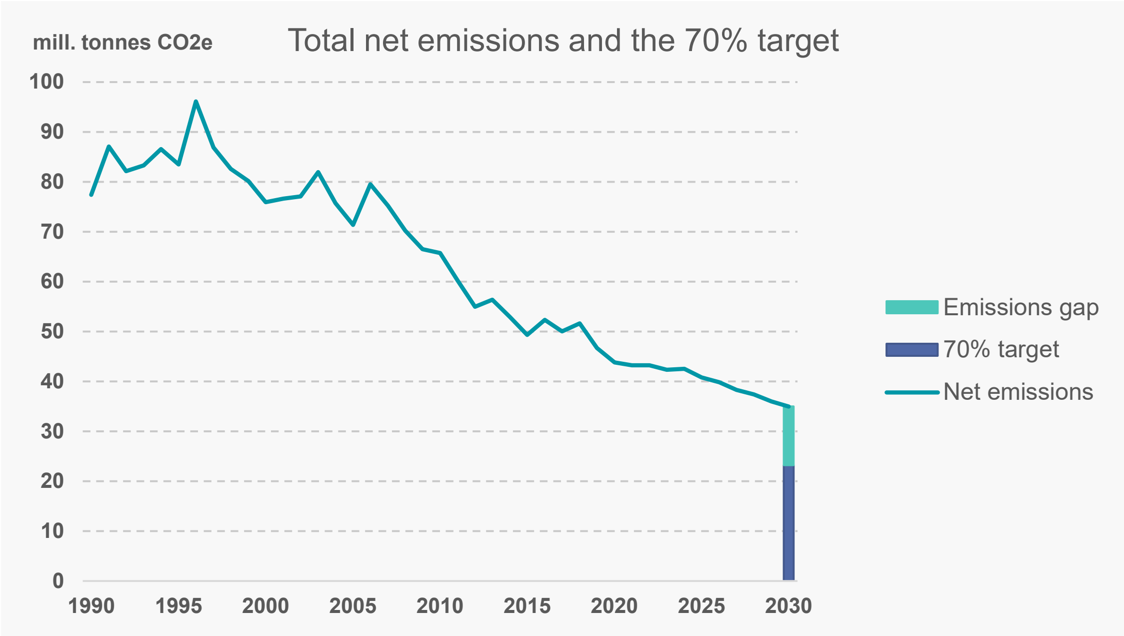
2 The overall picture

Denmark's **climate status**: In 2019, total greenhouse gas emissions, including carbon removals and emissions by soils and forests (LULUCF), came to 46.7 million tonnes CO_2e. This means that Danish greenhouse gas emissions have been cut by 40% compared to total Danish emissions in 1990.

Denmark's **climate outlook**: based on current adopted policies, total net emissions[5] are expected to have fallen to 35.0 million tonnes CO_2e in 2030, corresponding to a reduction of 55% in 2030 compared to the 1990 level. Thus, as things stand, projections reveal an estimated emissions gap of 15 percentage points, corresponding to 11.8 million tonnes CO_2e, from reaching the 70% target of the Climate Act. The anticipated development and the emissions gap are shown in figure 2.1.

[5]The concept of "total net emissions" refers to total emissions (including LULUCF) after inclusion of CCS.

Figure 2.1: Total net emissions and the 70% target.



The reduction in total net emissions of DKK 11.7 million tonnes CO_2e from 2019 to 2030 is due, in particular, to the following developments in sector emissions:

- **Electricity and district heating:** Emissions from the electricity and district heating sector (excluding waste incineration) are expected to be reduced by 4.7 million tonnes CO_2e from 2019 to 2030. Overall, the sector is therefore expected to emit less than 0.3 million tonnes CO_2e in 2030.
- **Waste:** Emissions from waste incineration are expected to be reduced by 1 million tonnes CO_2e from 2019 to 2030. Overall, waste incineration is therefore expected to emit 0.6 million tonnes CO_2e in 2030. Emissions from other waste management and from F gases will be reduced by 0.6 million tonnes CO_2e from 2019 to 2030, and will therefore emit 1.1 million tonnes CO_2e in 2030.
- **Transport:** Despite a continued increase in emissions from transport, emissions from the transport sector are expected to fall by 2 million tonnes CO_2e from 2019 to 2030, so that the sector as a whole will emit 11.5 million tonnes CO_2e in 2030. Reductions in emissions from passenger cars are expected to contribute half of overall reductions in emissions from the transport sector as a whole.
- **Manufacturing industries:** Emissions from manufacturing industries and building and construction will fall by 1.5 million tonnes CO_2e; from 5 million tonnes in 2019 to 3.5 million tonnes in 2030. The reduction is primarily due to a reduction in energy-related emissions from manufacturing industries, while the fall in process emissions will be significantly smaller.
- **Households:** Emissions from households, which stem primarily from individual heating, are expected to fall from a level of 2 million tonnes CO_2e in 2019 to 0.5 million tonnes CO_2e in 2030.
- **Biogas:** Biogas production is expected to increase considerably. Biogas is expected to account for 72% of mains gas in 2030. This renewable share of

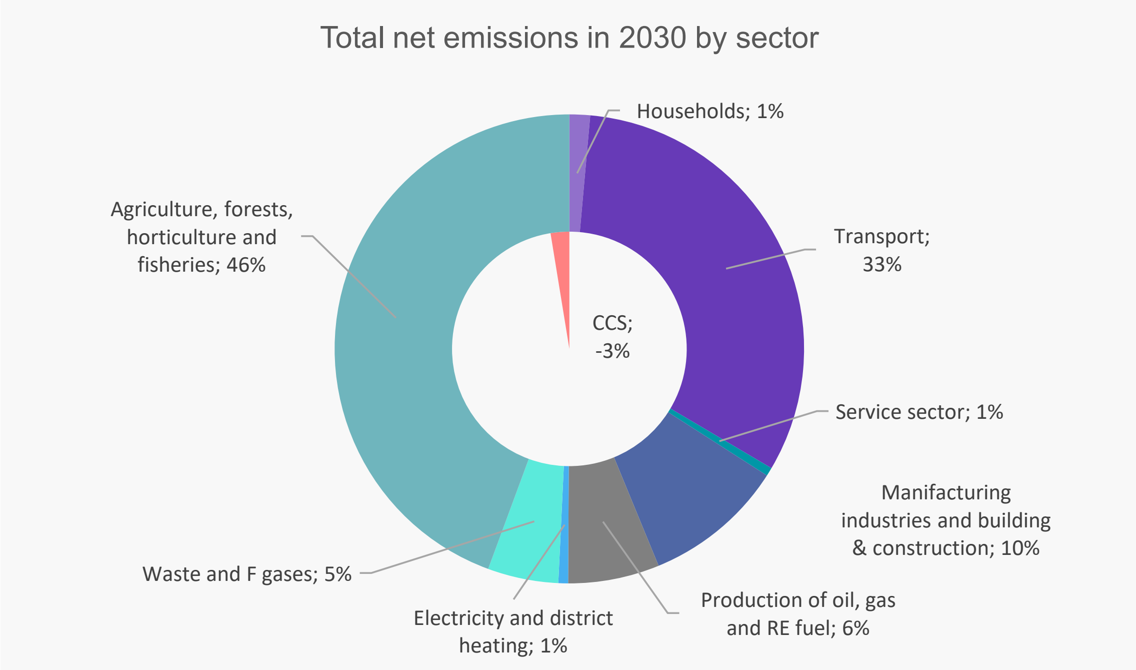
72% will have a significant impact on emissions from gas-consuming sectors. Due to the share of bio natural gas in mains gas, in 2030, emissions will be 2.3 million tonnes CO_2e lower than in a scenario with strictly non-renewable mains gas, and the share of bio natural gas will therefore contribute to emissions reductions in manufacturing industries and households, for example.

- **Agriculture, agricultural land, forests, horticulture and fisheries:** Total emissions from agriculture, forests, horticulture and fisheries are expected to increase by approx. 1 million tonnes CO_2e; from 14.9 million tonnes CO_2e in 2019 to 15.9 million tonnes CO_2e in 2030. This is due to a combination of several conflicting trends, including that emissions from forests[6] will increase by 3.1 million tonnes CO_2e from 2019 to 2030, that emissions from land use in agriculture will decrease by 1.3 million tonnes CO_2e from 2019 to 2030, and that emissions from livestock farming and manure management will decrease by 0.6 million tonnes CO_2e from 2019 to 2030.
- **CCS:** CCS is expected to reduce total emissions by 0.9 million tonnes CO_2 in 2030.

How total emissions in 2030 distribute across sectors is illustrated in figure 2.2.[7] As can be seen from the figure, emissions in 2030 will be concentrated on relatively few sectors, in that the transport sector and agriculture, agricultural land, forests, horticulture and fisheries together are expected to account for nearly 80% of total net emissions.

[6] The reason for this is primarily that new methodologies to determine emissions from forests mean that forests in 2019 contribute a net removal of 2.6 million tonnes CO2e, while in 2030 forests are expected to add net emissions of 0.5 million tonnes CO2e.
[7] The breakdown of sectors in CSO21 has been slightly changed compared to DECO20. The changes have been made to adhere to the *common reporting format* (CRF) used for international reporting and to provide more detailed reporting for businesses. Amongst other things, the changes mean that, in CSO21, emissions associated with individual heating fall under the consuming sectors, and that emissions from agriculture, agricultural land, forests, horticulture and fisheries include emissions from energy consumption by this sector, emissions from agricultural processes, and LULUCF emissions. The changes in the breakdown of sectors in CSO21 compared to DECO20 are further described in Appendix 3.

Figure 2.2: Total net emissions in 2030 by sector



Note: In CSO21, CCS is dealt with as negative emissions not broken down by sectors (see section 2.2).

2.1 Status of progress towards meeting reduction targets in the Climate Act and Denmark's EU obligations

Projected total emissions in 2030 will be 35.0 million tonnes CO_2e if no new measures are introduced in the climate and energy area after 1 January 2021, which is the cut-off date for including policy measures in CSO21. This leaves an emissions gap of 11.8 million tonnes CO_2e from the Climate Act's target of reducing emissions in 2030 by 70% compared to 1990.

Table 2.1: Status of progress towards reduction targets set out in the Climate Act[8]

	1990	2019	2025	2030	70% target	Gap from 70% target
CSO21 million tonnes of CO_2e	77.4	46.7	40.8	35.0	23.2	11.8
CSO21 reduction relative to 1990 emissions	0%	40%	47%	55%	70%	

Note: Pursuant to the Climate Act, the 70% target must be estimated as an average over three years to avoid fluctuations in individual years. However, CSO21 estimates emissions and the emissions gap as annual values, amongst other things because the projection of energy-related emissions is based on the assumption that all projection years are 'normal years'.

[8] In addition to the 70% reduction target in the Climate Act, through national agreements in the climate and energy area, several other targets have been set, for example in the context of the *energy agreement of 29 June 2018* and the *2020 climate agreement for energy and industry, etc*. Status of progress towards these targets is described in section 2.3 of sector memorandum 11B.

Progress in closing the emissions gap

The emissions gap of 11.8 million tonnes CO_2e in 2030 predicted by this year's projection is considerably smaller than the gap predicted in DECO20, which predicted a gap of 20 million tonnes CO_2e in 2030. The change in the emissions gap is attributable firstly to the many policy measures to reduce Danish greenhouse gas emissions introduced since the cut-off date for including policy measures in DECO20 (which was 1 May 2020). These new policy measures include the *2020 climate agreement for energy and industry, etc.*, the *climate plan for a green waste sector and circular economy*; the *green road transport agreement*, the *green tax reform agreement*, the 2021 Finance Act, and more.

Furthermore, CSO21 expects a significantly larger production of biogas than DECO20. This is due in part to the upcoming tendering procedure for biogas and green gases under the *2020 climate agreement for energy and industry, etc.*, but also due to a greater number of applications for the former, now discontinued, subsidy scheme for biogas. Most of the increase in biogas production is expected to be upgraded to bio natural gas and included in mains gas (see CSO21 memorandum on assumptions 4E). Finally, CSO21 also predicts lower emissions from LULUCF in 2030 than DECO20 did.

Historical reference for CSO21

The historical reference for CSO21 is 2019[9]. The calculation of emissions shows that total emissions fell by 4.9 million tonnes CO_2e from 2018 to 2019, of which more than half stemmed from reductions linked to electricity and district heating production.[10]The fall in emissions from electricity and district heating production is due to a large drop in coal consumption from 2018 to 2019 as well as a smaller drop in natural gas consumption, and both of these trends will continue in the projection period.

Note that considerable year-to-year fluctuations in emissions are likely to occur in general due to climatic conditions. This affects annual emissions from LULUCF and electricity production, in particular. The year-to-year fluctuations in emissions from electricity production will, however, decrease in future in step with phasing-out fossil power plants.

Denmark's EU obligations: non-ETS sectors 2021-2030

Under the EU 2030 climate and energy framework, Denmark has committed to reducing emissions from non-ETS sectors by 39% in the period 2021 to 2030 relative to the 2005 level. The emissions gap pertaining to this obligation is also considerably reduced in this year's projection. The cumulative emissions gap for the non-ETS obligation in the period 2021-2030 is thus expected to be approx. 3 million tonnes CO_2e in 2030. In comparison, the non-ETS emissions gap for 2021-2030 was predicted to be approx. 34 million tonnes CO_2e in DECO20 (see chapter 11). This development can be explained by

[9]2019 is the most recent year for which final energy statistics (Danish Energy Agency, 2020) and an emissions inventory (European Environment Agency, 2021) are available. Denmark's Energy and Climate Outlook 2020 (DECO20) had 2018 as the most recent statistical year.

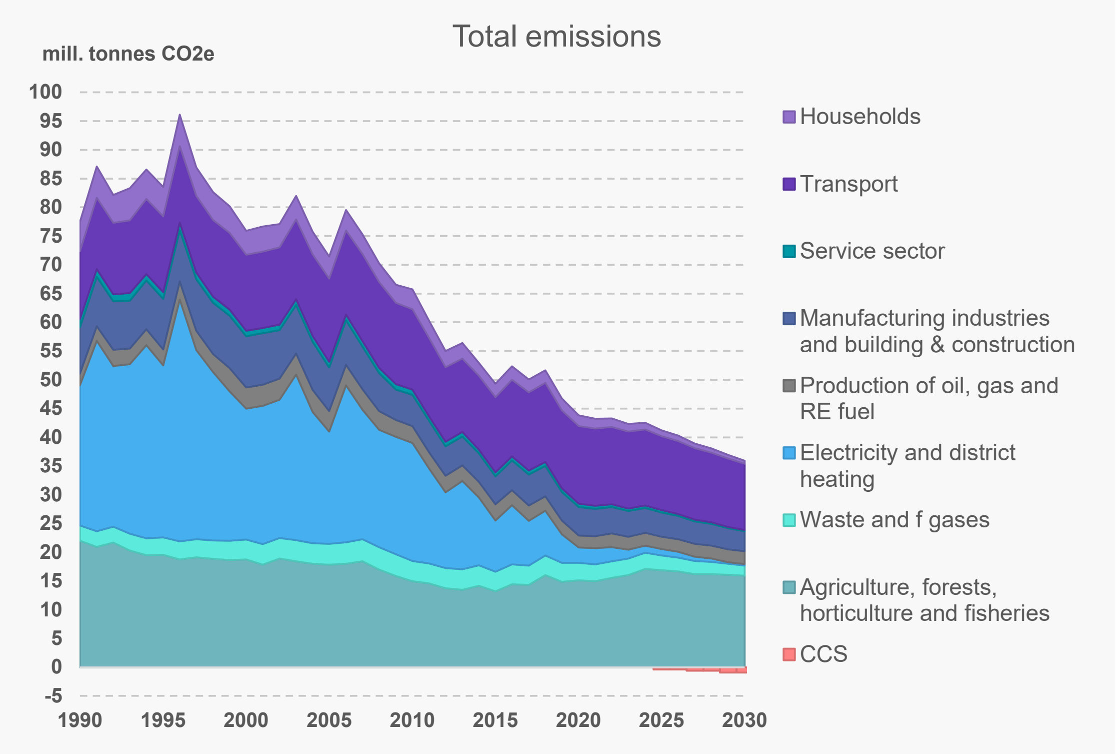
[10] The calculation of LULUCF emissions has moreover been changed since DECO20, as, amongst other things, a new methodology has been used to calculate forest emissions. This new methodology means that the considerable annual fluctuations in emissions seen when using the previous methodology have now been evened out across a longer period. For a more in-depth explanation see sector memorandum 10C on emissions from forests, as well as the following briefing document submitted to the Danish Parliament (only available in Danish):https://www.ft.dk/samling/20201/almdel/KEF/bilag/177/2326973.pdf

reductions in emissions from transport and households, including contributions from bio natural gas in mains gas.

2.2 *Trends in total emissions by sector*

Overall, Danish greenhouse gas emissions have been reduced by 40% in the period 1990 to 2019, and emissions are expected to be reduced by 55% in 2030 compared to 1990, if no new policies are adopted. Figure 2.3 shows trends in emissions by sectors, and carbon capture and storage (CCS).

Figure 2.3: Total emissions by sectors, and CCS



Note: See the note to figure 2.2 and section 2.2 on how CCS is illustrated.

Trends in emissions across sectors over time

Up to 2010, the electricity and district heating sector (excluding waste incineration) typically accounted for between 30% and 40% of total Danish emissions, but the share has since dropped significantly, see figure 2.3. In 2019, the sector thus accounted for 11% of total emissions, and in 2030 the sector is expected to account for less than 1% of emissions. Furthermore, previously, emissions from the electricity and district heating sector were characterised by considerable fluctuations. These fluctuations were due primarily to weather conditions, such as cold winters or fluctuations in precipitation amounts in the Nordic countries (which affect Nordic hydropower production). The fluctuations will decrease in future in step with phasing-out fossil power plants and the transition to electricity production based primarily on wind, solar and biomass.[11]

The share of total emissions contributed by other sectors will increase in step with falling emissions from electricity and district heating production. Historically, emissions from agriculture, forests, horticulture and fisheries have therefore gone from contributing around 25% of total emissions to contributing 32% of total emissions in 2019, and, according to the projection, will contribute 46% in 2030. Similarly, the transport sector contributed 15% to total emissions in 1990, 29% to total emissions in 2019, and, according to the projection, will contribute 33% to total emissions in 2030.

CCS

CCS is included in this year's projection for the first time as an expected source of emissions reduction in the projected period up to 2030. CCS deployment is expected to take place in continuation of the CCUS pool established as part of the *climate agreement for energy and industry, etc. 2020.* The expected annual CO_2 reduction effect from CCS is illustrated in table 2.2 below.

Table 2.2: Expected annual CO_2 reduction effect from CCS

	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
CO_2 (million tonnes)	0	0	0	0	0	0.4	0.4	0.6	0.6	0.9	0.9

Source: CSO21 memorandum on assumptions 7A: CCS (2021)

CCS can ensure zero emissions from fossil sources or process sources, or negative emissions from bioenergy sources. Due to the large uncertainty about future developments for CCS in Denmark, CSO21 does not include a specific assessment of which sectors will use CCS and will therefore have their emissions reduced. In CSO21, CCS is therefore dealt with as a separate source of negative emissions not broken down by sectors. It has however been assumed in CSO21 that the CO_2 reduction effect of CCS will be within ETS emission areas.

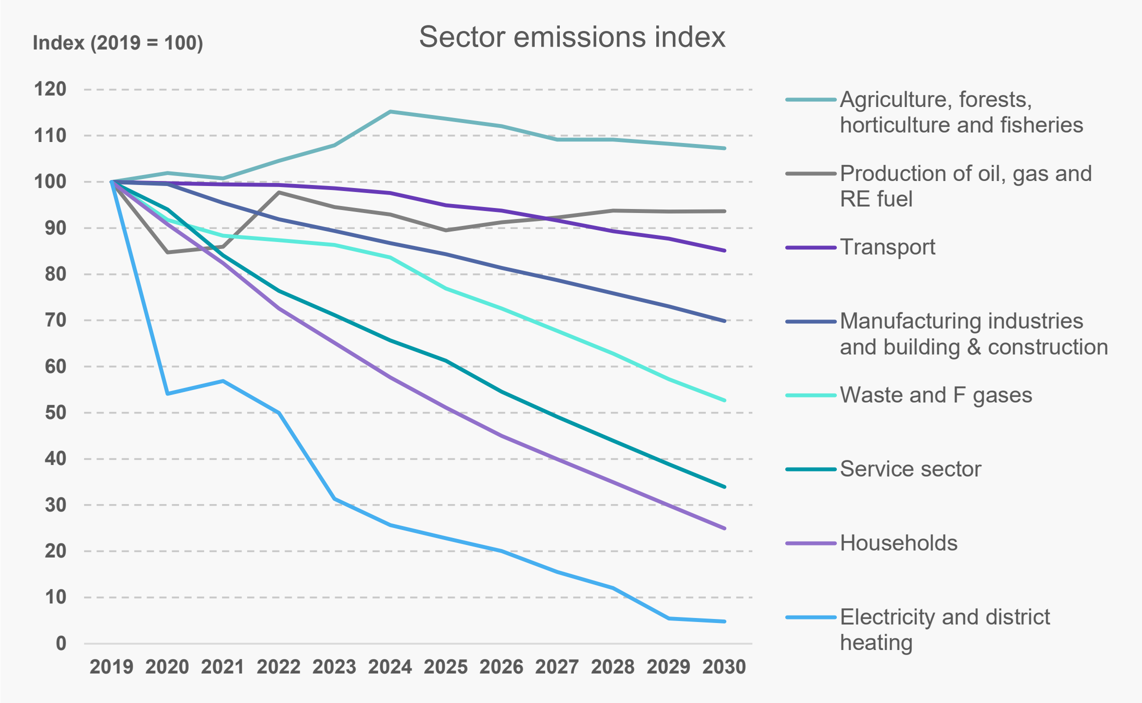
Projection of individual sector emissions 2019-2030:

The expected developments in individual sector emissions from 2019 to 2030 are illustrated in figure 2.4. Chapters 3-10 below examine the individual developments within these sectors. Noted that the sectoral division in CSO21 has been changed compared to DECO20. This means that, in CSO21, emissions associated with individual heating fall under the consuming sectors (e.g. households, the service sector and manufacturing industries).[12] Furthermore, the business sector has been divided into several sectors, and F gases are now included with the waste sector. See also Appendix 3 for a comparison of the sectoral division in CSO21 and DECO20, respectively.

[11] The projection of energy-related emissions assumes that all projection years are 'normal years'. The projection period therefore has no fluctuations in energy-related emissions due to passing weather conditions, such as cold periods and fluctuating wind or precipitation.

[12] Allocating emissions from individual heating in the consuming sectors harmonises with how these emissions are allocated in the CRF tables.

Figure 2.4: Trends in sector emissions 2019-2030 (2019 = index 100)



Note: CCS is not illustrated in this figure, as the technology was not well established in 2019. Also note that, in CSO21, figures for 2020 are projected estimates. The trend for 2020 is therefore not based on statistical data but on modelled results (see also section 2.5 on COVID-19 in CSO21).

Emissions from the electricity and district heating sector (excluding waste incineration) are expected to be reduced by 95% from 2019 to 2030 because of phasing-out coal and continued deployment of wind and solar capacities in electricity production, as well as massive deployment of heat pumps in district-heating production. Emissions from waste incineration, which are an integral part of electricity and district heating production, fall under the waste sector in CSO21, as do waste management and F gases. The measures set out in the *climate plan for a green waste sector and circular economy* are the main reason for an expected reduction in emissions from waste incineration of 59% in 2030 compared to 2019. Total emissions from waste and F gases will be reduced by 47% during this period.

Emissions from households, which stem primarily from individual heating, will fall by 75% from 2019 to 2030. The fall is primarily due to conversion away from oil- and gas-fired heating to heat pumps and district heating, driven by regulation and subsidy pools decided under the *2020 climate agreement for energy and industry, etc,* among other things. Furthermore, emissions from remaining gas-fired boilers will also be reduced because of the higher share of bio natural gas in mains gas. The same applies for the service sector, in which most emissions also come from individual heating systems.

Emissions from manufacturing industries and building and construction stem from energy consumption by the sector as well as from process emissions. Overall, emissions from the sector will fall by 30% from 2019 to 2030, which is due mainly to a drop in energy-related emissions from manufacturing industries, including, in particular, energy-related CO_2 emissions from "other manufacturing industries". Thus, from 2020 to 2030, energy-related CO_2 emissions from "other manufacturing industries" will fall by around 70%, primarily due to an increasing share of bio natural gas in mains gas. Energy-related CO_2 emissions from the production of cement, glass and tiles will fall by approx. 20 % from 2020 to 2030, while process emissions from cement, glass and tiles will fall by around 8% during the same period.

Despite increasing traffic, emissions from the transport sector will fall by almost 15% from 2019 to 2030. The drop in transport emissions is due in part to increased biofuel blending in petrol and diesel and more transition from conventional to electrical vehicles as a consequence of *the agreement on green road transport,* and in part to increased energy-efficiency improvements for new conventional vehicles.

Emissions from the agriculture, forests, horticulture and fisheries sector include emissions from energy consumption by the sector, as well as emissions associated with livestock farming, manure management and fertiliser use, and emissions associated with changes in the carbon pool on agricultural land, in forests and on other land (so-called LULUCF emissions). The increase in emissions from 2019 to 2030 from this sector is the overall result of a drop in emissions from agricultural production and from agricultural land combined with an increase in emissions from forests.

Biogenic emissions
CO_2 emissions from burning of biomass are 'carbon neutral' according to the UN IPCC methodology[13], even though burning of biomass causes CO_2 emissions. This means that biogenic CO_2 emissions are not included in national emissions inventory submissions to the UN, and they are therefore also not included in the calculation of the sector's emissions in CSO21, because, pursuant to the Climate Act, the calculation of emissions towards the 70% target must follow the UN IPCC methodology. Biogenic emissions from biomass burning are reported to the UN and to the EU as a so-called "memo item", and CSO21 presents the biogenic CO_2 emissions from total Danish burning of biomass for energy-related purposes (excluding bioethanol and biodiesel) in Appendix 5. The corresponding biogenic CO_2 emissions from the individual sectors are in appendices to the relevant underlying sector memoranda to CSO21[14].

2.3 Energy-related emissions and total energy consumption

The breakdown of emissions by sector presented in the section above shows the economic activities and players that generate emissions. However, this breakdown does not specify the types of emissions in question, nor whether the emissions come from energy consumption or other sources.

However, this information is provided in Denmark's emissions inventory submissions to the UN and the EU, which are based on the Common Reporting Format (CRF). The CRF tables break down emissions into five overarching CRF categories as well as a

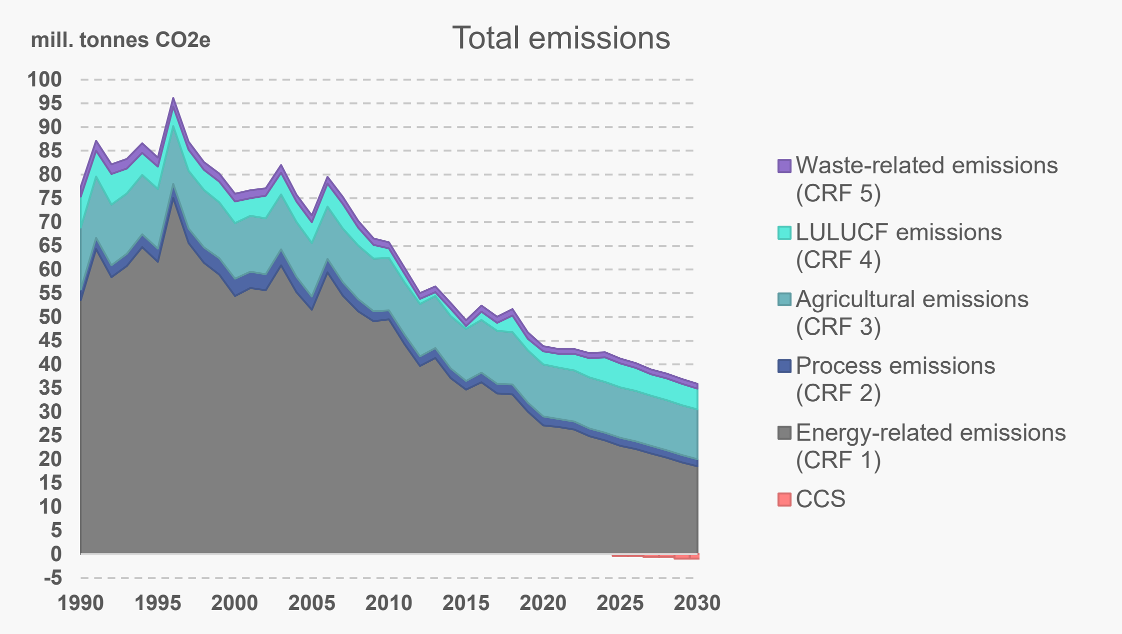
[13]This is because emissions associated with the use of biomass are included as part of LULUCF emissions in the country where, and at the time when, the biomass is harvested. Subsequent burning of the biomass is therefore not included in the calculation of emissions, as this would lead to double counting of the emissions in emissions inventories across sectors. See CSO21 memorandum on assumptions 2B for a description of the UN IPCC methodology for calculating CO_2 emissions from biomass.
[14] See also the section on biogenic CO_2 emissions in Global Reporting 2021.

large number of subcategories, amongst other things based on the type of activity causing the emissions.

Trends in energy-related emissions

The five overarching CRF categories are: 1) energy-related emissions (including emissions from waste incineration and transport); 2) emissions from industrial processes and product use; 3) agricultural emissions; 4) LULUCF emissions; and 5) waste-related emissions (excluding waste incineration).[15] Figure 2.5 shows total Danish emissions broken down by the five overarching CRF categories.

Figure 2.5: Total emissions 1990-2030 by CRF categories, and CCS



Note: See the note to figure 2.2 and section 2.2 on how CCS is illustrated.

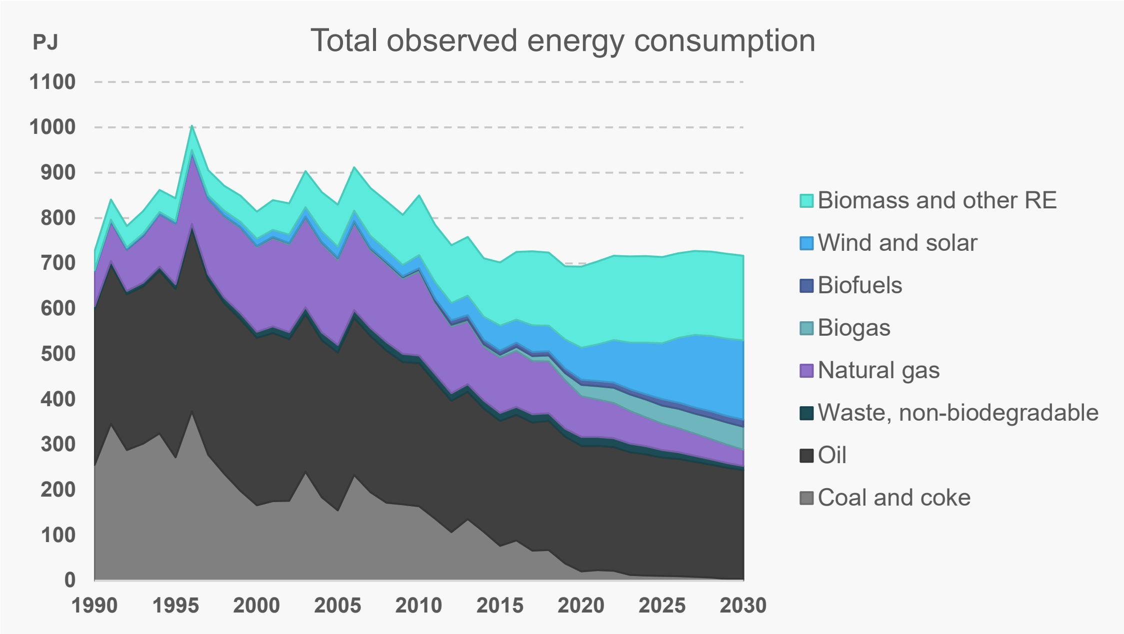
As can be seen from figure 2.5, historically, total energy-related emissions across sectors have typically constituted between 70% and 75% of total Danish emissions. However, in recent years, the energy-related emissions' share of total emissions has dropped below this level, and this trend is expected to continue in the projection period. Even so, energy-related emissions will still account for more than half of total emissions in 2030. This is due not least to transport sector emissions, which are expected to account for about 60% of energy-related emissions in 2030.

Trends in total energy consumption

Energy-related emissions arise from fossil energy consumption, and the development in these emissions therefore depends on the energy mix in energy consumption. Figure 2.6 shows the energy mix and developments observed in Danish energy consumption from 1990 to today, and onwards up to 2030.

[15] Emissions from CRF categories 2, 3, 4 and 5 have been broken down by only one or two of the sectors appearing in CSO21. Energy-related emissions from CRF category 1, however, appear in all the sectors in CSO21. In the data sheet with CRF tables, the CSO21 projection results have been broken down by 55 CRF subcategories, and Appendix 4 contains a table showing the relationship between the 55 subcategories and CSO21 sectors.

Figure 2.6: Total observed energy consumption 1990-2030



Note: Observed energy consumption has not been adjusted for electricity trade, nor for climate fluctuations.

Observed energy consumption is expected to remain at a fairly constant level throughout the projection period, see figure 2.6. The development in the fuel mix is also expected to reflect the historical trend of reduced fossil consumption, including, not least, the continuous reduction in coal consumption[16], combined with a continuous increase in renewables consumption. Naturally, this trend is also reflected in the total renewables share (RES) and the renewables shares in electricity and mains gas, respectively, which are shown in table 2.3 below.

Table 2.3: Renewables shares in electricity consumption and mains gas, and total renewables share

	2019	2025	2030
Renewables share in electricity consumption (RES-E)	65%	89%	97%*
Renewables share in mains gas	10%	42%	72%
Total renewables share (RES)	37%	50%	58%

**: A partial sensitivity calculation assuming that both energy islands will be in operation in 2030, shows a RES-E of 122% in 2030 (see chapter 8 and sector memorandum 8A).*
Source: Sector memoranda 7B, 8A and 11B.

The renewables share in mains gas is expected to be considerably higher in the projection than previously predicted, see table 2.3. This is due to a projected fall in mains gas consumption combined with a considerable increase in the production of bio natural gas (see memorandum on assumptions 4E). Bio natural gas in mains gas results in a reduction in emissions from the sectors that use mains gas, and the amount of bio natural gas plays a significant role for total emissions in CSO21. Were

[16] Coal consumption in the electricity and district heating sector will be phased out during 2028, but it is expected that coal and coke will still be used in manufacturing industries and in building and construction in 2030.

bio natural gas to be replaced by fossil natural gas in mains gas, total emissions in 2030 would be 2.3 million tonnes CO_2e higher than in the CSO21 basic scenario.

It should be noted that biogas production volume is not driven by the demand for biogas but by the subsidy schemes. A further reduction in the demand for mains gas would therefore result in a corresponding reduction in the consumption of fossil natural gas and, thus, an even higher share of renewables in the remaining mains gas, and vice versa.

The renewables share in electricity consumption (RES-E) is also following a strong upward trajectory and is expected to reach 100% in 2028. Wind and solar make up the largest renewables share in electricity consumption. The renewables share in electricity consumption is below 100% in 2030 because the energy islands cannot, at present, be included in the CSO21 basic scenario, which is a frozen-policy scenario[17]. The total share of renewables (RES) is also increasing steeply and is expected to reach 58% in 2030.

2.4 Uncertainty

As mentioned in chapter 1, it is important to consider the uncertainty associated with the projection when looking at the results presented in CSO21. This uncertainty is linked to developments in activity in society in general as well as in businesses with considerable greenhouse gas emissions (e.g. cement production and agricultural production).

There continues to be considerable uncertainty about the consequences of the COVID-19 pandemic, including the rate at which society will return to a more normal situation, and whether there will be any unpredicted structural or behavioural changes. In this context, note in particular that the year 2020 has been modelled as a 'normal projection year' in CSO21, although, in reality, 2020 was far from a 'normal' year. This is because there was not sufficient knowledge about the effects of the pandemic at the time of preparing the projection. Nonetheless, the COVID-19 pandemic *is* reflected in the projection of fuel prices and economic growth, amongst other things, (see CSO21 memorandum on assumptions 3A on fuel prices and 3D on economic growth). Furthermore, it should be noted that analyses from the International Energy Agency (IEA) indicate that, by the end of 2020, emissions by several of the world's major economies had rebounded to pre-pandemic levels (end-2019 levels).

Another source of uncertainty in the projection concerns uncertainty about investment behaviour, including, in particular, the phase-in rate for new technologies (e.g. electric cars in transport, emerging shifts away from fossil fuels in manufacturing industries and transitioning from natural gas boilers to other heating technologies in households). Furthermore, there will be uncertainty about the scope of the effect of the CCUS subsidy pool (see CSO21 memorandum on assumptions 7A).

[17] As described in memorandum on assumptions 4B, this means that neither the energy islands, nor offshore wind farm 3 which is now a part of the energy islands, are included in the CSO21 basic scenario in 2030. As described in the note to table 2.3, a partial sensitivity calculation that includes the energy islands results in a renewables share in electricity consumption of 122% in 2030. See sector memorandum 8A for an in-depth explanation of electricity production in the CSO21 basic scenario and the sensitivity calculation that includes the energy islands.

Finally, there is general uncertainty associated with the projection's assumptions, including assumptions about economic growth, price developments for resource inputs and technological advances.

The following sector chapters include examples of important uncertainties and sensitivity calculations for the relevant sector, and the underlying sector memoranda provide further in-depth descriptions of these.

3 Households

The household sector comprises all citizens residing in Denmark. About 5.8 million people live in approximately 2.7 million homes, and all households take individual decisions about how they will heat their houses and about their electricity consumption[18].

The household sector includes emissions linked to the household's consumption of individual heating. In 2019, the sector emitted about 2.1 million tonnes CO_2e, corresponding to approximately 4% of total Danish emissions. In 2030, the sector is expected to emit 0.5 million tonnes CO_2e, corresponding to approximately 1% of total Danish emissions.

The expected changes in sector emissions are due in particular to the following factors:

- Individual heating in households will become less CO_2-intensive because of conversion away from oil and gas to more heat pumps and more district heating. Furthermore, the percentage of bio natural gas in the gas grid will grow.
- Energy-efficiency improvements in the form of energy improvements in buildings and better building standards for new buildings mean that building consumption for heating will not increase, even though the heated

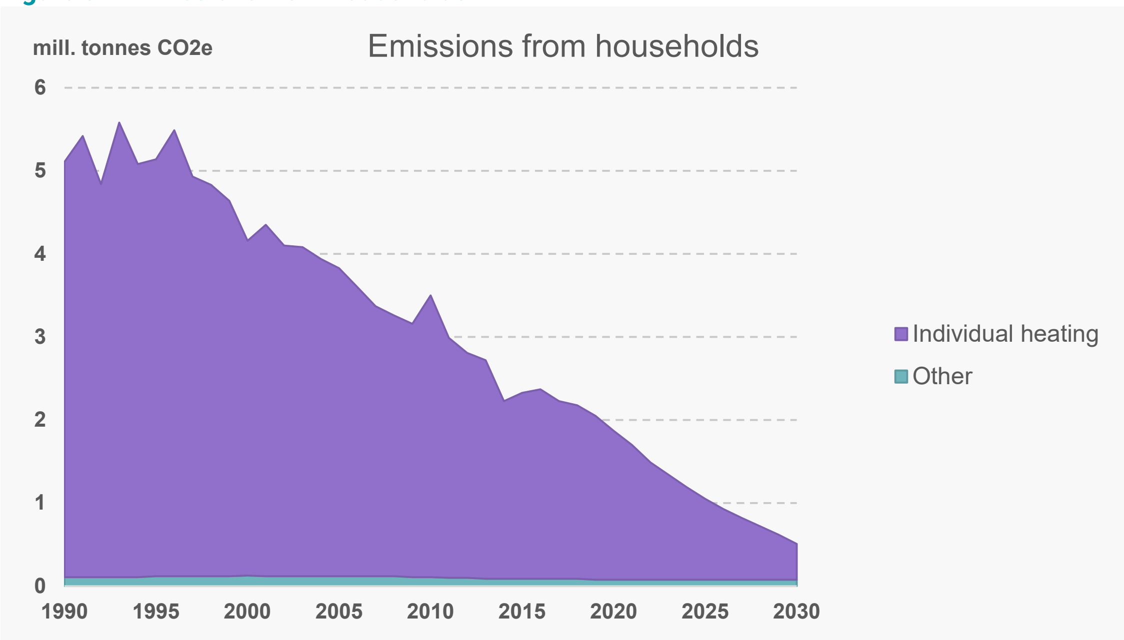
[18] Source: Statbank Denmark, Statistics Denmark. FOLK1A: Population at the first day of the quarter by region, sex, age and marital status; and BOL101: Dwellings by region, type of resident, use, tenure, ownership and year of construction

floor area will. Conversion to district heating and heat pumps also means that the heating technologies used will be more efficient.

3.1 Emissions from the household sector

This chapter describes energy consumption by households and emissions for a subset of energy consumption, i.e. emissions from individual heating such as oil- and gas-fired heating, as well as emissions from patio heaters, petrol-powered lawnmowers and similar[19]. Energy consumption in households consists of approx. 80% space heating and about 20% electricity consumption.

Figure 3.1: Emissions from households



Note: Other includes patio heaters, petrol-powered lawnmowers and similar.

Total emissions by the sector for the period 1990-2030 are illustrated in figure 3.1.

Sector emissions are exclusively energy-related emissions (CRF-1) from individual heating with oil-fired, gas-fired, and coal/coke-fired boilers as well as from the use of patio heaters, petrol-powered lawnmowers and similar. Total emissions from the household sector are therefore expected to drop by about 75% from 2019 to 2030. Only emissions associated with final energy consumption in households have been included. This means that emissions associated with the production of electricity and district heating are not included in figure 3.1.

Looking instead at energy consumption, energy consumption for heating is expected to remain relatively unchanged, whereas electricity consumption for lighting and appliances is expected to rise.

Expected developments after 2019 are driven in particular by policies such as the *2020 climate agreement for energy and industry etc.*, which through subsidies and taxes

[19] Household consumption of fuel for transport, including petrol, diesel and electricity for electric cars, is described in chapter 4 and sector memorandum 4A on transport.

provides an incentive to improve the energy efficiency of buildings and move away from fossil heating systems towards heat pumps and district heating. Note that the shift away from oil-fired boilers actually began before these measures, although the measures do help to strengthen the phasing-out of oil-fired boilers and they have accelerated a significant shift away from gas-fired heating.

3.2 Energy consumption by the household sector

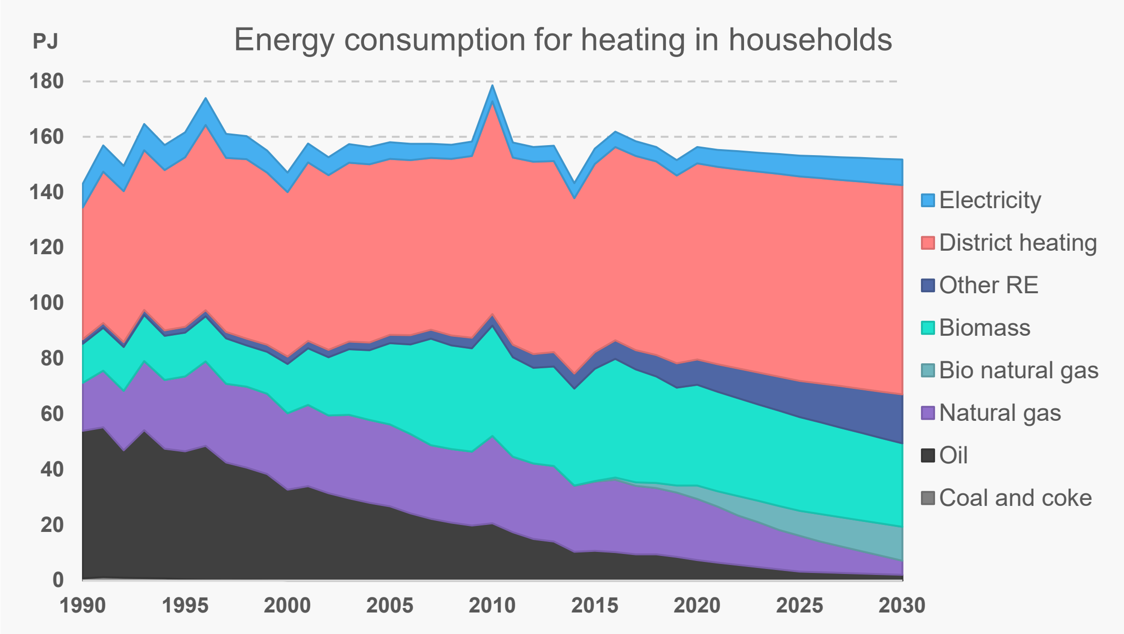
Energy consumption for heating in households

Developments in emissions and energy consumption associated with heating in households is driven by several factors, including household choice of heating, the floor area of households to be heated, and developments in the efficiency of different types of heating,

Approx. 65,000 heat pumps were installed in 2020, of which approx. 80% were air-to-air. Air-to-air heat pumps can supply most of the space heating for many dwellings, but they are usually used in combination with other types of heating. About 9,000 houses changed from oil-fired to another type of heating, and about 3,000 houses changed away from gas-fired. Furthermore, approximately 1,000 homes converted from other types of heating to gas-fired heating, while almost none changed to oil-fired. In 2030, approx. 250,000 houses are expected to have oil-fired or gas-fired boilers as their primary heating technology. It is also expected that an approximately equal number of houses will have heat pumps and gas-fired heating, respectively, as their primary heating technology in 2030.

Figure 3.2 shows that, after 2019, household heating is expected to be increasingly covered by district heating and electricity for electric radiators and heat pumps, bio natural gas and other renewable energy (in particular ambient heat in the form of heat pumps and some solar energy), and to a lesser degree by natural gas, oil and biomass. In 2030, the expected energy mix in households for heating will primarily consist of district heating, biomass and heat pumps, supplemented by electricity and mains gas. Mains gas comprises natural gas and bio natural gas, and emissions associated with consumption of mains gas depend on the percentage of bio natural gas in the mains gas.

Figure 3.2: Energy consumption for heating in households, by energy product



Notes: Historical values for energy consumption are stated as the actual figures. Other renewable energy includes ambient heat and solar energy. Mains gas is divided into natural gas and bio natural gas based on the overall percentage of bio natural gas in the system.

The heated floor area is expected to increase by around 2% in single-family houses, and about 10% in blocks of flats from 2019 and up to 2030. Even though floor area will increase, energy consumption for heating is expected to fall by about 5% for single-family houses, and to remain relatively unchanged for blocks of flats in 2030. Heating consumption per square metre in homes has generally fallen since 2010 and is expected to fall further up to 2030. Developments are affected by household building improvements, and the fact that new buildings require less energy for heating than the existing building stock. Furthermore, a shift is expected towards heating technologies with higher heating efficiency, e.g. heat pumps and district heating.

CO_2e emissions associated with heating both single-family houses and blocks of flats are expected to drop by about 80% up to 2030. Besides an assessment of the economic feasibility of the different heating technologies, developments are based on an expectation that all the funds in politically earmarked funding schemes for conversion of oil-fired and gas-fired boilers will be spent so that the number of houses heated with oil-fired or gas-fired boilers is considerably reduced up to 2030. Conversion away from oil-fired and gas-fired boilers towards heating technologies that emit less CO_2e is expected to contribute a reduction of around 0.9 million tonnes CO_2e in 2030. In addition to the reductions from converting to cleaner heating technologies, there is an expected reduction in emissions from households' individual heating because of an increased percentage of bio natural gas in the gas grid. The expected share of bio natural gas in the gas grid will contribute a reduction of around 0.7 million tonnes CO_2e in 2030.

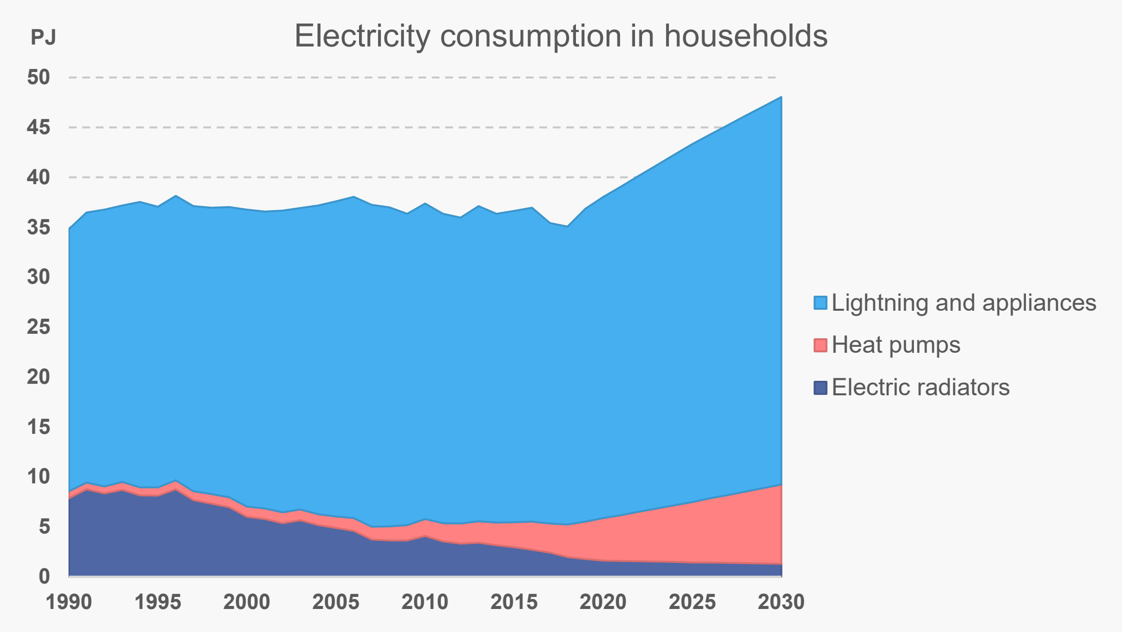
Note that any additional conversions away from mains gas will lead to a corresponding reduction in consumption of fossil natural gas, and therefore also in emissions, because the supply of bio natural gas is determined by subsidies for bio natural gas, and not by the demand for mains gas. A full phasing out oil and mains gas from individual heating would therefore lead to a reduction in total emissions of around 1.1 million tonnes CO_2e in 2030, corresponding to what sector emissions would be without including an effect of the bio natural gas.

Electricity consumption in households

Electricity consumption in households is used for lighting and appliances, as well as for heating with heat pumps and electric radiators.

Figure 3.3 shows that, after having been fairly constant since 1990, electricity consumption in households is expected to increase by approx. 30% from 2019 to 2030. Electricity consumption for electric radiators is expected to decline slightly, whereas electricity consumption for heat pumps and for lighting and appliances is expected to rise.

Figure 3.3: Electricity consumption in households broken down by energy service



Note: Historical values for energy consumption are stated as the actual figures.

The increase in electricity consumption for appliances is driven by a combination of expected increases in purchases and use of appliances on the one side, and efficiency improvements in new appliances on the other. The expected increase in purchases and use of appliances is due to expected economic growth and consequential increases in disposable household income. Appliances are expected to become more efficient because of minimum requirements for energy efficiency (ecodesign requirements) and stricter requirements for energy labelling.

Historically, efficiency improvements for appliances have been able to match increases in income and consequential increases purchases and use of appliances, so that the observed electricity consumption for appliances has been more or less stable. A continued increase in the number of electricity-based energy services in the home, particularly in connection with communication, IT and other new services, will lead to increasing electricity consumption. This increase in the number of services is no longer expected to be offset by the significant efficiency improvements of recent years, for example in cooling systems, washing machines, dishwashers, lighting, standby consumption and circulation pumps. This means that higher electricity consumption for appliances is likely, as shown in figure 3.3.

3.3 Uncertainty and sensitivity

With regard to the household sector, future developments in behaviour comprise significant uncertainty. Households are composed of many different actors with different preferences, and who do not always make rational decisions. Moreover, preferences change over time in ways which can be difficult to predict. Overall trends are the sum of many individual choices and are therefore exceedingly difficult to project.

According to the projection, a significant drop in household gas consumption is expected after 2019. The drop is primarily driven by conversion from gas-fired heating to heat pumps and district heating. If household gas consumption is reduced by 25% in 2030 compared to the projection, it will mean that emissions attributable to individual heating are reduced by 0.11 million tonnes CO_2e. Emissions for the overall system will be reduced by a total of 0.24 million tonnes CO_2e. However, if household gas consumption is instead *increased* by 25% in 2030, it will mean that emissions attributable to individual heating *increase* by 0.13 million tonnes CO_2e. Emissions for the whole system will increase by a total 0.24 million tonnes CO_2e. The amount of bio natural gas in the gas grid in 2030 is kept constant in this sensitivity calculation.

4 Transport

The transport sector includes both private and public passenger transport as well as transport of goods divided into the following five categories[20]:

- Road transport
- Rail transport
- Domestic aviation
- Domestic shipping
- Other transport (defence and leisure craft)

In 2019, the transport sector emitted 13.5 million tonnes CO_2e, corresponding to 29% of total Danish emissions. In 2030, the transport sector is expected to emit 11.5 million tonnes CO_2e, corresponding to 33% of total Danish emissions.

The expected developments in emissions are primarily attributable to the following factors in road transport, which is responsible for most of the emissions:

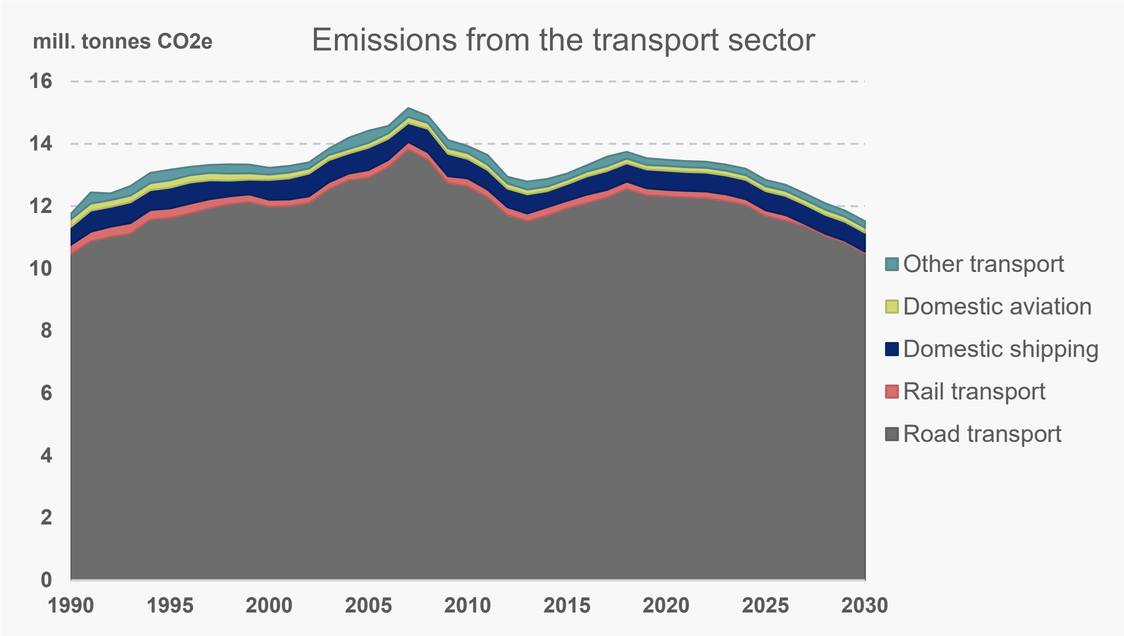
- Growing traffic (number of kilometres driven will increase)
- Beginning electrification of road transport, especially for passenger cars through transition from fossil fuels to electric vehicles
- More biofuel blending (and other renewable fuels) in petrol and diesel
- Energy-efficiency improvements in new conventional vehicles

[20] Emissions from international aviation and shipping are not included in the Danish climate accounts in accordance with the UN IPCC methodology, but they are described in Global Reporting 2021.

4.1 Transport-sector emissions

The transport sector is seeing increasing traffic because of increasing economic activity in society. Up to 2007, this led to a gradual increase in emissions from the transport sector. Lower economic activity in the period around the financial crisis in 2007-2009 caused emissions to fall until they once again rose from 2013-2018. This development is described in figure 4.1, which shows greenhouse gas emissions from the transport sector in the period 1990-2030, broken down by transport category. Total emissions are expected to be more or less stable up to 2023, followed by a drop, primarily as a result of developments in road transport. In contrast to historical trends, in future, a decoupling between economic activity and emissions is expected, as reduced emissions are expected despite economic growth and increased traffic.

Figure 4.1. Emissions from the transport sector broken down by transport category

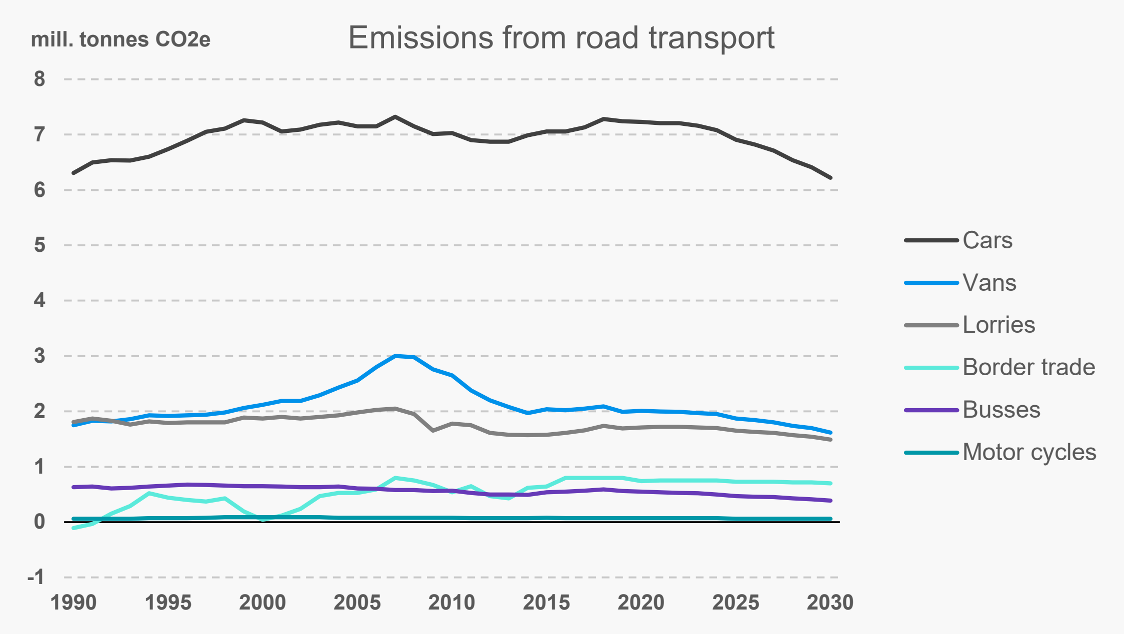


Emissions from road transport

In 2019, road transport emitted 12.3 million tonnes CO_2e, corresponding to approximately 90% of total emissions from the transport sector, and in 2030 emissions are expected to fall to around 10.5 million tonnes CO_2e.

As shown in figure 4.2, passenger cars contribute the most to road-transport emissions, followed by vans and lorries. Passenger cars account for around 60% of total road-transport emissions. In accordance with the UN IPCC methodology, emissions associated with cross-border trade in fuel are included in the country where the vehicle tanked up. Emissions from cross-border trade, i.e. the fuel tanked up in Denmark but consumed abroad are calculated separately in CSO21 and maintained at the 2019 level in the projection period. Note that this is an estimated level, as cross-border trade cannot be calculated exactly.

Figure 4.2. Emissions from road transport by vehicle



Traffic work is expected to continue to rise for all types of vehicle. From 2019-2030, overall traffic for road transport is expected to increase by approx. 21%. Despite this, from 2019 and up to 2030, a reduction in emissions of greenhouse gases from all vehicle types is expected. The expected decrease in emissions from road transport is primarily due to continued energy-efficiency improvements for conventional vehicles, increased biofuel blending in petrol and diesel, as well as more transition to alternative fuels, especially electric cars. Blending with biofuels and other renewable fuels is assessed to provide a direct CO_2 reduction in 2030 of about 1.2 million tonnes compared to a development with no blending. Similarly, replacement of conventional passenger cars with electric and plug-in hybrid cars is expected to reduce emissions by about 1.4 million tonnes CO_2.

Emissions from rail transport, domestic aviation and domestic shipping

In 2019 rail transport emitted 0.2 million tonnes of CO_2e. Up to 2030, a reduction is expected in emissions, as inter-city and regional trains, which are responsible for most of the emissions are electrified. In 2030, total emissions from rail transport are expected to be around 0.06 million tonnes CO_2e.

Emissions from domestic aviation are expected to increase from 0.15 million tonnes CO_2e in 2019 to 0.17 million tonnes CO_2e in 2030. Note that the projection does not consider the effects of COVID-19. The higher emissions from domestic aviation are due to an increase in jet-fuel consumption. Although there have been reports from the aviation industry about increased blending of renewable fuels up to 2030, this has not been included in the projection, as the reports are not binding and not considered to be cost-effective without further regulation of the area. Emissions from shipping are expected to drop slightly from 0.61 million tonnes CO_2e in 2020 to 0.60 million tonnes CO_2e in 2030 as a result of electrification of some ferry services.

4.2 Energy consumption by road transport

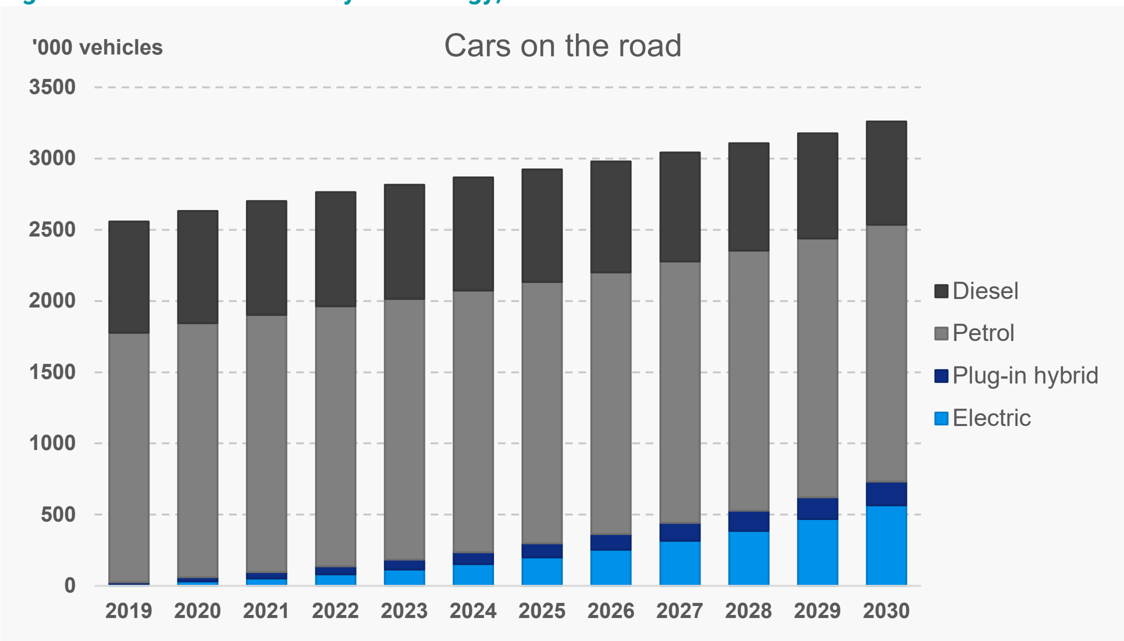
Emissions from transport come from energy consumption by the sector. As road transport accounts for by far the majority of the total transport emissions, this section is about developments in energy consumption by road transport, for which technological developments and the composition of fuels determine emissions.

Transition of vehicles in road transport

The EU CO_2 Regulation sets requirements for emissions from new cars, vans and lorries. The requirements will be tightened regularly up to 2030, and to avoid large fines, auto manufacturers are likely to accelerate production and sales of zero- and low-emission vehicles and improve fuel efficiency for new conventional vehicles. This will promote technological developments, reduce prices for zero- and low-emission vehicles, and increase the range of choice of these. Together with the expected deployment of public charging infrastructure, these factors mean that zero- and low-emission vehicles will meet the requirements and preferences of more consumers.

Sales of electric cars in particular are therefore likely to increase considerably, and by 2030 electric and plug-in hybrid cars are expected to amount to about 48% of all new car registrations. This trend is expected to increase the percentage of zero- and low-emission cars on the road to about 22% in 2030, corresponding to around 730,000 electric and plug-in hybrid cars, of which purely electric vehicles will amount to about 75%, as shown in figure 4.3. A beginning transition is also expected for vans, so that the number of electric cars and vans in 2030 will total around 800,000. See sector memorandum 4A for developments in the number of vehicles on the road for vans, busses and lorries, broken down by fuel technology.

Figure 4.3. Number of cars by technology, 2019-2030

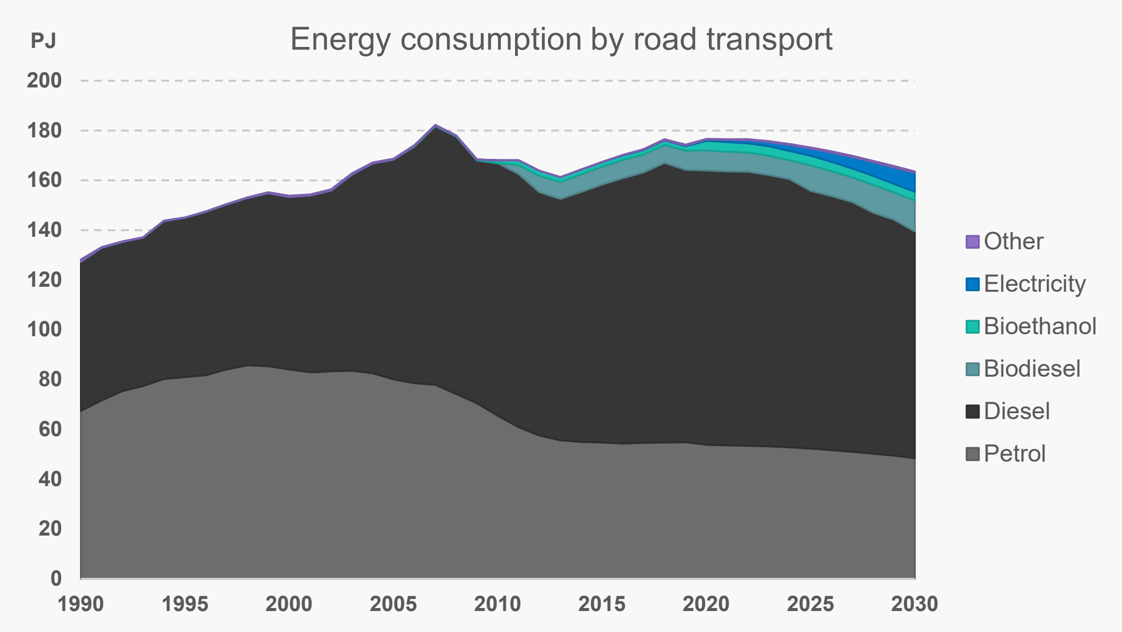


Although sales of the electric and plug-in hybrid cars are expected to increase, petrol and diesel cars are still expected to amount to around 78% of cars on the road in 2030. This is due to inertia in the transition because of the relatively long lifetime of vehicles.

Energy consumption and biofuel blending in road transport

Emissions from conventional vehicles are expected to fall because of energy efficiency improvements in new vehicles and more biofuel (and other renewable fuels) blending in petrol and diesel. Increased biofuel blending is a result of the upcoming Danish CO_2 displacement requirement [21]to be introduced from 2022, and which will be gradually tightened up to 2030. Trends in energy consumption by road transport by fuel since 1990 and up to 2030 are described in figure 4.4.

Figure 4.4. Energy consumption in road transport by energy product



Note: Other includes gas and hydrogen

Consumption of fossil fuels, in particular diesel, is expected to fall, while consumption of renewable energy is expected to increase up to 2030. Through blending in diesel and petrol, in 2030 biodiesel and bioethanol together are likely to cover about 10% of energy consumption by road transport, corresponding to approx. 16 PJ. Electricity consumption is expected to be at around 7.7 PJ in 2030 and will thereby account for about 5% of energy consumption by road transport. Note with regard to electricity consumption that electric cars are more energy efficient than fossil-powered cars, and therefore electricity covers a proportionately larger share of traffic than the share of energy consumption.

4.3 Uncertainty and sensitivity

The projection of energy consumption and emissions in the transport sector is associated with significant uncertainty. It is difficult to give an overall assessment of the uncertainty because the projection is based on a number of assumptions that may pull developments in opposite directions.

Road transport is responsible for by far the majority of emissions from the transport sector, and uncertainty associated with projecting road transport will therefore have the greatest significance for the overall picture. The most important factors in this

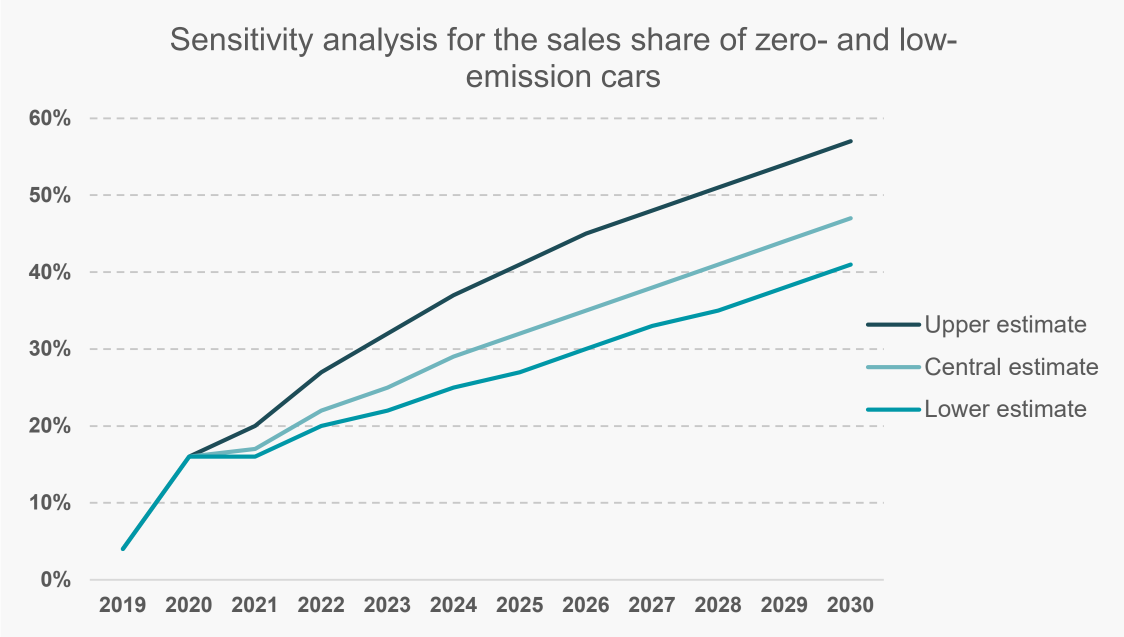
[21] The CO2 displacement requirement was adopted with the agreement on the green transition of road transport on 4 December 2020 and it requires reductions in cradle-to-grave emissions from fuels used by transport.

context are trends in traffic, the rate of transition to electrically powered vehicles as well as biofuel blending in petrol and diesel.

Traffic work is expected to increase for all types of vehicle and there is approximate proportionality between traffic and energy consumption and emissions, respectively. If traffic in 2030 is 10% lower or higher than assumed, energy consumption and corresponding emissions will fall or increase by 10%, respectively, corresponding to changes in emissions of around 1 million tonnes CO_2e.

In relation to the rate of transition of cars, zero- and low-emission cars are expected to amount to about 48% of new car registrations in 2030, corresponding to an accumulated number on the roads of around 730,000. This development is based on expected developments in technology, prices and supply of zero- and low-emission cars. If these factors develop either more or less favourably than assumed, the transition from fossil-powered cars to electric cars will be faster or slower than expected, respectively, and this will be reflected in emissions. Figure 4.5 shows an uncertainty range for sales of zero- and low-emission cars such that the number of zero- and low-emission cars will be within the interval 630,000-910,000 in 2030. This has been assessed to provide a change in emissions from road transport of -0.3 million tonnes CO_2 to +0.15 million tonnes of CO_2 compared to the central estimate in the projection. Similarly, considerable uncertainty is associated with the transition of vans, where the projection assumes a spill-over effect from technological developments for passenger cars.

Figure 4.5. Sensitivity analysis for the percentage of zero- and low-emission cars of total car sales, 2019-2030



In the calculation of the national emissions, biofuels contribute the same (per MJ) to the climate accounts, regardless of their cradle-to-grave emissions. Emissions are only from the fossil fuels displaced by biofuels. This means that the greater the volume of sustainable biofuels, the more the national emissions calculated will increase. This is because the lower the cradle-to-grave emissions of biofuels, the lower the volume of biofuels necessary to blend to meet the displacement requirement. And if less biofuel is blended, the percentage of fossil fuel will grow and so will emissions.

The uncertainty linked to biofuel blending in petrol and diesel will increase in line with tightening the CO_2 displacement requirement, see sector memorandum 7B. Uncertainty is assessed to be largest after 2025, when the existing standards E10 and B7 will no longer be sufficient to comply with the requirement. The projection assumes that the displacement requirement will mean that gradually more sustainable biofuels will be used up to 2030, when a direct CO_2 reduction of about 1.2 million tonnes will be achieved. If, instead, it is assumed that the use of biofuels with sustainability corresponding to the level in 2019 is used, a larger volume will have to be blended to meet the displacement requirement, and CO_2 reductions will increase by 0.1-0.15 million tonnes in 2030. The larger reduction in emissions included in the Danish climate accounts will, however, be at the cost of higher emissions in the production of biofuels.

Furthermore, there is considerable uncertainty linked to cross-border trade, and this trade affects the amount of fuel pumped into vehicles in Denmark and, thus, emissions of greenhouse gases that are included in the Danish climate accounts. For example, cross-border trade not only depends on Danish regulation but also on what happens outside Denmark with an impact on the price difference between petrol and diesel across borders.

5 Service sector

The service sector includes the private service sector, the public service sector and wholesale and retail. The private service sector covers a broad range of sectors, including restaurants, banks and data centres, while the public service sector includes day-care centres, schools, hospitals and public administration.

In 2019, the service sector emitted about 0.6 million tonnes CO_2e, corresponding to more than 1% of total Danish emissions. In 2030, the sector is expected to emit 0.2 million tonnes CO_2e, corresponding to less than 1% of total Danish emissions. By far the majority of the sector's energy consumption is electricity and district heating, while fossil emissions primarily come from natural gas used for individual heating, and developments in emissions are primarily due to the following factors:

- Phase-out of natural gas through conversion to heat pumps
- Increased share of bio natural gas in the grid, which lowers emissions from the remaining gas consumption

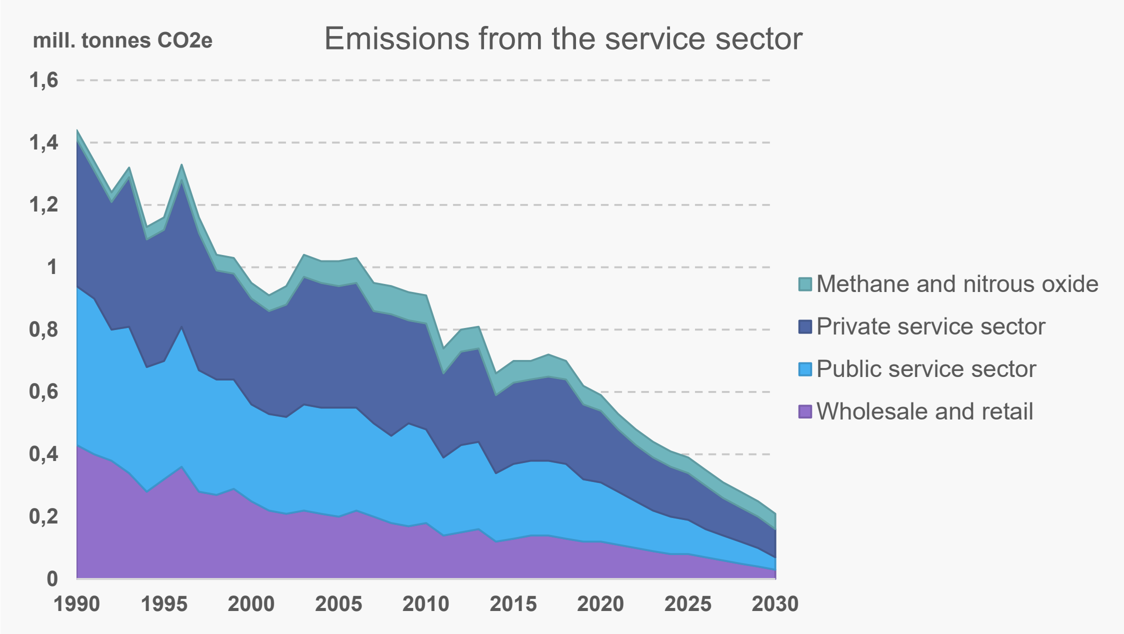
Deployment of data centres, which belong under the private service sector category, will lead to significant increases in electricity consumption by the service sector in 2030. However resource consumption and emissions associated with this are included in chapter 8 on the electricity and district heating sector, as also applies for other electricity and district heating consumption by the sector.

5.1 Service-sector emissions

The service sector consumes 12% of total final energy consumption, but it accounts for just 1% of total emissions. By far the majority of the sector's emissions come from fossil fuels used for space heating. Emissions from the sector are expected to fall to

0.2 million tonnes CO_2e in 2030, corresponding to a decrease of 85% compared to 1990. The decrease has been driven by phasing out oil and gas for space heating and increasing use of district heating, and up to 2030 it is expected to be driven by conversion from natural gas to primarily heat pumps. The remaining emissions in 2030 will come primarily from the remaining natural-gas-fired heating for space heating and from fossil energy consumption for medium-temperature process heat. Medium-temperature process heat is used at hospitals, laundries and in restaurants, among other things.

Figure 5.1: Service-sector emissions by sectors



Note: The category "methane and nitrous oxide" covers methane and nitrous oxide emissions linked to energy-related emissions in the service sectors, although they are not allocated to the private service sector, the public service sector and wholesale and retail, respectively.

Total emissions by the service sector are illustrated in figure 5.1. Emissions from this sector only include energy-related emissions,[22] with the largest emissions from the private service sector. Energy-related emissions include emissions from individual space heating, internal transport and process heat. The relatively low emissions should be seen in light of the fact that emissions derived from consumption of electricity and district heating are included in the calculation of emissions from the electricity and district heating sector presented in chapter 8.

Natural gas makes up the majority of fossil-energy consumption by the service sector. Gas consumption by the service sector was 9 PJ in 2019 and is expected to drop to 5 PJ in 2030. The reduction in gas consumption is primarily due to conversion from gas-fired to other types of heating (including in particular heat pumps). Emissions attributable to this will fall further as a consequence of the significant increase in the percentage of bio natural gas in mains gas. By converting from gas in heating, for

[22] In CSO21, F gases from cooling systems and air conditioning, etc., which are process emissions, are included in the emissions calculation in chapter 9 on waste and F gases, because it has not been possible to break emissions from F gases down by CSO21 sector.

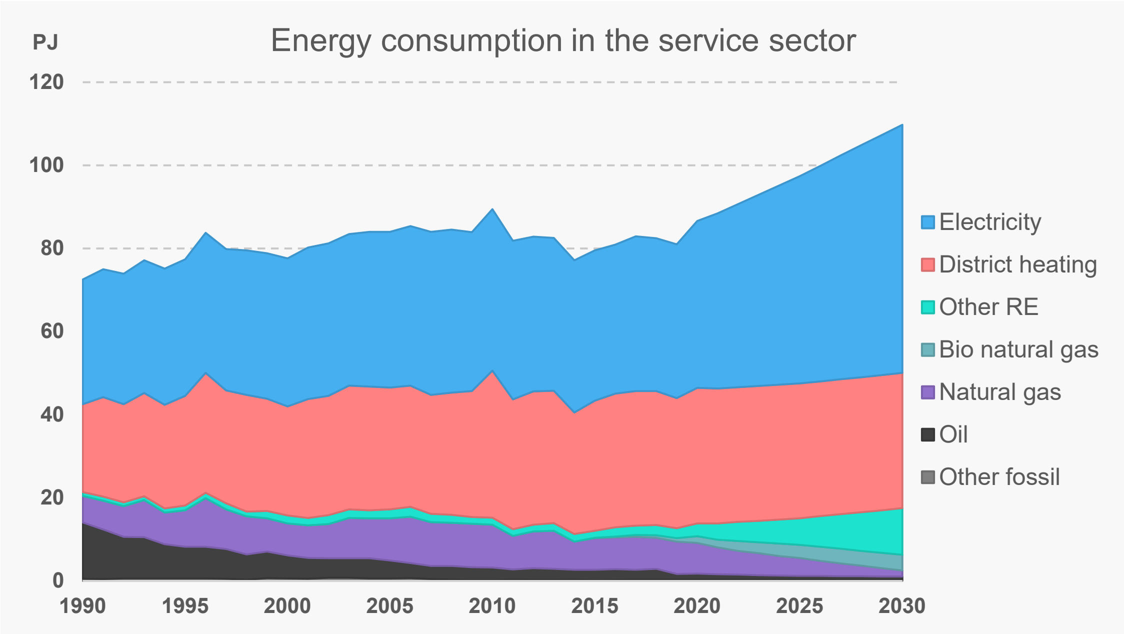
example, the percentage of bio natural gas in the remaining gas consumption will rise, and this will lead to further CO_2e reductions.

5.2 Energy consumption by the service sector

While emissions from the service sector are falling, the opposite applies for energy consumption, which is expected to increase by 51% from 1990 to 2030, see figure 5.2. The increase in energy consumption is mainly due to establishment of data centres. Today, less than 1 PJ of electricity is used in data centres in Denmark, but this is expected to increase to 10 PJ in 2025, and to more than 17 PJ in 2030. Even though data centres will be responsible for a considerable part of the electricity consumption by the sector, most of the electricity consumption is likely to continue to be for direct use in the rest of the sector. In the private service sector, besides data centres, electricity consumption is particularly within the restaurant sector, while schools, day-care centres and hospitals account for a substantial amount of electricity in the public service sector. Furthermore, increasing electricity consumption for heat pumps is expected.

In 2030, electricity is expected to account for 63% of the sector's final energy consumption. This means that the service sector will account for 37% of total final electricity consumption. However, not only electricity consumption for data centres will increase. The expected growth in the sector will also cause a general increase in energy consumption.

Figure 5.2: Energy consumption in the service sector by energy product

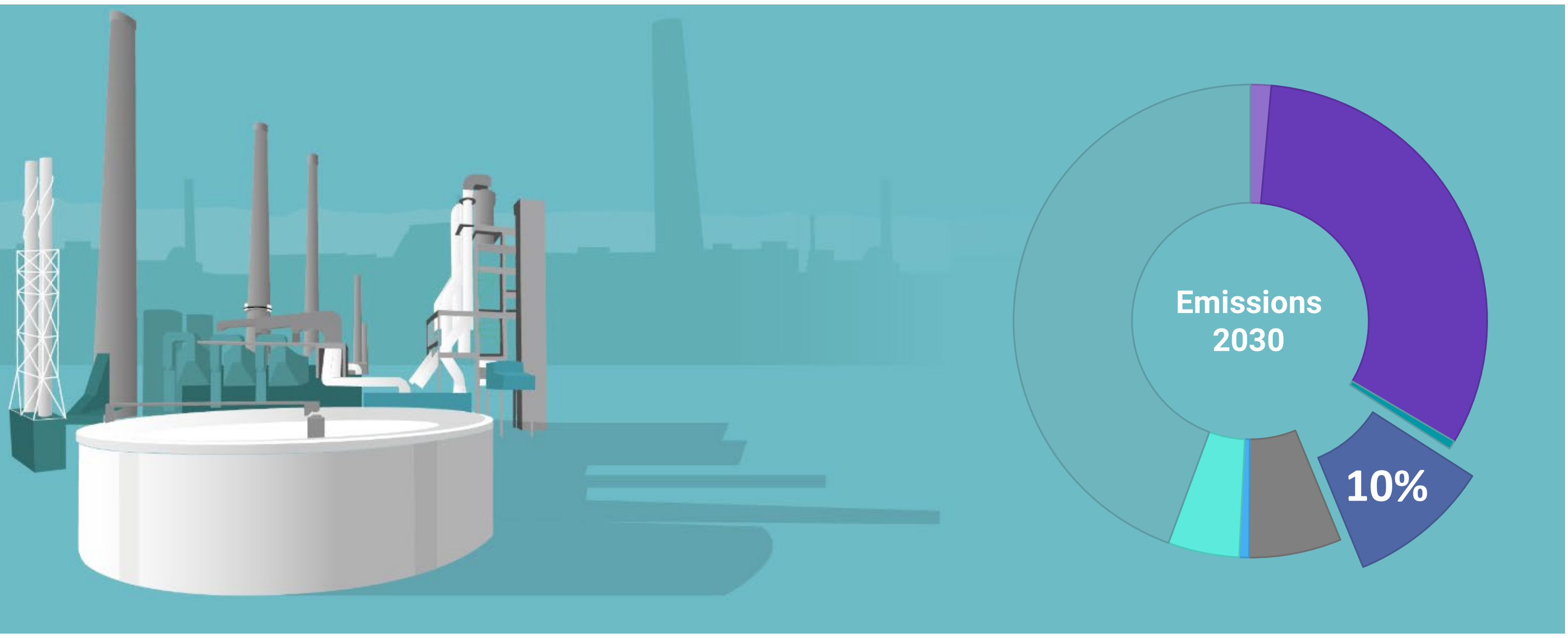


Energy consumption for retail and wholesale is expected to increase by 20% in 2030, while energy consumption for the public sector is likely to remain almost constant. As described, the increase in energy consumption for the private service sector is driven by the establishment of new data centres, but even without these, consumption is expected to increase by 13%.

5.3 Uncertainty and sensitivity

There is a particularly high uncertainty associated with the deployment of data centres within the service sector, as the data centre industry is undergoing rapid development. There is also great uncertainty about future technological developments and the impact of these on the electricity consumption and consumption profile of datacentres, and this is described in more detail in the memo on development of data centres and their impact on the energy system (*Udviklingen af datacentre og deres indvirkning på energisystemet*) drawn up by COWI A/S for the Danish Energy Agency (2021). Electricity consumption of 17 PJ is expected for data centres in 2030, but with a range of outcomes of between 12 and 22 PJ.

Emissions from the sector are relatively limited, but as part of the explanation for this is the increased share of bio natural gas in the mains gas grid, the changes in the sector's gas consumption will have derived impacts on the total emissions exceeding the impact on the sector's own emissions.



6 Manufacturing industries and the building and construction sector

Manufacturing industries include enterprises which produce goods sold to private individuals and other enterprises. These include food, textiles, furniture, electronic equipment, chemical and pharmaceutical products, as well as building materials and machinery. The building and construction sector includes businesses involved in all types of work within building and construction.

Manufacturing industries and the building and construction sector are referred to here together as industrial activities.

In 2019, these sectors emitted about 5 million tonnes CO_2e, corresponding to 11% of total Danish emissions. In 2030, the sectors are expected to emit 3.5 million tonnes CO_2e, corresponding to 10% of total Danish emissions. The expected changes in emissions from these sectors are due in particular to the following expectations regarding future energy consumption:

- More widespread electrification and higher energy efficiency, including more use of heat pumps for internal exploitation of surplus heat
- Larger percentage of biogas in mains gas

6.1 Emissions from industrial activities

Emissions from industrial activities can be either energy-related or process-related. Energy-related emissions are emissions resulting from using fossil fuels for production processes, including process heat and internal transport. Process-related emissions are emissions associated with chemical production processes. Emissions from consumption of electricity and district heating as well as from refining are not dealt with in this chapter, as they are included in the calculation of emissions from the electricity and district heating sector (see chapter 8) and the calculation of emissions from the production of oil, gas and renewable fuels (see chapter 7).

With regard to energy-related emissions, the manufacturing industries sector has relatively large emissions linked to a number of production processes which require high temperatures achieved via direct feed of primarily fossil fuels. For example, this applies in production of cement, tiles, quicklime, and stone and glass wool. Because of the need for high temperatures, these production processes often cannot be electrified with existing technologies and emissions linked to them are therefore difficult to reduce through electrification.

Furthermore, there are process emissions that are independent of the fuel used and that occur as the product of a chemical process. The largest source of process emissions is manufacturing processes in which clay, chalk and limestone are included as a raw material, for example in cement and tile.

The building and construction sector uses considerably less energy and emits less CO_2 per unit produced than the manufacturing sector. Most of the energy consumption and emissions in the building and construction sector are related to internal transport, e.g. construction machines.

Figure 6.1 shows the historical and projected CO_2e emissions for industrial activities, broken down by manufacturing industries and the building and construction sector and broken down by whether they are energy-related or process-related. Total emissions from 1990 to 2019 have fallen by 3.1 million tonnes CO_2e, corresponding to 38% for the entire period. Up to 2030, emissions from industrial activities are expected to fall by a further 1.5 million tonnes CO_2e.

Figure 6.1: Emissions from manufacturing industries and building and construction, broken down by energy-related emissions and process emissions

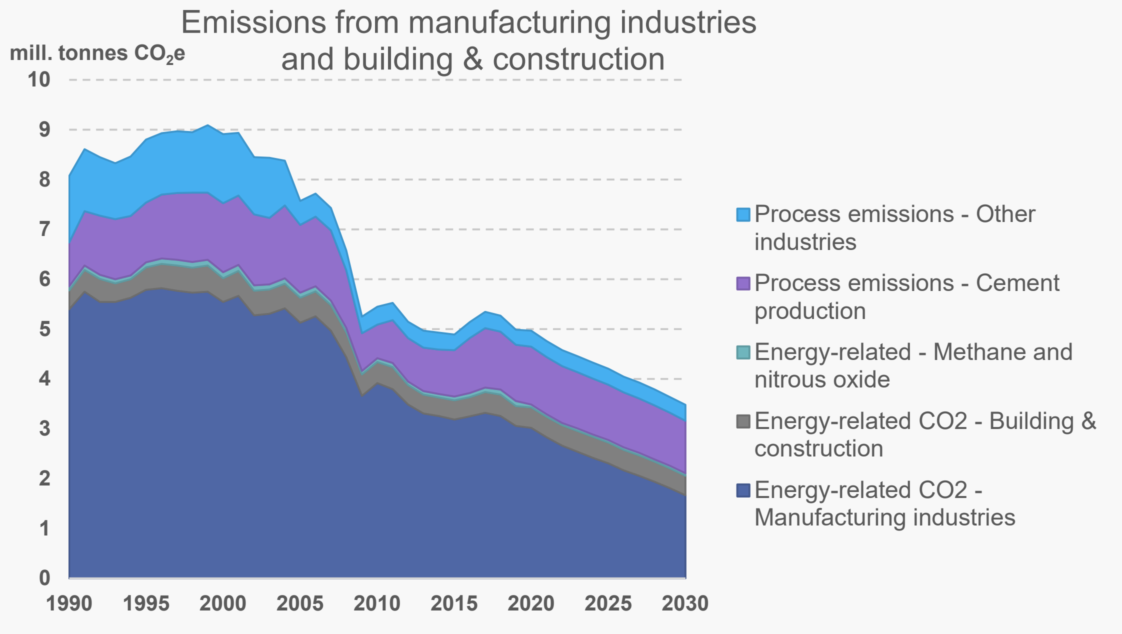


Figure 6.1 also shows that emissions have primarily fallen in manufacturing industries since 1990, and this is also where the largest relative contributions are expected up to 2030. Nevertheless, emissions from other sectors are also expected to follow a downward trend, albeit limited because within certain areas it is likely to be difficult to electrify or convert to renewable energy, either because this is not possible with existing technology, or because it is not financially attractive under current conditions.

Energy-related emissions from manufacturing industries can be further divided into the cement, glass and tile manufacturing industries, as well as other manufacturing industries. About 71% of the expected reductions from manufacturing industries for the next 10 years are expected to be in “other manufacturing industries”, while approx. 28% of reductions are expected to be in cement, glass and tile manufacturing industries.

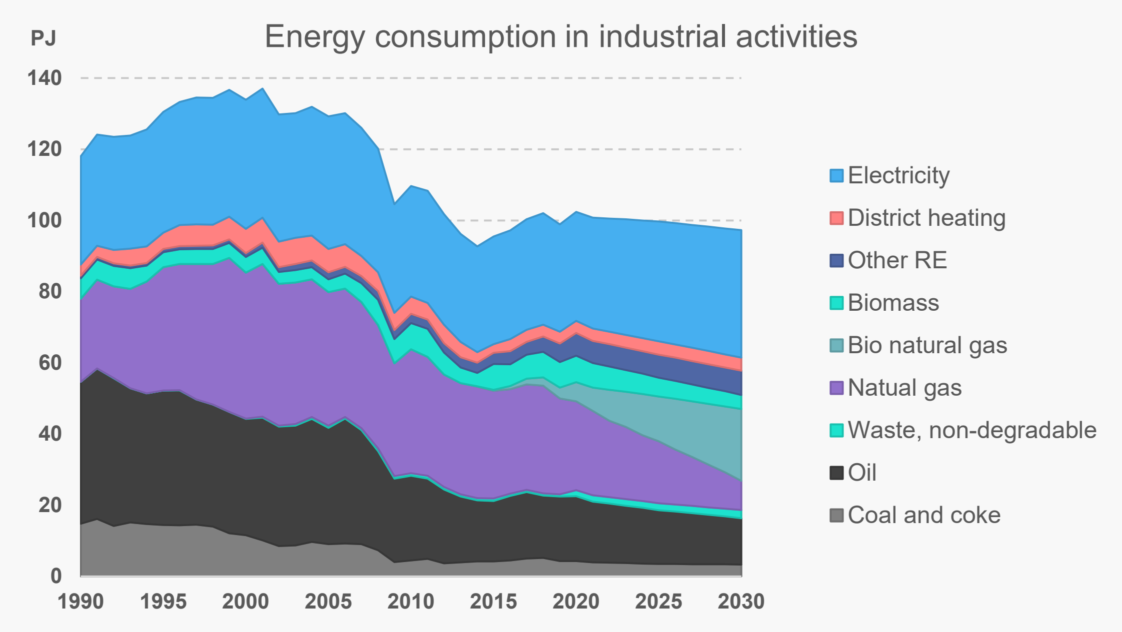
6.2 Energy consumption by industrial activities

Figure 6.2 shows that total energy consumption by industrial activities fell from 118 PJ in 1990 to 99 PJ in 2019, corresponding to a decrease of 16.2%. Up to 2030, a further drop is expected in energy consumption by industrial activities, although significantly less than seen hitherto. The drop in both periods can be explained by energy-efficiency improvements and, with respect to the historical trend, structural shifts towards less energy-intensive industries.

Moreover, figure 6.2 shows that up to 2030 there will be a higher than previously anticipated shift in the composition of energy, in which fossil fuels are displaced by renewable energy and electricity. In 2030, the expected amount of renewable energy in industrial activities is expected to exceed the amount of fossil energy. The drop in use of fossil fuels primarily reflects an expected considerable increase in the share of bio natural gas in mains gas, and an increase in the use of waste (including biodegradable waste), which will displace coal and pet coke in cement production.

Use of bio natural gas by industrial activities depends on the total consumption of mains gas, which comprises natural gas and bio natural gas. Conversions away from mains gas will lead to a corresponding reduction in consumption of fossil natural gas, and therefore also in emissions, because the supply of bio natural gas is determined by subsidies for bio natural gas, and not by the demand for mains gas.

Figure 6.2: Final energy consumption in industrial activities by energy product

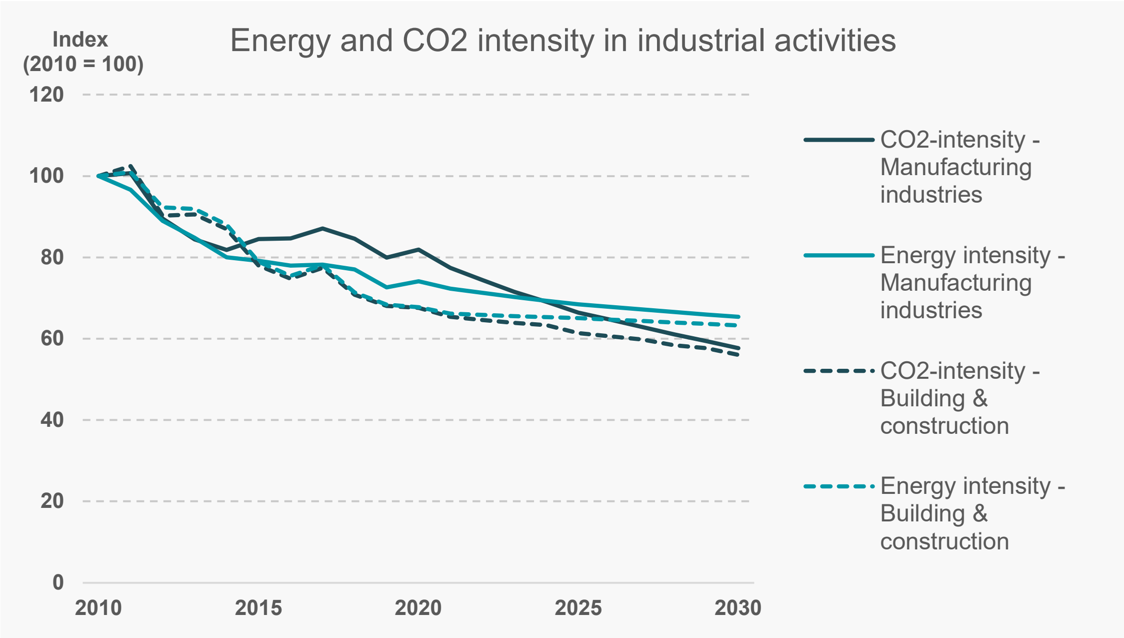


Note: Mains gas is divided into natural gas and bio natural gas on the basis of the overall percentage of bio natural gas in the system.

The CO_2 intensity of the business sector is a key indicator for CO_2 emissions per economic unit produced. The CO_2 intensity will be lower if industry becomes more efficient or replaces fossil fuels with renewables. Structural shifts in the business sector can also affect CO_2 intensity.

Both CO_2 intensities and energy intensities in industrial activities have been decreasing since 2010, and this trend is expected to continue up to 2030, although for energy intensities only slightly. CO_2 intensity falls faster than energy intensity because CO_2 reductions primarily take place as a result of changes in fuels away from fossil fuels and towards increased electrification and increased volumes of biogas in mains gas.

Figure 6.3: Energy intensity and CO_2 intensity in industrial activities



Furthermore, in future, increased internal exploitation of surplus heat is expected in manufacturing industries due to the use of heat pumps. Surplus heat is expected to be used for both space heating and medium-temperature process heat, and it replaces a large amount of mains gas and to a lesser extent solid fuels, and thereby exploitation of surplus heat helps to reduce CO_2e emissions from industrial activities.

6.3 Uncertainty and sensitivity

Uncertainty in emissions from industrial activities is associated with activity levels for both manufacturing industries and the building and construction sector. For the cement, glass and tile industries there are also uncertainties associated with fuel consumption in production and the finished cement product.

The sector memorandum for industrial activities describes how the sector's total emissions will vary as a consequence of the variations in the central assumptions for emissions in connection with cement production compared to the basic scenario. Variations in the most important parameters are presented in memorandum on assumptions 7D Cement production. These variations relate to the share of alternative fuels, average shares of cement clinker in the finished cement product, as well as any changes in activity levels compared to the basic scenario. The variations are presented as a sensitivity analysis in the sector memorandum for industrial activities. The sensitivity analysis shows a range in emissions from 0.3 million tonnes CO_2e lower to 0.4 million tonnes CO_2e higher in 2030 compared to the basic scenario, corresponding to -10% and +13%, respectively, of total emissions from manufacturing industries in 2030.

In connection with CSO21, no possible structural and activity-related changes as a consequence of the Covid-19 pandemic have been assessed.

7 Production of oil, gas and renewable fuels

Production of oil, gas and renewable fuels includes oil and gas extraction from the North Sea, refining, biogas production, Power-to-X (PtX) and biofuel production. In 2019, production of oil, gas and renewable fuels emitted about 2.4 million tonnes CO_2e, corresponding to 5.1% of total Danish emissions. In 2030, the sector is expected to emit 2.3 million tonnes CO_2e, corresponding to 6.5% of total Danish emissions. Production of renewable fuels gives rise to a reduction in emissions from other sectors, to the extent that the products displace fossil fuels in these sectors. With regard to biogas, all the production is used in Denmark and it displaces fossil fuels, thereby contributing to CO_2e reductions. On the other hand, oil, gas, biofuels and PtX products are traded with other countries, and therefore production of these is not directly linked to Danish consumption.

The expected changes in sector emissions are due in particular to the following factors:

- Ageing oil and gas fields in the North Sea
- Biogas deployment
- Deployment of PtX in the form of electrolysis capacity

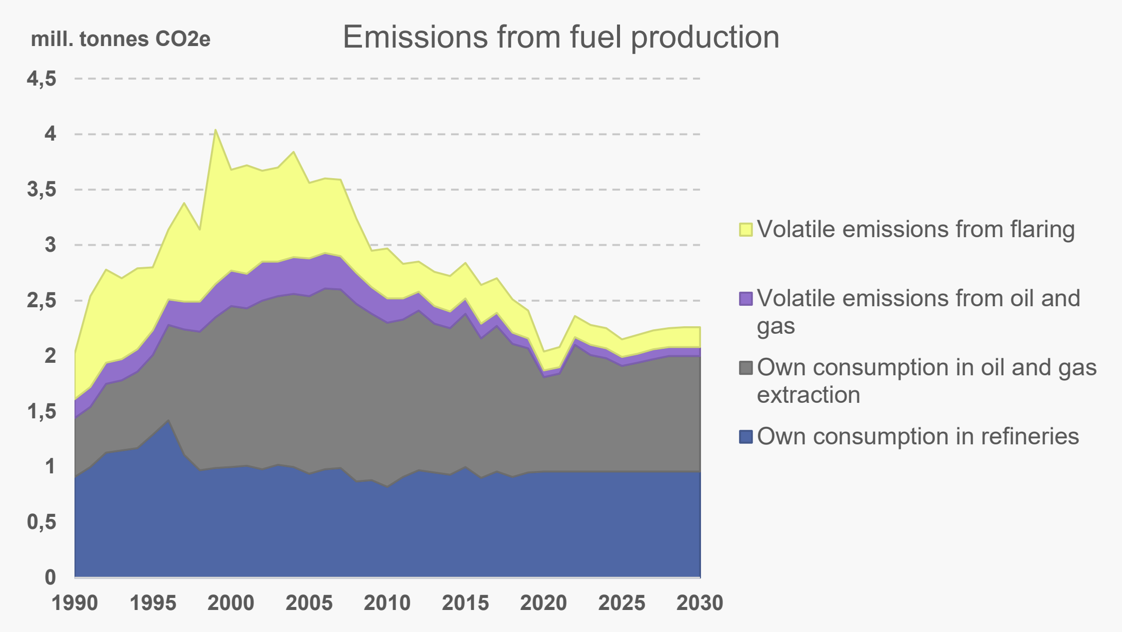
7.1 Fuel-production emissions and development

The primary reason for emissions from the production of oil, gas and renewable fuels is own consumption of fossil fuels on extraction platforms in the North Sea and at refineries. A small part of the emissions is due to flaring, i.e. burning gas that, for safety or technical reasons, cannot be recovered on extraction platforms in the North Sea or at refineries. Finally, fuel production is the reason for volatile emissions such as evaporation, emissions from leaks, etc. which account for a very small part of the sector's total emissions. Emissions associated with leakage from biogas production are included with emissions from the waste sector.

Total emissions by the sector for the period 1990-2030 are illustrated in figure 7.1. There are falling emissions through the 2000s, in particular because of falling emissions from flaring, while emissions in the projection period from 2020 to 2030 are expected to remain almost constant.

Consumption of fossil fuels at refineries and drilling rigs constitutes the majority of emissions and is expected to amount to around 90% of emissions from the sector by 2030. The reduction in emissions from 2020-2021 is because of retrofitting the Tyra field, which put the field out of service. The Tyra field is expected to be in full operation again from 2023.

Figure 7.1: Emissions from fuel production broken down by own consumption and volatile emissions

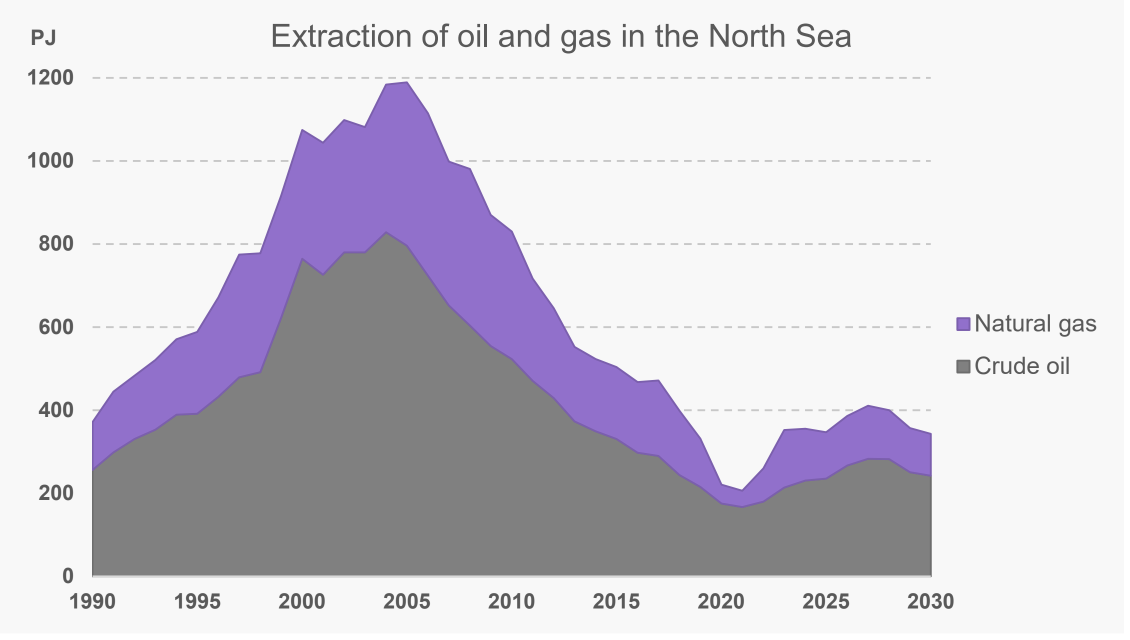


Oil and gas extraction in the North Sea

The amount of emissions in the sector is closely linked to changes in production of oil and gas. Figure 7.2 shows developments in the extraction of crude oil and natural gas from 1990 to 2030. Extraction of oil and gas from the North Sea was about 370 PJ in 1990 and increased in the following years to approximately 1,190 PJ by the mid-2000s, since when the trend has been downward. Expected extraction of oil and gas from the North Sea in 2030 is around 340 PJ. Extraction is expected to increase slightly from 2023 to 2028, and then to fall due to the ageing fields and falling extraction potential. Despite the increasing production, emissions are expected to drop after 2023, in part because the retrofitted plant on the Tyra field is expected to be more efficient, and this will reduce flaring and own consumption of gas per unit produced. Together, this means that, even though extraction is expected to rise, emissions are expected to remain almost unchanged up to 2030.

The projection of the extraction of oil and gas from the North Sea and the associated own consumption and flaring have been adjusted for the direct effect of the agreement on the future for gas extraction in the North Sea (*Aftale om fremtiden for olie- og gasindvinding i Nordsøen*) (Government et al., 2020). The direct effects of the agreement on oil and gas production only concern potentials in relation to exploration and technology, and thus have no effect on extraction from the existing fields other than the technological development. Any indirect, negative effects of the agreement, such as changes in willingness to invest in the Danish part of the North Sea, including investments in existing fields, are not reflected in the projection. These are expected to be reflected in the next oil and gas forecast by the Danish Energy Agency for 2021, and thereby also in CSO22.

Figure 7.2. Oil and gas extraction in the North Sea by energy product



Refining

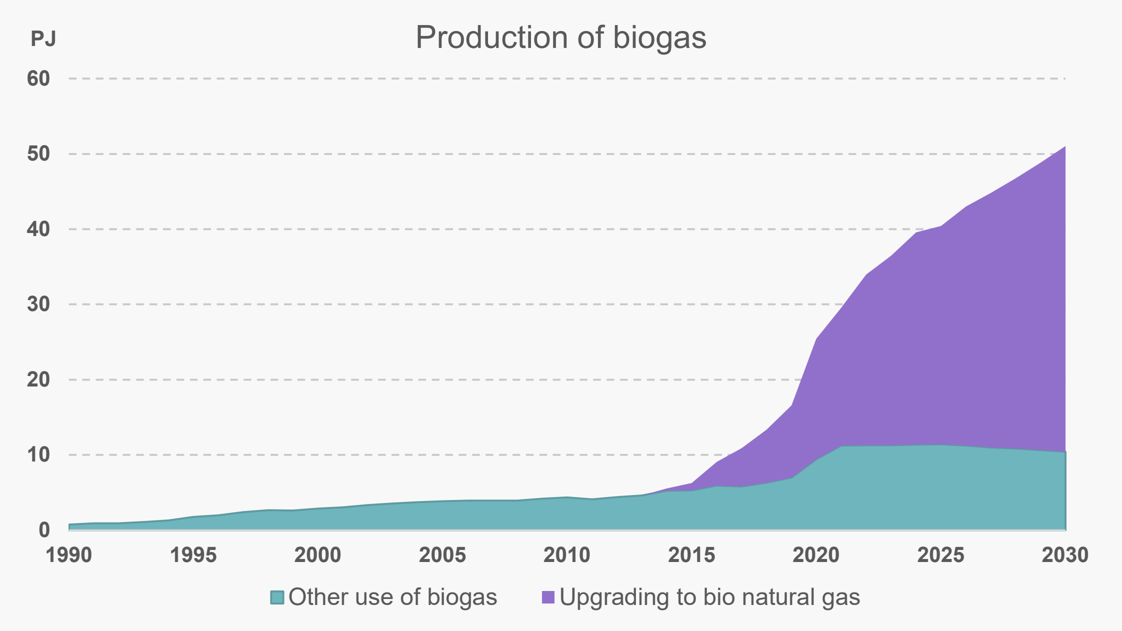
Refineries are expected to maintain a constant level of activity up to 2030, and thus expected emissions associated with refining are also likely to be constant in the period, as shown in figure 7.1.

Production of biogas, PtX and biofuels

Biogas is produced at a number of different installations in Denmark, of which the majority are agricultural installations. Production of biogas is illustrated in figure 7.3 for the period 1990 to 2030. Production of upgraded biogas in particular grew significantly over the 2010s. Gradually increasing biogas production is expected in the years up to 2030, so that, in 2030, production of biogas will be 50 PJ. The majority of the biogas produced is expected to be upgraded to bio natural gas and included in mains gas, while a smaller percentage is expected to be used directly for electricity and heat production.

It is expected that the increase in upgraded biogas in mains gas will displace fossil natural gas, as biogas production for upgrading is subsidised. Therefore, the increased production of upgraded biogas is not a result of increased demand for upgraded biogas, but rather it is driven by subsidy schemes for biogas production. Changes in demand for mains gas will therefore impact fully in the part of mains gas consumption that remains fossil natural gas and thus change the renewable share of mains gas.

Figure 7.3. Production of biogas by use



In CSO21, PtX is only included in the form of electrolysis capacity to produce green hydrogen. Any further conversions to other e-fuels such as ammonia and methanol are not included in CSO21. On the basis of the assumed deployment of electrolysis capacity to 132 MW from 2024 and onwards (see memorandum on assumptions 7B on PtX) hydrogen production is expected to be around 1.2 PJ in 2030 against almost non-existent production of green hydrogen in 2019. Electricity consumption for electrolysis is expected to fall to approximately 1.8 PJ in 2030.

Biofuels are also produced in Denmark. Emissions associated with this production are included in the climate accounts of other sectors, and there is no data basis to identify those explicitly in CSO21.

7.2 Uncertainty and sensitivity

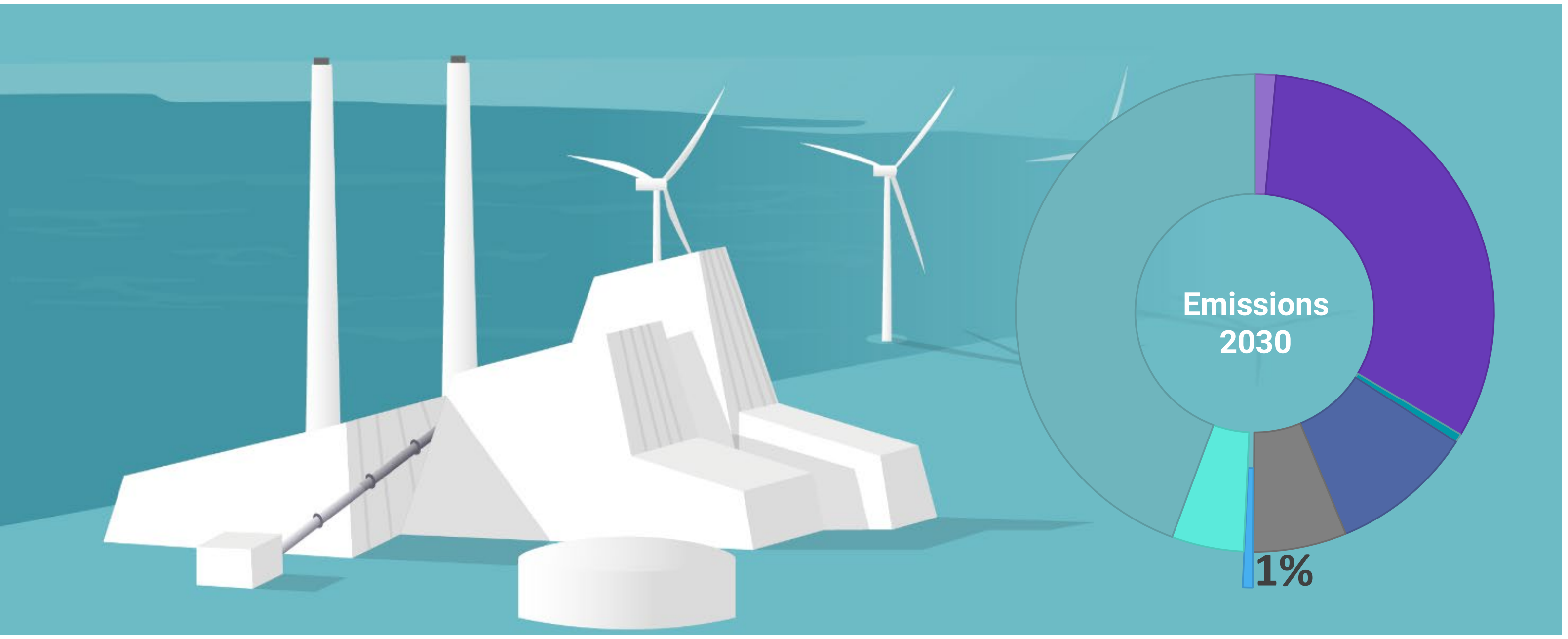
Uncertainty regarding expected oil and gas extraction is described in the Danish Energy Agency's production forecast for oil and gas. Uncertainty is particularly associated with the projection of the technological resources and exploration resources, and this uncertainty increases up to 2030. Furthermore, there is uncertainty about any negative indirect effects attached to the agreement on the future for oil and gas extraction in the North Sea (*Aftale om fremtiden for olie- og gasindvinding i Nordsøen*) (Government et al., 2020), for example, changes in willingness to invest, although the effect of these is likely to be limited in the period up to 2030.

Emissions from refineries are conditional on the assumption of unchanged activity, and decisions on the future activity of the two large refineries may prove to deviate from the assumption incorporated in CSO21.

With regard to biogas, there are significant uncertainties in the projection of developments in biogas production, because the design of the upcoming tendering procedures for new biogas and other green gases has not yet been established. There are also uncertainties regarding the production scope of the non-open subsidy scheme. An increase in biogas production of 5 PJ of upgraded biogas in 2030 means a reduction in the total national emissions of 0.3 million tonnes CO_2e, and vice versa.[23]

With respect to PtX, electrolysis capacity is associated with uncertainty, both in terms of size and the rate of deployment. Tendering procedures for PtX are assumed to give rise to 100 MW electrolysis. If, instead, it is assumed that a tendering procedure for PtX will give rise to 300 MW electrolysis, the projection shows that hydrogen production will be 2.9 PJ in 2030, and electricity consumption for electrolysis will be 4.5 PJ. Changes in electrolysis capacity have no influence on national emissions, as sales of the hydrogen produced for transport or industrial purposes, for example, have not been incorporated in CSO21. This is because there are no statutory requirements to use PtX fuels or great market demand in a frozen-policy scenario. This means that it has implicitly been assumed in CSO21 that the hydrogen generated will either displace other renewable energy in Denmark, or be incorporated in products sold abroad.

[23] Only the direct effect on CO2e has been included, while the effect of methane and nitrous oxide in agricultural emissions has not been included.



8 Electricity and district heating

The electricity and district heating sector includes the majority of installations that supply Danish society with electricity and district heating, although not waste incineration plants, which are dealt with separately in chapter 9[24]. The sector includes CHP units that supply both electricity and district heating, wind turbines and photovoltaic modules that generate electricity, as well as boilers, solar heating and heat pumps that supply district heating.

In 2019, the electricity and district heating sector emitted about 4.9 million tonnes CO_2e, corresponding to 11% of total Danish emissions. In 2030, the sector is expected to emit 0.2 million tonnes CO_2e, corresponding to 0.7% of total Danish emissions. The expected changes in sector emissions are due in particular to the following factors:

- phase-out of the last coal-fired CHP plants,
- continued deployment of wind power and photovoltaic modules,
- significant further deployment of heat pumps to produce district heating, and
- reduction in CHP based on natural gas.

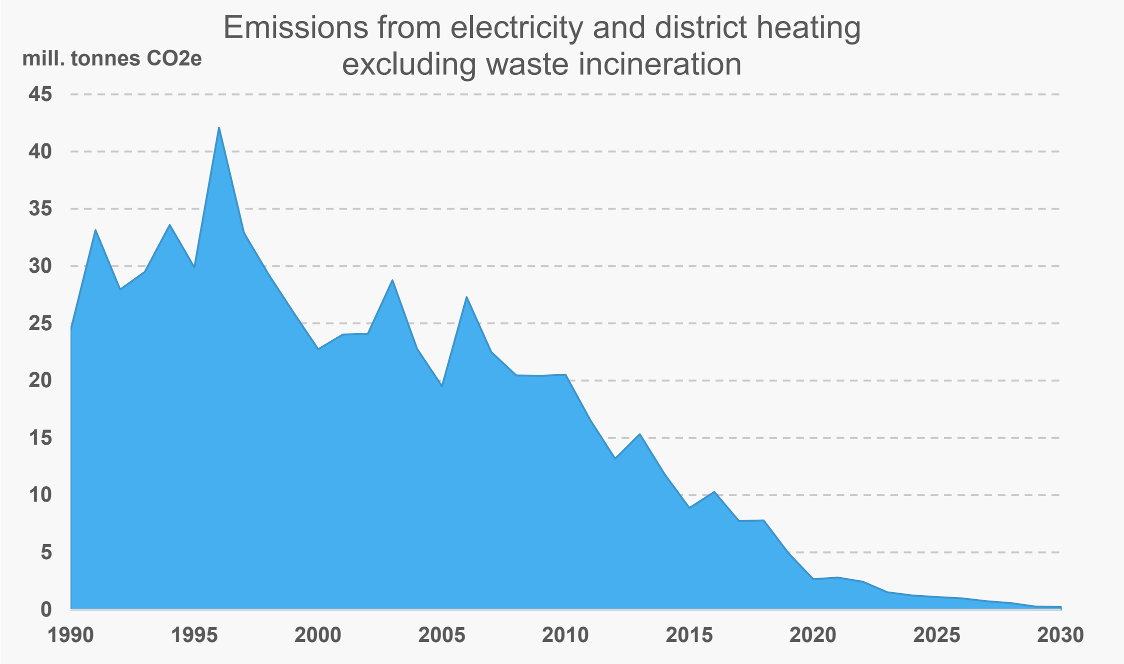
8.1 Emissions from the electricity and district heating sector

Total emissions by the electricity and district heating sector for the period 1990-2030 are illustrated in figure 8.1 below. Emissions from the sector only include energy-

[24] Waste incineration plants also supply electricity and district heating, but in CSO21 they are dealt with as part of the waste sector in chapter 9. Furthermore, there are a number of autoproducers, who also contribute to electricity and district heating production. Autoproducers are producers whose primary product is not energy. In CSO21, energy consumption and associated greenhouse gas emissions from autoproducers are stated under the sectors that the producers belong to.

related emissions (CRF-1) derived from the combustion of fossil fuels such as coal, oil and natural gas.

Figure 8.1: Developments in greenhouse gas emissions from the electricity and district heating sector, excluding waste incineration in the period 1990 – 2030 (million tonnes CO_2e).



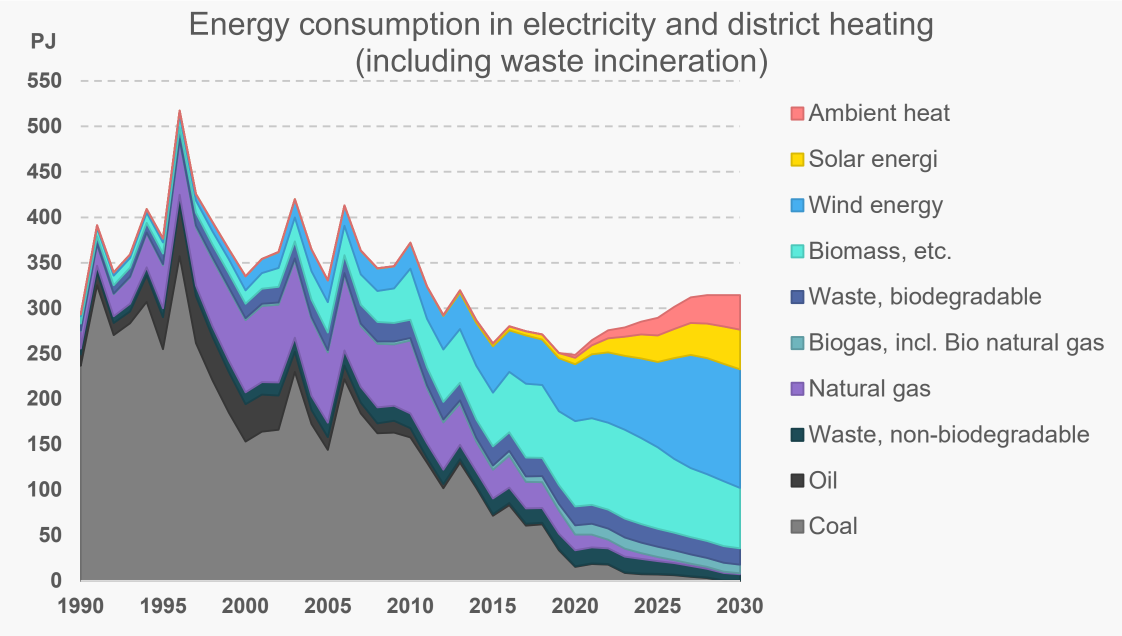
As figure 8.1 shows, from 1990 to today the electricity and district heating sector moved from having large greenhouse gas emissions to having a significantly weaker climate footprint. This trend is expected to continue over the projection period up to 2030, and emissions from the sector are expected to be 0.2 million tonnes CO_2e in 2030, corresponding to a reduction of 99% compared to 1990.

8.2 Energy consumption by the electricity and district heating sector

In the period from 1990 to 2010, the electricity and district heating sector accounted for about one-third of total emissions of greenhouse gases. This means that, although in 1990 the sector was an important part of the climate challenge, in the future it will very much be part of the solution, as the electricity and district heating produced on the basis of renewable energy is expected to play an important role in reducing the climate impact of other sectors. This could be through electrification of transport, heating and industrial processes, and through conversion to district heating of buildings previously heated by natural gas. For the same reason, electricity consumption is expected to increase significantly in the projection period up to 2030.

The continuing decrease in emissions from the electricity and district heating sector is thus not because of falling activity in the sector, but rather it is due to a fundamental restructuring of the way in which electricity and district heating are produced. As shown in figure 8.2 below, developments in the electricity and district heating sector are characterised by an almost full transition to renewable energy, and this is primarily a result of phasing-out coal-fired cogeneration at large-scale plants, conversion to biomass, and continued deployment of onshore and offshore wind power and photovoltaic modules.

Figure 8.2: Energy consumption in the electricity and district heating sector, by type of energy[25] (PJ).



Consumption of fossil fuels for electricity and district heating production is expected to fall by 89% in 2030 compared to 2019. Growing contributions to district heating production from heat pumps and surplus heat from the corporate sector are expected to reduce the sector's burning of biomass in the period up to 2030 by around 18% compared to consumption in 2019.

The projection shows that the electricity and district heating sector will only have a marginal effect on Danish greenhouse gas emissions by 2030. Danish electricity production in 2030 will primarily be based on solar and wind energy, and the remaining thermal share of electricity production will primarily be based on biomass. Fossil fuels will therefore only be for peak periods and as a reserve.

From a climate perspective, it is therefore expected that Danish electricity supply can promote the green transition, as renewables-based electricity can supply other sectors and thus contribute to reducing their respective emissions, either directly or indirectly through electrification, for example in the manufacture of synthetic green fuels (Power-to-X). However, this requires that increasing electricity consumption is accompanied by continued deployment of more renewable energy.

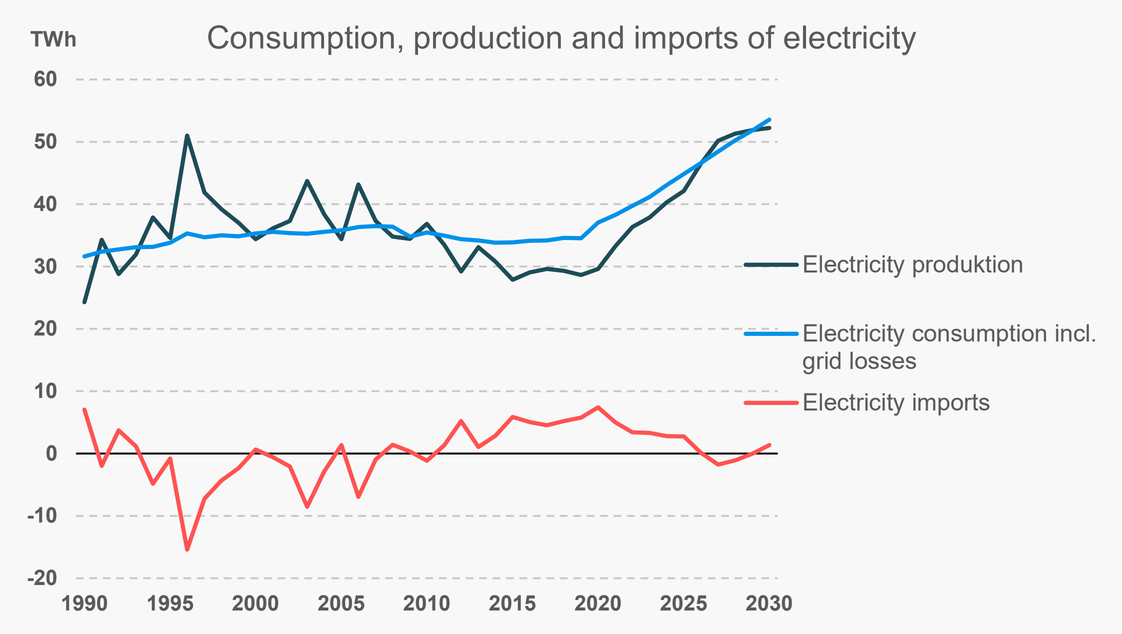
8.3 Electricity balance

The Danish electricity system is strongly integrated into the northern European electricity market, and historically the balance between domestic electricity production and electricity imports has fluctuated considerably, depending on conditions on the

[25] Although waste incineration is not included in the calculation of greenhouse gas emissions from the electricity and district heating sector, waste incineration is included in the calculation of energy consumption by the sector, because waste incineration plays an important role in the district heating sector.

market, and these are affected by weather conditions such as precipitation, temperature and wind.

Figure 8.3: Electricity consumption, including transmission and distribution losses, electricity production and electricity imports.



Under the assumptions made, including assumptions about energy islands[26], domestic electricity consumption is expected to exceed domestic electricity production at the end of the projection period, following a period of net exports.

The results are associated with significant uncertainty linked to several factors, both on the production side, e.g. on the launch of future offshore wind farms and solar PV projects, and with respect to demand, including developments in electricity consumption by large data centres. Given meteorological fluctuations, it is likely that there will be years with net electricity exports, and years with the net electricity imports in the future too, but these fluctuations will affect emissions less and less.

The energy islands are expected to influence the Danish electricity balance considerably. When the energy islands have been realised, Denmark will have a large surplus of green electricity to exploit in electrification of other sectors or to export to countries neighbouring Denmark, and it is expected this will displace fossil-based electricity production with a consequential positive climate impact[27].

8.4 Uncertainty and sensitivity

Because of the very high share of renewables in electricity and district heating production, the uncertainty in the projection pertains to a lesser extent to future greenhouse gas emissions and to a higher extent to the scope and pace at which the sector will be able to contribute to the transition in other sectors.

[26] The energy islands are not included in the CSO21 basic scenario, as described in memorandum on assumptions 4B. Offshore wind

[27] The climate impacts of the energy islands in countries neighbouring Denmark are illustrated in more detail in section 3.4 in the Global Report.

Historically, variations in precipitation, temperature and winds have affected emissions from the electricity and district heating sector significantly, with variations of +/- 5 million tonnes CO_2e. In line with the transition to renewable energy, sector emissions are expected to be less affected by meteorological fluctuations, with variations in the range of 0.1-0.2 million tonnes of CO_2e in 2030.

The most important uncertainties for the sector are with respect to framework conditions. The framework conditions include fuel and CO_2-allowance prices, developments in electricity consumption, planning aspects regarding national deployment of offshore installations, onshore installations and photovoltaic modules, as well as changes in the composition of electricity production capacity abroad. Furthermore, there is uncertainty about future investments in the district heating sector, among other things due to uncertainty concerning price developments for heat pumps and how these influence investment decisions.

Sector memorandum 8A on the electricity and district heating sector includes more sensitivity analyses. The section below only describes how the projection could be affected if the energy islands are established by 2030.

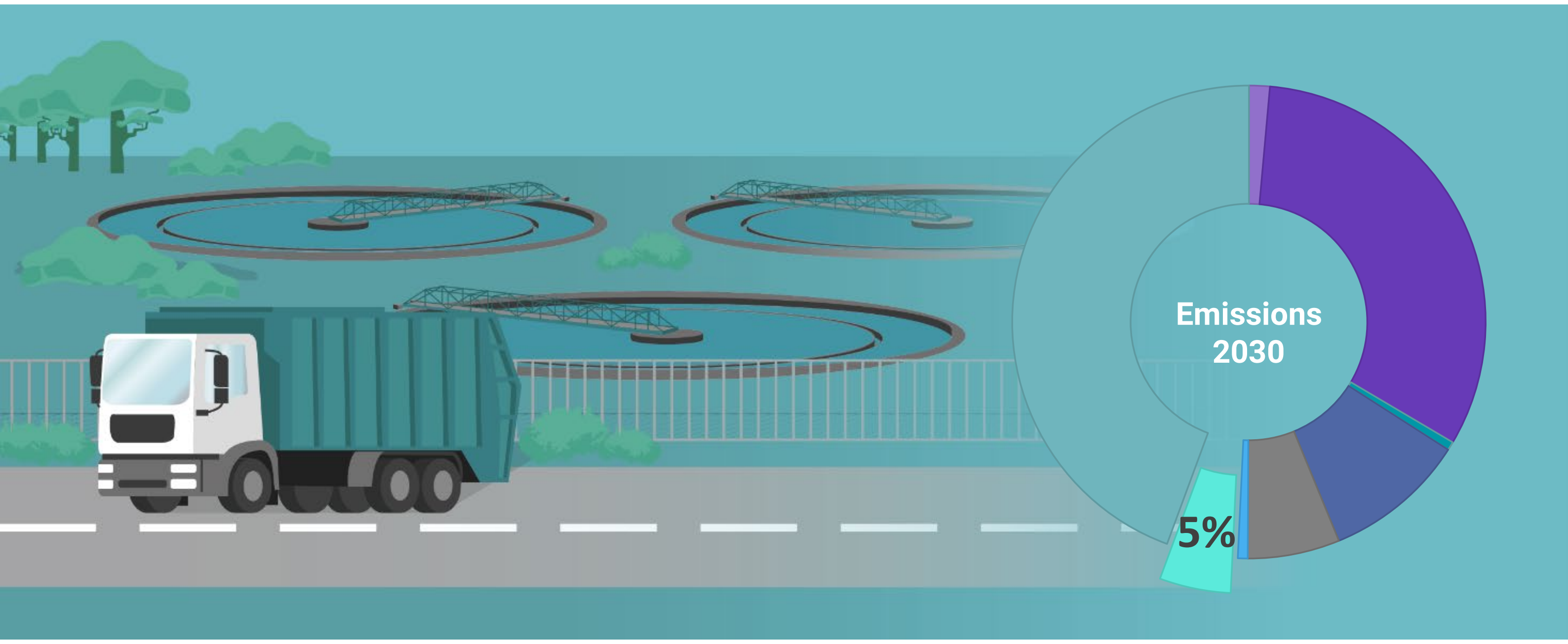
Alternative scenario with energy islands

The energy islands are not included in the CSO21 basic scenario. Therefore, the system and climate consequences of starting up the energy islands for the Danish electricity and district heating sector have been illustrated in a partial sensitivity calculation, which assumes that the two energy islands will be realised and connected to the grid on 1 January 2030, while domestic electricity consumption is kept unchanged[28].

The sensitivity calculation with the energy islands shows an increase in the share of renewables in electricity consumption from 97% to 122%. A renewables share in electricity consumption of more than 100% means that, with the energy islands, Denmark is expected to have a large surplus of green electricity that can be utilised to reduce greenhouse gas emissions from other sectors through direct or indirect electrification, or to displace fossil electricity production in countries neighbouring Denmark.

The sensitivity calculation also shows that, on their own, the energy islands have no great significance for Danish emissions of greenhouse gases. Start-up of the energy islands in 2030 is expected to reduce emissions from the electricity and district heating sector by 0.03 million tonnes CO_2e in 2030 compared to the CSO21 basic scenario. The reason for the small effect on Danish emissions is that there is already very little fossil-based electricity production in Denmark. However, the energy islands are expected to have a positive climate impact on the European electricity system, as Danish electricity exports will displace fossil-based electricity production abroad.

[28] Sector memorandum 8A contains a complete description of the assumptions behind the sensitivity calculation with the energy islands.



9 Waste and F gases

This chapter is about waste and the associated greenhouse gas emissions from a number of processes linked to waste processing (incineration and landfilling), wastewater, biogas plants, and composting, including emissions of F gases across sectors. In 2019, the sector emitted about 3.3 million tonnes CO_2e, corresponding to approximately 7% of total Danish emissions. In 2030, waste and F gases are expected to emit 1.8 million tonnes CO_2e, corresponding to 5% of total Danish emissions. The expected changes in sector emissions are due in particular to the following factors:

- The *climate plan for a green waste sector and circular economy* is expected to help reduce emissions from waste incineration by 60% by 2030 in relation to emissions in 2019.
- Methane emissions from landfills are expected fall by 81% in 2030 compared to the 1990 emissions, partly due to the ban on landfilling since 1997.
- Regular tightening of regulations on F gases with high climate impacts such as refrigerants is expected to reduce F-gas emissions by 71% in 2030 compared to emissions in 2019.

9.1 Emissions from waste and F gases

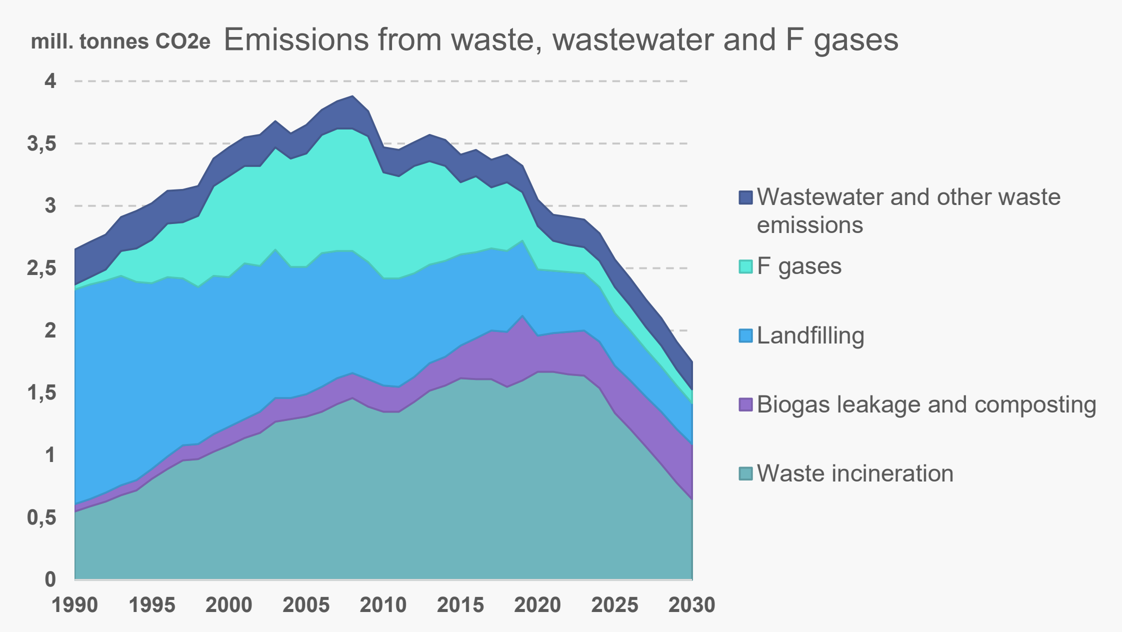
Greenhouse gas emissions from the waste sector are composed of CO_2, methane, nitrous oxide and F gases[29]. The amount of emissions is primarily determined by how

[29] F gases are not categorised under waste in reporting to the United Nations, but in CSO21 it has been decided to describe all F-gas emissions in this section. This is because F gases are emitted by several different sectors, for example because there are emissions when filling F gases (e.g., in refrigerators and heat pumps) and when using and disposing of appliances using F gases, and it has not been possible to divide all F-gas emissions between the sectors included in CSO21.

waste is processed. This is by incineration, landfilling or reuse, for example. The largest source of emissions from the sector in 2019 was waste incineration, with about 48% of total emissions from the sector, followed by emissions from landfills, which accounted for around 18% of the sector's emissions. Besides waste processing, there are emissions from the sector from composting, wastewater, leakage from biogas plants and leakage of F gases.

Waste incineration is closely linked with the electricity and district heating sector, because waste incineration plants contribute to both electricity and district heating production. However, in CSO21, emissions from incinerated waste are reported in the waste sector and not in the utilities sector.

Figure 9.1: Total emissions from waste and F gases



Note: The projection applies a leakage rate from biogas plants of 1%, while the leakage rate in historical years is currently set at 4.2%, see explanation below.

Total emissions from waste and F gases for the period 1990-2030 are illustrated in figure 9.1. Emissions include energy-related emissions from waste incineration, process emissions in the form of refrigerants, and waste-related emissions from processing waste and wastewater, as well as leakages of biogas.

Waste incineration

Emissions from waste incineration are expected to be reduced to 0.65 million tonnes CO_2e in 2030, corresponding to a reduction of 60% compared to 2019. However, as there was less waste incineration in 1990, emissions are expected to be 18% higher in 2030 than in 1990. Future reductions will be the result of measures in the *climate plan for a green waste sector and circular economy*, which are expected to lead to a fall in waste volumes for incineration, including a drop in imports of waste, and an increasing rate of recycling. This will lead to a reduction in volumes of plastics in the waste incinerated, and this in turn will lead to a significant reduction in fossil waste volumes.

Landfilling
Emissions of methane from landfills are likely to continue falling up to 2030. This is because, much of the carbon content in organic waste landfilled in the past has already been released as methane, and not much new organic waste is landfilled following the landfill ban in 1997. In 2030, emissions from landfills are expected to fall by a total of 81% compared to the 1990 emissions, so that remaining annual emissions total 0.33 million tonnes CO_2e. Today, most organic waste is recycled, biogasified and incinerated. In future small quantities of organic waste types that are harmful to the environment are likely to be landfilled. The falls in emissions from organic waste landfilled in the past will more than outweigh new emissions arising from newly landfilled waste in the period up to 2030. Reduction effects from bio-covers on landfills have not been included, as these effects have yet to be documented.

Composting
Emissions from composting are expected to remain more or less constant until 2030 at about 0.16 million tonnes CO_2e annually, because waste volumes composted are expected to remain more or less unchanged up to 2030.

Biogas leakage
Methane emissions from leakages at biogas plants are expected to rise to [30]about 0.25 million tonnes CO_2e in 2030 due to the large, expected increase in the production of biogas from manure-based biogas plants. The amount of manure gassified is expected to increase from 7.2 million tonnes in 2019 to more than 25 million tonnes in 2030. For projection years from 2020 and onwards, emissions of methane from biogas plants have been calculated by assuming that about 1% of the methane produced is emitted from installations as leakage. In the national emission inventory for the historical years, this emissions factor is currently set at 4.2%, and this makes the historical emissions, including in the most recent statistical year (2019), seem larger and the decrease seen in the first projected year (2020) seem particularly significant. The Danish Centre for Environment and Energy is currently awaiting results from a measuring project which is expected to document a lower emissions factor, and if this holds true, emissions in 2019 will in practice not be higher than in projected years.

Wastewater
Emissions from wastewater treatment plants are expected to remain at approximately the current level of about 0.2 million tonnes CO_2e annually up to 2030, at which time they will therefore be about 25% lower than in the 1990 baseline year. Emissions consist of methane and nitrous oxide from different parts of the wastewater process from the sewerage, storage and treatment systems. As noted in sector memorandum 9A on waste, reduction effects of the agreed cap on nitrous oxide emissions from large treatment plants are not included. The effects of this will be included in future projections once these have been documented.

F gases
F gases are a of group potent greenhouse gases used as refrigerants, among other things. In future emissions are expected to fall significantly to approx. 0.1 million tonnes CO_2e in 2030, although the level of emissions will still be around 2.6 times

[30] Emissions from manure management in agriculture will also fall, see sector memorandum 10B on emissions from agriculture and agricultural land.

higher than in 1990[31]. Emissions peaked at around 1 million tonnes CO_2e in 2009, and in 2019 and had been reduced to around 0.4 million tonnes CO_2e. Among other things, the drop in emissions will be because more climate-friendly technologies will increasingly replace the most climate-harmful F gases up to 2030. This trend is partly due to the reduction requirement in an EU Regulation (Regulation 517/2014), the ban laid down in the Executive Order on regulation of certain industrial greenhouse gases (1326 of 19/11/2018) and tighter regulations as a consequence of the *climate agreement for energy and industry etc.* of June 2020, in which it was decided to increase the tax on F gases and to repeal the *de minimis* limit for the tax.

9.2 Uncertainty and sensitivity

Estimates of emissions for waste and F gases are based on waste volumes and other activity data, as well as estimated emissions factors. There is considerable uncertainty associated with estimating historical and future waste volumes and emissions factors, for example because there is considerable uncertainty associated with estimating the volumes of organic waste landfilled over many decades. The most important sensitivities are:

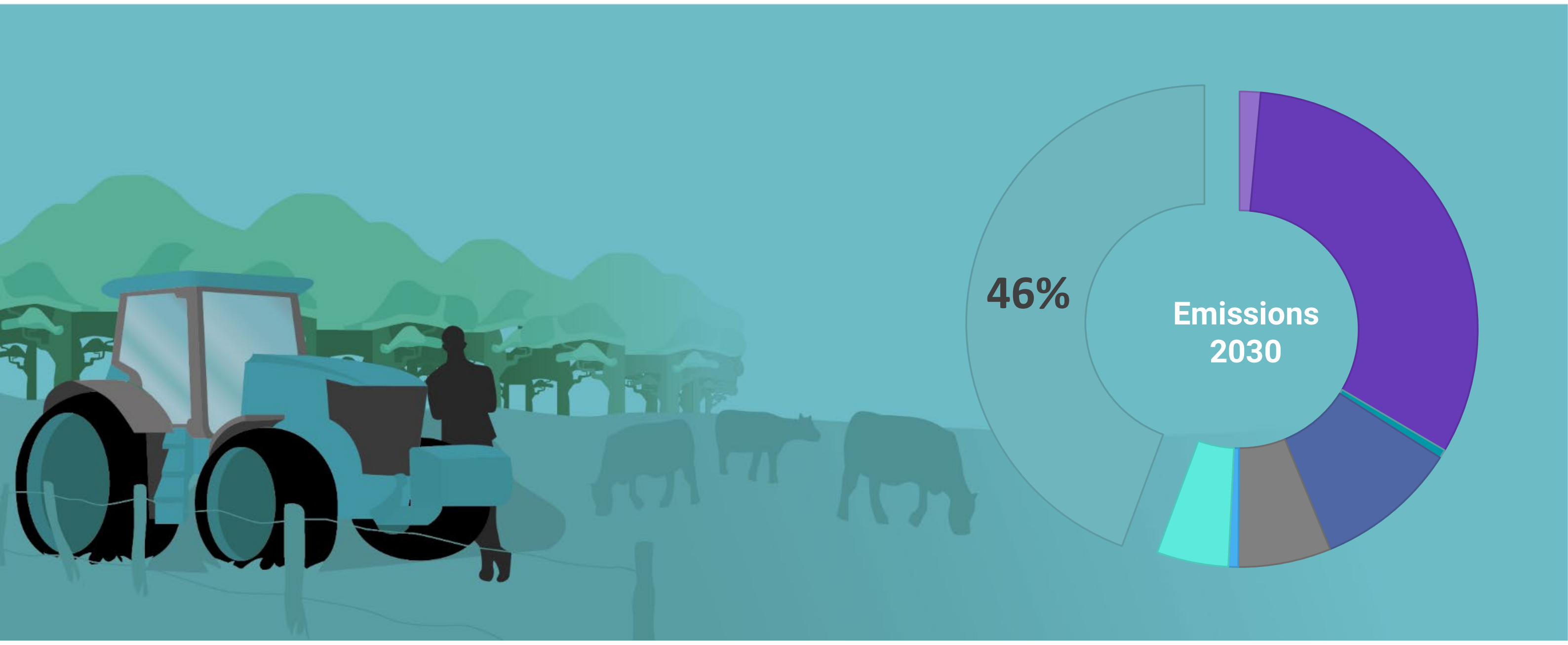
- Production at biogas plants is expected to triple in 2030 in relation to 2019, and since methane leakage from plants is assumed to be directly proportional to the scope of biogas production, the emissions estimate is sensitive to the expected increases in production realised. Furthermore, it has been assumed that a leakage rate of 1% will lead to emissions of about 0.25 million tonnes of CO_2e in 2030. However, if the leakage rate is not 1% but instead turns out to be 4.2%, for example, as hitherto assumed, emissions will increase by 2030 to more than 1 million tonnes CO_2e.

- In relation to waste incineration, several factors contribute to an expected emissions factor for waste in 2030, including the rate of separation for plastic, and the percentage of plastic waste in imported waste in 2030. For example, a change in the percentage of fossil waste of +/-15% could lead to the total emissions from waste incineration varying by +/- 0.1 million tonnes CO_2.

In accordance with the *climate plan for a green waste sector and circular economy*, the climate projection assumes that the total capacity of waste incineration plants in 2030 will be reduced by 30%. At present, there is no politically adopted plan for how capacity adaptation is to be observed. In a scenario in which this capacity adaptation is not realised, and instead capacity is only reduced by 15%, emissions would be between 0.6 and 0.7 million tonnes CO_2e higher in 2030 than otherwise calculated in the projection.

For further information about trends in emissions from the waste sector, as well as uncertainties and sensitivities, see sector memorandum 9A on waste and F gases, and memoranda on assumptions 4F and 6A on waste and F gases.

[31] Under the Kyoto Protocol, the baseline year for F gases was set at 1995, because there is no complete inventory of F-gas emissions going back to 1990. Comparing with the 1995 emissions, F-gas emissions will be reduced by 67% in 2030.



10 Agriculture, agricultural land, forests, horticulture and fisheries

This chapter describes the expected developments in emissions linked to agricultural production of livestock and crops, emissions from land use (LULUCF), primarily in agriculture and forests, as well as emissions related to energy consumption by agriculture, horticulture, fisheries and forestry.

In 2019, agriculture, agricultural land, horticulture, fisheries and forests emitted a total of about 15 million tonnes CO_2e, corresponding to around 32% of total Danish emissions. In 2030, the sectors are expected to emit approx. 16 million tonnes CO_2e, corresponding to approx. 46% of total Danish emissions. The expected changes in emissions from the sectors are due in particular to the following:

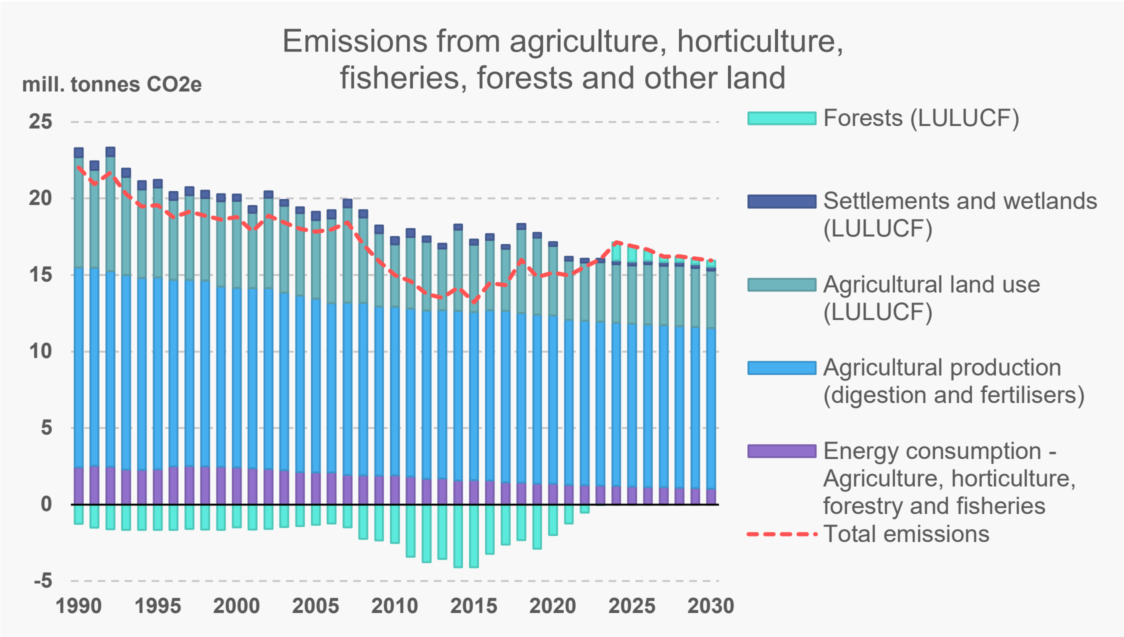
- Decreasing carbon sequestration in Danish forests.
- Drop in emissions from agricultural production of livestock and crops (see text box 10.1) due to a drop in emissions from manure management and fertiliser use.
- Drop in emissions from land used primarily for agriculture. This is partly due to the expected reduction in the area of organic soils, as well as increased uptake in mineral soils.

10.1 Agriculture, agricultural land, forests, horticulture and fisheries

Danish agricultural emissions of greenhouse gases are closely linked to changes in livestock populations and types, including in particular trends in cattle and pig populations. However, how agricultural land is managed is also crucial. Furthermore, Danish forests have for many years acted as net removers of CO_2, through increases in forest carbon stocks, but it seems this will change over the next few years, when forests will move from being net removers to becoming net emitters. Emissions from energy consumption by the sector constitute only a small proportion of total emissions from the sector. Energy consumption is particularly associated with internal transport (including especially agricultural machinery and fishing vessels) and process heat (e.g. heating greenhouses and livestock sheds).

Total CO_2e emissions by the agriculture, horticulture, fisheries and forestry sector for the period 1990-2030 are illustrated in figure 10.1. Emissions are particularly driven by developments in agricultural production of livestock and crops, and agricultural land use. Emissions from agricultural production are expected to amount to around 66% of total emissions from the sector in 2030, while the LULUCF sectors and energy consumption by agriculture, horticulture, forestry and fisheries are expected to account for approx. 28% and 6%, respectively.

Figure 10.1: Emissions from agriculture, horticulture, fisheries, forests and other land, broken down by energy-related emissions, emissions from agricultural production and LULUCF emissions.



Note: The individual emissions categories are described in text box 10.1 below.

Text box 10.1: Total emissions from agriculture, horticulture, fisheries, forests and other land use by sources and sectors.

Emissions from agricultural production of livestock and crops:
Agricultural production of livestock and crops in livestock housing systems and on cropland causes, in particular, emissions of the greenhouse gases methane (CH_4) from livestock digestion and from manure management, and nitrous oxide (N_2O) from manure management and fertiliser use, including artificial fertilisers and crop residues. For a more detailed description of emissions from agricultural production, see sector memorandum 10B on emissions from agricultural processes and land.

Emissions from forests and other land use, particularly in agriculture: Emissions include the role of forests and other land (primarily cropland and grassland in agriculture) as carbon stocks. CO_2 is either stored in or released from trees, plants and soils, depending on how the soils and forests are used. Overall, emissions are calculated in the LULUCF sector (Land Use, Land-Use Change and Forestry). In this climate projection, as well as the associated sector memoranda, the LULUCF sector is divided into two main categories of which emissions and uptake from forests are described in sector memorandum 10C on emissions from forests, whereas cropland and grassland (agricultural land) are described as part of sector memorandum 10B on emissions from agricultural processes and land. For a more detailed review of emissions from these categories see these sector memoranda.

Emissions from energy consumption in agriculture, horticulture, forestry and fisheries: Emissions from energy consumption are due to the use of fossil fuels for internal transport and process heat. Emissions associated with the sector's consumption of electricity and district heating are included in emissions from the electricity and district heating sector. For a more detailed description of emissions from energy consumption in agriculture, horticulture, forestry and fisheries, see sector memorandum 10A on energy consumption in agriculture, horticulture, forestry and fisheries.

Emissions from agricultural production of livestock and crops
Figure 10.1 above shows that emissions from agricultural production have fallen from 13.1 million tonnes CO_2e in 1990 to 11.1 million tonnes CO_2e in 2019, corresponding to a reduction of 15%. Emissions are expected to fall further by 0.6 million tonnes CO_2e up to 2030. This corresponds to a reduction of around 5% in the period from 2019 to 2030. The reduction is the result of two conflicting trends: On the one hand, an increasing number of livestock and associated increasing emissions, e.g. from livestock digestion, and, on the other hand, a drop in emissions from agricultural manure management and fertiliser use.

The drop in emissions from fertiliser use up to 2030 is driven in particular by an expected decrease in consumption of artificial fertilisers. The lower future demand for fertilisers will partly be a consequence of a fall in the total area of agricultural land, amongst other things as agricultural land is converted to settlements, forests or allocated for other uses, and partly as a consequence of increasing volumes of slurry available for use as fertiliser and requirements for increased exploitation of the nitrogen content in livestock manure.

The trend towards fewer greenhouse gas emissions from manure management is partly due to an expected increased use of emission-reducing environmental technologies, such as in-house slurry acidification and slurry cooling, but also, in particular, due to an expected major increase in the percentage of cattle and swine manure gassified. A total of approx. 7 million tonnes of manure was sold to biogas plants in 2019. This figure is expected to increase to almost 26 million tonnes manure in 2030 following the establishment of more biogas plants, some prompted by new subsidy schemes for biogas production. Gasification of cattle and swine manure is expected to reduce emissions from manure management, among other things because of the shorter period in which the manure is in stables and in storage.

With no new measures, total emissions from agriculture from livestock and crop production, manure management and fertiliser use are expected to be approx. 10.5 million tonnes CO_2e in 2030.

Emissions from agricultural land
Figure 10.1 above shows that emissions from agricultural land and other land have fallen from approx. 7.8 million tonnes CO_2e in 1990 to 5.3 million tonnes CO_2e in 2019, corresponding to a reduction of approx. 30%. Emissions are expected to fall to approx. 4 million tonnes CO_2e in 2030. Most of these emissions come from cropland and grassland in agriculture, while settled areas and wetlands together account for only a small share of emissions (0.3 million tonnes CO_2e in 2019).

The expected reduction in emissions from agricultural land can be explained by an expected reduction in the area of drained cropland and grassland on organic soils, often referred to as organogenic soils. These soils make up approx. 6% of Danish agricultural land and contain more than 6% carbon. Emissions from carbon rich organic soils are expected to fall by approx. 10% from 2019 to 2030, and will therefore contribute to reducing emissions from organic soils in agriculture. The reduction is due in particular to set-aside of land from crop farming as a consequence of state-funded subsidy schemes.

The fall in net emissions from agricultural land is also extensively due to increased sequestration in mineral soils. These mineral soils, which contain less than 6% carbon, make up approx. 94% of Danish agricultural land, and sequester carbon because of increased yields and more crop residues, for example. In future, in normal weather years, total removals by mineral soils are expected to be around 0.9 million tonnes CO_2e on average.

Removals and emissions in forests
Danish forests and wood products had net emissions of carbon in 1990 corresponding to 1.3 million tonnes CO_2e. Danish forests have since grown, in both area and density (growing stock per hectare). When forests grow, the trees remove CO_2 from the atmosphere, and in 2019 Danish forests and wood products accounted for net removals of 2.9 million tonnes CO_2e. Whether forests contribute net removals or net

emissions depends on the relationship between annual growth (annual increment) and annual felling/decomposition.

Up to 2030, forests are expected to take on a new role as net carbon sources instead of net carbon sinks, as forests are expected to have small annual net emissions in 2030. The reason for this is an expected regeneration of forests, as old trees are expected to be felled and replaced by new trees. It is uncertain when the trees will be felled as, in principle, many tree species can grow much older. Felling of trees is expected to be based on forest owners' economic rationale in light of the market for wood, etc. After old trees are felled, it takes a long time for new trees in the forest to absorb the same amount of carbon as was bound in the older generation of trees felled. Carbon pools trapped in forest land and wood products are expected to emit approx. 1/4 million tonnes CO_2e on average annually over the next ten years, from and including 2021 and until 2030. In 2030, these emissions are expected to be at 0.4 million tonnes CO_2e.

Energy consumption in agriculture, horticulture, forestry and fisheries
Emissions from energy consumption in agriculture, horticulture, forestry and fisheries are expected to be reduced from 2.4 million tonnes CO_2e in 1990 to approx. 1 million tonnes CO_2e in 2030. This corresponds to a reduction of approx. 57% in the period referred to. In 2019, these emissions were at 1.4 million tonnes CO_2e.

For agriculture, horticulture and forestry, sector emissions from energy consumption come mainly from consumption of fossil fuels in internal transport (including especially agricultural machinery) and process heat (e.g. for heating greenhouses and livestock sheds). In 2019, energy-related emissions from agriculture, horticulture and forestry were at approx. 1 million tonnes CO_2e and these emissions are expected to fall by an additional 0.3 million tonnes CO_2e up to 2030. This means that these sectors will have nearly halved their energy-related emissions in 2030 compared to 1990. The reduction is expected to be driven in part by continuous energy-efficiency improvements and in part by the substitution of fossil fuels for heat pumps, for example to deliver process heat to nurseries.

Emissions by the fisheries sector are mainly linked to diesel fuel consumption by fishing vessels. Since 1990, emissions from diesel have dropped by about 64% and were at 0.3 million tonnes CO_2e in 2019. The drop in emissions is assessed to be due to falling activity and to changes in the structure of the fishing fleet towards fewer but larger and more energy-efficient vessels. The projection assumes that the downward trend in emissions from the fisheries sector will continue, and the sector's energy consumption is expected to be cut by an additional 11% over the period from 2019 to 2030.

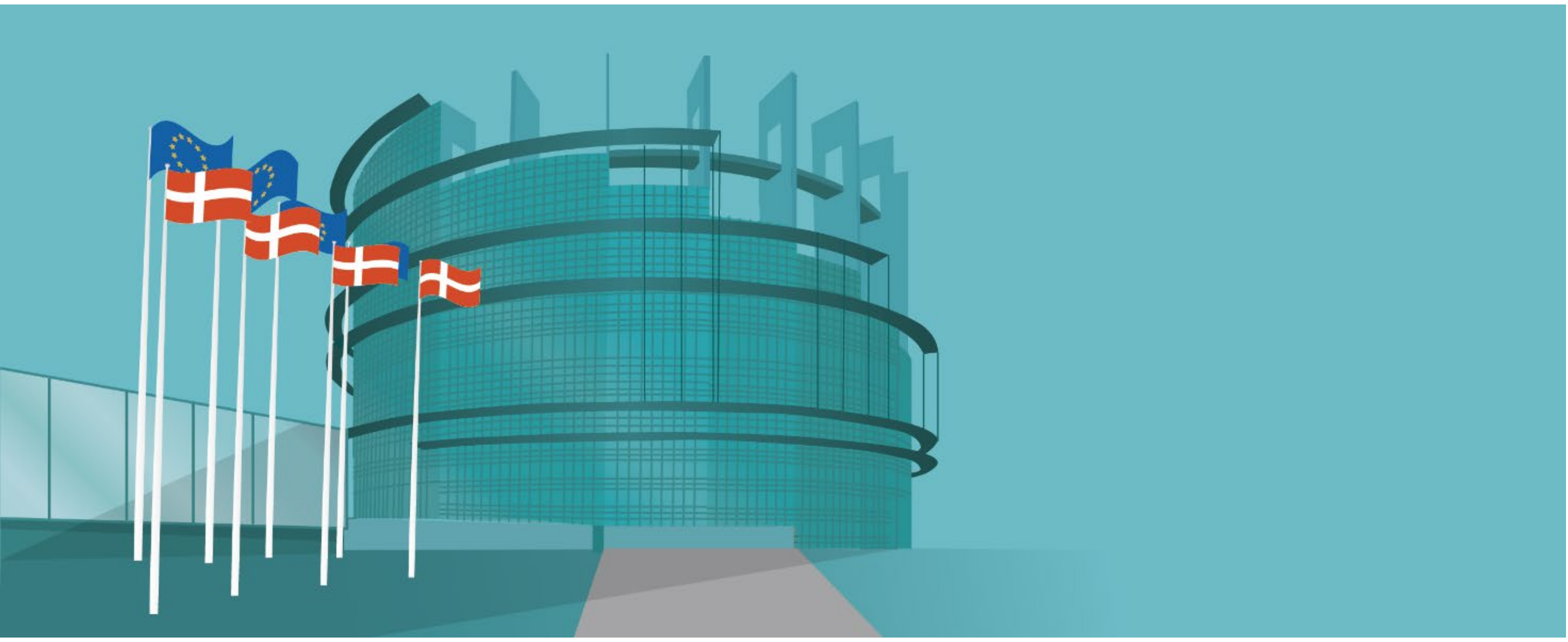
10.2 Uncertainty and sensitivity

There is generally considerable uncertainty associated with calculating and projecting expected future emissions from agricultural production, from land use in agriculture and from forests. This is because these emissions cannot be measured but must be estimated based on various activity and calculation assumptions. For example, future emissions from agriculture depend extensively on developments in livestock (cattle and swine) populations, and these developments are obviously uncertain and depend on the market situation, amongst other things. For example, it has been assessed that a development with either 15% more or 15% fewer dairy cows in 2030 will increase or cut annual emissions by at least 0.5 million tonnes CO_2e.

Estimates of emissions from agricultural land with mineral soils are weather-dependent and also depend on several other factors, such as the amount of crop residues left on fields. Mineral soils are generally expected to contribute an average annual removal of approx. 0.9 million tonnes CO_2e in future. Future observed emissions could however fluctuate considerably from year to year due to weather conditions, as has been the case historically. Historically, there have been individual years with emissions of up to 0.5 million tonnes CO_2e and removals of up to 1.2 million tonnes CO_2e, and in one case the climate impact of mineral soils fluctuated by approx. 1.4 million tonnes CO_2e from one year to the next.

Furthermore, note that there is great uncertainty about emissions from carbon rich soils because these depend on such factors as carbon content and water saturation, and the emission estimates do not consider the water saturation of carbon rich soils. These factors are currently not well known and work has therefore been commenced to quantify emissions depending on soil carbon content and water saturation. The DCE has performed a rough sensitivity calculation which technically assumes that the emissions from the areas are only half as large as the emission factors used. With this calculation, emissions in 2030 are reduced from 4.4 million tonnes CO_2e to 2.4 million tonnes CO_2e.

Finally, net removals or net CO_2 emissions in forests extensively depend on the age mix in forests, as well as on expected future felling rates, which, in turn, depend on the demand for wood products and bioenergy. See the sector memoranda for a more detailed explanation of the above. The sector memoranda provide examples of uncertainties associated with estimating emissions, as well as sensitivity calculations to illustrate how the expected emissions may change if one or more of the calculation assumptions mentioned above are changed.



11 Denmark's EU obligations

Denmark has a series of obligations in the EU under the 2030 climate & energy framework. At overall level, these are set out in the Governance Regulation (Regulation (EU) 2018/1999 of the European Parliament and of the Council of 11 December 2018 on the Governance of the Energy Union and Climate Action). Denmark is therefore obligated, within the period 2021 to 2030, to:

a) reduce emissions in its non-ETS sectors[32] according to a specific reduction trajectory;
b) provide balanced or positive LULUCF accounts of emissions and removals from forests, cropland, grassland and wetlands according to specified criteria;
c) meet a number of obligations for the use of renewable energy and energy-efficiency improvements.

Below is a summary status of progress towards these obligations according to CSO21. See sector memoranda 11A and 11B for more details.

11.1 Status of progress for non-ETS emissions and LULUCF

Table 11.1 specifies Denmark's EU obligations with regard to non-ETS and LULUCF emissions and gives a summary status report on the prospect of these obligations being met according to CSO21.

[32] The non-ETS sectors primarily comprise transport, agriculture, businesses, waste/wastewater and households.

Table 11.1: Summary status of progress towards Denmark's obligations in the EU with regard to non-ETS emissions and LULUCF.

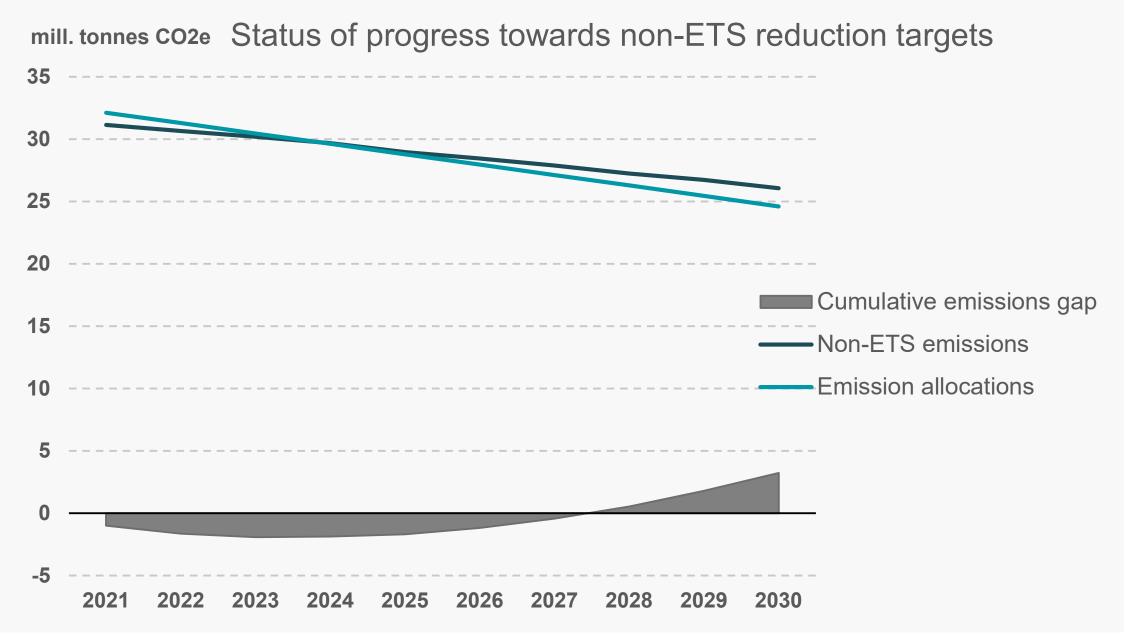
Indicator	Obligation	Expected status	Primary uncertainty
Reduction of non-ETS emissions	39% reduction in 2030 compared to 2005 according to a specific reduction trajectory	Will not be met without new measures or use of credits. A 35% reduction is expected in 2030 compared to 2005; i.e. a gap of 4 percentage points in 2030, corresponding to a cumulative gap of approx. 3 million tonnes CO_2e in 2030.	Uncertainty in particular about the projection of livestock populations in agriculture and emissions from transport
LULUCF credits	The "no debit rule" stipulating that the LULUCF sector must deliver balanced or positive climate accounts according to specified calculation rules	Met. Cumulative LULUCF credits will correspond to 23 million tonnes CO_2e in 2030.	Uncertainty in particular about future emissions from forest land older than 30 years and about emission factors for agricultural land

Figure 11.1 illustrates the trend in non-ETS emissions and in progress towards meeting the reduction obligation.

As can be seen, non-ETS emissions in the period 2021 to 2023 are expected to be lower than the emission allocations by virtue of the annual reduction targets. Surplus emission allocations in individual years can be transferred to later years.

The cumulative gap is expected to be approx. 3 million tonnes CO_2e in 2030. This shortfall can be offset by implementing further climate measures, by using emission allowances from the EU ETS, or by using part of the accumulated LULUCF credits (see sector memorandum 11A).

Figure 11.1: Status of progress towards non-ETS reduction targets, 2021-30



11.2 Status of progress for renewable energy and energy efficiency

Table 11.2 specifies Denmark's EU obligations with regard to renewable energy and energy efficiency and gives a summary status report on the prospect of these obligations being met according to CSO21.

Table 11.2: Summary status of progress towards Denmark's obligations in the EU with regard to renewable energy and energy efficiency

Indicator	Obligation	Expected status	Primary uncertainty
Renewables share (RES)	Ambitious contribution to the common EU renewable energy target of 32% for the EU as a whole.	Met. A renewables share of 58% exceeds the share that was reported to the EU in 2020 (NECP, 2020), which the European Commission assessed to be "sufficiently ambitious". Implementation track meets the requirements in the Regulation	Renewables shares in transport (RES-T) and in electricity consumption (RES-E), particularly with regard to the commissioning date for offshore wind and solar PV
Renewables share in transport (RES-T)	At least 14% in 2030	Met. 31% in 2030	Degree of electrification and RES-E
Advanced biofuels in transport	At least 0.2% in 2022, 1.0% in 2025 and 3.5% in 2030 (calculated under the RES-T definition)	Obligations for 2022 and 2025 are expected to be met. It is currently not possible to predict with certainty whether the 2030 requirement will be met without additional measures. However, regulation of ILUC effects or similar must be introduced from 2025. This is expected to have a positive effect on specific future compliance with the requirement for advanced biofuels, because it is expected to reduce consumption of first-generation biofuels, for example.	
Renewables share in heating and process energy (RES-H&C)	Annual increase of 1.1 percentage points, except when RES-H&C exceeds 60%	Met. Per increase rate in 2021 and by exceeding 60% from 2022.	Developments in district heating and in the deployment of heat pumps in households and industry
Energy savings	0.8% annually from 2021 to 2030 relative to average energy consumption in the period 2016 to 2018.	Assessed to be met according to an analysis concluding that Denmark is on track to over-achieving the EU requirement for energy by 27% (see: "Danmark sparer på energien og står til at opfylde EU's krav om energibesparelser med 127 pct.")[33]	See the analysis that is the basis for this expectation

Figure 11.2 illustrates the trend in renewables shares

The total share of renewables (RES) is expected to increase from 37% in 2019 to 58% in 2030.[34]

The renewables share in electricity consumption (RES-E) is expected to increase from 65% in 2019 to 97% in 2030. RES-E is expected to reach 100% in 2028. Towards the end of the projection period, increasing electricity consumption is therefore expected to be

[33] https://kefm.dk/Media/C/4/Minianalyse%20-%20Energieffektivisering.pdf.

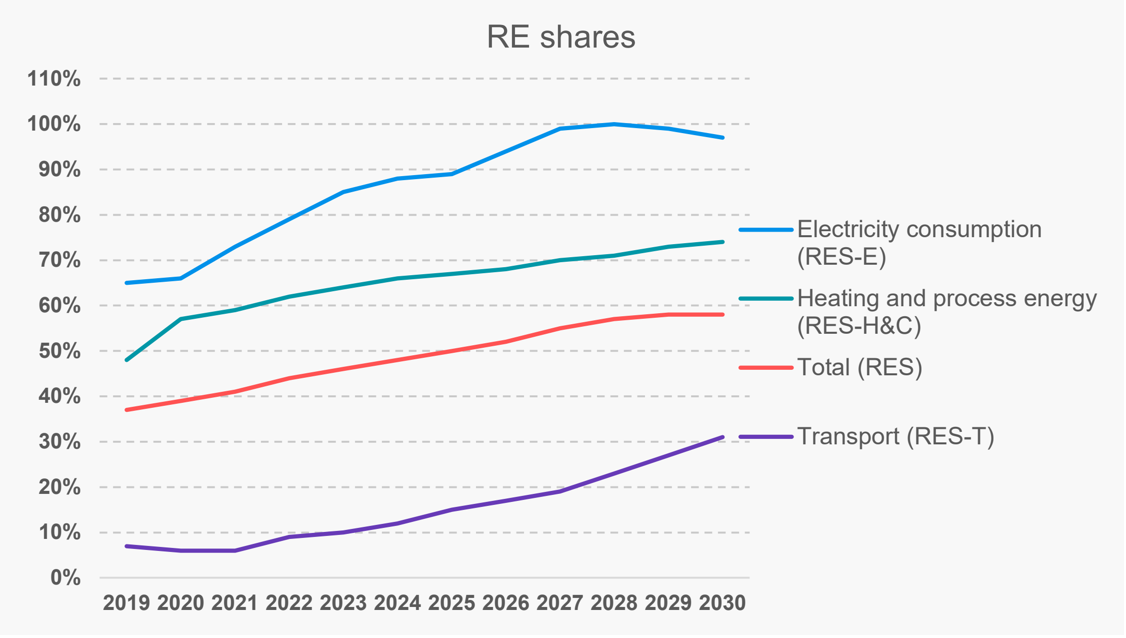
[34] In this context, the total share of renewables is calculated before any statistical transfer between Member States.

greater than deployment of renewable energy in the electricity supply system. Sensitivity calculations show that full commissioning of the energy islands with 5 GW in 2030 will cause the renewables share in electricity consumption (RES-E) to increase to 122% and the total share of renewables (RES) to increase to 66%. There is uncertainty in particular about the commissioning date for future offshore wind farms (including energy islands) and large solar installations.

The renewables share in heating and process energy (RES-H&C) is expected to increase from 48% in 2019 to 73% in 2030, which will be due in particular to an increasing share of bio natural gas in gas consumption and increased use of heat pumps in households, industry and district heating.

The renewables share in the transport sector (RES-T) is expected to increase from 7% in 2019 to 31% in 2030, which is due in particular to tighter requirements for biofuel blending in diesel and petrol, as well as to electrification of cars and vans and rail transport.

Figure 11.2: Renewables shares in total energy consumption, electricity consumption, heating and process energy, and transport



Note: Renewables shares (RES) have been calculated according to the Renewable Energy Directive/Eurostat.

11.3 Uncertainty and sensitivity

Non-ETS emissions are particularly sensitive to developments in transport and agriculture, deployment of heat pumps in space heating and industry, as well as production, management and use of biogas.

Renewables shares in individual years are particularly sensitive to commissioning dates for offshore wind and solar PV. Sensitivity calculations show that full commissioning of the energy islands with 5 GW in 2030 will cause the renewables share in electricity consumption (RES-E) to increase to 122% and the total share of renewables (RES) to increase to 66%.

Finally, note that, in December 2020, the EU heads of state and government agreed to raise the 2030 emission reduction target from 40% (excluding LULUCF) to at least 55% (including LULUCF) compared to 1990. At the time of writing, it is not known whether this new EU target will affect Denmark's obligations.

Appendix 1: List of CSO21 sector memoranda and memoranda on assumptions

In addition to the main report, CSO21 comprises 13 sector memoranda and 31 memoranda on assumptions (only available in Danish). All of these memoranda are shown in the list below.

CSO21 sector memoranda

Memorandum no.	Sector memorandum
3A	Households
4A	Transport
5A	Service sector
6A	Manufacturing industries and building and construction
7A	Fuel production
7B	Share of renewable fuels in fuel consumption
8A	Electricity and district heating (excluding waste incineration)
9A	Waste and F gases
10A	Energy consumption in agriculture, horticulture, forestry and fisheries
10B	Emissions from agricultural processes and agricultural land
10C	Emissions from forests
11A	Denmark's greenhouse gas emission obligations in the EU
11B	Denmark's EU obligations towards renewable energy and selected national agreements

CSO21 memoranda on assumptions

Memorandum no.	Memorandum on assumptions
0	Introduction to CSO21 assumptions material
1A	RAMSES model
1B	IntERACT model
1C	FREM transport model
1C-ART	ART car population model
1C-BVM	Car type choice model
1C-Vej	Road transport in FREM
2A	New policies included in CSO21
2B	Emission inventory principles in CSO21
2C	New policies not included in CSO21
2D	How business sector input has been managed in CSO21
3A	Fuel prices

Memorandum no.	Memorandum on assumptions
3B	CO_2 allowance price
3C	Electricity production capacities abroad and interconnectors
3D	Assumptions about economic growth
4A	Production capacities in the district heating sector
4B	Offshore wind
4C	Onshore wind
4D	Solar
4E	Biogas production
4F	Waste incineration
5A	Car type choice assumptions
5B	Biofuels
6A	Waste (excluding waste incineration), wastewater and F gases
6B	Agriculture
6C	Forests (LULUCF)
6D	Agricultural land and other land (excluding forests (LULUCF))
7A	CCS
7B	PtX
7C	Oil-gas projection
7D	Cement production

Appendix 2: List of CSO21 datasheets

A number of data sheets are published in the context of CSO21. The data sheets are listed in the table below. (The data sheets are only available in Danish and the column 'File name' therefore lists the Danish file names).

Table A2.1: CSO21 datasheets

File name	Description
KF21 resultater - Tal bag figurer	• Includes the data behind figures in the CSO21 main report and sector memoranda • Includes links to data for the indicators listed in the 2020 Climate Action Plan
KF21 forudsætninger - Tal bag figurer	• Includes the data behind figures in CSO21 memoranda on assumptions
KF21 CRF-tabel	• Emission inventories per greenhouse gas type for the years 1990-2030 Statistical years are observed years, while the projection period uses 'normal years'. • CSO21 uses Danish Energy Agency historical emissions data. Totals are identical with Danish Centre for Environment and Energy (DCE) emissions data, but there are slight differences in how emissions break down between certain categories. • CSO21 has been calculated using the new global warming potential factors from the IPCC's 5th Assessment Report (AR5).
KF21 CRF-tabel (opgjort med AR4 GWP-faktorer)	• CSO21 calculated using the global warming potential factors from the IPCC's 4th Assessment Report (AR4). Published to show the significance of the change in GWP factors from AR4 to AR5 (see also memorandum on assumptions 2B). • Note that DECO20 was calculated using AR4 GWP factors.
Energibalance	• National energy balance for fuels for the years 2015-2030
Sektordataark	• Sector data sheets • Transport • Agriculture and LULUCF

Appendix 3: The relationship between CSO21 sectors and DECO20 sectors

Emissions are broken down by eight sectors and CCS in CSO21. The sectoral divisions have been slightly changed compared to DECO20, amongst other things in order to adhere to the CRF categories used for international reporting. The two tables below show the CSO21 sectors and the most important changes in the sectoral division compared to DECO20.

Table A3.1: CSO21 sectors

CSO21 sector	Remarks
Households	Excluding energy consumption and emissions arising from transport
Transport	
Service sector	Including data centres
Manufacturing industries and building and construction	Excluding F gases
Production of oil, gas and renewable fuels	
Sector data sheets	Excluding emissions from waste incineration
Waste and F gases	Including emissions from waste incineration, wastewater, leakage from biogas plants, etc. and all F gases
Agriculture, agricultural land, forests, horticulture and fisheries	Including energy consumption by the sector

Note: Because CCS has not been broken down by sectors in CSO21, the technology is instead dealt with as a separate source of negative emissions not broken down by sectors.

Table A3.2: Changes in the sectoral division in CSO21 compared to DECO20

Emissions from	Sector in DECO$_2$0	Sector in CSO21	Reason for change
Individual heating	"Utilities and heating"	The consuming sectors (households, service, manufacturing, etc.)	So as to follow the CRF approach used in international reporting.
Businesses	"Industry and services"	Broken down by four sectors: • Service sector • Manufacturing industries and building and construction • Production of oil, gas and renewable fuels • Agriculture, horticulture, fisheries, forests and other land.	In order to satisfy a wish for a more detailed breakdown for businesses
Energy consumption in agriculture, horticulture, forestry and fisheries	"Industry and services"	Agriculture, agricultural land, forests, horticulture and fisheries	In order to have all emissions from this production in the same sector

Emissions from	Sector in DE$CO_2$0	Sector in CSO21	Reason for change
F gases	"Industry and services" (under manufacturing industries)	Together with waste	F gases arise from several sectors and it has not been possible to break them down by CSO21 sectors.
Indirect CO_2 emissions	In separate category	Broken down by sectors	

Appendix 4: The relationship between CSO21 sectors and the CRF tables

The sectoral division in CSO21 follows the categories in the CRF tables as far as possible. The table below shows how the different greenhouse gases under the various CRF categories break down by CSO21 sectors (here identified by chapter numbers in the main report).

Table A4.1: The relationship between CRF categories and CSO21 sectors

CRF code	Description	CO_2, CH4, N2O, Indirect CO_2	HFCs, PFCs, SF6
1A1a	Public electricity and heat production (ex. Waste incineration)	08	09
1A1ax	Public electricity and heat production (Waste incineration)	09	09
1A1b	Petroleum refining	07	09
1A1c	Other energy industries (oil/gas extraction)	07	09
1A2	Combustion in manufacturing industry	06	09
1A2gvii	Industry - Other (mobile)	06	09
1A3a	Domestic aviation	04	09
1A3bi	Road transport - Cars	04	09
1A3bii	Road transport - Light duty trucks	04	09
1A3biiix	Road transport - Heavy duty trucks	04	09
1A3biiiy	Road transport - Busses	04	09
1A3biv	Road transport - Motorcycles and mopeds	04	09
1A3bx	Road transport - Border trade	04	09
1A3c	Railways	04	09
1A3d	Domestic navigation	04	09
1A4ai	Commercial and institutional	05	09
1A4aii	Commercial and institutional (mobile)	05	09
1A4bi	Residential	03	09
1A4bii	Residential (mobile)	03	09
1A4ci	Agriculture, forestry and aquaculture	10	09
1A4cii	Ag./for./fish. (mobile)	10	09
1A5bi	Military (mobile)	04	09
1A5bii	Recreational boats (mobile)	04	09
1B2a	Fugitive emissions from oil	07	09
1B2b	Fugitive emissions from gas	07	09
1B2c	Fugitive emissions from flaring	07	09

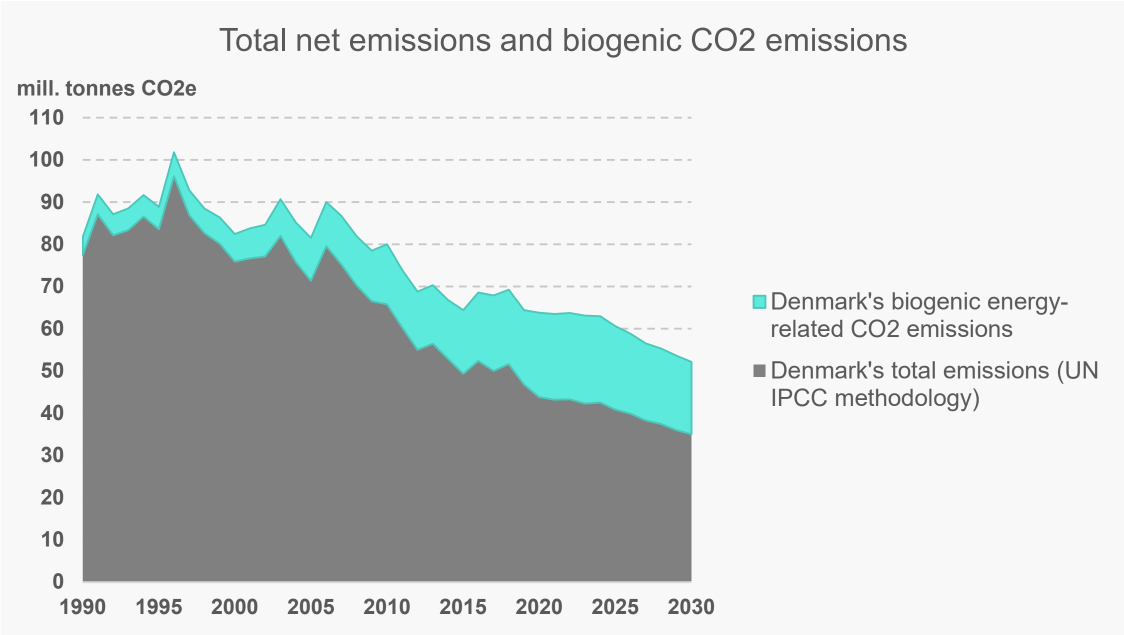
CRF code	Description	CO_2, CH4, N2O, Indirect CO_2	HFCs, PFCs, SF6
2A0	Mineral industry - excl. cement production	06	09
2A1	Mineral industry - cement production	06	09
2B	Chemical industry	06	09
2C	Metal industry	06	09
2D	Non-energy products from fuels and solvent use	06	09
2E	Electronic industry	06	09
2F	Product uses as ODS substitutes	06	09
2G	Other product manufacture and use	06	09
2H	Other industrial processes	06	09
3A	Enteric fermentation	10	09
3B	Manure management	10	09
3D	Agricultural soils	10	09
3F	Field burning of agricultural residues	10	09
3G	Liming	10	09
3H	Urea application	10	09
3I	Other carbon-containing fertilizers	10	09
4A	Forest land	10	09
4B	Cropland	10	09
4C	Grassland	10	09
4D	Wetlands	10	09
4E	Settlements	10	09
4F	Other Land	10	09
4G	Harvested wood products	10	09
4H	Other LULUCF	10	09
5A	Solid waste disposal	09	09
5B	Biological treatment of solid waste	09	09
5C	Incineration and open burning of waste	09	09
5D	Wastewater treatment and discharge	09	09
5E	Other waste	09	09

Note: 03 is households; 04 transport; 05 service sector; 06 manufacturing industries and building and construction; 07 production of oil, gas and renewable fuels; 08 electricity and district heating; 09 waste and F gases; 10 agriculture, agricultural land, forestry, horticulture and fisheries. CH4 is methane, N20 is nitrous oxide, and HFCs, PFCs and SF6 are F gases.

Appendix 5: Total biogenic emissions

In CSO21, emissions from this sector have been calculated following the UN IPCC methodology, because the Climate Act stipulates that the calculation of emissions towards the 70% target has to follow the UN IPCC methodology. CO_2 emissions from burning biomass are therefore defined as 'carbon neutral' in the country where the biomass is consumed, and these emissions are therefore not included in the calculation of emissions (see CSO21 memorandum on assumptions 2B). Pursuant to the UN IPCC methodology, CO_2 emissions from burning biomass should, however, be calculated and reported under a so-called "memo item". This appendix shows the biogenic energy-related CO_2 emissions from burning biomass across sectors. The CO_2 emissions from consumption of bioethanol and biodiesel are not included in the calculation, however.

Figure A5.1: Total net emissions and biogenic energy-related CO_2 emissions (excluding bioethanol and biodiesel)



Note: As mentioned in chapter 2, the concept of "total net emissions" refers to total emissions (including LULUCF) after inclusion of CCS.

As can be seen from figure A5.1, total biogenic energy-related CO_2 emissions (excluding bioethanol and biodiesel) followed an upward trend from 1990 to 2019, when they totalled 17.7 million tonnes CO_2e. Biogenic CO_2 emissions will increase further during the first half of the projection period and will be 20.8 million tonnes CO_2e in 2023. After this they are expected to fall to 17.1 million tonnes CO_2e in 2030.

Three sectors account for 80-90% of biogenic energy-related CO_2 emissions in the projection period. Thus, the electricity and district heating sector (excluding waste incineration) accounts for 53% of biogenic energy-related CO_2 emissions in 2019 and 47% of these emissions in 2030. Waste and F gases account for 13% of the biogenic energy-related CO_2 emissions in 2019 and 12% of these emissions in 2030, while households account for 23% in both 2019 and 2030.

This is the first time that biogenic emissions are being reported with the projection, and the calculation in CSO21 of biogenic emissions deviates slightly from the calculation of these emissions in historical years by the Danish Centre for Environment and Energy (DCE). These emissions figures will be consolidated as best as possible before CSO22.

Appendix 6: Glossary and abbreviations

Glossary

Biofuels: Biofuels produced from biological materials. A distinction is made between first- and second-generation biofuels. First generation biofuels are primarily ethanol and biodiesel produced on the basis of food crops. Bioethanol is typically produced from crops containing starches and sugar, such as cereal and sugar cane, while biodiesel is typically produced from oil crops, such as rapeseed, soybean and palm. Second generation biofuels are typically produced from residual products from agriculture and industry.

Biogenic CO_2 emissions: CO_2 emissions arising from burning biomass.

Biomass: An umbrella term for all organic material that is the product of photosynthesis in plants driven by solar energy. The most common products in an energy context are straw, fuel wood, wood chips, wood pellets, wood waste, biodegradable waste, etc.

Bio natural gas: Biogas that has been upgraded to meet the supply requirements for gas in the grid.

CO_2 intensity: A measure of the amount of CO_2 emissions relative to economic production. Is calculated as the ratio between CO_2 emissions and production value.

Common Reporting Format (CRF): Standard format for reporting emission inventories in accordance with the UN IPCC methodology for calculating emissions.

Greenhouse gas emissions: Greenhouse gases include carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O) and fluorinated greenhouse gases (F gases). The gases have different greenhouse effects but are converted into **CO_2 equivalents** (abbreviated **CO_2e**) based on their Global Warming Potential (GWP) over a 100-year time period relative to CO_2. CO_2e emissions are therefore a way in which to estimate greenhouse gas emissions that allows for adding up different greenhouse gases with different impacts on the greenhouse effect with regard to the potency of the gas and the time it is in the atmosphere. With the CO_2e unit, the climate impact of the individual gas is converted to what the corresponding impact in units of CO_2.

Energy intensity: A measure of energy consumption relative to economic production. Is calculated as the ratio between energy consumption and production value.

Final energy consumption: Final energy consumption is energy consumption delivered to end users, i.e. private and public-sector businesses as well as households. Uses include: manufacture of goods and services, space heating, lighting and other appliance consumption as well as transport. Added to this is oil consumption for non-energy purposes, i.e. lubrication and cleaning as well as bitumen for paving surfaces.

Energy consumption in connection with extraction of energy, refining and conversion is not included in final energy consumption. The definition and breakdown of final energy consumption follow the International Energy Agency's (IEA's) and Eurostat's guidelines. Energy consumption for transport by road and railway, by sea, by air, and by pipeline - irrespective of consumer - is subsequently taken out of the total final energy consumption figure as an independent main category. This means that energy consumption by businesses and households is calculated exclusive of consumption for transport purposes. Moreover, final energy consumption excludes cross-border trade in oil products, defined as the quantity of petrol, gas/diesel fuel and pet coke, which due to differences in price is purchased by private individuals and transport operators etc. on one side of the border and consumed on the other side of the border.

Observed (actual) energy consumption: Observed energy consumption is found by adding distribution losses and energy consumption in connection with energy extraction and refining to final energy consumption. To this figure is added own consumption of energy in connection with production of electricity and district heating.

Greenhouse gas emissions NOT covered by the EU ETS system (non-ETS): Non-ETS emissions primarily stem from transport, agriculture, households, other business, waste, and a number of small-scale CHP plants, i.e. numerous large and small emissions sources. Regulation takes place through national measures by the individual countries which have received reduction targets relative to 2005 levels. The baseline year is 2005, as this year was the earliest year with data that made it possible to distinguish between ETS and non-ETS emissions.

ILUC effect: When biomass for use as biofuels is grown in an area that was previously used for food production, then this food production will be transferred to new land because the demand for food products is assumed to be unchanged. ILUC emissions are emissions that occur when previously unfarmed land is converted to agricultural land to produce food crops as the indirect result of the use of biofuels.

Indirect emissions: Indirect CO_2 is calculated on the basis of emissions of CH_4, NMVOC and CO, which oxidize to CO_2 in the atmosphere. Only fossil emissions of CH_4, NMVOC and CO are included in the calculation.

Carbon pool: Forests and other land (primarily cropland and grassland in agriculture) is an important carbon pool, as CO_2 can be either stored in or released from trees, plants and soils. The size of the carbon pool in forests and other land depends on how the land and the forests are used.

Greenhouse gas emissions covered by the EU ETS system (ETS): ETS emissions include emissions from energy production, heavy industry, aviation and other large point sources. The total number of emission allowances is set at EU level and this number is tightened annually. The allowances are traded on a common European market. Companies trade in emission allowances on the market, which means that direct regulation of emissions from the ETS sector cannot be implemented at national level.

Mains gas: In Denmark, fossil natural gas is mixed with bio natural gas (i.e. upgraded biogas) in the mains gas grid. Consumers do not have the option of choosing which type of natural gas is used, as fossil natural gas and bio natural gas are mixed together in the gas grid and become mains gas.

LULUCF: Inventory of carbon removals and emissions linked primarily to soil cultivation and forestry activities.

RE (renewable energy): Defined as solar energy, wind power, hydropower, geothermal energy, ambient heat for heat pumps and bioenergy (straw, wood chips, firewood, wood pellets, wood waste, bioliquids, bio natural gas, biodegradable waste and biogas).

Renewables shares: For a summary of the principles for determining renewables shares, see the Annex to sector memorandum 11B.

Abbreviations

DECO20: Denmark's Energy and Climate Outlook 2020

CO_2e: CO_2 equivalents

CRF: *Common Reporting Format*

DCE: Danish Centre for Environment and Energy, Aarhus University

ETS: The European Emission Trading System

ILUC: *Indirect Land Use Change*

CSO21: Denmark's Climate Status and Outlook 2021

LULUCF: Land Use & Land Use Change & Forestry

NECP: National Energy and Climate Plan

PJ: Peta Joule

PtX: Power-to-X

RES: Renewable energy share (total renewables share)

RES-E: Renewable energy share - electricity (renewables share in electricity)

RES-H&C: Renewable energy share - heating and cooling renewables share in heating and process energy)

RES-T: Renewable energy share - transportation (renewables share in transport)

TWh: Terawatt-hour

RE: Renewable energy

Appendix 7: References

Each CSO21 sector memorandum contains a list of references for the memorandum in question. This appendix covers only references relevant for the main report and which are not part of the CSO21 material. See Appendix 1 for a list of CSO21 sector memoranda and memoranda on assumptions

Agreement on green road transport: *Aftale om grøn omstilling af vejtransporten af 4. dec. 2020* (https://fm.dk/media/18300/aftale-om-groen-omstilling-af-vejtransporten.pdf)

Agreement on green tax reform: *Aftale om Grøn Skattereform af 8. dec. 2020* (https://fm.dk/media/18317/aftale-om-groen-skattereform.pdf)

COWI for the Danish Energy Agency (2021). Memo on development of data centres and their impact on the energy system: *Udviklingen af datacentre og deres indvirkning på energisystemet* https://ens.dk/service/fremskrivninger-analyser-modeller/klimastatus-og-fremskrivning

Danish Energy Agency, Denmark's Energy and Climate Outlook 2020 (DECO20) https://ens.dk/sites/ens.dk/files/Basisfremskrivning/basisfremskrivning_2020.pdf.

Danish Energy Agency (2020). Energy statistics 2019: *Energistatistikken 2019* https://ens.dk/service/statistik-data-noegletal-og-kort/maanedlig-og-aarlig-energistatistik

EU. Regulation 2018/1999 on the Governance of the Energy Union and Climate Action. (2018).

EU regulations on CO_2 emissions (EU):
2019/631: https://eur-lex.europa.eu/legal-content/DA/TXT/PDF/?uri=CELEX:32019R0631&from=EN
2019/1242: https://eur-lex.europa.eu/legal-content/DA/TXT/PDF/?uri=CELEX:32019R1242&from=DA

European Environment Agency (2021). Inventory submission March 15 2021, for years 1990-2019 https://cdr.eionet.europa.eu/dk/eu/mmr/art07_inventory/ghg_inventory/envye3nrg/.

2021 Finance Act: *Finanslov 2021* https://fm.dk/media/18330/aftale-om-finansloven-for-2021-og-aftale-om-stimuli-og-groen-genopretning.pdf

Ministry of Climate, Energy and Utilities (2021). Briefing on preliminary emissions figures for 2019: *Orientering om foreløbige udledningstal for 2019* https://www.ft.dk/samling/20201/almdel/KEF/bilag/177/2326973.pdf

Ministry of Climate, Energy and Utilities (2021). Analysis concluding that Denmark is on track to over-achieving the EU requirement for energy by 27%: *Danmark sparer på energien og står til at opfylde EU's krav om energibesparelser med 127 pct.* https://kefm.dk/Media/C/4/Minianalyse%20-%20Energieffektivisering.pdf

2020 climate agreement for energy and industry, etc.: *Klimaaftale for energi og industri mv. 2020 af 22. juni 2020* (https://www.regeringen.dk/publikationer-og-aftaletekster/klimaaftale-for-energi-og-industri-mv-2020/)

Climate Act and explanatory notes: *Klimalov og bemærkninger til lovforslaget* https://www.ft.dk/samling/20191/lovforslag/L117/index.htm.

Climate plan for a green waste sector and circular economy: *Klimaplan for grøn affaldssektor og cirkulær økonomi af 16. juni 2020* (https://www.regeringen.dk/media/9591/aftaletekst.pdf)

Statbank Denmark, Statistics Denmark. FOLK1A: Population at the first day of the quarter by region, sex, age and marital status; and BOL101: Dwellings by region, type of resident, use, tenure, ownership and year of construction