Danish Ministry of Climate,
Energy and Utilities

Denmark's Eighth National Communication and Fifth Biennial Report

– under the United Nations Framework Convention on Climate Change

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and
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2023

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Introduction

At the United Nations Conference on Environment and Development in Rio de Janeiro in June 1992, more than 150 countries signed the UN Framework Convention on Climate Change (the Climate Convention).

On 21 December 1993 the Climate Convention was ratified by a sufficient number of countries, including Denmark, for it to enter into force on 21 March 1994. Currently, there are 198 Parties (197 States and 1 regional economic integration organization) to the United Nations Framework Convention on Climate Change.

This report is Denmark's Eighth National Communication under the Climate Convention (NC8) and the fifth under the Kyoto Protocol as well as Denmark's Fifth Biennial Report under the Climate Convention (BR5). Since Denmark's ratification of the Climate Convention covers the entire Realm, the report also includes information on Greenland and the Faroe Islands. The Kyoto Protocol, however, only covers Denmark and Greenland due to a ratification with a territorial exclusion to the Faroe Islands. The second commitment period of the Kyoto Protocol only covers Denmark as part of the EU due to a planned ratification with a territorial exclusion to Greenland. The report is organised in accordance with the guidelines for national communications adopted by the parties to the Climate Convention and as far as possible it follows the Annotated Outline for the Fifth National Communication suggested by the Climate Secretariat in June 2009.

A summary of reporting of the supplementary information under Article 7, paragraph 2, of the Kyoto Protocol is given in Table 0.1. This table allows identifying the Kyoto Protocol elements that are allocated in different sections of the report.

TABLE 0.1 SUMMARY OF REPORTING OF THE SUPPLEMENTARY INFORMATION UNDER ARTICLE 7, PARAGRAPH 2, OF THE KYOTO PROTOCOL IN THE NC8.

Information reported under Article 7, paragraph 2	Chapter in NC8
National systems in accordance with Article 5, paragraph 1	3.3
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Information under Article 10: - Art 10a (programmes to improve the quality of local emission factors, activity data and/or models which reflect the socio-economic conditions of each Party for the preparation and periodic updating of national inventories) - Art 10b (measures to mitigate climate change and measures to facilitate adequate adaptation to climate change) - Art 10c (transfer of, or access to, environmentally sound technologies, know-how, practices and processes pertinent to climate change, in particular to developing countries) - Art 10d (maintenance and the development of systematic observation systems and development of data archives to reduce uncertainties related to the climate system etc.) - Art 10e (the development and implementation of education and training programmes)	Art. 10a: 3.3 Art. 10b: 4 and 6 Art. 10c: 7 Art. 10d: 8 Art. 10e: 9
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In addition to efforts described in this report, Denmark also contributes to the European Union's common efforts under the Climate Convention, the Kyoto Protocol and the Paris Agreement. Such efforts have – and will in the future – be transposed by implementation of common and coordinated policies and measures to reduce greenhouse gas emissions, including under the European Energy Union. Further information on the EU's climate policy etc. is available in the EU's Eighth National Communication submitted to the UNFCCC in December 2022.

The Danish Ministry of Climate, Energy and Utilities has been in charge of coordinating the work relating to Denmark's Eighth National Communication. Contributions have been made by the institutions mentioned in Box 0.1.

BOX 0.1 INSTITUTIONS CONTRIBUTING TO NC8 AND BR5

Danish Ministry of Climate, Energy and Utilities and Danish Energy Agency, Danish Meteorological Institute and Geological Survey of Denmark and Greenland thereunder;
Ministry of Children and Education;
Ministry of Environment of Denmark and Environmental Protection Agency and Danish Nature Agency thereunder;
Ministry of Food, Agriculture and Fisheries and Danish AgriFish Agency thereunder
Ministry of Foreign Affairs;
Ministry of Industry, Business and Financial Affairs and the Danish Business Authority thereunder;
Ministry of Social Affairs, Housing, and Senior Citizens;
Danish Ministry of Taxation;
Ministry of Transport;
Faroe Islands - contributions from and coordinated by the Environment Agency;
Greenland - contributions from and coordinated by the Ministry of Agriculture, Self-Sufficiency, Energy and Environment;
Roskilde University;
Technical University of Denmark;
University of Copenhagen;
University of Southern Denmark;
Aalborg University;
Aarhus University and DCE - Danish Centre for Environment and Energy thereunder.

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EXECUTIVE SUMMARY

1 Executive Summary

1.1 National circumstances relevant to greenhouse gas emissions and removals

1.1.1 General

The Kingdom of Denmark – the Realm - comprises Denmark, Greenland and the Faroe Islands. The UN Framework Convention on Climate Changes has been ratified on behalf of all three parts of the Realm.

Today, Denmark has a population at around 5.9 mill. and a total area of 43,054 km^2. More than 60% of the area is used for agricultural purposes, while 13% is forested and 14% is towns, roads and scattered housing, while the rest consists of natural areas, including lakes, watercourses, heath, etc.

The Danish climate is temperate with precipitation evenly distributed over the year. The mean annual temperature is 8.7ºC and mean annual precipitation is 759 mm.

From 1990 to 2021 the Danish economy grew at an average annual growth rate of 1.7% measured in GDP (fixed prices). In 2008, 2009 and 2020 the economy contracted by 0.5%, 4.9% and 2.0% respectively. In 2021, the economy showed a positive growth rate again with a growth rate of 4.9%. In 2021, GDP (in current prices) was DKK 2,504 billion, corresponding to DKK 428 thousand per capita (1 Euro = approximately DKK 7.43 in 2022).

1.1.2 Energy, transport, the household sector and the business sector

Denmark is no longer self-sufficient in energy, due primarily to the decrease in production of oil and gas in the North Sea. Renewable energy is increasingly contributing to the energy supply.

Despite the economic growth, total energy consumption has remained largely unchanged at between 800 PJ and 900 PJ since 1980, however with a decrease below 800 PJ since 2011 – partly due to an increase in net imports of electricity and partly due to energy savings. Denmark's dependence on oil and coal has fallen, and particularly within electricity and heat production, Denmark has succeeded in substituting with other fuels. For 2021, 41.8% of the observed gross consumption of energy was supplied by renewable energy (for 2020, 39.5% and according to the EU methodology 31.7% in 2020). The renewable energy resources are mainly wind energy and biomass, which are used to produce electricity, combined heat and power, or district heating.

The observed energy consumption in 2021 was 705 PJ. In 2020, energy production and supply alone accounted for 19% of Denmark's total emissions of greenhouse gases (excluding LULUCF), primarily CO_2.

The energy consumption in the household sector primarily comprises heating and electricity consumption. Since 2000 the net heat demand per m^2 has decreased and was in 2021 approx. 24.5% below the level in 1990. In the period 1990-2021 the economic development in total private consumption showed a 64.5% increase, whereas total household electricity consumption increased by 9.0% only.

Denmark is a relatively small and densely populated country with a large share of the population living in cities. This influence the transport activity in Denmark.

Industry's production value accounted for about 19.4% of total production in 2020. The largest sectors of industry are the food, drink and tobacco, engineering industries (furniture/machinery/metal/electronics), and phamaceutical/chemical industries. By far the largest part of the greenhouse gas emissions in the business sector, is CO_2 from energy consumption, which in 2021 accounted for about 20% of Denmark's observed emissions of CO_2 related to energy consumption.

1.1.3 Waste, agriculture and forestry

The waste sector's methane emissions accounted for 2.0% of the total greenhouse gas emissions in 2020. Methane emissions from the waste sector are expected to fall in the future due to the obligation the municipalities have had since 1997 to send combustible waste for incineration. In addition, gas from a number of landfill sites is used in energy production, which helps to reduce both CO_2 and methane emissions.

The agricultural area in Denmark has fallen from 72% of the total area in 1960 to 61% in 2021. The number of farms has fallen by 69% from 1980 to 2021, while the average size of farms has increased by 246% in the same period, from 24 ha to 83 ha. At approximately 10%, agricultural exports still make up a large proportion of Denmark's total exports .

Approximately 15% of Denmark is forested, and the Forestry Act protects a very large part of the existing forest from other land use. The ambition is to have about 25% of Denmark's area forested by the end of the 21st century.

1.1.4 Greenland and the Faroe Islands

Greenland is the world's largest island, with an area of 2.2 mill. km^2, 81% of which is covered by the ice sheet. From north to south, Greenland extends over 2,600 km. Greenland has a population of around 56,400, and fishing is the main occupation.

Greenland's climate is Arctic. The warmest recorded temperature since 1958 is 25.9ºC, while temperatures can fall to below -70ºC on the inland ice sheet.

The Faroe Islands consist of 18 islands with a total area of 1,399 km^2 and have a population of around 53,600. The climate is characterised by mild winters and cool summers and the weather is often moist and rainy. The mean annual temperature is 7.0ºC in Tórshavn.

The Faroe Islands is a modern, developed society with a standard of living comparable to other Nordic countries. Fishery and fish farming along with the related industries, are of such importance that their influence determines the overall performance of the Faroese economy. The export of demersal and pelagic fish together with the export of salmon amounts to over 90 % of the total export of the Faroe Islands. In the last few years tourism has started to grow and the tourist industry today amounts to around 2,5 % of the total gross value added of the Faroese economy.

1.2 GREENHOUSE GAS INVENTORY INFORMATION

Denmark's greenhouse gas inventories are prepared in accordance with the guidelines from the Intergovernmental Panel on Climate Change (IPCC).

Table 1.1 shows Denmark's, Greenland's and Faroe Islands' total emissions of the greenhouse gases CO_2, CH_4 and N_2O and the industrial gases HFCs, PFCs and SF_6 from 1990 to 2020, calculated in CO_2 equivalents in accordance with the general rules for inventories under the Climate Convention.

Table 1.2 shows Denmark's total emissions of the greenhouse gases CO_2, CH_4 and N_2O and the industrial gases HFCs, PFCs and SF_6 from 1990 to 2020, calculated in CO_2 equivalents.

TABLE 1.1 DENMARK'S, GREENLAND'S AND THE FAROE ISLANDS' TOTAL EMISSIONS AND REMOVALS OF GREENHOUSE GASES, 1990 - 2020
Source: *Nielsen et al. (2022a).*

GREENHOUSE GAS EMISSIONS	1990	1995	2000	2005	2010	2015	2020
		CO_2 equivalent (kt)					
CO_2 emissions without LULUCF	54879	62690	55641	52974	50732	36544	29948
CO_2 emissions with LULUCF	61453	67806	60511	57831	52953	37093	32806
CH_4 emissions without LULUCF	7954	8362	8229	8016	7689	7210	7165
CH_4 emissions with LULUCF	8216	8615	8472	8249	7917	7441	7403
N_2O emissions without LULUCF	8555	7761	7378	5987	5684	5732	5816
N_2O emissions with LULUCF	8626	7828	7435	6035	5728	5781	5864
HFCs	NO,NE,NA	258	773	928	859	518	482
PFCs	NO,NA	1	23	19	10	0	0
Unspecified mix of HFCs and PFCs	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA
SF_6	42	104	57	21	37	122	46
NF_3	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA
Total (without LULUCF)	71430	79175	72101	67944	65011	50125	43458
Total (with LULUCF)	78338	84611	77271	73082	67505	50954	46601
Total (without LULUCF, with indirect)	72550	80232	72939	68628	65501	50438	43695
Total (with LULUCF, with indirect)	79458	85668	78109	73766	67994	51267	46838
GREENHOUSE GAS SOURCE AND SINK CATEGORIES	**1990**	**1995**	**2000**	**2005**	**2010**	**2015**	**2020**
		CO_2 equivalent (kt)					
1. Energy	53725	61699	54928	52261	50687	35891	28778
2. Industrial processes and product use	2345	2901	3707	2792	1937	1889	2076
3. Agriculture	13440	12821	11974	11547	11171	11193	11368
4. Land use, land-use change and forestry	6908	5436	5170	5138	2494	829	3143
5. Waste	1920	1753	1492	1344	1216	1153	1235
6. Other	NO	NO	NO	NO	NO	NO	NO
Total (including LULUCF)	78338	84611	77271	73082	67505	50954	46601

Note: NO: Not Occuring, NE: Not Estimated (partly), NA: Not Applicable (partly)

1.2.1 Carbon dioxide, CO_2

Most CO_2 emissions come from combustion of coal, oil and natural gas in energy industries, residential properties and in manufacturing industry (44% in 2015). Road transport is also a major contributor. For total transport, the share was 42% in 2020). The relatively large fluctuations in the emissions from year to year are due to trade in electricity with other countries - primarily the Nordic countries.

In 2020, total actual CO_2 emissions inventoried under the Climate Convention for Denmark, excluding land-use change and forestry (LULUCF) and indirect CO_2, were about 47 % lower than in 1990. If LULUCF and indirect CO_2 is included, net emissions were about 49 % lower.

The reduction since 1990 is due, in particular, to a significant change in the use of fuels in energy production from coal to natural gas and renewable energy, more widespread use of CHP and improved energy efficiency.

1.2.2 Methane, CH_4

Anthropogenic methane emissions primarily stems from agriculture, landfills and the energy sector, among which agriculture contributes the most by far. The emissions from agriculture are due to enteric fermentation in farm animals and the handling of manure. Over the time series from 1990 to 2020, the emission of CH_4 from enteric fermentation has decreased by around 9 % due to a decrease in the number of cattle. However, in the same period the emissions from manure management increased by around 18 % due to a change in animal housing systems from traditional systems with solid manure towards slurry-based housing systems.

Emissions of methane from landfills are decreasing, because the production of methane has fallen year by year since the ban on landfilling of combustible waste in 1997.

The emissions from energy production have been rising with increasing use of gas engines. However legislation establishing emission limits for existing gas-driven engines and decreased use of gas engines has resulted in lower emissions.

In 2020, total methane emissions were 10% below the 1990 level.

1.2.3 Nitrous oxide, N_2O

Agriculture constitutes the largest source by far of nitrous oxide emissions since it can be formed in the ground, where bacteria convert nitrous compounds from fertiliser and manure. Bacterial conversion of nitrogen also occurs in drain water and coastal water due to leaching and run off. From 1990, nitrous oxide emissions from agriculture have decreased by 25 % due to legislation to improve the utilisation of nitrogen in manure. A small share of nitrous oxide emissions originates from power and district heating plants, and cars with catalytic converters.

In 2020, total nitrous oxide emissions were 32% below the 1990 level.

1.2.4 The industrial gases HFCs, PFCs and SF_6

The contribution of f-gases (HFCs, PFCs and SF_6), to Denmark's total emissions of greenhouse gases is relatively modest. However, the emissions of these gases increased significantly during the 1990s. HFCs, which are primarily used in refrigeration and air conditioning, are the biggest contributor to f-gas emissions. From 1995 to 2020 annual emissions of HFCs increased from 241 to 335 Gg of CO_2 equivalents. However, emissions of HFCs peaked at 989 kt of CO_2 equivalents in 2009.

The total emissions of HFCs, PFCs and SF_6 increased by 5% from 1995 to 2020.

1.2.5 Total Danish emissions and removals of greenhouse gases

In 2020, the total Danish emissions (i.e. without Greenland and the Faroe Islands) were estimated to 41,509 kt of CO_2 equivalents (excl. LULUCF). If greenhouse gas emissions by sources and removals by sinks from forests and soils are included (i.e. with LULUCF), then net total Danish greenhouse gas emissions excluding indirect CO_2 corresponded to 44,616 kt of CO_2 equivalents in 2020 – including indirect CO_2 to 44,853 kt of CO_2 equivalents in 2020.

Of the total Danish greenhouse gas emissions in 2020, CO_2 made up 69.7%, methane 16.5%, nitrous oxide 12.9%, and f-gasses 0.9.

TABLE 1.2 DANISH GREENHOUSE GAS EMISSIONS AND REMOVALS BY GAS AND SOURCE AND SINK CATEGORIES IN 1990 - 2020
Source: *Nielsen et al. (2022a).*

GREENHOUSE GAS EMISSIONS	**1990**	**1995**	**2000**	**2005**	**2010**	**2015**	**2020**
		CO_2 equivalent (kt)					
CO_2 emissions without LULUCF	53,585	61,614	54,306	51,535	49,204	35,228	28,282
CO_2 emissions with LULUCF	60,125	66,695	59,141	56,356	51,389	35,741	31,103
CH_4 emissions without LULUCF	7,906	8,314	8,182	7,969	7,642	7,164	7,117
CH_4 emissions with LULUCF	8,169	8,567	8,425	8,202	7,870	7,394	7,356
N_2O emissions without LULUCF	8,468	7,676	7,291	5,899	5,598	5,648	5,729
N_2O emissions with LULUCF	8,539	7,743	7,349	5,947	5,642	5,697	5,777
HFCs	NO,NA	258	766	909	837	467	335
PFCs	NO,NA	1	23	19	10	0	0
Unspecified mix of HFCs and PFCs	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA
SF_6	42	104	57	21	37	121	46
NF_3	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA
Total (without LULUCF)	**70,002**	**77,967**	**70,625**	**66,351**	**63,328**	**48,628**	**41,509**
Total (with LULUCF)	**76,875**	**83,368**	**75,760**	**71,453**	**65,786**	**49,420**	**44,616**
Total (without LULUCF, with indirect)	**71,122**	**79,024**	**71,463**	**67,034**	**63,817**	**48,941**	**41,746**
Total (with LULUCF, with indirect)	**77,995**	**84,425**	**76,598**	**72,136**	**66,275**	**49,733**	**44,853**
GREENHOUSE GAS SOURCE AND SINK CATEGORIES	**1990**	**1995**	**2000**	**2005**	**2010**	**2015**	**2020**
		CO_2 equivalent (kt)					
1. Energy	52,425	60,620	53,589	50,818	49,155	34,571	27,106
2. Industrial processes and product use	2,343	2,899	3,698	2,770	1,913	1,835	1,925
3. Agriculture	13,338	12,719	11,871	11,443	11,069	11,092	11,268
4. Land use, land-use change and forestry	6,874	5,401	5,135	5,102	2,458	792	3,107
5. Waste	1,896	1,729	1,467	1,319	1,191	1,130	1,210
6. Other	NO	NO	NO	NO	NO	NO	NO
Total (including LULUCF)	76,875	83,368	75,760	71,453	65,786	49,420	44,616

Note: NO: Not Occuring, NE: Not Estimated (partly), NA: Not Applicable (partly)

1.2.6 Greenland's emissions and removals of greenhouse gases

In 2020, Greenland's total emission of greenhouse gases excluding LULUCF was 575.35 kt CO_2 equivalent, and 576.69 kt CO_2 equivalent including LULUCF.

Stationary combustion plants (77.1 %) and transport (16.2 %) represent the largest categories. The net CO_2 emission from forestry etc. was 0.2 % of the total emission in CO_2 equivalents in 2020. Total GHG emissions in CO_2 equivalents excluding LULUCF have decreased by 11.9 % from 1990 to 2020 and decreased 11.7% including LULUCF.

1.2.7 The Faroe Islands' emissions and removals of greenhouse gases

In 2020, the Faroe Islands' total emission of greenhouse gases including LULUCF was 1,409 kt CO_2 equivalent.

The main part - i.e. 81 % - of the emissions were from the fuel consumption including waste incineration in the energy sector in 2020. Almost 10 % were from Industrial processes and Product Use, 6 % from Agriculture, 2 % from LULUCF and 1 % from Waste. The fluctuations in the GHG emissions in the Energy sector are decisive for the fluctuations in the total GHG emissions. The emissions from the Waste, Agriculture and LULUCF sectors are relative small and constant. Emissions from Industrial processes and Product Use have increased significantly since 2012. In 2020, the total emissions were 65 % above 1990, the base year.

1.2.8 The national system for the estimation of greenhouse gas emissions

In pursuance of Article 5, Section 1 of the Kyoto Protocol, the Parties to the Protocol shall establish national systems for the estimation of greenhouse gas emissions.

The Danish Centre for Environment and Energy (DCE) is responsible for producing the Danish greenhouse gas emission inventories and the annual reporting to the UNFCCC and the DCE has been designated the single national entity under the Kyoto Protocol. DCE is therefore the contact point for Denmark's national system for greenhouse gas inventories under the Kyoto Protocol.

The work on the annual inventories is carried out in cooperation with other Danish ministries, research institutes, organisations and private enterprises.

The Danish emissions inventory is based on the 2006 IPCC guidelines for calculation of greenhouse gas emissions and the European CORINAIR program for calculation of national emissions. Generally, emissions are calculated by multiplying the activity data (e.g. fuel consumption, number of animals or vehicles) by an emission factor (e.g. the mass of material emitted per unit of energy, per animal or per vehicle).

Uncertainty in the greenhouse gas inventories is calculated as recommended in the IPCC guidelines and covers 100% of total Danish greenhouse gas (GHG) emissions. The result of the calculations shows that total GHG emissions were calculated to have an uncertainty of 14.0% and the uncertainty in the trend in GHG emissions since 1990 was calculated to be ± 3.1 %. The uncertainties are largest for N_2O emissions from stationary combustion and agricultural land and CH_4 emissions from enteric fermentation and solid waste disposal on land.

As part of the national system, DCE is drawing up a manual to use in quality assurance and quality control of the emission inventories.

DCE produces an annual report (National Inventory Report) for the Climate Convention in which the results of the calculations are presented and the background data, calculation methods, plan for quality assurance and control, uncertainty and recalculations are described and documented.

Over the years, improvements have been made regarding the quality and documentation of the greenhouse gas inventory as a result of the quality assurance and control procedures and the evaluations of national and international experts.

1.2.9 The National Registry for accounting of assigned amounts and credits from sinks and JI- and CDM-projects

Denmark's national allowances registry and other EU Member States national allowances registers are part of the EU emissions trading scheme, which entered into force on 1 January 2005. The 16th of October 2008 the EU ETS was included in the international emissions trading system under the Kyoto Protocol after successful connection to the International Transaction Log. As of June 2012 the EU ETS operations were centralized into a single European Union registry operated by the European Commission and as of December 2012 the Danish Business Authority has been responsible for administering the Danish KP Registry as well as Danish accounts in the consolidated EU ETS Registry.

Since Denmark's Seventh National Communication to the Climate Convention was published, only minor changes have occurred regarding the National Registry.

1.2.10 Trends in Danish greenhouse gas emissions from the base year under the Kyoto Protocol

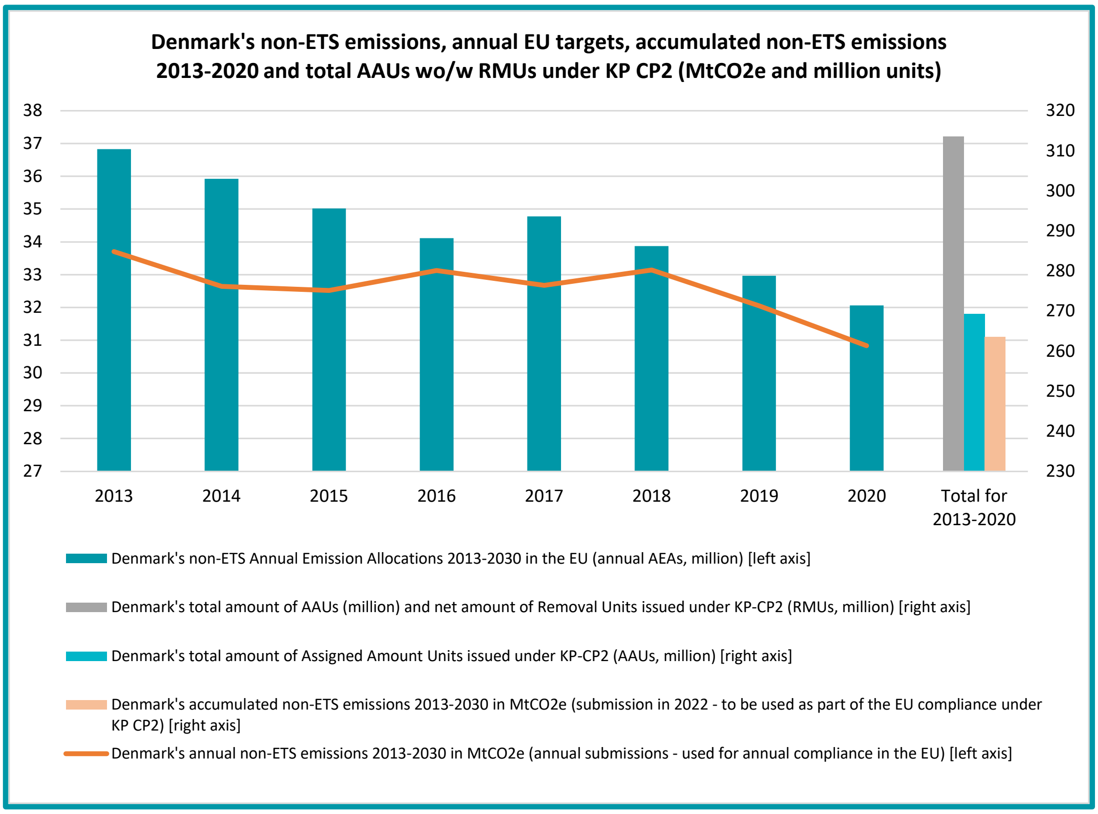
In relation to the protocol's second commitment period 2013-2020, the quantified emission limitation and reduction commitment (QELRC) for the European Union, its member States and Iceland will be fulfilled jointly in accordance with Article 4 of the Kyoto Protocol.

Denmark's contribution to fulfil the commitments of the European Union, its Member States and Iceland under Article 3 of the Kyoto Protocol in the second commitment period 2013-2020 was determined by an agreement under Article 4 of the Kyoto Protocol.

In Figure 1.1, Denmark's total non-ETS emission for the period 2013-2020 is shown together with Denmark's assigned amount, holdings of other KP units and the net-issuance of Removal Units (RMUs). With an excess of approximately 5.8 million AAUs, it is expected that also the final compliance assessment after the so-called "true-up" period will show, that Denmark is in compliance with the reduction target under the Kyoto Protocol's second commitment period.

In addition, and in accordance with the rules adopted for the 2nd commitment period of the Kyoto Protocol, a net amount of 44.3 million RMUs have been issued from the LULUCF activities in Denmark 2013-2020. This is also illustrated in Figure 1.1 as total issuance of units (AAUs plus net-RMUs) under the 2nd commitment period of the Kyoto Protocol.

FIGURE 1.1: GREENHOUSE GAS EMISSIONS IN DENMARK'S NON-ETS SECTORS 2013-2020, ANNUALLY AND ACCUMULATED, DENMARK'S TARGET PATH IN THE EU AND THE TOTAL AMOUNT OF AAUS UNDER 2ND COMMITMENT PERIOD OF THE KYOTO PROTOCOL



Note that both the left and right y axis does not begin at 0.

1.3 POLICIES AND MEASURES

1.3.1 Denmarks climate policy

Since the Brundtland Commission's report, "Our Common Future", from 1987, Denmark's climate policy has developed in collaboration with the different sectors of society, and in line with international climate policy, and results from related scientific research.

Thus, since the end of the 1980s a considerable number of measures to reduce emissions of greenhouse gases have been implemented.

Some of the measures have been implemented with reduction of greenhouse gas emissions as the main objective, others were aimed at achieving environmental improvements for society in general, e.g. by introducing environmental taxes and involving the public in the debate and decisions concerning the environment.

Since 2001, focus has also been on efforts to reduce emissions and meet the near-term international greenhouse gas emission reduction targets – i.e. for 2008-2012 under the first commitment period of the Kyoto Protocol and the EU Burden Sharing and for 2013-2020 under the second commitment period of the Kyoto Protocol and the EU Effort Sharing Decision and for 2021-2030 under the Paris Agreement and the EU burden sharing of the EU National Determined Contribution through the EU

Effort Sharing Regulation – with view to meet the long-term EU target: a climate-neutral society by 2050.

In relation to the period 2013-2020, Denmark was committed to a reduction in non-ETS emissions rising to 20% by 2020 relative to 2005. Furthermore, Denmark was committed to reach a 30% share of renewables in energy use by 2020.

In relation to the period 2021-2030, and as part of the EU's so-called Intended Nationally Determined Contribution under the Paris Agreement, Denmark is committed to a reduction in non-ETS emissions rising to 50% by 2030 relative to 2005. Furthermore, Denmark will allocate funds that sets a course towards a Renewable Energy share of approximately 55% in energy use by 2030.

The current framework for Denmark's energy and climate policy is the Danish Climate Act adopted by the Danish Parliament in 2020.

Central in the Danish Climate Act are the goals of reducing Danish greenhouse gas emissions by 70 per cent in 2030 compared to the 1990 level, and reaching climate neutrality by 2050 at the latest. The Danish government pursue to advance the climate neutrality target to 2045, and set a target of 110 per cent reduction in 2050 compared to 1990 level.

After the adoption of the Climate Act, more than 75 green agreements have been concluded and over DKK 110 billion has been prioritized to the major climate agreements. This include for example, agreements on a high and more harmonized CO2e tax for industry etc., a significant expansion of Denmark's renewable energy production and a binding reduction target for the agriculture and forestry sector, which will all contribute significantly to achieving the 70 per cent target.

Danish climate policy is based on two pillars – the European and the national.

The EU determins a large part of the framework conditions, in the form of e.g. objectives, requirements and quota trading system under which the Danish climate effort operates. Common climate regulation in the EU can be to the advantage of Denmark, as it creates more uniform conditions of competition and export opportunities for Danish companies.

The EU has an overall climate target to lower total CO_2e emissions by at least 55 per cent in 2030 compared to the 1990 level. As a follow-up to the EU's 2030 climate goals, the EU Commission presented the so-called Fit for 55 legislative package in July 2021, which has since been supplemented with additional EU proposals in December 2021 (the so-called "Winter package"). Fit for 55 contains a large number of proposals that involves a historically broad revision of the EU's climate and energy regulation, as well as new regulation being proposed within, among other things, transportation. A large number of the Fit for 55 negotiations have been completed. The final agreements between the Council and the European Parliament on the building directive, the hydrogen and gas market package and the methane regulation are expected to be reached during 2023.

1.3.2 Legislative arrangements and enforcement and administrative procedures

The legal basis for the division of powers into the legislative, executive, and judicial power is the Danish Constitution, *Danmarks Riges Grundlov*.

The Constitution includes the legal basis for how the Regent acts on behalf of the Realm in international affairs, and he cannot act without the consent of the Folketing in any way that increases or restricts the area of the Realm, or enter into obligations requiring cooperation of the Folketing or which in some other way are of great significance to the Realm. Neither can the Regent, without the consent of the Folketing, cancel an international agreement entered into with the consent of the Folketing.

1.3.3 Policies and measures and their effects

Allowance regulation

For many of the energy producers and a large part of the energy-intensive industry, the Danish implementation of the EU Directive establishing a scheme for greenhouse gas emission allowance trading within the Community form the framework for Danish efforts (EU ETS). The companies that are covered by the scheme, and whose activity thus is limited by a quota, can plan their climate action themselves. They can choose to reduce their own emissions when this is most appropriate, or they can buy allowances or credits from project-based emission reductions when this is considered most appropriate. The companies covered by the scheme will thus have the possibility of ongoing adjustment of their action so that it is always as effective as possible.

After phase 1 (2005-2007), phase 2 (2008-2012) and phase 3 (2013-2020), the EU ETS is now in phase 4 (2021-2030). The allowances for the installations in the EU ETS have been calculated in accordance with the EU legislation. The legislative framework of the EU ETS for its next trading period 2021-2030 (phase 4) was revised in early 2018 to enable it to achieve the EU's 2030 emission reduction targets in line with the 2030 climate and energy policy framework and as part of the EU's contribution to the 2015 Paris Agreement.The Fit for 55 package endorsed on 8 February 2023 by the Permanent Representatives Committee proposes to revise several pieces of EU climate legislation, including the EU ETS, setting out in real terms the ways in which the Commission intends to reach EU climate targets under the European Green Deal. The revised EU ETS Directive, which will apply for the period 2021-2030, will enable this through a mix of interlinked measures eg. a mayor revision of EU ETS as well as inclusion of ETS Maritime and ETS Transport, Building and Industries.

The Kyoto Protocol mechanisms

For the period 2008-2012, the flexible Kyoto Protocol mechanisms have been important elements in supplementing domestic reduction measures aimed at fulfilling the international climate commitment under the Kyoto Protocol and the subsequent EU Burden Sharing Agreement.

For the period 2013-2020, the government has not used the flexible Kyoto Protocol mechanisms for the achievement of Denmark’s target under the EU Effort Sharing

Decision - also to be seen as Denmark's contribution to the EU joint target under the 2nd commitment period of the Kyoto Protocol.

Taxes and duties

The levels of taxes and duties are also having an effect on several greenhouse gas emitting activities across sectors. Denmark has special taxes on motor vehicles, energy products, alcohol, tobacco, and a number of other products. During the 1990s a number of new environmental taxes were introduced. These taxes were placed on consumer goods that caused pollution or were scarce (water, energy products such as such as oil, petrol, electricity, etc.) or on discharges of polluting substances (CO_2, HFCs, PFCs, SF_6, SO_2, and sewage). Taxes are imposed on mineral oil, tobacco, and alcohol in accordance with EU legislation.

The new cross-sectoral focus on Carbon Capture and Storage and Green Research

In 2022, Denmark adopted a so-called green tax reform with the objective of achieving a reduction of 4.3 million tonnes of CO_2 emissions annually by 2030. This green tax reform entails the introduction of a more consistent CO_2 tax structure.

By 2030, companies outside the EU's Emissions Trading System (ETS) will face a uniform CO_2 tax rate of 750 DKK/tonne, while ETS companies will be subject to a CO_2 tax rate of 375 DKK/tonne. Notably, mineralogical processes, particularly subject to risks of carbon leakage, will be subject to a reduced tax rate of 125 DKK/tonne. As part of the reform, tax revenues generated would be allocated to support further reductions and removals, for example through Carbon Capture and Storage (CCS) initiatives. Approximately 17 billion DKK are expected to be allocated for a CCS funding scheme between 2026 and 2043. The CCS funding scheme is expected to achieving reduction/removals of 1.8 million tonnes of CO_2 emissions annually by 2030.

The allocation of research funding in Denmark's government budget is subject to annual negotiation among the Parties in the Danish parliament, based on a proposal presented by the government.

In recent years, the Danish research and innovation policy has placed a strong emphasis on addressing climate challenges and contributing to the goals defined in the Danish Climate Act.

The 2022 budget includes a research reserve agreement of DKK 2.4 billion, with budgetary reservations extending from 2023 to 2025.

The energy sector

Energy production and energy-consuming activities in the different sectors are the main contributors to the total emissions of CO_2 due to use of coal, oil and natural gas. The energy sector is therefore pivotal in the efforts to reduce the emissions of CO_2.

Many initiatives have been taken over the years to reduce the emissions, and work is still going on to find the best and most cost-effective measures with the objective to fulfil Denmark's international climate obligations.

Danish experience shows that through persistent and active energy policy focus on enhanced energy efficiency and conversion to cleaner and renewable energy sources, it is possible to sustain high economic growth and at the same time reduce fossil fuel dependency and protect the environment.

The energy sector is fully liberalised. Today, electricity production from Danish power plants is controlled by market forces. Danish electricity generation is traded freely across national borders on the Nordic and the north-German electricity markets. Thus there is a significant extent of integration in the Northern European electricity market. This entails, for example, that increased use of renewable energy in the Danish electricity system or enhanced efforts to save electricity do not automatically mean that generation at coal-fired power plants is reduced correspondingly during the first commitment period of the Kyoto Protocol 2008-2012.

The introduction of the CO_2 allowance regulations through the EU emissions trading scheme (EU ETS) has been pivotal for Denmark’s possibilities to comply with the climate commitments. The EU ETS constitutes a central instrument in ensuring that the Danish energy sector is enabled to provide the reductions required if Denmark is to comply with its climate obligations. At the same time, the EU ETS permits significant improvements to the cost effectiveness of Denmark's climate effort.

The government’s long-term objective is to become a nation with an energy supply solely based on renewable energy sources and thus independent of fossil fuels.

The objective of the Danish energy policy today is security of supply, environmental concerns, energy savings and well-functioning energy markets within frameworks that secure cost effectiveness. Several initiatives often meet more than one of the purposes mentioned at the same time. Efforts concerning climate change should thus be seen in a broader context than CO_2 alone, not least when it comes to the purpose and calculation of effects.

Denmark gave priority to renewable energy sources and energy efficiency early on. Most of the public support schemes and regulations have prioritised energy efficiency and renewable energy.

A vast range of measures have been applied over the years to achieve the various energy policy objectives mentioned above.

Taxes have been used for a number of years as measures which also lead to a reduction of the CO_2 emissions from the energy sector - partly with a view to a general reduction and partly to promote the use of fuels with lower CO_2 emissions, mainly biomass. This includes lower CO_2 emissions, e.g. natural gas and biomass. Such taxes are still being used.

Increased use of CHP and enlarging the areas receiving district heat have been main elements of the Danish strategy to promote efficient use of energy resources ever since the end of the 1970s.

Renewable energy sources have been promoted with economic measures, including the tax system and through production grants. The increasing use of renewable energy sources is reducing emissions of CO_2 from fossil fuels. The long term goal for the Danish government is to be a climate neutral society by 2045. In Climate Projection 2022, the estimates for 2030 are the following: approximately 63% renewable energy in gross energy consumption; approximately 109% of electricity consumption to be supplied by renewable energy; gross energy consumption will decrease slightly towards 2030; and by 2030 greenhouse gas emissions will be reduced by 57% compared to 1990. The expansion of energy from offshore wind turbines will – according to the estimated results in Climate Projection 2022 – help ensure that 64% of the nation's energy needs are met with renewable energy by 2030.

The introduction of the CO_2 allowance regulations through the EU emissions trading scheme (EU ETS) has been pivotal for Denmark's possibilities to comply with the climate commitments.

In December 2020, a broad majority in the Danish Parliament reached a deal on the future of fossil extraction in the North Sea, which led to the cancellation of the 8th licensing round and all future tender rounds to extract oil and gas. The deal also establishes a final phase-out date of fossil extraction by 2050 and lays out plans for a just transition of impacted workers.

The business sector

In addition to the key instrument - allowance regulation - the ongoing initiatives to reduce the emissions from the business sector include promotion of energy savings and energy efficiency improvements, conversion of energy production to cleaner fuels and initiatives to reduce the emissions of industrial gases.

The transport sector

The transport sector's greenhouse gas emissions peaked in 2007. The baseline scenario from 2022 (Climate Projection 2022) predicts the sectors overall greenhouse gas emissions to decrease by 29% from 2007 to 2030.

The electrification of light vehicles has increased over recent years due to the technical improvements of the EV-cars as well as political action. The national measures for the transport sector aims at creating the right incentives structures as well as planning for and funding charging infrastructure on the state road network and make available the regulatory framework for a proper charging infrastructure overall. Regarding charging infrastructure, EUR 43 million have been set aside from 2020-2022 to co-fund charging infrastructure projects at housing associations as well as on private and municipal areas. Furthermore, with Infrastrukturplan 2035 (Infrastructureplan 2035), there was allocated EUR 67 million in the period 2022-2030 to the roll out of charging infrastructure along state roads.

The registration tax and the annual tax (the green owner tax), which is dependent on the energy efficiency of the vehicle as well as fuel taxes, are assessed to have had considerable effects on CO_2 emissions. With *Aftale om grøn omstilling af vejtransporten* (Agreement on green transition of the road transport) it was among other things decided to rearrange the registration tax, so it further promotes the uptake of low and zero emission cars.

The household sector

With a view to reducing both direct and indirect CO_2 emissions from the domestic sector, a wide range of initiatives have been launched. The initiatives promote electricity savings, savings in energy consumption for space heating and fuel conversion (from electric heat and oil to district heat, natural gas and renewable energy).

The portefolio of initiatives in the household sector include energy taxes, CO_2 taxes , energy labelling of buildings, energy labelling of buildings when built, sold or rented, regular energy labelling of large buildings and public buildings, minimum energy requirements and energy labelling of appliances, information initiative towards private households and support for the substitution of individual oil-based furnaces.

In June 2021, Denmark adopted part 2 of Denmark's long-term renovation strategy (LTRS) to support the renovation of the national building stock. The strategy contains two non-binding indicative milestones for 2030, 2040 and 2050. The determination of the indicative milestones are based on agreements such as the Climate Agreement for Energy and Industry etc. of 22 June 2020 and Green Housing Agreement 2020 of 19 May 2020. The strategy describes various initiatives aimed at promoting the renovation of the Danish building stock and efforts aimed at insuring energy efficiency in the national building stock.

Industrial processes

Process emission of CO_2 from cement production have since 2005 been subject to regulation under the EU ETS.

When the only nitric acid production facility in Denmark stopped in 2004, nitrous oxide emissions decreased with by approx. 0,9 mill. tonnes of CO_2 equivalents.

The regulation of emissions of the industrial greenhouse gases (HFCs, PFCs and SF_6) is 2-phased, consisting partly in a tax and partly in a statutory order on discontinuation of the use of the gases in new installations. The tax is imposed on the substances on importation because none of them is produced in Denmark.

In July 2002 a statutory order on regulation of the industrial greenhouse gases entered into force. It includes a general ban on use of the industrial greenhouse gases in a wide range of new installations/products from 1 January 2006, including, for example, domestic refrigerators and freezers, PUR foam, etc.

Agriculture, forestry and fisheries

Within the agricultural sector the following measures have reduced, or will reduce, emissions: ban on burning straw on fields, Action Plans for the Aquatic Environment I and II and the Action Plan for Sustainable Agriculture, Action Plan for the Aquatic Environment III, the Ammonia Action Plan, Action Plan for Joint Biogas Plants and subsequent follow-up programmes, Environmental Approval Act for Livestock Holdings as well as other political agreements in the past addressing the agricultural sector's emissions of greenhouse gasses. Since the last NC-reporting the political agreements have been addressing "GHG accounting and awareness building at farm-level", "Climate-friendly feed production for pigs" and "Promotion of green bio-refining" cf. the agreement of 2nd May 2019, "Multifunctional Land Reparcelling

Fund” cf. the agreement of 19th September 2019 and “Green Transition of The Agricultural Sector” cf. the agreement of 4th October , 2021 where the latter includes requirement for reduction of methane from enteric rumen fermentation, the use of feed additives, inhibiting production of methane from enteric rumen fermentation, which is expected to decrease the emissions of methane from dairy cows. The agreement from 2021 also sat the ambition of restoring and rewetting 100,000 hectares of carbon rich peat soils (from a total of 169,000-171,000 hectares) before 2030 with the purpose of reducing both greenhouse gas and nitrogen emissions from agricultural soils and forests in Denmark.

Biogas from digestion of manure and organic wastes carries a number of advantages when used to substitute fossil energy: reductions in emissions of greenhouse gases, better utilization of manure as fertiliser, recycling and use of organic wastes for energy and fertiliser purposes etc. In order to stimulate expansion of the biogas sector, financial support has been provided to investments in biogas plants since 2010 and an adjusted subsidy on the sales price of electricity production based on biogas since 2012. The 2022 greenhouse gas emission projection expects a further increase in biogas production from 27 PJ in 2021 to 38 PJ in 2025 with a peek of 49 PJ in 2030 when considering biogas facilities mainly based on agricultural sources. Findings from a project on methane leakage from biogas plants resulted in the formulation of new regulation, which was put into effect 1 January 2023. The regulation dictates the reporting of annual mandatory leak detection and repair to the Danish Energy Agency, regular self-monitoring, as well as a 1 % limit on methane loss from upgrading facilities.

The LULUCF sector

The emission of GHGs from the LULUCF sector (Land Use, Land Use Change and Forestry) includes primarily the emission of CO_2 from land use and small amounts of N_2O from disturbance of soils not included in the agricultural sector.

The LULUCF sector is subdivided into six major categories:

- Forest
- Cropland
- Grassland
- Wetlands
- Settlements
- Other Land

Forests and forestry are important due to CO_2 sequestration and emissions as a consequence of trees growing, respiring and decomposing. Danish forests contain a considerable store of CO_2 absorbed from the atmosphere. When new forests are established, new CO_2 stores are created. Afforestation is therefore a useful climate policy instrument.

The national forest programme includes evaluation of the possibilities offered by the Kyoto Protocol for economically viable CO_2 sequestration in forests. The political goal with the most direct influence on increased carbon sequestration is the declaration of intent from 1989 to double the forested area in Denmark within 100 years. Various measures have been taken towards achieving this goal. As part of the Common Agricultural Policy Reform 2022-2027, DKK 600 million has been allocated to afforestation. In 2022, the government announced in its government platform that it will present an ambitious forest plan for the establishment of 250.000 hectares of new forest in Denmark. Establishment of new forests will contribute to reaching climate neutrality and, in time, net negative emissions.

For the agricultural soils and land-uses measures such as ban on burning straw on fields and support for planting of windbreaks have reduced, or will reduce CO_2 emissions and enhance CO_2 sequestration.

The waste sector

The waste sector's contribution to reduction of greenhouse gas emissions consists mainly in: reducing landfilling of organic waste, utilising gas from discontinued/existing landfill sites and the waste as an energy source.

The Statutory Order on Waste was amended from 1 January 1997, to introduce a municipal obligation to assign combustible waste to incineration (corresponding to a ban on landfilling combustible waste). As a result of this, large quantities of combustible waste that used to go to landfill sites are now either recycled or used as fuel in Denmark's incineration plants.

In 2005, the Danish EPA supported initiation of a development project aiming at documenting the oxidation of methane in landfill biocovers. On the basis of many years of research the Technical University of Denmark has established a viable methodology for documentation of greenhouse gas emissions reductions achieved through the installation of a bio-cover system on landfills. Furthermore, methane generated from waste in some Danish landfills gets collected (to the extent possible) in dedicated gas collection systems and is used for energy generation.

1.3.4 Policies and measures in accordance with Article 2, of the Kyoto Protocol

Denmark's climate efforts – a step on the way to sustainable development

In 2015, United Nation countries adopted the 2030 Agenda for Sustainable Development and its 17 Sustainable Development Goals. In June 2021, an updated action plan, including new policy initiatives, was published. One example is the policy of screening all new bills for their impact relating to the Sustainable Development Goals. In June 2021, also Denmark's second Voluntary National Review was published with an assessment of the progress since the first review in 2017.

Efforts for international air transport and shipping

Denmark recognises that the international aviation and maritime transport sectors are large and rapidly growing sources of greenhouse gas emissions and have to be dealt with at all levels.

Denmark recognizes that the International Civil Aviation Organization (ICAO) has taken measures to reduce greenhouse gas emissions from the aviation sector by introducing the Carbon Offsetting and Reduction Scheme for International Aviation

(CORSIA) and by adopting a long term aspirational goal (LTAG) for international aviation of net-zero carbon emission by 2050. However, Denmark emphasizes that the measures taken by ICAO are insufficient and that ambition should be ramped up significantly.

Denmark welcomes that the IMO in July 2023 adopted the 2023 IMO Strategy on Reduction of GHG Emissions from Ships. The 2023 revision on the IMO GHG strategy significantly increase the levels of ambitions and brings them in line with the Paris Agreement's temperature goal. Denmark has both in the preparatory work and during negotiations contributed actively to the work on developing of the 2023 IMO Strategy on reduction of GHG emissions from ships.

Efforts to limit adverse effects in other countries

In connection with Denmark's contribution to international climate efforts, in accordance with the Kyoto Protocol Denmark will endeavour to implement policies and measures under article 3 of the Protocol in such a way that adverse effects in other countries are minimised.

1.3.5 Greenland

High basic energy demands and the expected emergence of an industrial sector indicate that Greenland's energy consumption is unlikely to decrease significantly over the coming years. Nevertheless, an existing hydropower plant is to be expanded while a new plant is to be built in the coming years. Government policies aim at reducing energy consumption, where possible, and to improve efficiency in existing energy production and supply.

During the last decades it has been a consistent priority to expand the use of renewable energy and today approximately 66% of the national energy supply is based on hydropower. Concurrently, potentials for wind energy, solar energy and hydrogen-based energy production are being explored on a smaller scale with possibilities for future expansion.

Policies and measures targeting energy production and energy consumption have multiple purposes. In addition to emission reductions, the shift to renewable energy sources is associated with a decreasing dependence on imported fossil fuels and positive effects on the local and regional environment. Improving the efficiency of the current energy production and supply system is cost-reducing and at the same time contributes to reducing GHG emissions. Energy-saving policies, acts and measures are therefore often designed to address a wider range of priorities; of which the reduction of GHG emissions remains predominant.

1.3.6 Faroe Islands

The Climate Convention was ratified by the Realm, and therefore applies for the Faroe Islands. When ratifying the Kyoto Protocol in 1997 the Danish government took a territorial reservation for the Faroe Islands. The Faroese Government decided in 2016 to become a party to the Paris Agreement.

In 2019, the Faroese Ministry of Health and the Interior presented a proposal for a new Climate and Energy Policy for the Faroe Islands 2020 to 2030. The plan was never politically adopted but worked partly as a foundation for a new working group with members from the Faroese Environment Agency and the Ministry of Environment, Trade and Industry who in 2021 delivered a proposal to a new Climate and Energy Policy, which The Faroese Parliament adopted in May 2022, now covering the years 2022-2032 and containing 25 measures to reduce the emission of greenhouse gases.

1.4 PROJECTIONS AND THE TOTAL EFFECT OF POLICIES AND MEASURES

In 2022, the 2022 baseline scenario with a projection of Denmark’s greenhouse gas emissions 2021-2035 – i.e. a with existing measures (WEM) or frozen policy scenario – was published by the Ministry of Climate, Energy and Utilities in *Denmark's Climate Status and Outlook 2022* - the CSO22-report (*DEA 2022)*.

Denmark's Climate Status and Outlook 2022 (CSO22) is an account of how Danish greenhouse gas emissions have developed from 1990 to 2020, 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 2035 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 or the EU before 1 January 2022, or arising out of binding agreements. The policy freeze pertains to Danish and EU climate and energy policy only, and it does not reflect the assumption that developments in general will come to a halt. For example, economic growth and demographic trends are not part of the freeze.

CSO22 thus serves to examine to what extent Denmark's climate and energy targets and commitments will be met within the framework of current regulation. CSO22 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.

Pursuant to the Danish Climate Act of 18 June 2020 (the Climate Act) a climate status and outlook report must be drawn up annually[1].

The Climate Act stipulates that Denmark is to reduce emissions of greenhouse gases by 50-54% in 2025 and 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.

As shown in Figure 1.1 total Danish greenhouse gas emissions have exhibited a downward trend since the mid-1990s. In 2020, total emissions had fallen by about 43% compared with 1990.

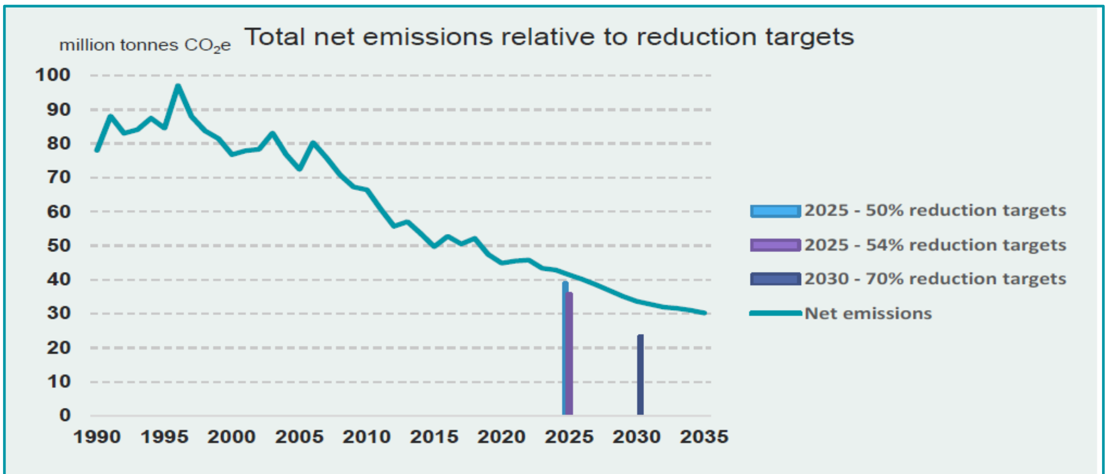
[1] The Climate Act also requires global reporting on the international impacts of Danish climate efforts. The annual global reporting for 2022 has been prepared and published as a separate publication in parallel with CSO22. References to CSO22 therefore only pertain to Denmark’s national climate status and outlook.

Progress towards the domestic targets set out for 2025 and 2030 in the Danish Climate Act

Based on policies adopted policies adopted until 1 January 2022, total net emissions are expected to have fallen to 41.4 million tonnes CO_2e in 2025 and 33.6 million tonnes CO_2e in 2030, corresponding to a reduction of 47% in 2025 and 57% in 2030 compared to the 1990 level. Thus, as things stood by 1 January 2022, the CSO22 projections reveal an estimated emissions gap of 3-7 percentage points in 2025 and 13 percentage points in 2030 compared with the reduction targets set out for 2025 and 2030 in the Climate Act. This corresponds to a shortfall of 2.4-5.5 million tonnes CO_2e in 2025 and 10.1 million tonnes CO_2e in 2030. In 2035, total net emissions are expected to have been reduced additionally to 30.2 million tonnes CO_2e.

Naturally, the projections in Denmark's Climate Status and Outlook reports are linked to uncertainty, and the uncertainty in CSO22 is particularly pronounced. This greater general uncertainty is due partly to uncertainty as to the effects of the Covid-19 pandemic and partly the effects of the current uncertainties in the energy markets following from the situation in Ukraine, which, as already mentioned, have not been included in CSO22.

FIGURE 1.1 TOTAL DANISH GREENHOUSE GAS NET-EMISSIONS (I.E. WITH LULUCF AND WITH INDIRECT CO_2) IN THE BASIC SCENARIO (WEM) AND THE 2025 AND 2030 DOMESTIC TARGETS IN THE DANISH CLIMATE ACT



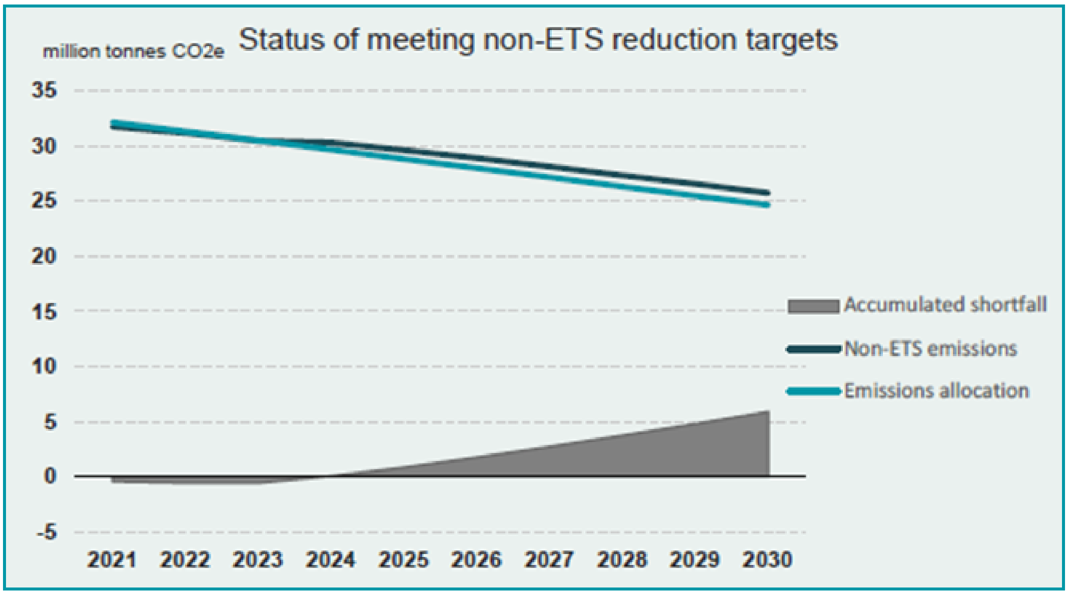
Note: The extra partial effect of higher allowance prices on emissions from refineries of around 0.08 million tonnes CO2, which has been deducted from the emissions gap for 2030 (cf. table 2.1) is not reflected in emissions estimates in this figure.

Progress towards Denmark's non-ETS target for 2021-2030 in the EU

Figure 1.2 illustrates the development in non-ETS emissions and status of progress with regard to reduction obligations. As can be seen, in the period 2021 to 2023, non-ETS emissions are expected to be lower than the emission allocations by virtue of the current reduction trajectory. On the other hand, from 2024 to 2030, non-ETS emissions are expected to be higher.

Surplus emission allocations in individual years can be transferred to later years, and, overall, this means there will be an expected cumulative emissions gap of 5.9 million tonnes CO_2e in 2030. This shortfall can be offset by implementing further climate measures or by using part of the accumulated LULUCF credits and/or EU ETS allowances.

FIGURE 1.2 STATUS OF PROGRESS TOWARDS NON-ETS REDUCTION TARGETS, 2021-30



Greenland

Greenland is likely to experience significant industrial growth over the coming years, which will impact on future emission levels. Possible sources of new emissions includes further growth in the mining industry with the establishment of new mines.

A number of exploration projects are ongoing, however the projected emissions related to these projects are subject to a significant degree of uncertainty and future scenarios have therefore not been included.

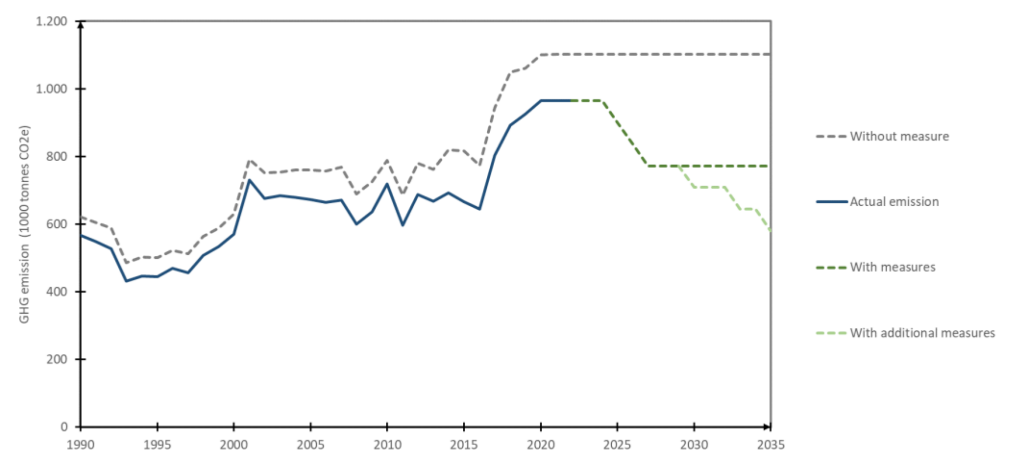
Faroe Islands

Figure 1.3 shows a simple projections for the emissions of greenhouse gases in the Energy sector (excl. Transport) in the Faroe Islands, 2022-2035.

The with measures graph, from 1990-2021, is based on actual emissions data (exported from the CRF). The with measures projection 2022-2035 is primariliy based on the estimated effect of the mitigations due to the installation of two new windmill parks, one in year 2025 (25 MW in Klivaløkshagi, Sandoy) and another in year 2026 (25 MW on Glyvrafjall, Eysturoy) and on the assumption that the total yearly emissions in 2022-2035 otherwise is the same as in 2021.

The addidtional measures graph takes into account the plan to install four windmill parks respectively in 2027, 2030, 2033 and 2035, each with 25 MW, in total 100 MW.

Figure 1.3 Faroe Island's Total Greenhouse Gas Emissions in kt in 1990-35. Emissions in 1990-2021 are observed. Emissions 2022-2035 are projected.



1.5 Vulnerability assessment, climate change impacts and adaptation measures

The climate is changing, and in all likelihood we will see more changes in the future. In the long term, the future climate is strongly dependent on the future emissions of greenhouse gasses and other substances that influence the climate. The development in greenhouse gas emissions is especially dependent on three factors: demographic development, the rate and spread of implementation of energy-efficient technologies, particularly in the energy and transportation sectors, and the socio-economic development in general. The changing climate with rising temperatures, changing precipitation patterns, an increase in extreme weather events and rising sea levels will have a broad impact on ecosystems and society in general.

Denmark is generally and has historically been a robust country in relation to climate-related incidents. This must, among other things, be seen in the context of geographical conditions, where, for example, Denmark, unlike several other European countries, does not have mountains or large rivers. Agricultural land is well-drained and many farmers are able to irrigate in dry periods. Moreover, the Danish population is aware of, and uses, systematic warning systems of extreme weather events and the consequences of such events.

Adaptation measures in Denmark

In March 2008, the Danish government launched the first Danish strategy for adaptation to a changing climate.

The strategy was followed by an action plan for a climate-proof Denmark, which was launched in December 2012. The action plan is based on the notion that a responsible climate policy must do more than just work towards limiting climate change in the long term. It must also ensure the action necessary right now to adapt our society to a climate that is already changing.

The action plan presented 64 new initiatives and gave at the same time an overview of initiatives already set in motion by the government to ensure that Denmark will become resilient to climate change.

All parts of society must contribute to climate change adaptation in Denmark. Climate change adaptation is first and foremost based on initiatives at local level and involves the local authorities, companies or individuals. The individual stakeholders know the local conditions best, and are consequently in the best position to make decisions on adaptation.

Central government itself has a responsibility as the owner of infrastructure, buildings and land. However, the principle role for central government is to establish an appropriate framework for local climate change adaptation by, for example, adapting laws and regulations, but also by ensuring coordination and providing information. A solid framework for the efforts must support the specific parties involved, so that they can address the challenge in a socio-economically appropriate manner at the right time.

From 2012-2014 the Minister for the Environment established a task force on climate change adaptation as a sounding board for the municipalities with regards to their preparation of municipal climate change adaptation plans. All 98 Danish municipalities finalised their action plans by 2014. The objective of this task force was also to ensure up-to-date data and relevant knowledge on the Danish Portal for Climate Change Adaptation www.klimatilpasning.dk.

Guidance tools for municipalities, enterprises and citizens

Central government continuously evaluates the need for guidance on climate change adaptation.

One example is the *Danish Climate Atlas*. In 2019, the Danish Meteorological Institute (DMI) launched The Danish Climate Atlas as an regional assessment of IPCC-scenarios, which provides data on municipality, drainage basin and coastal stretch levels showing future changes in temperature, precipitation, extreme precipitation, relative sea level and storm surge heights. It thereby gives an indication of areas with a particular future risk of being impacted by extremes. The tool provides fundamental climate data for planning adaptation.

Data in the Climate Atlas shows the future Danish climate in the beginning, middle and end of the century for different greenhouse gas emission scenarios. The Danish Climate Atlas is an authoritative data set on the projected physical changes in weather and climate, e.g. precipitation until it hits the ground and sea water until it hits the coast. In order to assess e.g. risk of flooding, the data in the Climate Atlas needs to be combined with local data and knowledge on ground water levels, sewers, dikes etc. to complete the full impact analyses of the changing climate conditions.

New governmental initiatives

At the end of 2022, a new Danish government took office. In the new government's work plan for its term of office, it is highlighted that despite significant efforts to counteract climate change, it is also necessary to further secure Denmark against floods and extreme weather. The government will therefore present a national climate adaptation plan, which supports that the necessary measures are implemented in a timely manner, as well as ensuring that the measures are organized as best as possible.

Adaptation measures in Greenland

The Government of Greenland is initiating projects aimed at mainstreaming adaptation efforts in the management and development of various sectors. A series of assessments of how the public sector can promote adaptation to climate change was launched in 2011. The first assessment focus on ’Opportunities for climate change adaptation in the fisheries and hunting industry’ (September 2012). The assessement is conducted on the basis of existing scientific assesments and local knowledge. The assessment report draws up a range of conlusions pointing to the fact that climate change has both direct and indirect consequences, often resulting in significant and unpredictable impacts on the fishing and hunting sector.

Efforts and actions towards the adaptation to climate change should therefore be viewed as a continuous process to be dealt with in close cooperation with the public administration, the scientific community and the industry and various local stakeholders.

An integrated adaptation and mitigation assessment of the shipping sector was completed for political deliberation in 2015.

The latest assessment ‘Opportunities for climate change adaptation in the agricultural sector’ was completed for political deliberation in June 2017. The assessment describes the consequences of climate change towards 2050 for the agricultural sector with a focus on how climate change can affect livestock, grazz production, crops and watering.

To ensure that the public, the municipalities and the businesses know about the consequences of climate change, the government of Greenland administrates the website http://climategreenland.gl/. The aim of the website is to provide an overview of some of the ways in which Greenland is affected by a changing climate and how this is dealt with.

Adaptation measures on the Faroe Islands

So far, no known adaptation measures have been implemented, nor planned in the Faroe Islands.

The University of the Faroe Islands and Tórshavn Municipality have been participants of a now completed project on climate change adaptation in regions in the Nordic countries and with regions in the United Kingdom and Ireland. The programme aimed to tackle Climate Change on local and regional levels by increasing public awareness and using models of best practices to develop Climate Adaptation Plans for local authorities. The project also tested how prepared Faroese municipalities are compared with municipalities in Sweden.

1.6 FINANCIAL RESOURCES AND TRANSFER OF TECHNOLOGY

Denmark is one of the few developed countries that fulfil the UN goal of contributing a minimum of 0.7 percent of Gross National Income (GNI) as Official Development Assistance (ODA).

In June 2021, "The World We Share" superseded "The World 2030" as Denmark's development strategy for 2021-2025. The new strategy confirms Denmark's commitment to provide 0.7 percent of GNI as ODA and makes the fight to stop climate change and restore balance to the planet one of the pillars of Danish development cooperation.

Denmark provides and mobilises climate finance to developing countries through a range of channels and instruments. Through development cooperation programmes, Denmark provides climate-relevant ODA with a particular focus on the poorest and most vulnerable developing countries. Climate-relevant ODA comprises bilateral support to a number of countries with whom we have expanded partnerships; support through Danish multi-country programmes and instruments, such as the strategic sector cooperation with other Danish authorities, Danida Sustainable Infrastructure Finance, business instruments, framework agreements with Danish civil society partners and the climate envelope; and support through dedicated climate funds and programmes, such as the Green Climate Fund, the Least Developed Countries Fund, the Sustainable Energy Facility for Africa (SEFA) or the UNEP Copenhagen Climate Centre.

In addition, Denmark mobilises climate finance through various international and multilateral development financing institutions, such as the Investment Fund for Developing Countries (IFU), the World Bank and the African Development Bank.

Denmark seeks to support both adaptation and mitigation related action with a view to contribute to sustainable development. Denmark is committed to a balance of climate finance supporting mitigation and adaptation measures. Danish support to adaptation-related activities and programmes addresses the underlying causes of vulnerability, and contribute to building resilience against crises, natural disasters and the impacts of climate change. The support also assists developing countries in their efforts to integrate adaptation and emissions reduction in their national planning, and policy preparation and implementation, including as part of a country's National Adaptation Plan (NAP) and Nationally Determined Contribution (NDC).

Through both multilateral and bilateral assistance, Denmark supports increased access to sustainable energy in developing countries, improvement in energy efficiency and improved access to climate-friendly technologies. This is done by strengthening national and local knowledge and capacity, by supporting policy development and implementation, and through support to investments in preparation and implementation of specific mitigation projects. Furthermore, Denmark offers technical assistance and advice on development of investment opportunities and by strengthening local businesses in developing countries.

A significant part of Danish climate engagements targets a range of expanded partnership countries, with whom Denmark has a long-term partnership for sustainable development. The Danish representations in partner countries have the primary responsibility for dialogue with the respective partner countries about programming and management of the development cooperation, including support to climate action. Denmark cooperates with national and local government authorities, international agencies, civil society organisations, private companies, research institutions and other relevant actors, and specific projects and programmes are identified and prepared in close collaboration with national partners.

1.7 RESEARCH AND SYSTEMATIC OBSERVATIONS

Research and observations within climate in the broad sense of the word are going on at a number of institutes and organisations and cover a wide range of disciplines, from natural science to evaluation of policies and measures and societal aspects.

The Danish Meteorological Institute (DMI) carries out observations of climate parameters (atmosphere and ocean) under the World Meteorological Organisation's (WMO) programmes and sub-programmes: the World Weather Watch Programme (WWW), Global Atmosphere Watch (GAW), the Global Observing System (GOS), the Global Climate Observing System (GCOS) and the Global Ocean Observing System (GOOS). DMI also participates in the Network for the Detection of Atmospheric Composition Change (NDACC). Climate monitoring and research has been a key task for DMI for 150 years.

Aarhus University (AU) is part of the Integrated Carbon Observation System (ICOS) monitoring greenhouse gas emissions and concentrations and the Aerosol, Clouds and Trace Gases Research Infrastructure (ACTRIS) providing data on short-lived atmospheric constituents. DCE – the National Centre for Environment and Energy, Aarhus University (AU) is in charge of monitoring the effects of climate change on nature and the environment.

The Technical University of Denmark (DTU) is a founding member and national contact point of the European Climate Research Alliance (ECRA). Denmark is currently active in ECRA's collaborative programmes via DMI (polar research) and DTU (programmes on sea level, hydrology and high impact events, where DTU coordinates the latter). DTU (Space) monitors a significant number of essential climate variables with respect to, in particular, sea ice, sea level, ice sheets, the state of the ocean and large-scale hydrological systems using remote sensing and participates in a large number of international initiatives in this regard.

KU have taken charge of the Danish parts of the three European research infrastructures: Analysis and experimentation on ecosystems (ANAEE), Long Term Ecological Research (LTER) and Integrated Carbon Observation System (ICOS).

Danish research competence concerning the physical expressions of past climate change is particularly at the Geological Survey of Denmark and Greenland (GEUS), the University of Copenhagen (KU) and Aarhus University (AU). GEUS also has competencies in glaciological studies of the Greenland ice sheet and the ice sheet's interaction with climate change, and in the effect of climate change on the water cycle in nature. The Geophysical Department and the Geological Institute at KU and the Department of Ecoscience at AU have very great expertise in palaeoclimate data, and the climate group at KU is known worldwide for its ice core drilling and analyses. The departments of Bioscience and Environmental Science at AU and Department of Biology at KU contribute important research competence in relation to the effect of climate change on ecosystems.

The National Centre for Climate Research at DMI has an extensive international scientific record within regional climate modelling and is the leading national authority on regional climate change projections. Data and knowledge about the future climate in Denmark is presented in the Danish Climate Atlas[2]. The National Centre for Climate Research also operates global climate models in order to investigate interactions and feedback mechanisms between atmosphere, ocean, land surface and ice on a larger scale. In addition to a special focus on the climate in the Kingdom of Denmark, the modelling efforts have a particular focus on the North Atlantic and the polar regions. Several other Danish institutions, notably KU, AU, GEUS and the Technical University of Denmark (DTU) also work in this field or with different aspects of climate research. The Ministry of Science, Technology and Innovation, the Coordination Unit for Research in Climate Change Adaptation and the Ministry of Climate and Energy, published in 2009 a Mapping of Climate Research in Denmark[3].

It is partly on the basis of research competencies in the above areas that Denmark also participates actively in the work of the Intergovernmental Panel on Climate Change (IPCC). Denmark has contributed to IPCC work, for example through contributions to all six Assessment Reports. Experts from several Danish universities and institutions, including DTU, KU, AU, Aalborg University (AAU), Copenhagen Business School (CBS), DMI and GEUS have contributed to Special Reports and Working Group contributions in the IPCC 6th Assessment Cycle. DMI has the role of National Focal Point for Denmark to the IPCC.

Danish research contributes to all six core projects under the World Climate Research Programme: the Climate and Cryosphere (CliC), Climate Variability and Predictability (CLIVAR), Earth System Modelling and Observations (ESMO), the Global Energy and Water Cycle Experiment (GEWEX), Regional Information to Society (RifS) and Stratospheric Processes and their Role in Climate (SPARC).

Danish Centre for Energy and Environment (DCE) – Aarhus University, the Greenland Institute of Natural Resources (GINR) and Asiaq, Greenland Survey are in charge of monitoring the effect of climate change on nature and the environment in Greenland. Greenland Ecosystem Monitoring (GEM) constitutes the main monitoring programme on ecosystems and climate change in Greenland. GEM covers marine, terrestrial, limnic, atmospheric and glacial components of different monitoring sites in Greenland, which also operate as key sites for climate research. The GINR conducts research into Arctic ecosystems and how they are affected by climatic and human impacts. The GINR also monitors the living resources and the environment in Greenland and advises the Government of Greenland and other authorities on sustainable exploitation of living resources and safeguarding the environment and biodiversity.

At Aarhus University, the Interdisciplinary Centre for Climate Change (iCLIMATE) promotes interdisciplinary research aimed at understanding the climate system, climate change, and human-climate interactions and providing services and solutions to the private and public sectors.

A webportal, Isaaffik Arctic Gateway (isaaffik.org), was established in 2015 in order to facilitate arctic scientific collaboration. It presents an overview of current and

[2] https://www.dmi.dk/klimaatlas/

[3] *The Ministry of Science, Technology and Innovation, Coordination Unit for Research in Climate Change Adaptation and the Ministry of Climate and Energy, 2009:* Mapping of Climate Research in Denmark (in Danish).

future expeditions, research projects and courses. Among other, it enables researchers and institutions to coordinate logistics, which are often costly parts of projects in the Arctic.

In the Faroe Islands, research related to climate and climate changes is primarily conducted on the Faroe Marine Research Institute but also on the Faroe Islands' National Museum and the University of the Faroe Islands. The Faroese Marine Research Institute is also responsible for a series of systematic ocean climate observing systems. Other institutions, The Road Authority and the Faroese Meteorological Office are as well responsible for some systematic climate observations.

1.8 EDUCATION, TRAINING AND PUBLIC AWARENESS

Denmark has a long tradition for involving the public in the environment field. This tradition was followed up by an international agreement - the Aarhus Convention from 1998. On climate change, anthropogenic greenhouse gas emissions and political reactions in terms of policies and measures there is an ongoing public debate in the media and elsewhere.

Education and postgraduate education programmes

The education system in Denmark has a long-lasting tradition and practice in preparing and empowering students to live, learn, work and participate in a society with freedom and democracy. The overall management and democratic learning culture of schools combined with the framework curricula and learning objectives of all subjects provide the basis for pupils and students to develop necessary knowledge and skills to contribute to sustainable development, peace, human rights and global citizenship, in line with the Sustainable Development Goal for quality education for all, SDG 4.

Information on climate change and sustainable development in general for teachers involved in primary and lower secondary education is also available on several web-sites e.g. under the Ministry of Children and Education. Sustainable development has also been a part of Danish upper secondary education for a number of years. The reform of upper secondary education, which was launched in august 2017, has a strengthened focus on sustainable development.

The universities in Denmark also offers education in climate as an integral part of many educational programmes – which are often offered with cooperation with other relevant institutions such as DMI, DCE, GEUS etc.

Furthermore, it has been decided with a political agreement from 2021 that the purpose clause in the Act on Vocational Training must be amended in order to clarify the importance of vocational training's contribution to the green transition.

Climate information

A considerable amount of information on climate change and Danish policies is provided on the websites of Danish ministries, universities and institutions.

Danish participation in international climate activities

The Danish Meteorological Institute and Danish universities contribute to international climate assessments, notably the IPCC Assessment Reports and assessments by the Arctic Monitoring and Assessment Programme of the Arctic Council, such as the Adaptation Actions for a Changing Climate science report for the Baffin Bay/Davis Strait.

2 NATIONAL CIRCUMSTANCES

- RELEVANT TO GREENHOUSE GAS EMISSIONS AND REMOVALS

Contents

2 National circumstances
- relevant to greenhouse gas emissions and removals

The Kingdom of Denmark comprises Denmark, Greenland and the Faroe Islands. The UN Framework Convention on Climate Change has been ratified on behalf of all three parts of the Realm. Therefore, this report includes information about Denmark, Greenland and the Faroe Islands. However, at the present time, more information is available on Denmark than on the other parts of the Realm. Where tables, figures, and other information in this report also cover Greenland and/or the Faroe Islands, this is stated.

2.1 Denmark

Denmark's national circumstances relevant to greenhouse gas emissions and removals are described in this Section. Among the most significant circumstances affecting greenhouse gas emissions and removals in Denmark are the following:

- Denmark is situated in a temperate climate zone. This implies a need for heating, especially during wintertime, and significant inter-annual variations in greenhouse gas emissions due to inter-annual variations in winter-temperatures.
- Denmark is an industrialised country with arable land and an economy based on manufacture of commodities, agricultural products and services for the global market. This implies a need for energy supply and electricity production.
- Denmark is a flat country. This implies insignificant access to hydro power in domestic electricity production and a long history of dependence on fossil fuels in the country's energy supply, especially coal and oil. Until 1980s this was almost solely based on imports, but in the period 1997-2012 Denmark was self-sufficient in energy due to production of oil and gas in the North Sea.
- Denmark has no nuclear power. Since 1990 Denmark has increasingly had a shift from coal and oil to natural gas and renewable energy sources, increased the use of combined heat and power production and decentralised power production, where the combined production is utilised for district heating. Together with improvements in energy efficiency, keeping energy demand almost constant despite a significant economic growth, and initiatives regarding the agricultural sector, waste, industrial greenhouse gases etc., Denmark's emissions of greenhouse gases related to domestic activities, including domestic electricity demand, have been decreasing.

- Denmark's electricity production capacity is an integral part of the Nordic electricity market, in which hydro power in Norway and Sweden is also an integral part. This implies significant inter-annual variations in Denmark's total greenhouse gas emissions, with elevated emission levels in years with low precipitation in Norway and Sweden and vice versa. In 1990, the base year under the United Nations Framework Convention on Climate Change and the Kyoto Protocol, Denmark's total greenhouse gas emissions were extremely low due to an extremely large electricity import from the Nordic countries, which experienced particularly high precipitation that year.

These highlighted national circumstances are not the only national circumstances relevant to Denmark's greenhouse gas emissions and removals. In the rest of this Section, further information on relevant national circumstances and indicators is given.

As briefly introduced above, policies and measures in Denmark also affect Denmark's greenhouse gas emissions and removals. Further information on policies and measures relevant to Denmark's greenhouse gas emissions and removals is included in Chapter 4.

2.1.1 Form of government and structure of administration

Denmark is a constitutional monarchy, and the power of the state is divided between the legislative branch, the executive branch, and the judicial branch. According to the Constitution of the Realm, legislative power lies with the Folketing, which consists of 179 members, two of whom are elected in the Faroe Islands and two in Greenland. The members are elected by the population for a period of normally four years. A new general election can mean that a member sits for less than this period.

The executive branch - the government - cannot have a majority of the Folketing against it, cf. the regulations in the Danish Constitution on votes of no confidence. Since 1953, Denmark has often had a minority government, i.e. a government supported by a minority of the members of the Folketing. In these situations the government will need to include a support party.

The number of ministers in the government varies. Since 1971 Denmark has had a Minister for the Environment and a Ministry of the Environment, which also had primary responsibility for Denmark's policy on climate change until 2007. In 2007 a Ministry of Climate and Energy (now: Ministry of Climate, Energy and Utilities) was established. The minister for Climate, Energy and Utilities has the primary responsibility for coordination and implementation of legislation, plans etc. relating to Denmark's climate policy and is representing Denmark in international negotiations on climate change issues.

For the last more than thirty years, other ministries have also worked with environmental and climate issues. In 1988 the government decided to follow up the UN report on sustainable development, the Brundtland report, in which one of the main messages was the necessity of integrating the environmental issue into the administration within sectors such as transport, agriculture, and energy.

For this reason, a number of sector ministries have drawn up action plans in which the environment is an integral element. Examples are sector plans for energy, transport, agriculture, and development assistance. In the climate area, an overall status report was presented in connection with the proposal for ratification of the

Kyoto Protocol in April 2002. This status report was followed by a national Climate Strategy for Denmark for 2008-2012. In December 2008 Denmark and the other EU member states adopted the EU Climate and Energy Package. With this package Denmark's primary climate and energy objectives until 2020 was established in line with the second commitment period of the Kyoto Protocol. As a follow-up to the adoption of the Paris Agreement under the United Nations Framework Convention on Climate Change in 2015 and to the adoption of a joint EU NDC for 2021-2030 and the necessary legal framework for burden sharing and implementation in 2018, a new Danish Climate Act was adopted in June 2020. The Climate Act establishes new domestic climate targets for 2030 and 2050, schedules for annual greenhouse gas projections and annual assessments of progress, a new Climate Council to provide analysis and advices in their assesments of progress with policies and measures and schedules for assessing and – if necessary revising targets.

One of the main cornerstones of Danish democracy is autonomous local government. Specific environmental action takes place not only at national level but also at municipal level. The state sets the national rules and framework for environmental administration, while the municipalities, working within this framework, plan and decide initiatives that implement and support the national legislation.

In 2007 the structure of the Danish public sector was reformed. With a view of merging smaller municipalities to have at least 20,000 (and preferably 30,000) citizens the number of Danish municipalities was reduced from 271 to 98. Along with the reform of the municipal structure, the Danish parliament reformed the regional structure in Denmark – closing down 14 counties and opening up five new regions. The reform led to several changes in the division of labour between the state, the (new) regions, and the municipalities.

The importance of local involvement is stressed in Agenda 21 - a global agenda for sustainable development in the 21st century, which was adopted at the Rio Conference in 1992. The government supports popular interest and participation in climate and environmental issues in different ways - including through implementation of the Pan-European Aarhus Convention and support for the local Agenda 21 work initiated by most of the Danish municipalities.

In the light of Denmark's role as host for the Fifteenth Conference of the Parties under the UNFCCC in December 2009, many additional initiatives to raise awareness and involve citizens, municipalities, the business community and other stakeholders have been taken – both at national and local level. Several municipalities have committed themselves to local targets for reducing greenhouse gas emissions (the "Climate Municipality"-project 2007-2021: https://www.dn.dk/om-os/projekter-og-kampagner/klimakommuner/ and the follow-up "DK2020"-project: https://www.realdania.org/whatwedo/grants-and-projects/dk2020 established "to support municipalities in developing, upgrading or adjusting their existing work on climate action to global best practice, and in ultimately developing climate action plans in line with the 1.5 degree goal in the Paris Agreement, meaning that the climate action plans must show the way towards local climate neutrality in 2050 – or sooner").

2.1.2 Population

Today, Denmark has a population at around 5.9 mill. As can be seen from Table 2.1, population growth has been relatively small in the last 42 years.

TABLE 2.1 POPULATION OF DENMARK
Source: Statistics Denmark.

	1980	1990	2000	2010	2015	2020	2021	2022
Denmark's population (in mill.)	5.12	5.14	5.33	5.54	5.66	5.82	5.84	5.87

The latest forecasts show that population growth will continue to be moderate in the years ahead. For example, the population is expected to reach 6.0 mill. in 2030, rising to 6.3 mill. in 2050.

Today, the population density is 136 per km^2.

Today, 81% of Danish wage earners are employed in service sectors, while 18% are employed in manufacturing, construction and supply sectors and 1% in agriculture, forestry and fisheries.

2.1.3 Geography

Denmark consists of the Jutland peninsula and more than 400 islands. It has a total area of 43,054 km^2 and lies at about 55° N and 11° E.

The whole of the country is lowland. The surface was formed by Ice Age glaciers and glacial streams. The highest hill is approximately 170 metres above sea level.

The coastline has a length of more than 7,300 km. To protect low-lying land against flooding and storm surge, it has been necessary to build dikes or other permanent installations along about 1,800 km of coastline. In addition, sandbags, breakwaters and similar protect other parts of the coastline, which would otherwise erode because they consist of soft materials deposited during the last Ice Age.

A rise in the water level due to climate change would obviously affect the protection of the coasts and create a greater risk of flooding and erosion.

The Danish landscape is indelibly stamped by the high population density. More than 60% of the land is used for agriculture or horticulture. Woodlands take up approx. 13%, while towns, roads and scattered habitation take up 14%. The rest is nature or listed areas such as lakes, watercourses, heaths, dunes and beaches.

In relation to its size, Denmark is home to a wide variety of flora and fauna - in all, about 30,000 native, introduced or invasive species of plants and animals, excluding bacteria, unicellular algae and certain lower animal groups.

2.1.4 Climate

The Danish climate is temperate with precipitation evenly distributed over the year. The country lies in the zone of prevailing westerly winds, which is characterised by fronts, low pressures, and changeable weather. Compared with other regions on the same latitude as Denmark, the climate is relatively warm due to the warm North Atlantic current that originates in the tropical sea off the southeast coast of the USA.

Denmark has a distinctly coastal climate, with mild, damp winters and cool, unsettled summers. Average temperatures vary from about one and a half degree in winter to about 15 and a half degrees in summer. However, the weather in Denmark is greatly affected by the proximity of both the sea and the continent. This means that the weather can change, depending on the prevailing wind direction. The westerly wind from the sea brings relatively uniform weather in summer and winter: mild in winter and cool in summer. When the wind comes from south or east, the weather in Denmark is more similar to that of the continent: warm and sunny in summer and cold in winter. The weather in Denmark thus depends very much on the wind direction and the season.

Atmospheric pressure

Average atmospheric pressure in Denmark shows seasonal variation, on average reaching a minimum in November and a maximum in May.

Denmark's highest-ever atmospheric pressure, 1062.2 hPa, was recorded in Skagen on January 23 1907, while just one month later, on February 20, the lowest atmospheric pressure in the history of Denmark was also recorded in Skagen, at 943.5 hPa.

Temperature

The annual mean temperature varies from year to year, from below 6ºC to 10ºC, with an average of 8.7ºC (1991-2020 level) and 9.1ºC (2011-2020 level)). The coldest year so far was 1879, with a mean temperature of 5.9ºC, while the warmest recorded year was 2014, with 10.0ºC. The four years 2007, 2014, 2018 and 2020 are the warmest ever recorded in Denmark. 2007 and 2018 both had a mean temperature of 9.5°C, 2020 had a mean temperature of 9.8°C. This is followed by 2006, 2008 and 2019 with 9.4°C. Since 1988, the majority of years has been warmer than the average 1991-2020, and the temperature has shown a sharply rising trend from the 1990s. Since 1870, the temperature in Denmark has risen by about 1.5ºC, but the ten warmest years have occurred between 1989 and the present. The present temperature level is the highest in the time series and the period 2011-2020 is the warmest decade since records began. See Figures 2.1 and 2.2.

The temperature in January and February averages around 1.5ºC (1991-2020 level); around 1.8ºC (2011-2020 level) but can vary greatly from more than 15ºC to below -31ºC. The average temperature in July and August is around 16.9ºC (1991-2020); around 16.8ºC (2011-2020), but again can vary from -2ºC to more than.

Precipitation

Average annual precipitation varies greatly from year to year and from place to place. The lowest annual precipitation for the country as a whole was 466 mm in 1947, and the highest was 905 mm in 1999 and 2019, while the average annual precipitation is 759.1 mm (1991-2020 level); 781.6 mm (2011-2020 level).

The wettest period is normally June to January, while the driest is February to May.

In the winter months, precipitation is sometimes in the form of snow. Annual precipitation in Denmark has on average increased by about 150 mm since 1870. See Figures 2.1 and 2.3.

FIGURE 2.1 MONTHLY CLIMATOLOGICAL STANDARD NORMALS FOR DENMARK 1991-2020 (TEMPERATURE AND PRECIPITATION)

Source: https://www.dmi.dk/vejrarkiv/normaler-danmark/

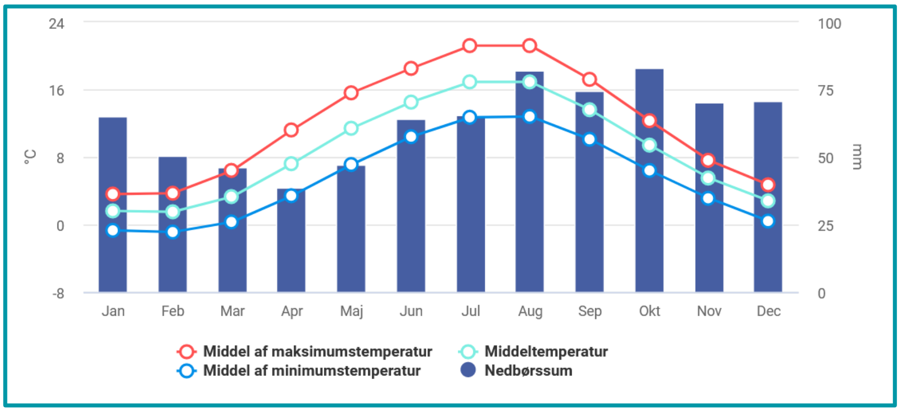


FIGURE 2.2 ANNUAL MEAN TEMPERATURE IN DENMARK 1874-2021 IN °C, WITH CLIMATE NORMALS

Source: J. Cappelen: Denmark – DMI Historical Climate Data Collection 1768-2020. DMI report 21-02 (2021)

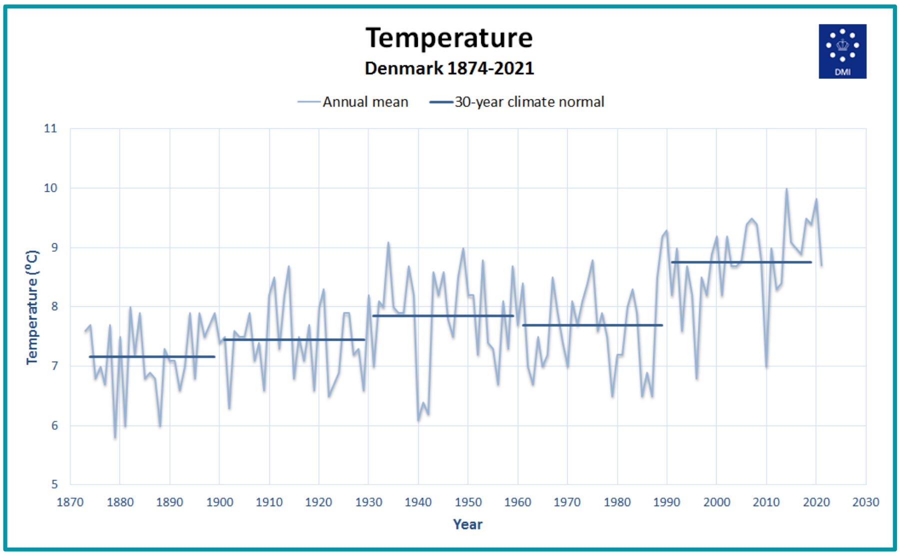
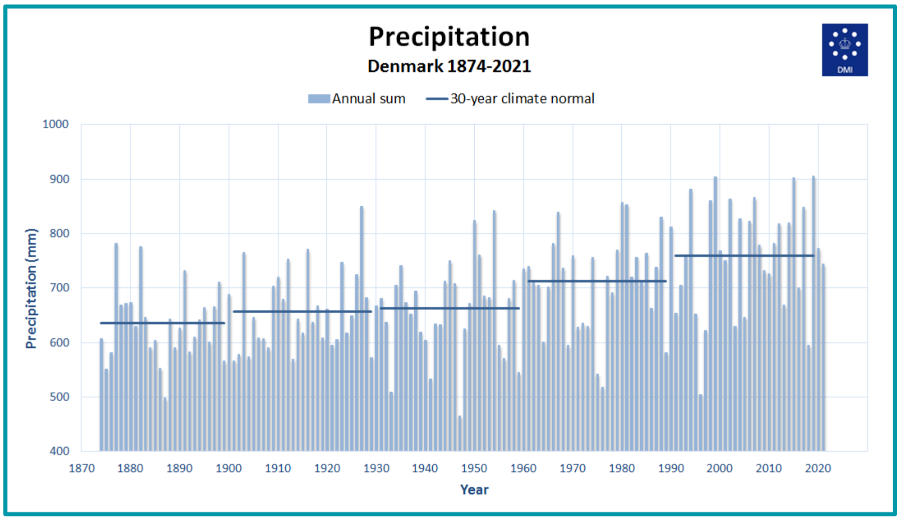


FIGURE 2.3 DANISH ANNUAL PRECIPITATION 1874-2021 IN MM, WITH CLIMATE NORMALS

Source: J. Cappelen: Denmark – DMI Historical Climate Data Collection 1768-2020. DMI report 21-02 (2021)



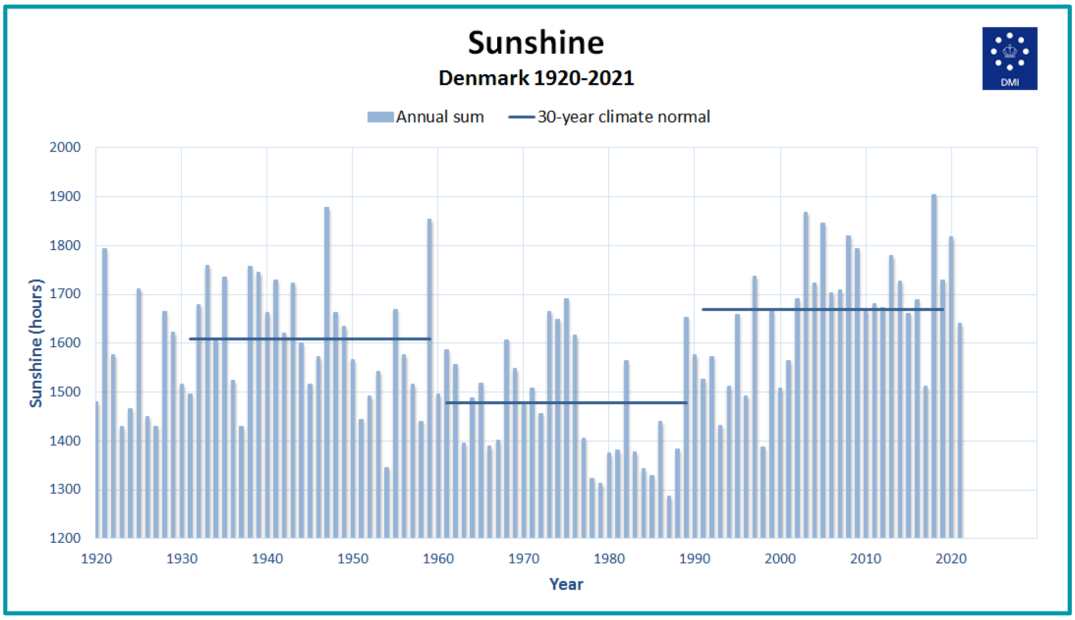
Hours of sunshine

On average, Denmark as a whole has about 1,668.9 hours of sunshine annually (1991-2020 level); 1,717.9 hours (2011-2020 level), but this figure varies greatly from year to year. The sunniest year was 2018, with 1,905.0 hours, and the least sunny was 1987, with 1,287 hours. There is least sunshine in January and December, with an average of about 47 hours (1991-2020 level); 46 hours (2011-2020 level) , while May, June and July have the most sunshine, with an average of about 230 hours (1991-2020 level); about 238 hours (2011-2020 level).

Since 1980, the trend has been towards more hours of sunshine. See Figure 2.4.

FIGURE 2.4 ANNUAL HOURS OF SUNSHINE IN DENMARK 1920-2021, WITH CLIMATE NORMALS

Source: J. Cappelen: Denmark – DMI Historical Climate Data Collection 1768-2020. DMI report 21-02 (2021)



Wind

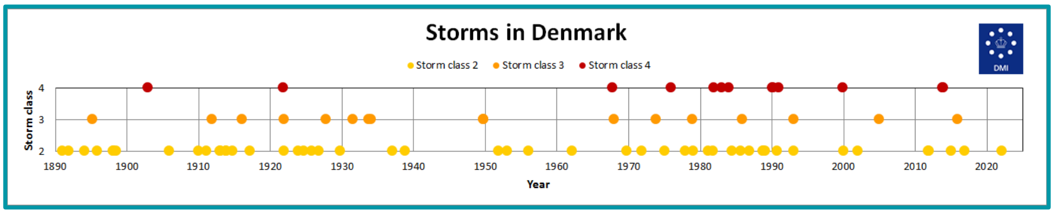
The annual mean wind velocity at three coastal locations, Skagen, Hvide Sande and Gedser are between 7.0 to 7.8 m/s (1989-1998 level), and the wind is most frequently from westerly directions, from which about 30-40% of all winds come.

The number of days with severe wind (≥ 10.8 m/s) varies from about 30 in some places inland to above 170 days at Skagen. On average, above storm-force (≥ 24.5 m/s) occurs along the Danish coasts every second to three years. A Danish list of storms has 53 cases with storm force and above in the periode 1891-2022. In December 1999 large parts of Denmark were hit by the worst-ever measured hurricane, and in the North Sea at an oil rig mean wind velocities (average over 10 minutes) of more than 50 m/s (approx. 180 km/h) were recorded, with gusts of about 60 m/s (approx. 216 km/h). During hurricane “Allan” on October 28 2013 record-breaking 10 minutes mean winds; 39,5 m/s (approx. 142 km/h) and gusts; 53,5 m/s (approx. 193 km/h) were registered at two coastal stations.

Since the mid 1800's and up until today, studies show no general change, only variations, in wind climate.

A windier climate was registered at the beginning and end of the 1900's, whereas the period from 1930 to early 1960's has been relatively less windy, like the first decade of this millennium. In the last couple of years hurricanes/strong storms seem to have changed this picture, see Figure 2.5. Class 4 storms are ≥ 28,5 m/s, class 3 are ≥ 26,5 m/s and class 2 are ≥ 24,5 m/s.

FIGURE 2.5 DANISH HURRICANES AND HURRICANE-LIKE STORMS IN 5-YEAR GROUPS 1891-2021.
Source: https://www.dmi.dk/fileadmin/user_upload/Bruger_upload/Stormlisten/STORMS_IN_DENMARK_SINCE_1891.pdf

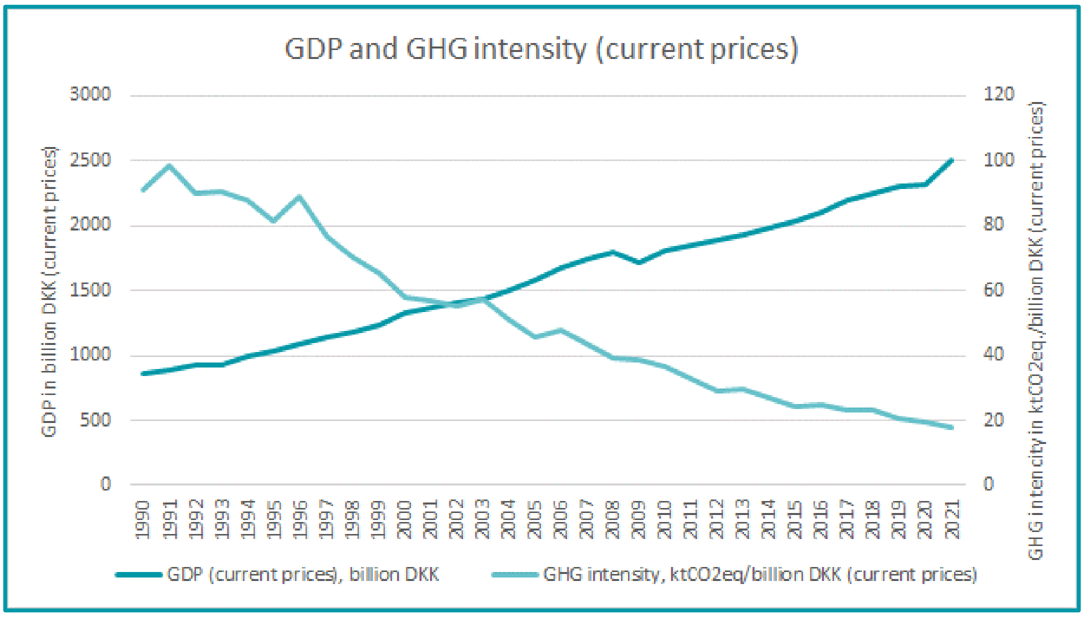


2.1.5 Economy

From 1990 to 2021 the Danish economy grew at an average annual growth rate of 1.7% measured in GDP (fixed prices). In 2008, 2009 and 2020 the economy contracted by 0.5%, 4.9% and 2.0% respectively. In 2021 the economy showed a positive growth rate again with a growth rate of 4.9%. In 2021, GDP (in current prices) was DKK 2,504 billion, corresponding to DKK 428 thousand per capita (1 Euro = approximately DKK 7.43 in 2022).

In Figure 2.6, the development in the economy 1990-2021 is shown together with the development in the greenhouse gas intensity (i.e. greenhouse gas emission per DDK GDP) in the same period. The decrease in greenhouse gas intensity suggests a decoupling of greenhouse gas emission from economic growth.

FIGURE 2.6 DEVELOMENTS IN THE DANISH ECONOMY AND THE GREENHOUSE GAS INTENSITY 1990-2021 (FOR GREENHOUSE GAS EMISSIONS IN 2021 A PROXY ESTIMATE, USING AR4 GWPS, HAS BEEN USED).
Source: Statistics Denmark, Nielsen et al. (2022a) and the Danish Ministry of Climate, Energy and Utilities



Denmark has a very export and import intensive economy, and thus the country is sensitive to global economic trends. In addition, public expenditure accounts for a large part of final consumption, cf. Table 2.2.

TABLE 2.2 KEY FIGURES FOR THE DANISH ECONOMY. 2017-2021, DKK BILLION, CURRENT PRICES
Source: Statistics Denmark.

Key parameters	**2017**	**2018**	**2019**	**2020**	**2021**
	Billion DKK				
GDP	2,193	2,253	2,311	2,321	2,551
Imports	1,051	1,136	1,192	1,129	1,327
Exports	1,208	1,275	1,355	1,279	1,497
Consumer spending	1,017	1,059	1,085	1,074	1,156
Public expenditure	535	547	558	574	612
Gross investment	484	509	505	522	612

The Danish economy is specialised in the tertiary sectors, as both primary and secondary sectors, i.e. agriculture and industry, account for less than 20 percent of total gross value added (GVA), cf. Table 2.3.

TABLE 2.3 THE BUSINESS SECTOR'S CONTRIBUTION TO GROSS VALUE ADDED (GVA), 2017-2021, DKK MILLION, CURRENT PRICES
Source: Statistics Denmark.

Sector	**2017**	**2018**	**2019**	**2020**	**2021**	**Share in 2021**
	Million DKK					%
Agriculture, Forestry and Fisheries	28,614	23,132	29,263	32,073	27,776	1.3
Raw materials, industry and energy	348,305	358,721	368,700	346,588	377,916	17.0
Construction	106,586	110,521	109,875	111,112	121,706	5.5
Trade, transport and communication	468,794	477,318	496,405	510,079	617,908	27.8
Finance and residential business	308,420	319,983	327,391	333,413	344,216	15.5
Services	646,155	665,486	679,944	682,688	731,521	32.9
Total	**1,906,874**	**1,955,161**	**2,011,578**	**2,015,953**	**2,221,043**	**100.0**

2.1.6 Energy

Energy production and energy-consuming activities are one of the main contributors to the emissions of greenhouse gases in Denmark. In 2020 the energy sector alone (energy production, supply and fugitive) accounted for 19% of Denmark's total emissions of greenhouse gases (excluding LULUCF), primarily CO_2. In addition there are emissions from the energy-consuming activities in the transport sector, industry and households.

Production of primary energy

Primary energy refers to crude oil, natural gas, renewable energy (including renewable waste) and non-renewable waste.

In 2021, primary energy production was 399 PJ. As can be seen from Table 2.4, primary energy production peaked at 1312 PJ in 2005. After the peek, production of oil and gas in the North Sea has declined so Denmark is no longer 100% self-sufficient in energy as shown in Table 2.5.

As also shown in Table 2.4 production of renewable energy is increasingly contributing to the country's energy supply.

TABLE 2.4 PRIMARY ENERGY PRODUCTION (PJ)

Source: Danish Energy Agency (2022a)

	1980	1990	1995	2000	2005	2010	2015	2019	2020	2021
Production, total	**40**	**424**	**655**	**1165**	**1312**	**979**	**676**	**523**	**398**	**399**
Crude oil	13	256	392	765	796	523	331	216	151	139
Natural gas	0	116	197	310	393	307	174	116	50	53
Renewable energy	23	45	57	76	106	131	156	175	181	191
Non-renewable waste	5	7	10	14	17	17	16	16	16	16

TABLE 2.5 DEGREE OF SELF-SUFFICIENCY (%)

Source: Danish Energy Agency (2022a)

	1980	1990	1995	2000	2005	2010	2015	2019	2020	2021
Energy, total	**5**	**52**	**78**	**139**	**154**	**120**	**90**	**70**	**56**	**55**
Oil	2	72	105	203	226	168	118	77	64	57

In 2021, there were twenty oil and gas fields of varying size in the so-called Central Graben of the Danish sector of the North Sea (fifteen oil and five gas fields). Seven fields are situated in the northern part of the Central Graben, while all the other fields are situated in the southern region of the Central Graben. Denmark is the third largest oil producer in Western Europe. The offshore Tyra gas field in the North Sea is shut down for redevelopment from September 2019 to winter 2023/2024.

The developments in the production of oil and gas in the North Sea 1990-2021 are shown in Figure 2.7 together with the developments in production of renewable energy etc. and the gross energy consumption in Denmark in the same period.

Production of renewable energy includes wind power, wood, straw, biogas, renewable waste and others (hydropower, geothermal energy, solar energy and heat pumps). Production of renewable energy was 190.5 PJ in 2021, which is an increase of 319% compared to 1990.

In 2021, wind power production was 57.8 PJ. Production from wood products, biogas, straw and renewable waste (i.e. the carbon fraction of biogenic origin) waste in 2021 was 42.3 PJ, 26.2 PJ, 21.6 PJ, and 19.5 PJ, respectively.

The development in renewable energy production by type and in share of total energy consumption is shown in Figure 2.8.

FIGURE 2.7 THE DEVELOPMENTS 1990-2021 IN DENMARK'S PRODUCTION OF CRUDE OIL, NATURAL GAS AND RENEWABLE ENERGY ETC. AS WELL AS THE DEVELOPMENT IN DENMARK'S GROSS ENERGY CONSUMPTION (ADJUSTED) IN PJ

Source: Danish Energy Agency (2022a)

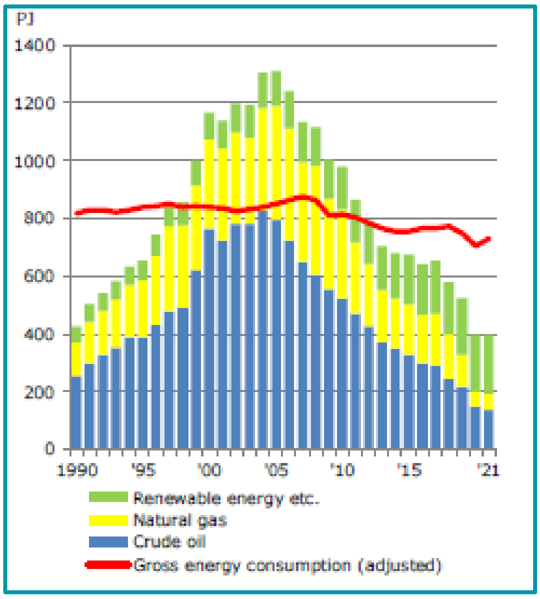
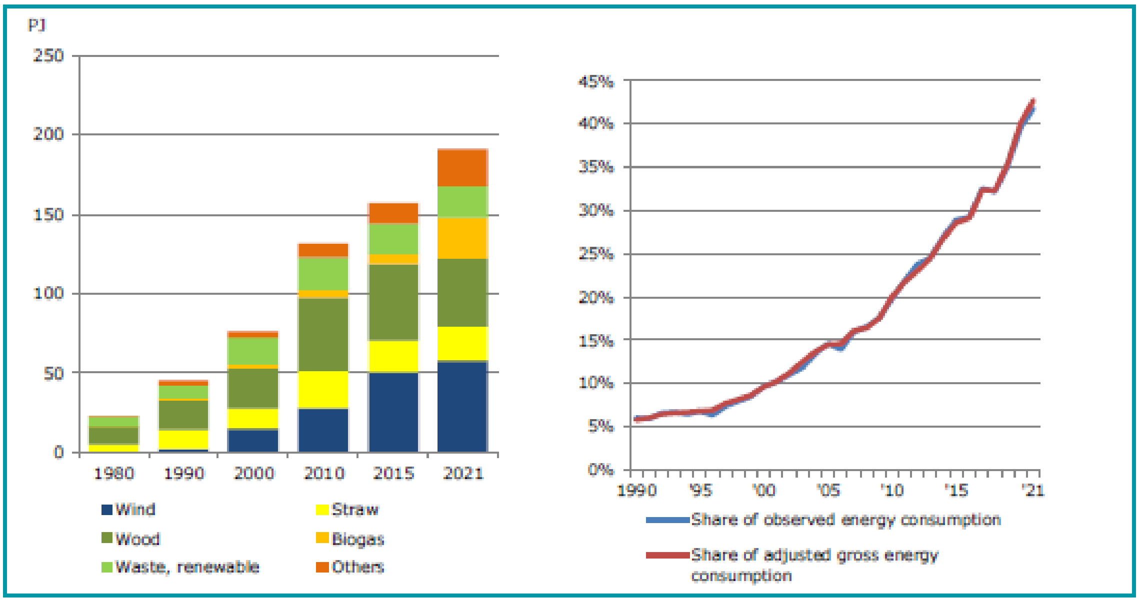


FIGURE 2.8 THE DEVELOPMENT IN DENMARK'S PRODUCTION OF RENEWABLE ENERGY - BY TYPE IN PJ (LEFT) AND AS SHARE OF TOTAL ENERGY CONSUMPTION IN % (RIGHT)

Source: Danish Energy Agency (2022a)

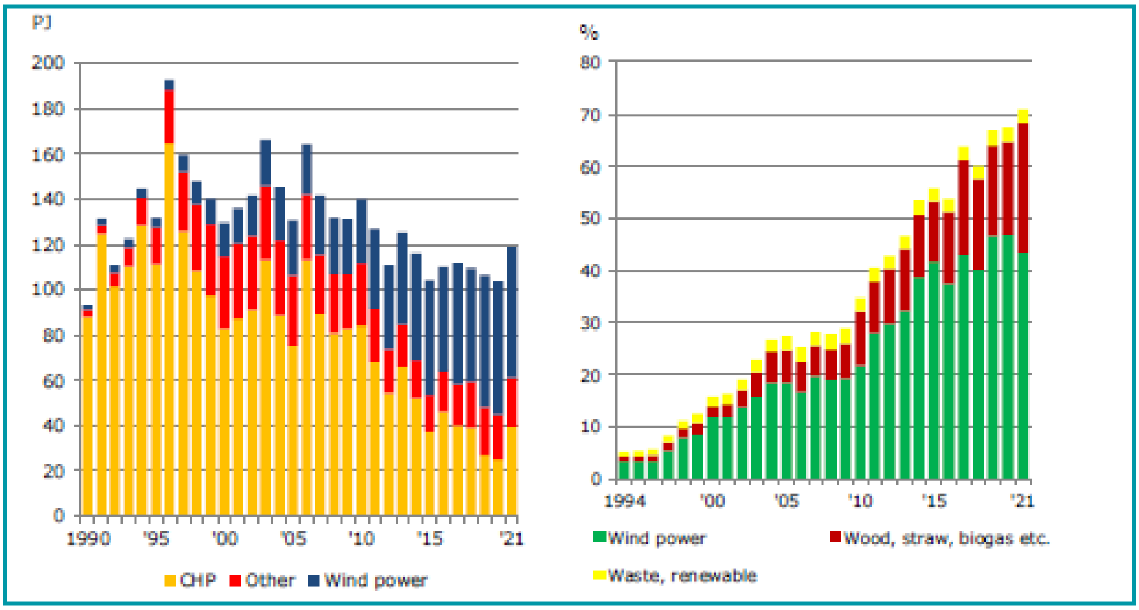


Production of electricity and district heating

In 2021, electricity production was 119 PJ. Electricity is generated at large-scale power units, at small-scale CHP units, by wind turbines and by autoproducers (i.e. small producers, whose main product is not energy). The development 1990-2021 in electricity production by type and the share of domestic electricity supply generated by renewables is shown in Figure 2.9.

FIGURE 2.9 THE DEVELOPMENT 1990-2021 IN DENMARK'S ELECTRICITY PRODUCTION BY TYPE IN PJ (LEFT) AND THE SHARE OF DOMESTIC ELECTRICITY SUPPLY GENERATED BY RENEWABLES IN % (RIGHT)

Source: Danish Energy Agency (2022a)



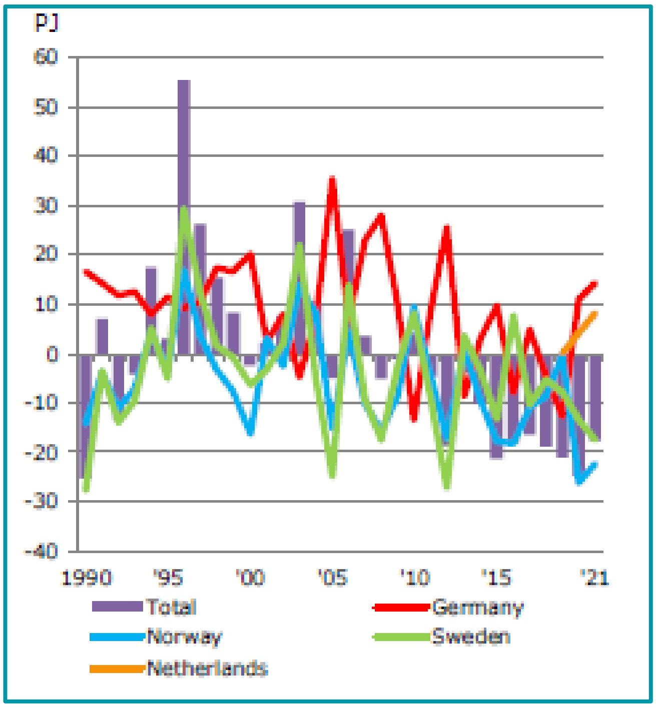
Large-scale power units generate electricity, partly as separate electricity production, and partly as combined heat and power production (CHP). Of the total electricity production of 118.9 PJ, 39.6 PJ (33.2%) were generated from large-scale power units – 15.7 PJ (13.2%) as separate production. Separate electricity production varies greatly from year to year due to fluctuations in foreign trade in electricity. In 2021, electricity production from small-scale units and autoproducers was 8.7 PJ (7.3%) and 8.1 PJ (6.8%), respectively.

In 2021, wind turbines, photovoltaics and a very small amount of hydropower generated 62.6 PJ (52.6% of total electricity production).

In Denmark, the foreign trade in electricity varies more than in any other European country as shown in Figure 2.10. Foreign trade is strongly affected by price trends on the Nordic Electricity Exchange, Nord Pool, which is significantly influenced by the varying precipitation patterns in Norway and Sweden where electricity production is dominated by hydropower. In 2021, Denmark had overall net imports of electricity of 17.5 PJ. This was the result of net imports of 22.3 PJ from Norway and 17.5 PJ net imports from Sweden, whilst the net exports to Germany was 14.3 PJ and 8 PJ to the Netherlands. The peak in Denmark's greenhouse gas emissions in 1996 is interlinked with the peak in net exports of electricity in 1996.

FIGURE 2.10 NET EXPORTS OF ELECTRICITY BY COUNTRY AS THE ACCUMULATED RESULT FOR THE YEAR (NEGATIVE = NET IMPORT FOR THE YEAR), PJ

Source: Danish Energy Agency (2022a)

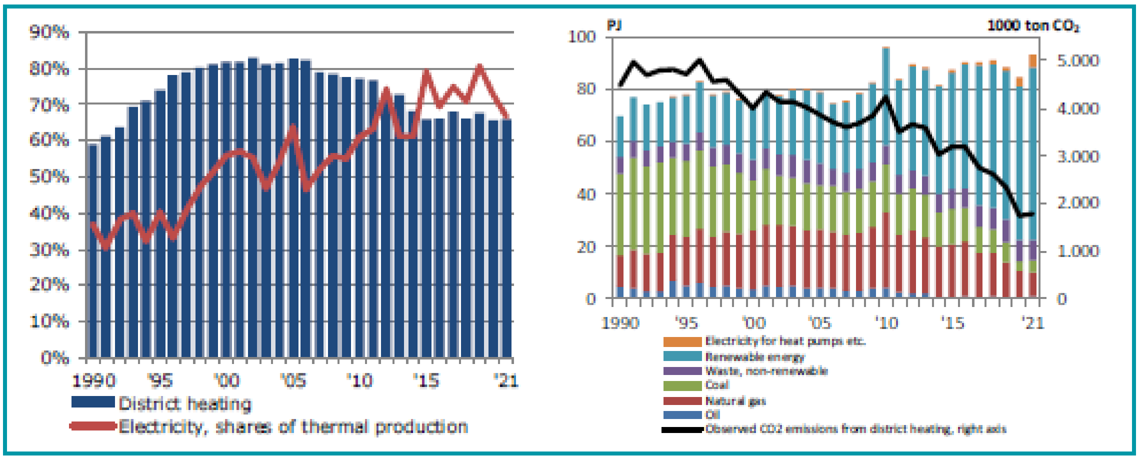


By generating electricity and district heating together (CHP), it is possible to exploit the large amounts of heat generated through thermal production of electricity.

In 2021, 72.1% of thermal electricity production (i.e. total production excl. wind, solar and hydropower) was produced simultaneously with heating as shown in Figure 2.11. This figure also shows a significant increase in this share compared with 1990 – a trend to be seen dispite large inter-annual variations primarily linked to inter-annual variations in wind power generation.

FIGURE 2.11 CHP SHARES OF ELECTRICITY AND DISTRICT HEATING PRODUCTION IN % (LEFT) AND THE DEVELOPMENT 1990-2021 IN ENERGY CONSUMPTION FOR PRODUCTION OF DISTRICT HEATING IN TOTAL AND BY FUEL IN PJ SHOWN TOGETHER WITH THE DEVELOPMENT IN CO_2 EMISSIONS FROM PRODUCTION OF DISTRICT HEATING IN 1000 TONNES CO_2 (RIGHT)

Source: Danish Energy Agency (2022a)



In 2021, 65.8% of district heating was produced with electricity. This share is still an increase in comparison to 1990, but also a significant decrease since the peak in 2006.

The development in district heating, both total and by fuel, is also shown in Figure 2.11 – together with the development in CO_2 emissions from production of district heating.

Energy consumption

Despite the economic growth, total energy consumption has remained largely unchanged at between 800 PJ and 900 PJ since 1980, however with a decrease below 800 PJ since 2011 – partly due to an increase in net imports of electricity cf. Table 2.6 and partly due to energy savings cf. Table 2.7 (showing gross energy consumption adjusted for foreign electricity trade and climate fluctuations).

TABLE 2.6 OBSERVED ENERGY CONSUMPTION (PJ)

Source: Danish Energy Agency (2022a)

	1980	1990	1995	2000	2005	2010	2015	2019	2020	2021
Energy consumption, total (observed)	**830**	**752**	**841**	**816**	**835**	**846**	**719**	**713**	**657**	**705**
Oil	555	343	372	370	348	316	276	279	236	244
Natural gas	0	76	133	186	188	185	120	105	84	86
Coal and coke	252	255	272	166	155	164	76	38	34	45
Waste, non-renewable	5	7	10	14	17	17	18	19	19	18
Renewable energy	23	45	57	79	122	168	208	250	259	295
Net imports of electricity	-4	25	-3	2	5	-4	21	21	25	18

Denmark's dependence on oil and coal has fallen. In the production of electricity and heat in particular, oil and coal have been substituted with other fuels. Thus, natural gas and renewable energy are increasingly being used in district heating. For electricity, the share of renewables etc. has increased steadily since 1990.

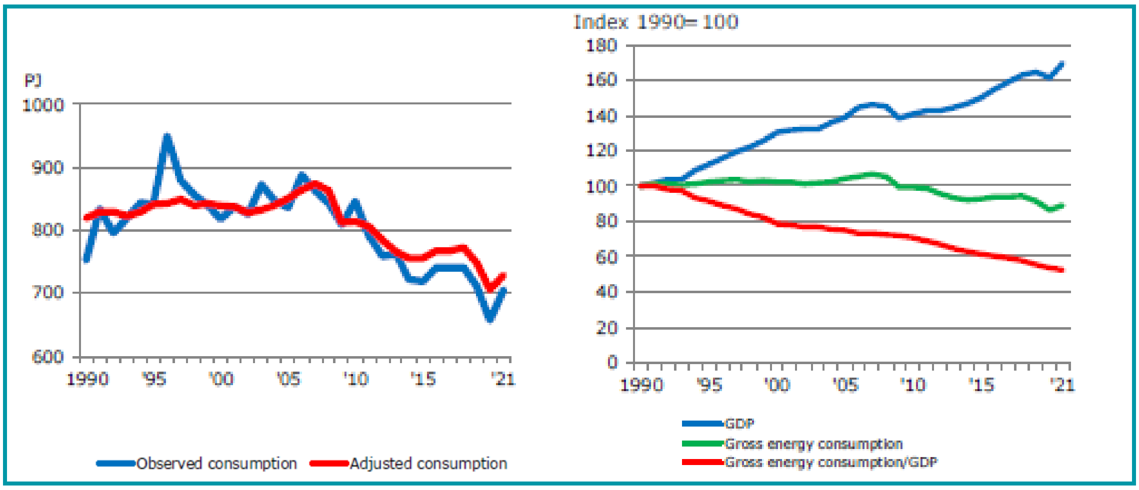
For 2021, 41.8% of the observed gross consumption of energy shown in Table 2.6 was supplied by renewable energy (for 2020, 39.5% and according to the EU methodology 31.7% in 2020). The renewable energy resources are mainly wind energy and biomass, which are used to produce electricity, combined heat and power, or district heating.

Observed energy consumption shows the registered amount of energy consumed in a calendar year. Observed energy consumption was 705 PJ in 2021, which is 6.3% lower than the 1990 level.

Adjusted gross energy consumption is derived by adjusting observed energy consumption for the fuel consumption linked to foreign trade in electricity. The adjusted gross energy consumption is moreover adjusted for climate variations with respect to a normal weather year. The purpose of this consumption figure is to provide a clearer picture of trends in domestic energy consumption. Figure 2.12 compares the trend in observed energy consumption with the trend in adjusted gross energy consumption 1990-2021. The trend in adjusted gross energy consumption is also compared with the trend in GDP in the same period, including the trend in energy intensity (i.e. energy consumtion divided by GDP).

FIGURE 2.12 TRENDS IN OBSERVED AND ADJUSTED GROSS ENERGY CONSUMPTION (LEFT) AND TRENDS IN GDP, ADJUSTED GROSS ENERGY CONSUMPTION AND ENERGY INTENSITY (RIGHT)

Source: Danish Energy Agency (2022a)



In 2021, the adjusted gross energy consumption was 729 PJ as shown in Table 2.7, which is 8.3% lower than the 1990 level. In Table 2,7, the adjusted gross energy consumption is also shown by type of fuel.

TABLE 2.7 ADJUSTED GROSS ENERGY CONSUMPTION IN PJ AND BREAKDOWN BY FUELS (I.E. ADJUSTED FOR CLIMATE FLUCTUATIONS AND NET IMPORTS OF ELECTRICITY)

Source: Danish Energy Agency (2022a)

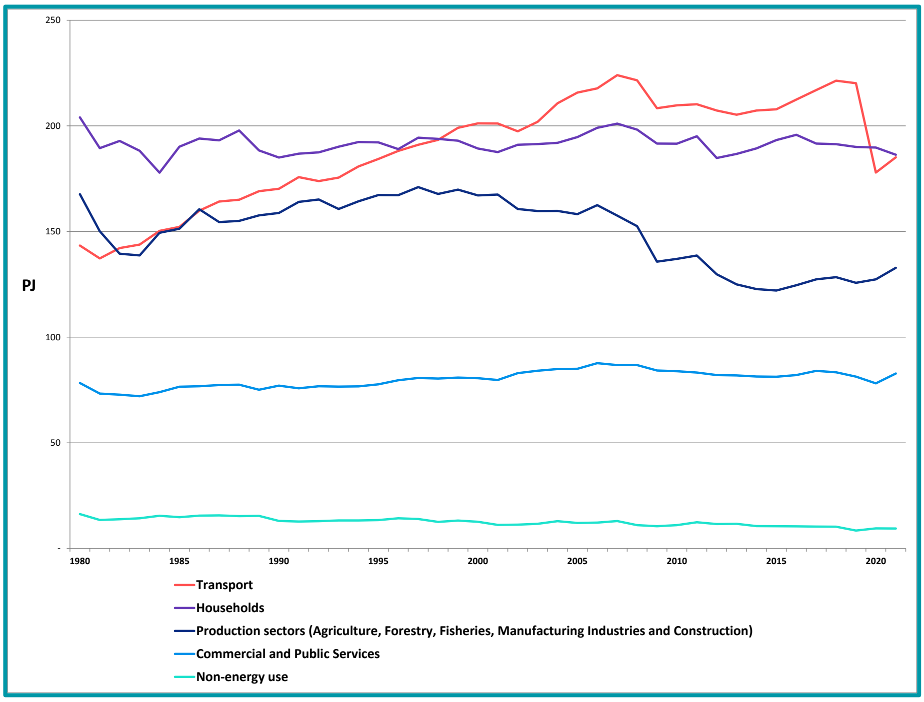
	1980	1990	1995	2000	2005	2010	2015	2019	2020	2021
Gross energy consumption, total (adjusted)	**814**	**819**	**839**	**839**	**850**	**814**	**755**	**749**	**706**	**729**
Oil	546	355	374	376	352	312	278	281	238	245
Natural gas	0	82	134	192	192	176	133	113	96	91
Coal and coke	241	327	265	175	166	147	111	70	69	63
Waste, non-renewable	5	8	10	14	17	16	18	19	20	19
Renewable energy	22	48	57	81	123	163	216	266	283	311

The sectoral distribution of the adjusted gross energy consumption in 2021 was as follows: industry and agriculture accounted for 24%, the household sector for 29%, transport for 26% and commercial and public services for 15%. Non-energy purposes accounted for the remaining 1%.

Figure 2.13 shows adjusted energy consumption by sector. Over the 41 years covered by the figure, consumption in the transport sector has risen, whereas consumption in the production sectors has fallen. Energy consumption in the household and service sectors as well as non-energy use has not changed much over the period, but some inter-annual variations can be seen.

FIGURE 2.13 ADJUSTED GROSS ENERGY CONSUMPTION, BREAKDOWN BY SECTOR

Source: Danish Energy Agency (2022a)



Final energy consumption

The final energy consumption is derived by subtracting transformation and distribution losses as well as energy uses in the energy sector from the adjusted gross energy consumption. This is shown in Figure 2.14. The adjusted final energy consumtion by fuel is also shown in Figure 2.14 and in Table 2.8.

FIGURE 2.14 ADJUSTED GROSS ENERGY CONSUMPTION AND ADJUSTED FINAL ENERGY CONSUMPTION (TOP) AND ADJUSTED FINAL ENERGY CONSUMPTION BY FUEL (MIDDLE) AND BY SECTOR (BOTTOM)

Source: Danish Energy Agency (2022a)

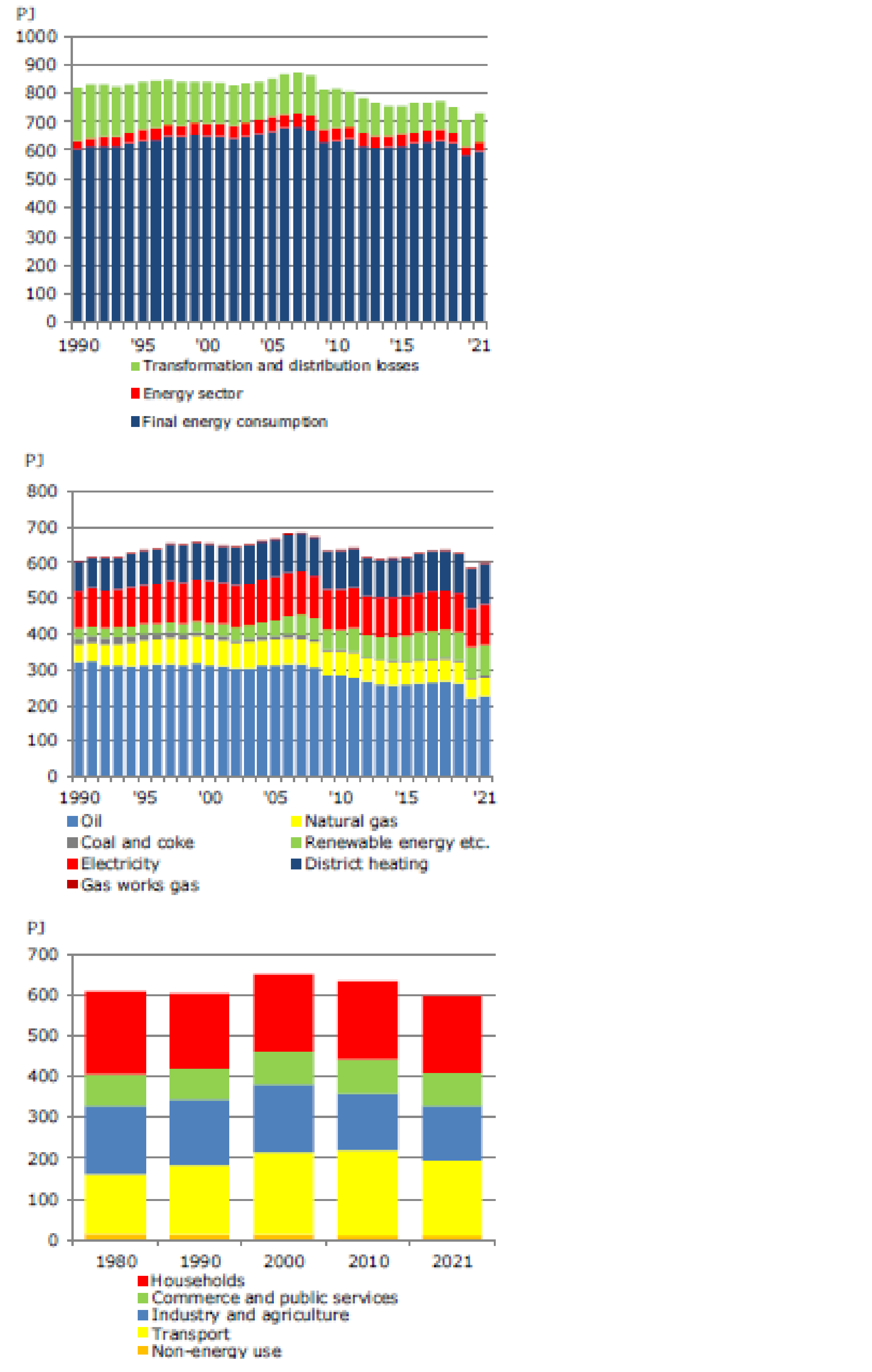


TABLE 2.8 FINAL ENERGY CONSUMPTION, ADJUSTED (PJ)

Source: Danish Energy Agency (2022a)

	1980	1990	1995	2000	2005	2010	2015	2019	2020	2021
Final energy consumption, total (adjusted)	**610**	**604**	**635**	**651**	**666**	**633**	**615**	**626**	**583**	**597**
By energy commodity										
Oil	431	322	313	312	312	284	258	263	220	226
Natural gas	-	50	70	73	72	68	62	59	54	52
Coal and coke	22	17	16	12	11	6	5	5	5	6
Waste, non-renewable	0	0	1	1	1	1	1	2	2	2
Renewable energy	16	28	27	32	43	54	70	77	82	85
Electricity	78	103	111	118	121	115	111	111	110	115
District heating	58	82	95	102	105	107	107	109	109	111
Town gas	5	2	1	1	1	0	1	1	1	1
By sector										
Non-energy use	16	13	13	13	12	11	11	8	9	9
Transport (including fuel sold for international aviation)	143	170	184	201	216	210	208	220	178	185
Production sectors (Agriculture, Forestry, Fisheries, Manufacturing industries and Construction)	168	159	167	167	158	137	122	126	127	133
Commercial and public sectors	78	77	78	81	85	84	81	81	78	83
Households	204	185	192	189	195	192	193	190	190	186
Final energy consumption, total (observed)	**617**	**580**	**631**	**633**	**658**	**660**	**606**	**617**	**568**	**601**

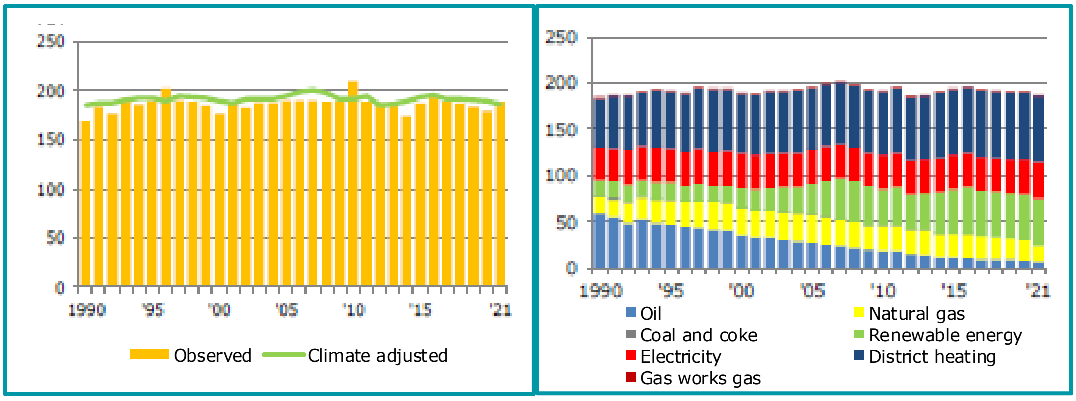
2.1.7 Household sector

Household energy consumption has been rather constant over the period 1990-2021 as shown in Figure 2.15. Compared with 1990, climate-adjusted energy consumption of households grew by 0.7%. The interannual variations show that household energy consumption is greatly influenced by the weather. The years 1990, 2000 and 2014 were very hot years with low energy consumption, whereas 1996 and 2010 were exceptionally cold. In 2021 climate-adjusted energy consumption by households was 186.3 PJ, accounting for 31.2% of total final energy consumption in Denmark. 152.4 PJ of the 186.3 PJ was used for heating and 34 PJ were used for electrical appliances etc. Households also consume a small amount of motor gasoline for garden tools etc., LPG (bottled gas) and gas works gas for other purposes, which in the energy statistics is included under road transport.

There have been significant changes in the composition of household energy consumption since 1990 as shown in Figure 2.15. Oil consumption decreased throughout the period shown due to a shift to district heating and natural gas. Firewood and wood pellets consumption has increased significantly since 2000[1]. In 2021 district heating amounted to 38.7% of household energy consumption, and renewable energy and electricity amounted to 26.9% and 20.9%, respectively. Consumption of natural gas, oil and gas works gas amounted to 9.9%, 3.5% and 0.2%, respectively. Household electricity consumption remained more or less constant in the period 1990 to 2000. Electricity consumption showed an increasing trend from 2002 to 2006, whereas consumption in the period from 2009 to 2021 has fluctuated around approximately 35 and 39 PJ.

FIGURE 2.15 ENERGY CONSUMPTION IN HOUSEHOLDS – TOTAL AND BY ENERGY PRODUCTS (CLIMATE ADJUSTED), PJ

Source: Danish Energy Agency (2022a)



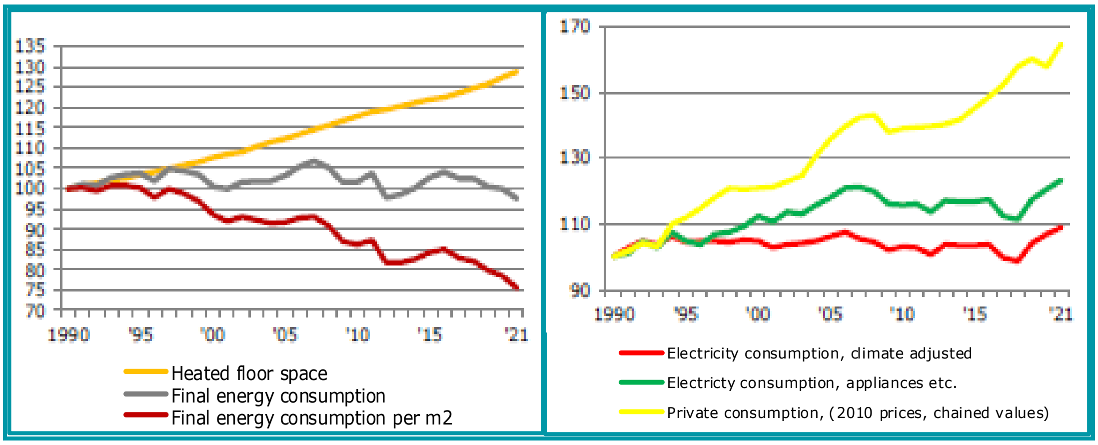
In the period 1990 to 2021,except for 2001, 2012 and 2013, climate-adjusted energy consumption for heating (space heating and hot water) in dwellings has fluctuated between 0.2% and 6.7% above the level in 1990 as shown in Figure 2.16. This is the combined result of a 28.9% increase in total heated area in the period and a 24.5% decrease in energy consumption for heating per m^2. The latter can be explained by improvements in the insulation of older dwellings as well as a shift away from old oilfired boilers to more efficient natural gas boilers and district heating installations. In addition, according to the building regulations, new homes must have lower energy consumption per m^2 than existing homes. The increase in the use of biomass, which is less energy efficient, will have an effect in the opposite direction, however.

Dispite the economic development with a 64.5% increase in total private consumption from 1990 to 2021, total household electricity consumption increased only by 9.0% in the same period as shown in Figure 2.16. This is partly due to significant falls in the specific electricity consumption of electrical appliances. From Figure 2.16 it can be seen that electricity consumption for appliances and lighting etc. increased only by 23.1% in the same period.

[1] Note: The population base for the firewood survey has been increased and therefore firewood consumption figures before and after 2015 are not fully comparable.

FIGURE 2.16 CHANGES IN ENERGY CONSUMPTION IN HOUSEHOLDS FOR HEATING COMPARED WITH THE AREA HEATED AND CHANGES IN ELECTRICITY CONSUMPTION FOR APPLIANCES ETC. IN HOUSEHOLDS, EXCL. ELECTRIC HEATING. INDEX 1990 = 100.

Source: Danish Energy Agency (2022a)



2.1.8 Transport

Denmark is a relatively small and densely populated country with a large share of the population living in cities.

In urban areas most people have good access to public transport and major investments in better public transport infrastructure are currently taking effect. The main railway connection between West and East Denmark will be improved in the near future and this is expected to reduce travel times substantially and attract more travellers in years to come. Furthermore, the Copenhagen Metro is being extended with a circle line and a new connection to the north of Copenhagen Harbour. However, in many rural areas, public transport is less frequent than in the urban areas.

In Denmark, many commuters use their bicycle to travel to and from work and for other purposes, particularly during the summer. Even though the cost of car ownership is very high in Denmark compared to neighbouring countries, there are approximately 2.4 mill. registered cars in Denmark.

Efficient and flexible transportation of goods and persons is a vital element of the foundation of the Danish welfare society. At the same time, transport as such is an important economic sector that contributes to economic growth, employment, and foreign trade.

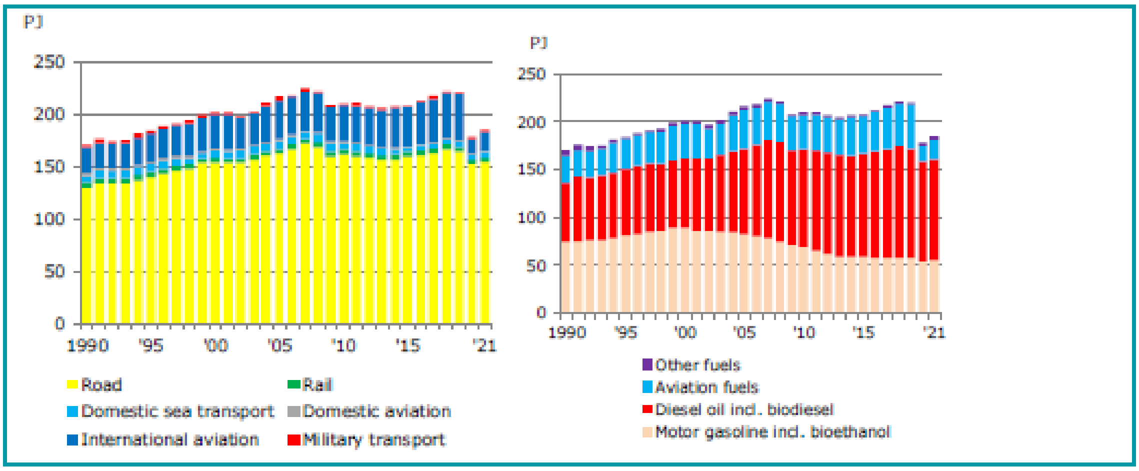
Denmark’s geography, with most people travelling short distances to and from work and a very high number of inhabited islands, makes Denmark an attractive country in which to use electric cars. The range of an electric car is sufficient to cover most people’s daily transport needs.

In the 1980s a nationwide network of gas pipelines connecting the gas in the North Sea to individual consumers was established. The conditions for wider use of natural gas in the transport sector are in place. Also, since Denmark is a country with a large agricultural sector, there are good possibilities for production of biogas, which could be used for transport.

The trends 1990-2021 in energy consumption for transport are shown in Figure 2.17 by transport type and by fuel type.

FIGURE 2.17 ENERGY CONSUMPTION FOR TRANSPORT - BY TRANSPORT TYPE (LEFT) AND BY FUEL TYPE (RIGHT) IN PJ

Source: Danish Energy Agency (2022a)



Energy consumption for transport followed an upward trend until 2007, when energy consumption was at 224.0 PJ (see Figure 2.17). In 2009, energy consumption fell to 208.4 PJ. In 2021, energy consumption was calculated at 185.1 PJ, which is an increase of 4.1% from 2020. Compared with 1990, energy consumption for transport has increased by 8.8% in 2021. Energy consumption for road transport was 154.7 PJ in 2021, which is 1.8% higher compared with 2020. Energy consumption for road transport is calculated as sales in Denmark, adjusted for border trade. Energy consumption for international aviation grew steadily throughout almost the whole period 1990-2019. In 2020, consumption decreased significantly. From 2020 to 2021 consumption increased by 28.4%, but is in 2021 still 59.1% lower than in 2019 – the year before the COVID-19 pandemic.

Consumption of motor gasoline (including bioethanol) rose by 2.5% from 2020 to 2021, while consumption of diesel oil (including biodiesel) increased by 1.2%. Consumption of bioethanol and biodiesel together increased by 2% from 2020 to 2021. Considering developments from 1990 to 2021, consumption of motor gasoline (including bioethanol) fell by 25.2%, while consumption of diesel oil (including biodiesel) grew by 71.9%. Consumption of aviation fuels decreased by 31,8%. Consumption of other types of fuel fell by 27.9% in the same period. Other types of fuel include electricity consumption by railways.

2.1.9 The business sector

Industry's production value accounted for about 19.4% of total Danish production in 2020. Table 2.9 shows that the largest industries in Denmark are the food, drink and tobacco, engineering industries (furniture/machinery/metal/electronics), and phamaceutical/chemical industries.

TABLE 2.9 PRODUCTION VALUE BY INDUSTRY IN 2020, DKK MILLION (CURRENT PRICES).

Source: Statistics Denmark.

Manufacturing industry	**788,669**
Food, drink and tobacco	166,770
Textile, leather and clothing	10,560
Wood, paper and printing	27,555
Refineries	18,522
Chemical industry	49,314
Phamaceuticals	139,004
Plastics, glass and cement	47,632
Metal	60,054
Electronics	33,996
Manufacturing of electrical equipment	19,690
Machinery	142,849
Transport equipment	11,294
Furniture and Other industries	61,427

The total business sector (manufacturing, building and construction, together with commercial and public services) accounted for about 20% of Denmark's observed emissions of CO_2 related to total energy consumption in 2021.

In the energy statistics, manufacturing industry includes agriculture, forestry and horticulture, fishing, manufacturing (excl. refineries), as well as construction. In 2021, climate-adjusted energy consumption in manufacturing industry was 132.8 PJ, which is 4.3% higher than the year before. Compared with 1990, energy consumption decreased by 16.3%. Electricity consumption in 2021 was 39.4 PJ after adjusting for climate variation. This is an increase by 4.9% compared with the year before. Compared with 1990, electricity consumption increased by 7.5%. The trends 1990-2021, both in total final energy consumption and electricity consumption in the manufacturing industry, are shown in Figure 2.18.

In the energy statistics, the commercial and public service sector includes wholesale, retail, private and public services. In 2021, climate-adjusted energy consumption was 82.8 PJ, which is 6.0% higher than the year before. Compared with 1990, consumption increased by 7.5%. Climate-adjusted electricity consumption in 2021 was 34.6 PJ, which is 6.8% more than the year before. Compared with 1990, electricity consumption increased by 14.8%. The trends 1990-2021, both in total final energy consumption and electricity consumption in the commercial and public service sector, are shown in Figure 2.18.

From the mid 1980s and to around 1990, energy intensity (energy consumption in relation to gross value added) for the business sector remained at the same level. Since 1990 the energy intensities in the different subsectors, except for construction, have shown decreasing trends as shown in Figure 2.19.

FIGURE 2.18 ENERGY AND ELECTRICITY CONSUMPTION IN MANUFACTURING INDUSTRY (LEFT) AND THE COMMERCIAL AND PUBLIC SERVICE SECTORS (RIGHT), CLIMATE ADJUSTED, PJ

Source: Danish Energy Agency (2022a)

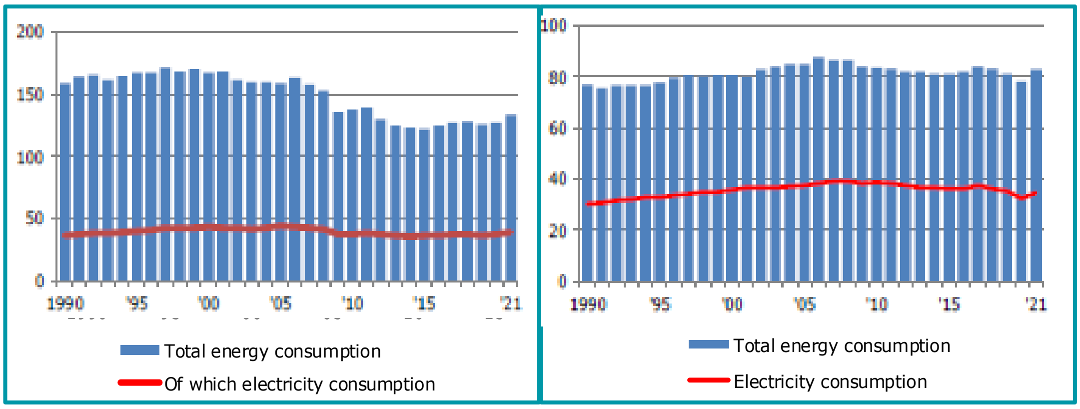
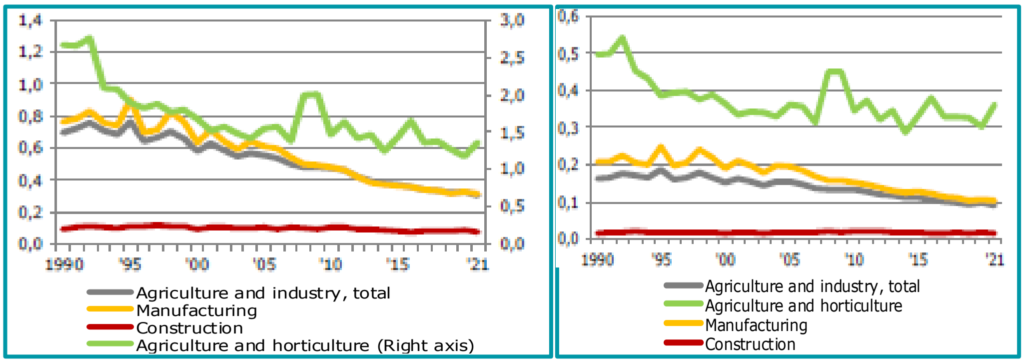


FIGURE 2.19 TRENDS IN ENERGY (LEFT) AND ELECTRICITY (RIGHT) INTENSITIES IN AGRICULTURE AND INDUSTRY, CLIMATE ADJUSTED, TJ PER DKK MILLION GVA (2010 PRICES, CHAINED VALUES)

Source: Danish Energy Agency (2022a)



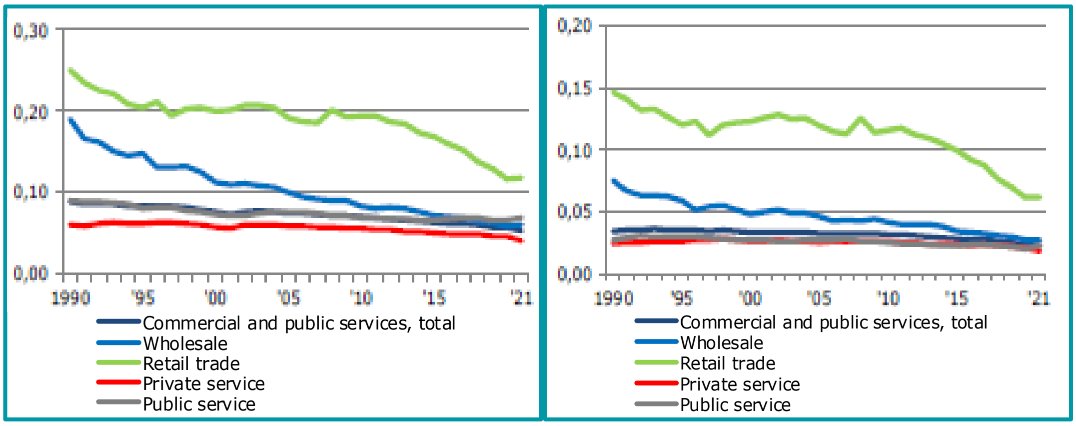
The change in the trends in energy and electricity intensities in the beginning of the 1990s corresponds with a move from a period of low economic growth to a period of high growth, implying better utilisation of production capacity. At the same time, from 1993 the first CO_2 taxes were introduced on energy consumption by businesses, with associated subsidies for energy savings, agreement schemes etc. Advice to businesses from electricity companies was also introduced in the early 1990s.

The main measures to curb the industrial sector's energy consumption have been based on the green tax package for businesses passed by the Danish parliament in mid 1990s.

As shown in Figure 2.20, there has been a steady decrease in energy intensity for the commercial and public services sectors since 1990. Energy intensity in the commercial and public services sector fell by 39% from 1990 to 2021. In the same period also the electricity intensity fell in the commercial and public services sector, but only by 34.9%.

FIGURE 2.20 TRENDS IN ENERGY (LEFT) AND ELECTRICITY (RIGHT) INTENSITIES IN COMMERCIAL AND PUBLIC SERVICES, CLIMATE ADJUSTED, TJ PER DKK MILLION GVA (2010 PRICES, CHAINED VALUES)

Source: Danish Energy Agency (2022a)



2.1.10 Waste

The waste sector's contribution to emissions of greenhouse gases consists primarily of methane and accounted for 2.0% of the total greenhouse gas emissions in 2020. Methane emissions come from the decomposition of organic waste at landfill sites and – to a minor extent – from biogas plants, wastewater treatment and compost production. In 2020, a total of 18.3 million tonnes of waste, including soil and rocks from earth and construction works, were generated in Denmark of which 48% were recycled or re-used, 34% were soil and rocks from earth and construction works, 16% were incinerated af 2% were land-filled, the latter equal to 0.4 million tonnes of waste.

Methane emissions from the waste sector are expected to fall in the future because the municipalities are now obliged to assign all waste suitable for incineration to incineration plants. This means that only a small quantity of organic waste will be deposited at landfills compared with the quantity deposited before the introduction of this obligation in 1997.

In addition, gas from a number of landfills is being used in energy production, which contributes to a direct reduction in methane emissions and an indirect reduction in CO_2 emissions.

Emissions of the industrial gases HFC and SF_6 from disposal of, for example, refrigerators and certain thermal glazing, which contain these substances, are included under the business sector.

There are also CO_2 emissions in connection with disposal of oil-based products, e.g. packaging, plastic bags, etc. Since waste incineration in Denmark is included in energy production, these CO_2 emissions must be included under the energy sector in accordance with the inventory rules from the IPCC.

Finally, in connection with incineration, a large amount of the waste is used as an energy source. As many of the incineration plants as possible have been converted to CHP production. In other words, the heat is used to supply district heating, and the electricity is sold to electricity suppliers. Both in 2020 and 2021, waste incineration contributed with 8.9% of total primary energy production in Denmark.

2.1.11 Buildings and urban structure

One-twentieth of the area of Denmark is urbanised. 85% of Danes are town-dwellers, and most enterprises, institutions, etc., are situated in towns. Many air pollution problems are therefore concentrated in the towns.

On 1 January 2013, the total built-up area was 727.5 mill. m^2. Table 2.10 shows the distribution of the area between housing, factories, offices, etc.

TABLE 2.10 KEY FIGURES FOR THE STOCK OF BUILDINGS 2011-2022 (1 JANUARY), MILL. M^2
Source: Statistics Denmark

	2011	2015	2020	2021	2022
Total building area	**716.8**	**734.4**	**759.8**	**775.6**	**781.6**
Buildings for year-round habitation	320.3	329.3	342.9	347.0	351.1
Factories and workshops	67.2	67.5	53.8	53.2	52.7
Commerce, trade and administration	71.5	74.5	90.8	92.1	92.7
Institutions and buildings for cultural and recreational purposes	120.4	126.1	146.7	160.6	170.9
Farm buildings	137.5	136.9	125.4	122.6	114.1

Today, about 6 Million m^2 are built per year. In recent years, house building has accounted for slightly more than half of all investment in building activities, and about half of the investment in the housing sector has gone on alterations and extensions.

Towns and cities are generally characterised by separation of residential and industrial areas, industrial buildings being situated in specially designated zones on the outskirts of the towns. The growth in the service industries and the growth in manufacturing with a small environmental impact imply new possibilities for integrating industry and housing, thereby reducing the need for transport between home and work.

Approximately two-thirds of the total building space is heated. The most important types of heating are district heating and central heating using gas and oil. Half of the heated space is heated by district heating and, as seen from Table 2.11, the use of both district heating and natural gas has increased at the expense of oil.

TABLE 2.11 DEVELOPMENT IN THE MAIN FORMS OF HEATING IN BUILDINGS, IN % OF TOTAL HEATED SPACE
Source: Statistics Denmark.

	Unit	2011	2015	2020	2021	2022
Total heated space	Mill. m^2	495	508	529	541	546
District heating	%	51	52	54	55	55
Central heating with oil	%	17	15	11	10	9
Central heating with natural gas	%	18	19	18	18	17
Central heating with solid fuels	%	3	4	4	4	4
Heating with electricity	%	7	7	6	6	6
Furnaces fired by oil and similar	%	1	1	0	0	0
Furnaces fired by solid fuels	%	1	1	0	0	0
Heat pumps	%	1	2	4	5	6
Other heating	%	0	0	0	0	0
No heating or no information	%	1	1	1	1	1

2.1.12 Agriculture

The agricultural area in Denmark has fallen from 72% (30,900 km^2) of the total area in 1960 to 61% (26,184 km^2) in 2021. Table 2.12 shows the breakdown of the development since 1990 by type of crop or use.

The proportion of agricultural land under grass and whole seed in rotation and permanent grass fell considerably from 1970 to 1990, but rose considerably during the 1990s, partly due to increasing use of grass fields for dairy farming, and partly due to the change in EU subsidy schemes, which means that grass or industrial seed must be grown on set-aside land. Furthermore the area with maize and cattle feed is included with the area with grass and whole seed, and the area with maize has increased significantly since 1980s. This is due in part to a warmer climate, which has made maize easier to grow.

During the 1990s interest in organic farming increased considerably. In 2021 organic farms accounted for approximately 10% of land under cultivation.

From 1980 to 2021 the number of farms fell with 69% from 119,155 to 31,395. In the same period the average size of farms increased from 24 ha to 83 ha. This development has reduced the importance of agriculture as a source of primary employment. However, in the same period agricultural production has grown, both in quantity and value, and agricultural exports still make up a large proportion of Denmark's total exports.

During the last 40 years use of nitrogen by agriculture has varied greatly. Up to 1990 there was a big increase in the use of fertiliser (both manure and chemical, but during the 1990s use of fertiliser decreased considerably until 2015. The trends in the statistics for imported chemical N-fertilisers show an increase again after 2015. The same trends can be seen for the import of phosphorus and potassium in fertilisers.

Cattle population fell by 45% from 1970 to 2015 cf. Table 2.12. Most of the cattle are dairy cows. Since milk production remained approximately unchanged throughout the period, the fall in cattle population is due to higher productivity per animal. In the same period, the pig population increased by 50%. The sheep population has more than doubled in relation to 1970, while the poultry population in 2015 was a little below the level of 1970. Since the 1970s, initiatives aimed at nutrients etc. have led to favourable trends, including with regard to greenhouse gases, where agriculture has reduced emissions by about 18.5% since 1990. Emissions of methan and nitrous oxide from agriculture (i.e. excluding emissions from energy consumption) accounted for approximately 21% of Denmark's total emissions of greenhouse gases in 2015.

TABLE 2.12 STATISTICS ON AGRICULTURAL LAND, FARMS, CHEMICAL FERTILISERS AND LIVESTOCK
Source: Statistics Denmark

	Unit	1990	2000	2010	2020	2021
Agriculture and horticulture in total	Km^2	27,883	26,470	26,464	26,200	26,184
Grain (to maturity)	%	56	57	56	52	52
Grass and whole seed in rotation	%	12	16	21	20	19
Grass outside of rotation	%	8	6	8	8	9
Industrial crops (seeds)	%	10	4	6	6	6
Root crops	%	7	4	3	4	4
Seeds for sowing	%	2	3	3	4	4
Set-aside	%	-	7	1	3	3
Pulses (to maturity)	%	4	1	0	1	1
Horticultural crops	%	1	1	1	1	1
Christmas trees and decorative greenery	%	-	-	1	1	1
Other crops	%	0	0	1	0	0
Area with organic farming	%	-	3	6	10	10
Total number of farms	No.	79,338	54,541	42,099	33,148	31,395
Average size of farms	ha	35	49	63	79	83
Nitrogen in chemical fertilisers	’000 tonnes N	395	234	197	228	-
Phosphorus	’000 tonnes P	39	16	11	18	-
Potassium	’000 tonnes K	124	65	45	81	-
Cattle	’000	2,239	1,868	1,571	1,499	1,488
Pigs	’000	9,497	11,921	13,173	13,163	13,168
Sheep	’000	159	145	160	135	135
Poultry	’000	16,249	21,830	18,731	22,133	21,892

2.1.13 Forestry

Approximately 15% of Denmark is forested. Originally focus was mainly on the production potential of primarily conifers, but in recent years focus has changed towards indigenous, deciduous tree species as offering greater long-term production and nature potential. Denmark's forests are managed as closed canopy forests. The main objective is to ensure sustainable and multiple-use management of the forests and to manage them in line with overall management of the countryside. Instead of clear-cut systems, forest owners are to a higher degree applying near-to-nature forest management regimes. Unlike our Scandinavian neighbours, in Denmark forestry does not play an important role in the national economy.

The Danish Forest Act protects a very large part of the existing forests against conversion to other land uses. This is also the case for afforested areas for which public subsidies are made available. In principle, this means that most of the forested land in Denmark will remain as forest.

The ambition is to have about 25% of Denmark's area forested by the end of the 21st century. A considerable increase in the forest area is therefore to be achieved.

Denmark is the only part of the Realm in which forestry is practised. Greenland and the Faroe Islands have almost no forest.

2.2 GREENLAND

2.2.1 Form of government and structure of administration

Today, Greenland is a self-governing, autonomous country within the Kingdom of Denmark. The system of governance is parliamentary democracy. The colonial history of Greenland began with the Norwegian priest Hans Egede who arrived in 1721 and established missions various places in Greenland. It remained a colony until 1953, when Denmark unilaterally changed the status of Greenland from being a colony to a constituency in the Danish Kingdom. This development of administrative status marked the beginning of a new societal development in Greenland. Until 1979 the Greenlanders pursued to obtain more autonomy. A practice, which was intensified in the 1970s and led to the introduction of Greenlandic Home Rule in 1979. With the transition to Home Rule, Greenland established its own government and parliament, entitled to legislate and manage many parts of the administration.

On 21 June 2009, the Act on Greenland Self-Government came into force. The Act grants Greenland more autonomy and recognises the Greenlandic people as a people pursuant to international law with the right to self-determination. It also establishes *Kalaallisut*, the Inuit language spoken in Greenland, as the official language. In accordance with Chapter 8, §21 of the Self-Government Act, the people of Greenland can become independent by a referendum in Greenland, when they shall so decide. With the Self-Government Act, Greenland is still within the Realm and shares some fields of responsibility with Denmark and the Faroe Islands, i.e. the Constitution, franchise and the eligibility for election, citizenship and central institutions like the National Bank. Greenlandic authorities today manage most domestic affairs, legislate and have full financial responsibility in the acquired areas, including areas such as health, fisheries, education, science and research, environment and climate, taxation, mining and natural resources, infrastructure, trade, spatial planning, social affairs and housing to mention some. Responsibility for the Supreme Court, foreign affairs, defence and security policy as well as exchange rate and monetary policy fall within the jurisdiction of the central authorities of the Realm, however, as stipulated in the Self-government Act, Greenland may act in international affairs on areas of own competence and where not applicable, the Governments of Denmark and Greenland shall cooperate with a view to safeguarding the interests of Greenland as well as the general interests of the Kingdom of Denmark.

Inatsisartut, the parliament, has 31 members. The members are elected directly at general elections held every four years. The last election was held on 6 April 2021. The parliament elects a government responsible for the central administration under the Prime Minister of Greenland.

The administration is divided into eleven ministries. The Minister for Agriculture, Self-sufficiency, Energy and Environment represents Greenland in international negotiations on climate change. The ministry has primary responsibility for coordination and implementation of legislation, plans etc. for the climate area.

Greenland Self-Government

The Act on Self-Government states that Greenland can have jurisdiction and financial responsibility for almost all aspects of public affairs if Inatsisartut, the Parliament, so decides. The Self-Government Act also outlines the future economic relationship between Denmark and Greenland. Since the 2009 Act, Greenland has taken over the responsibility, and thus the legislative and executive powers, within the area of mineral resources. Greenland's economy is mainly reliant on fisheries. Other sectors contributing to Greenland's economy include minerals and tourism. Denmark provides a general annual financial subsidy to Greenland to cover the expenses relating to the areas that have surpassed to the Government of Greenland. With the Self-government Act the subsidy amount was frozen, however, adjusted to inflation levels. This mean, as Greenland takes over more areas of competence from Denmark, the amount will not increase. Additionally, Denmark funds the judicial system, including the police, courts and correctional institutions, as they remain a part of Danish responsibility. Future revenues from mineral activities will reduce the state subsidy by half the revenues exceeding DKK 75.0 mill. annually.

International Relations

Greenland was, through the relation to Denmark, part of the European Union until it left in 1985 and acquired status as an Overseas Country and Territory (OCT). Greenland also receives an annual subsidy from the European Union to the amount of roughly over EUR 30 million that historically was linked to Greenland giving EU fisheries rights in Greenland waters.

In accordance with the 2009 Self-government Act*,* the Government of Greenland (Naalakkersuisut) may negotiate and conclude international agreements with foreign states and international organisations, including administrative agreements, which exclusively concern Greenland and entirely relate to fields of responsibility taken over by Greenland.

For agreements that fall outside this scope and which are thus concluded by the Danish Government or jointly, the Self-Government Act contains rules and regulations for the involvement of the Self-Government authorities. Accordingly, the Danish Government is required to notify Naalakkersuisut in advance of negotiations regarding agreements under international law which are of particular importance to Greenland. Before they are concluded or terminated, such agreements must be submitted to Naalakkersuisut for comments.

Denmark has ratified the Climate Convention with the consent of Naalakkersuisut. The Kyoto Protocol was ratified by Denmark in agreement with Greenland, on 31 May 2002. The Government of Greenland requested a territorial exemption for reduction commitments when Denmark ratified the second commitment period of the Kyoto Protocol.

In August 2012 a cooperation agreement relating to the international climate change negotiations was signed by representatives from the Danish Government and the Government of Greenland. The agreement serves to facilitate closer cooperation on matters of mutual interest and to improve Greenlandic access to information and consultation in relation to the UNFCCC negotiations.

On 31 March 2016 Naalakkersuisut agreed to request Denmark to make a territorial reservation against the Paris Agreement in connection with the ratification of the agreement. The territorial reservation means that Greenland doesn't have any international reduction commitments.

However, during the UN's COP26 climate summit in 2021 the Greenlandic Prime Minister announced that the Government of Greenland will give up the exemption from the agreement and seek to have the national assembly commit to deliver objectives for reducing greenhouse gas emissions. Following the decision, the Government of Greenland (Naalakkersuisut), will proceed with a domestic national ratification process via the parliament (Inatsisartut).

2.2.2 Population

The population of Greenland has increased by 13.5% since 1980. Today the total population is around 56,421 cf. Table 2.13. Of these 90% were born in Greenland.

TABLE 2.13 POPULATION OF GREENLAND (WITH 2030 PROJECTION)

Source: Naatsorsueqqissaartarfik - Statistics Greenland, 2022

	1980	*1990*	*2000*	*2010*	*2021*	*2030*
Population	49,773	55,558	56,124	56,452	56,421	54,452

Estimated changes in the population show a decrease towards 2030, but the proportion of the population born outside Greenland is not expected to change.

Migration and immigration patterns are dominated by the strong, historical connections between Greenland and Denmark. Every year throughout the period 1993-2021, more people moved away from Greenland than to Greenland. In 2021 a total of 1,962 people immigrated while 2,184 people emigrated (i.e. net emigration: 222). The net emigration in 2020 of 42 persons was the lowest number of annual net emigrations since 2012. This is believed to be due to the COVID-19 pandemic.

The population density in 2021 was 0.14 per km^2 of ice-free area.

2.2.3 Geography

With an area of 2,166,086 km^2, Greenland is the world's largest island. It extends over almost 24 latitudes. The northernmost point is Cape Morris Jessup, only 740 km from the North Pole, while Cape Farewell in the south shares latitude with Oslo, Norway.

Greenland is covered by the Greenland Ice Sheet, a continuous, slightly convex ice sheet that covers 81% of the island and reaches heights of 3,700 m above sea level.

The coastal line stretches 44,087 km and is dominated by deep fiords and archipelagos. The population of Greenland lives in the coastal regions, where there is little ice.

Access to open waters implies good opportunities for fishery, hunting and transportation by sea, which are all important to Greenland society.

Greenland is surrounded by Atlantic and Arctic waters. The North Atlantic Ocean lays to the south and the Greenland Sea and the Denmark Strait to the east. The Denmark Strait is located between Greenland and Iceland and is 240 km wide. The west coast of Greenland meets the Davis Strait and Baffin Bay, and in the north, Greenland is separated from Canada by Smith Sound and Nares Strait. In Nares Strait a mere 26 km separates Greenland from Ellesmere Island, Canada. North of Greenland lays Lincoln Sea and Wandels Sea in the Arctic Ocean.

2.2.4 Climate

Greenland has an Arctic climate. About 80% of the land is covered by an ice sheet that is more than 3 km high, while the ice-free land areas are limited to a 50-300 km wide coastal strip. In southern Greenland, in the inner valleys of the fjord systems, the climate is sub-Arctic. Here, the mean air temperature can rise to above 10 °C in July. The climate in southwest Greenland, where most of the population of 55,000 lives, is low-Arctic. This part of Greenland is characterised by relatively mild winters with high rates of snowfall and occasional thaw, and wet summers with average temperatures of less than 10 °C in the warmest month.

North and northeast Greenland are parts of the high-Arctic zone. The climate is continental with very cold winters down to below -45 °C in north Greenland. Temperatures are rarely above 0 °C from September to May. Parts of north Greenland are characterised as polar deserts with less than 25 mm precipitation per year, corresponding to about 1 % of the precipitation at the southern tip of Greenland. The continental climate in high-Arctic Greenland is determined by sea ice from the Arctic Ocean, which makes up the pack ice belt, often up to several hundred kilometres wide, floating southwards along the east coast of Greenland. In recent years, the extent of the Arctic ice pack has been reduced for long periods of time. This has led to unusual events such as wave erosion along the coasts, which had not seen open sea to the same extent previously. The climate in high-Arctic Greenland is also greatly influenced by the amount and spread of sea ice.

Atmospheric pressure

Atmospheric pressure is generally highest in April-May when the weather in Greenland is most stable. In the summer months, variations in atmospheric pressure are limited. During winter, the variations are greater due to larger differences between the north and the south. The higher atmospheric pressure in the north leads to a greater frequency of cold winds from northerly directions and higher wind speeds.

The highest pressure extremes in Greenland occur during winter because of the large temperature difference in the atmosphere. The highest atmospheric pressure measured in Greenland was 1064.4 hPa, recorded on 18 January 1958. The lowest was 932.1 hPa, measured on 15 January 1988.

Wind

Storms typically occur in connection with the passage of low-pressure systems. Between these systems, there are undisturbed periods of varying duration throughout the year, when the wind is governed by local conditions.

An example is the katabatic wind system of the ice sheet. Katabatic winds blow down an incline, moving from the central part of the ice sheet towards the edge. The wind speed accelerates with increasing incline of the surface, and the topography can cause funnelling of the wind, which results in extremely high wind speeds at the edge of the ice sheet. However, calm wind conditions are also common in Greenland. In some areas on the east coast little or no wind is recorded 60 % of the time.

Gusts can be very strong. E.g. wind speeds of up to 75.1 m/s was measured in Danmarkshavn on 13 January 1975, but even stronger gusts undoubtedly occur in connection with piteraqs, which is a katabatic wind. Such katabatic winds from the ice sheet occur in several locations in Greenland, and they are characterised by a very abrupt change from low wind speeds to storm.

Temperature

The summer temperatures on both the west and the east coast differ by only a few degrees from south to north, despite a distance of about 2,600 km. This is due to the midnight sun during summer in north Greenland. Conversely, winter darkness and the absence of warm sea currents mean that temperatures during winter differ considerably from north to south.

There is also a large difference in the temperature conditions at the outer coast and along the inner fjords. During summer, drift ice and cold surface water cools the air by the coast compared to the ice-free fjords, while the open sea is less likely to freeze during winter, causing the air to be warmer along the coast than in the fjord areas.

Foehn winds can disturb this picture during winter. Foehn winds are very common in Greenland and the hot, dry winds can increase temperatures by 30 ºC within a relatively short period of time, resulting in the melting of snow and ice. Relatively high temperatures in the winter period are often the result of Foehn winds.

The highest temperature recorded in Greenland since 1958 is 25.9 ºC recorded in Manitsoq in July 2013.

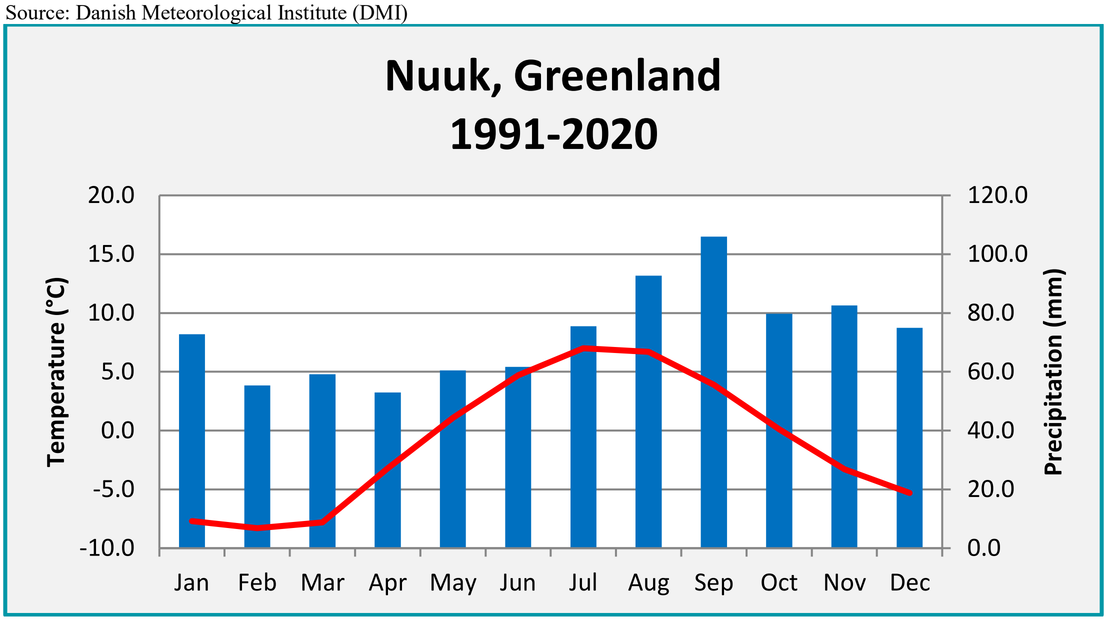
In Greenland, frost can occur in all months of the year except in the inner fjord areas at Narsarsuaq Airport and Kangerlussuaq during summer.

The coldest place in Greenland is on top of the ice sheet, where the temperature can fall to below -70 ºC. In the 1950s, a British research station measured -70 °C and a DMI station measured -64.9 °C at Summit in the middle of the ice cap.

Apart from the ice cap, the coldest temperatures measured in Greenland are in Hall Land and Kap Morris Jesup on the north coast with yearly mean temperatures of -18.7 °C (1991-1996) and -15.6 °C (2010-2020). The lowest temperature was -52.1°C measured at Hall Land in January 1989 and possibly even lower as this type of station does not measure absolute minimum temperatures.

The mean air temperatures measured during the new climate normal period 1991-2020 were higher than those measured in the previous climate normal period 1961-1990 at all stations in Greenland cf. Figure 2.21. In recent years, several warm summers in Greenland have been registered. In 2012, such a summer was followed by a number of unusual melting events, also in the middle of the ice sheet (Summit) and in 2021, there were recordbreaking high monthly mean temperatures (July, August and September) at several stations on the east coast. Extreme events in Greenland such as in 2012 and 2021 cannot be regarded as ‘unnatural’, but the likelihood and severity of these events increase with a warmer climate in Greenland.

FIGURE 2.21 CLIMATOLOGICAL STANDARD NORMAL FOR NUUK 1991-2020
Source: Danish Meteorological Institute (DMI)



Precipitation

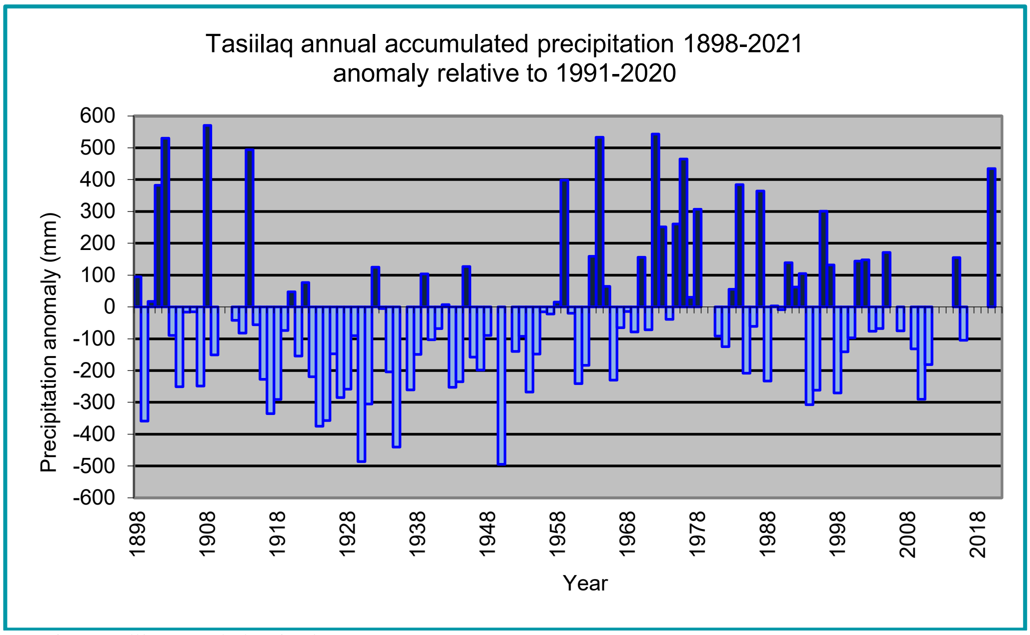
Recorded precipitation in Greenland decreases with rising latitude and from coastal to inland areas. Particularly for stations in south Greenland the seasonal variations are considerable.

In the south and especially in the south-eastern regions of Greenland, precipitation is high (e.g. in Tasiilaq cf. Figure 2.22). Average annual precipitation amounts range from app. 800 to 2,500 mm along the coasts. Further inland, towards the ice sheet, substantially less precipitation is recorded. In the northern regions of Greenland there is very little precipitation, ranging from 325 mm to below 150 mm per year (e.g. in Danmarkshavn cf. Figure 2.22). Some areas in north Greenland are characterized as 'Arctic deserts', i.e., areas that are almost free of snow in winter, and where evaporation in summertime can exceed precipitation.

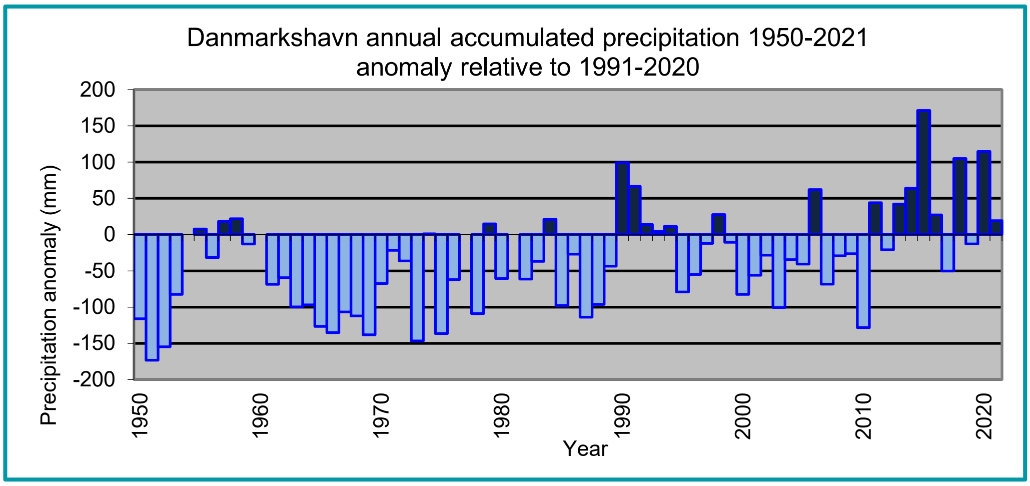
Not surprisingly, snow is very common in Greenland. At most stations in the coastal regions snow can fall all year around without necessarily forming a snow cover on the ground. The highest snow depths are seen in southern Greenland, averaging from one to more than two metres snow during winter and sometimes reaching up to six metres. In southern Greenland, the snow cover can disappear altogether during winter in connection with warm Foehn winds.

Further north, snow covers are usually already formed in most places by September and normally disappears again in June or July.

FIGURE 2.22 ANNUAL PRECIPITATION (MM) IN TASIILAQ 1898-2021 (TOP) AND IN DANMARKSHAVN 1950-2021 (BOTTOM), ANOMALY RELATIVE TO 1991-2020.
Source: Danish Meteorological Institute (DMI)



Data from Tasiilaq are missing for the years 1910-1911, 1936, 1949, 1951, 1979-1980, 2006, 2008, 2012-2014, 2017-2019, and 2021.



Data from Danmarkshavn are missing for the years 1954, 1960, 1977 and 1981.

Variations in daytime length

The area of Greenland, which lies north of the Arctic Circle, 66.5 ºN, has midnight sun and polar night of varying lengths depending on the latitude. Midnight sun occur when the sun is above the horizon 24 hours a day, while polar night occurs when the sun does not rise above the horizon at all.

Despite the long periods of polar night during winters, the northern stations measure a higher number of hours of sunshine than the southern stations. This is due to the longer days during summer and a generally less dense cloud cover. Although the surface of the soil receives more solar heat around summer solstice compared to soil surfaces in the tropics, a considerable part of the energy is reflected because of the oblique angle of incidence, but it is also reflected by snow and ice-covered surfaces.

2.2.5 Economy

The economy of Greenland is a small-scale economy based on trade with other countries (see Table 2.14 for key figures).

Under the Danish Realm, Greenland received an annual state subsidy to finance fields of responsibility assumed from Denmark. Under Self-Government, Greenland will still receive an annual grant, but the new fields of responsibility must be financed by the Government of Greenland. Future revenues from mineral activities in Greenland will reduce the state subsidy by half the revenue exceeding DKK 75 mill. The 2020 national budget of Greenland saw a GDP of DKK 276,100 per capita.

TABLE 2.14 KEY FIGURES FOR THE GREENLAND ECONOMY IN 2011, 2014, 2015, 2018 AND 2020. CURRENT PRICES (EXCEPT FOR GDP) IN DKK MILLION.

Source: Naatsorsueqqissaartarfik - Statistics Greenland, 2022

	2011	*2014*	*2015*	*2018*	*2020*
GDP[1]	14,008	12,444	12,165	15,084	15,481
State subsidy (block grant)	3,555	3,301	3,533	3,833	3,911
Imports	5,350	4,866	4,487	5,294	6,218
Exports	2,636	3,139	2,738	4,439	5,304
Public expenditure	9,346	10,139	10,122	11.591	12.613
Annual growth in GDP	0.5 %	4.7 %	-2.5 %	0,6 %	0,4 %

[1] 2010 prices, chained values.

Exports

The fishing industry is of immense importance to the economy of Greenland, as fish and seafood are the only large-scale export from Greenland (see Table 2.15). The estimated relationship between GDP and the real export value of fish and seafood shows that a 1% increase in the export value of fish and seafood leads to a 0.29% increase in Greenland GDP, according to time series data ranging back to 1966. Therefore, changes in both the world market prices and the availability of important stocks of fish are important to the entire economy.

TABLE 2.15 VALUE OF EXPORTS IN 2000, 2007, 2012, 2016 AND 2020 IN DKK MILLION (2010-PRICES, CURRENT VALUES).

Source: Naatsorsueqqissaartarfik - Statistics Greenland, 2022

	2000	*2007*	*2012*	*2016*	*2020*
Total value of exports	2,205	2,326	2,782	3,867	5,304
Total value of export of food, fish and seafood	2,105	1,904	2,521	3,431	4,861
Value of export of single stocks as share of total value of export of fish and seafood					
Northern shrimp	63.8 %	59.4 %	56.2 %	44.9 %	48.8 %
Atlantic cod	2.5 %	9.4 %	6.7 %	11.2 %	8.6 %
Greenland halibut	17.3 %	23.2 %	26.1 %	31.3 %	29.6
Snow crab	10.8 %	1.9 %	1.7 %	1.7 %	3.4
Other	3.7 %	4.5 %	9.1 %	10.5 %	9.5

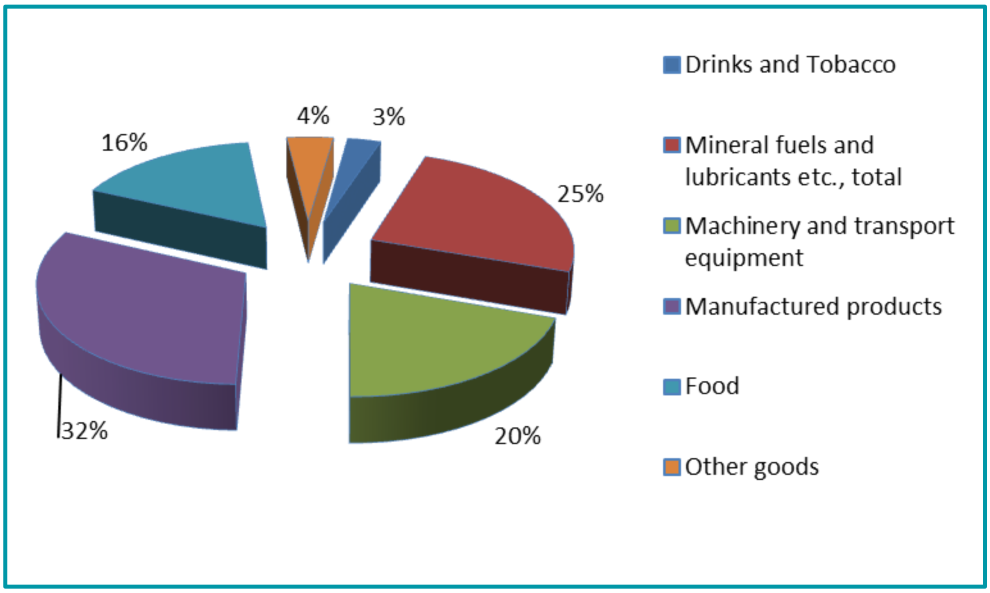
Commercial hunting is common in the northern and eastern parts of Greenland and locally the income from hunting is important to the wellbeing of the community, but hunting does not contribute extensively to the national economy.

Imports

As the inland production is limited, Greenland is an open economy depending on imports of a wide range of goods. The most recent statistics on import are presented in Figure 2.23.

FIGURE 2.23 IMPORTS IN 2016

Source: Naatsorsueqqissaartarfik - Statistics Greenland, 2017



2.2.6 Energy

Greenland has high basic energy demands. Expenditures related to transportation and energy supply are considerable due to the large size of the country, the widely dispersed population and the Arctic climate.

For the past decade, Greenland has been investing significantly in hydropower, and today 72% of the national energy supply is based on renewable sources. Despite these investments, Greenland's CO_2 emissions have been increasing until 2011, since when emissions have reduced. Greenland is still very dependent on the import of fossil fuels.

Energy production and supply

Because of the vast distances between towns in Greenland, it is neither financially nor technically viable to establish a supply grid connecting them. This means that each town and settlement has its own power plant or combined heat and power plant (CHP plant) – a so-called island operation. At the same time, the climatic conditions mean that towns and settlements cannot bear lengthy interruptions in their electricity supply. Therefore it is also necessary to have reserve and emergency plants. There is only one power plant that supplies two towns: the Qorlortorsuaq hydropower plant, which has supplied both Narsaq and Qaqortoq in South Greenland with electricity since 2008. In both towns there are still back-up plants.

Hydropower generation

Greenland has invested in renewable energy since the 1990s with annual investments making up 1% of GDP. Prior to 1993, all energy production for electricity and district heating was based on diesel-driven power generation and CHP plants. Today five hydropower plants cover 66% of total energy supply and contribute to an increasing degree of self-sufficiency in the energy sector cf. Table 2.16.

TABLE 2.16 GREENLAND'S HYDROPOWER PLANTS IN 2022

Source: The Department of Agriculture, Self-Sufficiency, Energy and Environment, Government of Greenland (2022)

Name	Area of Supply	In Operation Since	Capacity in Megawatt
Utoqqarmiut Kangerluarsunnguat	Nuuk	1993	45 MW
Aammangaaq	Tasiilaq	2004	1.2 MW
Qorlortorsuaq	Narsaq og Qaqortoq	2008	7.6 MW
Sisimiut	Sisimiut	2010	15 MW
Paakitsoq	Ilulissat	2013	22.5 MW

The Greenlandic Parliament, Inatsisartut, passed a bill in the fall of 2021, deciding to expand the Utoqqarmiut Kangerluarsunnguat hydro power plant, which is supplying Nuuk, and to construct a new hydropower plant in Kuussuup Tasia to supply Qasigiannguit and Aasiaat. The Utoqqamiut Kangerluarsunnguat (Nuuk) expansion includes a new 55 MW power station, which will increase the total capacity of the plant to 100 MW. The Kuussuup Tasia hydropower plant is expected to have the same capacity of around 21 MW as the Paakitsoq hydropower plant in Ilulissat. Preliminary studies of other potentials continue.

Greenland's enormous untapped hydropower resources exceed the domestic demands several times and Greenland has the potential to become a net energy exporter. On 10 May 2022, the Minister for Agriculture, Self-sufficiency, Energy and Environment announced during the World Hydrogen Summit in Rotterdam that Greenland's largest untapped hydropower potentials Tasersiaq and Tarsartuup Tasersua will be launched for competitive tender. The Government of Greenland has started the process of attracting investors who might be interested in building a hydroelectric power plant in Tasersiaq and Tarsartuup Tasersua. Investors must be ready to invest in hydropower production as well as one or more off-take industries that can exploit the green energy from the hydropower plant. In addition to a comprehensive data package, the Government of Greenland invites investors to participate in a market dialogue to ensure that a broad, international competition of tenderers and investors can offer their views on the tendering procedure and contribute to making the content of the conditions as attractive as possible. These dialogues took place from September till November 2022.

Fossil-fuel-based power generation

Greenland is still very dependent on the import of fossil fuels for power generation. Today, approximately 28% of the total energy supply from the public utility company Nukissiorfiit is based on oil, which is largely a reflection of the island-operation system, in which most settlements outside the larger towns depend on fuel-based power generation.

District-Heating

The production and supply of heating takes place in a number of ways. Integrated supply facilities for heating and electricity exist in a number of places, where hydropower plants and fuel-based power plants generate surplus heat, which is then used for district heating. In addition, waste incineration contributes to the heating supply in a number of towns and settlements.

An increasing share of the heating supply is based on surplus hydroelectricity from the five hydropower plants. When these are already operating on maximum capacity , oil boilers supplements to the demand in order to secure stable supply.

Finally, a considerable amount of the heating supply, especially in smaller settlements, is still based on fuel-based district heating systems. This is largely a consequence of the island-operation system, where large-scale power generation facilities are not technically or financially viable.

Energy consumption

Energy consumption increased significantly from 1990 until 2011, especially in 2010 and 2011 due to the growth in geological surveys, which are very fuel-intensive. As a result, Greenland experienced the largest consumption ever recorded in 2011 (11,071 TJ). Since 2011 there has been no oil exploration. This standstill combined with an economic recession has caused a drop in total energy consumption in 2012-2014 to 2009-levels. In 2020 energy consumption increased by 3.5% to 8,627 TJ (see Table 2.17 and Figure 2.24), compared to 1990, while it decreased by 1,9% compared to 2019. The energy level is believed to have decreased due to the Covid-19 pandemic and the resulting less air traffic.

Despite an increase in the production of renewable energy over the last decade, Greenland is still dependent on imports of fossil fuels. With a total share of approximately 82%, the large majority of energy consumption is based on fossil fuels. This includes consumption in households, production industries, energy and water supply, the transportation sector, public and private services as well as wholesale and retail.

In 2010 and 2011 emission of greenhouse gasses increased significantly due to an increase in fuel combustion caused by the initiation of oil exploration. This caused emissions from energy consumption to rise by 14.5% in 2010 and by 6.9% in 2011. Due to the absence of oil exploration since 2011, emissions from energy consumption have now dropped below 1990 levels to 576.35 kton CO_2-equivalents in 2020.

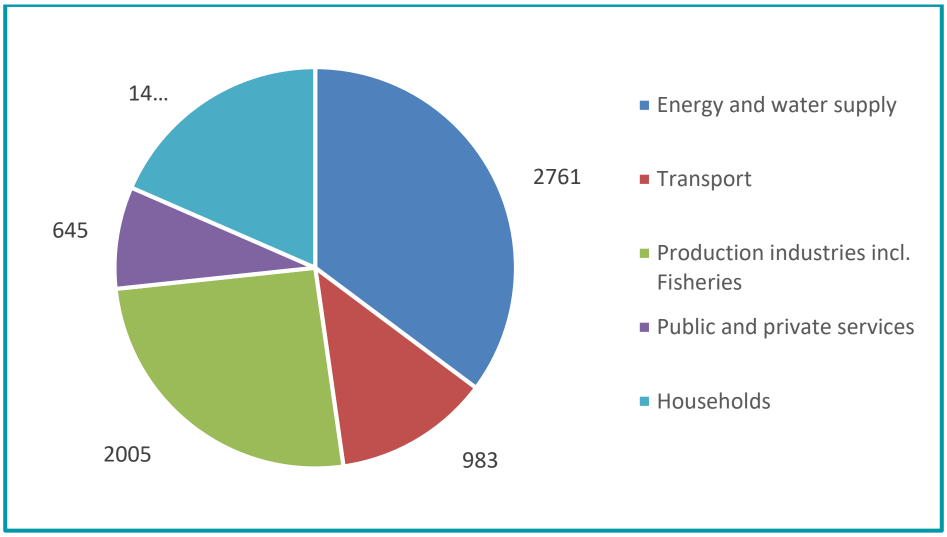
Table 2.17 Energy consumption by source in 2010, 2015 and 2020

Source: Naatsorsueqqissaartarfik - Statistics Greenland based on information from Polaroil A/S, Statoil A/S and Nukissiorfiit.

	2010 Unit GJ	2015 Unit GJ	2020 Unit GJ	2010 Unit GWh	2015 Unit GWh	2020 Unit GWh
Hydropower	1,012	1,480	1,513	281	411	420
Energy recovered from waste	90	98	103	25	27	29
Petroleum	839	702	468	233	195	130
Solar	7,720	5,302	5,463	2,144	1,472	1,564
Fueloil	50	447	282	14	124	78
Gasoline	585	585	815	162	162	226
Liquified petroleum gas (LPG)	4	3	3	1,1	0,8	0,8
Wasteoil	9,	9	9	2,5	2,5	2,5
Consumption of energy, total	**10,309,106**	**8,626,206**	**8,827**	**2,864**	**2,396**	**2,451**

FIGURE 2.24 DISTRIBUTION OF GROSS ENERGY CONSUMPTION IN 2020

Source: Naatsorsueqqissaartarfik - Statistics Greenland, 2022 - Greenland's Energy Consumption 2020



2.2.7 Transport

Passenger transport is primarily by air, although one ferry and a number of small passenger vessels operate in Greenland waters. Table 2.18 present the most recent numbers from 2016.

TABLE 2.18 GREENLANDIC AND FOREIGN VESSELS OPERATING IN GREENLANDIC WATERS

Source: Ministry of Health and Infrastructure, Government of Greenland and Marine Rescue Coordination Center Nuuk, 2017

		2008	2010	2012	2016
Research/ Ice breakers/ Government	Private ice breakers	2	3	1	0
	Research vessels	23	22	24	24
	Special purpose vessels	10	24	14	0
Shipping	Bulk carriers and container ships	24	24	21	32
	Tankers	6	10	6	5
Passenger Transport	Ferry	1	1	1	1
	Passenger vessels	11	-	10	12
	Passenger cruise ship	36	38	30	42
Fishing	Large commercial fishing vessels	10	29	23	25

Passenger transport by air

The regions of Greenland are connected by ships, aeroplanes and helicopters.

Since the 1990s, Greenland has seen an increase in both sea and air passenger transport, and the need for flexible and fast transport between the towns has increased in parallel to the general development of society.

Year-round scheduled air services connects Greenland with the outside world, through Copenhagen, Denmark and Reykjavik, Iceland.

Passenger transport by land

There are no roads connecting towns and settlements in Greenland, but in most towns, there are bus services. Private car ownership is common, and the number of taxies is generally high.

In 2021 there were 16.057 vehicles registered by the motor vehicle administration. Greenland had 7.599 cars, 236 taxis, 124 buses, 222 emergency vehicles, 2.234 commercial vans and trucks, 4 motorcycles, 3.545 snowmobiles/snow scooters and 2.093 vehicles registered as “others”. 1.446 of the registered vehicles are full electric or plug-in hybrid cars.

Passenger transport by sea

Passenger transport by sea is serviced by one ferry and small vessels, operating in Greenland waters. The ferry sails along the west coast of Greenland, while passenger vessels carry both passengers and goods between towns and settlements.

Private boat ownership is common, and boats are used for local transportation as well.

Cruise ship tourism

Greenland has seen an increase in tourism since the turn of the century, and especially cruise ship tourism has increased. The number of cruise ships sailing in Greenland has been increasing year by year. However, during the COVID-19 pandemic the activity was at its lowest, but the activity has increased in the aftermath of COVID-19. With the rise of commercial tourism there has been increased focus on cruise ship activity and the protection of the arctic environment and nature. In 2019 a total of 53 cruise ships operated in Greenland waters. There were no cruise ships in Greenlandic waters in 2020 and 2021 due to the COVID-19 pandemic.

Shipping

Royal Arctic Line (RAL) is the major shipping agent in Greenland, enjoying a government-issued concession that gives it a virtual monopoly on containerized shipping. Royal Arctic Line connects Greenland with Europe, primarily through the port of Aarhus in Denmark and Nuuk in Greenland. Almost all cargo to and from Greenland passes through this route. In 2017 Royal Arctic Line signed an agreement with Icelandic Eimskip for the cooperation of building three container vessels and sharing capacity. This agreement also solidified the establishment for new routes via Reykjavik, Iceland.

Greenland experienced an increase in shipping during the mid-00s, attributed to an increase in exports of fish and shrimp and increased imports of consumer goods, machinery and materials for construction. In recent years commercial shipping activity has declined from the high in 2008. This appears to be due to a decrease in commerce overall rather than an indication of declining importance of the shipping trade in Greenland.

The planned opening of large-scale mining are likely to greatly increase shipping between Greenland and world markets, in particular to Europe and North America.

2.2.8 Industry

Greenland has a small inland production of industrial produce and exports are based almost entirely on fisheries, while most industrial produce is imported.

Fishery

Fish and seafood is the single most important export commodity in Greenland that consists of more than 250 species. In 2020 over 91 % of the total export value was connected to fisheries. The main catches connected to this are prawns, halibut and cod which consist of the export value. Fishing activities are conducted both on-shore and offshore where fishermen process their catches in production facilities on land or on-board their fishing vessels. The main economic activity in Greenland is fishing and it is mainly concentrated on the west coast.

Mineral industry

The mineral industry is developing, and the industry might be of crucial importance to the industrial development of Greenland.

The Greenland Government, has issued a series of licences for the exploration of minerals (see Table 2.19).

The exploration activitives have shown that there are economic potentials related to a wide range of mineralisations. The current exploitation licences are targeted at the exploitation of gold, zink/lead, iron and anorthosite, and promising exploration projects are targeting eudialyt, rare earth elements, nickel and other minerals.

In 2017, the ruby and sapphire mine at Qeqertarsuatsiaat started production. The mine is located south of Nuuk and has production facilities at the mine site and in Nuuk.

Other projects have been granted an exploitation licence:

- White Mountain, a very large anothosite deposit, located near Kangerlussuaq.In September 2015, the company Lumina Sustainable Materials was granted an exploitation licence.
- Citronen Fjord, a giant zink and lead deposit of more than 130 million tonnes ore. The project is located in the Northeast of Greenland. An exploitation licence was granted in December 2016 and the company Ironbark A/S is still currently seeking funding and are developing the construction plans.

TABLE 2.19 MINERAL ACTIVITIES: PROSPECTING, EXPLORATION AND EXPLOITATION LICENCES IN 1995, 2000, 2004, 2008, 2012, 2016 AND 2022.

Source: Mineral Licence and Safety Authority, Government of Greenland

	Prospecting licences	***Exploration licences***	***Exploitation licences***	***Small scale licences***
1995	21	35	-	-
2000	15	24	-	-
2004	12	22	1	-
2008	12	68	3	-
2012	25	79	4	12
2016	11	58	7	49
2022	14	86	7	30

Moreover, a series of mature exploration projects are getting closer to exploitation. Licences to exploit mineral resources are granted by the Government of Greenland after an extensive process, including public consultation of an EIA (Environmental Impact Assessment) and a SIA (Social Impact Assessment). For each project an IBA (Impact Benefit Agreement) is signed by the company, the municipality and the Government of Greenland to ensure benefits from the projects for the local community and Greenland as a whole. The IBA is adjusted annually.

Currently the following projects are approaching maturity:

- Killavaat Alannguat, a worldclass REE (rare earth elements) deposit. The exploration licence was granted to Tanbreez Mining Greenland A/S. The resource is estimated at around 4 billion tonnes of ore. The deposit is situated in South Greenland and is expected to employ approximately 60-80 people in an open-pit operated all year round. Mine life is expected to exceed 20 years.
- Dundas Titanium near Moriusaq. Exploration approval was given in 2021. In 2022 plans for the infrastructure were made.

- Greenland Anorthosite Mining. The project works with mapping the Anorthosite deposit. The SIA and EIA are almost ready for appovals.
- Greenland Resources, Molybdan deposit by Malmbjerget near Mestersvig at the East coast of Greenland. Works on SIA and EIA are ongoing.
- AEX Gold Nalunaq, ongoing exploration for resource estimation for a re-opening of the Nalunaq Goldmine in Southern Greenland.

The labour market in Greenland

As society resembles strong aspects of the Scandinavian welfare model, public administration and services dominate the labour market in Greenland (see Table 2.20).

TABLE 2.20 LABOUR MARKET STATISTICS WITH BUSINESS NOMENCLATURE, 2022, IN FULL-TIME EQUIVALENTS.

Source: Naatsorsueqqissaartarfik - Statistics Greenland, 2022

Sector	Full-Time Equivalents	%
Public administration and service	11527	43
Fisheries, catches and agriculture	4211	16
Trade	3011	11
Transport	2004	7.5
Building and construction	2039	7.6
Other service industries	353	1.3
Information and communication	605	2.25
Banking and finance	218	0.8
Estate	282	1
Liberal, scientific and technical services	302	1
Administrative services and support services	409	1.8
Hotels and restaurants	708	2.6
Energy and Water supply	444	1.6
Not known	275	1
Industry	246	1
Mineral extraction	94	0

Greenland is likely to see an increase in industrial production within the next decade. The exploration of minerals may result in new mining projects.

2.2.9 Waste

The waste sector contributed with 2.8% of the total GHG emissions in 2020, 46.4% of the total CH_4 emissions and 53.9% of the total N_2O emissions. Two-thirds of waste from other sectors is produced by households, while the remaining waste is produced in commercial activities.

The Ministry of Nature and Environment under the Greenland Government conducted a study of the composition of both household waste and waste from commercial activities in 2006. From this study the most important waste fraction is organic waste (44%), followed by combustible waste (17.5%), both wet and dry paper and cardboard (18%), glass (7.5%), plastics (7%), metal (3.5%) and environmentally hazardous waste (1.5%).

The composition of waste from commercial activities includes comparatively more paper and cardboard (27%), more plastic waste (9%), more environmentally hazardous waste (3%) and more non-combustible waste (5%), but less glass (3%), metal (3%), organic waste (34%) and other combustible waste (16%).

Today, solid waste management is based on incineration facilities and open landfills (see Table 2.21). In six cities incineration plants are in use, handling approximately 65% of the waste produced in Greenland. Much of the residual heat from the six facilities is used for district heating.

In small towns and settlements, 46 small-scale incineration facilities were established during the period 1995-2003. They incinerate approximately 9% of the waste produced. The small-scale incineration facilities were introduced as an environmentally sound alternative to the use of open landfills. The project cannot be deemed successful and the majority of small-scale incineration facilities are either broken or not in use. In these areas open landfills are still in use. The Greenlandic municipalities have since 2014 worked to clean up 18 landfills in towns and villages.

However, waste management is undergoing fundamental change and the work structured by the Government of Greenland’s Waste Management Plan 2020-2031. The Government and the municipalities have decided to establish a national waste incineration solution. Greenland is therefore in the process of building two new nationwide, modern waste incineration plants. The new national waste incineration plants are expected to be ready in 2024. They must handle waste from all over Greenland in an environmentally, healthy and optimal way. Residual heat from waste incineration will supplement existing energy sources in an efficient way in the two cities. When the new waste incinerators are ready, the current six old incinerators will be closed.

Since 1990 Greenland has seen an increase in the amount of waste produced. However, within the same period of time new facilities for waste incineration have increased incineration with energy recovery, while both open burning and disposal has decreased.

There are no waste water treatment plants in Greenland, and waste water produced both on land and at sea is disposed of into the ocean. Households are generally connected to public sewers, but there are still households with no access to sewerage. Industrial waste water management is regulated by Government regulations on environmental operational permits.

TABLE 2.21 WASTE MANAGEMENT IN GREENLAND. 1990, 1995, 2000, 2010, 2015 AND 2020, IN '000 TONNES. WASTE DISPOSAL IS CORRECTED FOR OPEN BURNING
Source: Naatsorsueqqissaartarfik - Statistics Greenland, 2022 - Modelbased estimates

	1990	1995	2000	2010	2015	2020
Managed waste disposal corrected for open burning	6.1	6.4	4.9	4.4	4.6	4.8
Unmanaged waste disposal corrected for open burning	1.4	1.3	0.9	0.7	0.6	0.5
Waste incineration; energy recovery	5.5	6.1	11.3	17.1	18.7	20.5
Waste incineration	0.0	0.2	3.1	3.5	3.5	3.7
Open burning	16.6	17.2	12.9	11.5	11.5	11.8
Total waste produced	**29.5**	**31.2**	**33.1**	**37.2**	**38.9**	**41.3**

2.2.10 Buildings

According to the housing statistics of 2021 there were a total of 22.076 households in Greenland cf. Table 2.22.

The public sector plays a very important role in the housing sector. Most housing are publicly owned either by the municipalities, the government or built privately with a government grant. Grants are available to people who want to build houses according to the co-builder scheme, cooperative housing, private houses, as well as public rental housing. The public sector also subsidises renovation and improvements to private homes, e.g., insulation and replacement of windows reducing the energy consumption. A large part of the houses are 35 – 40 years old, and a renovation program has been initiated. With the renovation of the older buildings, the aim is to replace the building materials with maintenance-free and sustainable building materials that can benefit the climate and reduce energy consumption in the individual houses.

TABLE 2.22 HOUSEHOLD STATISTICS: DISTRIBUTION OF HOUSEHOLDS, TOTAL NUMBER OF HOUSEHOLDS, IN 2009, 2012, 2015, 2018 AND 2021.
Source: Naatsorsueqqissaartarfik - Statistics Greenland, 2022.

	2009	2012	2015	2018	2021
Capital	6114	6718	7072	7395	7586
Towns with more than 3000 residents	6434	6633	6659	6664	6663
Towns with 700-3.000 residents	5179	5167	4999	4834	4812
Settlements with less than 50 residents	215	95	152	166	151
Total number of households	21305	22003	22007	22042	22076

2.2.11 Agriculture

Agriculture is scarce in Greenland due to climatic conditions, but agricultural activities are found in South Greenland (see Table 2.23).

Even though Greenland has seen an increase in agriculture, farming and livestock are still small of scale. Since 1990 the area of improved grassland has increased by more than 100%, while the number of farms has seen a major decrease to around 50 %. The average farm is estimated at 22-28 hectares.

TABLE 2.23 CROPLAND AND MOUNTAINOUS GRASSLAND, IN HECTARES, IN 1990, 2001, 2007, 2012, 2017 AND 2021

Source: Naatsorsueqqissaartarfik - Statistics Greenland, Agricultural Advisory Service, Ministry of Agriculture, Self-Sufficiency, Energy and Environment, 2022.

	1990	2001	2007	2012	2017	2021
Cropland	490	776	973	1090	1148	1183
Mountainous grassland	242,000	242,000	242,000	242,000	242,000	242,000

The mountainous grassland is only used for grazing in the short summer period of 4-5 months for the stock of sheep. The major part of the mountainous grassland is bare rock and mountains.

The agricultural yield i.e. hay produced per hectare are lower, compared to farming in marginal lands in Iceland and northern Scandinavia. However, in order to develop sustainable farming and increase the variety of products, more land must be cultivated and a higher productivity per hectare.

The increase in improved grassland is a result of the increased demand for fodder for sheep, cattle and horses (see Table 2.24).

Further information is available from Agricultural Consulting Services[2].

TABLE 2.24 STOCK OF SHEEP AND REINDEERS IN 1990, 2000, 2008, 2012, 2017 AND 2021

Source: Naatsorsueqqissaartarfik - Statistics Greenland, Agricultural Advisory Service and Ministry of Agriculture, Self-Sufficiency, Energy and Environment, 2022.

	1990	2000	2008	2012	2017	2021
Sheep	19,929	20,444	21,080	21,110	17,592	17,501
Reindeer (domestic)	6,000	2,000	2,500	2,000	2,200	1,130
Cattle (for meet)	0	0	49	147	193	330

2.2.12 Forestry

Greenland has a few forests, which may qualify to the FAO criteria of forest definitions. The major forest areas are:

A natural forest in the Qinngua valley of 45 ha consisting mainly of Betula Pubescens ssp. Czerepanovii, which in the period 1990 to 2020 has had an average height of six meters and approx. 100 trees per ha. It is thus assumed that it has had the same biomass for the whole period. An additional 187 ha other planted forest. The largest of this is an arboretum (a research area) where different species and origins of trees are investigated which are adaptable to the harsh climate.

[2] http://www.nunalerineq.gl/english/landbrug/index-landbrug.htm

2.3 The Faroe Islands

2.3.1 Form of government and structure of administration

The Faroe Islands have home rule status, and their internal affairs are governed by the Faroese parliament (the Løgting). The Faroe Islands are not a member of the EU.

International agreements ratified by the Danish government do not cover the Faroe Islands, unless the Faroese government specifically requests to be a part of the agreement.

Denmark's ratification of the Climate Convention covers the Faroe Islands as well, but at the request of the Faroese government, geographical exemption was taken for the Faroe Islands in connection with Denmark's ratification of the Kyoto Protocol.

2.3.2 Population

As of January 2022, the Faroe Islands had a population of 53,615, of which 20,849 lived in the capital conurbation. The Faroese population has been on a steady rise since 2013, resulting in an increase of 5,586 so far. Through the last 50 years, the Faroe Islands have experienced periods with both increase and decrease in the population. In the period from 1989 to 1995, a serious deterioration in the economy caused a steep rise in unemployment and ensuing massive emigration decimating the population. However, this trend reversed to a net immigration in subsequent years, and in 2003, the population finally reached the same level as before the crisis. The population kept a relatively constant level from 2004 through 2013, which was when the ongoing population growth started. As a result of the population growth, the Faroese population reached a milestone in April 2017 and passed 50,000 for the first time.

2.3.3 Geography

The Faroe Islands consist of 18 small, mountainous islands situated in the North Atlantic at about 62ºN and 7ºW. The islands extend over 113 km from north to south and 75 km from east to west, and the total land area is 1,399 square kilometres. The highest points, up to 880 metres above sea level, are on the northern islands. 17 of the islands are inhabited.

2.3.4 Climate

The climate in the Faroe Islands is strongly affected by the warm North Atlantic current (the Gulf Stream) and the frequent passage of cyclones, which, depending on the location of the polar front, mainly comes from southwest and west. The climate in the Faroe Islands is maritime and thus characterised by mild winters and cool summers and the weather is often moist and rainy.

The Azores High is sometimes displaced towards the Faroe Islands, in which case settled summer weather with fairly high temperatures may prevail for several weeks. During the winter time, the course of the lows may be more southerly than normal, in which case cold air from the north dominates the weather. This situation may result in sunny weather with an unusually high frequency of days with frost but also snowfall. The latter occurs in conjunction with the build-up of showers in the cold air above the relatively warm sea water. The northern part of the islands particularly almost always experience wintry weather with snow or frost for a prolonged period during the winter time. Occasionally, some of the fjords freeze over with a thin layer of ice.

The maritime climate is also a result of the cold East Iceland current (polar current), which splits into two currents from eastern Iceland towards the Faroe Islands. The mixing of the water masses from the cold East Iceland current and the warm Gulf Stream causes a relatively big difference in the sea temperatures around the islands. This in turn causes local variations in the climate.

Atmospheric pressure

The normal atmospheric pressure at sea level in Tórshavn is 1007.8 hPa on an annual basis (1991-2020). It is lowest from November to February (1001.8-1004.0 hPa) and highest in May (1014.2 hPa) and June (1013.6 hPa). The lowest atmospheric pressure recorded was 930.3 hPa (Vága Floghavn) on 11 January 1993, and the highest was 1048.9 hPa, recorded on 13 December 1995 and on 28 March 2020. The islands have long periods with both low pressure and high pressure.

The Faroe Islands are situated close to the common cyclone tracks and the atmospheric pressure is subject to frequent and substantial changes. A rise or fall of 20 hPa within 24 hours is possible in all months. The average annual range in atmospheric pressure is approximately 80 hPa. The atmospheric pressure is more changeable in the winter months compared to the summer months. The range in the winter months is approximately double that in the summer months.

Wind

The mean wind speed is generally high in the Faroe Islands, particularly during autumn and winter. The mean annual wind speed in Tórshavn is 6.6 m/s. It is normally lowest during summer (average 5.0 m/s) and highest during winter (average 7.8 m/s). May to August are normally without strong winds, i.e. storm, while autumn and winter are particularly windy with numerous gales, usually blowing from west and south-west.

The highest 10-minute mean winds were 50 m/s (180 km/h), recorded at Mykines Lighthouse on 7 March 1997 and 15 January 1999. On 7 March 1997, gusts of almost 67 m/s (approx. 241 km/h) were recorded at Mykines Lighthouse.

Temperature

The annual mean temperature in Tórshavn is 7.0 °C (1991-2020), which is 0.2 °C higher compared to the previous annual mean temperature from 1981-2010 (6.8 °C). The temperature in January and February is 4.3 to 4.0 °C respectively (1991-2020) cf. Figure 2.25. In July and August, the temperature ranges from 10.8 to 11.2 °C (1991-2020). The annual mean temperature is lowest inland on the northern islands and highest at the coast on the southern islands.

The temperature fluctuations in the Faroe Islands are generally small, but it does happen that the temperature reaches 20 °C. In Tórshavn, the highest temperature between 1991-2020 was 20.0 °C on 12 June 1992 and also 20 August 2004. The lowest temperature was -9.2 °C on 1 March 1998. The absolute highest temperature recorded in the Faroe Islands was 26.3 °C observed at Vága Floghavn on 17 July 2003. During wintertime, the temperature sometimes drops below 0 °C. The absolute lowest temperature registered in the Faroe Islands was -12.3 °C, which was observed at Vaga Floghavn 4 March 2001.

Temperatures in Tórshavn are higher today than they were in 1873. This temperature increase primarily took place during 1920-1940 and yet again since the 1980’s cf.

Figure 2.26. The period 2011-2020 was the warmest decade since records began and the present temperature level is the highest in the Tórshavn time series. In 2014, there was a record high annual temperature in Tórshavn (8.1 °C).

FIGURE 2.25 CLIMATOLOGICAL STANDARD NORMAL FOR TÓRSHAVN 1991-2020. PLEASE NOTICE THAT THE CALCULATED CLIMATE NORMAL FOR HOURS OF BRIGHT SUNSHINE ONLY COVERS THE PERIOD 2007-2020
Source: Danish Meteorological Institute (DMI)

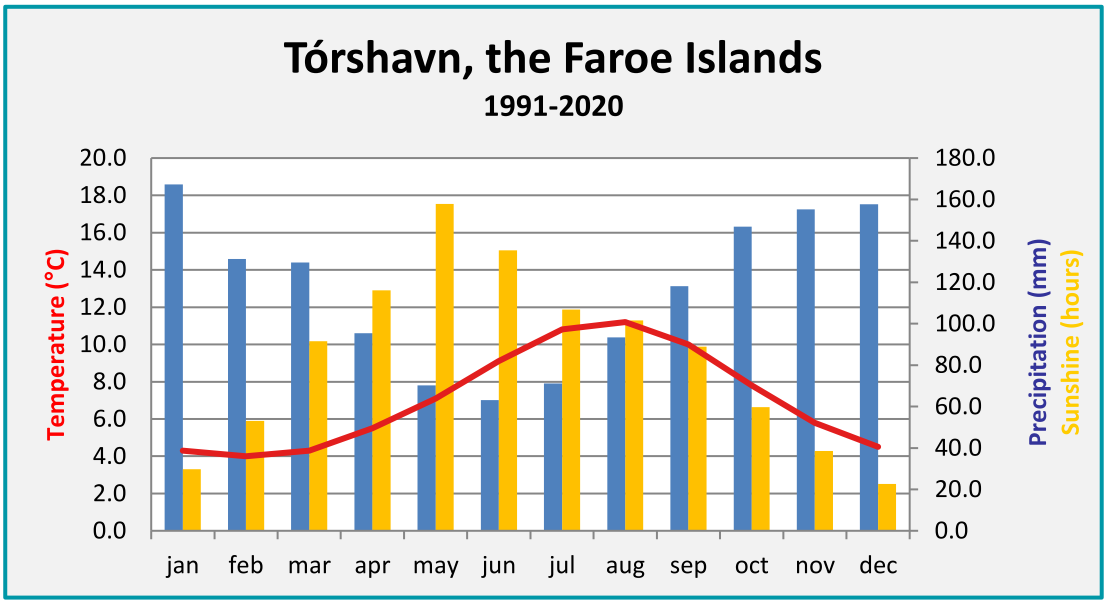
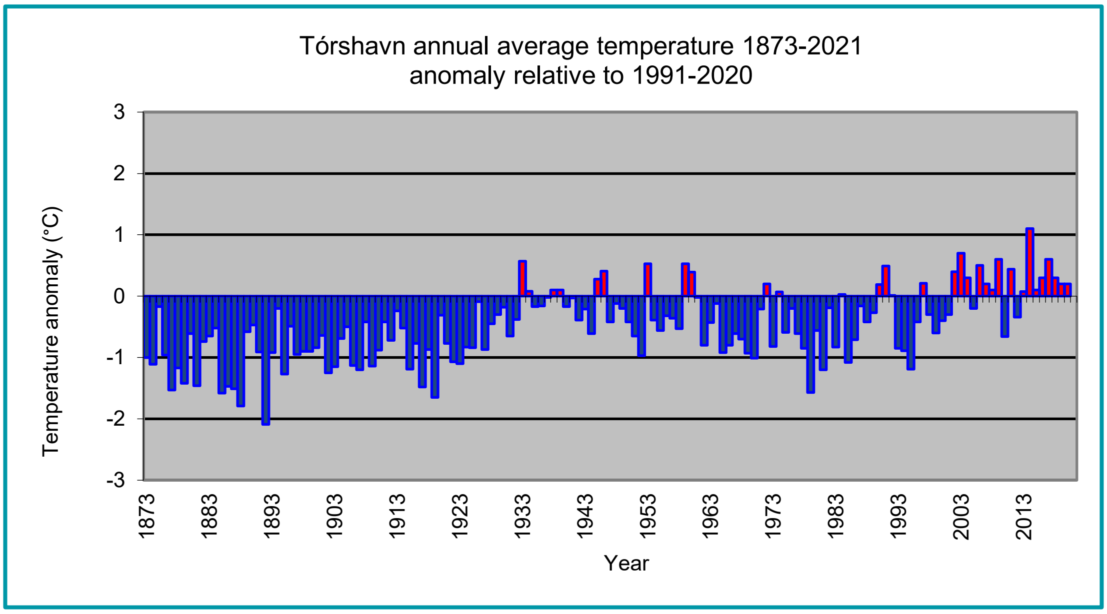


FIGURE 2.26 ANNUAL MEAN TEMPERATURE IN TÓRSHAVN 1873-2021, ANOMALY RELATIVE TO 1991-2020. PLEASE NOTICE THAT THE YEAR 2021 IS MISSING.
Source: Danish Meteorological Institute (DMI)



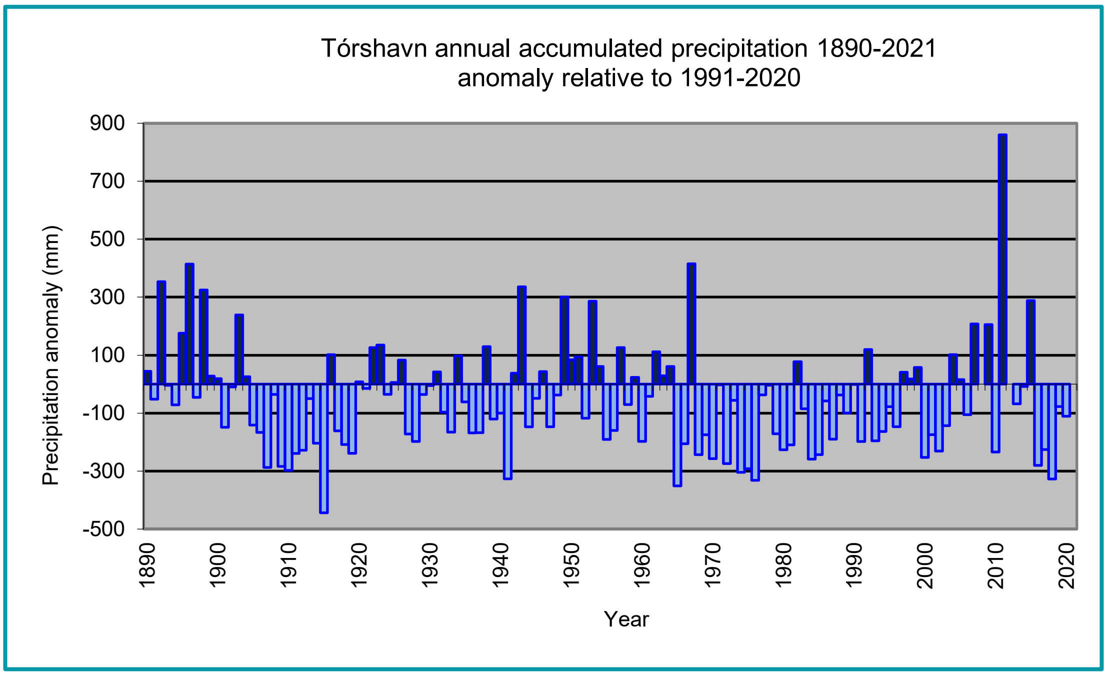
Precipitation

Annual precipitation in Tórshavn is 1399.2 mm (1991-2020), with the highest precipitation amounts in autumn and winter and the lowest precipitation amounts in spring and summer. The precipitation pattern reflects the topography of the islands, the precipitation being lowest near the coastal areas and rising to a peak at the center of the hilliest islands. Nearly all coastal areas receive around 1,000 mm per year, rising to above 3,000 mm in the central parts.There are large geographical variations in precipitation, mainly due to the topography of the islands.

The coasts on the southern and western islands receive the least precipitation and the northern hilly islands the most. Above 3,000 mm has been measured in the northern hilly islands and it is estimated that more than 4,000 mm can be reached. Indeed, it rains a lot, and the number of rainy days is high (264.3 days a year (days with precipitation >= 0.1 mm), 1991-2020). In the winter, precipitation often falls as snow. There is no snow at all in June, July, and August, but there can be snow in September.

Since the mid 1970s, precipitation in Tórshavn has been roughly stable, with an small increasing trend in recent years. See Figure 2.27.

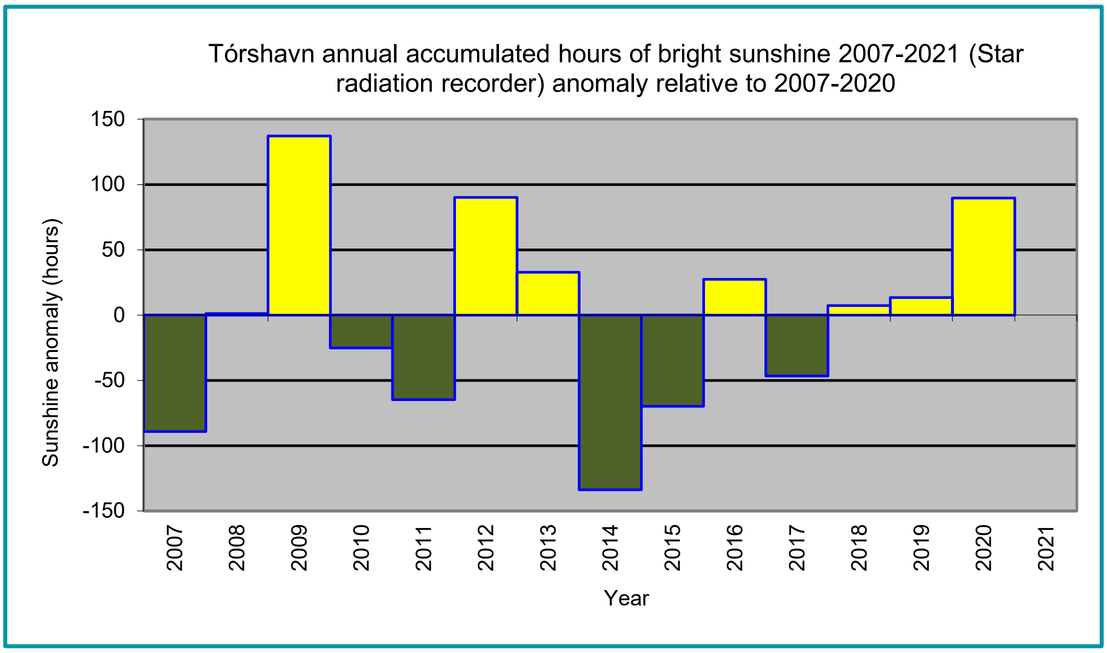
FIGURE 2.27 ANNUAL PRECIPITATION (MM) IN TÓRSHAVN 1890-2021, ANOMALY RELATIVE TO 1991-2020. PLEASE NOTICE THAT THE YEARS 2008, 2012 AND 2021 ARE MISSING.
Source: Danish Meteorological Institute (DMI)



Hours of sunshine

In the period 2007-2020 Tórshavn had an average of 1002.1 hours of bright sunshine per year. The months May (157.8) and June (135.4) receives the highest number of hours of bright sunshine. The lowest number of hours of bright sunshine occurs in December (22.7) and January (29.8). Sometimes in December, only a few hours of bright sunshine is. The anomaly relative to 2007-2020 is shown in Figure 2.28.

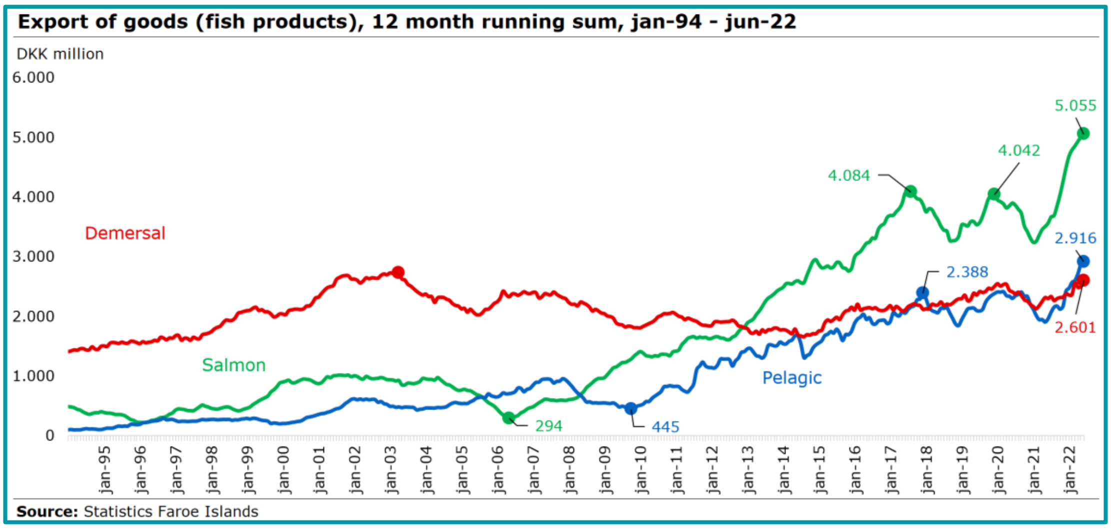
FIGURE 2.28 ANNUAL HOURS OF SUNSHINE IN TÓRSHAVN 2007-2021, ANOMALY RELATIVE TO 2007-2020. PLEASE NOTICE THAT DATA FROM 2021 ARE MISSING.
Source: Danish Meteorological Institute (DMI)



2.3.5 Economy

The Faroe Islands is a modern, developed society with a standard of living comparable to other Nordic countries. Fishery and fish farming along with the related industries, are of such importance that their influence determines the overall performance of the Faroese economy. The export of demersal and pelagic fish together with the export of salmon amounts to over 90 % of the total export of the Faroe Islands. In the last few years tourism has started to grow and the tourist industry today amounts to around 2,5 % of the total gross value added of the Faroese economy. The economy has a high dependence on exporting fish products and is therefore vulnerable to the changes in catches, fish prices, and exchange rates in the international market for fish. Hence, the economy is not as diversified as in other highly developed countries. However, the prices and catches of demersal and pelagic fish rarely move along with changes in the prices or amount produced of salmon. The Faroese economy has thus become more diversified than it was until around 2007. The export value of salmon was around DKK 300 million in 2007 and is estimated to be DKK 5.000 million in 2022. The export value of demersal fish has been more stable along the years and is estimated to be around DKK 2.600 millions in 2022 while the export of pelagic fish has increased from around DKK 450 million in 2010 to almost DKK 3.000 millions in 2022. The large increase in the export value of pelagic fish is due to the fact that Faroe Islands since 2010 has received a larger share of the total quota of mackerel and herring (Figure 2.29).

FIGURE 2.29 EXPORTS OF GOODS
Source: Hagstova Føroya - Statistics Faroe Islands



In the aftermath of the financial crisis in 2008, the employment rate rose to 8,1 % in 2011 but has afterwards been falling gradually and is currently 0.9 % (April 2022). The growth in GDP in nominal terms has been high for several years. The high activity is reflected in the low unemployment rate and urgent demand for labour in both the private and public sector. Wage expenditures are high, the number of employees so far in 2022 has hit a record, and there is still a surplus on the trade balance of goods. The Faroese Economic Council has in cooperation with Statistics Faroe Islands estimated the GDP growth figures in current prices to be 7.3 % in 2021, 11.2 % in 2022 and 2.6 % in 2023 (cf. Table 2.25).

TABLE 2.25 GDP IN CURRENT PRICES
Source: Hagstova Føroya - Statistics Faroe Islands and the Economic Council.

	2019	2020	2021	2022	2023
Est. GDP-growth in current prices	8,6%	-2,8%	7,3%	11,2%	2,6%

Note: 2019 - 2020 are calculated by Statistics Faroe Islands. 2021 - 2023 are estimated by the Economic Council.
Source: Statistics Faroe Islands and the Economic Council.

In 2022 the GDP growth is however marked by the high inflation. The GDP growth in 2022 does not reflect a significant growth in economic activity as compared to 2021, but rather that the goods and services exported and imported have become more expensive (the GDP growth in 2022 would be lower if it was calculated in constant prices, but a GDP deflator is currently unavailable for the Faroese economy).

The steep rise in the consumer price index in the 2nd quarter of 2022 is as high as it has ever been in the Faroe Islands in the past 14 years. Along with price increments for food in general, increasing oil prices have had a significant impact on the disposable income of the households, as oil is used both to heat homes and fuel cars in the Faroe Islands. The very most products that are consumed in the Faroese economy are imported, and the inflation hitting import goods is contributing to push GDP growth in current prices down in 2022. In the construction industry rising materials prices have been a challenge for a while and the high activity in the construction industry has also led to wage pressures as the construction industry still reports a high demand for labour. The tourism industry, on the other hand, is characterised by great optimism; demand is high and 2022 is expected to become a record year. A large number of foreign workers are employed by Faroese companies in both the construction-, tourist-, and fish processing industry. GVA by industry is shown in Table 2.26.

TABLE 2.26 GROSS VALUE ADDED 2020 BY INDUSTRY
Source: Hagstova Føroya - Statistics Faroe Islands

Industry, 2020.	Gross Value Added (DKK mill.)	%
Fishing	2.024	11%
Aquaculture	868	5%
Agriculture, mining and quarrying	38	0%
Manufacture of food products and beverages	1.454	8%
Other industry, excluding energy	773	4%
Electricity, gas and water supply	448	2%
Construction	1.641	9%
Wholesale and retail trade, hotels and restaurants	1.904	10%
Transportation and storage	1.293	7%
Information and communication	516	3%
Financial intermediation, including insurance and pension funding	673	4%
Real-estate and renting	1.816	10%
Public administration	904	5%
Education	1.021	5%
Health and social work	2.193	12%
Other service activities	1.106	6%
Total	**18.672**	**100%**

2.3.6 Energy

The joint municipal company, SEV, is the major producer of electricity in the Faroe Islands. In addition, there are a couple of smaller producers of wind power. In 2021 production amounted to about 424 mill. kWh cf. Table 2.27. Of this, about 24 % was based on hydroelectricity, 13 % on wind power cf. Table 2.28. A minor part was based on biogas, sun power and tidal power, while the remainder was produced at diesel-driven plants. The windpower has increased more than100-fold since year 2000. Sales of electricity in 2020 were distributed between 49 % primary sector, production and construction, 23 % for households and 26 % for the service sector, with the remainder for street lighting etc.

Since a number of hydrocarbon discoveries in British territorial waters close to the Faroese border in the 1990s, there has been a reasonable expectation that there is oil in Faroese territory. The first licensing round for hydrocarbon exploration was held in 2000, the second in 2004, the third in 2008, the fourth in 2018 and the fifth in 2019. The first licences for exploration and production of hydrocarbons in the subsoil off the Faroe Islands were granted in August 2000 and the first three exploration wells were drilled in 2001. Since then, six wells have been drilled. One in 2003, one in 2006, one in 2007/08 and one in 2010. In 2012 one well was initiated but was suspended and finalized in 2014, the same year as the last well, so far, was drilled in Faroese territory. Most wells have found either traces or shows of oil or gas, including one discovery, but none of the finds have yet been commercially viable.

Today hydrocarbon licences in the Faroes territory can be applied for through out of round bids, also called the Open Door regime, which means that applications are welcome at any time.

TABLE 2.27 ELECTRICITY PRODUCTION 1999-2021 (GWH)

Source: Hagstova Føroya - Statistics Faroe Islands.

	2000	2005	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Hydro-power	76	99	67	93	100	91	121	133	106	111	108	204	109	100
Diesel power	136	136	199	167	181	180	150	126	159	163	180	230	249	262
Wind power	1	10	14	15	11	22	35	56	52	60	64	53	47	54
Sun	-	-	-	-	-	-	-	-	-	-	-	-	0	0,2
Biogass	-	-	-	-	-	-	-	-	-	-	-	-	1	7
Tidal	-	-	-	-	-	-	-	-	-	-	-	-	-	0,01
Total	**213**	**245**	**280**	**274**	**292**	**293**	**305**	**314**	**317**	**334**	**352**	**486**	**407**	**424**

TABLE 2.28 ELECTRICITY PRODUCTION 1999-2021 (%)

Source: Hagstova Føroya - Statistics Faroe Islands

	2000	2005	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Hydro-power	36	40	24	34	34	31	40	42	33	33	31	42	27	24
Diesel power	64	55	71	61	62	62	49	40	50	49	51	47	61	62
Wind power	0	4	5	5	4	7	11	18	16	18	18	11	12	13
Sun	-	-	-	-	-	-	-	-	-	-	-	-	0,05	0,05
Biogass	-	-	-	-	-	-	-	-	-	-	-	-	0,3	1,6
Tidal	-	-	-	-	-	-	-	-	-	-	-	-	-	0,001
Total	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**

2.3.7 Transport

Goods transport between the Faroe Islands and the rest of the world is mainly by sea. Two shipping companies operate freighter services all year round.

Besides Vágar Floghavn, the Faroe Islands have 12 helicopter pads. Air services are provided by the Faroese company ATLANTIC AIRWAYS and since 2017 and and 2021 also by respectively SAS and the Norwegian company Widerøe, but both with a relative low frequency. The number of destinations as well as air travellers to and from the Faroe Islands has risen sharply in the last few years.

Passenger transport by sea mainly takes place in the summer period. There are both regular services (Smyril Line) and cruise liners. The number of foreign passenger ships calling at the Faroe Islands has generally been increasing in recent years.

For 20-30 years up to the beginning of the 1990s and again over the last two decades or so, major investments have been made in enlarging and modernising the transport infrastructure in the islands and the communication links with the outside world. The first subsea tunnel in the Faroe Islands, Vágatunnilin, opened in 2002, connecting Vágoy (airport) with Streymoy (with Tórshavn, capital). In 2006, the second subsea tunnel, Norðoyartunnilin, which joins Borðoy with Eysturoy, opened. And in 2020 the third subsea tunnel, which joined Tórshavn with Eysturoy (Runavík and

Strendur) opened. “Eysturoyartunnilin” is the first subsea tunnel in the world with a roundabout. Constructing roads, tunnels, and harbours is costly because of the difficult topographical conditions. Since 2017, the number of motor vehicles has been increasing by more than 1,300 per year.In 2022 there were 41.400 motor vehicles, of which about 27.950 were cars and 11.215 lorries, vans and buses.

2.3.8 Industry

The sectoral composition of the Faroese economy reveals a relatively large primary sector, brought about by the sizeable fishing fleet and a thriving fish farming industry.

As a result, fish and fish products accounted for 92.4% of the export of goods in 2021 and about 65% of total foreign income stemmed from fish and fish-related industries.

However, during several years, employment in the primary and secondary sector has been decreasing. Since 2008 the employment in the primary sector has been around 10%, and in the secondary sector around 20% cf. Table 2.29.

TABLE 2.29 DISTRIBUTION OF EMPLOYMENT BY SECTORS, 2021
Source: Hagstova Føroya – Statistics Faroe Islands

	Faroe Islands				
	1985	1995	2005	2015	2021
Primary sector	15,4%	14,1%	11,5%	10,5%	10,2%
Secondary sector	31,5%	21,8%	23,2%	20,0%	20,4%
Tertiary sector	53,1%	64,1%	65,3%	69,5%	69,4%

2.3.9 Waste

There are two waste incineration plants on the Faroe Islands, one in Hoyvík and one in Leirvík. Both plants perform energy recovery operations. Figure 2.30 shows the amounts of waste incinerated on the Faroe Islands 1990-2020. A substantial increase in the amounts of burned municipal waste was seen in 2019 which was the same in 2020.

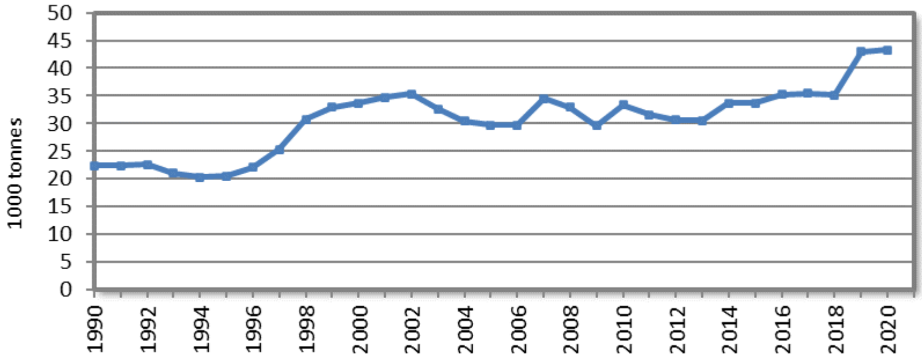
Open burning of waste is prohibited and is also not occurring in the Faroes.

In the Faroe Islands, many households have a septic tank through which domestic wastewater (sewage) flows for basic mechanical treatment. Industrial wastewater, e.g., from the fishing industry, is treated mechanically (oil/fat separation). Only a very few wastewater handling plants are treating the wastewater chemically and/or biologically.

Several land-based solid waste disposals facilities are located on the Faroe Islands.

The first biogas facility on the Faroe Island, FORKA, did open in Hoyvík in 2020. Primarily receiving organic waste from the aquaculture industry and from agriculture. Composting in the Faroes is primarily a small-scale activity in private households only. In recent years though, some Faroese municipalities, are about to establish compost sites where people can deliver their organic household waste.

FIGURE 2.30 INCINERATION OF MUNICIPAL WASTE ON THE FAROE ISLANDS, 1990-2020.



2.3.10 Buildings and urban structures

Most of the population live in and around the capital area and the larger villages. After many years focusing on connecting the smaller villages by road the focus has now shifted to connecting the larger islands by tunnels making most of the Faroe Island accessible by road.

Housing is still predominantly single-family houses, most of which are relatively large and of high standard. In recent years some apartment buildings have been built. There is currently high demand for housing, both flats and houses.

2.3.11 Agriculture

Farming in 2021 accounted for only 0.1% of the Faroe Islands' gross value added at factor cost.

By adapting a more self-sufficient approach to food production in the Faroe Islands, the government is providing grants for investments in farming.

With about 5% of the land under cultivation, the Faroe Islands can supply just over half of its total demand for lamb, most of its demand of milk, 20% of its demand for potatoes, and a small fraction of demand for beef. In 2021 the Faroe Islands had approximately 1150 dairy cows and 75,000 breeding ewes.

2.3.12 Forestry

There is no commercial forestry in the Faroe Islands, but there are are nearly 25 plantations covering less than 0.1% of the total area.

References:

Statistics Denmark: https://www.dst.dk/da/ or https://www.dst.dk/en/

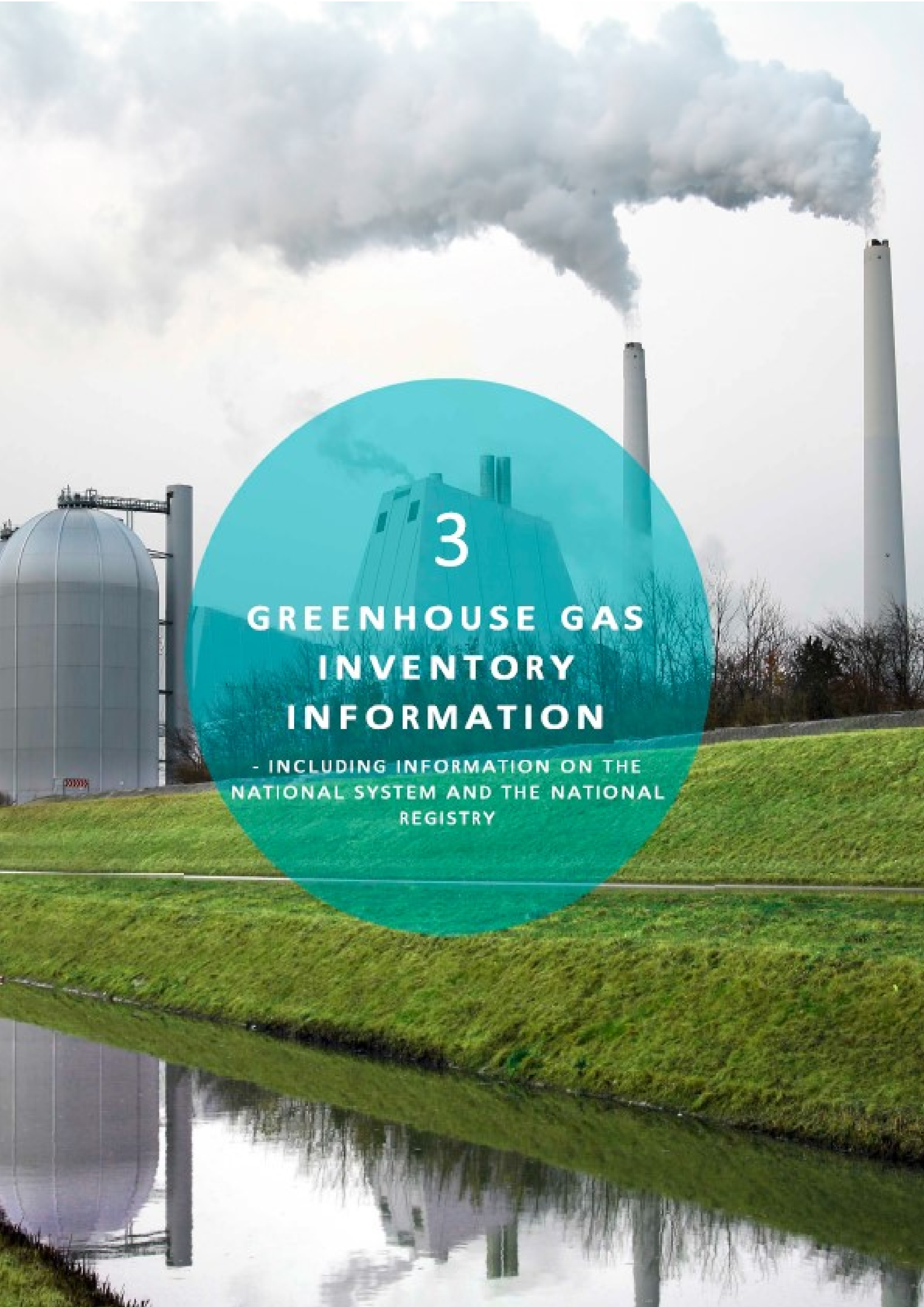
Danish Meteorological Institute (DMI): https://www.dmi.dk/

Danish Energy Agency (2022a): E2021 – Energy Statistics for (1980/1990-) 2021 published in December 2022 (https://ens.dk/ or https://ens.dk/en)

Nielsen et al., 2022a: Denmark's National Inventory Report (NIR) 2022 - Emission Inventories 1990-2020 – Submitted under the United Nations Framework Convention on Climate Change and the Kyoto Protocol, Scientific Report from DCE – Danish Centre for Environment and Energy, No. 494, 2022, Aarhus University (link: https://dce2.au.dk/pub/SR494.pdf)

Naatsorsueqqissaartarfik - Statistics Greenland, 2022: https://stat.gl/ or https://stat.gl/default.asp?lang=en

Hagstova Føroya - Statistics Faroe Islands: https://hagstova.fo/fo or https://hagstova.fo/en



3

GREENHOUSE GAS INVENTORY INFORMATION

- INCLUDING INFORMATION ON THE NATIONAL SYSTEM AND THE NATIONAL REGISTRY

Contents

3 Greenhouse gas inventory information
- including on national systems and the national registry

3.1 SUMMARY TABLES OF GREENHOUSE GAS INVENTORIES

Denmark's greenhouse gas inventories are prepared in accordance with the guidelines from the Intergovernmental Panel on Climate Change (IPCC).

The Danish emission inventories follow the methodologies described in the EMEP/EEA guidebook[1] and the IPCC's guidelines[2]. In accordance with the latter guidelines, some of the methodologies and emission factors have been modified so that they better reflect Danish conditions.

A description of methods, emission factors and activity data is given in Denmark's national inventory reports (NIR)[3] to the Climate Convention and the Kyoto Protocol, which also includes data in the common reporting format (CRF). The latest NIR and the latest combined Danish inventory of greenhouse gases and other air pollutants can be seen at Aarhus University's website[4] and in Nielsen et al., 2022a.

Greenhouse gas inventories for Greenland and the Faroe Islands are included in the national emission inventory reports to the Climate Convention.

Since the UNFCCC has been ratified on behalf of all three parts of the Realm, the Kyoto Protocol has been ratified on behalf of Denmark and Greenland, and only Denmark is a part of the European Union territory to which the EU agreement on joint fulfilment under Article 4 of the Kyoto Protocol applies, three sets of CRF tables are reported annually. For the second commitment period of the Kyoto Protocol, Greenland does not have a reduction commitment and hence the CRF for Denmark only should be assessed in connection with the Doha amendment. The most aggregated summary tables are shown in this Chapter in Table 3.1 (Denmark, Greenland and the Faroe Islands), Table 3.2 (Denmark), Table 3.3 (Greenland), Table 3.4 (Faroe Islands) and Table 3.6 (Denmark and Greenland) respectively.

CRF summary tables for Denmark with more disaggregated information on Danish source categories are given in Annex A1.

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[1] EMEP/EEA (2019): EMEP/EEA air pollutant emission inventory guidebook 2019 . Available at: https://www.eea.europa.eu/publications/emep-eea-guidebook-2019 (05-10-2022).

[2] IPCC (2006): 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Inventories, Prepared by the National Greenhouse Gas Inventories Programme, Eggleston H.S., Buendia L., Miwa K., Ngara T. and Tanabe K. (eds). Published: IGES, Japan. (06-06-2017).

[3] Nielsen et al., 2022a.

[4] http://envs.au.dk/videnudveksling/luft/emissioner/emissioninventory/

In all summary tables, the base year presented is the base year under the Climate Convention; 1990. Under the UNFCCC, time series of emission inventories, including emissions in 1990, are often recalculated in the annual reporting due to new knowledge regarding emission factors, activity data, methodologies, etc. Under the Kyoto Protocol, the assigned amount for Denmark for the period 2013-2020 was determined in 2017 on the basis of the base year reported in the annual inventory reporting in 2016. The fixed base year and the calculation of the assigned amount under the Kyoto Protocol are further described in section 3.5.

3.2 DESCRIPTIVE SUMMARY OF DENMARK'S EMISSIONS AND REMOVALS OF GREENHOUSE GASES

The total inventories for Denmark, Greenland and the Faroe Islands (the Realm) are given in Table 3.1.

Since the fifth National Communication, full CRF tables have been elaborated for Greenland and the Faroe Islands. This means that three separate CRF tables are created and then the submissions to the Climate Convention and the Kyoto Protocol are aggregated. The process for aggregating the different submissions is described in the NIR (Nielsen et al., 2022a). The documentation of the Greenlandic and Faroese inventories has also been greatly expanded and the documentation for Greenland is now presented in a separate chapter in the NIR, while the documentation for the Faroe Islands is included in an annex to the NIR.

Greenland's and the Faroe Islands' greenhouse gas emissions are small compared with those of Denmark (each about 1% of the total emissions), and they have been almost constant since 1990.

The emissions from the Realm (i.e. including emissions from Greenland and Faroe Islands) of the greenhouse gases CO_2 (carbon dioxide), CH_4 (methane), N_2O (nitrous oxide), and the so-called potent greenhouse gases (F-gases), which include HFCs (hydrofluorocarbons), PFCs (perfluorocarbons), SF_6 (sulphur hexafluoride) and NF_3 (nitrogen trifluoride) during the period 1990-2020 are shown in Table 3.1 and Figures 3.1-3.4 aggregated into the IPCC's six main sectors and the most relevant sub-sectors. Total greenhouse gas emissions for Denmark measured in CO_2 equivalents on the basis of the global warming potential of each gas are shown together with the distribution with respect to gas and source/sector in Table 3.2. The development in Danish greenhouse gas emissions from 1990-2020, broken down by source and sink categories from Table 10 of the CRF, is shown in Annex A1.

In the following sections 3.2.1 to 3.2.6, further information on Danish emissions of individual greenhouse gases, indirect greenhouse gases and SO_2 is provided.

Separate summary information on Greenland’s and the Faroe Islands’ greenhouse gas emissions are shown in section 3.2.7 and section 3.2.8 respectively.

TABLE 3.1 DENMARK'S, GREENLAND'S AND THE FAROE ISLANDS' TOTAL EMISSIONS AND REMOVALS OF GREENHOUSE GASES, 1990 - 2020

Source: Nielsen et al., 2022a.

GREENHOUSE GAS EMISSIONS	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
	CO_2 equivalent (kt)															
CO_2 emissions without LULUCF	54879	65460	59627	61713	65729	62690	76027	66644	62436	59878	55641	57356	56924	62090	56536	52974
CO_2 emissions with LULUCF	61453	71353	66447	67198	70762	67806	80488	71567	67250	64990	60511	61739	62326	67235	61427	57831
CH_4 emissions without LULUCF	7954	8144	8213	8406	8287	8362	8472	8356	8409	8303	8229	8469	8411	8432	8257	8016
CH_4 emissions with LULUCF	8216	8405	8472	8663	8542	8615	8723	8605	8656	8547	8472	8710	8649	8669	8492	8249
N_2O emissions without LULUCF	8555	8389	8111	7870	7814	7761	7381	7442	7439	7444	7378	7164	7055	6920	6610	5987
N_2O emissions with LULUCF	8626	8459	8181	7940	7883	7828	7446	7506	7500	7503	7435	7220	7108	6971	6660	6035
HFCs	NO,NE,NA	NO,NE,NA	4	110	157	258	399	399	532	678	773	775	799	819	878	928
PFCs	NO,NA	NO,NA	NO,NA	NO,NA	0	1	2	5	11	16	23	28	28	25	21	19
Unspecified mix of HFCs and PFCs	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA
SF_6	42	61	86	98	118	104	59	71	58	63	57	29	24	30	32	21
NF_3	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA
Total (without LULUCF)	71430	82054	76041	78198	82105	79175	92340	82917	78886	76381	72101	73820	73240	78316	72333	67944
Total (with LULUCF)	78338	88278	83190	84009	87462	84611	97118	88152	84008	81798	77271	78500	78934	83750	77509	73082
Total (without LULUCF, with indirect)	72550	83225	77182	79322	83186	80232	93396	83898	79838	77272	72939	74634	74009	79063	73045	68628
Total (with LULUCF, with indirect)	79458	89449	84331	85133	88543	85668	98173	89134	84960	82688	78109	79314	79703	84496	78221	73766

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
	CO_2 equivalent (kt)															
1. Energy	53725	64385	58538	60718	64724	61699	75201	65740	61684	59288	54928	56753	56232	61534	55943	52261
2. Industrial processes and product use	2345	2473	2528	2605	2724	2901	3050	3135	3269	3545	3707	3561	3489	3497	3322	2792
3. Agriculture	13440	13268	13069	12981	12814	12821	12406	12429	12405	12014	11974	11978	12019	11793	11733	11547
4. Land use, land-use change and forestry	6908	6224	7149	5811	5357	5436	4777	5236	5123	5417	5170	4679	5694	5433	5176	5138
5. Waste	1920	1927	1906	1894	1844	1753	1684	1613	1528	1533	1492	1529	1500	1493	1335	1344
6. Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Total (including LULUCF)	78338	88278	83190	84009	87462	84611	97118	88152	84008	81798	77271	78500	78934	83750	77509	73082

GREENHOUSE GAS EMISSIONS	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
	CO_2 equivalent (kt)														
CO_2 emissions without LULUCF	60931	56171	52676	50217	50732	45705	41268	43126	38920	36544	38349	36275	36317	32601	29948
CO_2 emissions with LULUCF	65953	61474	56543	53367	52953	47376	42500	43995	40501	37093	39991	37852	39808	35248	32806
CH_4 emissions without LULUCF	7907	7879	7760	7625	7689	7523	7415	7325	7283	7210	7273	7271	7314	7148	7165
CH_4 emissions with LULUCF	8138	8109	7989	7853	7917	7847	7644	7553	7511	7441	7506	7506	7551	7386	7403
N_2O emissions without LULUCF	5852	6002	6024	5796	5684	5693	5594	5592	5713	5732	5847	5922	5665	5858	5816
N_2O emissions with LULUCF	5899	6048	6069	5840	5728	5736	5638	5636	5758	5781	5894	5966	5712	5903	5864
HFCs	950	985	985	1010	859	779	784	723	666	518	586	494	593	465	482
PFCs	21	21	18	20	10	8	3	4	3	0	0	1	0	1	0
Unspecified mix of HFCs and PFCs	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA
SF_6	35	29	31	35	37	78	130	150	155	122	104	76	74	72	46
NF_3	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA
Total (without LULUCF)	75696	71087	67494	64703	65011	59786	55195	56919	52740	50125	52158	50038	49964	46145	43458
Total (with LULUCF)	80996	76666	71636	68125	67505	61825	56699	58060	54593	50954	54081	51895	53738	49075	46601
Total (without LULUCF, with indirect)	76337	71685	68064	65209	65501	60207	55576	57277	53067	50438	52459	50333	50245	46412	43695
Total (with LULUCF, with indirect)	81637	77264	72205	68631	67994	62246	57080	58418	54920	51267	54382	52190	54019	49342	46838

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
	CO_2 equivalent (kt)														
1. Energy	60202	55380	52081	50001	50687	45329	40742	42513	38226	35891	37509	35310	35363	31704	28778
2. Industrial processes and product use	2849	2885	2579	2155	1937	2080	2122	2091	2054	1889	2109	2100	2149	1974	2076
3. Agriculture	11269	11460	11462	11270	11171	11162	11167	11164	11306	11193	11365	11438	11254	11282	11368
4. Land use, land-use change and forestry	5300	5579	4142	3422	2494	2039	1504	1141	1853	829	1923	1857	3774	2930	3143
5. Waste	1376	1362	1372	1277	1216	1216	1164	1151	1154	1153	1176	1190	1197	1185	1235
6. Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Total (including LULUCF)	80996	76666	71636	68125	67505	61825	56699	58060	54593	50954	54081	51895	53738	49075	46601

3.2.1 Carbon dioxide, CO_2

Most CO_2 emissions come from combustion of coal, oil and natural gas in energy industries, residential properties and in manufacturing industry. Road transport is also a major contributor. Outside the energy sector, the only major CO_2 emissions come from cement production, which accounts for 2-3 % of the annual national total. The transport sector is the only major emitting sector that has shown an increasing trend since 1990. However, in the latest years, CO_2 emissions from the transport sector have stabilised.

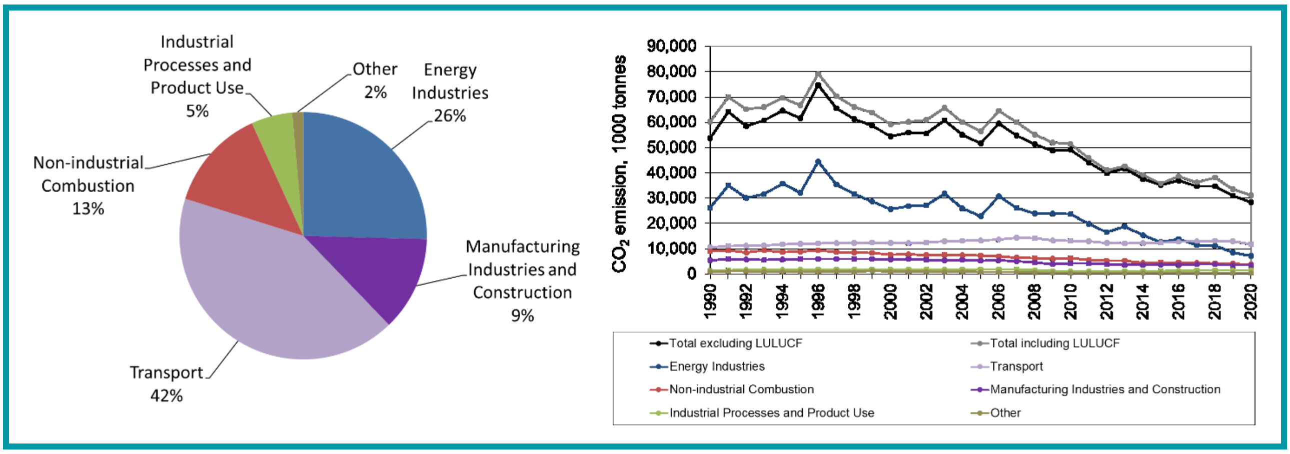
The relatively large fluctuations in the emissions from year to year are due to trade in electricity with other countries - primarily the Nordic countries. The large emissions in 1991, 1994, 1996, 2003 and 2006 are due to large electricity exports.

From 1990 to 1996, emissions showed a rising trend, but they have fallen since 1997 because many power stations have changed their fuel mix from coal to natural gas and biomass. Additionally, the production of renewable energy (mainly wind) has increased significantly. As a result of the reduced use of coal in recent years, most of the CO_2 emissions now come from combustion of oil or oil-based products, both in stationary and mobile sources. Also, there has been a decrease in gross energy consumption, especially since 2006.

In 2020, total actual CO_2 emissions inventoried under the Climate Convention for Denmark, excluding land-use change and forestry (LULUCF) and indirect CO_2, were about 47 % lower than in 1990. If LULUCF and indirect CO_2 is included, net emissions were about 49 % lower.

FIGURE 3.1: CO_2 EMISSIONS BY SECTOR (2020) AND DEVELOPMENT IN 1990-2020

Source: Nielsen et al., 2022a.



3.2.2 Methane, CH_4

Anthropogenic methane (CH_4) emissions primarily stem from agriculture, landfills, and the energy sector, among which agriculture contributes the most by far.

The emissions from agriculture are due to the formation of methane in the digestive system of farm animals (enteric fermentation) and manure management. Over the time series from 1990 to 2020, the emission of CH_4 from enteric fermentation has decreased by around 9 % due to a decrease in the number of cattle. However, in the same period the emissions from manure management increased by around 18 % due to a change in animal housing systems from traditional systems with solid manure towards slurry-based housing systems.

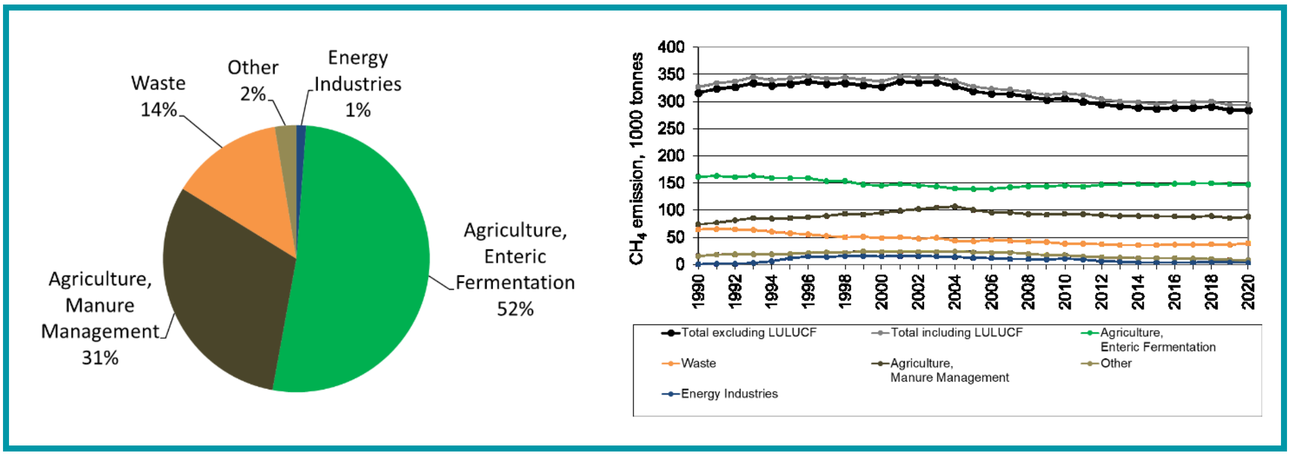
Emissions of methane from landfills are decreasing, because of the ban on landfilling of combustible waste. This has led to a decrease in the amount of landfilled biodegradable waste and hence the emissions. Also, contributing to the decrease in emissions was the increased CH_4 recovery in the early part of the time series. This recovery has decreased in later years due to less CH_4 generation in the landfills.

Emissions of methane from the energy sector increased up to 2003 due to increased use of gas-driven engines, which emit large amounts of methane compared to other combustion technologies. However in later year's new legislation establishing emission limits for existing gas-driven engines came into force pursuant to Statutory Order No. 720 of 5 October 1998, and combined with decreased use of gas engines, this has resulted in lower emissions.

In 2020, total CH_4 emissions were 10 % below the 1990 level.

FIGURE 3.2 CH_4 EMISSIONS BY SECTOR (2020) AND DEVELOPMENT IN 1990-2020

Source: Nielsen et al., 2022a.



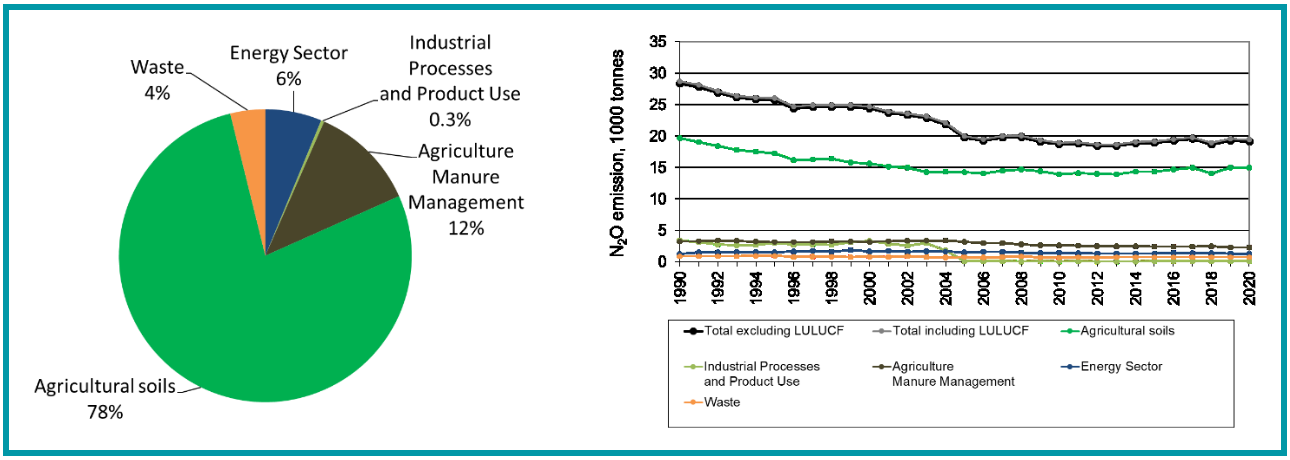
3.2.3 Nitrous oxide, N_2O

Agriculture constitutes the largest source by far of nitrous oxide (N_2O) emissions, since N_2O can be formed in the ground, where bacteria convert nitrous compounds from fertiliser and manure. Bacterial conversion of nitrogen also occurs in drain water and coastal water due to leaching and run off. This nitrogen largely comes from agriculture's use of fertiliser, and emissions from these sources are therefore included under agriculture. From 1990, N_2O emissions from agriculture have decreased by 25 % due to legislation to improve the utilisation of nitrogen in manure. The legislation has resulted in less nitrogen excreted per unit of livestock produced and a considerable reduction in the use of nitrogen fertilisers. The basis for the N_2O emission is then reduced. A small share of the nitrous oxide emissions originates from power and district heating plants, and cars with catalytic converters. Previously, a plant producing nitric acid was in operation in Denmark. However, this plant shut down in 2004, eliminating N_2O emissions from this activity.

In 2020, total N_2O were 32 % below the 1990 level.

FIGURE 3.3 N_2O EMISSIONS BY SECTOR (2020) AND DEVELOPMENT IN 1990-2020

Source: Nielsen et al., 2022a.



3.2.4 The f-gases: HFCs, PFCs, and SF_6

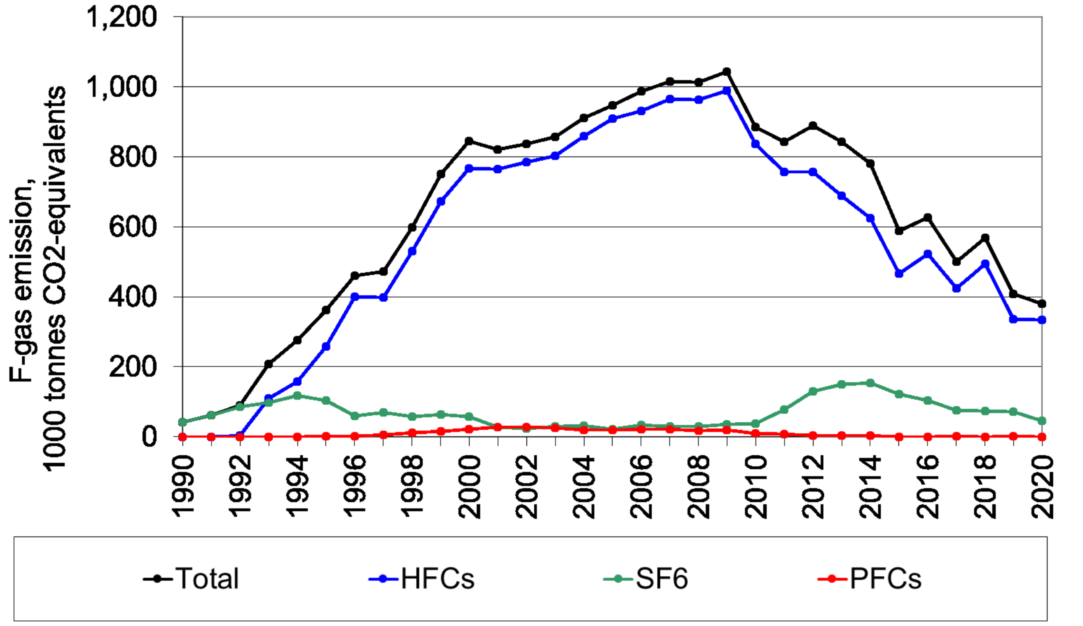
The contribution of f-gases (HFCs, PFCs, SF_6 and NF_3), to Denmark's total emissions of greenhouse gases is relatively modest. However, the emissions of these gases increased significantly during the 1990s. Collection of data on the consumption of these substances started in the mid-1990s. Therefore, f-gas data and emissions inventories from before 1995 are less certain than in 1995 and later. In accordance with the Kyoto Protocol, Denmark has selected 1995 as the base year for the f-gases. There is no consumption of NF_3 in Denmark at any point during the time-series.

The HFCs, which are primarily used in refrigeration and air conditioning, are the biggest contributor to f-gas emissions. From 1995 to 2020 annual emissions of HFCs increased from 241 to 335 kt of CO_2 equivalents. However, emissions of HFCs peaked at 989 kt of CO_2 equivalents in 2009. Emissions of PFCs peaked in 2002 with 28 kt of CO_2 equivalents, but has now been almost entirely phased out, with the emission in 2020 being 0,01 kt of CO_2 equivalents. The emissions of SF_6 decreased from 104 kt CO_2 equivalents in 1995 to 46 kt CO_2 equivalents in 2020. Emissions of SF_6 peaked between 2012 and 2016 due to double glazed windows using SF_6 in the early 1990'ties were being decommissioned. The emission peak in 2014 was at 154 kt of CO_2 equivalents.

The total emissions of HFCs, PFCs and SF_6 increased by 5 % from 1995 to 2020.

FIGURE 3.4 DEVELOPMENT IN HFC, PFC, AND SF_6 EMISSIONS IN 1990-2020

Source: Nielsen et al., 2022a.



3.2.5 Total Danish emissions and removals of greenhouse gases

Table 3.2 and figures 3.5 and 3.6 show the development in the Danish greenhouse gas emissions and removals as CO_2 equivalents and by gases and sources according to the reporting guidelines under the Climate Convention (i.e. without Greenland and the Faroe Islands). CO_2 is the most important greenhouse gas, followed by N_2O and CH_4. As mentioned previously, emissions fluctuate in line with trade in electricity. To illustrate this, the emissions in 1996 (excl. LULUCF) were estimated to 91,048 kt of CO_2 equivalents, whereas the total greenhouse gas emissions in 2003 were estimated to 76,721 kt of CO_2 equivalents (excl. LULUCF). In 2020 the total emissions were estimated to 41,509 kt of CO_2 equivalents,

Of the total Danish greenhouse gas emissions excluding LULUCF and indirect CO_2 in 2020, CO_2 made up 68.1%, methane 17.1%, nitrous oxide 13.8%, and f-gases 0.9%. If greenhouse gas emissions by sources and removals by sinks from forests and soils are included (i.e. with LULUCF), then net total Danish greenhouse gas emissions excluding indirect CO_2 corresponded to 44,616 kt of CO_2 equivalents in 2020 and the distribution between gases are 69.7 %, 16.5 %, 12.9 % and 0.9 % for CO_2, CH_4, N_2O and f-gases respectively.

As mentioned, the emissions from Greenland (cf. section 3.2.7) and the Faroe Islands (cf. section 3.2.8) only contribute with a very small share to the total emissions; hence the trends as described in sections 3.2.1-3.2.4 are basically the trends in the emissions from Denmark. Therefore the discussion is not repeated in this section. The discussion of emissions of precursor gases, i.e. NO_x, NMVOC, CO and SO_2, is included in this section because the inventory of these gases is not complete for the Realm.

FIGURE 3.5 DANISH GREENHOUSE GAS EMISSIONS BY TYPE OF GAS, DISTRIBUTION IN 2020 AND TIME SERIES 1990 - 2020.

Source: Nielsen et al., 2022a.

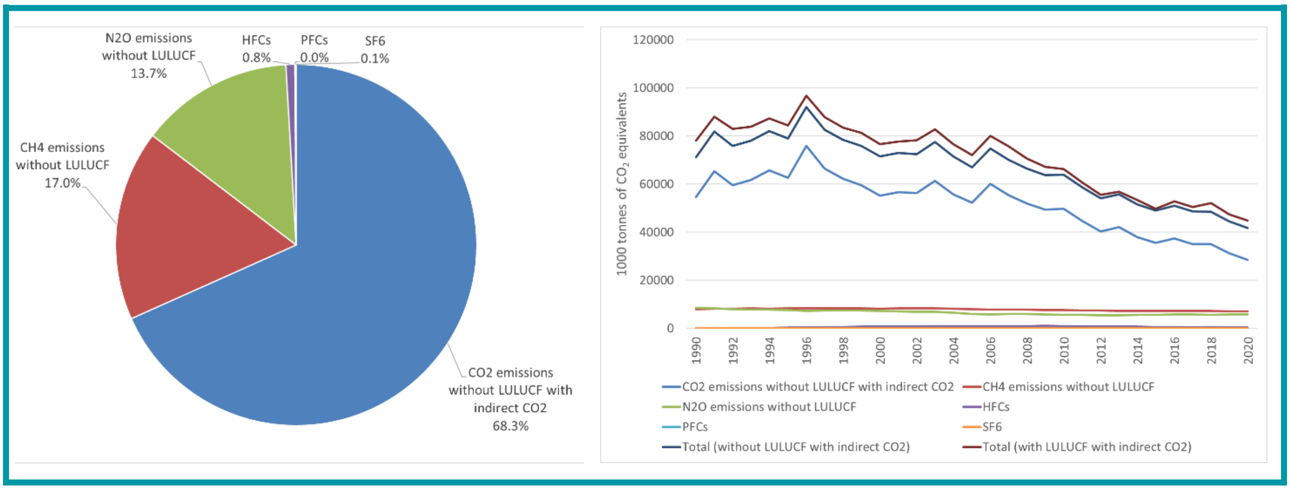


FIGURE 3.6 DANISH GREENHOUSE GAS EMISSIONS IN CO_2 EQUIVALENTS DISTRIBUTED ON MAIN SECTORS FOR 2020 (EXCLUDING LULUCF AND INDIRECT CO_2) AND TIME SERIES FOR 1990 TO 2020.

Source: Nielsen et al., 2022a.

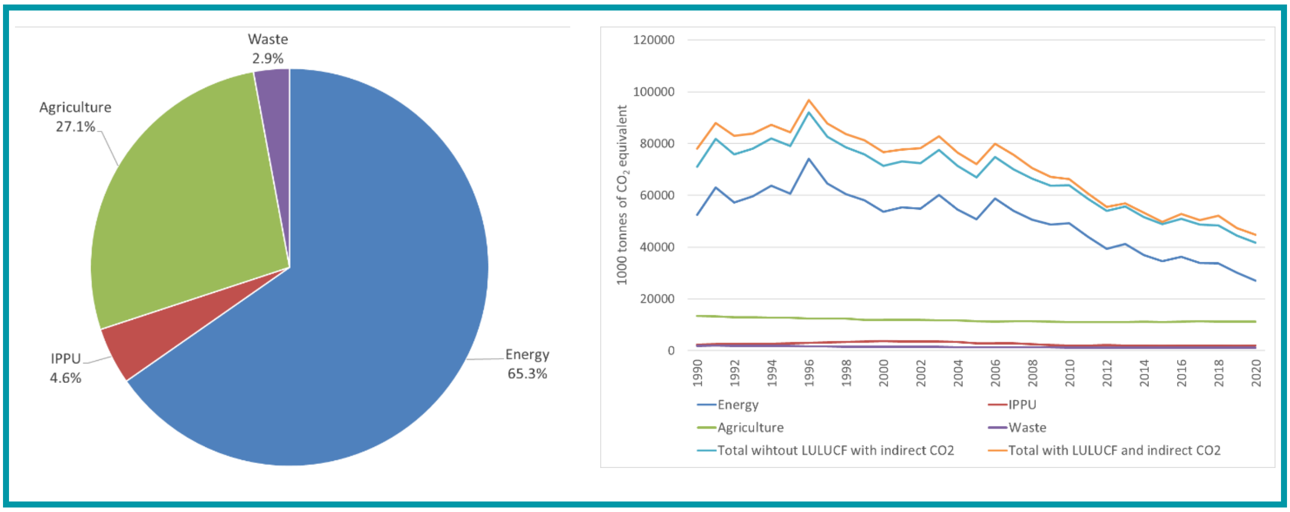


TABLE 3.2 DANISH GREENHOUSE GAS EMISSIONS AND REMOVALS BY GAS AND SOURCE AND SINK CATEGORIES IN 1990 - 2020

Source: Nielsen et al., 2022a.

GREENHOUSE GAS EMISSIONS	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
	CO_2 equivalent (kt)															
CO_2 emissions without LULUCF	53,585	64,200	58,391	60,637	64,698	61,614	74,869	65,469	61,238	58,652	54,306	55,896	55,554	60,645	55,100	51,535
CO_2 emissions with LULUCF	60,125	70,059	65,177	66,088	69,696	66,695	79,295	70,358	66,018	63,731	59,141	60,244	60,921	65,755	59,956	56,356
CH_4 emissions without LULUCF	7,906	8,097	8,167	8,361	8,240	8,314	8,424	8,307	8,361	8,255	8,182	8,422	8,364	8,386	8,210	7,969
CH_4 emissions with LULUCF	8,169	8,358	8,426	8,618	8,495	8,567	8,675	8,556	8,608	8,500	8,425	8,663	8,603	8,623	8,445	8,202
N_2O emissions without LULUCF	8,468	8,302	8,025	7,786	7,711	7,676	7,294	7,357	7,352	7,358	7,291	7,076	6,967	6,833	6,523	5,899
N_2O emissions with LULUCF	8,539	8,373	8,095	7,855	7,780	7,743	7,360	7,420	7,413	7,417	7,349	7,132	7,020	6,884	6,572	5,947
HFCs	NO,NA	NO,NA	4	110	157	258	399	398	530	673	766	764	785	802	859	909
PFCs	NO,NA	NO,NA	NO,NA	NO,NA	0	1	2	5	11	16	23	28	28	25	21	19
Unspecified mix of HFCs and PFCs	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA
SF_6	42	61	86	98	118	104	59	71	58	63	57	29	24	30	31	21
NF_3	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA
Total (without LULUCF)	**70,002**	**80,661**	**74,673**	**76,991**	**80,925**	**77,967**	**91,048**	**81,606**	**77,551**	**75,017**	**70,625**	**72,215**	**71,721**	**76,721**	**70,743**	**66,351**
Total (with LULUCF)	**76,875**	**86,850**	**81,787**	**82,768**	**86,247**	**83,368**	**95,791**	**86,807**	**82,639**	**80,399**	**75,760**	**76,860**	**77,381**	**82,119**	**75,884**	**71,453**
Total (without LULUCF, with indirect)	**71,122**	**81,831**	**75,814**	**78,115**	**82,005**	**79,024**	**92,103**	**82,588**	**78,502**	**75,907**	**71,463**	**73,029**	**72,490**	**77,468**	**71,454**	**67,034**
Total (with LULUCF, with indirect)	**77,995**	**88,021**	**82,929**	**83,892**	**87,327**	**84,425**	**96,846**	**87,789**	**83,591**	**81,290**	**76,598**	**77,673**	**78,150**	**82,865**	**76,595**	**72,136**

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
	CO_2 equivalent (kt)															
1. Energy	52,425	63,120	57,298	59,638	63,689	60,620	74,038	64,561	60,482	58,060	53,589	55,290	54,858	60,085	54,503	50,818
2. Industrial processes and product use	2,343	2,471	2,525	2,603	2,722	2,899	3,048	3,132	3,265	3,538	3,698	3,548	3,472	3,477	3,300	2,770
3. Agriculture	13,338	13,166	12,968	12,881	12,694	12,719	12,302	12,325	12,301	11,912	11,871	11,875	11,916	11,691	11,630	11,443
4. Land use, land-use change and forestry	6,874	6,190	7,115	5,777	5,322	5,401	4,743	5,201	5,088	5,383	5,135	4,644	5,660	5,398	5,141	5,102
5. Waste	1,896	1,903	1,882	1,869	1,819	1,729	1,659	1,587	1,502	1,507	1,467	1,503	1,475	1,468	1,309	1,319
6. Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Total (including LULUCF)	76,875	86,850	81,787	82,768	86,247	83,368	95,791	86,807	82,639	80,399	75,760	76,860	77,381	82,119	75,884	71,453

GREENHOUSE GAS EMISSIONS	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
	CO_2 equivalent (kt)														
CO_2 emissions without LULUCF	59,488	54,709	51,256	48,851	49,204	44,248	39,871	41,773	37,578	35,228	37,033	34,780	34,725	30,955	28,282
CO_2 emissions with LULUCF	64,473	59,976	55,088	51,966	51,389	45,883	41,066	42,606	39,122	35,741	38,639	36,321	38,180	33,566	31,103
CH_4 emissions without LULUCF	7,860	7,832	7,713	7,578	7,642	7,476	7,368	7,278	7,237	7,164	7,226	7,224	7,268	7,101	7,117
CH_4 emissions with LULUCF	8,091	8,062	7,942	7,806	7,870	7,800	7,597	7,506	7,464	7,394	7,459	7,460	7,504	7,339	7,356
N_2O emissions without LULUCF	5,764	5,914	5,936	5,710	5,598	5,607	5,509	5,508	5,629	5,648	5,763	5,837	5,580	5,772	5,729
N_2O emissions with LULUCF	5,811	5,960	5,981	5,754	5,642	5,650	5,552	5,552	5,673	5,697	5,811	5,881	5,627	5,817	5,777
HFCs	931	965	964	989	837	757	756	689	625	467	523	424	495	336	335
PFCs	21	21	18	20	10	8	3	4	3	0	0	1	0	1	0
Unspecified mix of HFCs and PFCs	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA
SF_6	34	29	30	35	37	77	129	150	154	121	104	75	73	71	46
NF_3	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA
Total (without LULUCF)	**74,097**	**69,470**	**65,918**	**63,183**	**63,328**	**58,174**	**53,637**	**55,402**	**51,225**	**48,628**	**50,650**	**48,343**	**48,141**	**44,237**	**41,509**
Total (with LULUCF)	**79,362**	**75,013**	**70,024**	**66,570**	**65,786**	**60,176**	**55,105**	**56,506**	**53,041**	**49,420**	**52,537**	**50,163**	**51,879**	**47,130**	**44,616**
Total (without LULUCF, with indirect)	**74,739**	**70,068**	**66,488**	**63,689**	**63,817**	**58,595**	**54,018**	**55,759**	**51,552**	**48,941**	**50,951**	**48,638**	**48,422**	**44,504**	**41,746**
Total (with LULUCF, with indirect)	**80,003**	**75,611**	**70,593**	**67,076**	**66,275**	**60,597**	**55,486**	**56,863**	**53,368**	**49,733**	**52,837**	**50,458**	**52,160**	**47,397**	**44,853**

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
	CO_2 equivalent (kt)														
1. Energy	58,754	53,914	50,657	48,632	49,155	43,868	39,341	41,157	36,880	34,571	36,189	33,810	33,766	30,052	27,106
2. Industrial processes and product use	2,827	2,862	2,555	2,131	1,913	2,056	2,092	2,055	2,010	1,835	2,044	2,028	2,048	1,842	1,925
3. Agriculture	11,166	11,357	11,360	11,168	11,069	11,060	11,065	11,062	11,205	11,092	11,265	11,339	11,154	11,183	11,268
4. Land use, land-use change and forestry	5,264	5,543	4,106	3,386	2,458	2,002	1,468	1,105	1,816	792	1,886	1,820	3,738	2,893	3,107
5. Waste	1,351	1,337	1,346	1,252	1,191	1,191	1,139	1,128	1,130	1,130	1,152	1,166	1,173	1,160	1,210
6. Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Total (including LULUCF)	79,362	75,013	70,024	66,570	65,786	60,176	55,105	56,506	53,041	49,420	52,537	50,163	51,879	47,130	44,616

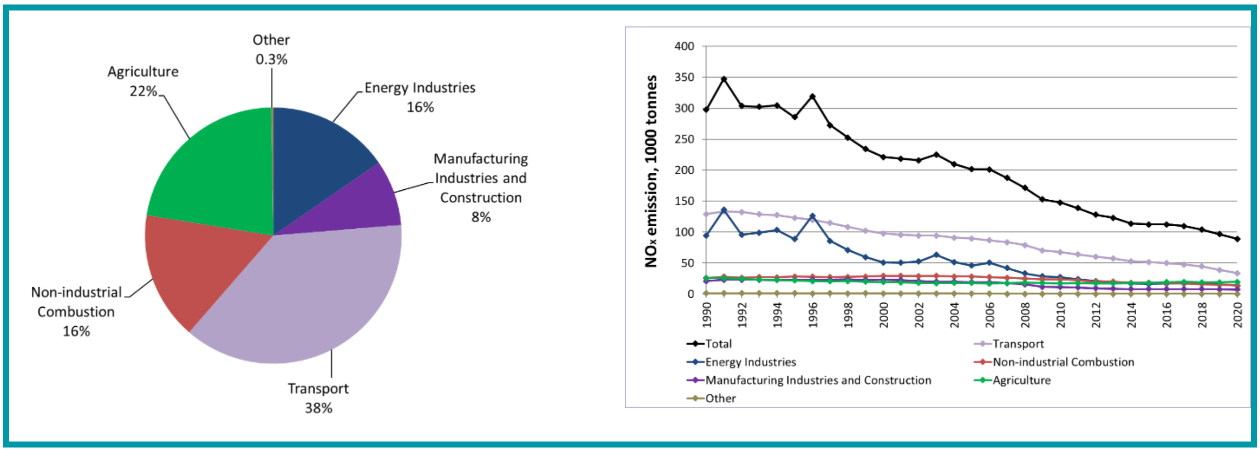
3.2.6 Danish emissions of indirect greenhouse gases and SO_2

NO_X

The three largest sources of emissions of nitrogen oxide (NO_x) are transport, agriculture, non-industrial combustion (e.g. other mobile sources such as fishing vessels and agricultural vehicles) and energy industries. In 2020, the transport sector contributed 38 % of total Danish NO_x emissions, and the transport emissions have decreased from 129 kt in 1990 to 34 kt in 2020 – a fall of 74 %. The increased use of low-NO_x burners and de-NO_x units at power and district heating plants has reduced emissions from these plants. In addition, the increased number of cars fitted with catalytic converters has contributed to the trend in reductions.

FIGURE 3.7: NO_X EMISSIONS BY SECTOR (2020) AND DEVELOPMENT IN 1990-2020

Source: Nielsen et al., 2022b.

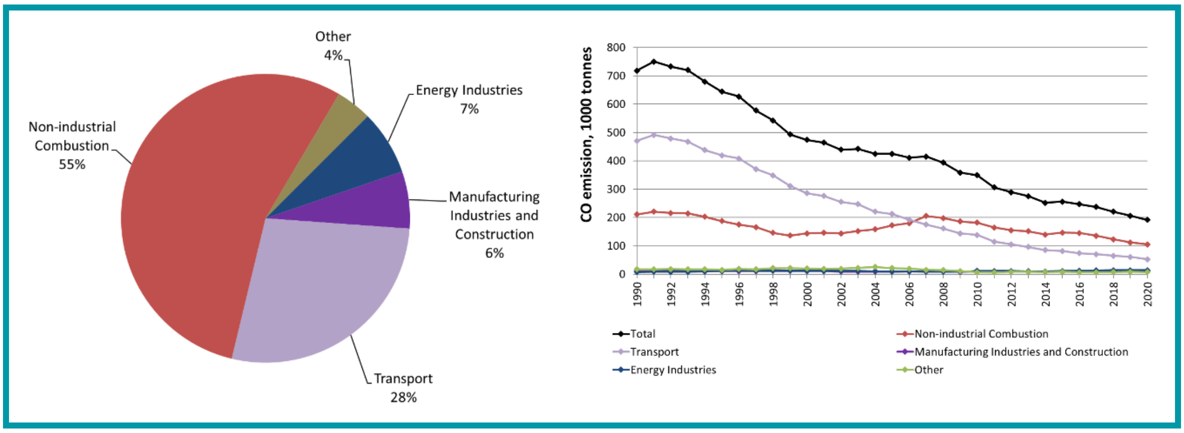


CO

Non-industrial combustion, mainly residential wood combustion and non-road machinery, accounts for more than two thirds of the CO emission. Road transport still accounts a large part of the CO emissions, but the CO emissions from this source has decreased significantly, due to the introduction of catalytic converters for vehicles in 1990. Emissions of CO were reduced by 73% from 1990 to 2020.

FIGURE 3.8: CO EMISSIONS BY SECTOR (2020) AND DEVELOPMENT IN 1990-20120

Source: Nielsen et al., 2022b.

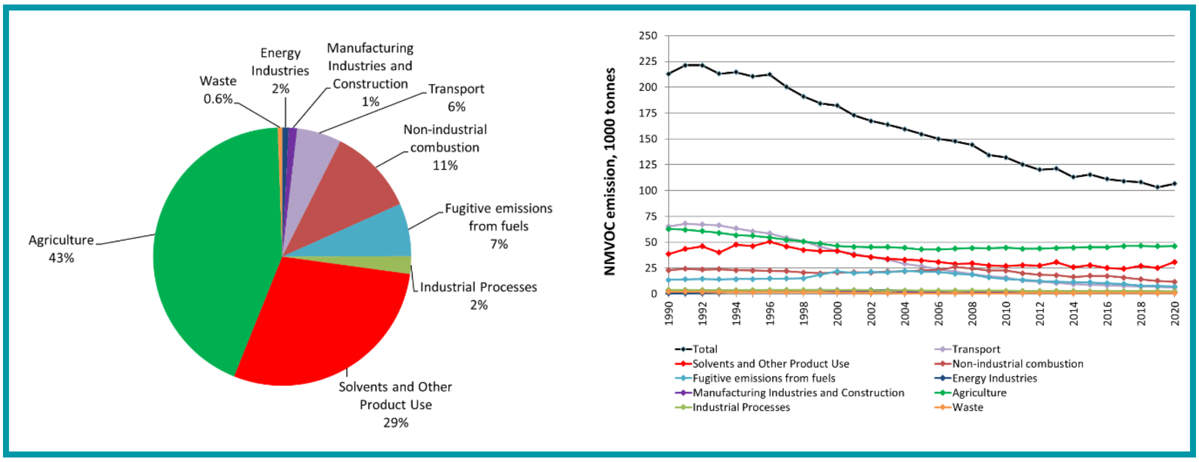


NMVOC

The most significant emission sources of NMVOC are agriculture, use of solvents and non-industrial combustion. Total anthropogenic emissions of NMVOC were reduced by 50 % from 1990 to 2020 – especially due to the increased number of cars fitted with catalytic converters and reduced emissions in connection with use of organic solvents.

FIGURE 3.9: NMVOC EMISSIONS BY SECTOR (2020) AND DEVELOPMENT IN 1990-2020

Source: Nielsen et al., 2022b.

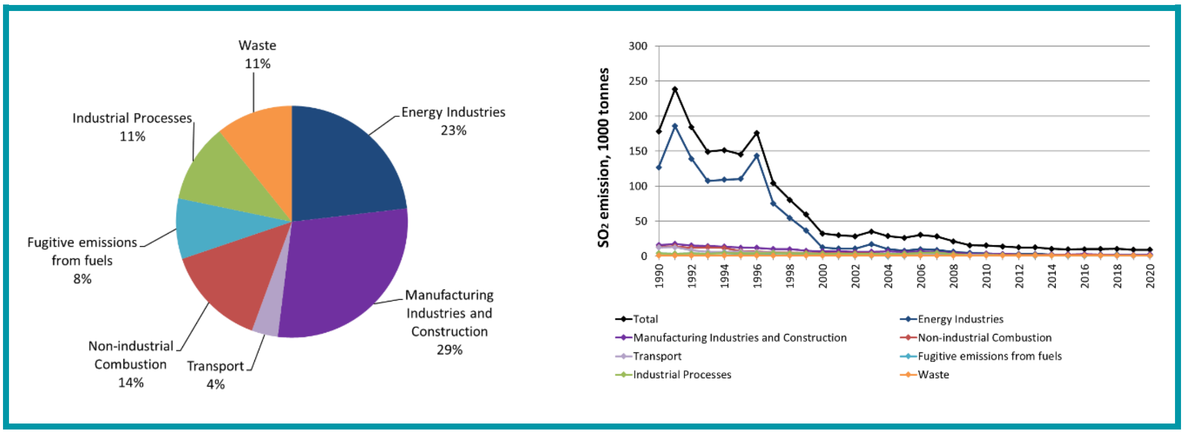


SO_2

The greater part of all SO_2 emissions comes from combustion of coal and oil at power plants, district heating plants and manufacturing plants. Emissions of SO_2 have undergone a remarkable development - from 1990 to 2020 total emissions fell by 95%. The reason for this is primarily the installation of desulphurisation units at the large power plants as well as the use of fuels with low sulphur content for power stations, industry and the transport sector.

FIGURE 3.10: SO_2 EMISSIONS BY SECTOR (2020) AND DEVELOPMENT IN 1990-2020

Source: Nielsen et al., 2022b.



3.2.7 Greenland's emissions and removals of greenhouse gases

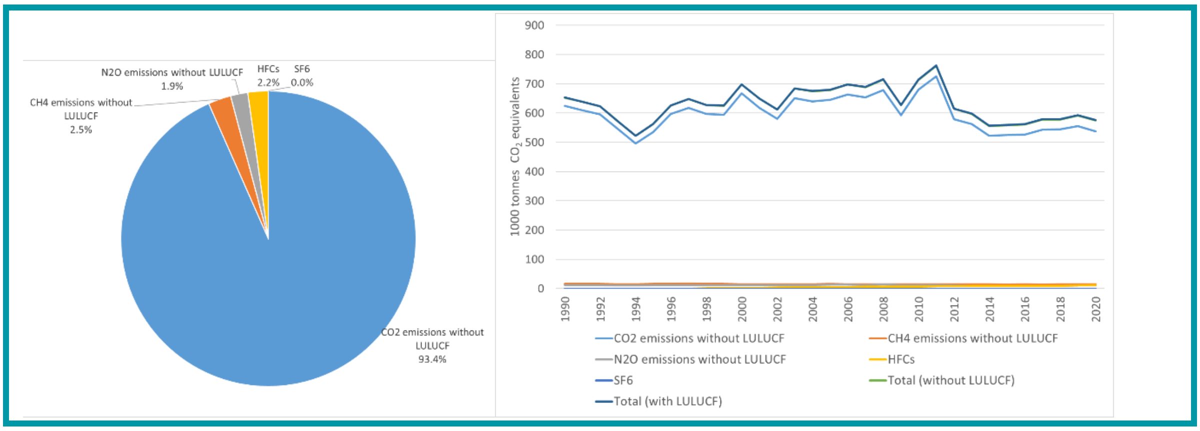
3.2.7.1 Summary information from Greenland's greenhouse gas inventory

In 2020, the total emission of greenhouse gases excluding LULUCF was 575.35 kt CO_2 equivalent, and 576.69 kt CO_2 equivalent including LULUCF.

Figure 3.11 shows the total greenhouse gas emissions in CO_2 equivalents from 1990 to 2020. The emissions have not been corrected for temperature variations. CO_2 is the most important greenhouse gas. In 2020, CO_2 contributed to the total emission in CO_2 equivalent excluding LULUCF with 93.4 %, followed by CH_4 with 2.5 %, N_2O with 1.9 % and F-gases (HFCs) with 2.2 %. Since 1990, these percentages have been increasing for F-gases, and falling for CO_2 and N_2O, and stable for and CH_4. Greenland has no consumption of PFC.

FIGURE 3.11 GREENHOUSE GAS EMISSIONS BY TYPE OF GAS IN CO_2 EQUIVALENTS, DISTRIBUTION IN 2020 AND TIME SERIES 1990 - 2020.

Source: Ministry of Agriculture, Self-Sufficiency, Energy and Environment, Government of Greenland, 2022.

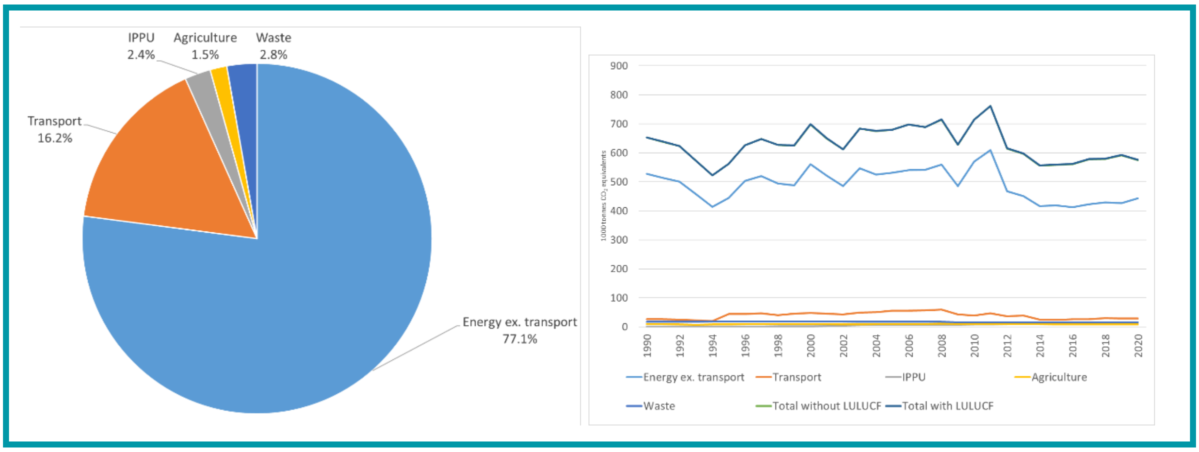


Stationary combustion plants and transport represent the largest categories. In 2020, energy excluding transport accounted for 77.1 % of the total emission in CO_2 equivalents excluding LULUCF; see Figure 3.12. Transport contributed with 16.2 %. Industrial processes and product use, agriculture and waste contributed to the total emission in CO_2 equivalents with 6.7 %.

The net CO_2 emission from forestry etc. was 0.2 % of the total emission in CO_2 equivalents in 2020. Total GHG emissions in CO_2 equivalents excluding LULUCF have decreased by 11.9 % from 1990 to 2020 and decreased 11.7% including LULUCF.

FIGURE 3.12 GREENLAND'S GREENHOUSE GAS EMISSIONS IN CO_2 EQUIVALENTS, SOURCE/SECTOR – DISTRIBUTION IN 2020 AND TIME SERIES 1990 – 2020

Source: Ministry of Agriculture, Self-Sufficiency, Energy and Environment, Government of Greenland, 2022.



3.2.7.2 Summary information on Greenland's national inventory arrangements

Greenland's national inventory is compiled by Statistics Greenland and then submitted to DCE (Danish Centre for Environment and Energy). DCE reports to the UNFCCC on behalf of the Danish Realm.

TABLE 3.3 GREENLAND'S GREENHOUSE GAS EMISSIONS AND REMOVALS BY GAS AND SOURCE AND SINK CATEGORIES IN 1990 - 2020

Source: Nielsen et al., 2022a.

GREENHOUSE GAS EMISSIONS	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
	CO_2 equivalent (kt)															
CO_2 emissions without LULUCF	625	610	596	546	496	534	597	618	597	595	668	618	580	651	641	645
CO_2 emissions with LULUCF	625	610	596	546	496	535	597	618	598	595	668	619	580	651	641	646
CH_4 emissions without LULUCF	16	16	16	15	15	16	16	17	17	16	16	16	15	15	16	16
CH_4 emissions with LULUCF	16	16	16	15	15	16	16	17	17	16	16	16	15	15	16	16
N_2O emissions without LULUCF	12	12	12	11	11	12	12	12	13	13	13	13	12	13	13	13
N_2O emissions with LULUCF	12	12	12	11	11	12	13	12	13	13	13	13	12	13	13	13
HFCs	NO,NE	NO,NE	NO,NE	0	0	0	0	0	1	1	2	3	4	5	6	6
PFCs	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Unspecified mix of HFCs and PFCs	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
SF_6	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	0	0	0	0	0	0	0	0	0	0	0
NF_3	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Total (without LULUCF)	653	638	623	572	523	562	626	648	628	625	698	650	612	684	675	679
Total (with LULUCF)	653	639	624	573	523	563	626	648	628	626	699	650	612	684	676	680
Total (without LULUCF, with indirect)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total (with LULUCF, with indirect)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
	CO_2 equivalent (kt)															
1. Energy	625	625	610	596	546	496	534	597	618	597	594	668	618	580	650	641
2. Industrial processes and product use	1	1	1	1	1	1	1	0	1	1	2	3	4	5	6	7
3. Agriculture	10	10	10	9	8	8	9	10	10	10	10	9	9	9	9	10
4. Land use, land-use change and forestry	0	0	0	0	0	0	0	0	0	1	1	1	1	0	1	1
5. Waste	18	18	18	18	18	18	18	19	19	19	19	18	18	18	18	18
6. Other																
Total (including LULUCF)	653	653	639	624	573	523	563	626	648	628	626	699	650	612	684	676

GREENHOUSE GAS EMISSIONS	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
	CO_2 equivalent (kt)														
CO_2 emissions without LULUCF	663	654	678	594	679	726	580	563	523	526	527	544	545	555	537
CO_2 emissions with LULUCF	663	655	679	594	680	727	581	564	524	527	528	545	546	557	538
CH_4 emissions without LULUCF	16	16	16	15	15	15	15	15	15	14	14	14	14	14	14
CH_4 emissions with LULUCF	16	16	16	15	15	15	15	15	15	14	14	14	14	14	14
N_2O emissions without LULUCF	13	13	14	12	12	12	11	10	10	10	10	10	10	11	11
N_2O emissions with LULUCF	13	13	14	12	12	12	11	10	10	10	10	10	10	11	11
HFCs	6	6	7	7	7	8	8	9	9	10	10	10	10	11	13
PFCs	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Unspecified mix of HFCs and PFCs	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
SF_6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NF_3	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Total (without LULUCF)	697	689	715	627	714	761	615	597	556	559	561	578	578	592	575
Total (with LULUCF)	698	689	716	628	715	762	616	598	557	560	562	579	580	593	577
Total (without LULUCF, with indirect)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total (with LULUCF, with indirect)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
	CO_2 equivalent (kt)														
1. Energy	663	654	679	593	680	726	579	563	522	525	526	543	544	555	537
2. Industrial processes and product use	7	7	8	8	8	9	9	10	10	11	11	11	11	12	14
3. Agriculture	10	10	11	9	10	10	10	9	9	9	9	8	8	9	9
4. Land use, land-use change and forestry	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
5. Waste	18	18	18	17	16	17	16	15	15	15	15	15	16	16	16
6. Other															
Total (including LULUCF)	698	689	716	628	715	762	616	598	557	560	562	579	580	593	577

3.2.8 The Faroe Islands' emissions and removals of greenhouse gases

3.2.8.1 Summary information from Faroe Islands' greenhouse gas inventory

Table 3.4 and figures 3.13 and 3.14 show the development in the Faroe Islands' greenhouse gas emissions and removals as CO_2 equivalents and by sources and gases according to the reporting guidelines under the Climate Convention (i.e. the Faroe Islands' contribution to the total of the Realm).

As shown in Figure 3.13 the development in total greenhouse gas emissions in CO_2 equivalents (including LULUCF) has increased by 74 % from 1990 to 2020. The total Faroese greenhouse gas emissions corresponded to 1.4 Mt of CO_2 equivalents in 2020, including emissions from LULUCF.

As also shown in Figure 3.13 the main part - i.e. 81 % - of the emissions were from the fuel consumption including waste incineration in the energy sector in 2020. Almost 10 % were from Industrial processes and Product Use, 6 % from Agriculture, 2 % from LULUCF and 1 % from Waste. The fluctuations in the GHG emissions in the Energy sector are decisive for the fluctuations in the total GHG emissions. The emissions from the Waste, Agriculture and LULUCF sectors are relative small and constant. Emissions from Industrial processes and Product Use have increased significantly since 2012. Though, new data suggests that a coming recalculation will most likely reduce the emission from the sector with 40-50 %.

From 1990 to 1993, a decrease in total Faroese greenhouse gas emissions is observed, due to an economic crisis in the Faroe Islands, which lasted for 6-8 years. From 2001 to 2007, the emissions were rather stabile. In 2008-2011 the emissions from Faroese fishing vessels were – except for 2010 – significantly lower than previous years, especially due to rising oil prices and lower prices on fish. The decrease is concealed by emissions related to new bunkering activity starting in 2009 that has led to a substantial increase in the number of foreign fishing vessels bunkering in the Faroe Islands. In general, the total emission of greenhouse gases on the Faroe Islands were relative stabile from 2001 until 2016, around and above 800 thousand tonnes of CO_2 equivalents pr. year. A significant and step rise in the emission was seen in 2017 and every year after, increasing the emissions to more than 1.3 mill. CO_2 equivalents in 2020.

FIGURE 3.13 GREENHOUSE GAS EMISSIONS BY SECTOR FOR 2015 AND DEVELOPMENT 1990 TO 2020

Source: Nielsen et al. (2022a).

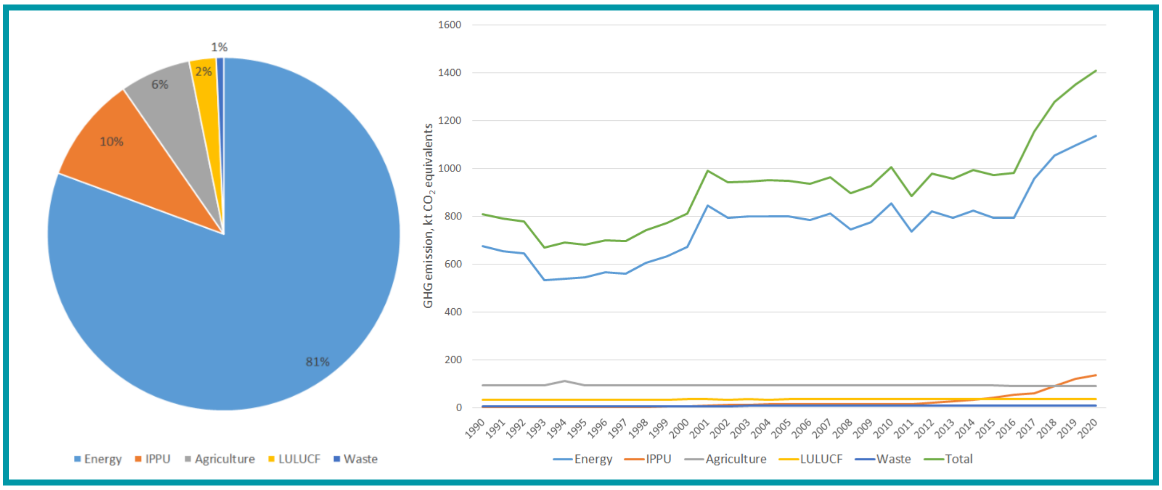
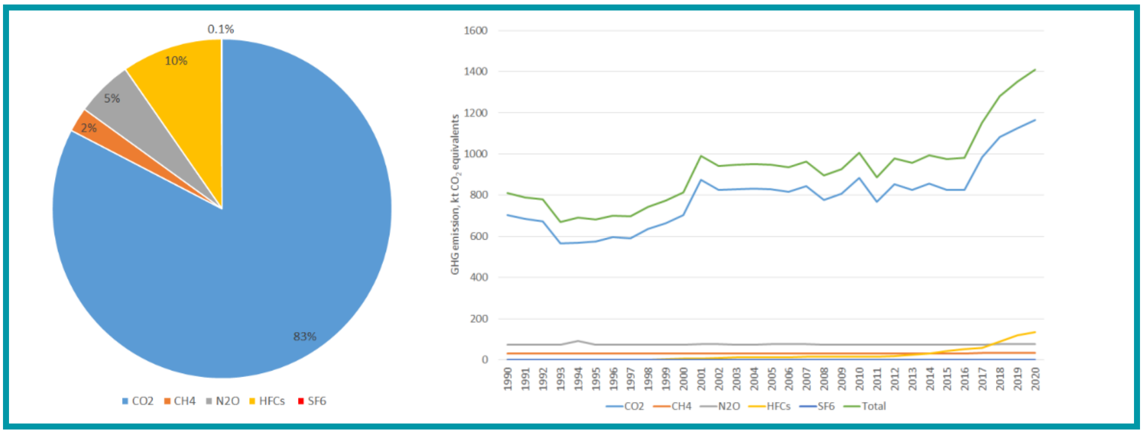


Figure 3.14 shows that CO_2 is the most important greenhouse gas, followed by F-gases, CH_4 and N_2O. Of the total Faroese greenhouse gas emissions in 2020, CO_2 made up 83 %, F-gases (HFCs and SF_6) 10 %, nitrous oxide 5 % and methane 2 %.

FIGURE 3.14 EMISSIONS OF GHG BY GAS IN 2015 AND DEVELOPMENT 1990 TO 2020.

Source: Nielsen et al. (2022a).



Carbon dioxide, CO_2

The emission of CO_2 in the Faroe Islands is from fuel consumption (incl. waste incineration). The trend in the total emission of CO_2 (Figure 3.15) is nearly identical with the trend of the total emission of GHG in the Faroe Islands (Figure 3.14) showing the trends in CO_2 emissions in the period from 1990 to 2015. After the economic decline in the 1990s, the emissions rose and were rather constant until 2007. From 2008 to 2011, the effort in the Faroese fishing fleet was significantly lower than previous years, also meaning a significant reduction in oil consumption. This reduction is not visible in the figure 3.15 since new oil bunkering activity (mostly used by foreign fishing vessels) started in 2009, and thus increasing the emissions.

As seen in figure 3.15, the rise in the total emission in 2017 and 2018 is due to more energy usage on fishing vessels, whereas the rise in 2019 and 2020 is mainly due to increase in use of fuel in fishing vessels and in production of public electricity.

FIGURE 3.15 TOTAL CO_2 EMISSIONS AND BY SECTOR, DEVELOPMENT 1990 TO 2020

Source: Nielsen et al. (2022a).

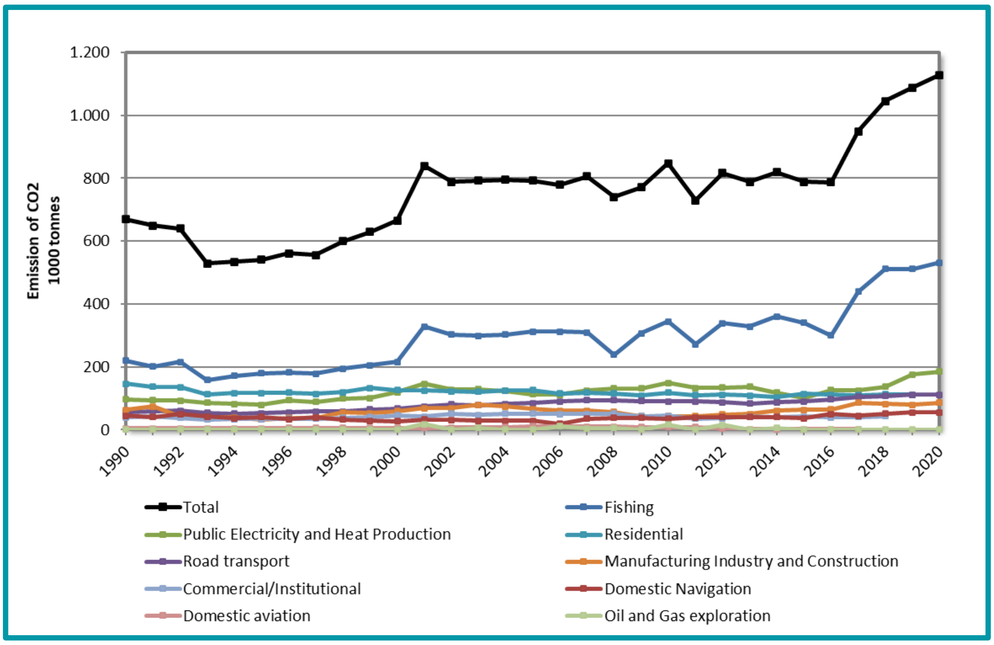
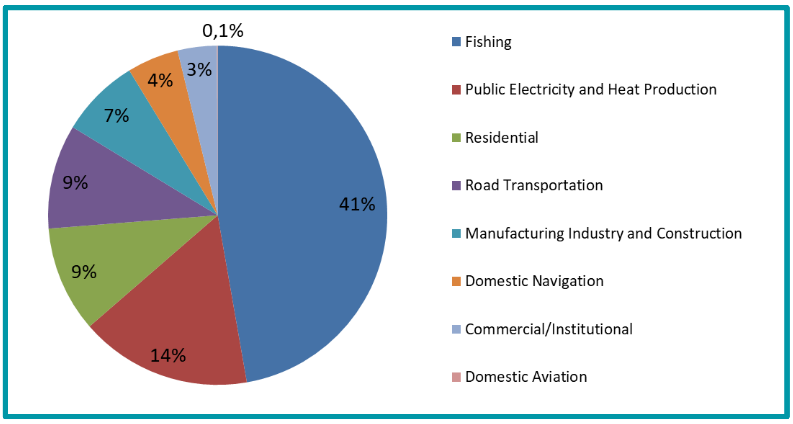


Figure 3.16 shows how the CO_2 emissions are distributed between the sub-categories in the energy sector. In 2020, 41 % of the emission of CO_2 came from fishing vessels. Public Electricity and Heat Production, Residential and Road Transportation accounted respectively for 14 %, 9 % and 9 % of the total CO_2 emission.

FIGURE 3.16 EMISSIONS OF CO_2 IN THE ENERGY SECTOR, DIVIDED IN FUEL CONSUMPTION CATEGORIES, 2020

Source: Nielsen et al. (2022a).

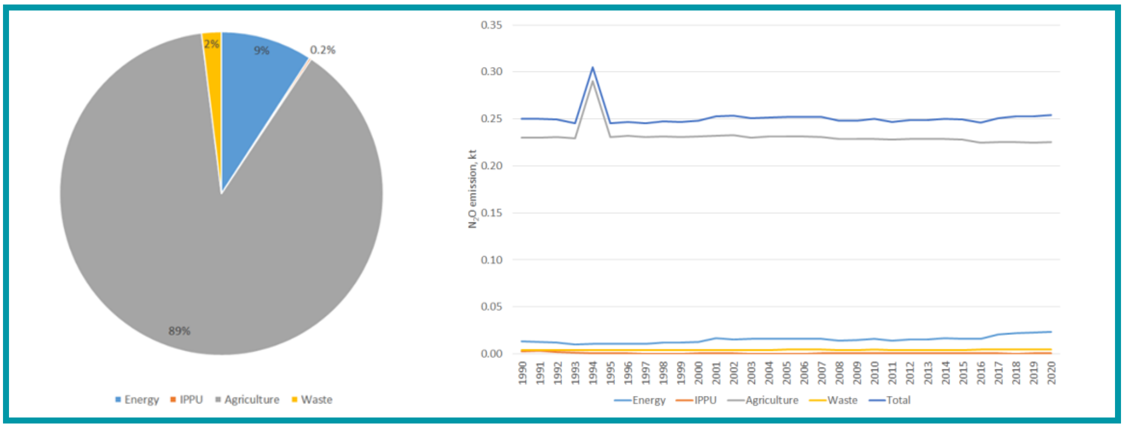


Nitrous oxide, N_2O

Figure 3.17 shows the emissions of nitrous oxide in the Faroe Islands 1990-2015. Almost all of the N_2O emissions are from the Agricultural sector (89 %), mostly from animals grazing on agricultural soils. A smaller contribution was from energy and wastewater treatment. The peak in 1994 is an error which will be further investigated for the next inventory submission.

FIGURE 3.17 N_2O EMISSIONS BY SECTOR IN 2020 AND DEVELOPMENT 1990-2020

Source: Nielsen et al. (2022a).

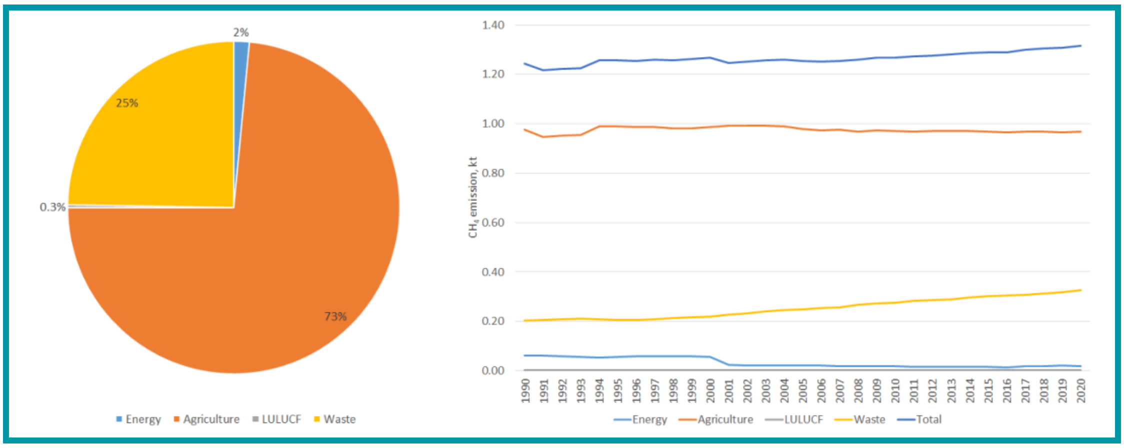


Methane, CH_4

Figure 3.18 shows the emissions of methane in the Faroe Islands 1990-2020. Most of the methane emission is from the agriculture sector, especially from enteric fermentation (73 %). The second largest CH_4 source was the waste sector (landfills and wastewater treatment) accounting for 25 %. Most of the emission of CH_4 in the energy sector is due to aviation activity.

FIGURE 3.18 CH_4 EMISSIONS BY SECTOR IN 2020AND DEVELOPMENT 1990-2020

Source: Nielsen et al. (2022a).

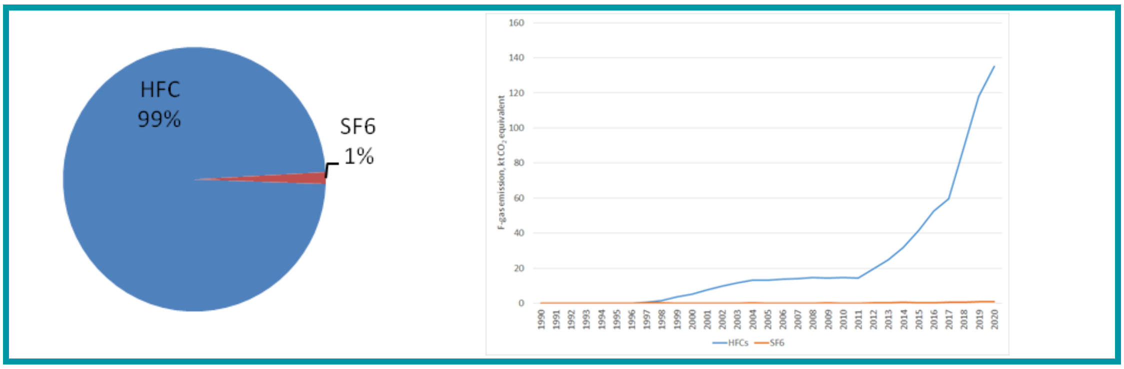


The f-gases: HFCs, PFCs, SF_6 and NF_3

Figure 3.19 shows the emissions of F-gases, HFCs and SF_6 respectively in the years 1990-2020. Most of the emission is HFCs, used for refrigeration purposes, as substitutes for HCFCs. After the emissions increased in the period 1996-2005, the emissions were rather stable at around 14,000 tonnes of CO_2 equivalents pr. year until 2011. Since then, the emissions have increased yearly, and in 2020, the emissions of HFCs have eight folded since 2012, to in total around 135 kt of CO_2 equivalents. This is due to more use of HFC-125 and HFC-143a, both components in the HFC-blend HFC-507a, which in recent years has been used as a substitute when phasing out HCFC-22 (ozone depleting freezing agent) on fishing vessels. As mention before, these emissions are now beeing recalucated and the total emission of f-gases are expected to be reduced by 40-50 % in the next inventory.

FIGURE 3.19 F-GAS EMISSIONS, BY TYPE OF GAS IN 2020 AND DEVELOPMENT 1990-2020

Source: Nielsen et al. (2022a).



Neither PFCs nor NF_3 have been used in the Faroe Islands.

3.2.8.2 *Summary information on Faroe Islands' national inventory arrangements*

The Environment Agency (FEA), an agency under the Ministry of Environment (www.umhvorvi.fo), is responsible for the annual preparation and submission to the UNFCCC of the Faroe Islands' contribution to the Kingdom of Denmark's National Inventory Report and the GHG inventories in the Common Reporting Format in accordance with the UNFCCC Guidelines. The inventory is done with guidance from and in co-operation with DCE. The work is carried out in co-operation with Statistics Faroe Islands, other Faroese ministries, research institutes, organisations and companies.

For more comprehensive information, e.g. about the inventory preparation, calculation methods, annual reporting, improvements of emissions inventories, please see Nielsen et al. (2022).

TABLE 3.4 FAROE ISLANDS' GREENHOUSE GAS EMISSIONS AND REMOVALS BY GAS AND SOURCE AND SINK CATEGORIES IN 1990 - 2020

Source: Nielsen et al., 2022a.

GREENHOUSE GAS EMISSIONS	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**
	CO_2 equivalent (kt)															
CO_2 emissions without LULUCF	670	650	640	530	535	541	562	557	601	630	667	841	790	794	796	794
CO_2 emissions with LULUCF	704	684	674	564	570	575	596	591	635	664	702	875	824	829	830	829
CH_4 emissions without LULUCF	31	30	31	31	31	31	31	31	31	31	32	31	31	31	31	31
CH_4 emissions with LULUCF	31	30	31	31	31	31	31	31	31	32	32	31	31	31	31	31
N_2O emissions without LULUCF	75	75	74	73	91	73	74	73	74	73	74	75	76	75	75	75
N_2O emissions with LULUCF	75	75	74	73	91	73	74	73	74	73	74	75	76	75	75	75
HFCs	NO	NO	NO	NO	0	0	0	1	1	4	5	8	10	12	13	13
PFCs																
Unspecified mix of HFCs and PFCs																
SF_6	NO	NO	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NF_3																
Total (without LULUCF)	775	755	745	634	658	646	667	663	708	739	778	955	907	912	916	914
Total (with LULUCF)	809	789	779	668	692	680	701	696	741	773	812	990	941	947	950	949
Total (without LULUCF, with indirect)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total (with LULUCF, with indirect)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**
	CO_2 equivalent (kt)															
1. Energy	674	655	644	534	539	545	565	561	605	634	671	845	794	798	800	798
2. Industrial processes and product use	2	2	2	1	1	1	1	2	3	5	7	9	11	13	15	15
3. Agriculture	93	92	93	92	111	93	94	93	94	93	94	94	94	93	94	93
4. Land use, land-use change and forestry	34	34	34	34	34	34	34	34	34	34	35	34	34	35	34	35
5. Waste	6	6	6	6	6	6	6	6	7	7	7	7	7	7	7	8
6. Other																
Total (including LULUCF)	809	789	779	668	692	680	701	696	741	773	812	990	941	947	950	949

GREENHOUSE GAS EMISSIONS	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
	CO_2 equivalent (kt)														
CO_2 emissions without LULUCF	781	808	741	772	848	731	817	790	820	790	789	951	1047	1090	1129
CO_2 emissions with LULUCF	816	843	776	807	884	766	853	825	855	825	824	986	1082	1125	1164
CH_4 emissions without LULUCF	31	31	31	32	32	32	32	32	32	32	32	32	33	33	33
CH_4 emissions with LULUCF	31	31	31	32	32	32	32	32	32	32	32	32	33	33	33
N_2O emissions without LULUCF	75	75	74	74	75	74	74	74	75	74	73	75	75	75	76
N_2O emissions with LULUCF	75	75	74	74	75	74	74	74	75	74	73	75	75	75	76
HFCs	14	14	15	14	15	14	19	25	32	42	52	59	89	118	135
PFCs															
Unspecified mix of HFCs and PFCs															
SF_6	0	0	0	0	0	0	0	0	1	0	0	1	1	1	1
NF_3															
Total (without LULUCF)	901	929	861	892	969	851	943	921	959	938	947	1118	1244	1317	1374
Total (with LULUCF)	936	964	896	928	1005	886	978	956	994	974	982	1153	1280	1353	1409
Total (without LULUCF, with indirect)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total (with LULUCF, with indirect)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
	CO_2 equivalent (kt)														
1. Energy	785	812	745	776	853	735	822	794	824	794	793	956	1053	1096	1135
2. Industrial processes and product use	15	16	16	15	16	16	21	26	34	43	54	61	91	120	137
3. Agriculture	93	93	92	92	92	92	92	92	92	92	91	91	91	91	91
4. Land use, land-use change and forestry	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35
5. Waste	8	8	8	8	8	8	8	9	9	9	9	9	9	9	10
6. Other															
Total (including LULUCF)	936	964	896	928	1005	886	978	956	994	974	982	1153	1280	1353	1409

3.3 NATIONAL SYSTEMS IN ACCORDANCE WITH ARTICLE 5, PARAGRAPH 1, OF THE PROTOCOL

This section contains information required under Article 7 of the Kyoto Protocol.

3.3.1 Objectives

In pursuance of Article 5, Section 1 of the Kyoto Protocol, the Parties to the Protocol shall establish national systems for the estimation of greenhouse gas emissions. The objective of establishing the national systems is to ensure good quality inventories. This is achieved by following the IPCC Guidelines for planning, implementation and execution of the activities connected with the work on the greenhouse gas inventories. The national system must also ensure that the inventories are transparent, consistent, comparable, complete and accurate.

3.3.2 Organisation of work, data collection, etc.

The Danish Centre for Environment and Energy (DCE) at Aarhus University[5] is responsible for producing the Danish greenhouse gas emission inventories and the annual reporting to the UNFCCC and DCE has been designated the single national entity under the Kyoto Protocol. DCE is therefore the contact point for Denmark's national system for greenhouse gas inventories under the Kyoto Protocol. Furthermore, DCE participates in work under the auspices of the UNFCCC, where guidelines for reporting are discussed and decided upon, and it participates in the EU monitoring mechanism for inventories of greenhouse gases, where guidelines for reporting to the EU are regulated.

The work on the annual inventories is carried out in cooperation with other Danish ministries, research institutes, organisations and private enterprises. The most important partners for this work are mentioned in Box 3.1. For more comprehensive information on the data collection, please see Nielsen et al. (2022a) Chapter 1.3 and the individual sector chapters.

The partners mentioned in Box 3.1 provide a range of data that are needed to produce the inventory. DCE therefore has formal agreements with many of the partners to ensure that DCE receives the necessary data on time.

[5] Danish Centre For Environment And Energy, Aarhus University. Frederiksborgvej 399, 4000 Roskilde Denmark. Contact: Ole-Kenneth Nielsen okn@envs.au.dk

BOX 3.1 DCE'S PARTNERS IN THE WORK ON THE ANNUAL INVENTORIES

The Danish Energy Agency, the Danish Ministry of Climate, Energy and Utilities:
Annual energy statistics that are compatible with the format used for emission inventories, fuel consumption data for large incineration plants and plant data reported under the EU ETS.

The Danish Environmental Protection Agency, the Danish Ministry of Environment:
Database on waste volumes and emissions of fluorinated greenhouse gases (F-gases).

Statistics Denmark, the Danish Ministry of the Interior and housing:
Statistical yearbook, sales statistics for industry, and agricultural statistics.

Department of Animal Science, Aarhus University:
Data on use of fertiliser, fodder, and data on nitrogen emissions from livestock.

The Danish Road Directorate, the Danish Ministry of Transport:
Number of vehicles grouped by categories corresponding to the EU classifications, kilometres travelled and speeds in town and on main roads and motorways.

The National Centre for Forest, Landscape and Planning, Copenhagen University:
Background data for forests and emissions/ removals associated with forestry.

The Civil Aviation Administration, the Danish Ministry of Transport:
Aircraft data (aircraft types and flight routes) for all flight departures and arrivals at Danish airports.

DSB (Danish Railways), the Danish Ministry of Transport:
Fuel-related emission factors for diesel locomotives.

Danish enterprises:
Environmental accounts and other information.

3.3.3 Calculation methods

The Danish emission inventory is based on the 2006 IPCC guidelines for calculation of greenhouse gas emissions and the European CORINAIR (COoRdination of INformation on AIR emissions) program for calculation of national emissions. Generally, emissions are calculated by multiplying the activity data (e.g. fuel consumption, number of animals or vehicles) by an emission factor (e.g. the mass of material emitted per unit of energy, per animal or per vehicle). Activity data are mainly based on official statistics. The emission factors are either plant-specific, country-specific, default factors from the IPCC guidelines or values from international scientific literature and are selected in accordance with the 2006 IPCC Guidelines. For more information on the methodologies and selection of emission factors and other calculation parameters, please refer to Chapter 1.4 and the individual sector chapters in Nielsen et al. (2022a).

3.3.4 Key categories

The choice of methodological tier for the individual categories depends, among other things, on the significance of the source. The categories that together accounted for 95 % of greenhouse gas emissions in the base year, in 2020 or accounted for 95 % of the change in emission levels from the base year to the most recently calculated year (2020) are defined as key categories according to the IPCC guidelines. An analysis of the Danish inventory shows that 47 categories account for 95 % of total greenhouse gas emissions when considering the inventory including LULUCF and using Approach 1 of the 2006 IPCC Guidelines and that the four largest sources – together accounting for about 44 % – are CO_2 emissions from road transport, CO_2

from combustion of natural gas at stationary combustion plants, CH_4 from enteric fermentation and CO_2 emissions from combustion of coal at stationary combustion plants. For more information on the identified key categories for the trend and by using approach 2, please refer to Nielsen et al. (2022a).

3.3.5 Procedure for recalculation

At the same time as the annual calculation of emissions for a new year are being made, any necessary recalculations of emission inventories from previous years are also carried out. Recalculations are made if errors or oversights are found or if better knowledge becomes available, e.g. updated statistical data, improvements of methodologies, and updated emission factors due to new knowledge and research. In order to ensure consistent emission inventories, recalculations will be carried out on the whole time series, as much as circumstances permit and following the guidance in the IPCC guidelines.

3.3.6 Uncertainty

Uncertainty in the greenhouse gas inventories is calculated as recommended in the IPCC guidelines and covers 100 % of the total Danish greenhouse gas (GHG) emissions reported under the Kyoto Protocol. The result of the calculations shows that total GHG emissions were calculated using Approach 1 of the 2006 IPCC Guidelines to have an uncertainty of 14.0 % and the uncertainty in the trend in GHG emissions since 1990 was calculated to be ± 3.1 %. The uncertainties are largest for N_2O emissions from stationary combustion and agricultural land and CH_4 emissions from enteric fermentation and solid waste disposal on land.

3.3.7 Quality assurance and quality control

As part of the national system, DCE is drawing up a manual to use in quality assurance and quality control of the emission inventories. The manual is in accordance with the 2006 IPCC Guidelines. The ISO 9000 standards are also being used as important input for the plan.

Reports are written for all sources of emissions and these describe in detail and document the data and calculation methods used. These reports are evaluated by persons external to the DCE who are experts in the area in question, but not directly involved in the inventory work. In addition, a project has been completed in which the Danish calculation methods, emission factors and uncertainties are compared with those of other countries, in order to further verify the correctness of the inventories.

For more detailed description of the QA/QC system, please see the Danish National Inventory Report (Nielsen et al., 2022a).

3.3.8 Annual reporting

The DCE produces an annual report (National Inventory Report (NIR)) for the Climate Convention in which the results of the calculations are presented and the background data, calculation methods, plan for quality assurance and control, uncertainty and recalculations are described and documented. At the request of the Climate Convention, the report is evaluated each year by international experts. Over the years, improvements have been made regarding the quality and documentation of the greenhouse gas inventory as a result of the quality assurance and control procedures and the evaluations of national and international experts.

3.3.9 Activities under Article 3.3 and 3.4 of the Kyoto Protocol

Under the Kyoto Protocol, Denmark and Greenland elected activities Cropland Management and Grazing Land Management. The documentation for the methodologies used in estimating the emissions and removals from the elected activities are described in detail in the National Inventory Report (Nielsen et al., 2022a). Documentation is provided in the NIR for both Denmark and Greenland in separate chapters as per recommendations received by Expert Review Teams during their annual reviews of the greenhouse gas inventory.

3.3.10 Information under Article 10(a) of the Protocol on improvements of emission inventories

A number of improvements have been made to the Danish greenhouse gas emission inventories since Denmark's Seventh National Communication to the Climate Convention (NC7). The improvements have either been done on the initiative of DCE, or as a result of external reviews of the inventories. The majority of improvements have been concerned with better documentation, i.e. improvements in transparency. Furthermore, overall focus in future will be on improving procedures for quality assurance and control and on improving documentation of the national emission factors.

3.3.11 Procedures for the official consideration and approval of the inventory

The complete emission inventories for the three different submissions (EU, Kyoto Protocol and UNFCCC) by Denmark are compiled by DCE and sent for official approval along with the documentation report (NIR). The emission inventory is finalised no later than March 15, so that the official approval is prior to the reporting deadlines under the UNFCCC and the Kyoto Protocol.

3.4 National Registry

3.4.1 Background

Since NC7 was published, minor changes have occurred regarding the National Registry. This chapter describes the National Registry as it has been operated since June 2012, when the EU ETS operations were centralized into a single European Union registry operated by the European Commission.

During the period up to 2021 the ETS operated in 31 countries: the 28 EU Member States plus Iceland, Liechtenstein and Norway, covering CO_2 emissions from installations such as power stations, combustion plants, oil refineries and iron and steel works, as well as factories making cement, glass, lime, bricks, ceramics, pulp, paper and board.

Directive 2009/29/EC, adopted in 2009, provided for the centralization of the EU ETS operations into a single European Union registry operated by the European Commission as well as for the inclusion of the aviation sector. At the same time, and with a view to increasing efficiency in the operations of their respective national registries, the EU Member States who are also Parties to the Kyoto Protocol plus Iceland, Liechtenstein and Norway decided to operate their registries in a consolidated manner in accordance with all relevant decisions applicable to the establishment of Party registries - in particular Decision 13/CMP.1 and Decision 24/CP.8.

3.4.2 Statutory basis

The National Emission Trading Registry (the Danish accounts in the EU ETS Registry as well as the Danish national KP Registry) is administered pursuant to Danish Act on CO_2 Allowances (Act no. 1605 of 14 December 2016). The Act implements EU Directive 2003/87/EC (EU ETS directive) as amended by EU Directive 2009/29/EC. Pursuant to sections 21 and 22 of the Act, the Danish Minister for Industry, Business and Financial Affairs is responsible for administering the Danish KP Registry as well as Danish accounts in the consolidated EU ETS Registry. In Executive Order no. 1357 of 17 December 2012, the Danish Minister for Industry and Financial Affairs delegated the administration of the registries to the Danish Business Authority.

Executive Order no. 1636 of 13 December 2017 on the EU ETS Registry and the Danish Kyoto Registry sets the requirements for account holders e.g. the requirements for documentation and the applicable fees to be paid for accounts in the registries.

3.4.3 Organisation and operation of the Registry

The Danish national registry is operated as part of the Consolidated System of EU Registries. The consolidated platform which implements the national registries in a consolidated manner (including the registry of the EU) is called the Union registryand was developed together with the new EU Registry on the basis the following modalities:

(1) Each Party retains its organization designated as its registry administrator to maintain the national registry of that Party and remains responsible for all the obligations of Parties that are to be fulfilled through registries;

(2) Each Kyoto unit issued by the Parties in such a consolidated system is issued by one of the constituent Parties and continues to carry the Party of origin identifier in its unique serial number;

(3) Each Party retains its own set of national accounts as required by paragraph 21 of the Annex to Decision 15/CMP.1. Each account within a national registry keeps a unique account number comprising the identifier of the Party and a unique number within the Party where the account is maintained;

(4) Kyoto transactions continue to be forwarded to and checked by the UNFCCC Independent Transaction Log (ITL), which remains responsible for verifying the accuracy and validity of those transactions;

(5) The transaction log and registries continue to reconcile their data with each other in order to ensure data consistency and facilitate the automated checks of the ITL;

(6) The requirements of paragraphs 44 to 48 of the Annex to Decision 13/CMP.1 concerning making non-confidential information accessible to the public would be fulfilled by each Party through a publically available web page hosted by the Union registry;

(7) All registries reside on a consolidated IT platform sharing the same infrastructure technologies. The chosen architecture implements modalities to ensure that the consolidated national registries are uniquely identifiable, protected and distinguishable from each other, notably:

(a) With regards to data exchange, each national registry connects to the ITL directly and establishes a distinct and secure communication link through a consolidated communication channel (VPN tunnel);

(b) The ITL remains responsible for authenticating the national registries and takes the full and final record of all transactions involving Kyoto units and other administrative processes such that those actions cannot be disputed or repudiated;

(c) With regards to the data storage, the consolidated platform continues to guarantee that data is kept confidential and protected against unauthorized manipulation;

(d) The data storage architecture also ensures that the data pertaining to a national registry are distinguishable and uniquely identifiable from the data pertaining to other consolidated national registries;

(e) In addition, each consolidated national registry keeps a distinct user access entry point (URL) and a distinct set of authorisation and configuration rules.

Following the successful implementation of the Union Registry, the 28 national registries concerned were re-certified in June 2012 and switched over to their new national registry on 20 June 2012. Croatia was migrated and consolidated as of 1 March 2013. During the go-live process, all relevant transaction and holdings data were migrated to the Union Registry platform and the individual connections to and from the ITL were re-established for each Party. The changes to the national registry since NC6 are shown in Table 3.5.

TABLE 3.5 CHANGES TO THE EU NATIONAL REGISTRY SINCE NC7 (JANUARY 2018)

Source: Danish Business Authority

Reporting Item	Description of changes, if any
15/CMP.1 Annex II.E paragraph 32.(a) Change of name or contact	None
15/CMP.1 Annex II.E paragraph 32.(b) Change regarding cooperation arrangement	No change of cooperation arrangement occurred during the reported period.
15/CMP.1 Annex II.E paragraph 32.(c) Change to database structure or the capacity of national registry	Versions of the Union registry released after the last NC submission) introduced other minor changes in the structure of the database. These changes were limited and only affected EU ETS functionality. No change was required to the database and application backup plan or to the disaster recovery plan. No change to the capacity of the national registry occurred during the reported period.
15/CMP.1 Annex II.E paragraph 32.(d) Change regarding conformance to technical standards	Each release of the registry is subject to both regression testing and tests related to new functionality. These tests also include thorough testing against the DES and were successfully carried out prior to each release of a new version in Production. Annex H testing is carried out every year. No other change in the registry's conformance to the technical standards occurred for the reported period.
15/CMP.1 Annex II.E paragraph 32.(e) Change to discrepancies procedures	No change of discrepancies procedures occurred during the reported period.

3.4.4 Administrative set-up

The administration of the Danish national registry and, thus, the role as registry administrator is situated with the Danish Business Authority under the Danish Ministry of Industry, Business and Financial Affairs.

Users can contact the Danish Business Authority directly by phone or email for help in using the Registry.

Businesses and users of the Registry are kept informed about regulations, news etc. through regular updates on the Danish Business Authority's website, the news on the Registry website and a newsletter from the Registry staff. The newsletter is issued as required and informs about new regulations and opportunities as well as any planned temporary closures (for updates etc.).

The Danish Business Authority performs Know Your Customer Checks (KYC) before giving new businesses or users access to the registry and reassess the KYC on regular basis. Furthermore the Danish Business Authority seek to minimize the risk of fraud through profound checks of trading and cooperation with Financial Investigation Units as well as registry administrators in other countries.

3.4.5 Registry software

The Danish Business Authority is using the common software developed by the European Commission. Further information on the National Registry is included in the Annexes A2, A3 and A4.

3.5 Inventory information, targets and compliance under the Kyoto Protocol

As mentioned above, the GHG inventory of the Kingdom of Denmark under the Kyoto Protocol covers Denmark and Greenland as the Kyoto Protocol was ratified in 2002 with a territorial exclusion to the Faroe Islands in accordance with a request from the Faroese Parliament.

3.5.1 2008-2012

In the protocol's first commitment period 2008-2012 Denmark took on – as Denmark's contribution to the joint 8% reduction target of 15 Member States of the European Union – a 21% reduction target. Denmark is part of the European Union while Greenland is not. Greenland had a 8% reduction target in the protocol's first commitment period. Both EU15, Denmark and Greenland reached these targets[6]. The combined greenhouse gas emissions of Denmark and Greenland are shown in Table 3.6.

[6] http://unfccc.int/kyoto_protocol/final_compilation_and_accounting_report_for_the_first_commitment_period/items/9691.php

TABLE 3.6 DENMARK'S AND GREENLAND'S TOTAL EMISSIONS AND REMOVALS OF GREENHOUSE GASES, 1990 – 2020, INCLUDING IN THE FIRST COMMITMENT PERIOD 2008-2012 UNDER THE KYOTO PROTOCOL

Source: Nielsen et al., 2022a.

GREENHOUSE GAS EMISSIONS	Base year(CC)	1990	1995	2000	2005	**2008**	**2009**	**2010**	**2011**	**2012**	2013	2014	2015	2016	2017	2018	2019	2020	**Change from base to latest reported year**
	CO_2 equivalent (kt)																		**%**
CO_2 emissions without LULUCF	54210	54210	62149	54974	52180	51935	49445	49883	44974	40451	42336	38100	35754	37560	35324	35270	31511	28819	-46.8
CO_2 emissions with LULUCF	60750	60750	67230	59809	57001	55767	52560	52069	46610	41647	43170	39646	36267	39167	36866	38725	34123	31642	-47.9
CH_4 emissions without LULUCF	7923	7923	8331	8198	7985	7729	7594	7657	7492	7383	7293	7251	7178	7241	7239	7282	7116	7132	-10.0
CH_4 emissions with LULUCF	8185	8185	8583	8441	8218	7958	7821	7886	7816	7612	7521	7479	7408	7473	7474	7518	7353	7370	-10.0
N_2O emissions without LULUCF	8480	8480	7687	7304	5912	5950	5722	5610	5619	5520	5518	5638	5657	5773	5847	5590	5783	5740	-32.3
N_2O emissions with LULUCF	8551	8551	7754	7361	5960	5995	5766	5654	5663	5564	5562	5683	5706	5821	5891	5637	5827	5788	-32.3
HFCs	NO,NE,NA	NO,NE,NA	258	768	914	970	996	845	765	765	698	634	477	533	434	505	347	347	100.0
PFCs	NO,NA	NO,NA	1	23	19	18	20	10	8	3	4	3	0	0	1	0	1	0	100.0
Unspecified mix of HFCs and PFCs	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	0.0
SF_6	42	42	104	57	21	30	35	37	77	129	150	154	121	104	75	73	71	46	7.4
NF_3	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	0.0
Total (without LULUCF)	70655	70655	78529	71323	67030	66633	63811	64042	58935	54252	55999	51781	49187	51212	48921	48719	44828	42084	-40.4
Total (with LULUCF)	77529	77529	83930	76459	72133	70739	67198	66500	60939	55721	57104	53599	49980	53099	50742	52458	47723	45193	-41.7
Total (without LULUCF, with indirect)	71774	71774	79586	72161	67714	67203	64317	64531	59356	54633	56356	52108	49500	51512	49216	49000	45095	42321	-41.0
Total (with LULUCF, with indirect)	78648	78648	84988	77297	72816	71309	67704	66990	61359	56102	57462	53925	50293	53400	51037	52739	47990	45430	-42.2

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Base year(1)	1990	1995	2000	2005	**2008**	**2009**	**2010**	**2011**	**2012**	2013	2014	2015	2016	2017	2018	2019	2020	**Change from base to latest reported year**
	CO_2 equivalent (kt)																		**%**
. Energy	53027	53027	63707	57872	60153	64155	61123	74602	65134	61027	58605	54208	55847	55386	34354	34310	30607	27643	-47.9
2. Industrial processes and product use	2344	2344	2470	2523	2593	2706	2879	3022	3106	3205	3444	3634	3519	3473	2039	2059	1854	1939	-17.3
3. Agriculture	12640	12640	12466	12290	12239	12083	12088	11669	11680	11693	11324	11237	11234	11312	11347	11162	11191	11277	-15.5
4. Land use, land-use change and forestry	4902	4902	4262	4995	4251	3956	4190	3397	3886	4067	4129	4208	4965	6065	1822	3739	2894	3108	-54.8
5. Waste	1781	1781	1788	1768	1767	1697	1616	1580	1504	1464	1535	1531	1566	1595	1181	1188	1176	1226	-35.9
6. Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.0
Total (including LULUCF)	74694	74694	84693	79449	81002	84597	81896	94270	85309	81455	79036	74818	77132	77831	50742	52458	47723	45193	-41.7

3.5.2 2013-2020

In relation to the protocol's second commitment period 2013-2020, the quantified emission limitation and reduction commitment (QELRC) for the European Union, its member States and Iceland will be fulfilled jointly in accordance with Article 4 of the Kyoto Protocol.

Denmark's contribution to fulfil the commitments of the European Union, its Member States and Iceland under Article 3 of the Kyoto Protocol in the second commitment period 2013-2020 was determined by an agreement under Article 4 of the Kyoto Protocol. This agreement was submitted to the UNFCCC secretariat in June 2016 as part of Denmark's Initial Report submitted in accordance with Decision 2/CMP.8 to facilitate the calculation of the assigned amount pursuant to Article 3, paragraphs 7bis, 8 and 8bis (cf. Decision 1/CMP.81) and Article 4, of the Kyoto Protocol for the second commitment period. As the target for the second commitment period under the Kyoto Protocol was ratified with territorial exclusion to Greenland in accordance with an agreement with the government of Greenland, the assigned amount for Denmark excludes Greenland and is solely based on the agreement between the European Union, its Member States and Iceland and the application of Article 3, paragraph 7bis of the Kyoto Protocol.

The respective emission level allocated to Denmark is set out in the agreement between the EU, its 28 Member States at the time of the agreement and Iceland. The emission level allocated to Denmark is related to the EU's total reduction commitment through the EU Effort Sharing Decision (ESD) as part of the 2020 EU Climate and Energy Package adopted in 2009. With the ESD, Denmark has undertaken a legal commitment to reduce total emissions of greenhouse gases not covered by the EU Emission Trading Scheme by 20 per cent in 2020, compared to the level of these emissions in 2005. Furthermore, in the period 2013-2019 these emissions also have to stay below a fixed annual amount of so-called Annual Emission Allocation (AEA). These annual targets have become progressively stricter up to the end-target in 2020. However, overachievement in one year could be carried forward and used for target achievement in the subsequent years.

The sum of the respective annual emission levels 2013-2020 allocated to Denmark under the ESD (269,321,526 units) and the application of Article 3, paragraph 7bis of the Kyoto Protocol (56,364 units) is equal to Denmark's share of the total assigned amount for EU27, United Kingdom and Iceland. In accordance with the review report from the review of Denmark's Initial Report submitted in accordance with Decision 2/CMP.8 to facilitate the calculation of the assigned amount[7], 269,377,890 assigned amount units (AAUs) were issued by Denmark for the second commitment period under the Kyoto Protocol in 2021 as the second commitment period of the Kyoto Protocol entered into force on 31 December 2020.

Denmark's assigned amount is shown in Table 3.7 together with the base year information and the calculated minimum holding of 242,440,102 tonnes CO_2 equivalents in the National Registry – the so-called commitment period reserve (CPR).

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[7]https://unfccc.int/documents/9933#beg

TABLE 3.7 DENMARK'S BASE YEAR EMISSIONS, ASSIGNED AMOUNT AND COMMITMENT PERIOD RESERVE FOR THE SECOND COMMITMENT PERIOD UNDER THE KYOTO PROTOCOL

Source: The UNFCCC's report of the review of Denmark's initial report to be submitted in accordance with Decision 2/CMP.8 to facilitate the calculation of the assigned amount, 2017.

Tonnes CO_2 equivalents	Denmark under the EU
CO_2 (1990)*	54,785,159
CH_4 (1990)*	7,864,426
N_2O (1990)*	7,799,032
HFCs (1995)	241,456
PFCs (1995)	634
SF_6 (1995)	102,398
Base year	**70,793,103**
Land-use change: Deforestation in 1990 (Article 3.7bis as contained in the Doha amendment to the Kyoto Protocol)	8,807
Application of Article 3.7bis (80% of emissions from deforestation in 1990 times 8)	56,364
Total Assigned Amount 2013-2020	**269,377,890**
Commitment Period Reserve (CPR)	**242,440,102**

* including indirect CO_2 emissions and excluding LULUCF

The developments in Danish emissions and removals of greenhouse gases in the EU territory (i.e. excluding Greenland and Faroe Islands) from 1990 to 2020 (the most recent inventory year), as they are to be inventoried under the Kyoto Protocol, are shown in Table 3.8.

TABLE 3.8 DENMARK'S TOTAL EMISSIONS AND REMOVALS OF GREENHOUSE GASES, 1990 – 2020, INCLUDING IN THE SECOND COMMITMENT PERIOD 2013-2020 UNDER THE KYOTO PROTOCOL

Source: Nielsen et al., 2022a (1990-2020).

GREENHOUSE GAS EMISSIONS	Base year(CC)	1990	1995	2000	2005	2008	2009	2010	2011	2012	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**Change from base to latest reported year**
	CO_2 equivalent (kt)																		**%**
CO_2 emissions without LULUCF	53585	53585	61614	54306	51535	51256	48851	49204	44248	39871	41773	37578	35228	37033	34780	34725	30955	28282	-47.2
CO_2 emissions with LULUCF	60125	60125	66695	59141	56356	55088	51966	51389	45883	41066	42606	39122	35741	38639	36321	38180	33566	31103	-48.3
CH_4 emissions without LULUCF	7906	7906	8314	8182	7969	7713	7578	7642	7476	7368	7278	7237	7164	7226	7224	7268	7101	7117	-10.0
CH_4 emissions with LULUCF	8169	8169	8567	8425	8202	7942	7806	7870	7800	7597	7506	7464	7394	7459	7460	7504	7339	7356	-10.0
N_2O emissions without LULUCF	8468	8468	7676	7291	5899	5936	5710	5598	5607	5509	5508	5629	5648	5763	5837	5580	5772	5729	-32.3
N_2O emissions with LULUCF	8539	8539	7743	7349	5947	5981	5754	5642	5650	5552	5552	5673	5697	5811	5881	5627	5817	5777	-32.3
HFCs	NO,NA	NO,NA	258	766	909	964	989	837	757	756	689	625	467	523	424	495	336	335	100.0
PFCs	NO,NA	NO,NA	1	23	19	18	20	10	8	3	4	3	0	0	1	0	1	0	100.0
Unspecified mix of HFCs and PFCs	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	0.0
SF_6	42	42	104	57	21	30	35	37	77	129	150	154	121	104	75	73	71	46	7.4
NF_3	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	0.0
Total (without LULUCF)	70002	70002	77967	70625	66351	65918	63183	63328	58174	53637	55402	51225	48628	50650	48343	48141	44237	41509	-40.7
Total (with LULUCF)	76875	76875	83368	75760	71453	70024	66570	65786	60176	55105	56506	53041	49420	52537	50163	51879	47130	44616	-42.0
Total (without LULUCF, with indirect)	71122	71122	79024	71463	67034	66488	63689	63817	58595	54018	55759	51552	48941	50951	48638	48422	44504	41746	-41.3
Total (with LULUCF, with indirect)	77995	77995	84425	76598	72136	70593	67076	66275	60597	55486	56863	53368	49733	52837	50458	52160	47397	44853	-42.5

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Base year(1)	1990	1995	2000	2005	2008	2009	2010	2011	2012	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**Change from base to latest reported year**
	CO_2 equivalent (kt)																		**%**
. Energy	52425	52425	60620	53589	50818	50657	48632	49155	43868	39341	41157	36880	34571	36189	33810	33766	30052	27106	-48.3
2. Industrial processes and product use	2343	2343	2899	3698	2770	2555	2131	1913	2056	2092	2055	2010	1835	2044	2028	2048	1842	1925	-17.8
3. Agriculture	13338	13338	12719	11871	11443	11360	11168	11069	11060	11065	11062	11205	11092	11265	11339	11154	11183	11268	-15.5
4. Land use, land-use change and forestry	6874	6874	5401	5135	5102	4106	3386	2458	2002	1468	1105	1816	792	1886	1820	3738	2893	3107	-54.8
5. Waste	1896	1896	1729	1467	1319	1346	1252	1191	1191	1139	1128	1130	1130	1152	1166	1173	1160	1210	-36.2
6. Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.0
Total (including LULUCF)	76875	76875	83368	75760	71453	70024	66570	65786	60176	55105	56506	53041	49420	52537	50163	51879	47130	44616	-42.0

However, it is only Denmark's total emission of greenhouse gases not covered by the EU Emission Trading Scheme (non-ETS) for the whole period 2013-2020, which should be compared with Denmark's total assigned amount or total holdings of KP units valid for the second commitment period.

In Table 3.9, Denmark's total non-ETS emission for the period 2013-2020 is shown together with Denmark's assigned amount, holdings of other KP units and the net-issuance of Removal Units (RMUs). With an excess of approximately 5.8 million AAUs, it is expected that also the final compliance assessment after the so-called "true-up" period will show, that Denmark is in compliance with the reduction target under the Kyoto Protocol's second commitment period.

TABLE 3.9 DENMARK'S TOTAL EMISSION OF GREENHOUSE GASES NOT COVERED BY THE EU EMISSION TRADING SCHEME (NON-ETS) FOR THE WHOLE PERIOD 2013-2020, DENMARK'S ASSIGNED AMOUNT UNDER THE SECOND COMMITMENT PERIOD OF THE KYOTO PROTOCOL AND THE EXPECTED COMPLIANCE DUE TO THE EXPECTED EXCESS OF AAUS

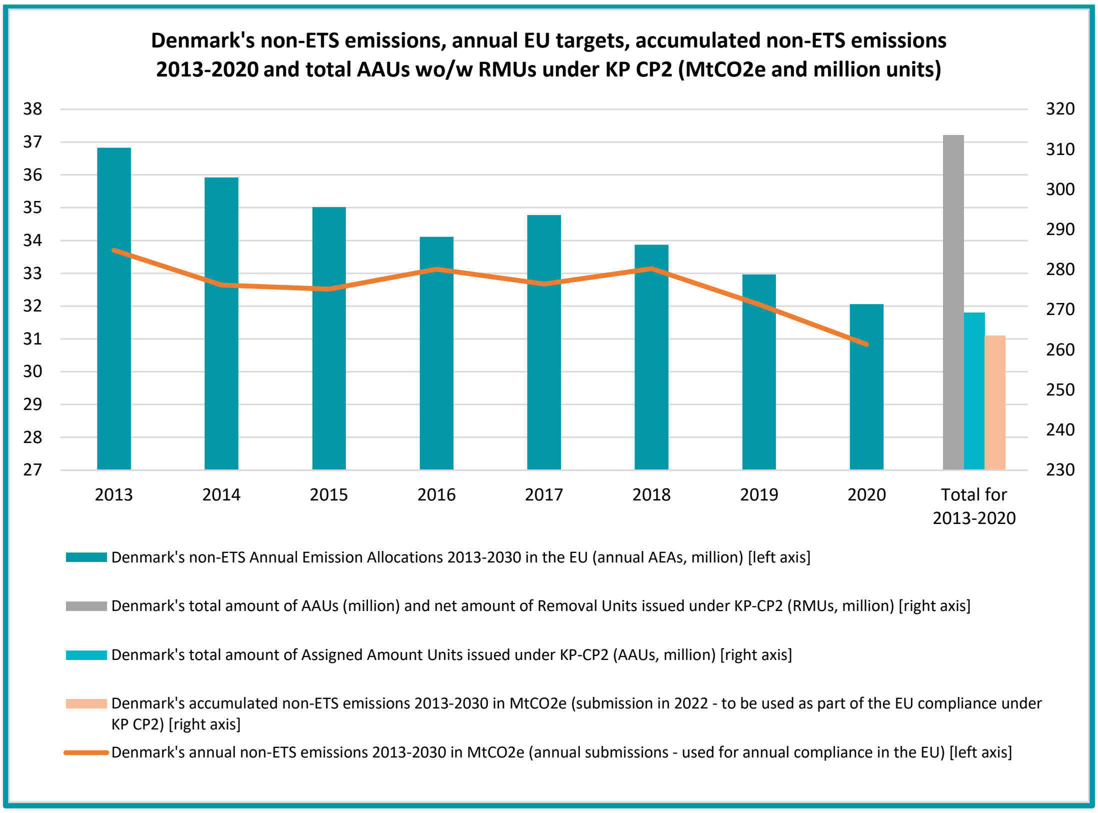
Sources: Nielsen et al., 2022a, the Ministry of Climate, Energy and Utilities and the initial review report in relation to the report submitted in accordance with Decision 2/CMP.8 to facilitate the calculation of the assigned amount and

Tonnes CO_2 equivalents or number of units (one unit equals one tonne)	**Denmark under the EU**	**Unit**
Denmark's total emission of greenhouse gases not covered by the EU Emission Trading Scheme (non-ETS) for the whole period 2013-2020	**263,530,288**	Tonnes of CO_2 equivalents
Holdings of Assigned Amount Units (AAUs) issued for 2013-2020	**269,377,890**	No. of units
Excess of AAUs	**5,847,602**	No. of units
Holdings of ERUs (in Party holding accounts)	0	No. of units
Holdings of CERs (in Party holding accounts)	0	No. of units
Net-issuance of RMUs (RMUs issued minus net-source cancelled RMUs)	44,255,992	No. of units

Both the annual compliance in the EU and the accumulated compliance under the Kyoto Protocol's second commitment period is illustrated in Figure 3.20.

The estimated overachievement for the period 2013-2020 under the Kyoto Protocol (5.8 million AAUs) defers from the overachievement within the EU in the same period (14.9 million AEAs) because of an EU internal adjustment of Annual Emission Allocations (AEAs) in 2017 under the EU Effort Sharing Decision to take into account the effect of the shift from using IPCC 1996 Revised Guidelines to using IPCC 2006 Guidelines, which gave Denmark additional AEAs. This EU internal change did not change the EU joint commitment under 2nd commitment period of the Kyoto Protocol and the amount of Assigned Amount Units (AAUs) to be issued by Denmark under the protocol. In addition, and in accordance with the rules adopted for the 2nd commitment period of the Kyoto Protocol, a net amount of 44.3 million RMUs have been issued from the LULUCF activities in Denmark 2013-2020. This is also illustrated in Figure 3.20 as total issuance of units (AAUs plus net-RMUs) under the 2nd commitment period of the Kyoto Protocol.

FIGURE 3.20 GREENHOUSE GAS EMISSIONS IN DENMARK'S NON-ETS SECTORS 2013-2020, ANNUALLY AND ACCUMULATED, DENMARK'S TARGET PATH IN THE EU AND THE TOTAL AMOUNT OF AAUS UNDER 2ND COMMITMENT PERIOD OF THE KYOTO PROTOCOL.



Note that both the left and right y axis does not begin at 0.

References:

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4

POLICIES AND MEASURES

- INCLUDING THOSE IN ACCORDANCE WITH ARTICLE 2 OF THE KYOTO PROTOCOL, AND DOMESTIC AND REGIONAL PROGRAMMES AND/OR LEGISLATIVE ARRANGEMENTS AND ENFORCEMENT AND ADMINISTRATIVE PROCEDURES

Contents

4 Policies and measures

- including those in accordance with Article 2 of the Kyoto Protocol, and domestic and regional programmes and/or legislative arrangements and enforcement and administrative procedures

4.1 Climate policy and the policy-making process

Since the Brundtland Commission's report, “Our Common Future”, from 1987, Denmark's climate policy has developed in collaboration with the different sectors of society, and in line with international climate policy, and results from related scientific research.

Thus, since the end of the 1980s a considerable number of measures to reduce emissions of greenhouse gases have been implemented.

Some of the measures have been implemented with reduction of greenhouse gas emissions as the main objective, others were aimed at achieving environmental improvements for society in general, e.g. by introducing environmental taxes and involving the public in the debate and decisions concerning the environment.

Since 2001, focus has also been on efforts to reduce emissions and meet the near-term international greenhouse gas emission reduction targets – i.e. for 2008-2012 under the first commitment period of the Kyoto Protocol and the EU Burden Sharing, for 2013-2020 under the second commitment period of the Kyoto Protocol and the EU Effort Sharing Decision and for 2021-2030 under the Paris Agreement and the EU burden sharing of the EU National Determined Contribution through the EU Effort Sharing Regulation – with view to meet the long-term EU target: a climate-neutral society by 2050.

Denmark’s international climate targets are described in Box 4.1.

BOX 4.1 INTERNATIONAL CLIMATE TARGETS

Since 1990 Denmark has undertaken or committed itself to several targets with respect to reducing greenhouse gas emissions:

- In accordance with the Climate Convention, to reduce total emissions of greenhouse gases in Denmark, Greenland and the Faroe Islands to the 1990 level by 2000. This target was achieved for total emissions excluding the land-use sector (LULUCF). Due to windfalls total emissions including LULUCF brought the Realm to within 1% of the target.
- As a contribution to stabilisation in the EU, Denmark committed itself to reducing CO_2 emissions in 2000 by 5% compared to the adjusted level for 1990. This target was fulfilled.
- In relation to the Kyoto Protocol, for the period 2008-2012 the EU committed itself to reducing emissions of greenhouse gases on average to 8% below the level in the base year; 1990 for CO_2, methane, and nitrous oxide and either 1990 or 1995 for industrial greenhouse gases. Denmark committed itself to a reduction of 21% as an element of the burden-sharing agreement within the EU. Both Denmark and the EU reached these targets for 2008-2012.
- In relation to the period 2013-2020, the EU reached an agreement in December 2008 on a climate and energy package and on a regulation on CO_2 from new vehicles. According to this package the EU was committed to reduce its overall emissions to at least 20% below 1990 levels by 2020. Under the EU burden sharing of the joint EU target for 2020, Denmark was committed to a reduction in non-ETS emissions in the period 2013-2020, rising to 20% by 2020 relative to 2005. The EU was also committed to reduce its ETS emissions to 21% below 2005 levels by 2020. The EU had also set itself a target of increasing the share of renewables in energy use to 20% by 2020. Under burden sharing of this EU target, Denmark was committed to reach a 30% share of renewables in energy use by 2020. Both Denmark and the EU reached these targets for 2013-2020.
- In relation to the period 2021-2030, the European Council agreed on the first 2030 climate and energy framework in October 2014. The first agreement on the 2030 framework, specifically the EU domestic greenhouse gas reduction target of at least 40%, formed the basis of the EU's contribution to the Paris Agreement. The EU's first so-called Intended Nationally Determined Contribution (INDC) was formally approved at an Environment Council meeting in March 2015. In May 2018 the EU member states reached the first agreement on the effort sharing for the period 2021-2030, where Denmark committed itself to a reduction in non-ETS emissions in the period 2021-2030 of 39% by 2030 relative to 2005. However, in June 2022, and as an implementation of the updated NDC submitted by the EU in December 2020 with a more ambitious EU domestic greenhouse gas reduction target of at least 55% by 2030 relative to 1990, Denmark committed itself to a reduction in non-ETS emissions in the period 2021-2030 of 50% by 2030 relative to 2005. The necessary EU legislation for this so-called "Fit for 55"-package is under implementation. According to this package, the EU is also committed to reducing its ETS emissions to achieve the 55% below 1990 levels by 2030 in total greenhouse gas emissions. The EU has also set itself the target of increasing the share of renewables in energy use to 40% by 2030. Denmark will allocate funds that sets a course towards a Renewable Energy share of approximately 55% in energy use by 2030.

The following sections contain more information about Denmark's climate relevant action plans until now and the climate policy framework until 2030.

This section is followed by sector by sector descriptions of Denmark's climate policies and measures.

4.1.1 National action plans

In 1988 the government issued the Government's Action Plan for Environment and Development. The plan was a follow-up on the Brundtland Report and was based in principle on striving for environmentally sustainable development. One of the main messages in the plan was the need to integrate environmental considerations into decisions and administration within such sectors as transport, agriculture and energy.

In the years since then, a number of ministries have prepared sector action plans in which the environment is an integral element. The sector action plans deal with the entire development in a sector combined with solutions to environmental problems caused by the sector. The sector plans for energy, transport, forestry, agriculture, the aquatic environment, waste, and development assistance are important examples.

The plans from the 1990s all contained specific environmental objectives and, usually, deadlines for achieving them. In addition, there were a number of concrete initiatives that are intended to lead to achievement of the objectives. Progress has been evaluated regularly to check whether the implementation of the plans resulted in achievement of the objectives. The results of the evaluations have been presented in political reports from the sector ministries or in special follow-up reports.

The evaluations and follow-up have often given rise to the preparation of new action plans, either because additional initiatives have been necessary in order to achieve the objectives or because the development of society or developments within the area in question have made it necessary to change both objectives and initiatives. Major sector plans, strategies and agreements that have been of importance for the reduction of greenhouse gas emissions are:

- The NPO Action Plan on pollution from livestock manure (1985)
- Action Plan for the Aquatic Environment I (1987)
- Energy 2000 (1990)
- Action plan for sustainable development in the agricultural sector (1991)
- Strategy for sustainable forest management (1994)
- Strategy 2000 - Danish strategy in the development assistance area (1995)
- Energy 21 (1996)
- Action plan for reduction of the transport sector's CO_2 emissions (1996)
- National sub-strategy for Danish environmental and energy research (1996)
- Action Plan for the Aquatic Environment II (1998)
- Action Plan II - Ecology in Development (1999)
- Waste 21 (1999)
- Action plan for reduction of industrial greenhouse gas emissions (2000)
- Reduction of the transport sector's CO_2 emissions - possibilities, policies and measures (2000)
- Reduction of the transport sector's CO_2 emissions - the government's action plan (2001)
- Denmark's national forest programme (2002)
- Denmark's National Strategy for Sustainable Development (2002)
- National Climate Strategy for Denmark (2003)
- Waste Strategy 2005-2008 (2003)
- Action Plan for the Aquatic Environment III (2004)
- 1st National Allocation Plan 2005-2007 under the EU-ETS (2004)
- Energy Strategy 2025 (2005)
- Action Plan for Strengthened Energy-saving Efforts (2005)
- 2nd National Allocation Plan 2008-2012 under the EU-ETS (2007)
- Political agreement on Energy (2008)
- Political agreement on a Green Transport Vision for Denmark (2009)
- Political agreement on a Tax Reform (2009)
- Growth with Consideration – the government’s strategy for sustainable development (2009)
- Strategy for reducing energy consumption in buildings (2009)
- Political agreement on a Green Growth Plan (2009)
- Waste Strategy 2009-2012 – Part I (2009)
- Waste Strategy 2009-2012 – Part II (2010)
- Energy Strategy 2050 (2011)
- Our Future Energy (2011)
- Political Agreement on Energy (2012)
- The Danish Climate Policy Plan – Towards a low carbon society (2013)

- The Agricultural Package (2016)
- The Energy Agreement (2018)
- Denmark's national forest programme (2018)
- The Climate and Air proposal "Together for a greener future" (2018)
- The political understanding "A fair direction for Denmark" (2019)
- Political agreement on a new Climate Act (2019)
- The Government's Climate Plan (May, 2020),
- Political Climate Agreement on Energy and Industy etc. 2020 (June, 2020)
- The Climate Plan for a Green Waste Sector and Circular Economy (June, 2020)
- The Danish Climate Act (June, 2020)
- The Government's Climate Programme 2020 and long-term strategy (Sep.2020)
- The Government's Climate Strategy (December, 2020)
- The Government's Climate Programme 2021 (September, 2021)
- Political agreement on a Green Transition of The Agricultural Sector (October, 2021)
- Political agreement on a Green Tax Reform (June, 2022)
- Political agreement on a new Green Fund in support of the green transition and the phasing out of fossil fuels (June, 2022)
- Political agreement on Expansion of Renewable Energy in electricity and heat supply and demand (June, 2022)
- The Government's Climate Programme 2022 (September, 2022)
- The Government Platform (December, 2022)

The sector plans deal with different aspects of the climate problem. In the energy and transport sectors, the main environmental concern has been the emissions of the greenhouse gas CO_2. The plans in these sectors were therefore to a great extent concerned with reducing CO_2.

The frameworks for the Danish energy sector is to create well-functioning energy markets within frameworks that address climate and environmental concerns and secure cost-effectiveness, security of supply, and efficient use of energy under conditions of a fully liberalised energy sector. Electricity production from Danish power plants is controlled by market forces and traded freely across national borders.

The introduction of CO_2 quota regulation as a common EU instrument has therefore been of absolute importance to Denmark meeting its climate commitments. From 2005, quota regulation through the EU emissions trading scheme (EU ETS) has been the key instrument to ensuring that the Danish energy sector can contribute to the reductions requisite to fulfilling Denmark's climate commitments.

In a historic perspective, several sector plans were not primarily focused on reducing greenhouse gas emissions, in part because the sectors are battling with other major environmental problems. For example, the main concern in the agricultural sector in the 1990s was the pollution of the aquatic environment. In the waste sector focus has been on reducing the volume of waste, and in the industrial sector, reduction of emissions/discharges of harmful substances to the atmosphere/aquatic environment, the use of toxic substances, etc. has been at the center of sectorial efforts in the past.

However, the implementation of most of the sector plans has also resulted in reduction of greenhouse gas emissions. For example, the reduction in nitrogen emissions from the agricultural sector, which is the result of the aquatic environment plans, is at the same time reducing emissions of the greenhouse gas nitrous oxide. The initiatives to reduce waste quantities mean fewer landfill sites and thus less formation and emissions of methane, and the on-going increase in forested area will mean increased removals of CO_2.

In addition, the energy and transport plans meant that changes were made in the energy and transport sectors. The initiatives in the energy sector have resulted in reduced energy consumption despite significant economic growth and, with that, reduced CO_2 emissions.

On the environment policy front, Denmark has participated actively in improving environmental protection in Europe through the EU cooperation and through bilateral environmental assistance to Central and Eastern European countries. On a number of points, the EU's environmental regulation has put Europe ahead of the rest of world environmentally. There are also many examples of EU rules having helped to strengthen environmental protection in Denmark. With the adoption of the Amsterdam Treaty, sustainable development became a main objective for the EU, and integrating environmental considerations in the EU's sector policies became an obligation.

4.1.2 Denmark's climate policy

In 2020, the Danish parliament adopted the Danish Climate Act. With the adoption of the Danish Climate Act, an ambitious direction was set for Danish climate policy and Denmark's climate diplomatic role in the world. Central in the Danish Climate Act are the goals of reducing Danish greenhouse gas emissions by 70 per cent in 2030 compared to the 1990 level, and reaching climate neutrality by 2050 at the latest. The Danish government pursue to advance the climate neutrality target to 2045, and set a target of 110 per cent reduction in 2050 compared to 1990 level.

After the adoption of the Climate Act, more than 75 green agreements have been concluded and over DKK 110 billion has been prioritized to the major climate agreements. This include for example, agreements on a high and more harmonized CO_2e tax for industry etc., a significant expansion of Denmark's renewable energy production and a binding reduction target for the agriculture and forestry sector, which will all contribute significantly to achieving the 70 per cent target.

The green transition takes place taking into account the guiding principles of the Climate Act. One principle is that efforts should take into account that climate challenge is a global problem. Therefore, Denmark should be a pioneering country that can inspire and influence the rest of the world. In addition, Denmark's should achieve its climate targets as cost-effective as possible with a focus on both the long-term green transition, sustainable business development and Danish competitiveness, healthy public finances and employment in support of developing Danish business life. Denmark should also be able to demonstrate that a green transition is possible while maintaining a strong welfare society and ensuring cohesion and social balance.

The government platform *Responsibility for Denmark* from December 2022 emphasizes that it is central to keep pace and ensure a thorough implementation of all of the climate measures agreed on the political level (see Box 4.2). As the targets are met, the government is prepared to set new, ambitious targets.

It is particularly important for Denmark to get independent of fossil fuels as soon as possible, both in light of the need for climate action and in light of the current war in Ukraine. The importance is reinforced by the geopolitical situation and the effect on the prices of electricity and gas in Denmark.

To support implementation at all levels, the government has set up a national energy crisis team (NEKST). NEKST's task is to identify solutions to green challenges, so that the pace can be set to get the green political agreements implemented. NEKST will, among other things, ensure national coordination of the roll-out of green heat, which aims to reduce the consumption of gas as quickly as possible and replace it with green solutions. In addition, NEKST also works to identify barriers to the agreed ambitions for scaling up solar and wind on land and recommend any measures to the government that can accelerate the expansion. NEKST acts operationally and can initiate solutions to the acute green challenges that can be solved immediately. This means that action can be taken quickly – also during NEKST's work. The government's committee for green transition follows the work of NEKST, and can continually ask NEKST new green tasks.

In addition to the significant efforts to counteract climate change, it is also necessary to secure Denmark better against more frequent floods and extreme weather events, already to be expected, unfortunately. The Danish government will therefore also draw up a national climate adaptation plan, which supports that efforts are launched in a timely manner and ensures that efforts are organized as best as possible.

In June 2022, a majority of Parties in the Danish Parliament reached a Climate Agreement on green electricity and heat, which, among other things, aims to ensure framework conditions that can enable a quadrupling of the total electricity production from solar energy and onshore wind towards 2030. In the agreement the parties also agree to enable the tendering of at minimum further 4 gigawatts (GW) of offshore wind for realization by 2030 at the latest, on the condition that the offshore wind does not negatively burden the state's finances over the project period. It is the expectation that the electricity from the offshore wind farms, among other things, can be utilised by Power-to-X (PtX) facilities in Denmark. However, the full potential is far from exhausted. The significant expansion of renewable energy can contribute green power to both direct electricity consumption in Denmark, export to the rest of Europe and green power to the production of green fuels for e.g. planes, ships and heavy transport.

On 30 May 2023, the government (Socialdemokratiet - The Social Democratic Party, Venstre - The Liberal Party of Denmark and Moderaterne – the Moderates) together with Socialistisk Folkeparti - the The Green Left, Liberal Alliance - the Liberal Alliance, Det Konservative Folkeparti - the Conservative People's Party, Enhedslisten – the The Red-Green Alliance, Radikale Venstre - the Danish Social Liberal Party, Dansk Folkeparti - the Danish People's Party and Alternativet - the Alternative signed an additional agreement on tender frameworks for 6 GW of offshore wind and Energy Island Bornholm. While the previous agreements set high ambitions, this agreement establishes the concrete tender framework. The agreement can potentially secure green electricity for 14 million Danish and European households or more, and for the first time, there will be state co-ownership of the 6 GW classic offshore wind farms. For the first time, a number of new access requirements are also being introduced to participate in the tenders, which should help to raise the bar for sustainability and social responsibility compared to previous tenders. The agreement also contributes to the security of energy supply. The establishment of a marine nature fund will i.a. contribute to improving the knowledge about the environment and nature effects of renewable energy development on the sea and to a cost-effective restoration of marine nature and biodiversity with a view to improving the environmental state of the sea.

Box 4.2 Climate policy statements in the government platform, December 2022

"**4. Ambitious Climate Action**

The climate crisis is our generation's biggest challenge.

With this government platform, the government is setting the most ambitious climate targets for Denmark ever.

The world is heading for temperature increases that far exceed the target of the Paris Agreement, and we already feel that the climate is changing.

At the same time, we are in the middle of a nature and biodiversity crisis. Plant and animal species are dying out faster than ever, and the natural challenges are massive and global.

Despite significant efforts to counteract climate change, it is also necessary to further secure Denmark against floods and extreme weather. The government will therefore present a national climate adaptation plan, which supports that the necessary measures are implemented in a timely manner, as well as ensuring that the measures are organized as best as possible.

The government will make the necessary decisions that bring Denmark fully on target with the reduction target for 2025 and 2030. The 70 per cent target will, among other things, be achieved by realizing the agricultural and forestry sector's reduction target corresponding to that agreed in the agricultural agreement from 2021.

It is absolutely central for the government to keep up the pace and ensure a thorough implementation of the many initiatives that have been politically adopted, so that we reach our goal. As the targets are met, the government is prepared to set new, ambitious targets.

It is imperative for both Denmark and Europe to quickly get rid of fossil fuels for security policy reasons – also for the sake of the prices of electricity and heating in Danish households. It is the government's aim that as many households as possible move away from individual gas and oil boilers as quickly as possible, which will contribute to lowering the Danes' expenditure on energy in the coming winters.

In order to support implementation at all levels, the government will therefore set up a national energy crisis staff (NEKST) following the same model as the national operational staff (NOST).

NEKST will, with the involvement of relevant social actors, i.a.:

- Ensure national coordination of the rollout of district heating and other efforts aimed at reducing the consumption of natural gas as quickly as possible and replacing it with renewable energy.
- Identify barriers to the agreed ambitions for scaling up solar and wind on land as well as offshore wind and recommend to the government any measures that can accelerate the expansion.
- Support expansion of the electricity grid in places where there are already challenges with capacity today, and contribute to ensuring that the expansion is at the forefront of electricity consumption and the production of power from renewable energy.

4.1 On target with the 70 per cent target

Denmark must be a green pioneering country that sets and fulfills ambitious climate goals and climate efforts and in this way inspires other countries to follow suit. It is the coupling of action on the green transition and continued economic growth that will make other countries look to Denmark. We must show the world that it is possible to balance high climate ambitions, competitive business life and social cohesion.

The government will:

- Meet the reduction target for 2025 – and meet the reduction target for 2030.
- Ensure that the greenhouse gas reductions that have been agreed politically are realized in practice.
- If the conditions change, so that the climate projection in 2025 or later shows that the 70 per cent target is not achieved with agreed concrete measures, propose additional concrete measures which ensure that we reach the target.
- Work for ambitious and cost-effective climate and energy regulation in the EU, which can contribute to achieving the 70 per cent target and at the same time make Europe independent of Russian fossil energy.

4.2 New climate targets

With our companies, technologies and knowledge, Denmark has an opportunity and an obligation to promote green solutions in the EU and globally. The government will work for an ambitious 2040 climate target in the EU and continue the work of entering into green strategic partnerships with other countries. The government will continue the authority cooperation with countries around the world on sharing Danish experience from decades of work with green transition.

As we reach the 70 per cent target, it is natural to set new targets that can continuously ensure a high pace at the same time as we increase the focus on the implementation of already decided initiatives.

The government will move forward the goal of climate neutrality to 2045. And set a new goal of 110 per cent reduction in 2050 compared to 1990.

The government will propose an ambitious reduction target for 2035 and assess whether the reduction target in 2030 needs to be adjusted further.

The government wants to raise the ambitions for Denmark's footprint in the world by setting a target for Denmark's climate effect understood as the international climate effect that results from the Danish export of energy technology and services. A solid professional foundation for the goal must be created in cooperation with Danish businesses before it is dealt with politically.

The government will reduce the climate footprint of public procurement, including the procurement of transport and the construction of public buildings.

The government will examine the consequences of setting a target for the CO_2e footprint for Danish consumption.

4.3 Vision for future Danish food production

Denmark is one of the most intensively cultivated countries in the world. We produce enough food to feed more than twice the amount of people as we are. This is good for the world, and it helps create export income and jobs.

We must produce food products of high quality and in an innovative, sustainable and more climate-friendly way. Danish agriculture is already strong when it comes to green innovation. It is the government's ambition to continue to develop – not dismantle – the Danish food production.

In the coming years, agriculture and the food sector face an ambitious transformation in many areas. Emissions must be significantly reduced, we must better protect our drinking water, have more nature and forest and strengthen ecology as well as the plant-based production. The government notes that the sector itself has high ambitions for the green transition.

The government will present a proposal for a climate tax on agriculture when the Expert Group for a Green tax reform have presented their conclusions. The climate tax must ensure implementation of the development track and fulfillment of the binding reduction target for the agricultural and forestry sector of 55-65 per cent in 2030 compared to 1990. The government will ask the expert committee to present different scenarios to achieve this goal in line with the recommendations presented by the committee in connection with the CO_2e tax on industry. This includes consideration of prevention of the relocation of production, involvement of international experience and the possibility of imposing a CO_2e tax on final consumption as a possible means of action.

The tax must be designed in a way where the sector is supported, so that the sector's competitiveness is not impaired, and thus jobs are not moved out of the country as a whole. In this way, the implementation will be in line with what was agreed upon by a broad majority of the Danish parliament with the Climate Act from 2020: "The achievement of Denmark's climate targets must be done as cost effectively as possible, taking into account the long-term green transition, sustainable business development and Danish competitiveness, sound public finances and employment, and that Danish business must be developed and not dismantled."

The reductions must be realised with a focus on moving from development to implementation of the development tracks that have been initiated with the Agreement on Agriculture. Here a total potential for reductions of DKK 5 million tonnes of CO_2e in 2030 was pointed to from brown biorefining, manure and fertilizer management, feed additives, doubling of the ecological area and additional stop of cultivation of organic soils. This potential is on the top of the already agreed upon reductions of approximately 1.9 million tonnes of CO_2e, where the means of action have already been decided with the agreement from 2021. The government will focus on getting these measures implemented as soon as possible.

Thus, investments must be made in the green transition, the food production and its competitive abilities. Danish food production must set an example to be followed in the restructuring of other countries' agriculture, and therefore it must be ensured that production is not just moved out of the country. Hence, the proceeds from the tax must be brought back to agriculture, so that the industry's transformation is supported. The government also wants to use part of the Green Fund on further investments in technology for the green transformation of the agricultural sector.

If we are to succeed in restructuring and developing Danish agriculture, we need to see all the efforts and challenges in conjunction.

The government will therefore set up a partnership with the agricultural sector, the food sector, nature organisations, consumer organisations, and municipalities, which will present a proposal for a comprehensive vision plan for Danish agriculture.

The partnership should present its recommendations at the end of 2023, so that a comprehensive plan of vision for Danish agriculture can be drafted in the first half of 2024. An overall plan of vision must also address all targets for land use in Denmark, including for agriculture, nature, development of renewable energy, etc.

In addition to the need for agreements on new initiatives for the food sector, the government will have focus on the implementation of the Agreement on Agriculture. This includes the stop of cultivation of organic soils, which is not happening fast enough."

"4.5 More Danish forest

The government will present an ambitious forest plan with a goal of establishing 250,000 hectares of new forest in Denmark. Establishment of new forest contributes significantly to achieve climate neutrality and, in the long term, net negative emissions.

The forest plan must ensure the greatest possible synergy and balance between the many purposes with new forest, identify key operators and already existing funds as well as considering different means of action.

This will be done in parallel with the drafting of the Plan of Vision, where, among other things, the focus will be on initiating private afforestation. The Forest Plan and afforestation is financed by the Green Fund, while the aim is to have a contribution as large as possible from private operators and existing grants.

4.6 Increase the expansion of renewable energy and transition away from fossil heating

We must get rid of Russian gas faster and turbocharge the green transition with more renewable energy. The North Sea and the Baltic Sea must be green powerhouses that supply green power to the rest of Europe. Unnecessary bureaucracy and an inappropriate division of tasks must not stand in the way of rapid and efficient expansion of renewable energy.

The government will:

- Shorten the processing time for the establishment of renewable energy so that it is not put on hold due to bureaucracy. In this context, the government will look at whether more flexible models can be established for the development of offshore wind while at the same time ensuring that society receives a fair share of the income from energy extraction on land and at sea - possibly in the form of an updated concession model. The government will also promote cooperation in the North Sea and Baltic Sea regions for a faster and coordinated expansion with the necessary infrastructure to promote the green transition and offshore wind.

- Initiate an analysis of whether the current division of tasks between state authorities, regions and municipalities can be made more efficient, with a view to ensuring a high pace in the development of renewable energy on land. Here, the government will work to ensure that the state will play an active role in the planning of energy parks as a supplement to the municipal planning of renewable energy projects. The development of the energy parks must be market-driven and handled by private actors.

- The government perceives the future energy system as critical infrastructure. When developing renewable energy and the Danish electricity grid, demands must therefore be made for the safest and most sustainable solutions on the market. Increased sustainability must be ensured in the tenders while observing the principles in the EU's taxonomy for environmental sustainability and the Danish climate objectives, as well as tools such as ESG and life cycle assessments. A particular challenge will be to create safe, stable and sustainable supply chains for the entire green transition from Europe and like-minded countries. The government will therefore engage wholeheartedly in the development of a new European industrial policy with this aim in mind.

- Increase the decoupling pool financed by the Green Fund, so that towards 2030 there are funds to promote Danes' decoupling from the gas grid by lifting the expenditure of approx. DKK 8,000, which the state gas distribution company Evida charges when disconnecting from the grid.

- Ensure a strong focus on energy efficiency in both private homes, businesses and public buildings.

- Initiate an expansion plan for the electricity grid and identify measures to support timely and effective investments in the electricity grid. The government will examine whether there is a need for further measures to utilize the electricity grid more efficiently, including, among other things, via a more flexible electricity consumption. This work is based on the efforts of NEKST and may result in changed grid regulation.

- Establish the partnership 'Together on climate', which will support accelerated climate action across the state, municipalities and regions, civil society and business with an emphasis on citizens.

- Increase the production of biogas so that Denmark can more quickly displace Russian natural gas. Including advancing the agreed tenders as far as possible.

4.7 A greener transport

The government wants to accelerate the development of green transport in Denmark towards 2030.

The government will:

- Look at the effects of the agreement on the green transformation of road transport with a view to making it more efficient in light of technological developments. Here, the possibilities for increasing the ambitions for the number of purely electric cars will be examined.

- Put further action behind the promotion of zero-emission trucks based on the pool for fuel infrastructure for heavy road transport from the Infrastructure Agreement in 2021. It must, for example, promote con-version of fleets and setting up charging stations.

- Introduce a passenger tax on air travel of an average of DKK 100. The generated revenue is used, among other things, on the airports and the surrounding areas, financing of the green domestic route and an increased check for the elderly.

- Make it possible to establish a green domestic route in 2025 and, by 2030 at the latest, fully green domestic flights financed by the passenger tax, as well as increasing the pace of the transformation of heavy transport as well as shipping and aviation, among other things by promoting electrification and green fuels."

4.9 The global climate effort

The government will work to ensure that the EU continues to be at the forefront of international climate agreements. Both when it comes to limiting the global climate footprint of the big emitters and rich countries - also outside their own borders - and about supporting the most vulnerable countries that suffer the greatest losses and damage as a result of global warming.

The government will present a plan for how Denmark can live up to its share of the total obligations in the global climate agreements, especially from COP15 and COP27, regarding financing for the world's poorest countries. It must be investigated how risk-averse public funds can be used as a means of leveraging more private funds.

4.1.2.1 The Danish Climate Act

The Government and Venstre (Liberal Party of Denmark, Dansk Folkeparti (Danish People's Party), Radikale Venstre (the Danish Social-Liberal Party) Socialistisk Folkeparti (Socialist People's Party), Det Konservative Folkeparti (Conservative People's Party) and Alternativet (the Alternative) concluded the Agreement on a Climate Act of 6 December 2019. The agreement is implemented in the Climate Act adopted by the Danish Parliament on 26 June 2020. The Climate Act sets a target of reducing greenhouse gas emissions in Denmark by 70% by 2030 compared to a 1990 baseline. At the same time, the Climate Act sets a long-term target for Denmark to be a climate-neutral society by 2050 at the latest.

The Climate Act targets and guiding principles

The Climate Act mandates the setting of a new national climate target every five years, with a 10-year perspective. This means that a new climate target for 2035 must be set in 2025. At the same time, the Climate Act stipulates that a new climate target must be no less ambitious than the most recently set target. This is in alignment with the “no backsliding” principle of the Paris Agreement. The Agreement on a Climate Act also sets out that in connection with the 2020 climate action plan, the Government must propose an indicative target for 2025. In May 2021, a majority of the parties in the Danish parliament agreed on an indicative target for 2025 of 50-54% reduction compared to the 1990 level, which was formally included in the Climate Act in December 2021.

The green transition of society entails multiple dilemmas and considerations that must be evaluated and prioritised. The parties to the agreement behind the Climate Act agree that the climate effort must adhere to a number of guiding principles, see box 4.3.

The Government’s climate policy efforts are based on the framework and requirements defined by the Climate Act. In other words the work – as described in this climate programme – represents an ambitious strategy for achieving the reduction targets in the Climate Act with due consideration of the principles that are also part of the act.

BOX 4.3 GUIDING PRINCIPLES FOR THE CLIMATE EFFORT, CF. THE POLITICAL AGREEMENT OF 6 DECEMBER 2019 ON A NEW DANISH CLIMATE ACT

The climate effort must adhere to a number of guiding principles:

1) The climate challenge is a global problem. Therefore, Denmark must be a leading nation in the international climate effort, a nation that can inspire and influence the rest of the world. Furthermore, Denmark has both a historical and a moral responsibility to take the lead.
2) The realisation of Denmark’s climate targets must be as cost effective as possible, taking into account the long-term green transition, sustainable business development and Danish competitiveness, sound public finances and employment, and that Danish business must be developed rather than diminished.
3) Denmark must show that a green transition is possible while maintaining a strong welfare society, where cohesion and social balance are secured.
4) The initiatives to be taken to reduce greenhouse gas emissions must result in real domestic reductions, but it must also be ensured that Danish measures do not simply relocate all of the greenhouse gas emissions out-side of Denmark’s borders.

Climate action plans at least once every five years

The Climate Act requires the Government to present a climate action plan with a ten-year perspective, at least once every five years, and, as a minimum, in connection with setting the climate targets.

The first *2020 Climate action plan* was published by the former government in December 2020.

The global dimension of the Climate Act

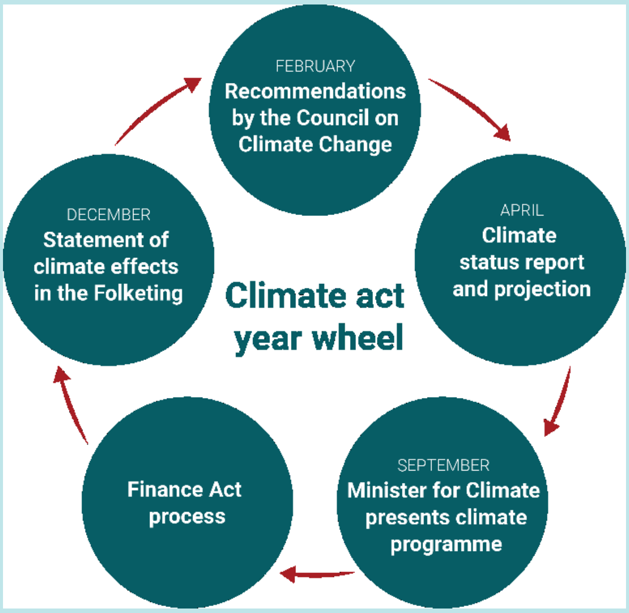
Denmark has an ambition to be a nation that inspire and influence the rest of the world. Accordingly, the Climate Act has an international perspective as well. The act stipulates that Denmark must work actively for realisation of the Paris Agreement target of limiting the global rise in temperature to 1.5 degrees Celsius. The act also requires annual status reporting in the climate programme of Denmark's international obligations and presentation of a global climate strategy and that the annual climate status and projection must contain a separate global report on the international effects of the Danish climate effort.

This includes information about reductions in international shipping and aviation and reductions from export of electricity from renewable sources, and efforts are also made to illustrate the effects of Danish import and consumption. In addition, information the Danish climate finance for developing countries must be included. The purpose of the reporting is to make Denmark's global impact on the climate visible. This will include adverse and positive impacts alike, such as from consumption and specific bilateral country partnerships, respectively, where Denmark helps the countries' energy sectors, etc., in the transition process.

The annual cycle under the Danish Climate Act (the «year wheel»)

The Climate Act gives Denmark a fixed annual cycle for Danish climate policy that obliges the incumbent Government at any time to work to meet the Climate Act targets. The elements in the annual cycle are illustrated and explored in box 4.4. According to the annual cycle, the Danish Council on Climate Change must advise the Government on the climate action.

BOX 4.4 THE ANNUAL CYCLE UNDER THE DANISH CLIMATE ACT



Annual recommendations from the Danish Council on Climate Change
The Council on Climate Change will advise the Government on climate efforts. The Climate Act strengthens this role by requiring the Council to annually assess the Government's climate efforts and make recommendations on the action going forward. In each year's climate programme, the Minister for Climate, Energy and Utilities must report on these recommendations and state the Minister's position on the recommendations. The Council on Climate Change must also assess whether the Government's climate efforts make it probable that the climate targets will be reached.

Climate status and projection
The Minister for Climate, Energy and Utilities presents each year a projection of the Danish greenhouse gas emissions. The climate status and projection provide an overall report on the expected emissions after incorporating the measures decided in the past year and any new knowledge in the form of technological developments, framework conditions or new knowledge of the impact of activities on greenhouse gas emissions. The annual climate status and projection will include a separate global reporting on the international effects of the Danish climate effort.

Climate programme
The Climate Act requires the Minister for Climate, Energy and Utilities to annually present a climate programme to the Danish Parliament, see below on the annual climate programme.

Finance Act process
The climate programme will be presented to the Danish Parliament in September to enable it to be taken into consideration during Finance Act deliberations.

Report to the Danish Parliament
After the annual Finance Act agreement, the Minister for Climate, Energy and Utilities must present a report on the effects of the Government's climate policy and, in this connection, answer questions at an interpellation debate in the Danish Parliament. This enables the Parliament to annually assess whether the Government's initiatives are sufficient for the Parliament to assess that the obligation to act is fulfilled, see below on the annual climate programme.

Climate programme and duty to take action

The Climate Act requires the Minister for Climate, Energy and Utilities to prepare a climate programme for the Danish Parliament each year. In September 2020, the first - *Climate Programme 2020* - was published by the former government and was thus written before the Climate Act year wheel had turned a full year.

The act makes requirements on the content of the programme to support regular follow-up on the aggregate climate effort in the period until the next sub-target. For instance, the climate programme provides a status report on the fulfilment of Denmark's climate targets and commitments and presents the Government's planned climate initiatives. The climate programme also has a global chapter that sets out the Government's long-term strategy for global climate action with specific initiatives to be launched in the coming year. Box 4.5 illustrates the Climate Act requirements for the contents of the climate programme.

BOX 4.5 THE CLIMATE ACT'S REQUIREMENTS ON THE CONTENT OF THE CLIMATE PROGRAMME

The climate programme must include the following:

1) A status report on fulfilment of the national climate targets
2) The planned climate initiatives and measures, including short- and long-term effect and the projected future effect thereof
3) A report on The Council on Climate Change's recommendations and the position of the Minister for Climate, Energy and Utilities on these recommendations
4) A status report on research and development of new climate initiatives
5) A status report on developments in climate science, including the latest IPCC reports
6) A description and status report on fulfilment of international climate targets
7) A global climate strategy

In addition to these requirements of the climate programme, the Minister for Climate, Energy and Utilities must, in the climate programme, provide an assessment of whether it appears probable that the national climate targets will be reached cf. box 4.6.

BOX 4.6 THE CLIMATE ACT ON DUTY TO TAKE ACTION

The Act features the following elements:

- In the climate programme, the Minister for Climate, Energy and Utilities must provide her/his assessment of whether it appears probable that the national climate targets mentioned in Article 1 will be reached.
- If it cannot be deemed probable that the national climate targets will be reached, in the climate programme the Minister for Climate, Energy and Utilities must present new initiatives with a reduction effect in the shorter term and initiatives with a reduction effect in the longer term, which together chart a path toward fulfilment of the national climate targets.

4.1.2.2 Denmark's climate policy and the EU climate policy

Danish climate policy is based on two pillars – the European and the national.

The EU framework and climate target

The EU determins a large part of the framework conditions, in the form of e.g. objectives, requirements and quota trading system under which the Danish climate effort operates. Common climate regulation in the EU can be to the advantage of Denmark, as it creates more uniform conditions of competition and export opportunities for Danish companies.

The EU has an overall climate target to lower total CO_2e emissions by at least 55 per cent in 2030 compared to the 1990 level. As a follow-up to the EU's 2030 climate goals, the EU Commission presented the so-called *Fit for 55* legislative package in July 2021, which has since been supplemented with additional EU proposals in December 2021 (the so-called "Winter package"). *Fit for 55* contains a large number of proposals that involves a historically broad revision of the EU's climate and energy regulation, as well as new regulation being proposed within, among other things, transportation. A large number of the *Fit for 55* negotiations have been completed. The final agreements between the Council and the European Parliament on the building directive, the hydrogen and gas market package and the methane regulation are expected to be reached during 2023.

Fit for the 55 package's importance for Danish fulfillment of the 70 per cent target

The Fit for 55 package is expected to contribute to Denmark's fulfillment of the domestic 70 per cent target, and the proposals in the package are considered to involve significant greenhouse gas reductions. At the same time, there are also proposals that can have significant economical consequences for the state, businesses and households.

A strengthened and expanded ETS will contribute to realizing Denmark's reduction obligations both under the burden-sharing regulation and the domestic 70 per cent target. By sending a price signal, it also supplements existing sector regulation such as CO_2 displacement requirements in the Renewable Energy Directive, the Building Directive and the Energy Efficiency Directive and thus contributes to increased reduction efforts.

4.2 LEGISLATIVE ARRANGEMENTS AND ENFORCEMENT AND ADMINISTRATIVE PROCEDURES

The legal basis for the division of powers into the legislative, executive, and judicial power is the Danish Constitution, *Danmarks Riges Grundlov*[1].

The Constitution includes the legal basis for how the Regent acts on behalf of the Realm in international affairs, and the Regent cannot act without the consent of the Folketing in any way that increases or restricts the area of the Realm, or enter into obligations requiring cooperation of the Folketing or which in some other way are of great significance to the Realm. Neither can the Regent, without the consent of the Folketing, cancel an international agreement entered into with the consent of the Folketing.

After a motion from the government, the Folketing thus gave its consent in 2002, allowing Her Majesty Queen Margrethe the Second, on behalf of the Realm and with territorial reservations for the Faroe Islands, to ratify the Kyoto Protocol. This was on 31 May 2002.

Denmark's implementation of the Kyoto Protocol in the first commitment period 2008-2012 has been effectuated by following up on the national Climate Strategy, sector-policy strategies with climate considerations, and concrete initiatives contributing to limiting or reducing greenhouse gas emissions, and implementation of the other parts of the Kyoto Protocol. The legislation necessary to do this has been adopted in pursuance of the Constitution regulations concerning legislative powers.

Pursuant to the Constitution, the Regent is the ultimate authority, cf. paragraphs 12-14:

> "**12.** Subject to the limitations laid down in this Constitutional Act, the King shall have supreme authority in all the affairs of the Realm, and shall exercise such supreme authority through the Ministers.
>
> **13.** The King shall not be answerable for his actions; his person shall be sacrosanct. The Ministers shall be responsible for the conduct of government; their responsibility shall be defined by statute.
>
> **14.** The King shall appoint and dismiss the Prime Minister and the other Ministers. He shall decide upon the number of Ministers and upon the distribution of the duties of government among them. The signature of the King to resolutions relating to legislation and government shall make such resolutions valid, provided that the signature of the King is accompanied by the signature or signatures of one or more Ministers. A Minister who has signed a resolution shall be responsible for the resolution."

With this background, the Regent delegates responsibility for various functions to government ministers through Royal resolutions. This makes the various ministers for different areas responsible for, e.g. making proposals for new/amended legislation made necessary by the Kyoto Protocol, enforcement of legislation and initiation of necessary administrative procedures.

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[1] The Danish Constitution (Danmarks Riges Grundlov) (http://www.retsinfo.dk/_GETDOCI_/ACCN/A19530016930-REGL /: http://www.folketinget.dk/pdf/constitution.pdf)

The total set of regulations (in Danish) can be accessed via Retsinformation[2] (online legal information system). Legislation concerning measures of importance to Denmark's commitments under the Kyoto Protocol will be enforced pursuant to the current legal basis, including pursuant to any penalty clause. Enforcement could also involve the judicial power.

As regards the institutional arrangements for the implementation the Kyoto Protocol concerning activities in connection with participation in the mechanisms under Articles 6, 12, and 17 of the Kyoto Protocol, these tasks have been delegated to the Danish Energy Agency (DEA) under the Ministry of Energy, Utilities and Climate. The DEA is also responsible for legislation and administration of the EU emission trading scheme. The supplementary regulations regarding the approval and use of JI/CDM credits and the Registry are now regulated in Statutory Order No. 118 dated 28 February 2008 with later amendments (https://www.retsinformation.dk/Forms/R0710.aspx?id=144489).

Among the national legislative arrangements and administrative procedures that seek to ensure that the implementation of activities under Article 3, paragraph 3, and the elected activities under Article 3, paragraph 4, also contribute to the conservation of biodiversity and sustainable use of natural resources is The Forest Act (Consolidating Act No. 315 of 28 March 2019), and the implementation thereof. Preservation of areas designated as forest reserve land and protection of natural habitats and habitats for species are among the foremost objectives of the Forest Act.

Furthermore, activities under Article 3, paragraph 3, and the elected activities under Article 3, paragraph 4 have to be implemented in accordance with Natura 2000, which are the Special Areas of Conservation (SAC) designated according to the European Union’s Habitats Directive and the Special Protection Areas (SPA) designated according to the European Union’s Birds Directive. The Danish Ramsar Sites are included in the Special Protection Areas.

The Ministry of Environment of Denmark, has the overall responsibility for the implementation of the Habitats Directive and the Birds Directive. The implementation includes the designation of 262 Special Area of Conservation, 113 Special Protection Areas and 28 Ramsar Sites. The rules for administration of the Danish Natura 2000 are laid down in Executive Order No. 1595 of 6 December 2018 on the Designation and Administration of Internationally Protected Sites and the Protection of Certain Species. Similar rules are integrated in other ministries legislation e.g. fisheries and constructions in marine areas.

4.3 Policies and measures and their effects

In this section, the individual measures relevant to Denmark’s climate policy are described. An overview of Denmark’s portfolio of existing (implemented or adopted) climate relevant policies and measures is contained in Annex B, where it is also indicated which of the meaures are new and which have expired or been updated etc.

Sections 4.3.1-4.3.4 include descriptions of the cross-sectoral policies and measures, allowance regulation, the Kyoto Protocol mechanisms, taxes and duties and carbon capture and storage. Sections 4.3.5-4.3.9 contain descriptions of policies and measures in the following IPCC source/sink and sector categories: Energy (including

[2] http://www.retsinfo.dk/

Transport), Industrial Processes and Product Use, Agriculture, LULUCF (Land-use, Land-use change and Forestry) and Waste.

Table 4.1 shows how the allocation to be used in connection with the annual emission inventories (the CRF/IPCC format) is aggregated into the sectors included in this Chapter on policies and measures.

TABLE 4.1 AGGREGATION OF SOURCE, SINK AND SECTOR CATEGORIES IN THE CRF/IPCC FORMAT INTO THE SECTORS INCLUDED IN THIS CHAPTER

Sectors in this chapter and Chapter 5	Sources/Sectors in the CRF/IPCC format	
Energy - with subsections on:	1.	Fuel combustion activities (1A) and Fugitive emissions from fuels (1B)
Business	1A2+ 1A4a+ 1A4c.	Manufacturing Industries and Construction Commercial/Institutional Agriculture, Forestry and Fisheries
Households	1A4b	Residential
Transport	1A3.	Transport (national)
Industrial Processes and Product Use	2.	Industrial processes and Product Use
Agriculture	3.	Agriculture
LULUCF	4.	Land-use, Land-use Changes and Forestry (LULUCF).
Waste	5.	Waste

Table 4.2 and Figure 4.1 show the main result of this aggregation, including indirect CO_2 emissions, for the historic greenhouse gas inventories in 1990, KP2 base year estimate for 1990/95[3] and 2020 as well as the 2022 projections of annual emissions in 2025, 2030, 2035 and 2040 in the "with existing measures" (WEM) scenario[4] – with and without emissions and removals in connection with land use, land-use change and forestry (LULUCF)[5].

In accordance with the reporting guidelines, the following sector sections in this chapter are subdivided by gas.

Separate estimate of the effect of the 2018 Energy Agreement
In this report the effects of the policies and measures *adopted* with the 2018 Energy Agreement is included in the "With Existing Measures" (WEM) greenhouse gas projection scenario from 2022.

In 2018, it was estimated that the *2018 Energy Agreement* alone will provide a 10-11 million tonnes reduction in Denmark's total greenhouse gas emissions by 2030. The majority of these reductions will be within sectors covered by the EU's Emissions Trading System (EU ETS) as approximately 0.15-0.25 million tonnes CO_2 is estimated to be the reduction in 2030 outside of the EU ETS (non-ETS). Accumulated over the non-ETS reduction commitment period 2021-2030 the energy agreement's initiatives are expected to reduce carbon emissions from the non-ETS sectors by approximately 1.1 to 1.5 million tonnes CO_2 in the period 2021-2030. The largest contributions come from new energy saving subsidies and the reduced electricity heating tax which makes it more attractive to switch to heat pumps. With

[3] Under the second commitment period of the Kyoto Protocol, Denmark's base year is 1990 for CO_2, methane and nitrous oxide, and 1995 for the industrial gases (HFCs, PFCs, SF_6 and NF_3 – however with no emissions of the latter) cf. Article 3.8 of the Protocol from the inventory reported, reviewed and resubmitted in 2016-2017 (https://unfccc.int/sites/default/files/resource/docs/2017/irr/dnk.pdf).
[4] https://ens.dk/en/our-services/projections-and-models/denmarks-energy-and-climate-outlook
[5] Under the Kyoto Protocol, the LULUCF category is dealt with separately under Articles 3.3 and 3.4.

these and other initiatives, the *2018 Energy Agreement* will help Denmark reach its 50% greenhouse gas emissions reduction target by 2030 in the non-ETS sectors.

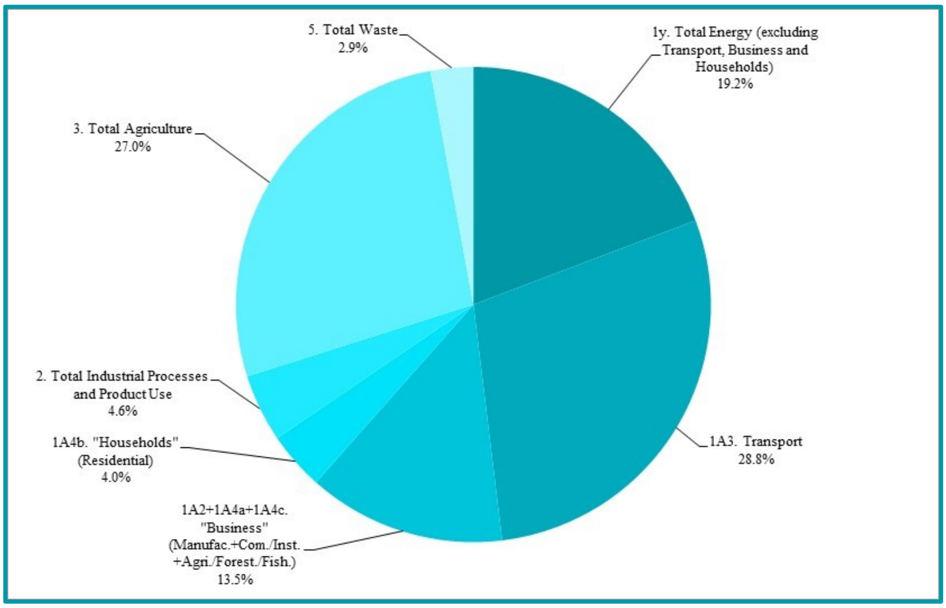
Separate estimates of the effects of political agreements since December 2019
The separate estimates of the effects of political agreements reached since December 2019, included in the statement by the Minister for Climate, Energy and Utilities submitted to the Danish parliament in May 2023, are included in Chapter 5.2.3.

TABLE 4.2 DENMARK'S GREENHOUSE GAS EMISSIONS 1990-2020, THE BASE YEAR UNDER THE SECOND COMMITMENT PERIOD OF THE KYOTO PROTOCOL AND THE MAIN RESULTS OF THE 2022 "WITH (EXISTING) MEASURES" (WEM) PROJECTION FOR 2025, 2030, 2035 AND 2040 BY SECTOR AND BY GAS (INCLUDING INDIRECT CO_2), WITH AND WITHOUT LULUCF AS REPORTED UNDER THE UNFCCC

Source: Nielsen et al. (2022a), Nielsen et al. (2022b), Danish Energy Agency (2022b) and Ministry of Climate, Energy and Utilities

GHG emissions (1990-2020) [2022 submission, AR4 GWPs] and projections (2021-2040) [WEM22 (KF22), AR4 GWPs]]	1990 MtCO2e	1990 % share for / in sector	KP2 BY MtCO2e	KP2 BY % share for / in sector	2015 MtCO2e	2015 % share for / in sector	Change from 1990 (%)	Change from KP2 BY (%)	2020 MtCO2e	2020 % share for / in sector	Change from 1990 (%)	Change from KP2 BY (%)	2025 MtCO2e	2025 % share for / in sector	Change from 1990 (%)	2030 MtCO2e	2030 % share for / in sector	Change from 1990 (%)	2035 MtCO2e	2035 % share for / in sector	Change from 1990 (%)	2040 MtCO2e	2040 % share for / in sector	Change from 1990 (%)
Total (including LULUCF, with indirect CO_2)	78.0	109.7	70.8	100.0	49.7	101.6	-36.2	-29.8	44.9	107.4	-42.5	-36.7	41.5	113.3	-46.8	34.1	112.3	-56.3	30.3	112.6	-61.1	30.3	112.6	-61.1
CO_2 (with indirect CO_2)	61.2	86.1	54.8	77.4	36.1	73.7	-41.1	-34.2	31.3	75.1	-48.8	-42.8	28.8	78.7	-53.0	21.6	71.2	-64.7	18.2	67.6	-70.3	18.2	67.6	-70.3
Methane	8.2	11.5	7.9	11.1	7.4	15.1	-9.5	-6.0	7.4	17.6	-10.0	-6.5	7.2	19.6	-12.1	7.3	24.1	-10.4	7.0	26.1	-13.9	7.0	26.1	-13.9
Nitrous oxide	8.5	12.0	7.8	11.0	5.7	11.6	-33.3	-27.0	5.8	13.8	-32.3	-25.9	5.3	14.3	-38.5	5.0	16.5	-41.4	5.0	18.4	-41.9	5.0	18.4	-41.9
Industrial gases	0.0	0.1	0.3	0.5	0.6	1.2	1287.6	70.8	0.4	0.9	796.3	10.3	0.2	0.7	465.9	0.2	0.5	277.3	0.1	0.5	230.1	0.1	0.5	230.1
Total (without LULUCF, with indirect CO_2)	71.1	100.0	70.8	100.0	48.9	100.0	-31.2	-30.9	41.7	100.0	-41.3	-41.0	36.6	100.0	-48.5	30.4	100.0	-57.3	27.0	100.0	-62.1	27.0	100.0	-62.1
CO_2 (with indirect CO_2)	54.7	76.9	54.8	77.4	35.5	72.6	-35.0	-35.1	28.5	68.3	-47.9	-47.9	24.3	66.3	-55.6	18.4	60.5	-66.4	15.3	56.9	-72.0	15.3	56.9	-72.0
Methane	7.9	11.1	7.9	11.1	7.2	14.6	-9.4	-8.9	7.1	17.0	-10.0	-9.5	6.9	18.8	-13.0	6.9	22.6	-13.1	6.6	24.4	-16.9	6.6	24.4	-16.9
Nitrous oxide	8.5	11.9	7.8	11.0	5.6	11.5	-33.3	-27.6	5.7	13.7	-32.3	-26.5	5.2	14.2	-38.5	5.0	16.3	-41.4	4.9	18.2	-42.0	4.9	18.2	-42.0
Industrial gases	0.0	0.1	0.3	0.5	0.6	1.2	1287.6	70.8	0.4	0.9	796.3	10.3	0.2	0.7	465.9	0.2	0.5	277.3	0.1	0.5	230.1	0.1	0.5	230.1
1. Total Energy (with indirect CO_2)	53.5	75.3	53.6	75.7	34.9	71.3	-34.9	-34.9	27.3	65.5	-48.9	-49.0	23.1	63.0	-56.9	17.1	56.2	-68.1	13.9	51.7	-74.0	13.9	51.7	-74.0
CO_2 (with all indirect CO_2 here in historic data)	52.8	98.6	52.9	98.6	34.1	97.8	-35.4	-35.5	26.7	97.7	-49.4	-49.5	22.4	97.2	-57.5	16.6	97.0	-68.7	13.5	97.0	-74.4	13.5	97.0	-74.4
Methane	0.4	0.7	0.4	0.7	0.4	1.1	-6.1	1.6	0.3	1.0	-32.2	-26.6	0.3	1.3	-21.4	0.2	1.3	-41.7	0.2	1.2	-56.9	0.2	1.2	-56.9
Nitrous oxide	0.4	0.7	0.4	0.7	0.4	1.1	9.7	8.8	0.4	1.3	-0.5	-1.3	0.3	1.5	-5.3	0.3	1.6	-22.0	0.3	1.8	-30.4	0.3	1.8	-30.4
2. Total Industrial Processes and Product Use	2.3	3.3	2.6	3.7	1.8	3.7	-21.7	-30.6	1.9	4.6	-17.8	-27.2	1.9	5.1	-19.8	1.8	5.9	-23.6	1.8	6.5	-24.9	1.8	6.5	-24.9
CO_2	1.3	54.5	1.3	48.3	1.2	66.7	-4.3	-4.1	1.5	79.1	19.2	19.4	1.6	86.2	26.8	1.6	89.9	26.0	1.6	90.9	25.2	1.6	90.9	25.2
Methane	0.0	0.1	0.0	0.1	0.0	0.2	46.4	45.5	0.0	0.1	-17.9	-18.5	0.0	0.0	-100.0	0.0	0.0	-100.0	0.0	0.0	-100.0	0.0	0.0	-100.0
Nitrous oxide	1.0	43.5	1.0	38.6	0.0	1.1	-98.1	-98.1	0.0	1.0	-98.0	-98.0	0.0	1.1	-98.0	0.0	1.1	-98.0	0.0	1.1	-98.0	0.0	1.1	-98.0
Industrial gases	0.0	1.8	0.3	13.0	0.6	32.1	1287.6	70.8	0.4	19.7	796.3	10.3	0.2	12.8	465.9	0.2	8.9	277.3	0.1	8.0	230.1	0.1	8.0	230.1
3. Total Agriculture	13.3	18.8	12.8	18.1	11.1	22.7	-16.8	-13.2	11.3	27.0	-15.5	-11.9	10.3	28.1	-22.9	10.1	33.1	-24.6	9.9	36.7	-25.8	9.9	36.7	-25.8
CO_2	0.6	4.6	0.6	4.8	0.2	1.6	-71.3	-71.5	0.3	2.3	-58.5	-58.9	0.2	2.0	-65.8	0.2	2.1	-65.8	0.2	2.1	-65.8	0.2	2.1	-65.8
Methane	5.9	44.2	5.8	45.6	5.9	53.2	0.1	1.3	5.9	52.2	-0.3	1.0	5.4	52.9	-7.7	5.4	53.7	-8.4	5.3	53.3	-10.5	5.3	53.3	-10.5
Nitrous oxide	6.8	51.2	6.3	49.6	5.0	45.2	-26.5	-20.9	5.1	45.5	-24.8	-19.1	4.6	45.0	-32.2	4.4	44.2	-35.0	4.4	44.5	-35.4	4.4	44.5	-35.4
4. Total Land-Use Categories (LULUCF)	6.9	9.7	0.0	0.0	0.8	1.6	-88.5	-	3.1	7.4	-54.8	-	4.9	13.3	-29.3	3.7	12.3	-45.7	3.4	12.6	-50.7	3.4	12.6	-50.7
CO_2 (for KP2 BY only GHG emissions from deforestation)	6.5	95.1	0.0	100.0	0.5	64.7	-92.2	-	2.8	90.8	-56.9	-	4.5	93.0	-30.9	3.2	86.9	-50.5	2.9	85.0	-56.0	2.9	85.0	-56.0
Methane	0.3	3.8	0.0	0.0	0.2	29.1	-12.1	-	0.2	7.7	-9.2	-	0.3	6.2	14.3	0.5	12.1	71.4	0.5	13.6	75.2	0.5	13.6	75.2
Nitrous oxide	0.1	1.0	0.0	0.0	0.0	6.2	-31.5	-	0.0	1.5	-33.2	-	0.0	0.8	-43.7	0.0	1.1	-43.7	0.1	1.5	-29.7	0.1	1.5	-29.7
5. Total Waste	1.9	2.7	1.8	2.5	1.1	2.3	-40.4	-36.0	1.2	2.9	-36.2	-31.5	1.4	3.7	-27.7	1.5	4.9	-21.9	1.4	5.1	-27.7	1.4	5.1	-27.7
CO_2	0.0	1.1	0.0	1.0	0.0	1.9	-0.9	23.1	0.0	1.9	5.4	30.9	0.0	1.5	-8.2	0.0	1.4	-8.2	0.0	1.5	-8.2	0.0	1.5	-8.2
Methane	1.6	85.1	1.7	94.8	0.9	78.8	-44.8	-46.9	0.9	76.1	-42.9	-45.0	1.1	83.2	-29.3	1.2	83.8	-23.1	1.1	81.8	-30.5	1.1	81.8	-30.5
Nitrous oxide	0.3	13.8	0.1	4.2	0.2	19.3	-16.5	195.6	0.2	18.2	-15.9	197.7	0.2	16.1	-15.9	0.2	14.9	-15.9	0.2	16.8	-12.0	0.2	16.8	-12.0
1x. Total Energy (excluding Transport)	42.8	60.1	42.9	60.6	22.2	45.3	-48.2	-48.3	15.3	36.7	-64.2	-64.3	11.1	30.2	-74.2	6.7	22.2	-84.3	5.5	20.3	-87.2	5.5	20.3	-87.2
CO_2 (with all indirect CO_2 here in historic data)	42.2	98.7	42.3	98.7	21.5	97.2	-48.9	-49.1	14.8	96.8	-64.9	-64.9	10.5	95.3	-75.0	6.3	93.9	-85.0	5.1	93.8	-87.8	5.1	93.8	-87.8
Methane	0.3	0.7	0.3	0.7	0.4	1.6	13.7	16.4	0.3	1.7	-17.9	-15.9	0.3	2.8	-1.6	0.2	3.4	-27.0	0.2	3.1	-46.0	0.2	3.1	-46.0
Nitrous oxide	0.3	0.6	0.3	0.6	0.3	1.2	-0.5	-1.0	0.2	1.5	-13.0	-13.4	0.2	1.9	-19.4	0.2	2.7	-30.9	0.2	3.1	-34.8	0.2	3.1	-34.8
1A3 Transport	10.8	15.2	10.7	15.2	12.7	26.0	18.0	18.6	12.0	28.8	11.5	12.1	12.0	32.9	11.5	10.3	34.0	-4.2	8.5	31.4	-21.7	8.5	31.4	-21.7
CO_2	10.6	98.4	10.6	98.5	12.6	98.8	18.6	18.9	11.9	98.8	12.1	12.4	11.9	98.9	12.2	10.2	99.0	-3.6	8.4	99.1	-21.1	8.4	99.1	-21.1
Methane	0.1	0.7	0.1	0.5	0.0	0.1	-84.7	-78.6	0.0	0.1	-88.9	-84.5	0.0	0.0	-100.0	0.0	0.0	-100.0	0.0	0.0	-100.0	0.0	0.0	-100.0
Nitrous oxide	0.1	0.9	0.1	0.9	0.1	1.1	36.7	34.4	0.1	1.1	32.4	30.1	0.1	1.1	32.0	0.1	1.0	1.5	0.1	0.9	-18.8	0.1	0.9	-18.8
1y. Total Energy (excluding Transport, Business and Households)	28.1	39.5	28.2	39.8	13.8	28.2	-50.8	-50.9	8.0	19.2	-71.4	-71.5	5.4	14.8	-80.7	3.3	10.9	-88.2	2.9	10.8	-89.6	2.9	10.8	-89.6
CO_2 (with all indirect CO_2 here in historic data)	27.8	99.0	27.9	99.0	13.5	97.6	-51.4	-51.6	7.8	97.0	-71.9	-72.0	5.1	94.1	-81.6	3.1	92.7	-89.0	2.7	93.8	-90.2	2.7	93.8	-90.2
Methane	0.2	0.5	0.1	0.5	0.2	1.5	35.6	45.1	0.1	1.7	-8.4	-2.0	0.2	4.2	53.1	0.2	4.8	6.5	0.1	3.8	-26.8	0.1	3.8	-26.8
Nitrous oxide	0.1	0.5	0.1	0.5	0.1	0.9	-9.0	-8.8	0.1	1.2	-28.9	-28.8	0.1	1.7	-35.8	0.1	2.4	-42.9	0.1	2.4	-50.0	0.1	2.4	-50.0
1A2+1A4a+1A4c: "Business" (Manufac.+Com./Inst.+Agri./Forest./Fish.)	9.5	13.4	9.6	13.5	6.2	12.6	-35.3	-35.4	5.6	13.5	-41.1	-41.1	4.7	12.7	-51.3	3.1	10.1	-67.8	2.4	8.8	-75.2	2.4	8.8	-75.2
CO_2	9.4	98.6	9.4	98.5	6.1	98.0	-35.7	-35.7	5.5	97.5	-41.7	-41.7	4.6	97.8	-51.6	3.0	97.1	-68.3	2.3	96.2	-75.8	2.3	96.2	-75.8
Methane	0.0	0.5	0.0	0.5	0.0	0.8	6.7	-0.7	0.1	1.0	30.2	21.1	0.0	0.6	-33.5	0.0	1.0	-33.5	0.0	1.3	-33.5	0.0	1.3	-33.5
Nitrous oxide	0.1	0.9	0.1	0.9	0.1	1.2	-16.0	-17.3	0.1	1.4	-10.7	-12.2	0.1	1.5	-21.3	0.1	2.0	-32.5	0.1	2.5	-32.5	0.1	2.5	-32.5
1A4b: "Households" (Residential)	5.1	7.2	5.2	7.3	2.2	4.4	-58.0	-58.1	1.7	4.0	-67.8	-67.9	1.0	2.7	-80.9	0.4	1.2	-93.0	0.2	0.7	-96.3	0.2	0.7	-96.3
CO_2	5.0	97.1	5.0	97.1	2.0	92.4	-60.0	-60.1	1.5	93.3	-69.1	-69.2	0.9	89.8	-82.4	0.3	77.8	-94.4	0.1	63.2	-97.6	0.1	63.2	-97.6
Methane	0.1	2.3	0.1	2.3	0.1	4.9	-11.2	-10.5	0.1	3.8	-47.9	-47.5	0.1	5.1	-58.2	0.0	11.1	-66.6	0.0	15.8	-74.9	0.0	15.8	-74.9
Nitrous oxide	0.0	0.6	0.0	0.6	0.1	2.7	80.9	80.3	0.0	2.9	51.5	51.0	0.1	5.1	58.1	0.0	11.1	26.5	0.0	21.1	26.5	0.0	21.1	26.5

FIGURE 4.1 DENMARK'S GREENHOUSE GAS EMISSIONS IN 2020 BY SECTOR
Source: Nielsen et al. (2022a) and the Danish Ministry of Climate, Energy and Utilities



4.3.1 Cross-cutting – The EU Emission Trading Scheme

EU ETS 2005-2007

Directive 2003/87/EC on trading in CO_2 allowances (the EU ETS Directive) in 2005 introduced a greenhouse gas emissions allowance trading scheme in the EU. The objective of the allowance scheme is to reduce emissions of greenhouse gases so that the EU and its Member States can meet their reductions commitments under the Kyoto Protocol and the EU Burden-Sharing Agreement.

EU ETS 2008-2012

According to the EU ETS Directive, each Member State had to prepare a national allocation plan before the trading period 2008-12.

The European Commission approved the Danish National Allocation Plan (NAP2) in 2007. The NAP contained a detailed plan for the reduction efforts. In the NAP, the gap between the emission target and emission under business as usual amounted to 13 million tonnes CO_2 per year. Of this gap, 5.2 million tonnes CO_2 are covered by efforts in the emission trading sector, while the remaining 7.8 million tonnes CO_2 are covered by efforts in the non-emission trading sector using various instruments, including the use of CDM credits, sinks and additional domestic efforts. The NAP also ensures that Denmark honours the supplementarity principle.

Via the NAP, the allowance regulation in Denmark included individual emission limits 2008-2012 for CO_2 emissions from several sectors, which together produce approx. half of Denmark's total greenhouse gas emissions. Denmark allocated a total of 125 million CO_2 emission allowances during the five years of the scheme. Of these, 2.5 million have been allocated to new production units and major expansions. The rest have been allocated free of charge to those production units covered by the trading scheme in 2007.

In the following, only the principles and general figures for Denmark's implementation of the EU ETS Directive via NAP2 will be described.

From the 1 January 2008 the first Kyoto Commitment Period (CP1) commenced. In practice the EU ETS has not changed for the Danish operators under the EU ETS, even after the Community Independent Transaction Log and the registries under the EU ETS connected to the International Transaction Log under the UN on 28 October 2008, as the registry was already ready to work in the international emissions trading system.

Relevant key figures in the NAP for Denmark for the period 2008 – 2012 are shown in Table 4.3.

TABLE 4.3: KEY FIGURES IN THE PROPOSAL FOR DENMARK'S NATIONAL ALLOCATION PLAN 2008-12
Source: Denmark's National Allocation Plan 2008-12 (NAP2), 2007

	2003 emissions	Projected emissions 2008-12	Quota allocation 2008-12	Quota allocation 2005-07
	Million tonnes CO_2 equivalents per year			
Sectors subject to allowances, in total	36.6	29.7	24.5	33.5
- electricity & heat production	28.1	20.5	15.8	21.7
- other sectors subject to allowances, incl. offshore industries-	8.5	9.2	8.2	7.1
- auction			0	1.7
- new installations			0.5	1
Sectors not subject to allowances	*37.8*[1]	*38.1*		
Total	74.4	67.8		

[1] On the basis of the European Commission's broad definition of enterprises covered.

Denmark was committed to reducing its national greenhouse gas emissions by 21% in 2008-12, compared to 1990/1995 level. That meant that emissions had to be reduced to an average 54.8 million tonnes of CO_2 equivalents annually for the period.

In NAP2, the deficit between expected Danish emissions of CO_2 and the target Denmark was committed to achieving was expected to 13 million tonnes for the period 2008-12 if no further initiatives were implemented. The NAP documented how this deficit would be reduced to zero. As stated in NAP2, Denmark would meet its commitment through a combination of domestic and foreign environmental and energy measures by the government and by Danish enterprises with CO_2 emissions.

Denmark has had an active, environmentally oriented energy policy since the 1970s, and since 1990 this has been supplemented by an actual climate policy which, on an international scale, has entailed a major strain - economically and/or via administrative regulations - on most greenhouse gas emissions, especially from businesses and sectors not subject to allowances.

The period 2008 – 2012 was finalized in 2013 with the final surrendering of allowances and credits by companies participating under the EU ETS.

The final EU ETS accounting in Denmark for the period 2008-2012 shows that total verified CO_2 emissions under the EU ETS in Denmark were a little below the total amount of allocated allowances cf. Table 4.4. However, some companies have to some extent surrendered credits from JI and CDM projects and presumably instead sold or banked their surplus EU allowances.

TABLE 4.4: VERIFIED CO_2 EMISSIONS UNDER THE EU ETS IN DENMARK, FREE ALLOCATIONS AND SURPLUS/DEFICIT FOR THE PERIOD 2008-2012

Source: Danish Energy Agency, May 2013

	Verified CO_2 emissions under the EU ETS in Denmark 2008-2012						Free allocation	Excess of quotas (negative number represents a deficit)
	2008	2009	2010	2011	2012	Annual Average 2008-12	Annual Average 2008-12	Annual Average 2008-12
	Million tonnes CO_2						Million tonnes EUAs	Million tonnes EUAs
Central power plants	17.6	17.8	17.2	13.8	10.9	15.46	13.4	-2.06
Industry and Service	5.3	4.3	4.2	4.3	4.3	4.48	5.8	1.32
Offshore	2.0	1.8	1.9	1.7	1.7	1.82	2.3	0.48
Other electricity and heat production	1.6	1.6	2.0	1.6	1.4	1.64	2.4	0.76
Total stationary[1]	**26.5**	**25.5**	**25.3**	**21.5**	**18.2**	**23.4**	**23.9**	**0.5**
Aviation[2]			(1.5)	(1.4)	1.3	1.3	1.1	-0.2

[1] In 2012, a total of 375 stationary installations were covered. Of these were 16 central power and heat plants, 111 manufacturing industries, 241 decentralized electricity and district heating plants and 7 offshore companies.

[2] In 2012, total CO_2 emissions from the 26 aircraft operators covered by the EU ETS in Denmark exceeded the free allocation of allowances for 2012. It should be noted that aviation emissions for 2012 cannot be compared with previous years, as aircraft operators in 2012 have been able to make use of the EU Commission's "stop- the-clock " decision. This decision, which applies only for 2012, gives an operator the opportunity to deduct CO_2 emissions related to flights in and out of the EU. Most operators chose to make use of this opportunity.

EU ETS 2013-2020

The EU Climate and Energy Agreement from December 2008 extended the ETS system to 2013-2020 in order for the EU to reduce CO_2-emissions by 20% in 2020. At the same time allocation was centralised and reduced, while auctioning is being/have been used more extensively since 2013.

Free allocation for stationary installations is carried out on the basis of benchmarks. These benchmarks reward best practice in low-emission production and are an important signal of the EU's commitment to moving towards a low-carbon economy.

Although auctioning is the default method for allocating emission allowances to companies participating in the EU ETS, the manufacturing industry continues to receive a share of free allowances until 2020 due to carbon leakage. The heat production also continues to receive free allowances – however declining from 80% of the benchmark in 2013 to 30% of the benchmark in 2020 for those not being exposed to carbon leakage.

The allowances for the installations in the EU ETS have been calculated for 2013-2020 in accordance with the EU benchmarking decision 2011/278/EU. The Danish National Implementation Measures (NIM) list was approved by the European Commission in January 2014.

Waste incineration plants which are primarily used for district heating were included in the ETS in Denmark by 1st of January 2013, while about 30 installations exclusively using biomass were excluded of the ETS. The inclusion of waste incineration plants lead to an increase in the total amount of CO_2-emission from the ETS in Denmark in 2013 compared to 2012.

Aviation has been a part of ETS since 2012. Aircraft operators get free allowances based on their activity and the scope.

EU ETS 2021-2030

The legislative framework of the EU ETS for its next trading period 2021-2030 (phase 4) was revised in early 2018 to enable it to achieve the EU's 2030 emission reduction targets in line with the 2030 climate and energy policy framework and as part of the EU's contribution to the 2015 Paris Agreement.

The revision focuses on:

– Strengthening the EU ETS as an investment driver by increasing the pace of annual reductions in allowances to 2.2% as of 2021 and reinforcing the Market Stability Reserve (the mechanism established by the EU in 2015 to reduce the surplus of emission allowances in the carbon market and to improve the EU ETS's resilience to future shocks).

– Continuing the free allocation of allowances as a safeguard for the international competitiveness of industrial sectors at risk of carbon leakage, while ensuring that the rules for determining free allocation are focused and reflect technological progress.

– Helping industry and the power sector to meet the innovation and investment challenges of the low-carbon transition via several low-carbon funding mechanisms.

The Fit for 55 package endorsed on 8 February 2023 by the Permanent Representatives Committee proposes to revise several pieces of EU climate legislation, including the EU ETS, setting out in real terms the ways in which the Commission intends to reach EU climate targets under the European Green Deal. The revised EU ETS Directive, which will apply for the period 2021-2030, will enable this through a mix of interlinked measures eg. a mayor revision of EU ETS as well as inclusion of ETS Maritime and ETS Transport, Building and Industries.

The revision focuses on:

- Free allowances in the Emissions Trading System (ETS) to be phased out from 2026
- Road transport and buildings in new ETS II from 2027
- New carbon leakage instrument to protect EU industry and increase global climate ambition
- A Social Climate Fund to combat energy and mobility poverty

Denmark's national allowance registry

Denmark's national allowance registry – (DK ETR – Emission Trading Registry[6]) has been operating since 1 January 2005. The DK ETR is used to allocate allowances to production facilities subject to allowances and enables trade in allowances among

[6] https://www.kvoteregister.dk

the allowance holders found in the registry. Since the 1st of July 2012 the DK ETR has been a part of the EU ETS that host the emission trading registry for all of the member states in the EU. The DK ETR is constructed so it also fulfils all Kyoto requirements.

The DK ETR is also functioning as the national registry under the Kyoto Protocol.

4.3.2 Cross-cutting – The Kyoto Protocol mechanisms

For the period 2008-2012, the flexible Kyoto Protocol mechanisms have been important elements in supplementing domestic reduction measures aimed at fulfilling the international climate commitment under the Kyoto Protocol and the subsequent EU Burden Sharing Agreement.

For the period 2013-2020, the government has not used the flexible Kyoto Protocol mechanisms for the achievement of Denmark's target under the EU Effort Sharing Decision - also to be seen as Denmark's contribution to the EU joint target under the 2nd commitment period of the Kyoto Protocol. For the achievement of the joint EU target for the EU Emissions Trading Scheme's contribution to the EU joint overall target under the 2nd commitment period of the Kyoto Protocol, Danish entities under the EU ETS have been able to make use of the flexible Kyoto Protocol mechanisms subject to the conditions in the EU legislation. In the ETS, the use of international credits 2013-2020 was capped (up to 50 % of the reduction required from EU ETS sectors by 2020). Quality standards also applied to the use of international credits in the EU ETS, including a ban on credits from LULUCF projects and certain industrial gas projects.

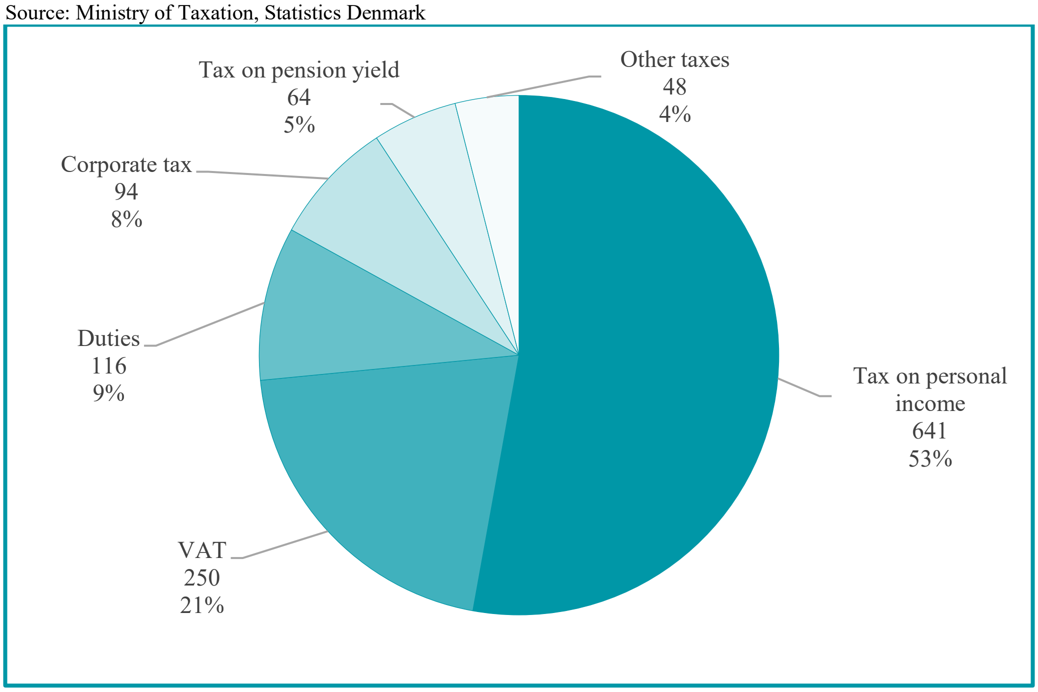
4.3.3 Cross-cutting – Taxes and duties

In Denmark, total taxes and duties made up a total of approx. 48% of GDP in 2021. The public sector provides childcare, education, unemployment benefits, health and disability benefits, old-age pensions, and many other services.

Personal income tax is the most important tax, constituting about half of total tax revenues. Other taxes are VAT, duties and corporation taxes. Danish VAT is relatively high, 25%, and there are no differentiated rates. There are a considerable number of additional consumption taxes and environmental taxes. The corporation tax rate is 22%.

Total revenue from all taxes and duties amounted to DKK 1,212 billion in 2021. The relative distribution is shown in Figure 4.2.

FIGURE 4.2 RELATIVE DISTRIBUTIONS OF TAXES AND DUTIES 2021 IN BILLION DKK AND PERCENTAGE
Source: Ministry of Taxation, Statistics Denmark



Taxes that influence Denmark's greenhouse gas emissions

Retail prices on products that influence Danish greenhouse gas emissions are, in most cases, the decisive factor determining the degree to which they are consumed. Energy prices influence the composition and total size of energy consumption. Therefore extra taxes and duties put on products influence the consumption of these products and the size of greenhouse gas emissions associated with the use of the products.

Denmark has special taxes on motor vehicles, energy products, alcohol, tobacco, and a number of other products. Taxes are in accordance with EU legislation.

The introduction of CO_2 taxes and the increase in the rates of individual energy taxes since 1990 have influenced the consumption of a number of energy products and have therefore reduced the CO_2 emissions associated with consumption of these products.

4.3.3.1 CO_2, CH_4, and N_2O - taxes and duties relevant to these emissions

4.3.3.1.1 Energy

Denmark has had taxes on energy for many years. Since the first oil crisis in the early 1970s, the rates of the taxes have been aimed at reducing consumption and promoting the instigation of more energy-saving measures. Lower energy consumption will reduce emissions of CO_2, methane (CH_4), and nitrous oxide (N_2O) associated with combustion of fossil fuels.

Danish energy taxes are laid down in the four Danish tax acts on mineral-oil, gas, coal, and electricity, respectively (Mineralolieafgiftsloven, Gasafgiftsloven, Kulafgiftsloven, and Elafgiftsloven). As from 1 January 2016 the tax rates set in these tax acts follow a yearly regulation based on the consumer price index of two years prior. Besides the energy taxes there is also a tax on CO_2, NO_x, sulphur and industrial gasses (see Table 4.5).

TABLE 4.5 ENERGY TAXES 2010, 2015 AND 2020-2023

Source: Ministry of Taxation

	Unit	2010	2015	2020	2021	2022	2023
Coal	*DKK/toe*	2,399	2,282	2,374	2,629	2,638	2,675
Natural gas	*DKK/toe*	2,405	2,282	2,374	2,629	2,638	2,675
Oil products[1]	*DKK/toe*	2,400	2,282	2,374	2,625	2,638	2,675
Electricity: For heating	*DKK/kWh*	0.545	0.380	0.210	0.008	0.008	0.008
Electricity: Other	*DKK/kWh*	0.659	0.878	892	90	0.900[2] 0.763[3] 0.723[4]	0.008[5] 0.697[6]
Waste: Heating from waste[7]	*DKK/toe*	1,930	1,901	1,980	2,190	2,198	2,227
Other compostable biomass	*DKK/toe*	0	0	0	0	0	0

[1]Only oil used for other purposes than motor fuels
[2]From 1 January 2022 – 30 June.
[3]From 1 July 2022 – 30 September 2022.
[4]From 1 October 2022 – 31 December 2022.
[5]From 1 January 2023 – 30 June 2023.
[6]From 1 July 2023 – 31 December 2023
[7]Tax rates on waste are rates on heat production (output) while tax rates on coal, natural gas and oil products are input rates. Rates correspond under the used convention in energy tax acts of heating efficiency for CHP plants.

A tax on NO_x (nitrogen oxides) was originally introduced as part of a 2008 energy agreement and came into effect on 1 January 2010 with a rate of 5 DKK per kg NOx. From 1 January 2012, a considerable increase in the taxation of NOx from 5 DKK per kg NOx to 25 DKK per kg NOx was implemented. However, the rate was reduced in 2016 to 5 DKK per kg NOx.

A tax on sulphur in fuels was introduced 1 January 1996 with a rate of 20 DKK per kg sulphur in fuels and a rate of 10 DKK for SO_2 emitted to the air. One of the side effects of this tax is assumed to be a reduction in CO_2 emissions.

In March 2012 a general agreement on Danish energy policy from 2012-2020 was made. The agreement seeks to ensure the transition from an energy supply based on fossil fuels to one based on renewable energy. Additional initiatives regarding taxes and duties have been adopted with the 2018 Energy Agreement and planned with the 2018 Climate and Air proposal. Further initiatives have been adopted with the 2020 Climate Agreement for energy and industry, the 2020 Green reform Agreement. To implement incitements to change to green energy and to meet the high energy prices several Agreements reducing the electricity tax was implemented in 2022, including the 2022 New reform package for Danish economy, the 2022 Compensation for citizens for higher energy prices Agreement, the 2022 Winter help Agreement. These initiatives are described later.

The Mineral-oil Tax Act entered into force on 1 January 1993. Before this, the tax on petrol was regulated via the Petrol Tax Act, which entered into force on 1 January 1983, and the Act on Taxation of Gas Oil and Diesel Oil, Heating Oil, Heating Tar, and Crude Oil was regulated via the Act on Taxation of certain Oil Products, which entered into force on 3 October 1977. Tax rates from recent years are shown in Table 4.6.

TABLE 4.6 TRENDS IN TAXES 2010, 2015 AND 2020-2023 UNDER THE MINERAL-OIL TAX ACT, STATED IN DKK/LITRE
Source: Ministry of Taxation

DKK per litre	2010	2015	2020	2021	2022	2023
Gas oil and diesel oil used as motor fuels	2.774	2.997	3.120	3.147	3.159	3.204
Light diesel oil	2.669	2.881	2.999	3.025	3.037	3.080
Diesel low in sulphur content	2.479	2.674	2.784	2.808	2.818	2.859
Diesel without sulphur	2.479	2.674	2.784	2.808	2.818	2.859
Fuel oil	2.330	2.215	2.324	2.552	2.561	2.598
Auto gas	1.726	1.814	1.903	1.905	1.912	1.939

From 1 June 1999 a tax differentiation between light diesel and diesel low in sulphur was introduced, to encourage the use of diesel low in sulphur, which is less polluting than light diesel. This was accomplished and a change took place soon after to the effect that almost all diesel sold was low in sulphur. The purpose of further differentiation from 1 January 2005 favouring sulphur-free diesel was likewise to encourage the use of this type of diesel in favour of diesel low in sulphur, and this has been successful.

In addition, tax differentiation has been introduced in order to achieve environmental goals other than direct reductions in greenhouse gas emissions. Thus tax differentiation has been introduced with a view to phasing out lead in petrol. The rate of tax to achieve this environmental goal is shown in Table 4.7.

Further, the tax rate for mineral oils used in business are increased with 6 DKK/GJ which is phased in from 2023 to 2025. The tax rate for mineral oils used in mineral processes etc. and agriculture etc. are increased with 6 DKK/GJ in 2025. Both taxes will be indexed yearly and are an implementation of the 2020 Green Tax reform Agreement.

TABLE 4.7 TRENDS IN TAXES ON DIFFERENT TYPES OF PETROL 2010, 2015 AND 2020-2023, DKK PER LITRE
Source: Ministry of Taxation

DKK per litre	2010	2015	2020	2021	2022	2023
Petrol, with lead[1]	4.567	4.959	5.162	5.207	5.227	5.301
Petrol, lead-free	3.881	4.209	4.382	4.419	4.436	4.499

[1] The term has been kept even though petrol companies in Denmark ceased using lead for octane improvement in 1994.

The gas tax on natural and town gas was introduced in its current form on 1 January 1996 with a rate for both natural and town gas at DKK 0.01/Nm^3. There has been taxation on gas, however, since 1 January 1979, when the tax on town gas and LPG was introduced. The tax on town gas was cancelled again in June 1983 and regulation of the tax on LPG was transferred to the Mineral-gas Tax Act when this Act entered into force. From 1 January 2015 a tax on biogas was introduced. The tax rates on gas from recent years are shown in Table 4.8.

Further, the tax rate for gas used in businesses are increased with 6 DKK/GJ which is phased in from 2023 to 2025. The tax rate for gas used in mineral processes etc. and agriculture etc. are increased with 6 DKK/GJ in 2025. Both taxes will be indexed yearly and are an implementation of the 2020 Green Tax reform Agreement.

TABLE 4.8 TAXES ON GAS 2010, 2015 AND 2020-2023, DKK PER NM^3
Source: Ministry of Taxation

DKK per Nm^3	2010	2015	2020	2021	2022	2023
Natural gas	2.270	2.158	2.246	2.486	2.496	2.531
Town gas	2.270	2.158	2.246	2.486	2.496	2.531

The coal tax was introduced on 1 July 1982 and constituted DKK 127/tonne for hard coal and DKK 91/tonne for lignite and lignite briquettes on the day of entry into force. In the period 1 January 1997 - 31 December 2015 the tax increased from DKK 950/tonne to DKK 1526/tonne for hard coal and DKK 700/tonne to DKK 1036/tonne lignite. The rates have since 2008 developed as shown in Table 4.9. With effect from 1 January 1999, the so-called waste heat tax introduced (see Law no. 437 of 26 June 1998) as part of the Coal Tax Act. The waste heat tax was introduced in connection with increases in general taxes on fossil fuels to avoid giving too much incentive in favour of waste-based heat production, and to counteract the increased incentive for incineration of waste instead of recycling. Since 1 January 2010 the tax has been based on the energy and CO_2 content of the waste. After the restructuring of the tax on waste, the waste incineration tax was transferred from the Waste Tax Act to the Coal Tax Act and carbon dioxide tax law (see Law no. 461 of 12 June 2009 and the entry into force of Executive Order no. 1125 of 1 December 2009). Context of the proposal was especially that the then tax structure for waste fuels and fossil fuels taken together could result in waste streams being affected, so waste is not disposed of where it was most effective regarding utilization of energy from waste. The purpose of the change was to make waste more cost-efficient, which means a welfare economic gain. The change improves the tax structure, because the waste now ordered virtually the same charges as fossil fuels. The restructuring charges will then be more neutral with respect to where the waste is burned. From 1 January 2010, energy from waste incineration is imposed a waste heat tax, surcharge and the CO_2 tax. CO_2 tax only applies for waste that is not biodegradable.

TABLE 4.9 TRENDS IN COAL TAXES 2010, 2015 AND 2020-2023, DKK PER TONNE
Source: Ministry of Taxation

DKK per tonne	2010	2015	2020	2021	2022	2023
Hard coal	1605	1526	1588.6	1758.1	1765	1790
Lignite	1089	1036	1078.5	1193.5	1198	1215

The electricity tax was introduced on 1 April 1977. With effect from 1 January 2013, the tax on electricity used for heating was reduced considerably, to take into account, that an increasing amount of renewable energy was being used in electricity production. It has been estimated that this will lead to an emission reduction outside the emissions trading scheme of 0.15 million tonnes CO_2 in 2015 and 0.29 million tonnes in 2018. Table 4.10 shows the development in electricity tax rates since 2010.

From 1 May 2018 until the end of 2019 the tax on electricity for heating was further reduced from DKK 0.407 per kWh by DKK 0.15 per kWh. In 2020 it was reduced by DKK 0.20 per kWh and from 2021 it was reduced by DKK 0.10 per kWh from 2021.

To implement elements of the 2020 Climate Agreement for energy and industry the tax on electrical heating was reduced from 0.155 DKK/kWh to 0.004 DKK/kWh for industries and to 0.008 DKK/kWh for households in 2021 in accordance with the EU minimum tax rates.

To support the green transition, a decrease on the electricity tax was agreed upon in the 2022 New reform package for Danish economic. The tax on electricity was reduced from 0,9 DKK/kWh to 0,796 DKK/kWh phased in from 2022-2030.

As a compensation for the high energy prices, the tax on electricity is temporarily reduced from 0,763 DKK/kWh to 0,723 in the 4th quarter of 2022 and further to 0,688 in 2023. Further, the Winter Help Agreement entailed a temporary reduction on the electricity tax to the EU minimum tax rate on 0,008 DKK/kWh in the first 6 months of 2023.

TABLE 4.10 TRENDS IN ELECTRICITY TAXES 2010, 2015 AND 2020-2023, DKK PER KWH
Source: Ministry of Taxation

DKK per kWh	2010	2015	2020	2021	2022	2023
Consumption of electricity, exceeding 4,000 kWh in all-year residences heated by electricity and electricity for space heating and comfort cooling in VAT registered business	0.545	0.380	0.210	0.008	0.008	0.008
Other electricity	0.659	0.878	0.892	0.900	0.900[1] 0.763[2] 0.723[3]	0.008[4] 0.697[5]

[1]From 1 January 2022 – 30 June.
[2]From 1 July 2022 – 30 September 2022.
[3]From 1 October 2022 – 31 December 2022.
[4]From 1 January 2023 – 30 June 2023.
[5]From 1 July 2023 – 31 December 2023.

The CO_2 tax on energy products was introduced on 1 March 1992 and was imposed on different types of energy products relative to their CO_2 emissions. A tax reduction was given to light and heavy industrial processes. From 1 January 2010 a structural change in the CO_2 tax was implemented as an adaption to the EU Emissions Trading Scheme. The tax rate was increased to DKK 150 /tonne of CO_2 indexed as mentioned below, cf. table 4.11. In total, this structural change in the CO_2 tax was estimated to lead to a reduction in the CO_2 emissions of 0.69 million tonnes.

Large waste incineration facilities are from 1 January 2013 included in the emissions trading scheme. This will lead to a reduction of CO_2 emissions outside the ETS of approximately 8.9 million tonnes.

Fossil energy products used for space heating are imposed the CO_2 tax regardless of the production is included in the ETS or not. Space heating included in the emission trading scheme is thus double taxed.

TABLE 4.11 CO_2 TAX RATES, 2000-2009, 2010, 2015 AND 2020-2023, STATED IN DKK PER TONNE OF CO_2

Source: Ministry of Taxation

DKK per tonne	2000-2004	2005-2009	2010[1]	2015	2020	2021	2022	2023
Basic rate								
Heating in industry	100	90	155.4	170.0	177.0	178.5	179.2	181.7
Light industrial processes								
Basic rate	90	90	-	-				
With a voluntary agreement	68	68	-	-				
Resulting subsidy	22	22	-	-				
Heavy industrial processes								
Basic rate	25	25	-	-				
With a voluntary agreement	3	3	-	-				
Resulting subsidy	22	22	-	-				
Industrial processes covered by the Emission Trading Scheme								
Basic rate [2]	-	-	0	0	0	0	0	0

1 As of 1 January 2010 a structural change in the CO_2 tax was implemented. For the industries not regulated by the emissions trading scheme, a fixed lump sum transfer based on historical emissions was given, while the base rate was considerably increased to match the expected price of CO_2 quotas.

2Before 2010, the industrial processes covered by the ETS were taxed according to the table, depending on the type of process

Table 4.12 shows examples of the different types of CO_2 taxes converted into consumer units.

In addition to this, there are CO_2 taxes on heating tar, crude oil, coke, crude oil coke, lignite briquettes and lignite, LPG, and other gases.

As of 1 January 2008 the CO_2 taxes follow a yearly regulation of 1.8% in the period 2008-2015, like the energy taxes. From 2016 the tax is regulated with the consumer price index two years prior as the energy taxes.

TABLE 4.12 EXAMPLES OF CO_2 TAXES

Source: Ministry of Taxation

	Unit	2010	2015	2020	2021	2022	2023
Gas oil and diesel oil	*DKK/litre*	0.413	0.451	0.469	0.474	0.475	0.482
Gas oil and diesel oil containing 4,8% bio fuel	*DKK/litre*	0.385	0.420	0.437	0.441	0.443	0.449
Fuel oil	*DKK/kg*	0.493	0.539	0.561	0.565	0.568	0.576
Lignite	*DKK/tonne*	225.8	306.8	319.4	322.1	323.4	328.0
Natural gas and town gas	*DKK/Nm³*	0.351	0.384	0.400	0.403	0.405	0.410
Petrol	*DKK/litre*	0.373	0.408	0.425	0.428	0.430	0.436
Petrol containing 4,8% bio fuel	*DKK/litre*	0.355	0.388	0.404	0.407	0.409	0.415

4.3.3.1.2 Transport

In the transport sector, the number of cars in Denmark and the use of motorised vehicles are influenced by the tax on cars and fuels. The latter has been described above.

The registration tax on motorised vehicles is based on the value of the vehicle. Further, an additional CO_2 element is added to the tax, so the cars that have higher CO_2-emissions also pay a higher tax. Passenger cars, light commercial vehicles and motorbikes are due to pay the registration tax.

Zero- and low-emission vehicles receive a tax advantage in the registration tax compared to conventional vehicles. The tax advantage is larger for zero-emission vehicles (typically electrical vehicles) than for low-emission vehicles (typically plug-in hybrid vehicles). For zero-emission vehicles, the registration tax is discounted to

40 % of the full tax, and then subtracted a flat fee of up to 165,000 DKK in 2023, while for low-emission vehicles, the registration tax is discounted to 55 % of the full tax, and then subtracted a flat fee of up to 47,500 DKK. The discount consists of a lower rate and a higher tax deduction. These tax advantages will be reduced gradually towards 2030, but not to zero.

Car owners have to pay half-yearly ownership taxes which for new cars registered after July 1st 2021 are differentiated in accordance with the CO_2-emissions, while for older cars, the taxes are differentiated in accordance with the fuel efficiency expressed in kilometres per litre.

4.3.3.2 HFCs, PFCs, and SF_6 - taxes and duties relevant to these emissions

Since 1 March 2001, imports of industrial gases HFCs, PFCs, and SF_6 (F-gases) in the industry/business sector have been subject to taxation. The tax is differentiated in accordance with the global warming potential of the substance with DKK 0.15 per kilogramme of CO_2 equivalents as the general principle and with DKK 600 per kilogramme as a general upper limit cf. the examples in Table 4.13.

As the taxes on industrial gases are based on the CO_2 tax, there was an increase in 2011, from DKK 0.10 per kilogramme of CO_2 equivalents to DKK 0.15, following the increased CO_2 tax rate shown in Table 4.11. The impact of this increase is expected to lead to a reduction in the emission of the industrial gasses of 0.02 million tonnes CO_2 equivalents.

There was a further increase in tax rates from July 1th 2021 by approximately 30 DKK per ton CO_2 equivalents, and tax rates are indexed in 2021 with 5.5 pct. and in 2024 with 3.6 pct., which is equivalent to an indexation of 1.8 pct. yearly in the period 2021-2025. Furthermore, the general upper limit of the tax rate of 600 DKK per kilogram was removed.

TABLE 4.13 EXAMPLES OF TAXES ON F-GASES, 2018 AND 2023
Source: Ministry of Taxation

Substance	GWP (AR4)	GWP (AR5)	Tax in DKK per kg 2018	Tax in DKK per kg 2023
HFC-134a	**1430**	**1300**	215	270
R404a (a combination of 3 HFCs)	**3922**	**3943**	588	738
SF_6	**22800**	**23500**	600	4,294

4.3.3.3 Tax on methane emissions from natural gas fired power plants - equal in terms of CO_2 equivalents to the CO_2 tax.

As of 1 January 2011, a tax on methane emissions - equal in terms of CO_2 equivalents to the CO_2 tax - from natural gas fired power plants was introduced. This is expected to reduce methane emissions from gas engines through behavioural changes such as changing from motor operation to boiler operation and establishing mitigation measures. Consumption is also expected to fall as the price of heat will increase. These behavioural changes will result in falls in the emissions of unburned methane from power stations. In addition, CO_2 emissions will fall and consumption of natural gas will fall. In total, a decline of 0.06 million tonnes CO_2 equivalent emissions in 2 out of 5 years is expected, corresponding to an average annual reduction effect of approximately 0.02 million tonnes CO_2 equivalent per year in 2008-12.

Table 4.14 contains an overview of all existing taxes and duties relevant to greenhouse gas emissions in Denmark.

TABLE 4.14 OVERVIEW OF TAX AND DUTY MEASURES

Name of mitigation action	Included in with measures GHG projection scenario *	Sector(s) affected	GHG(s) affected	Objective and/or activity affected	Type of instrument	Status of implementation	Brief description	Start year of implementation	Implementing entity or entities	Estimate of mitigation impact (not cumulative, in $ktCO_2e$)**	
										2020	2030
1-TD-01b: Mineral-oil Tax Act	Yes	2: Energy consumption, 3: Transport	Carbon dioxide (CO_2), Methane (CH_4), Nitrous oxide (N_2O)	2_14: Demand management/reduction, 3_20: Demand management/reduction	Economic, Fiscal	Implemented	Tax on mineral oil products in Denmark. The Mineral-oil Tax Act entered into force on 1 January 1993. Before this, the tax on petrol was regulated via the Petrol Tax Act, which entered into force on 1 January 1983, and the Act on Taxation of Gas Oil and Diesel Oil, Heating Oil, Heating Tar, and Crude Oil was regulated via the Act on Taxation of certain Oil Products, which entered into force on 3 October 1977. From 1 June 1999 a tax differentiation between light diesel and diesel low in sulphur was introduced, to encourage the use of diesel low in sulphur, which is less polluting than light diesel. This was accomplished and a change took place soon after to the effect that almost all diesel sold was low in sulphur. The purpose of further differentiation from 1 January 2005 favouring sulphur-free diesel was likewise to encourage the use of this type of diesel in favour of diesel low in sulphur, and this has been successful. In addition, tax differentiation has been introduced in order to achieve environmental goals other than direct reductions in greenhouse gas emissions. Thus tax differentiation has been introduced with a view to phasing out lead in petrol.	1993	Danish Ministry of Taxation	NE	IE
1-TD-02: Gas Tax Act	Yes	1: Energy supply, 2: Energy consumption	Carbon dioxide (CO_2), Methane (CH_4), Nitrous oxide (N_2O)	1_06: Efficiency improvement in the energy and transformation sector, 2_14: Demand management/reduction	Economic, Fiscal	Implemented	Tax on consumption of natural gas and town gas in Denmark.	1996	Danish Ministry of Taxation	NE	IE
1-TD-03: Coal Tax Act	Yes	1: Energy supply, 2: Energy consumption	Carbon dioxide (CO_2), Methane (CH_4), Nitrous oxide (N_2O)	1_06: Efficiency improvement in the energy and transformation sector, 2_14: Demand management/reduction	Economic, Fiscal	Implemented	Tax rated after the calorific value of coal, coke, furnace coke, coke gravel, crude coke, lignite briquettes and lignite, tall oil, wood tar, vegetable pitch etc.	1982	Danish Ministry of Taxation	NE	IE
1-TD-04: Electricity Tax	Yes	1: Energy supply, 2: Energy consumption	Carbon dioxide (CO_2), Methane (CH_4), Nitrous oxide (N_2O)	1_06: Efficiency improvement in the energy and transformation sector, 2_14: Demand management/reduction	Economic, Fiscal	Implemented	Tax on consumption of electricity. The electricity tax was introduced on 1 April 1977. With effect from 1 January 2013, the tax on electricity used for heating was reduced considerably, to take into account, that an increasing amount of renewable energy was being used in electricity production.	1977	Danish Ministry of Taxation	NE	IE
1-TD-05: CO_2 tax on energy products	Yes	1: Energy supply, 2: Energy consumption	Carbon dioxide (CO_2)	1_06: Efficiency improvement in the energy and transformation sector, 2_14: Demand management/reduction	Economic, Fiscal	Implemented	Tax on energy products depending on their contribution to CO_2 emissions. The CO_2 tax on energy products was introduced on 1 March 1992 and was imposed on different types of energy products relative to their CO_2 emissions. From 1 January 2010 a structural change in the CO_2 tax was implemented as an adaption to the EU Emissions Trading Scheme. The tax rate was increased to DKK 150 /tonne of CO_2 indexed. In addition to this, there are CO_2 taxes on heating tar, crude oil, coke, crude oil coke, lignite briquettes and lignite, LPG, and other gases. As of 1 January 2008 the CO_2 taxes follow a yearly regulation of 1.8% in the period 2008-2015, similar to the energy taxes. From 2016 the tax is regulated with the consumer price index two years prior.	1992	Danish Ministry of Taxation	NE	IE
1-TD-06: Green Owner Tax - a fuel-efficiency-dependent annual tax on motor vehicles	Yes	3: Transport	Carbon dioxide (CO_2), Methane (CH_4), Nitrous oxide (N_2O)	3_20: Demand management/reduction	Economic, Fiscal	Implemented	Car owners have to pay half-yearly taxes which for new cars from july 1st 2021 and onwards are differentiated in accordance with the expected CO_2-emissions.	1997	Danish Ministry of Taxation	NE	IE
1-TD-07: Registration Tax - a fuel-efficiency-dependant registration tax on passenger cars and vans	Yes	3: Transport	Carbon dioxide (CO_2), Methane (CH_4), Nitrous oxide (N_2O)	3_20: Demand management/reduction	Economic, Fiscal	Implemented	The registration tax on motorised vehicles is calculated on basis of the value of the vehicle. Further an additional CO_2 element is added to the tax, so the cars that have higher CO_2-emissions also pay a higher tax. Passenger cars, light commercial vehicles and motorbikes are due to pay the registration tax. Further the registration tax is lower for zero- and lowemissions cars to support the uptake of these	2000	Danish Ministry of Taxation	NE	IE
1-TD-08: Tax on HFCs, PFCs and SF6 - equivalent to the CO_2 tax	Yes	4: Industrial processes	Hydrofluorocarbons (HFC), Perfluorocarbons (PFC), Sulphur hexafluoride (SF_6)	4_28: Replacement of fluorinated gases by gases with a lower GWP value	Economic, Fiscal	Implemented	Tax on HFCs, SF_6 and PFCs. The tax is differentiated in accordance with the global warming potential of the substance with DKK 0.15 per kilogramme of CO_2 equivalents as the general principle and with DKK 600 per kilogramme as a general upper limit.	2001	Danish Ministry of Taxation	NE	IE
1-TD-09: Tax on methane from natural gas fired power plants - equivalent to the CO_2 tax	Yes	1: Energy supply	Methane (CH_4)	1_05: Reduction of losses, 1_08: Control of fugitive emissions from energy production	Economic, Fiscal	Implemented	Tax on methane emissions from natural gas fired power plants - equal in terms of CO_2 equivalents to the CO_2 tax. As of 1 January 2011 a tax on methane emissions - equal in terms of CO_2 equivalents to the CO_2 tax - from natural gas fired power plants was introduced. This is expected to reduce methane emissions from gas engines through behavioural changes such as changing from motor operation to boiler operation and establishing mitigation measures. Consumption is also expected to fall as the price of heat will increase. These behavioural changes will result in falls in the emissions of unburned methane from power stations. In addition, CO_2 emissions will fall and consumption of natural gas will fall. In total, a decline of 0.06 million tonnes CO_2 equivalent emissions in 2 out of 5 years is expected, corresponding to an average annual reduction effect of approximately 0.02 million tonnes CO_2 equivalent per year in 2008-12.	2011	Danish Ministry of Taxation	NE	IE

TABLE 4.14 OVERVIEW OF TAX AND DUTY MEASURES (CONTINUED)

Name of mitigation action	Included in with measures GHG projection scenario *	Sector(s) affected	GHG(s) affected	Objective and/or activity affected	Type of instrument	Status of implemen-tation	Brief description	Start year of imple-men-tation	Implementing entity or entities	Estimate of mitigation impact (not cumulative, in ktCO2e)**	
										2020	2030
1-TD-12: Extension of low process electricity tax for charging electric and plug-in hybrid cars that subscribe to driving power through a business service until 2031	Yes	3: Transport	Carbon dioxide (CO2)	3_19: Electric road transport	Economic	Implemented	Extension of low process electricity tax for charging electric and plug-in hybrid cars that subscribe to driving power through a business service until 2030	2020	Danish Ministry of Taxation	NE	IE
1-TD-13: Increase in CFC tax [enhancement of 1-TD-08]	Yes	4: Industrial processes	Hydrofluorocarbons (HFC), Perfluorocarbons (PFC), Sulphur hexafluoride (SF6)	4_28: Replacement of fluorinated gases by gases with a lower GWP value	Economic, Fiscal	Adopted	The tax on HFCs, SF6 and PFCs is increased by 1. july 2021. The taxrates for the gasses are increased by approximately 30 DKK pr. ton CO2e. The ceiling of the taxrate, which amounted to 600 DKK pr. kg, is removed. The taxrates are indexed in 2021 with 5.5 pct. and in 2024 with 3.6 pct., which is equivalent to an indexation of 1,8 pct. yearly in the period 2021-2025. The lower limit on taxation of import and manufactoring of gasses are removed. [enhancement of 1-TD-08]	2021	Danish Ministry of Taxation	NA	IE
1-TD-14: Mileage-based toll for trucks	Yes	3: Transport	Carbon dioxide (CO2)	3_20: Demand management/reduction, 3_21: Improved behaviour	Economic, Fiscal	Adopted	The mileage-based toll for trucks will be in place from 2025.	2021	Danish Ministry of Taxation	NA	IE
G12: Green tax reform, phase 1	Yes	2: Energy consumption, 3: Transport	Carbon dioxide (CO2), Methane (CH4), Nitrous oxide (N2O)	2_14: Demand management/reduction, 3_20: Demand management/reduction	Other	Implemented	The green tax reform, phase 1 aims for a higher and more uniform tax on CO2 emissions based on the existing energy tax system and extent the tax base to areas that are relatively well defined. [changes to 1-TD-1b, 1-TD-2, 1-TD-3 og 1-TD-04?]	2021	Danish Ministry of Taxation	NA	NE
G13: Increased space heating tax (fossil fuels) and reduced electric heating tax	Yes	2: Energy consumption	Carbon dioxide (CO2), Methane (CH4), Nitrous oxide (N2O)	2_14: Demand management/reduction	Other	Implemented	With the climate agrement for industri and energy in 2020, the space heating tax (fossil fuels) was increased by from 56,7 DKK pr. GJ to 62,3 DKK pr. GJ (in 2020 prices) and the electric heating tax was reduced from 15,8 øre/kWh to 0,4 øre/kWh for VAT registered business and 0,8 øre/kWh for households pr. 1. January 2021. [changes to TD-x (heat tax) and TD-4 (electricity tax)?]	2021	Danish Ministry of Taxation	NA	NE

* Here “Yes” means included in the "with measures" projection scenario, in principle. In most cases not based on separate annual estimates for each mitigation action, but either as a result of the assumption that the measure has contributed to the observed level of total Danish greenhouse gas emissions in the most recent inventory year available, when the projection was elaborated and therefore used as the starting point for the projections, or as part of the integrated models used to project the level of annual greenhouse gas emissions in future years.
** See explanatory note under Table 4.26.

4.3.4 Cross-cutting – Carbon Capture and Storage and Green Research

4.3.4.1 Carbon capture and storage

In 2022, Denmark adopted a so-called green tax reform with the objective of achieving a reduction of 4.3 million tonnes of CO_2 emissions annually by 2030. This green tax reform entails the introduction of a more consistent CO_2 tax structure. By 2030, companies outside the EU's Emissions Trading System (ETS) will face a uniform CO_2 tax rate of 750 DKK/tonne, while ETS companies will be subject to a CO_2 tax rate of 375 DKK/tonne. Notably, mineralogical processes, particularly subject to risks of carbon leakage, will be subject to a reduced tax rate of 125 DKK/tonne. As part of the reform, tax revenues generated would be allocated to support further reductions and removals, for example through Carbon Capture and Storage (CCS) initiatives. Approximately 17 billion DKK are expected to be allocated for a CCS funding scheme between 2026 and 2043. The CCS funding scheme is expected to achieving reduction/removals of 1.8 million tonnes of CO_2 emissions annually by 2030.

Moreover, Denmark has introduced a funding scheme to develop and showcase the country's first full value chain for carbon capture, utilization, and storage (CCUS). The CCUS funding scheme has a total budget of 16 billion DKK from 2025 to 2049 and is expected to achieving a reduction/removals of 0.9 million tonnes of CO_2 emissions annually by 2030. In the first competitive bidding funding round completed in May 2023, Ørsted was awarded a 20-year contract to capture and store 0.43 mio. tonnes of CO_2 annually from 2026 by means of BECCS.

Furthermore, a funding scheme has been adopted aimed at achieving carbon removals (negative emissions) from technological sources. This funding scheme has a budget of 2.5 billion DKK from 2025 to 2032, and is expected to achieving removals of 0.5 million tonnes of CO_2 emissions annually by 2030. The initiative provides support for carbon removals from a variety of biogenic sources, which includes CO_2 captured from biogas being upgraded to biomethane (Bio-CCS), CCS with biomass-based energy production (BECCS), CCS on the biogenic fraction of CO_2 captured from waste incineration and industrial plants, as well as direct carbon capture from the atmosphere and storage (DACCS).

These initiatives are included in Table 4.15.

4.3.4.2 Green research

The allocation of research funding in Denmark's government budget is subject to annual negotiation among the Parties in the Danish parliament, based on a proposal presented by the government.

In recent years, the Danish research and innovation policy has placed a strong emphasis on addressing climate challenges and contributing to the goals defined in the Danish Climate Act.

The 2022 budget includes a research reserve agreement of DKK 2.4 billion, with budgetary reservations extending from 2023 to 2025 as shown in Table 4.15. Notably, a significant portion of the total budget for 2022, amounting to DKK 1.6

billion, is specifically earmarked for green research, development, and demonstration projects. The allocation is distributed as follows:

- DKK 700 million for green research, technology, and innovation through Denmark's Innovation Fund.
- DKK 310.5 million for green missions.
- DKK 110 million for green research through Denmark's Free Research Foundation.
- DKK 40 million for the National Center for Climate Research (NCKF).
- DKK 40 million for enhancing green research supporting the public administration.
- DKK 13 million for international research collaboration and strengthened monitoring of green research.

In the 2023 research reserve agreement, totalling DKK 3.6 billion, nearly half of the funds, amounting to DKK 1.7 billion, are designated for research projects that support the green transition. These activities encompass various areas, including research on carbon capture and storage, as well as the utilization of CO_2 and green fuels within the transport and industrial sectors.

TABLE 4.15 CROSS-CRUTTING MEASURES – CARBON CAPTURE AND STORAGE AND GREEN RESEARCH

Name of mitigation action	Included in with measures GHG projection scenario *	Sector(s) affected	GHG(s) affected	Objective and/or activity affected	Type of instrument	Status of implemen-tation	Brief description	Start year of imple-men-tation	Implementing entity or entities	Estimate of mitigation impact (not cumulative, in ktCO2e)**	
										2020	2030
0-CC-01: Funds for supporting capturing and storing CO2 (CCS)	No	1: Energy supply, 4: Industrial processes	Carbon dioxide (CO2)	1_07: Carbon capture and storage or carbon capture and utilisation	Economic	Adopted	In 2022, Denmark adopted a so-called green tax reform with the objective of achieving a reduction of 4.3 million tonnes of CO2 emissions annually by 2030. This green tax reform entails the introduction of a more consistent CO2 tax structure. By 2030, companies outside the EU's Emissions Trading System (ETS) will face a uniform CO2 tax rate of 750 DKK/tonne, while ETS companies will be subject to a CO2 tax rate of 375 DKK/tonne. Notably, mineralogical processes, particularly subject to risks of carbon leakage, will be subject to a reduced tax rate of 125 DKK/tonne. As part of the reform, tax revenues generated would be allocated to support further reductions and removals, for example through Carbon Capture and Storage (CCS) initiatives. Approximately 17 billion DKK are expected to be allocated for a CCS funding scheme between 2026 and 2043. The CCS funding scheme is expected to achieving reduction/removals of 1.8 million tonnes of CO2 emissions annually by 2030.	2026	The Danish Ministry of Climate, Energy and Utilities	NA	IE
0-CC-02: Market-based subsidy pool for capturing and storing CO2	Yes	1: Energy supply, 4: Industrial processes	Carbon dioxide (CO2)	1_07: Carbon capture and storage or carbon capture and utilisation	Economic	Adopted	Denmark has introduced a funding scheme to develop and showcase the country's first full value chain for carbon capture, utilization, and storage (CCUS). The CCUS funding scheme has a total budget of 16 billion DKK from 2025 to 2049 and is expected to achieving a reduction/removals of 0.9 million tonnes of CO2 emissions annually by 2030. In the first competitive bidding funding round completed in May 2023, Ørsted was awarded a 20-year contract to capture and store 0.43 mio. tonnes of CO2 annually from 2026 by means of BECCS.	2025	The Danish Ministry of Climate, Energy and Utilities	NA	IE
0-CC-03: Technology-neutral funds for supporting CO2 capture etc.	Yes	1: Energy supply, 4: Industrial processes	Carbon dioxide (CO2)	1_07: Carbon capture and storage or carbon capture and utilisation	Economic	Adopted	A funding scheme has been adopted aimed at achieving carbon removals (negative emissions) from technological sources. This funding scheme has a budget of 2.5 billion DKK from 2025 to 2032, and is expected to achieving removals of 0.5 million tonnes of CO2 emissions annually by 2030. The initiative provides support for carbon removals from a variety of biogenic sources, which includes CO2 captured from biogas being upgraded to biomethane (Bio-CCS), CCS with biomass-based energy production (BECCS), CCS on the biogenic fraction of CO2 captured from waste incineration and industrial plants, as well as direct carbon capture from the atmosphere and storage (DACCS).	2025	The Danish Ministry of Climate, Energy and Utilities	NA	IE
0-CC-04: Investment in green research, development, and demonstration.	No	3: Transport, 4: Industrial processes, 5: Waste management/waste, 6: Agriculture, 7: LULUCF	Carbon dioxide (CO2), Methane (CH4), Nitrous oxide (N2O), Hydrofluorocarbons (HFC), Perfluorocarbons (PFC), Sulphur hexafluoride (SF6)	3_24: Other transport, 4_29: Other industrial processes, 5_38: Other waste, 6_45: Other agriculture. , 7_56: Other land use, land-use change and forestry	Economic	Adopted	Investment in green research, development, and demonstration cf. the research reserve agreement for 2022 and 2023 - 2025. EUDP is reported separately (23 / 2-EN-06). The allocation of research funding in Denmark's government budget is subject to annual negotiation among the Parties in the Danish parliament, based on a proposal presented by the government. In recent years, the Danish research and innovation policy has placed a strong emphasis on addressing climate challenges and contributing to the goals defined in the Danish Climate Act. The 2022 budget includes a research reserve agreement of DKK 2.4 billion, with budgetary reservations extending from 2023 to 2025.	2022	The Danish Ministry of Higher Education and Science	NA	IE

* Here "Yes" means included in the "with measures" projection scenario, in principle. In most cases not based on separate annual estimates for each mitigation action, but either as a result of the assumption that the measure has contributed to the observed level of total Danish greenhouse gas emissions in the most recent inventory year available, when the projection was elaborated and therefore used as the starting point for the projections, or as part of the integrated models used to project the level of annual greenhouse gas emissions in future years.
** See explanatory note under Table 4.26.

4.3.5 Energy (Fuel Combustion, including Transport, and Fugitive Emissions from Fuels)

Greenhouse gas emissions from energy (as defined by the 2006 IPCC Guidelines for greenhouse gas inventories – i.e. from energy consumption and – in the case of Denmark – from flaring) made up 60% of Denmark's total greenhouse gas emissions in 2020 (with LULUCF), of which CO_2 was the primary emission. 97.7% of the emissions from the energy sector are CO_2. 1.0% is methane (CH_4), and the remaining 1.3% is nitrous oxide (N_2O).

4.3.5.1 CO_2

Energy production and energy-consuming activities in the transport sector and industry are main contributors to the total emissions of CO_2 due to use of coal, oil and natural gas. The energy sector is, therefore, centrally placed in efforts to reduce emissions of CO_2.

Many initiatives have been taken over the years to reduce the emissions, and work is still going on to find the best and most cost-effective measures with the objective to fulfil Denmark's international climate obligations.

Danish experience shows that through persistent and active energy policy focus on enhanced energy efficiency and conversion to cleaner and renewable energy sources, it is possible to sustain high economic growth and at the same time reduce fossil fuel dependency and protect the environment.

The energy sector is fully liberalised. Today, electricity production from Danish power plants is controlled by market forces. Danish electricity generation is traded freely across national borders on the Nordic and the north-German electricity markets. Thus there is a significant extent of integration in the Northern European electricity market. This entails, for example, that increased use of renewable energy in the Danish electricity system or enhanced efforts to save electricity do not automatically mean that generation at coal-fired power plants is reduced correspondingly during the first commitment period of the Kyoto Protocol 2008-2012.

The introduction of the CO_2 allowance regulations through the EU emissions trading scheme (EU ETS) has been pivotal for Denmark's possibilities to comply with the climate commitments. The EU ETS constitutes a central instrument in ensuring that the Danish energy sector is enabled to provide the reductions required if Denmark is to comply with its climate obligations. At the same time, the EU ETS permits significant improvements to the cost effectiveness of Denmark's climate effort.

The government's long-term objective is to become a nation with an energy supply solely based on renewable energy sources and thus independent of fossil fuels.

The objective of the Danish energy policy today is security of supply, environmental concerns, energy savings and well-functioning energy markets within frameworks that secure cost effectiveness. Several initiatives often meet more than one of the purposes mentioned at the same time. Efforts concerning climate change should thus be seen in a broader context than CO_2 alone, not least when it comes to the purpose and calculation of effects.

Denmark gave priority to renewable energy sources and energy efficiency early on. Most of the public support schemes and regulations have prioritised energy efficiency and renewable energy. In this respect the development in Denmark has been quite different from other IEA countries, which have invested in new energy supply – notably nuclear energy.

Danish public support programmes have instigated competition amongst private companies. Most public support for energy research and development in Denmark has been open for competing applicants. Similarly, all procurement of energy technologies induced by public schemes has followed EU rules requiring open tenders or has left it to competitive markets in general.

A large number of policies and measures have been implemented over the years to meet the various energy-policy objectives cf. Table 4.16.

4.3.5.1.1 The allowance regulation relevant to the energy sector

A key instrument for reaching the goals for emission reductions is the EU Emission Trading Scheme (EU ETS), which is a CO_2 allowance scheme for energy production and energy-intensive industries as described in section 4.3.1. The EU Member States have devised this trading scheme for greenhouse gas emissions in order to fulfil the international climate commitments set out in the Kyoto Protocol, in particular with the aim of reducing CO_2 emissions from energy production and energy-intensive industries.

The allowances scheme entered into force on 1 January 2005. The 2005-2007 period was used as a testing phase. The EU ETS Directive has been revised a number of times.

The allowance allocation for 2008-2012 was determined on the basis of the national allocation plan from July 2006, submitted the European Commission. The EU ETS 2008-2012 has been an important measure in Denmark's fulfilment of its climate obligations under the first commitment period of the Kyoto Protocol. The scheme aligns well with government policy for the energy area on liberalisation of the energy markets and management of environment efforts by the market.

The installations subject to the allowance regulations account for a little less than half of Danish emissions of greenhouse gases. Almost all major Danish installations with considerable emissions are covered by the ETS. Most of these are generators of power and heat, the rest are industrial enterprises plus a few production units within the offshore sector.

Both the statutory and the administrative basis for the scheme have been established. The necessary legal basis was adopted by the Danish Folketing in June 2004 and the 2008-2012 national allocation plan was approved by the European Commission on 31 August 2007.

According to the national allocation plan for the period 2008-2012 an average annual allowance of 24.5 million tonnes CO_2 has been allocated. According to the allocation plan this should correspond to a drop in annual emissions of about 5 million tonnes per year in 2008-2012, or a reduction of about 17% compared with emissions expected in the national allocation plan for the period. This level was set by balancing environmental considerations against competitiveness and jobs:

- Electricity and heat producers were allocated about 15.8 million EAUs. The allowance for electricity generation is allocated as ”per kWh”, while for heat production allowances are allocated according to emissions in the base years 1998-2004.

- The other 133 installations (industry and offshore) have been allocated allowances corresponding to emissions in the base years 1998-2004. A total of 8.2 million tonnes CO_2 per year have been allocated to industry and offshore.

- A special reserve of 0.5 million tonnes CO_2 per year has been allocated with free allowances for new installations and significant extensions to existing units.

Allowances not allocated by the end of the commitment period or returned due to closures have been auctioned. The period 2008 – 2012 was finalized in 2013 with the final surrendering of allowances and credits by companies participating in the EU ETS as shown in section 4.3.1.

The new EU Climate and Energy Agreement from December 2008 extended the ETS system to 2013-2020 in order for the EU to reduce CO_2 emissions by 20% in 2020. At the same time allocation was centralised and auctioning is to be used more extensively from 2013. The allowances have been calculated for this period in accordance with the EU benchmarking decision 2011/278/EU.

The legislative framework of the EU ETS for its next trading period 2021-2030 (phase 4) was revised in early 2018 to enable it to achieve the EU's 2030 emission reduction targets in line with the 2030 climate and energy policy framework and as part of the EU's contribution to the 2015 Paris Agreement.

The Fit for 55 package, endorsed on 8 February 2023 by the Permanent Representatives Committee, proposes to revise several pieces of EU climate legislation, including the EU ETS, setting out in real terms the ways in which the Commission intends to reach EU climate targets under the European Green Deal. The revised EU ETS Directive, which will apply for the period 2021-2030, will enable this through a mix of interlinked measures - e.g. a mayor revision of EU ETS as well as inclusion of ETS Maritime and ETS Transport, Building and Industries.

4.3.5.1.2 Energy and CO_2 taxes

Taxes have also been used for many years as an instrument to reduce CO_2 emissions from the energy sector, since fuels used for heat production are subject to energy and CO_2 taxes. The main objective is general GHG reductions and the promotion of the use of fuels with lower CO_2 emissions, mainly biomass. Energy and CO_2 taxes are described in detail in section 4.3.3.

4.3.5.1.3 Combined heat and power and liberalisation of waste incineration

The main elements of the Danish strategy to promote renewable energy and the efficient use of energy resources since the end of the 1970s have been increased use of CHP and expanding of district heating areas. Effective heat supply planning has ensured the highest share of district heating and CHP in the Western Hemisphere. This has secured early markets for district heating technologies and a possibility for the use of many renewable energy sources like straw, municipal waste, wood waste and geothermal energy. CHP plants produce about 36% of Denmark's domestic electricity consumption, and the potential for further use of CHP is limited. Wind energy delivered about 53% of domestic electricity supply in 2021. Consequently, CHP production will decrease in the future, though CHP and the valuable services CHP plants provide - also in terms of back up capacity – will remain an integral part of the overall system.

Historically, CHP has been promoted in various ways, e.g. through favourable taxation schemes, and an obligation for consumers to connect to district heating systems, should they be rolled out in consumer areas. These were important schemes for expanding district heating in Denmark. However, due to an update to EU's state aid rules, the so-called "base subsidy" for decentral CHP plants was revoked in 2018, causing great change to the heating sector. The 2018 Energy Agreement aimed to modernise the heating sector and mitigating the impacts of eliminating the "base subsidy".

Regulatory constraints on the heat production of district heating plants were eliminated, giving them the freedom to invest in transitions to greener energy, e.g. heat pumps, biomass and geothermal systems, thus enabling the transition towards a renewable energy system. The regulatory relief for individual district heating plants depends on the size of their district heating areas. The last constraints are expected to be lifted by 2030 at the latest.

The 2018 Energy Agreement gave consumers a greater freedom of heating choice. The power to obligate consumers to be connected to the collective heating system was abolished. This allowed for investment in other individual heating solutions, e.g. heat pumps for single homes.

No new consumer obligations are permitted as from January 2019.

The purpose of the modernisation was to ensure that the district heating sector remained viable without public subsidies. In the short term, the elimination of this base subsidy may cause higher heating bills for some consumers. Therefore, the energy agreement also allocated DKK 540 million in the period 2018-2023 for targeted efforts to help heating plants and consumers, and to help manage stranded costs.

In 2020, Denmark adopted a new energy agreement where one of the initiatives targeted the transition to green district heating. With the agreement came a series of changes to the regulation of the heating sector that affected combined heat and power plants.

With the agreement, the cogeneration requirement was repealed, meaning that there is no longer a requirement for heat production facilities in central areas to have to be established as cogeneration. Furthermore, the fuel-binding requirement for the natural gas-based district heating areas was repealed, meaning that there is no longer a requirement for the cogeneration plants in these areas to produce heat/power with natural gas and/or oil. The purchase obligation for natural gas was repealed, while the purchase obligation for district heating was modernized. The modernization meant that the purchase obligation for district heating does not apply if a central heating plant's utilization of its own excess heat or production of renewable energy is more economically advantageous than district heating. Lastly, an adjustment to the socioeconomic requirement for new or refurbished heating plants was repealed, meaning that the project approving authority could choose not to compare the projects socio economy with fossil-based alternatives, to advance the establishment of green heating projects.

In 2022, Denmark again adopted a new energy agreement of which two initiatives will affect the combined heat and power plants. With the agreement, Denmark is working towards a complete prohibition against the approval of new projects for heat-only technologies that use fossil fuels as main fuel for base, upper base and peak loads for district heating. Only reserve or emergency load units are exempted.

Furthermore, the district heating companies must submit a plan for phasing out the natural gas in their purely heat-producing facilities (gas boilers) before the end of 2023. Thus, district heating companies producing heat and power with an installed gas boiler, must prepare a plan for the replacement of their natural gas consumption.

As almost all waste incineration plants in Denmark have energy recovery, primarily heat for district heating, emissions from waste incineration are reported under the IPCC catgory "Energy" (i.e. not under "Waste"). However, in Denmark, the waste sector is treated as one economic sector. Although CO_2 emissions from waste incineration are included under the EU ETS, additional national efforts have been made to seek to reduce these emissions. On June 16, 2020, the Danish Government and Parties representing a broad majority in the Danish Parliament entered into an agreement on a '*Climate plan for a green waste sector and a circular economy*'. As a follow-up to this plan, a supply-based model for waste incineration in Denmark was adopted by a majority in the parliament in June 2023. It is estimated that the implementation of this supply-based model will reduce CO_2 emissions from waste incineration in Denmark.

4.3.5.1.4 Renewable energy

The increasing use of renewable energy sources is reducing emissions of CO_2 from fossil fuels. The long term goal for the Danish government is to be a climate neutral society by 2045.

In Climate Projection 2022, the estimates for 2030 are the following: approximately 63% renewable energy in gross energy consumption; approximately 109% of electricity consumption to be supplied by renewable energy; gross energy consumption will decrease slightly towards 2030; and by 2030 greenhouse gas emissions will be reduced by 57% compared to 1990.

The expansion of energy from offshore wind turbines will – according to the estimated results in Climate Projection 2022 – help ensure that 64% of the nation's energy needs are met with renewable energy by 2030.

Onshore wind power and solar photovoltaic power
Electricity production from onshore wind and solar has historically been supported by various support schemes. Most recently, Denmark has carried out technology neutral tenders from 2018 to 2021 where onshore wind, solar PV and open-door offshore wind projects could compete for the lowest possible support. With the Climate Agreement from June 2022, the parties behind the agreement decided to discontinue the technology neutral tenders and it is expected that onshore wind and solar projects will be installed subsidy-free going forward.

Since 2018 Denmark has supported installation of R&D onshore wind turbines with the aim of supporting the technological development of wind energy and ensuring continued development activities. In 2022, a majority of parties entered into an agreement to continue the support. Denmark continuously works to support and ensure good framework conditions for testing experimental turbines, which can promote the industry's opportunities to bring new wind turbine types to the market. At present, a national screening is being carried out for the location of a possible third test centre as well as an EIA process with a view to adapting the Høvsøre test center to the wind turbine types of the future.

Offshore wind power
Since 2012, a number of political agreements have been concluded regarding offshore wind energy in Denmark. The agreements are *the 2012 Energy Agreement*, *the 2018 Energy Agreement*, *the 2020 Climate Agreement for Energy and Industry*, *the 2021 Additional Agreement on ownership and construction of the Energy Islands etc*., the 2021 and 2022 underlying tender preparing Partial Agreements, *the 2022 Additional Agreement for Energy Island Bornholm*, *the Finance Act of 2022, the 2022 Climate Agreement* and *the May 2023 Additional agreement on tender requirements for 6 GW OWF and Energy Island Bornholm*.

In accordance with *the 2012 Energy Agreement* the two Offshore Wind Farms (OWFs) Horns Rev 3 (407 MW) and Kriegers Flak (604 MW) has been fully commissioned in August 2019 and September 2021. Furthermore, the nearshore wind farms from *the 2012 Energy Agreement*, Vesterhav Syd (170 MW) and Vesterhav Nord (180 MW) are expected fully commissioned in 2023.

In *the 2018 Energy Agreement*, it was decided to establish three new OWFs towards 2030. The first OWF, Thor Havvindmøllepark (1000 MW), has finalized the tender process and is expected fully commissioned in 2027. The second OWF, Hesselø Havvindmøllepark, is delayed due to challenging seabed but is expected fully commissioned in 2029 with a capacity between 800 – 1.200 MW. The agreeing parties of *the 2020 Climate Agreement* decided that the third OWF is a part of the coming Energy Island Bornholm.

In *the 2020 Climate Agreement* it was decided to establish two Energy Islands with connected OWFs. One in the North Sea (10 GW) and one in the Baltic Sea (2 GW) on Bornholm. *The 2022 Additional Agreement for Energy Island Bornholm* expanded the capacity for Energy Island Bornholm with an additional 1 GW to a total of 3 GW. The Energy Island Bornholm is expected fully commissioned in 2030 and the 3 GW of the North Sea Energy Island is expected fully commissioned in 2033. *The 2020 Climate Agreement* stipulates a long-term ambition of minimum 10 GW connected to the North Sea Energy Island.

The Finance Act of 2022 further stipulated an additional tendering of 2 GW offshore wind energy. One of the 2 GW is placed at Energy Island Bornholm cf. *the 2022 Additional Agreement for Energy Island Bornholm*.

The 2022 Climate Agreement decided additional tendering of minimum 4 GW offshore wind energy with commissioning prior 2030.

Furthermore, the Danish Government has granted permits to establish Frederikshavn Havvindmøllepark. The project will have a capacity of 72 MW.

In May 2023, *the Additional agreement on tender requirements for 6 GW OW and Energy Island Bornholm* decided the tender requirements of 6 GW off-shore wind (OW) and 3 GW related to Energy Island Bornholm. Furthermore, this agreement allows overplanting and thus the potential for collectively 14 GW or more. The agreement enables that the tender process can begin, with the political aim of full commission of the collective 9 GW OW in 2030 and two years later for overplanting.

Biomass
In 2021, biomass accounted for approximately 58% of renewable-energy production, mostly in the form of straw, wood pellets, wood chip and biodegradable waste for incineration. Approximately 50% of the biomass was imported, mainly in the form of wood pellets (65 PJ), biofuels (12.9 PJ), wood chips (22 PJ), fire wood (1.6 PJ) and biodegradable waste for incineration (2.8 PJ).

The energy production from biomass has more than doubled since 1990 - primarily due to the policy agreement from 1993 (the Biomass Agreement: requires power plants to use 1.4 million tonnes of straw and wood, equivalent to almost 20 PJ per year) and the policy agreement from February 2008 on the increased use of straw and chips at the large co-generation plants (up to 700,000 tonnes in 2011). In recent years, the consumption have stabilised. However, from 2020 to 2021 the consumption of biomass increased due to an increased use of mainly wood.

Since the mid 1990s biogas plants have been established with reliable operation and with an sustainable economy, and they accounted for 13.8 % of renewable-energy production in.

Liquid biofuels, such as animal and vegetable oils, biodiesel and bioethanol, are used only on a small scale. Liquid biofuels from bio-waste by the so-called second-generation technologies are at a low level.

4.3.5.1.5 Fuel conversion from coal to natural gas

Substitution of coal and oil by natural gas reduces emissions of CO_2. The first Danish natural gas was landed from the Danish sector of the North Sea in 1984, and since then consumption of natural gas has increased to 193 PJ in 2001. Since then, consumption has decreased to 92 PJ in 2021 due mainly to high gas prices. In 2021, natural gas covered 13% of gross energy consumption. In the power sector, natural gas was introduced in 1985 and peaked with 25% around 2000. In 2021, this had decreased to 4%, mainly due to the relation between power prices and gas prices. The use of natural gas is expected to decrease further as a result of introducing more renewable energy and extensive energy-saving policies.

In 2021, a new gas strategy was published. The strategy explores the potential of biogas and other green gases and lay the foundation for achieving a 100% green gas system in Denmark, thus contributing to a climate-neutral Denmark by 2050 at the latest cf. the Danish Climate Act.

4.3.5.1.6 Research and development

Danish support for new energy technologies has been comprehensive and relatively stable. A long list of direct and indirect support schemes and policies have, in combination, created a domestic market which has given Danish companies a boost. This boost has enabled many companies to become international market leaders. Danish companies continue to enjoy commercial success within the energy-related marketplace.

R&D activities include energy savings, more efficient energy conversion, renewable energy technologies, Power-to-X, CCUS and efforts within System Integration and Smart Energy.

Research and development activities in the field of energy are not motivated solely by climate issues, but are relevant to climate issues, since they contribute to determining the overall framework for the CO_2 intensity of energy production and consumption in the future.

There is a broad political commitment to support R&D activities through public funding.

Thus Denmark has chosen to strengthen the dedicated public investments in clean energy research, development and demonstration focusing on reduction of technology costs and CO_2 emissions and with an emphasis on innovative projects that can be replicated and scaled up with the involvement of private investors. There are two major public funding instruments within energy technology.

The EUDP programme was established in 2008 and since then the programme has supported more than 1200 projects with a total of DKK 6 billion. On average, 45-50% of the activities under the Programme are financed by the EUDP and hence the private investments in the supported projects are of the same size as the public support leading to approximately to DKK 12 billion in total investments. The Danish Parliament has dedicated DKK 500 million for EUDP for the fiscal year 2022.

Activities relating to strategic research and innovation in general are since 2014 administrated by Danish Innovation Fond. The Fund covers all sorts of research and innovation projects and is not limited to energy matters. However, for 2023 at least DKK 320 million will be earmarked for R&D within new and clean energy technologies.

Four research missions have been launched in 2021. Three of them are related to the energy and climate field in themes like CCUS, Green Fuels and Environmental friendly Agriculture. They are now established as partnerships. In 2023, the public funding is DKK 300 million.

A minor programme, ELFORSK, is administrated by the Danish Energy Agency in collaboration with the Danish energy association Green Power . The objective is to support research and development of efficient energy use and flexibility solutions within electricity and energy via data, digitization and sector coupling in accordance with environmental and socio-economic considerations, including the dissemination of methods, solutions, analyses and models. The annual funds for this programme are DKK 25 million.

Intensifying energy and climate research as we move towards 2030 will ensure continued efforts to develop the technologies that will help Denmark’s energy system transition to cleaner and greener solutions. Research and development in new energy and climate technology solutions will also generate new opportunities for growth, jobs and Danish technology exports.

The research funding will support Denmark’s commitment to the international collaboration Mission Innovation, in which a number of countries have pledged to increase energy research funding by 2020. With an ambitious funding target of 1 billion DKK from 2024 onwards, Denmark further cements its long-term commitment to research, development and demonstration in the field of energy and climate. Through Danish initiatives such as the Energy Technology Development and Demonstration Program (EUDP) and Innovation Fund Denmark, Denmark is contributing to the global cooperation to develop the energy and climate technologies of tomorrow.

The EUDP funding will support the development and demonstration of Danish energy technology solutions, with a view to subsequent commercialisation. These solutions may range from new floating foundations for offshore wind turbines, to large scale demonstration projects such as Greensand, which injects CO_2 in the deployed oil fields in the North sea.

Strategic and applied energy research is among the many activities supported by Innovation Fund Denmark. This funding is awarded directly to talented researchers, entrepreneurs and companies, as well as to others with strong ideas about energy technology solutions for the benefit of society.

4.3.5.1.7 Energy savings

Reducing energy consumption by increasing energy efficiency and promoting energy saving is a very important element for Danish energy policy.

Among the grid and distribution companies (electricity, natural gas, oil and heating), the electricity companies have been working with energy savings since the early 1990s and the natural gas and district heating companies have been working with energy savings since 2000.

The Energy Efficiency Obligation Scheme
Since 2006, several political agreements have been reached to significantly strengthen the energy savings efforts in Denmark.

The obligations have been implemented as voluntary agreements between the energy minister and grid and distribution companies under the Energy Efficiency Obligation Scheme (EEO). The companies' costs are financed by a levy on their tariffs.

In the policy agreement from 2012, the obligation for the grid and distribution companies in the electricity, natural gas, district heating and oil sectors was increased by 75% in 2013 and 2014 (to 10.7 PJ) and by 100% in 2015 (to 12.2 PJ). In December 2016, the Minister of Energy, Utilities and Climate entered a new agreement on energy savings with the grid and distribution companies for the period 2016-2020. The obligation was decreased from 12.2 PJ to 10.1 PJ in 2016 to 2020. Following from a political agreement, the EEO was discontinued by the end of 2020 and replaced with new policy measures

Political Agreements directed towards energy efficiency / energy consumption
In May 2020, a political agreement to ensure green renovation of the social housing sector in 2020 and from 2021-2026 was reached. The agreement entails a structural shift in the Danish National Building Fund's support system containing a new green support criterion, a new green guarantee and a trial scheme for sustainable projects that will improve the energy efficiency of buildings in the social housing sector.

In June 2020, the Danish Climate Agreement for Energy and industry 2020 was reached. The agreement includes measures, which are expected to procure sizeable energy savings, which contributes to the fulfilment of the energy savings obligation. Policies include a substantial expansion and advancement of the subsidy scheme related to private enterprises, of the subsidy scheme related to residential buildings and the subsidy scheme to replace oil boilers with heat pumps in buildings outside the district heating and gas grids. Furthermore, the agreement includes funds for a focused energy efficiency effort in the period 2021-2030.

In December 2020, the political agreement A Green Transition of the Transport sector was reached. The agreement includes among other a reorganization of the current taxation of cars so that users have a greater incentive to choose electric cars over conventional fossil fuel technology.

In December 2020, an agreement on the state budget law for 2021 and on Stimuli and Green Recovery was reached. Along with other initiatives funds from 2021 and forward for a subsidy scheme, that provides subsidies to energy efficiency in regional and municipal buildings, incl. renovations, conversions from oil and gas boilers to heat pumps or district heating and digital solutions are allocated.

In December 2020, an agreement on a Green Tax reform was reached, which includes an increase in energy taxation on business energy consumption for process purposes. Inhere there are also allocated further funds for the for the competitive subsidy scheme related to private enterprises. With the agreement, it was agreed that energy taxes should be restructured to reflect CO_2-emissions. Starting 2025 and fully phased in by 2030, a tax will be set directly targeting CO_2-emissions which by 2030 will cost DKK 750 per tonnes of CO_2 for non-ETS businesses and DKK 375 per tonnes of CO_2 for ETS businesses, excepting businesses with mineralogical processes – these businesses will pay a tax of DKK 125 per tonnes of CO_2 emitted in 2030.

4.3.5.1.8 Stop for oil and gas extraction in the North Sea

In December 2020, a broad majority in the Danish Parliament reached a deal on the future of fossil extraction in the North Sea, which led to the cancellation of the 8th licensing round and all future tender rounds to extract oil and gas. The deal also establishes a final phase-out date of fossil extraction by 2050 and lays out plans for a just transition of impacted workers.

The stop for oil and gas extraction in the North Sea in 2050 and cancellation of 8th and future tender rounds for new licences for exploration and production of oil and gas as well as reducing the area for oil and gas extraction to the western part of the North Sea implies a cessation of all activities in 2050.

The agreement sets the direction towards a climate neutral Denmark and a complete phase-out of fossil fuel production by 2050, while simultaneously nailing down remaining rules to ensure stability and safeguard employment in the impacted regions.

The agreement includes of the following main elements

- A 2050 cutoff date for all oil and gas extraction.
- A cancellation of the 8th licensing round and all future licensing rounds.
- A commitment to lead a global campaign on the role of fossil fuel producing countries.
- A just transition initiative in the affected region to ensure development and employment.
- Remaining rules nailed down to ensure stability, including access to two other licensing schemes with limited scope. However any such permits would still have to adhere to 2050 date.
- An initiative to explore the potential of carbon capture and storage, using old oil and gas wells.

TABLE 4.16 MEASURES IN THE ENERGY SECTOR (SEE ALSO SPECIFIC ENERGY MEASURES IN TABLE 4.17 (BUSINESS), 4.18 (HOUSEHOLDS) AND 4.19 (TRANSPORT))

Name of mitigation action	Included in with measures GHG projection scenario *	Sector(s) affected	GHG(s) affected	Objective and/or activity affected	Type of instrument	Status of implemen-tation	Brief description	Start year of imple-men-tation	Implementing entity or entities	Estimate of mitigation impact (not cumulative, in ktCO2e)**	
										2020	2030
2-EN-01: EU-CO2-emission trading scheme for electricity and district heat production and certain industrial processes (incl. Business) and aviation from 2012 (EU ETS)	Yes	1: Energy supply, 3: Transport, 4: Industrial processes	Carbon dioxide (CO2), Nitrous oxide (N2O), Perfluorocarbons (PFC)	1_01: Increase in renewable energy sources in the electricity sector, 1_02: Increase in renewable energy in the heating and cooling sector, 1_03: Switch to less carbon-intensive fuels, 1_05: Reduction of losses, 1_06: Efficiency improvement in the energy and transformation sector, 3_23: Reduce emissions from international air or maritime transport, 4_27: Improved control of manufacturing	Regulatory, Economic	Implemented	A key instrument for reaching the goals for emission reductions is the EU Emission Trading Scheme (EU ETS), a cap and trade based CO2 allowance scheme for energy production and energy-intensive industries. The EU Member States progress with this trading scheme for greenhouse gas emissions in order to fulfil the international climate commitments set out in the Kyoto Protocol and Paris agreement, aiming to reduce CO2 emissions from covered installations and flights. The installations subject to EU ETS covers about half of Danish emissions of greenhouse gases. Statutory and administrative basis for the scheme have been established. Allowances prices have particular significance for Danish emissions as they affect the need to initiate other mitigation initiatives. Introducing the Marked Stability Reserve has had major impact on price levels thus supporting national efforts. Efforts to further increase the level of ambition in EU climate policy are key in the Danish government's climate change policy to achieve ambitious national targets. The legislative framework of the EU ETS (2021-2030) was revised in 2018 and 2023 to enable it to achieve the EU's 2030 emission reduction targets.	2005	The Danish Energy Agency , Entities under the EU ETS	NE	IE
2-EN-02: Biomass Agreement (Agreement on the use of biomass in electricity production)	Yes	1: Energy supply	Carbon dioxide (CO2)	1_01: Increase in renewable energy sources in the electricity sector	Economic, Voluntary/negotiated agreements	Implemented	In 2021, biomass accounted for approximately 58 % of renewable-energy production, mostly in the form of wood pellets, wood chip, straw and biodegradable waste for incineration. In 2021 approximately 50 % of the biomass was imported, mainly in the form of wood pellets, wood chips, fire wood and biodegradable waste. The energy production from biomass has more than doubled since 1990, and the consumption has now stabilized. However, from 2020 to 2021 the consumption of biomass increased due to an increased use of mainly wood pellets. Since the mid-1990s biogas plants have been established with reliable operation and with an acceptable economy biogas, and they now account for 13,8 % of renewable-energy production in 2021. Liquid biofuels, such as animal and vegetable oils, biodiesel and bioethanol, is used only on a small scale. Liquid biofuels from bio-waste by the so-called second generation technologies are at a low level.	1993	The Danish Energy Agency , Entities under the EU ETS	NE	IE
2-EN-03: Price supplement and subsidies for renewable energy production	Yes	1: Energy supply	Carbon dioxide (CO2)	1_01: Increase in renewable energy sources in the electricity sector	Economic	Implemented	The Danish state grants subsidies for renewable energy production from wind, solar and bio energy. From 2022 subsidies are financed on the Danish state budget and will replace the financing current Public Service Obligation (PSO) levied on domestic energy consumption which is being phased out. New RE installations in Denmark are primarily subsidised through tender based schemes where developers compete for a limited susidy budget. The different subsidy schemes contribute to increase the RE share in the Danish energy	2008	The Danish Energy Agency , Entities under the EU ETS	NE	IE
2-EN-04: Tenders for offshore wind turbines	Yes	1: Energy supply	Carbon dioxide (CO2)	1_01: Increase in renewable energy sources in the electricity sector	Regulatory	Implemented	In accordance with the 2012 Energy Agreement the two Offshore Wind Farms (OWFs) Horns Rev 3 (407 MW) and Kriegers Flak (604 MW) has been fully commissioned in August 2019 and September 2021. Furthermore, the nearshore wind farms from the 2012 Energy Agreement, Vesterhav Syd (170 MW) and Vesterhav Nord (180 MW) are expected fully commissioned in 2023. In the 2018 Energy Agreement , it was decided to establish three new OWFs towards 2030. The first OWF, Thor Havvindmøllepark (1000 MW), has finalized the tender process and is expected fully commissioned in 2027. The second OWF, Hesselø Havvindmøllepark, is delayed due to challenging seabed but is expected fully commissioned in 2029 with a capacity between 800 – 1.200 MW. The agreeing parties of the 2020 Climate Agreement decided that the third OWF is a part of the coming Energy Island Bornholm. In the 2020 Climate Agreement, it was decided to establish two Energy Islands with connected OWFs. One in the North Sea (10 GW) and one in the Baltic Sea (2 GW) on Bornholm. The 2022 Additional Agreement for Energy Island Bornholm expanded the capacity for Energy Island Bornholm with an additional 1 GW to a total of 3 GW. The Energy Island Bornholm is expected fully commissioned in 2030 and the 3 GW of the North Sea Energy Island is expected fully commissioned in 2033. The 2020 Climate Agreement stipulates a long-term ambition of minimum 10 GW connected to the North Sea Energy Island. The Finance Act of 2022 further stipulated an additional tendering of 2 GW offshore wind energy. One of the 2 GW is placed at Energy Island Bornholm cf. the 2022 Additional Agreement for Energy Island Bornholm. The 2022 Climate Agreement decided additional tendering of minimum 4 GW offshore wind energy with commissioning prior 2030. Furthermore, the Danish Government has granted permits to establish Frederikshavn Havvindmøllepark and Aflandshage Havvindmøllepark with a total capacity of 72 MW. In May 2023, the Additional agreement on tender requirements for 6 GW OW and Energy Island Bornholm decided the tender requirements of 6 GW off-shore wind (OW) and 3 GW related to Energy Island Bornholm. The May 2023 agreement, furthermore allows overplanting and thus the potential for collectively 14 GW or more. The agreement enables that the tender process can begin, with the political aim of full commission of the collective 9 GW OW in 2030 and two years later for overplanting.	2013	The Danish Energy Agency , Entities under the EU ETS	NE	IE

TABLE 4.16 MEASURES IN THE ENERGY SECTOR (SEE ALSO SPECIFIC ENERGY MEASURES IN TABLE 4.17 (BUSINESS), 4.18 (HOUSEHOLDS) AND 4.19 (TRANSPORT)) (CONTINUED)

Name of mitigation action	Included in with measures GHG projection scenario *	Sector(s) affected	GHG(s) affected	Objective and/or activity affected	Type of instrument	Status of implemen-tation	Brief description	Start year of imple-men-tation	Implementing entity or entities	Estimate of mitigation impact (not cumulative, in ktCO2e)**	
										2020	2030
2-EN-06: Energy development and demonstration	Yes	1: Energy supply	Carbon dioxide (CO2), Methane (CH4), Nitrous oxide (N2O)	1_01: Increase in renewable energy sources in the electricity sector, 1_02: Increase in renewable energy in the heating and cooling sector, 2_14: Demand management/reduction	Information	Implemented	Danish support for new energy technologies has been comprehensive and relatively stable. The creation of a domestic market has given Danish companies a boost. This boost has enabled many companies to become international market leaders. . R&D activities include energy savings, more efficient energy conversion, renewable energy technologies and efforts within System Integration and Smart Energy. The Danish Energy Technology Development and Demonstration Programme (EUDP) was established in 2007 and since then the programme has supported more than 1000 projects with a total of DDK 5 billion. On average, 50% of the activities under the Programme are financed by the EUDP and hence the private investments in the supported projects are of the same size as the public support leading to approximately to DKK 10 billion in total investments. In 2018, the energy and climate research was strengthened with the 2018 Energy Agreement with the intention to phase in additional state funding going from 580m DKK in 2020 to a target of 1 billion DKK annually from 2024. The research funding will support Denmark's commitment to the international collaboration Mission Innovation. With a funding target of 1 billion DKK from 2024 onwards, Denmark further cements its long-term commitment to research, development and demonstration in the field of energy and climate.	2008	The Danish Energy Agency	NE	IE
2-EN-07: Liberalization of waste incineration plants	Yes	1: Energy supply, 7: Waste management/waste	Carbon dioxide (CO2), Methane (CH4), Nitrous oxide (N2O)	1_05: Reduction of losses, 5_31: Enhanced recycling	Regulatory	Adopted	On June 16, 2020, the Danish Government and Parties representing a broad majority in the Danish Parliament entered into an agreement on a 'Climate plan for a green waste sector and a circular economy'. As a follow-up to this plan, a supply-based model for waste incineration in Denmark was adopted by a majority in the parliament in June 2023.	2025	The Danish Ministry of Climate, Energy and Utilities	NA	IE
2-EN-08: Phasing out fossil fuels and promoting locally based RE-heat by adjustment of requirements for district heating projects	Yes	1: Energy supply	Carbon dioxide (CO2), Methane (CH4), Nitrous oxide (N2O)	1_03: Switch to less carbon-intensive fuels, 1_06: Efficiency improvement in the energy and transformation sector	Regulatory	Adopted	The "social economy requirement" of district heating projects is adjusted in order to promote district heating projects based on RE-technologies and locally produced heating.	2021	The Danish Ministry of Climate, Energy and Utilities	NA	IE
2-EN-09: Establishment of two energy islands	Yes	1: Energy supply	Carbon dioxide (CO2), Methane (CH4), Nitrous oxide (N2O)	1_01: Increase in renewable energy sources in the electricity sector	Regulatory	Adopted	A broad majority of the Danish Parliament agreed on 22 June 2020 to initiate the realization of two energy islands. On 4 February 2021, the parties behind the climate agreement decided on the ownership and construction type of the energy island in the North Sea, which will be built as an artificial or caisson island where the state will have the majority of the ownership. The energy island will connect and distribute power from the surrounding offshore wind farms. The island will have a minimum capacity of 3 GW, with potential for expansion to 10 GW offshore wind. The energy island is to be located west of Jutland in the North Sea at a distance of approx. 80 km from the town of Thorsminde. The energy island will be able to serve offshore wind farms with a capacity of 3 GW with the option of expansion to 10 GW at a later stage and will become the largest offshore wind farm in Denmark	2021	The Danish Ministry of Climate, Energy and Utilities	NA	IE
2-EN-10: Stop oil and gas extraction in the North Sea in 2050 and cancellation of 8th and future tender rounds	Yes	1: Energy supply	Carbon dioxide (CO2), Methane (CH4), Nitrous oxide (N2O)	1_05: Reduction of losses	Regulatory	Adopted	The stop for oil and gas extraction in the North Sea in 2050 and cancellation of 8th and future tender rounds for new licences for exploration and production of oil and gas as well as reducing the area for oil and gas extraction to the western part of the North Sea implies a cessation of all activities in 2050.	2021	The Danish Ministry of Climate, Energy and Utilities	NA	IE

* Here "Yes" means included in the "with measures" projection scenario, in principle. In most cases not based on separate annual estimates for each mitigation action, but either as a result of the assumption that the measure has contributed to the observed level of total Danish greenhouse gas emissions in the most recent inventory year available, when the projection was elaborated and therefore used as the starting point for the projections, or as part of the integrated models used to project the level of annual greenhouse gas emissions in future years.

** See explanatory note under Table 4.26.

4.3.5.1.9 *Specific measures in the business sector (Fuel combustion in Manufacturing Industries and Construction, Commercial/Institutional and Agriculture, Forestry and Fisheries)*

Energy use in the business sector covers energy use in Manufacturing Industries and Construction, Commercial/Institutional and Agriculture, Forestry and Fisheries (cf. the 2006 IPCC Guidelines for greenhouse gas inventories). In 2020, energy use in the business sector was responsible for 12.4% of Denmark's total greenhouse gas emissions.

In 2020, the greenhouse gas emissions from energy use in the business sector decreased by approximately 43% from 8.8 million tonnes CO_2 equivalents in 1990 to 5.5 million tonnes CO_2 equivalents in 2020, primarily due to improvements in energy efficiency and energy savings.

According to the 2022 projection (CSO22), the expected emissions from the business sector's energy use are an average of 5.3 million tonnes CO_2 equivalents in 2021 decreasing to 3.2 million tonnes CO_2 equivalents in 2030.

The on-going initiatives to reduce emissions from the business sector include promotion of energy savings and energy-efficiency improvements as well as conversion of energy production from fossil process energy to less CO_2 emitting fuels. Certain energy-intensive businesses are also subject to allowances regulation as a consequence of the EU Emission Trading Scheme (ETS).

Analyses have shown that there is a significant potential for profitable energy-efficiency improvements within the business sector, so improving energy efficiency is a vital area of action. These energy efficiency improvements in themselves, however, will have a limited impact on CO_2 emissions. In order to reach emissions reduction targets, initiatives aimed at fuel shift will be introduced.

The measures implemented in the business sector are shown in Table 4.17.

Industry is responsible for most of the sectors' emissions of CO_2. The emissions come mainly from energy-consuming activities in industry. Cement and brick production also contributes especially high levels of CO_2, due to the raw materials used.

The main instrument to reduce CO_2 emissions in energy-intensive industry is the EU's emission allowance scheme, covering about 80 industry installations.

Business and industry have introduced major energy efficiency improvements over the past 25 years. This is mainly due to a green tax package for the business sector, which was firstly introduced in 1995. The package contained a combination of taxes and discounts for energy intensive enterprises. The package led to a higher CO_2 tax and the introduction of a space-heating tax for businesses. In order to get the tax discount, the eligible energy intensive enterprises have to sign an agreement on energy efficiency with the Danish Energy Agency. With the political agreement on economic growth from 2013, the CO_2 tax on electricity in production process in the industry was abolished and the voluntary agreement scheme ended. Electricity production is thus included in the ETS. With a political agreement on economy growth from July 2014 it was decided to revive the voluntary agreement scheme to subsidize electro-intensive enterprises for their payment of electricity tax – the so called Public Service Obligation levy (PSO). The PSO scheme entered into force in September 2015, and was phased out in 2020 (cf. the phase-out of the PSO mentioned in Chapter 4.3.4.1.4). In a political agreement from 2020 "Klimaaftalen for energi og industry mv.”, it was decided to incentivize usage of surplus heating from industrial processes for external purposes (e.g. district heating, industrial symbiosis). Thus, in 2021, a new voluntary scheme was introduced for businesses willing to make energy efficiency improvements in surplus heat used for external purposes. Businesses entering in to the scheme agrees to maintain ISO 50001:2018 with a focus on surplus heat and completing energy efficiency improvements related to surplus heat with a payback time less than five years. In return, the scheme subsidizes payment of the tax on externally used surplus heating. Currently, all surplus heating produced with other fuels than electricity is subject to taxation of 25 DKK/GJ. Participation in the scheme will lower the tax for externally delivered heat to 10 DKK/GJ (2018-prices).

Today businesses not included in the ETS are imposed the CO_2-tax on their fossil fuels for process and all businesses are imposed the CO_2-tax on their fossil fuels for space heating regardless whether the business is included in the ETS or not. Businesses pay an energy tax of DKK 4.5 per GJ (until March 2023) on their fossil fuels used for process and an energy tax of DKK 63.9 per GJ on their fossil fuels for space heating (2023 tax rates). Some businesses, e.g. mineralogical and metallurgical processes, are exempt of the energy tax on their process and agriculture pay a lower rate than DKK 4.5 per GJ. VAT registered businesses in general pay a tax on electricity of DKK 0.004 per kWh. From 2021 the tax rate applies for their electricity for space heating as well. Before 2021 the rate on their electricity for space heating was higher. With the agreement on a green tax reform in 2022 (“Aftale om Grøn skattereform for industry mv” of 24 June 2022), it was agreed that energy taxes should be restructured to reflect CO_2-emissions. Starting from 2023 and fully phased in by 2025, the reform will raise the energy tax on fossil fuels with DKK 6 per GJ. Starting 2025 and fully phased in by 2030, a tax will be set directly targeting CO_2-emissions, which by 2030 will cost DKK 750 for non-ETS businesses and DKK 375 for ETS businesses, excepting businesses with mineralogical processes. The latter will pay a tax of DKK 125 per ton CO_2 emitted in 2030.

As an element in the implementation of the 2012 energy policy agreement, a DKK 3.75 billion (in EUR 500 million) fund was established to subsidise industries to convert to renewable energy. As of August 2013, businesses have been able to get investment subsidy from this fund to convert from fossil fuel (i.e. coal, oil, gas) to renewable energy sources (i.e. biomass, solar, wind) or district heating in their production process. The subsidy also includes investments in energy-efficiency measures. The estimated effect of this “Renewables for industry” initiative is a reduction of 1 million tonnes of CO_2 per year from 2020 and onwards. As a result of a political agreement of November 2016, the scheme expired at the end of the 2016.

Large enterprises in Denmark are by law required to have a mandatory energy audit every fourth year, cf. paragraph 15 in law no. 296 of 17 March 2023 “lov om fremme af effektiv energianvendelse og drivhusgasreduktion”. The law transposes the energy efficiency directive article 8. In implementing the former article 8, Denmark has defined “large enterprises” as enterprises that do not fall under the category of micro, small and medium-sized enterprises as defined in accordance with the Commission’s recommendation 2003/361/EC of 6 May 2003. The definition of enterprises subject to mandatory energy audits will be revised in accordance with the new version of the Energy Efficiency Directive, to target instead enterprises with a high yearly energy consumption between 10-85 TJ. Enterprises with ISO 50.001 or ISO 14.001 are exempt. The deadline for the first energy audits was the 5 December 2015 and afterwards every fourth year. The scope of the energy audit is buildings, processes and transport. There is no requirement of implementing the energy saving proposals from the energy audits.

As part of a political agreement on economic growth from June 2014 a DKK 40 million (5.4 mio. EURO) fund was established to run a centre for energy savings in enterprises. The money was given for the period 2014-2017. The aim of the centre is to identify and exploit the energy efficiency potential already existing within primarily small and medium sized companies. The large companies are covered by the voluntary agrement scheme and the mandatory energy audit.

With a view to promote targeted energy savings, the 2018 Energy Agreement allows the current energy efficiency obligation scheme to expire by the end of 2020, and replaces it with a new subsidy scheme for energy efficiency improvements in businesses.

The 2018 Energy Agreement introduced a new scheme with subsidies for energy efficiency improvements in businesses from 2021-2024. The scheme was later prolonged with enhanced encouragements to make use of it. These funds will be limited to DKK 3.5 billion and there will be an individual subsidy cap. The scheme targets energy consumed in the delivery of services and manufacture of products – also known as “process energy”. As per January 2023, the scheme now subsidizes investments that reduce CO_2 emissions as well as improve energy-efficiency.

Denmark’s municipalities and regions own a total building mass of more than 36 million square metres. The energy efficient operation and renovation of these buildings holds great potential for reducing energy consumption. Therefore, the energy agreement allocates DKK 100 million annually in the period 2021-2024 for loans to finance energy renovations in buildings owned or operated by municipalities and regions.

The energy agreement allocates DKK 19 million in 2018, 33 million in 2019, 34 million in 2020, and 44 million annually from 2021-2024 for information activities relating to energy savings. This funding is also earmarked for the utilisation of data to promote energy efficiency.

TABLE 4.17 MEASURES IN THE BUSINESS SECTOR

Name of mitigation action	Included in with measures GHG projection scenario *	Sector(s) affected	GHG(s) affected	Objective and/or activity affected	Type of instrument	Status of implemen-tation	Brief description	Start year of imple-men-tation	Implementing entity or entities	Estimate of mitigation impact (not cumulative, in ktCO2e)**	
										2020	2030
3-BU-01: Agreements on energy efficiency with business.	Yes	2: Energy consumption	Carbon dioxide (CO_2), Methane (CH_4), Nitrous oxide (N_2O)	2_13: Efficiency improvement in industrial end-use sectors	Voluntary/negotiated agreements	Implemented	In connection with the implementation of the CO2 tax also a subsidy for CO2 tax discount for energy intensive industries was introduced. However, a condition for getting the CO2 tax discount is an agreement on improvements in energy efficiency between the company and the Danish Energy Agency. The first implementation period was 1993-2013. After one year expiration the voluntary agreement scheme was reintroduced in 2015. The electricity intensive companies get a subsidy for their PSO tax on electricity. The PSO-tax subisidy scheme was phased out with the end of 2020. The last subsidies was granted in january 2021.	1993	The Danish Energy Agency	NE	IE
3-BU-06: Circular on energy-efficiency in state institutions	Yes	2: Energy consumption	Carbon dioxide (CO_2), Methane (CH_4), Nitrous oxide (N_2O)	2_10: Efficiency improvements of buildings, 2_14: Demand management/reduction	Regulatory	Implemented	The circular require state institutions to: 1) Commit to two different energysavings targets (reduction of 42.480 MWh from 2021-2030 for buildings that are owned and used by the central government (e.i. EED art. 5) and 10 pct. reductions from 2021-2030 for the buildings that is not included in the EED art. 5 target, 2) Focus on energy efficiency in their behaviour 3) Buy energy efficient products 4) Operate state buildings in an energy efficient manner 5) Report the anual comsumption of energy and water to a public database, 6) Every ministry is required to develop an energy-effiencyplan on how they will reach to the target savings 7) Map all oilburners and gasfurnances in the buildings that are included in the circular.	2005	The Danish Energy Agency	NE	IE
3-BU-08: Renewables for the industry	Yes	1: Energy supply	Carbon dioxide (CO_2), Methane (CH_4), Nitrous oxide (N_2O)	1_01: Increase in renewable energy sources in the electricity sector, 1_02: Increase in renewable energy in the heating and cooling sector	Economic	Implemented	Businesses will be able to get support from a DKK 1.2 billion fund to convert to renewable energy sources or district heating in accordance with the following objectives: • Support businesses to replace fossil fuels with renewable energy – such as wind, solar, biogas or biomass – to power manufacturing, • Support businesses to replace fossil fuels by district heating. E.g. horticulture will be able to change from coal-fired boilers to district heating, • Support businesses to invest in energy-efficiency measures. The time limit within which the projects can request for support has been extended to 31 December 2023.	2013	The Danish Energy Agency , All public authorities and institutions	NE	IE
3-BU-09: Mandatory Energy Audit for large Enterprises	Yes	2: Energy consumption	Carbon dioxide (CO_2), Methane (CH_4), Nitrous oxide (N_2O)	2_13: Efficiency improvement in industrial end-use sectors	Regulatory	Implemented	Large enterprises in Denmark have by law for many years been required to have a mandatory energy audit every fourth year. The law is no. 345 of 8th of april 2014 "Lov om ændring af lov om fremme af besparelser i energiforbruget, lov om varmeforsyning, lov om kommunal fjernkølig og forskellige andre love". The law transposes the energy efficiency directive article 8. Denmark has defined large enterprise in accordance with the EU definitions saying that enterprises that do not fall under the category of micro, small and medium-sized enterprises, in accordance with the Commission's recommendation 2003/361/EC of 6 May 2003 concerning the definition of micro, small and medium-sized. Enterprises with ISO 50,001 or ISO 14,001 are exempt. The deadline for the first energy audits was the 5th of December 2015 and afterwards every fourth year. The scope of the energy audit are buildings, processes and transport. There is no requirement of implementing the energy saving proposals from the energy audits. With the Green Tax Reform agreed in June 2022, the requirement for energy audits was extended to include climate audits.	2014	The Danish Energy Agency	NE	IE
3-BU-11: Denmark's Export and Investment Fund (EIFO)	Yes	1: Energy supply, 2: Energy consumption, 3: Transport, 4: Industrial processes, 5: Waste management/waste	Carbon dioxide (CO_2), Methane (CH_4), Nitrous oxide (N_2O)	1_01: Increase in renewable energy sources in the electricity sector, 1_02: Increase in renewable energy in the heating and cooling sector, 1_03: Switch to less carbon-intensive fuels, 2_10: Efficiency improvements of buildings, 2_13: Efficiency improvement in industrial end-use sectors, 3_18: Low carbon fuels, 3_19: Electric road transport, 4_27: Improved control of manufacturing, 5_31: Enhanced recycling	Economic	Implemented	In 2022, the Danish Green Investment has been merged with Vaekstfonden and EKF Denmark's Export Credit Agency into Denmark's Export and Investment Fund (EIFO). The new fond still provides loan capital to invest in various projects facilitating a sustainable development of society. The fund is able to grant loans to all types of privately-held companies and non-profit housing associations as well as public companies and institutions, whose budgets are seperate from the state, the regions and the municipalities. The activities of the fund will have a positive environmental effect due to e.g. environmental savings, increased production of renewable energy sources, more resource-efficient utility of water and materials or better waste recycling.	2022	Ministry of Industry, Business and Financial Affairs	NA	IE

TABLE 4.17 MEASURES IN BUSINESS SECTOR (CONTINUED)

Name of mitigation action	Included in with measures GHG projection scenario *	Sector(s) affected	GHG(s) affected	Objective and/or activity affected	Type of instrument	Status of implemen-tation	Brief description	Start year of imple-men-tation	Implementing entity or entities	Estimate of mitigation impact (not cumulative, in ktCO2e)**	
										2020	2030
3-BU-13: Obligation for energy savings in government buildings	Yes	2: Energy consumption	Carbon dioxide (CO2), Methane (CH4), Nitrous oxide (N2O)	2_10: Efficiency improvements of buildings	Regulatory	Adopted	The obligation for energy savings in government buildings is an implementation of Articles 5 and 6 of the EU Energy Efficiency Directive (EED). Denmark is implementing the provision through the alternative method in which the energy consumption needs to be reduced by 42.480 MWh by 2030 compared to 2019. It is also a national policy measure to reduce the energy consumption in other buildings occupied by the state. Danish ministries are obligated to reduce energy consumption by about 10 pct. by 2030 compared to 2020.	2021	The Danish Ministry of Climate, Energy and Utilities	NA	IE
3-BU-14: Competitive subsidy scheme related to private enterprises	Yes	2: Energy consumption, 4: Industrial processes	Carbon dioxide (CO2), Methane (CH4), Nitrous oxide (N2O)	2_13: Efficiency improvement in industrial end-use sectors, 4_27: Improved control of manufacturing	Economic	Adopted	The subsidy scheme targets energy efficiency initiatives and the switch from fossil to renewable energy use in industry. Thus, the initiative will speed up energy efficiency measures and transition to green energy in industry, and lead to a reduction in greenhouse gas emissions. In total, 3.9 billion DKK is allocated to the scheme in the period 2020-2029.	2021	The Danish Ministry of Climate, Energy and Utilities	NA	IE
3-BU-15: Subsidy scheme for energy renovations in public buildings (municipalities and regions)	Yes	2: Energy consumption	Carbon dioxide (CO2), Methane (CH4), Nitrous oxide (N2O)	2_10: Efficiency improvements of buildings	Economic	Adopted	The Danish Government has established a subsidy scheme targeting energy renovations in public buildings of DKK 150 million annually in 2021 and DKK 145 million in 2022 (incl. derived tax losses). The subsidy will be targeted energy renovations in regional and municipal buildings with the lowest energy labels as well as the buildings that are heated by oil burners and gas furnaces. It is currently estimated that the effort can reduce greenhouse gas emissions by [0.004] million tonnes CO2 eq. in 2025 and 2030.	2021	The Danish Energy Agency	NA	IE
3-BU-16: Targeted support for horticulture	No	2: Energy consumption	Carbon dioxide (CO2)	2_14: Demand management/reduction	Economic	Adopted	The horticulture/green houses have good opportunities to transition away from fossil fuels, for example by converting to electric heat pumps, biomass, or district heating. However, their general competitive situation makes it difficult to bear the full economic cost of switching to renewable energy and a high CO2 tax is expected to result in reduced production, rather than transition to renewable energy. Therefore, there will be allocated funds to support the transition of the horticulture/greenhouses in 2025-2029.	2023	The Danish Ministry of Climate, Energy and Utilities	NA	IE
3-BU-17: Energy efficiency efforts	No	2: Energy consumption	Carbon dioxide (CO2)	2_10: Efficiency improvements of buildings, 2_11: Efficiency improvement of appliances, 1_06: Efficiency improvement in the energy and transformation sector	Economic	Adopted	The Danish Government has several energy efficiency efforts: - Buildings need an energy label after construction and on sale/rental. The label uses data and digital validation to improve accuracy. A new report layout was created in 2021 to improve user-friendliness, relevance, and actionable recommendations. - Denmark requires energy labels and plans for large public buildings every 10 years, and display them in a prominent place. A new regulation from 2021 aims to reduce energy consumption in central governmental buildings through renovations and behavioral measures. - Denmark has a national energy-labelling scheme for windows. The government offers a subsidy scheme for energy efficiency measures such as insulation, ventilation, and heat pumps. - DEA promotes energy-efficient behavior and solutions for households, businesses, and the public sector. They provide free advice, webinars, and local meetings to promote energy efficiency and the use of renewable energy sources. - Provides information and tools to craftsmen and educational institutions to promote energy efficiency. They also offer courses for craftsmen and collaborate with labor market training centers. - Energy companies offer subscription-based heat pump installations in smaller residential and commercial buildings since 2016. In 2020, a subsidy scheme was introduced for the company providing the subscription. - “Better Houses” promote energy renovation of buildings by providing a "one stop shop" service for homeowners, where they can contact one certified building contractor for overall counseling. Skilled craftsmen are educated to be advisors on energy renovation. - Denmark notified a long-term renovation strategy (LTRS) to support building stock renovation, including non-binding milestones for 2030, 2040 and 2050. The strategy outlines initiatives to promote energy efficiency in buildings.	2022	The Danish Ministry of Climate, Energy and Utilities	NA	IE

TABLE 4.17 MEASURES IN BUSINESS SECTOR (CONTINUED)

Name of mitigation action	Included in with measures GHG projection scenario *	Sector(s) affected	GHG(s) affected	Objective and/or activity affected	Type of instrument	Status of implemen-tation	Brief description	Start year of imple-men-tation	Implementing entity or entities	Estimate of mitigation impact (not cumulative, in ktCO2e)**	
										2020	2030
3-BU-19: Green reinsurance facility in EKF - now Denmark´s Export and Investment Fund	No	8: Other sectors	Carbon dioxide (CO2)	8_57: Member States shall provide a brief description of the objective.	Economic	Adopted	Green reinsurance facility in EKF - now Denmark´s Export and Investment Fund (new).	2023	Ministry of Industry, Business and Financial Affairs	NA	IE
3-BU-20: Green capital injection in Vaekstfonden - now Denmark´s Export and Investment Fund	No	8: Other sectors	Carbon dioxide (CO2)	8_57: Member States shall provide a brief description of the objective.	Economic	Adopted	Green capital injection in Vaekstfonden - now Denmark´s Export and Investment Fund (new).	2023	Ministry of Industry, Business and Financial Affairs	NA	IE

* Here “Yes” means included in the "with measures" projection scenario, in principle. In most cases not based on separate annual estimates for each mitigation action, but either as a result of the assumption that the measure has contributed to the observed level of total Danish greenhouse gas emissions in the most recent inventory year available, when the projection was elaborated and therefore used as the starting point for the projections, or as part of the integrated models used to project the level of annual greenhouse gas emissions in future years.
** See explanatory note under Table 4.26.

4.3.5.1.10 Specific measures in the transport sector

In 2020, the transport sector was responsible for 27.7% of Denmark's total greenhouse gas emissions. The emissions from the transport sector are primarily CO_2 with a share of 98.8% of the transport sector's total greenhouse gas emissions. Nitrous oxide makes up approximately 1.1% and methane about 0.1%.

The transport sector's greenhouse gas emissions peaked in 2007. The baseline scenario from 2022 (Climate Projection 2022) predicts the sectors overall greenhouse gas emissions to decrease by 29% from 2007 to 2030.

In 2020, the road transport was accountable for 91% of the sectors national emissions.

Table 4.18 shows the existing policies and measures within the transport sector.

The electrification of light vehicles has increased over recent years due to the technical improvements of the EV-cars as well as political action. The national measures for the transport sector aims at creating the right incentives structures as well as planning for and funding charging infrastructure on the state road network and make available the regulatory framework for a proper charging infrastructure overall.

The registration tax and the annual tax (the green owner tax), which is dependent on the energy efficiency of the vehicle as well as fuel taxes, are assessed to have had considerable effects on CO_2 emissions. With *Aftale om grøn omstilling af vejtransporten* (Agreement on green transition of the road transport) it was among other things decided to rearrange the registration tax, so it further promotes the uptake of low and zero emission cars. Further information on taxes is included in chapter 4.3.3.

Regarding charging infrastructure, EUR 43 million have been set aside from 2020-2022 to co-fund charging infrastructure projects at housing associations as well as on private and municipal areas. Furthermore, with Infrastrukturplan 2035 (Infrastructureplan 2035), there was allocated EUR 67 million in the period 2022-2030 to the roll out of charging infrastructure along state roads.

By April 2022, a new law called Lov om infrastruktur for alternative drivmidler til transport (Law on alternative fuels infrastructure for transport) entered into force. The regulation provide municipalities and regions the legal possibility to co-fund charging infrastructure, as well as it demands operators to display the ad-hoc price of charging and accept payment cards, if the charge point is located on public area, or if it has received public funds. Furthermore, the law makes sure Denmark fulfils its EU-obligations in the directive on the deployment of alternative fuels infrastructure (AFI-directive).

As a part of Infrastrukturplan 2035 (Infrastructureplan 2035), it was decided to set aside EUR 37 million for alternative fuels infrastructure for heavy good vehicles. The national roll-out of infrastructure for heavy good transport will be in conformity with the alternative fuels infrastructure regulation (AFIR).

A kilometer based and CO_2-differentiated toll for heavy good vehicles is to be launch from January 2025. To begin with, the charged road network will cover 10.900 km. From 2028 onwards, the toll will be extended to all public roads in Denmark. The average toll in 2030 will be EUR 0.17 per kilometre, while zero emission vehicles will get a substantial lower rate. The political decision in the toll in Aftale om kilometerbaseret vejafgift for lastbiler (Agreement on kilometre based toll for heavy good vehicles), is combined with a reform of the weight and dimension regulation for heavy good vehicles. The combined initiative is expected to reduce greenhouse gas emissions by 0.3 million tonnes CO_2e in 2025 and 0.4 million tonnes CO_2e in 2030.

When it comes to rail projects, the political parties behind *Infrastrukturplan 2035* agreed that train traffic in Denmark should be CO_2-neutral. The political parties allocated EUR 131.5 million for the purchase of four battery electric trains and charging infrastructure for the trains. Furthermore, EUR 37 million were set aside for grants to support charging infrastructure along private railways.

Pointing forward, the special focus will be to organize initiatives in those subsectors that are more challenging to transform like aviation, shipping and heavy road transport. For the aviation and shipping sectors, it is expected that especially renewable fuels such Power to X will contribute to the reduction of emissions.

TABLE 4.18 MEASURES IN THE TRANSPORT SECTOR

Name of mitigation action	Included in with measures GHG projection scenario *	Sector(s) affected	GHG(s) affected	Objective and/or activity affected	Type of instrument	Status of implemen-tation	Brief description	Start year of imple-men-tation	Implementing entity or entities	Estimate of mitigation impact (not cumulative, in ktCO2e)**	
										2020	2030
4-TR-01a: EU demands on vehicle manufactures to deliver fuel efficient cars and vans	Yes	3: Transport	Carbon dioxide (CO2)	3_16: Efficiency improvements of vehicles	Regulatory	Implemented	The EU's requirements on average CO2 emissions for passenger cars and vans, i.e. the mechanism imposing fines on manufacturers if they fail to comply with the CO2 targets.	2000	The European Commission	NE	IE
4-TR-07: Spatial planning	Yes	3: Transport	Carbon dioxide (CO2)	3_18: Low carbon fuels, 3_19: Electric road transport, 3_20: Demand management/reduction, 3_22: Improved transport infrastructure	Regulatory	Implemented	Spatial planning on state, regional and local level is also taking into account the objective to limit the growth in demand for passenger and freight transport and thereby reduce the number of vehicle kilometres driven and GHGs emitted. For example, spatial planning, in terms of urbanization and increased focus on minimising distances between residential areas/city centres and stations, help to reduce the need for transport.	2000	Municipalities	NE	IE
4-TR-10: Electrification of parts of the rail infrastructure	Yes	3: Transport	Carbon dioxide (CO2)	3_22: Improved transport infrastructure	Economic	Adopted	The entire danish railnetwork will be electrified with catenary lines or battery trains. BANEDANMARK is still in the process of electrifying. The last track will be electrified and ready for commissioning by the end of 2026 – i.e. full implementation by 2027.	2013	Ministry of Transport	NE	IE
4-TR-12: Investment in a tunnel under the Femern Belt	Yes	3: Transport	Carbon dioxide (CO2)	3_22: Improved transport infrastructure	Economic	Adopted	The tunnel under the Femern Belt will reduce CO2-emissions by potentially 200.000 tonnes per year. This is mainly because of the following effects: 1.Goods will shift from road to rail. 2. The travel distance from Copenhagen to Hamburg will be shortened. 3.The ferries between Denmark and Germany will cease to operate.	2028	Ministry of Transport	NA	IE
4-TR-13: Use of climate-friendly asphalt for all wear layer replacements on the state road network in 2020	Yes	3: Transport	Carbon dioxide (CO2)	3_22: Improved transport infrastructure	Regulatory	Implemented	Use of climate-friendly asphalt for all wear layer replacements on the state road network in 2020. The climate-friendly asphalt reduces the resistance between the tire and the road which leads to a reduction in fuel consumtion leading to a reduction in CO2-emissions.	2020	Ministry of Transport	NE	IE
4-TR-16: Allocated funds of DKK 250 million for green buses and green vehicles for demand responsive transport.	Yes	3: Transport	Carbon dioxide (CO2)	3_19: Electric road transport	Economic	Implemented	DKK 250 million is allocated for green buses and demand responsive transport in the annual budget from 2022-2026. Each year DKK 50 million will be given to the aplicants of the funds. The parties have agreed on the annual budget decided to allocate the first DKK 50 million to busses on regional routes.	2022	Ministry of Transport	NA	IE
4-TR-17: Requirements to promote green taxis	Yes	3: Transport	Carbon dioxide (CO2)	3_18: Low carbon fuels, 3_19: Electric road transport	Regulatory	Implemented	Of 1st January 2021 the energy and environmental requirements for taxies are tightened and new taxies (passenger car size) have to meet A++ requirements to be able to be a part of the industry.	2020	Ministry of Transport	NE	IE
4-TR-19: Implementation of pool for green transport in 2020 (DKK 75 million)	Yes	3: Transport	Carbon dioxide (CO2)	3_18: Low carbon fuels, 3_19: Electric road transport	Regulatory	Implemented	DKK 75 million was allocated in 2020 to extension of charging infrastructure and green transition of commercial transport.	2020	Ministry of Transport	NE	IE
4-TR-20: Minimum implementation of the Fuel Quality Directive (FQD)	Yes	3: Transport	Carbon dioxide (CO2)	3_18: Low carbon fuels	Regulatory	Implemented	Minimum implementation of the Fuel Quality Directive (FQD), i.e. a reduction of the greenhouse gas intensity of transport fuels by a minimum of 6% by 2020 and after 2020 compared to 2010 levels	2020	The Danish Ministry of Climate, Energy and Utilities	NE	IE
4-TR-21: Advancing and increasing the existing pool for green transport	Yes	3: Transport	Carbon dioxide (CO2)	3_18: Low carbon fuels, 3_19: Electric road transport	Economic	Adopted	An existing subsidy scheme for green transition of transport was increased with DKK 50 million to a total of DKK 475 million which was advanced to 2021. The funds were allocated to the transition of ferries, extension of charging infrastructure and transition of commercial transport.	2021	Ministry of Transport	NA	IE
4-TR-22: CO2 displacement requirements for RE fuels	Yes	3: Transport	Carbon dioxide (CO2)	3_18: Low carbon fuels	Regulatory	Implemented	"CO2 displacement" in relation to transport means well-to-wheel greenhouse gas reduction. A part of a political agreement from 2020 regarding the transport sector is to replace the current blending mandate with an obligation to reduce GHG intensity of fuels on a well-to-wheel basis. The new scheme is based on a technological neutral regulation, which promotes the use of RE-fuels with low GHG-intensity including new fuels such as Power-to-X based fuels. The obligation to reduce the GHG intensity of fuels is phased in from 3,4 % in 2022-2024 increasing to 5,2 % in 2025, 6 % in 2028 and 7 % in 2030. The target is estimated to reduce the CO2-emission by 0,7 mio. ton in 2025 and 1,4 mio. ton by 2030.	2022	The Danish Ministry of Climate, Energy and Utilities	NA	IE

TABLE 4.18 MEASURES IN TRANSPORT SECTOR (CONTINUED)

Name of mitigation action	Included in with measures GHG projection scenario *	Sector(s) affected	GHG(s) affected	Objective and/or activity affected	Type of instrument	Status of implemen-tation	Brief description	Start year of imple-men-tation	Implementing entity or entities	Estimate of mitigation impact (not cumulative, in ktCO2e)**	
										2020	2030
4-TR-23: Allocated funds for green transport 2021-2022 – The ferry subsidy scheme to support the green conversion of domestic ferries 2021-2022	Yes	3: Transport	Carbon dioxide (CO2)	3_18: Low carbon fuels, 3_19: Electric road transport, 3_22: Improved transport infrastructure	Regulatory, Economic	Adopted	A subsidy scheme of total DKK 230 million in 2021-2022 for green transition of transport was agreed in December 2020. The fund was allocated to the transition of ferries. Grants could be applied for the acquisition or leasing of new green ferries or for the retrofit of existing ferries. The grant also included any investments in necessary port adaptations.	2021	Ministry of Transport	NA	IE
4-TR-25: Climate-friendly cooperation agreements on green public transport	Yes	3: Transport	Carbon dioxide (CO2)	3_17: Modal shift to public transport or non-motorized transport, 3_19: Electric road transport	Economic	Adopted	Since June 2020 the Minister for Transport has agreed with municipalities and regions on "Climate-cooperation agreements on green public transport". With the agreement municipalities and regions are obliged to buy CO2-neutral or zero-emission busses whenever their old (diesel)busses needs to be replaced. By June 2022 29 municipalities and all five regions were a part of the agreement.	2021	Ministry of Transport	NA	IE
4-TR-26: Government subsidy for the purchase of four battery trains and charging infrastructure for battery trains in Holstebro and Skjern, cf. agreement on IP35	No	3: Transport	Carbon dioxide (CO2)	3_22: Improved transport infrastructure	Economic	Adopted	DKK 330 mio. (2021-prices) was allocated for the purchase of four battery trains and charging infrastructure in Holstebro and Skjern. The line between Holstebro and Skjern will be the first line with battery train operation in Denmark from 2025. The investment provides the opportunity to gain the necessry experience with battery train operation prior to the roll-out of battery train on other lines.	2023	Ministry of Transport	NA	IE
4-TR-27: Funds have been set aside for a green mobility model, where the traffic models that form the basis of decisions in the transport area are further developed, cf. agreement on IP35	No	3: Transport	Carbon dioxide (CO2)	3_22: Improved transport infrastructure	Economic	Adopted	DKK 6 million annually from 2022 to 2035 allocated for a green mobility model. The funding will support a further developement of traffic models that form the basis of decisions in the transport area.	2022	Ministry of Transport	NA	IE
4-TR-28: Pools respectively for cycling and charging infrastructure along the state road network, cf. agreement on IP35	No	3: Transport	Carbon dioxide (CO2)	3_22: Improved transport infrastructure	Economic	Adopted	Investments of 3 bil. in construktion of new, as well as upgrades of already existing cycel pathes. The funds will as well be spend in knowledge and innovation projects.	2022	Ministry of Transport	NA	IE
4-TR-29: Funds for the promotion of alternative fuels infrastructure in heavy good road transport cf. agreement on IP35.	No	3: Transport	Carbon dioxide (CO2)	3_22: Improved transport infrastructure	Economic	Adopted	A total allocation of DKK 275 million towards the deployment of alternative fuels infrastructure for heavy road transport. Initially, a strategy is being developed to support investment decisions that provide the best socio-economic returns in the long run. The strategy is completed, and the parties will meet and decide on the allocation of the funds.	2022	Ministry of Transport	NA	IE
4-TR-30: Funds for advisory center for bicycle promotion.	No	3: Transport	Carbon dioxide (CO2)	3_22: Improved transport infrastructure, 3_17: Modal shift to public transport or non-motorized transport	Economic	Adopted	The coalition will provide companies with advice on how to initiate biketransport upon employees, as well as provide advice in which ways electric bikes can partly cover the transport of goods. Funds for advisory center for bicycle promotion. The center must provide advice to companies on measures they can implement to push employees' transport choices in favor of the bicycle, as well as advice on how electric bicycles can cover part of the companies' need for goods transport and other commercial distribution.	2022	Ministry of Transport	NA	IE
4-TR-31: Funds set aside for the promotion of infrastructure for cycling, cf. agreement on Green transformation of road transport 2020.	No	3: Transport	Carbon dioxide (CO2)	3_22: Improved transport infrastructure, 3_17: Modal shift to public transport or non-motorized transport	Economic	Adopted	A fund of 370 mil. for cycel paths along the stat roads and 150 mil. for cycel paths along county roads. Funds set aside for the promotion of infrastructure for cycling, cf. agreement on Green transformation of road transport 2020. The financing for this comes from the Danish takeover from the EU's recovery facility. The funds is already executed.	2022	Ministry of Transport	NA	IE
4-TR-32: Subsidy for charging infrastructure for battery trains on the private railway lines.	No	3: Transport	Carbon dioxide (CO2)	3_22: Improved transport infrastructure	Economic	Adopted	In September 2022 a subsidy scheme of total DKK 275 million in 2025-2035 for charging infrastructure for battery trains on private railway lines was agreed on. The distribution of the subsidy scheme takes place according to an application principle, where the owner of the private railway (the regions) can get up to 65 per cent of the establishing cost covered per railway line. The Danish Transport Agency administers the subsidy scheme in order to ensure that the region's applications falls within the scope of the purpose of the scheme. The subsidy is given in terms of promoting a green transition and a CO2-neutral railway operation. Infrastructure Plan 2035 (IP35).	2022	Ministry of Transport	NA	IE
4-TR-33: Funds for the devlopment of charging infrastructure for light duty vehicles, Infrastructure Plan 2035	No	3: Transport	Carbon dioxide (CO2)	3_22: Improved transport infrastructure	Economic	Adopted	DKK 500 million from 2022-2030 allocated for extending charging infrastructure. The funding will support a high level of service for charging on longer car trips along the national road network. With the allocated framework, a geographical coverage of charging stations throughout the country can be ensured through public tendering, which promotes the green transition and supports the mobility of electric vehicle owners when they need to travel long distances.	2022	Ministry of Transport	NA	IE

TABLE 4.18 MEASURES IN TRANSPORT SECTOR (CONTINUED)

Name of mitigation action	Included in with measures GHG projection scenario *	Sector(s) affected	GHG(s) affected	Objective and/or activity affected	Type of instrument	Status of implemen-tation	Brief description	Start year of imple-men-tation	Implementing entity or entities	Estimate of mitigation impact (not cumulative, in ktCO2e)**	
										2020	2030
4-TR-34: Port subsidy scheme to support establishment of e.g. wharves, piers, road infrastructure at the port and on shore power supply, cf. agreement on Infrastructure Plan 2035 (IP35)	No	3: Transport	Carbon dioxide (CO2)	3_22: Improved transport infrastructure	Economic	Adopted	50 mio. DKK allocated to a port subsidy scheme to support the establishment of e.g. wharves, piers, road infrastructure at the port and on shore power supply	2022	Ministry of Transport	NA	IE
4-TR-35: Port and Fishing subsidy scheme to promote a green transition of ports and transition efforts within fishing and related ancillary industries.	Yes	3: Transport	Carbon dioxide (CO2)	3_22: Improved transport infrastructure	Economic	Adopted	25 mio. DKK allocated for a port and fishery subsidy scheme to help support a green transition of ports and transition efforts in the fishing industry and related secondary industries	2021	Ministry of Transport	NA	IE
4-TR-36: CO2-neutral charging infrastrukture on the state railways	Yes	3: Transport	Carbon dioxide (CO2)	3_22: Improved transport infrastructure	Economic	Adopted	DKK 650 mio. (2021-prices) was allocated for the establishment of the necessary charging infrasturkture for battery train operation on the state railway lines that are not planned to be fully electrified. The establishment of charging infrasturcture makes it possible to electrify the lines by implementing battery train operation. The roll-out of the charging infrastructure will be based on a detailed analysis. The charging infrastructure on the first line is expected to be ready for battery train operation around 2030.	2021 (funds and 2030 for effects)	Ministry of Environment of Denmark	NA	IE

* Here "Yes" means included in the "with measures" projection scenario, in principle. In most cases not based on separate annual estimates for each mitigation action, but either as a result of the assumption that the measure has contributed to the observed level of total Danish greenhouse gas emissions in the most recent inventory year available, when the projection was elaborated and therefore used as the starting point for the projections, or as part of the integrated models used to project the level of annual greenhouse gas emissions in future years.
** See explanatory note under Table 4.26.

4.3.5.1.11 Specific measures in the residential sector

In 2020, the residential/household sector contributed to Denmark's total national greenhouse gas emissions with 1.8 million tonnes of CO_2 equivalents, corresponding to a share of 4.1%. The residential sector in the greenhouse gas inventory only includes CO_2 emissions from burning of oil and natural gas since emissions from production of electricity and district heating used by households are attributed to the plants where the electricity and heat is produced.

In this section, measures addressing all types of energy consumption in the household sector are described, although some of the energy savings will result in emission reductions in the energy production sector.

In 2021, consumption of energy by households, including electricity and district heating, was responsible for around 29% of the total final energy consumption in Denmark.

The major part of energy consumption in households is used for space heating - 94% in 2021. District heating constituted 47% of household energy consumption for heating in 2021. When district heating is produced at CHP plants or with renewable energy, there are big CO_2 savings overall from the use of district heating instead of individual heating based on, for example, oil-fired boilers.

Oil consumption for heating is 4% of household energy consumption in 2021. According to Climate Projection 2022, oil is expected to amount to 1% of final energy consumption for heating in 2030, as it was assumed in Climate Projection 2022, that recent decades' phase-out of oil consumption for heating continues.

Up to 2003, households changed to gas in particular, but from 2004 onwards the change is more to wood pellets in particular. Up to 2030, the consumption of oil, gas and wood pellets is expected to fall. The falling consumption of wood pellets and fossil fuels will be offset by an increasing contribution from heat pumps and district heating.

Households' disposal of waste also contributes to emissions of methane from landfill sites.

The action being taken on households' waste and transport consumption is described in the sections on waste and transport. This section therefore concentrates on the possibilities of reducing the CO_2 emissions through savings in electricity and heating in households and the possibilities for conversion to more environment-friendly forms of heating. The possibilities for reduction in the public energy supply system are described in the section on the energy sector.

In 2021, the final energy consumption in the household sector was 155.1 PJ for space heating and hot water (climate-corrected) and 33.2 PJ of electricity for appliances, etc. Consumption for heating has fluctuated around a certain constant level for 10 years, in spite of an increase in the number of households and in the area heated.

Despite a rising number of electrical appliances, the associated electricity consumption has remained at a quite constant level over the past 15 years. This is because electrical appliances have become more efficient, partly because of the EU Ecodesign Directive and the Energy Labelling Directive.

Several political agreements include initiatives ensure that renewable energy output in Denmark matches the country's total electricity consumption by 2030 among others *Sub-agreement on Investments in a continuously greener Denmark* and *Supplementary agreement on energy island Bornholm 2022.*

With a view to reducing energy consumption and environmental impacts from the household sector, a wide range of initiatives have been launched, as described in Table 4.19 in order to promote:

- Electricity savings,
- Savings in energy consumption in space heating, and
- Fuel conversion (from the use of oil and gas to district heating and the use of renewable energy).

Several concrete measures and incentives already implemented are described below.

Energy taxes
All energy consumption for space heating as well as other energy consumption in households and the public sector, as well as non-VAT-registered businesses is subject to energy taxes. Throughout the 1990s CO_2 and energy taxes have steadily increased, but since 2002 they have been almost stable. The CO_2 tax was increased in 2010 by more than 50 pct. The increases have mainly affected households, helping to reduce their energy consumption.

As expanding infrastructure powered by renewable energy will be a key component in Denmark's successful green transition, the 2018 Energy Agreement included initiatives with a view to reducing taxes on electricity and restructure the rules on surplus heat utilisation. The rules for surplus heat has been simplified. As surplus heat often is boosted with electric heat pumps, the reduced rates on electricity has lowered the taxes on utilisation of surplus heat considerably. Further reductions of tax on electrical heating have been adopted with the 2020 Climate Agreement for energy and industry as well as increases of energy tax on fossil fuels for space heating. To implement incitements to change to green energy and to meet the high energy prices several agreements reducing the electricity tax on other electricity than electrical heating was implemented in 2022.

Increased electrification is essential to harnessing the full potential of green energy, and will enable the integration of fluctuating outputs of wind and solar energy into our energy system. Green electricity can be converted into heat and channelled through district heating systems or into large-scale heat storage facilities – ensuring a flexible energy system and optimum utilisation of green electricity.

Electrification of the energy system is thereby a cornerstone of the green transition.

Despite a steadily growing supply of green electricity, the taxes on electricity for households in Denmark remain very high. High taxes on electricity constrain the use of electricity by Danes, causing significant socioeconomic losses. To address this problem, tax on electrical heating was reduced from 0.155 DKK/kWh to 0.004 DKK/kWh for industries and to 0.008 DKK/kWh for households in 2021 in accordance with the EU minimum tax rates as part of the 2020 Climate Agreement. Furthermore several agreements reducing the electricity tax on other electricity than electrical heating was implemented in 2022. The electricity tax is further described in section 4.3.3.

The reduction of taxes is expected to trigger a rise in electricity consumption. However, the renewable energy output in Denmark is expected to match the country's total electricity consumption by 2030. Electrical heat pumps are furthermore expected to replace heating based on fossil fuels and biomass. A working group will be tasked with exploring electricity tariffs and related issues, including the conditions for certain groups of electricity customers and whether tariffs can be billed in a different and better way. The possibility of a dynamic electricity tax will also be explored. The tax reductions will equate to lower electricity bills, thus improving the productivity of businesses and the welfare of individual households.

CO_2 taxes

Some of the energy consumption in households is subject to CO_2 taxes. The CO_2 tax is further described in section 4.3.3.

Minimum energy requirements for buildings

Denmark has a long experience with energy efficiency and energy savings in buildings. From 1990 to 2021 final energy consumption for space heating has been reduced by 24.5% per m^2.

Most new buildings shall, according to the Danish Building Code, declare the total CO_2-eq emission from the lifecycle of the building, according to EN 15978. The obligatory modules are A1-A3, B4, B6, C3, C4 and D. Buildings larger than 1000 m^2 shall in addition to this also live up to a limit value of 12 kg CO_2-eq/m^2 per year using the same modules, except for D.

All new buildings must, according to the Danish building code, be constructed as nearly zero-energy buildings (NZEB). The benefits of reducing energy consumption are tangible: less fossil fuel is consumed and the environment has improved substantially. Strict and progressively tightened building regulations since 1977 have ensured a stable demand for energy-efficient building technologies.

Energy labelling of buildings when built, sold or rented

Energy labelling of buildings must be implemented after finishing the construction of a building and on the sale or rental of the building.

The climate agreement from 2020 contains measures to improve the use of data and digitization to promote energy efficiency. Particular emphasis is placed on using data to improve the quality of the energy label, which is implemented in accordance with the Directive on the energy performance of buildings. The energy label is based on a physical review of the building, where an energy labeling consultant collects information about the building. The energy labeling scheme uses automatic digital validations so that the energy labeling consultant's registrations are assessed already before the energy label is issued to the building owner. The validations were developed on the basis of errors in earlier energy labeling reports, which were found when using the database, e.g. missing registration of roofs. This means that this type of error is eliminated. More than 300 validations have been implemented in total.

In 2022, approximately 80,000 energy labeling reports have been prepared and they cover approximately 109,000 buildings. In total, approximately 236,000 profitable energy-saving proposals are indicated in the reported energy labels. The Danish Energy Agency is also working to simplify access to the energy label database, so that building owners and other stakeholders can better utilize the many data behind the energy label. To support the energy labels and savings proposals, a new report layout for the energy labeling reports has been prepared in 2021. The new energy labeling reports have been developed in collaboration with behavioral scientists to ensure that building owners are encouraged to carry out energy renovation of their buildings. The energy labeling report has therefore been improved on three key points; 1) user-friendliness 2) relevance – how relevant is the report perceived by the homeowner and 3) actionable – how easy is it for the homeowner to initiate renovations.

Regular energy labelling of large buildings and public buildings

The Energy Performing Certificate (EPC) consist of an energy label and an energy plan. For publicly owned buildings over 250 m^2 the EPC must be prepared regularly every ten years. Furthermore all large buildings over 600 m^2 which are frequently visited by the public must display the EPC in a prominent place clearly visible to the public.

Denmark has implemented a new administrative regulation from January 1 2021, which entails requirements for further reducing energy consumption in the period 2021-2030 in central governmental buildings. Energy savings will among others be obtained through energy renovations and behavioral measures.

Minimum energy requirements and energy labelling of appliances

The Danish Energy Agency has a national energy-labelling scheme for façade windows. Approximately 90 % of suppliers adhere to the scheme in 2019, and presently all suppliers adhere to the EC product regulation.

Danish authorities play an active role both in negotiation of compulsory EC requirements and in securing awareness of and compliance with these, including through information on the agency’s website. In general, the effect of EC product regulation is accounted for elsewhere.

Subsidy scheme related to buildings

The Subsidy scheme related to residential buildings is an application-based subsidy scheme, wherein private citizens can apply for grants subsidizing the installation of an electric heat pump when converting from gas-, oil- or pellet boilers or electrical heating. The scheme furthermore offers grants for general energy efficiency measures such as insulation, ventilation and energy efficient windows. Subsidies can be allocated to owners of buildings who have renovated their buildings in accordance with a specific list of energy savings belonging to the subsidy scheme.

The first application round for the scheme was held in 2020, with full disbursement of funds each year since. From 2023, the scheme will be divided into two separate schemes, each focusing on heat pumps and energy efficiency measures respectively. A total of 2.5 billion DKK has been allotted the scheme, including the two new separate schemes, during the years 2020-2026.

Information initiative towards private households

The Danish Energy Agency carries out efforts to promote energy-efficient behavior and energy-efficient solutions. The information efforts focus on both private households, business and the public sector.

Energy efficiency of buildings and support for energy efficient behavior in buildings is a central priority in the Danish information effort. The efforts includes the preparation of material on energy-efficient solutions, information on building regulations and easy access to information and knowledge on energy renovation. The Danish Energy Agency's website www.SparEnergi.dk and associated social media are the backbone of the agency's communication about energy-efficient solutions both in private households and in public and private companies.

Since 2016, private households have been able to get free, unbiased advice on energy consumption and energy-efficient solutions via phone and email. In addition, the Energy Agency offers both webinars and local inspiration meetings to promote knowledge of energy-efficient solutions, energy renovation and conversion away from fossil fuels in individual heating. The events are organized in collaboration with the local municipality. In 2022, 255 meetings were held. 60 % were local meetings 40% were held as webinars. The events contribute to increased energy efficiency and conversion away from oil and gas boilers to heat pumps and district heating.

Knowledge Centre for Energy Savings in Buildings

The Knowledge Centre for Energy Savings in Buildings is a service for craftsmen and educational institutions concerning energy efficiency improvements. The centre supplies the building professionals, schools and universities with knowledge, guides and online tools, promoting energy savings and good practice. They also provide courses to support the further education of craftsmen within the field. Furthermore, educational efforts are carried out by the labour market training centres.

Heat pumps as an energy service

In this initiative, which has been deployed since 2016, energy companies install, finance, run and maintain heat pumps installed in smaller residential and commercial buildings. Customers have no up-front investment cost but pay for the supplied heat much as they would for district heating. The initiative is targeting mainly areas without supply of natural gas or district heating.

The 2018 Energy Agreement focuses on the remaining oil-fired boilers and barriers to promote the use of heat pumps. In 2020 a subsidy scheme was introduced, where the energy service provider assumed ownership of the heat pump and responsibility for installation, operation and maintenance of the heat pump. The customer (owner of the building) typically paid a one-off payment, a subscription fee and a price for the delivered heat to the building. With heat pumps on subscription, the consumer avoided a large investment and at the same time obtained a number of service benefits. It is the company providing the heat pumps on subscription that was eligble for the subsidy.

"Better Houses"

"BetterHouses" is a scheme (voluntary and market-driven system) focusing on energy renovation of buildings. The aim is to make it easier for owners of buildings, mostly homeowners, to energy renovate by creating a "one stop shop" for energy renovation, where the owner only has to contact one certified building contractor and to get an overall counselling on energy renovation of the entire building. Skilled craftsmen are educated under the BetterHouses program to be advisors on energy renovation.

Long-term strategy for the renovation of the national building stock

As stated in article 2a of the energy performance of buildings directive (EPBD) each Member State must notify a long-term renovation strategy (LTRS) to support the renovation of the national building stock.

On 10 March 2020, Denmark published and notified part 1[7] of Denmark's LTRS to the Commission. However, the government decided, in connection with the notification of Denmark's National Energy and Climate Plan (NECP) at the end of

[7] https://ens.dk/ansvarsomraader/energibesparelser/byggeri-og-renovering

2019, that the indicative milestones for 2030, 2040 and 2050 would be determined in connection with the upcoming national climate action plans in order to be able to take into account possible effects of new initiatives.

On 22 June 2021, Denmark therefore notified part 2[8] of Denmark's LTRS, which contains two non-binding indicative milestones for 2030, 2040 and 2050 (see table 4.18b below). In addition, the strategy contains an explanation of how the milestones contribute to achieve the Union's energy efficiency targets in accordance with Directive 2012/27/EU on energy efficiency. Part 2 of Denmark's renovation strategy must therefore be seen in connection with part 1, in which existing and known tools in Denmark's energy renovation efforts are explained.

The determination of the indicative milestones are based on agreements such as the Climate Agreement for Energy and Industry etc. of 22 June 2020[9] and Green Housing Agreement 2020 of 19 May 2020[10].

The strategy describes various initiatives aimed at promoting the renovation of the Danish building stock and efforts aimed at insuring energy efficiency in the national building stock.

TABLE 4.18B NON-BINDING INDICATIVE MILESTONES FOR 2030, 2040 AND 2050

	2030	**2040**	**2050**
1) Reduction of the final energy consumption per m^2 for households	5%		
2) Reduction of the calculated energy consumption per m^2 for households	10%	19%	28%

[8] https://ens.dk/ansvarsomraader/energibesparelser/byggeri-og-renovering
[9] https://kefm.dk/aktuelt/nyheder/2020/jun/bred-klimaaftale-bringer-danmark-tilbage-i-den-groenne-foerertroeje
[10] https://www.regeringen.dk/aktuelt/tidligere-publikationer/groen-boligaftale-2020/

TABLE 4.19 MEASURES IN THE HOUSEHOLD (RESIDENTIAL) SECTOR

Name of mitigation action	Included in with measures GHG projection scenario *	Sector(s) affected	GHG(s) affected	Objective and/or activity affected	Type of instrument	Status of implemen-tation	Brief description	Start year of imple-men-tation	Implementing entity or entities	Estimate of mitigation impact (not cumulative, in ktCO2e)**	
										2020	2030
5-HO-01: Minimum energy requirements for buildings	Yes	2: Energy consumption	Carbon dioxide (CO2), Methane (CH4), Nitrous oxide (N2O)	2_10: Efficiency improvements of buildings	Regulatory, Information	Implemented	Denmark has a long experience with energy efficiency and energy savings in buildings. From 1990 to 2017 energy consumption for heating has been reduced by 16.1% per m2. All new buildings must, according to the Danish building code, be constructed as nearly zero-energy buildings (NZEB). The benefits of reducing energy consumption are tangible: less fossil fuel is consumed and the environment has improved substantially. Strict and progressively tightened building regulations since 1977 have ensured a stable demand for energy-efficient building technologies. Energy labelling of buildings must be implemented after finishing the construction of a building and on the sale or rental of the building - primarily heating consumption. This applies in principle for all buildings, irrespective of size, apart from production facilities, factories etc. The energy performance is expressed by a numeric indicator of primary energy in kWh/m2 per year based on the primary energy factor. The Energy Performing Certificate (EPC) consist of an energy label and an energy plan. For publicly owned buildings over 250 m2 the EPC must be prepared regularly every ten years. Furthermore all large buildings over 600 m2 which are frequently visited by the public must display a valid EPC in a prominent place clearly visible to the public. Most new buildings shall, according to the Danish Building Code, declare the total CO2-eq emission from the lifecycle of the building, according to EN 15978. The obligatory modules are A1-A3, B4, B6, C3, C4 and D. Buildings larger than 1000 m2 shall in addition to this also live up to a limit value of 12 kg CO2-eq/m2 per year using the same modules, except for D.	1997	Ministry of Social Affairs, Housing and Senior Citizens	NE	IE
5-HO-02: Energy labelling of electric appliances	Yes	2: Energy consumption	Carbon dioxide (CO2), Methane (CH4), Nitrous oxide (N2O)	2_11: Efficiency improvement of appliances	Information	Implemented	Minimum energy requirements and energy labelling of appliances: Energy labelling (A-G) of white goods, lighting, air con etc. is compulsory within the EU. The European Community also has mandatory energy requirements for some 20 energy-consuming products, such as electric motors, circulators, white goods etc. There are also voluntary labelling schemes (Energy Star, Energy Arrow, windows, boilers) for a number of products. Danish authorities play an active role both in negotiation of the requirements and in securing compliance with the compulsory requirements - e.g. through market surveillance. The Danish Energy Agency offers advice on its website to end-users in order to promote energy-efficient appliances and products.	1992	The Danish Energy Agency	NE	IE
5-HO-03: Substitution of individual oil-based furnaces	Yes	2: Energy consumption	Carbon dioxide (CO2), Methane (CH4), Nitrous oxide (N2O)	2_14: Demand management/reduction	Economic, Information	Implemented	This support scheme supplies subsidies for companies, which offer electric heat pumps on subscription for private year-round housing. The subsidy pool among others is designed to give aid to citizens who wish to convert to an electric heat pump, but who have limited financing opportunities. The subsidy will amount to approximately DKK 25.000 per electric heat pump on average.	2010	The Danish Energy Agency	NE	IE
5-HO-04: Better Houses	Yes	2: Energy consumption	Carbon dioxide (CO2), Methane (CH4), Nitrous oxide (N2O)	2_10: Efficiency improvements of buildings	Information	Implemented	"BetterHouses" is a scheme (voluntary and market-driven system) from the Danish Energy Agency focusing on energy renovation of buildings. The aim is to make it easier for owners of buildings, mostly homeowners, to energy renovate by creating a "one stop shop" for energy renovation, where the owner only has to contact one certified building contractor and to get an overall counselling on energy renovation of the entire building. Skilled workmen are educated under the BetterHouses program to be advisors on energy renovation. The Danish Energy agency approves the BetterHouses firms and professionals like architects, engineers, craftsmen, energy consultants and building designers can take training courses to become BetterHouses advisors. The training is carried out at academies of higher education. A Better Houses advisor can manage the process and can follow the project all the way from plan to completed renovation.	2014	The Danish Energy Agency	NE	IE
5-HO-05: Strategy for Energy renovation of buildings	Yes	2: Energy consumption	Carbon dioxide (CO2), Methane (CH4), Nitrous oxide (N2O)	2_10: Efficiency improvements of buildings	Information, Education, Research	Implemented	The long-term renovation strategy supports the renovation of the national stock of residential and non-residential buildings. The strategy shall contribute to the fulfilment of the EU's long-term goal for 2050 of reducing greenhouse gas emissions by 80-95% compared with 1990. The goal is to achieve a highly efficient and decarbonised building stock by 2050 and facilitate the cost-effective transformation of existing buildings into nearly zero-energy buildings (NZEBs). The strategy includes the status of energy efficiency of buildings in Denmark, normative instruments (e.g. component-specific requirements in connection with renovations), financial instruments (e.g. taxes and grants) and informative instruments (e.g. information for citizens, energy rating of buildings or additional training of tradesmen).	2014	The Danish Energy Agency	NE	IE

TABLE 4.19 MEASURES IN THE HOUSEHOLD (RESIDENTIAL) SECTOR (CONTINUED)

Name of mitigation action	Included in with measures GHG projection scenario	Sector(s) affected	GHG(s) affected	Objective and/or activity affected	Type of instrument	Status of implementation	Brief description	Start year of implementation	Implementing entity or entities	Estimate of mitigation impact (not cumulative, in ktCO2e)**	
										2020	2030
5-HO-07: Green renovations of social housing sector	Yes	Energy	CO2, CH4, N2O	2_10: Efficiency improvements of buildings	Regulatory, Economic	Implemented	On the 19 May 2020, the Government reached a political agreement to ensure green renovation of the social housing sector in 2020 and from 2021-2026. The agreement entails a structural shift in the Danish National Building Fund's support system containing a new green support criterion, a new green guarantee and a fund for experiments that will improve the energy efficiency of buildings in the social housing sector.	2021	Ministry of Social Affairs, Housing and Senior Citizens	NA	IE(G1)
5-HO-08: Phasing out of oil and gas boilers by subsidies for conversion to green solutions [= 5-HO-03 changed and enhanced]	Yes	Energy	CO2, CH4, N2O	2_14: Demand management/reduction	Economic	Adopted	Reducing energy consumption by increasing energy efficiency and promoting energy saving is a very important element for Danish energy policy, hence phasing out oil-, and gas boilers alongside other less efficient heating sources by subsidies for conversion to green solutions have been essential towards fulfilling the ambitions of the climate agreements. This is through various support schemes, subsidising these conversions to more green alternatives in various models, ranging from one-time subsidies to the individual citizen to subscription solutions, which aid citizens who wish to convert to an electric heat pump, but who have limited financing opportunities.	2021	The Danish Ministry of Climate, Energy and Utilities	NA	IE(G1)
5-HO-09: Increase in allocated funds for phasing out oil and gas boilers until 2025 [= 5-HO-08 further enhanced]	Yes	Energy	CO2, CH4, N2O	2_14: Demand management/reduction	Economic	Adopted	Reducing energy consumption by increasing energy efficiency and promoting energy saving is a very important element for Danish energy policy. With the increased interest seen from both a political perspective besides the immense interest seen from the public, further grants have been granted to the support schemes for phasing out oil-, and gas boilers by subsidies for conversion to green solutions.	2021	The Danish Ministry of Climate, Energy and Utilities	NA	IE(G1)
5-HO-10: Grants for green housing improvements (the Building Pool)	Yes	Energy	CO2, CH4, N2O	2_10: Efficiency improvements of buildings, 2_14: Demand management/reduction	Economic	Adopted	The Building Pool targets energy savings in private year-round housing. The subsidy pool i.e. supports the replacement of oil and gas burners with heat pumps (i.e. reduction in CO2-emissions from the individual heating sector), insulation of the climate screen and optimization of the operation of the building. In 2023, the pool is split into two pools; one for replacement of oil and gas burners with heat pumps (Heat pump pool) and one for energy optimizations i.e. insulation of the climate screen (Energy Renovation pool). The funding is split in 70% for the Heat Pump Pool and 30% for the Energy Renovation Pool in 2023.	2020	The Danish Energy Agency	IE(G1)	IE(G1)
5-HO-11: Grants for individual heat pump when scrapping oil- or gas boilers (The Scrapping Scheme)	Yes	Energy	CO2, CH4, N2O	2_14: Demand management/reduction	Economic	Adopted	The scrapping scheme targets oil, gas and biomass boiler owners who wants to change their heating source to leasing a heat pump. The subsidy pool i.e. supports the conversion into a geener heating solution by making it possible to lease instead of buy a heat pump, i.e. for lower-income groups. The Scrapping Scheme contains 220 mio. DKK in total in 2020-2026.	2020	The Danish Energy Agency	IE(G1)	IE(G1)

* Here "Yes" means included in the "with measures" projection scenario, in principle. In most cases not based on separate annual estimates for each mitigation action, but either as a result of the assumption that the measure has contributed to the observed level of total Danish greenhouse gas emissions in the most recent inventory year available, when the projection was elaborated and therefore used as the starting point for the projections, or as part of the integrated models used to project the level of annual greenhouse gas emissions in future years.

** See explanatory note under Table 4.26.

4.3.5.2 CH_4 (methane)

Total emissions of methane from the energy sector account for about 1.1% of the sector's greenhouse gas emissions, corresponding to about 0.5 million tonnes CO_2 equivalents. Many small sources contribute to this overall relatively minor source of greenhouse gas emissions. The biggest single contribution comes from gas-fired CHP plants, which emit unburnt natural gas. With a view to minimising the emissions, a 1998 Statutory Order, in force from 2006 to 2013, has limited emissions of nitrogen oxides, unburnt carbon hydrides, including methane, and carbon monoxide etc.. However, the limit value for unburned hydro carbons was removed in a revision of the Statutory Order entering into force on 7 January 2013.

As of 1 January 2011 a tax on methane emissions - equal in terms of CO_2 equivalents to the CO_2 tax - from natural gas fired power plants was introduced (see chapter 4.3.3.3.).

4.3.5.3 N_2O (nitrous oxide)

Nitrous oxide accounts for 0.8%, or 0.4 million tonnes CO_2 equivalents, of the energy sector's total greenhouse gas emissions. Within energy, emissions of nitrous oxide from transport have increased since the introduction of new cars with catalytic converters in 1990. However, as the population of cars from before 1990 is almost zero today, no further increase in specific nitrous oxide emissions from cars with catalytic converters is expected.

4.3.6 Industrial Processes and Product Use (IPPU)

The greenhouse gas emissions from industrial processes and product use made up 4.3% of Denmark's total greenhouse gas emissions in 2020 (with LULUCF), of which CO_2 was the primary emission. 79% of the sector's emissions are CO_2, primarily from cement production, and 20% are emissions of the industrial gases HFCs, PFCs, and SF_6. The remaining share of 1% are emissions of nitrous oxide.

4.3.6.1 CO_2 - Cement production

Cement production results in large emissions of CO_2. The production process itself is very energy-intensive, and a large quantity of CO_2 is emitted in connection with the production process.

Cement production in Denmark is concentrated in a single company. About half of the emissions come from the company's energy consumption and the other half from chalk, which is one of the raw materials used in the process. A lot has been done within the cement industry. For example, in the last 20 years the Danish cement producer has significantly reduced its CO_2 emissions per tonne cement produced.

Since 2005, all CO_2 emissions from cement production in Denmark are subject to the EU ETS.

4.3.6.2 N_2O - Production of nitric acid

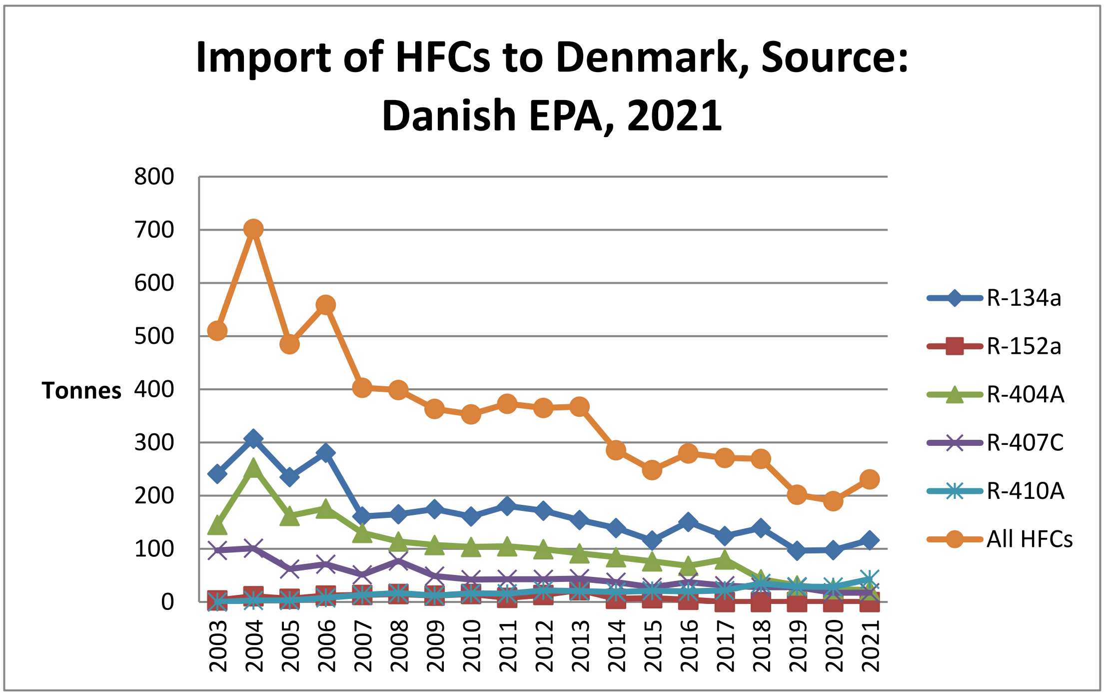
In the period 1990-2004, Danish greenhouse gas emission inventories included emissions of nitrous oxide (N_2O) from the production of nitric acid in connection with the production of fertilizer from a single plant in.

In mid 2004, the owner decided to stop production of fertilizer and so production of nitric acid in Denmark. Emissions of nitrous oxide from production of nitric acid in 2003 corresponded to 0.9 million tonnes CO_2 equivalents. In 2004 emissions were about one-half of this, and from 2005 they ceased entirely cf. market conditions for production of fertilizer in Europe.

4.3.6.3 HFCs, PFCs and SF_6 - Consumption of these substances

Emissions of the so-called industrial gases HFCs, PFCs, and SF_6 are in accordance with the emission inventories included in the industrial sector. This is also the case for emissions from other sectors during use and scrapping of equipment containing HFCs, PFCs and SF_6. These gases are used for several purposes including as refrigerants and blowing agents, etc. (HFCs) and insulator gas in high voltage switchgear (SF_6). Since there is no production of these gases in Denmark, all emissions are related to the import of the substances. The developments in imports of chemical mixtures containing HFCs in recent years are shown in Figure 4.3.

FIGURE 4.3 IMPORT OF HFCS TO DENMARK 2000-2021 IN TONNES HFCS
Source: Danish Environmental Protection Agency



The Danish regulation of emissions of the industrial greenhouse gases (HFCs, PFCs, and SF_6) is 2-phased, since there is a consumer tax on the import of the substances and also a statutory order regulating the use of the gases in new facilities and products. Both measures are further described below.

According to model-based calculations, the combined effect of taxation and regulation of F-gases compared to a business as usual scenario starting in 2000 is an approximately 2 million tonnes of CO_2 equivalents reduction in annual F-gas emissions in 2021. The accumulated emission savings over the period from 2000 to 2021 is estimated at approximately 12 million tonnes of CO_2 equivalents.

4.3.6.3.1 *Taxes on HFCs, PFCs and SF_6*

Taxes corresponding to their GWP have been imposed on each of the greenhouse gases from March 2001 in combination with the Danish CO_2 tax of approximately DKK 0.19 per kg CO_2 as described in section 4.3.3. This means that HFC-134a is subject to a tax of DKK 270/kg, as it has a GWP of 1,430.

The tax is imposed on the substances on importation because none of them is produced in Denmark. The tax is payable whether the substances are imported as pure substances or as part of imported products. If the content in the products is not known, the tax is based on a fixed tariff.

The tax is payable on a wide range of products, including:

- Refrigerating and freezing plants
- Air-conditioning plants
- PUR foam for cooling plants, district heating pipes, insulated gates and doors, panels for refrigeration and freezer rooms, extruded polystyrene for insulation (XPS foam), jointing foam
- Spray canisters
- Insulation gas

The tax is also payable on services on existing and new installations/products.

4.3.6.3.2 *Regulation of HFCs, PFCs and SF_6*

On 15 July 2002, a statutory order on the regulation of certain industrial greenhouse gases came into force.

This Statutory Order includes a general ban on the use of industrial greenhouse gases in a great number of new facilities and products from 1 January 2006, including household cooling and freezing appliances, PUR foam, etc. However, some products and applications are exempted from the ban. This applies, for example, to servicing existing plants, mobile cooling plants, including mobile air conditioning plants, the use of HFCs in cooling and air conditioning plants with fillings between 0.150 and10 kg HFC, SF_6 in high voltage plants, etc. The Statutory order was revised in May 2017 in order to reflect the development of new low GWP, fluorinated refrigerants such as HFOs. The only change is that the revised order does not cover HFOs. All other provisions remains unchanged. The Statutory Order was revised again in November 2018 allowing the use of HFCs in certain hermetically sealed heat pumps in amounts up to 50 kg. The purpose of the revision was to remove barriers for the use of medium size heat pumps in the energy system.

In May 2021 the general exemption for equipment with fillings between 0.150 and 10 kg HFC was changed so that this exemption only applies to hermetically sealed equipment. For other types of equipment a limit of 5 tons of CO_2 equivalents was introduced. The purpose is to encourage the use of low GWP refrigerants.

To ensure the best possible implementation of the phase-out dates for the refrigeration sector, a total of DKK 12 million was reserved for the period 2005-2007 for development of alternatives and for subsidies for implementation of the alternatives developed in the previous years. A knowledge centre for HFC-free cooling has been established. This centre disseminates knowledge and offers technical assistance.

As from 2015 to 2017 DKK 1,5 million is reserved for promoting cooling equipment relying on natural refrigerants and retrofitting existing equipment to use refrigerants with lower GWP.

To ensure regeneration and environmentally friendly destruction of newly developed flammable fluorinated refrigerants DKK 2.5 million is granted from 2017 to 2019 to upgrade the existing return system (see Chapter 4.3.4).

In 2019 an information campaign costing 300.000 DKK aiming at preventing illegal imports of HFC is expected to be launched.

An overview of the above measures regarding industrial processes is given in table 4.20.

TABLE 4.20 MEASURES IN THE INDUSTRIAL PROCESSES SECTOR

Name of mitigation action	Included in with measures GHG projection scenario	Sector(s) affected	GHG(s) affected	Objective and/or activity affected	Type of instrument	Status of implemen-tation	Brief description	Start year of imple-men-tation	Implementing entity or entities	Estimate of mitigation impact (not cumulative, in ktCO2e)**	
										2020	2030
6-IP-01: Regulation of use of HFCs, PFCs and SF6 (phasing out most of the uses) - Statutory order on fluorinated greenhouse gasses	Yes	Industry/Industrial Processes	HFCs, PFCs, SF6	4_28: Replacement of fluorinated gases by gases with a lower GWP value	Regulatory	Implemented	Import, sale and use of the substances or new products containing the substances is forbidden from 1 January 2006 with some exceptions.	2006	The Danish Environmental Protection Agency	IE(G1)	IE(G1)

* Here "Yes" means included in the "with measures" projection scenario, in principle. In most cases not based on separate annual estimates for each mitigation action, but either as a result of the assumption that the measure has contributed to the observed level of total Danish greenhouse gas emissions in the most recent inventory year available, when the projection was elaborated and therefore used as the starting point for the projections, or as part of the integrated models used to project the level of annual greenhouse gas emissions in future years.

** See explanatory note under Table 4.26.

4.3.7 Agriculture

The primary occupational sectors agriculture, forestry and fisheries are generally considered as one single economic sector in Denmark, although the importance of the individual sectors differs greatly with respect to Denmark's emissions and uptake of greenhouse gases. Agricultural farms have emissions of primarily methane and nitrous oxide as described in this section. Liming, urea application and other carbon-containing fertilizers are minor sources of CO_2 emissions. The CO_2 emissions by sources and removals by sinks in relation to Denmark's agricultural soils and forests are included under the LULUCF sector described in Section 4.3.7. CO_2 emissions from energy use in agriculture are included under energy (section 4.3.4).

The agricultural sector contributes in 2020 with 27.1 % of the total emission in CO_2 equivalents (excl. LULUCF and indirect CO_2) and the major part is related to the livestock production. Since 1990, the agricultural emission has decreased 15.5 % (mainly due to a decrease in the N_2O emission). Agriculture is the overall most important sector regarding emissions of N_2O and CH_4. In the same year, the contribution of N_2O and CH_4 from agriculture to the national total emission of these gases was 89.6% and 82.6%, respectively. N_2O emissions from agriculture decreased by 24.8% and the CH_4 emissions from agriculture decreased by 0.3% from 1990 to 2020 (Nielsen et al., (2022a)).

Table 4.21 shows measures for greenhouse gas emission reductions within agriculture.

Policies and measures relevant for the agricultural sector which have affected or will affect the sector's greenhouse gas emissions are:

- Ban on burning of straw on fields
- Action Plans for the Aquatic Environment I and II and Action Plan for Sustainable Agriculture
- Action Plan for the Aquatic Environment III
- Ammonia Action Plan
- Action Plan for Joint Biogas Plants and subsequent follow-up programmes, including the New Energy Policy Agreement
- Environmental Approval Act for Livestock Holdings
- Agreement on Green Growth 2009
- Agreement on Green Growth 2.0
- Subsidy for conversion of arable land on organic soils to nature
- Political Agreement on a Food and Agricultural Package and the political Agreement on Targeted Regulation and subsequent agreements [such as the national budget for 2020, which includes allocation of additional funding for afforestation and environment- and climate-technologies]
- Agreement on Nature (the Nature Package)
- Advisory task force on barriers for reducing the hydraulic retention time of manure before being delivered to biogas plants (PSO Agreement of 17 November 2016)
- National Green Climate Fund – Initiatives in agriculture 2017

- GHG accounting and awareness building at farm-level. Climate-friendly feed production for pigs. Promotion of green bio-refining. (Agreement of 2nd May 2019)
- Multifunctional Land Reparcelling Fund (Agreement of 19th September 2019)
- Agreement on a Green Transition of The Agricultural Sector (4th October , 2021).

Stronger research efforts in agriculture affecting all greenhouse gases

Development of new solutions and new technologies could support a climate-friendly food production in the future. At the same time, there is a need to know more about how greenhouse gas emission reductions can be obtained in the best way with the technology we already have available today.

Funded by the National Green Climate Fund other research work in agriculture was initiated in 2019 as mentioned in chapter 4.3.4:

- Climate accounts and information on individual farm-level
- Climate-friendly feed production
- Promotion of green bio refining
- Promotion of green building

Further information is included in chapter 4.3.4.

In 2019, DKK 90 million was allocated for climate change mitigation research in agriculture in the period 2019-2021 and a research programme has been launched consisting of 10 projects. An additional DKK 30 million has been allocated to this initiative in 2022.

Furthermore, DKK 40 million has been allocated to climate research in agriculture in 2020 as part of the Danish Green Development and Demonstration Programme (GUDP).

In 2021, 2022 and 2023, a total of DKK 435 million has been allocated to a Research program for farm-level inventories of greenhouse gas and nutrient emissions. The purpose of this research program is to contribute to a robust level of knowledge on significant emissions of GHG and nitrogen at farm-level.

In 2023, DKK 110 million has been allocated to further research in three development initiatives with greenhouse gas reduction potentials in the agricultural sector, hereunder biorefining of waste and residues (biochar), manure management and feed additives for reducing the production of enteric methane in dairy cows. All initiatives are part of the Agreement on a Green Transition of The Agricultural Sector from October 2021.

4.3.7.1 CH_4 (methane)

Methane emissions mainly stem from the agricultural sector, contributing, in 2022 with 82.6% of total Danish CH_4 emissions, corresponding to 5.8 million tonnes CO_2 equivalents (Nielsen et al., (2022a). Agricultural systems have two main sources of methane. Methane is formed through enteric fermentation of feed during digestion in livestock (51.7%) and management of animal manure (30.9%).

Danish agriculture's biggest contribution to the methane emissions comes from dairy cows.

In the digestion process, methane is a by-product of the fermentation of feed in the rumen, primarily from grass and roughage fodder such as grass, grass silage and maize silage. In addition, methane is formed by microorganisms during conversion of carbon in the manure under anaerobic conditions, increasing with increasing temperatures and pH. These conditions especially occur in manure stores and housing systems with slurry (liquid manure) or deep litter. Methane from manure management in Denmark is primarily linked to pig production.

The emission of methane from agriculture has remained more or less stable in the period from 1990 to 2020, and the total CH_4 emission from the agriculture sector has decreased 0.3 % in the same period. At present, the number of dairy cows in Denmark is projected to increase slightly in combination with an increased milk production per dairy cow, which again could cause the feed intake and thus the methane emissions from enteric rumen fermentation to rise. At the same time, the CH_4 emissions from manure are expected to slightly decrease due to an increasing share of the manure expected to be treated in biogas plants or acidified in the livestock housing system (the stable). The effect on methane emissions from acidification needs further documentation. As a part of the Agreement on a Green Transition of The Agricultural Sector of October 2021 and the included requirement for reduction of methane from enteric rumen fermentation, the use of feed additives, inhibiting production of methane from enteric rumen fermentation, is expected to decrease the emissions of methane from dairy cows.

4.3.7.1.1 Biogas

Biogas from digestion of manure and organic wastes carries a number of potential advantages when used to substitute fossil energy: reductions in emissions of greenhouse gases, better utilization of manure as fertiliser, recycling and use of organic wastes for energy and fertiliser purposes etc. However, there are also environmental challenges for example increased ammonia emission and odour from the biogas plants.

As part of the Danish Rural Development Programme 2007-2013, financial support has been provided to investments in biogas plants in 2010 and in 2012. In 2012 support was awarded to both new and existing biogas plants to the amount of DKK 262 million.

In order to stimulate expansion of the biogas sector the subsidy on the sales price of electricity production based on biogas was adjusted by the Energy Policy Agreement of 22 March 2012. The Agreement resulted in an amendment to the Promotion of Renewable Energy Act of 27 December 2008.

The Energy Policy Agreement continued funding biogas for combined heat and power (CHP) and introduced subsidy equality so that biogas sold to the natural gas grid would receive the same subsidy as biogas used at CHP plants. In addition the agreement also introduced a new subsidy when biogas is used in industrial processes, as a fuel for transport or for the production of heat.

As part of the PSO Agreement of 17 November 2016, it was decided to establish and fund an advisory task force with the aim of investigating and removing barriers for reducing the hydraulic retention time of manure before being delivered to biogas plants. This included an earmarking of DKK 9.0 million for developing solutions in existing biogas plants and associated suppliers of feedstock to reduce the retention time of manure in the housing system prior to the treatment in the biogas plant. This is expected to increase the production of biogas per unit input of manure while at the same time reducing emissions of methane from the housing system, and thus reduce methane emissions while increasing biogas production at the same time.

The 2022 greenhouse gas emission projection expects an increase in biogas production from 27 PJ in 2021 to 38 PJ in 2025 with a peek of 49 PJ in 2030 when considering biogas facilities mainly based on agricultural sources.

As part of the 2018 energy agreement, it was decided to no longer permit new applicants to the existing subsidy schemes for the use of biogas from January 1st 2020.

In 2019, a targeted effort to reduce methane emissions from Danish biogas plants was initiated. The findings from the project showed higher emissions than formerly assumed from the production of biogas. This resulted in the formulation of new regulation, which was put into effect 1 January 2023. The regulation dictates the reporting of annual mandatory leak detection and repair to the Danish Energy Agency, regular self-monitoring, as well as a 1 % limit on methane loss from upgrading facilities. It is expected that a new campaign to measure the effect of the regulation will take place in 2025.

4.3.7.2 N_2O (nitrous oxide)

Agriculture is the largest source of nitrous oxide emissions in Denmark. In 2020, 89% of the total Danish N_2O emissions came from agriculture, corresponding to 5.1 million tonnes of CO_2 equivalents (Nielsen et al., (2022a)). The process of emission of N_2O occurs in some types of manure storage facilities and during conversion of mineral and organic bound nitrogen (e.g. in manure and applied wastewater sludge) in the soil. Some of the leached nitrogen is also converted into nitrous oxide. Nitrogen entering the soil with applied fertiliser and manure, and through plant residue, is the main sources of nitrous gas emissions.

Likewise, ammonia (NH_3) volatilisation contributes to the greenhouse effect because some of the ammonia nitrate ends up as nitrous oxide in the atmosphere. Ammonia volatilisation into the atmosphere stems almost exclusively from agriculture, through conversion processes from manure, fertiliser, sludge, crop residue and treatment of straw with ammonia. In particular, the emissions occur during handling of manure in animal housing, during storage and transport of manure, and from grazing animals[11] (*Nielsen et al., (2018a)*).

The main reason for the drop in the overall emissions of N_2O from the agricultural sector of 25% from 1990 to 2020 is enforced legislation (see below) to reduce nitrogen leaching by improving the utilisation of nitrogen binding in manure, as well as measures to reduce the application of mineral fertilizers to soils. The legislation has resulted in a considerable reduction in the use of mineral fertilisers. It has also helped, that the market driven effort to improve the feeding efficiency (and thereby also the farmers economy) have reduced the nitrogen excreted per unit livestock produced. The basis for the N_2O is then reduced (*Nielsen et al., (2017a)*). Implementation of the Action Plans for the Aquatic Environment II and III contribute the most to this reduction[12,13]. Further projected decrease in N_2O emissions towards 2020 is mainly attributed to areas being

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[11] Mikkelsen et al., 2005: Mikkelsen, M.H., Gyldenkærne, S., Poulsen, H.D., Olesen, J.E. & Sommer, S.G. (2005). Opgørelse og beregningsmetode for landbrugets emissioner af ammoniak og drivhusgasser 1985-2002. Arbejdsrapport fra DMU Nr. 204 (in Danish).

[12] Olesen et al., 2004: Olesen, J.E., Petersen, S.O., Gyldenkærne, S., Mikkelsen, M.H., Jacobsen, B.H., Vesterdal, L., Jørgensen, A.M.K., Christensen, B.T., Abildtrup, J., Heidmann, T. & Rubæk, G. (2004). Jordbrug og klimaændringer - samspil til vandmiljøplaner. DJF rapport Markbrug nr. 109. (in Danish).

[13] Olesen, 2005: Olesen, J.E. (2005). Muligheder for reduktion af drivhusgasemissioner i jordbruget. I: Olesen, J.E. (red). Drivhusgasser fra jordbruget - reduktionsmuligheder. DJF rapport Markbrug nr. 113, s. 12-32. (in Danish).

taken out of agricultural production for urban development and infrastructure etc., and to anticipated increased shares of organic agriculture (DCE, December 2014).

In 2016, the Political Agreement on a Food and Agricultural Package from 2015) allowed Danish farmers to use more nitrogen in the fields through a lifting of the reduced fertilizer standards for nitrogen. The potential slight increase in future N_2O emissions resulting from this policy change is sought mitigated by correspondingly implementing measures for ensuring optimization of N-binding and carbon sequestration in agricultural soils (e.g. catch crops).

In 2021, the Agreement on a Green Transition of The Agricultural Sector (further elaborated in section 4.3.7.2.5), introduced measures that will reduce the nitrogen discharge to coastal waters by approx. 10,800 tons in 2027. The effort is substantial and in line with the requirements of the EU Water Framework Directive. As a part of the agreement, DKK 249 million (approximately EUR 33 million) has been allocated to initiate the development of a new farm-level nitrogen regulatory model, which is expected to reduce nitrogen emissions by 6,500 tons by 2027. The regulatory model is expected to introduce farm-level measures i.e. crop selection, catch crops and various other management instruments into the regulation.

4.3.7.2.1 Action Plans for the Aquatic Environment I and II and Action Plan for Sustainable Agriculture

One of the main purposes of the Action Plans for the Aquatic Environment and the Action Plan for Sustainable Agriculture was to reduce agriculture's nutrient losses to the aquatic environment.

The action plans was implemented as regulation of farmers' behaviour. The Action Plan for the Aquatic Environment I was initiated in 1987, and the Action Plan for Sustainable Agriculture in 1991. In particular, these action plans included requirements concerning closed periods for applying slurry, ensuring a better utilisation of manure as well as minimum slurry storage capacity, mandatory incorporation of manure into the soil shortly after application, and winter green fields. The Action Plan for the Aquatic Environment II from 1998 contained a number of additional measures, including re-establishment of wetlands, afforestation, agreements on environment friendly agricultural measures, establishment of organic farming on an additional 170,000 ha, improved utilization of fodder, reduced animal density, use of catch crops, reduced fertilisation norms, and increased efficiency in use of nitrogen in manure. The aim of the political plans, which has now been reached, was to reduce nitrogen leaching by 100,000 tonnes N/year up to the year 2003[14]. The benchmark for the evaluation of the agricultural nitrogen leaching, as part of the final evaluation of the Action Plan for the Aquatic Environment II in December 2003, was 311,000 tonnes N per year. The evaluation showed that measures already implemented in addition to the measures agreed upon and financed by Action Plan II would result in a reduction of the total nitrogen leaching from agriculture (root zone and stable and storage facilities) of around 149,000 tonnes N per year. This corresponds to a reduction of around 48% of 311,000 tonnes N. After taking into account the calculation uncertainties, the nitrogen discharge reduction goal of 49% was achieved.

[14]Grant et al., 2000: Grant, R., Blicher-Mathiesen, G., Jørgensen, V., Kyllingsbæk, A., Poulsen, H.D., Børsting, C., Jørgensen, J.O., Schou, J.S., Kristensen, E.S., Waagepetersen, J. & Mikkelsen, H.E. (2000). Vandmiljøplan II - midtvejsevaluering. Miljø- og Energiministeriet, Danmarks Miljøundersøgelser, Silkeborg, Denmark. 65 pp (in Danish).

Specifically, these action plans have reduced the emissions of nitrous oxide. There have presumably also been small effects on methane emissions from manure stores, particularly as a consequence of increased use of anaerobic fermentation of manure in biogas plants and the reduced use of deep litter. The increased use of catch crops and larger overall areas with organic farming would also be expected to an increased storage of carbon in the soil.

Most of the changes in nitrous oxide emissions from agriculture through the period since 1990 can be attributed to these action plans. However, it has been calculated that even without the action plans there would have been a reduction in emissions, although to a much lesser extent, due to an overall optimization and improvement of farming techniques and management practices. The effect of these action plans on emissions of nitrous oxide has been calculated at about 2.2 million tonnes CO_2 equivalents/year[19]. There are no estimates of the effect of the Action Plans I and II for the Aquatic Environment and the Action Plan for Sustainable Agriculture on carbon storage in the soil.

As stated in section 4.3.2.7 the Agreement on a Green Transition of The Agricultural Sector, introduced measures that will reduce the nitrogen discharge to coastal waters by approx. 10,800 tons in 2027. The effort is based on voluntary contributions from farmers. An environmental guarantee is introduced and every second year, a stocktaking of the ongoing rollout of the collective measures will be carried out. The guarantee implies that if the presupposed reduction level from the voluntary collective nitrogen measures cannot be achieved, regulatory measures will be implemented. It is estimated that the efforts will reduce greenhouse gas emissions by 0.31 million tons of CO_2e in 2025 and 0.64 million tons of CO_2e in 2030.

4.3.7.2.2 The Ammonia efforts

Ammonia emitted from agriculture will stimulate emissions of nitrous oxide when it is deposited in other ecosystems. Reducing ammonia emissions will therefore also result in a reduction of nitrous oxide emissions from that step in the production system. However, as the reduced ammonia emissions increase the nitrogen content in the manure, more nitrogen will, depending on the regulation, be applied to agricultural soils, increasing ammonia as well as nitrous oxide emissions during application. Together with the Action Plans for the Aquatic Environment I, II and III, the Ammonia Action Plan, which was adopted in 2001 carried a projected reduction of ammonia emissions by an estimated 15-20,000 tonnes of nitrogen annually. Hence, ammonia evaporation from agriculture should be reduced from 90,000 tonnes of nitrogen in the mid-1990s to approximately 60,000 tonnes of nitrogen in 2004.

The measures covered by the Ammonia Action Plan are:

1) Optimisation of manure handling in stables for cattle, pigs, poultry and fur animals.
2) Rules on covering storage facilities for solid manure and slurry tanks.
3) Ban on overall surface spreading and reduction of the time from field application of manure to incorporation in soil.
4) Ban on ammonia treatment of straw.

Following from an ex-ante analysis in 2001, these measures were estimated to have lowered the level of annual emissions of nitrous oxide corresponding to 34,000 tonnes of CO_2 equivalents from 2010. A shorter period of exposure for spread manure was estimated to have the greatest effect with an estimated reduction of 13,000 tonnes of CO_2 equivalents in annual emissions[22].

In 2018, a 22 per cent decrease in emissions of ammonia from agriculture from 2001 to 2016 could be seen – corresponding to a reduction of 75,000 tonnes CO_2 equivalents in annual N_2O emissions. From 1990 to 2016 there was a 43 percent decrease - corresponding to a reduction of 200,000 tonnes CO_2 equivalents in annual N_2O emissions. The target level of approximately 60,000 tonnes of nitrogen in emissions of ammonia from agriculture was reached in 2011.

In 2019, further measures to reduce emissions of ammonia from agriculture was implemented. However, the effect on greenhouse gas emissions is estimated to be neutral.

4.3.7.2.3 Action Plan for the Aquatic Environment III and the agreements of Green Growth

With the political agreement on the Action Plan for the Aquatic Environment III (APAE III) of 2 April 2004, a number of measures were implemented to follow up on the results attained via the previous plans. This third action plan contains targets with respect to nitrogen, phosphorus, sensitive natural areas, and slurry odour. It is a 10-year agreement, and was, in 2008 and 2011, evaluated with respect to the Water Framework Directive and the Habitats Directive. Special emphasis in the APAE III was on the use of catch crops, stricter requirements for use of manure as well as afforestation and agro-environmental measures. In addition, the agreement includes research initiatives aimed at slurry odours and reduction of emissions of nutrients, e.g. research into technology to manage slurry, ammonia etc. The effect of the action plan for the period 2008-2012 was projected at 0.2 million tonnes CO_2 equivalents/year[15].

In 2008 the APAE III was evaluated on results, adequacy of tools and economic aspects to ensure that activities and expected results were achieved. The main conclusions for a number of measures were that implementation and effects have not been as anticipated. At the midterm evaluation of the APAE III, covering the years 2004-2007, no reductions in the production of animal manure were recorded, nor any decrease in the use of mineral fertilizers. Furthermore, no significant reductions in nitrogen leaching were proved for the investigated period (Waage Petersen et al., 2008).Thus, no change in the key parameters that provided reduction in the emissions of greenhouse gasses in the earlier action plans for the aquatic environment have happened so far, and it may therefore be difficult to reach the initial target.

In 2009, the Danish government launched the Green Growth Agreement (GGA) – as a plan for ensuring better conditions for nature and the environment while allowing agriculture to develop as a business. The GGA is a long-term plan for Danish nature, environment and agriculture with the purpose of ensuring that a high level of environmental, nature and climate protection goes hand in hand with modern and competitive agriculture and food industries.

The GGA was augmented in 2010 by the Green Growth Agreement 2.0, containing a series of initiatives to improve agriculture and food sector growth conditions and thus help to secure employment on farms, in the food industry and downstream industries.

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[15] Olesen et al., 2001: Olesen, J.E., Andersen, J.M., Jacobsen, B.H., Hvelplund, T., Jørgensen, U., Schou, J.S., Graversen, J., Dalgaard, T. & Fenhann, J. (2001). Kvantificering af tre tiltag til reduktion af landbrugets udledning af drivhusgasser. DJF-rapport Markbrug 48. (http://web.agrsci.dk/djfpublikation/djfpdf/djfm48.pdf , in Danish).

Furthermore, the GGA 2.0 supported the ongoing development of bioenergy with the aim of contributing to support Denmark's target of 30 per cent renewable energy by 2020 and fulfilment of Denmark's climate goals.

The GGA contains targets with respect to discharges of nitrogen and phosphorus to the aquatic environment, protection of nature and biodiversity, development of renewable energy in the agricultural sector including biogas plant, reduction of harmful pesticides, development of the organic sector and strengthened initiatives within research and development within the agricultural and food sectors.

The GGA also dealt with the problems previously encountered in achieving the expected goals through the APAE III. The measures in the GGA likewise pursued the achievements of the objectives of the Nitrates Directive on reducing discharges of nitrogen and phosphorus, as the target in APAE III were included in the GGA target. Different from the former APAE's were also the switch from a target on N leaching from the root zone to a target on N discharge to the aquatic environment. As the GGA worked to implement the EU Water Framework Directive, some measures were targeted sub-catchment while some measures were general rules.

The initiatives incorporated in the GGA were projected to reduce the agricultural sector's overall emissions of greenhouse gases by about 800,000 tonnes of CO_2 equivalents annually. Of this, about 400,000 tonnes reduction were expected to be derived from a green, market-based re-structuring of nitrogen regulation.

4.3.7.2.4 Environmental Approval Act for Livestock Holdings

The Environmental Approval Act for Livestock Holdings was implemented on 1 January 2007, providing national minimum requirements for environmental protection (odour, ammonia, nitrate, phosphorous, landscape, etc.) when livestock holdings are established, expanded or changed. The purpose of the Act was also to ensure the use of best available techniques (BAT).

The measures covered by the Environmental Approval Act for Livestock Holdings in 2007 were:

- 300 m buffer zones around ammonia-sensitive areas where no extension of livestock farms can take place if such an extension would lead to increased ammonia deposition in natural areas vulnerable to ammonia.
- Demand for a general reduction of ammonia emissions relative to a production facility with the lowest ammonia emission norm: 2007: 15%, 2008: 20%, 2009: 25%.
- Demands for injection of animal slurry on black soil and grass within buffer zones (1 km from vulnerable natural areas and, from 2011, in the whole country).
- Demand for fixed cover on most new containers for solid manure and slurry tanks (if they are within a distance of 300 meter to neighbours or vulnerable natural areas).
- Environmental standards and limits for nitrate-leaching to surface waters and groundwater depending on vulnerability, e.g. denitrification capacity and standards for phosphorous surplus depending on soil type and drainage.
- Environmental standards and limits for maximum deposition of ammonia on vulnerable nature and maximum odour impact on neighbours and cities.

The effect of these measures on greenhouse gas emissions has not yet been quantified.

The Environmental Approval Act for Livestock Holdings was changed in 2011, and the environmental standards for ammonia were heightened trough several measures. The general reduction goal was increased to a reduction of 30%, the specific ammonia reduction requirements were introduced with a maximum for total deposition to certain ammonia sensitive areas. This replaced the 300 meter buffer zones. In general this led to an overall tightening of the ammonia reduction with local exceptions.

In 2017 the act was once again changed, introducing a new permit scheme based on the size and character of the floor area, where animals are kept. In this sceme the permit is expressed in square meters as opposed to the former sceme based on number of animals. The environmental standards for ammonia were maintained on the same level.

Finally the act has also been revised in 2023 to form the basis for implementing specific measurements to reduce greenhouse gasses from livestock production. As of may 2023 frequent removal of manure from pig houses is required corresponding to an effect of 0.16 million ton of CO_2e per year in 2030. In 2025 it is expected to also require a reduction of methane emissions from cattle corresponding to an effect of 0.16 million ton of CO_2e per year in 2030.

4.3.7.2.5 Political Agreement on a Food and Agricultural Package and the political Agreement on Targeted Regulation and subsequent agreements

In 2015 the Green Growth Agreement was replaced by the Political Agreement on a Food and Agricultural Package (FAP) which ensures better production conditions for farming, while at the same time handling a number of the key environmental challenges.

The agreement includes a diverse package of measures designed to make a shift in the way environmental regulation in the agricultural sector is carried out, from a general regulation to a targeted approach. The fertilization standards for the agricultural sector was lifted to the level of economic optimum and a new targeted regulation based on specific environmental goals for the aquatic environment and ground water resources is introduced from 2019.

The re-establishment of wetlands, rewetting of organic soils and afforestation (conversion of arable land) remain important measures to reduce the loss of nitrogen to the aquatic environment. As a part of the FAP a comprehensive support scheme for catch crops was also introduced. The agreement also included changes to the regulation on the use of catch crops in Danish agriculture: a requirement of catch-crops as compensation for livestock-related nitrogen leaching and additional catch-crops as part of a targeted regulation. The aforementioned regulatory schemes on catch crops were implemented in addition to the already existing two other schemes, covering mandatory catch crops and catch crops as part of the EU requirement of environmental focus area.

Demands on growing catch crops in the autumn to reduce the nitrate leaching do also sequester CO_2. Based on plans for future agricultural regulations the area is expected to increase significantly towards 2021. In 2018 an additional agreement on Targeted Regulation was agreed upon. In addition to catch crops measures such as energy crops, reduced fertilizer/manure application, fallow land etc. was introduced as a part of the scheme. Money was also allocated to develop technologies from biorefining from grass with the aim of commercializing green bio refining and thus increase the demand for grass and other crops with lower climate- and environmental footprint.

In 2019, a political agreement was settled on frontloading the positive climate and nutrient effects of targeted regulation from 2021 to 2020. From 2019 to 2020 there will be a substantial increase in agricultural land with catch crops (potentially 550,000 hectares out of a approximately 2.6 mill. hectares of arable farmland). As a part of targeted regulation, the farmer can choose a number of alternative measures to catch crops to mitigate nutrient leaching. From 2020, all alternative measures have a positive climate effects.

As a part of the Political Agreement on a Food and Agricultural Package money was also allocated for afforestation, environmental and climate technologies and conversion of arable land on organic soils to nature under the Danish Rural Development Programme funded by the European Agricultural Fund for Rural Development (EAFRD). As a part of the agreement on the national budget of 2020, an additional 35 mio. DKK have been allocated for afforestation purposes and 170 mio. DKK for investments at farm-level, including environmental and climate technologies.

In 2021, the Political Agreement on a Food and Agricultural Package (FAP) was replaced by the Agreement on a Green Transition of The Agricultural Sector (4th October, 2021). The agreement consists of directly implementable initiatives and initiatives with potential depending on research and demonstration.

Importantly, the agreement contains a binding reduction target for the agricultural and forestry sector of 55 to 65 percent CO_2e reduction in 2030 compared to the emissions in 1990. According to estimates when the agreement was reached, this equals a reduction of approximately 6 to 8 million tons CO_2e. A binding target means that the reductions have to be found in one way or another, and it therefore requires that agriculture delivers a significant contribution to the national 70 percent reduction target in the Danish Climate Act.

According to estimates when the agreement was reached, the initiatives under the agreement that are ready for implementation, is expected to deliver a total reduction in GHG-emissions of 1.9 million tons CO_2e by 2030. A part of the GHG-reductions will occur in the LULUFC-sector. The initiatives include restoration of peatlands (ambition of restoring 100,000 hectares), reduction of nitrogen emissions to the environment, greenhouse gas reducing requirements in the animal production sector and increased afforestation.

The agreement includes a number of development-initiatives, with potentials depending on research and demonstration. Collectively, they were – at the time when the agreement was reached – estimated to have the potential to reduce GHG-emissions by additionally 5 million tons CO_2e by 2030. The estimated effects of the agreement is being consolidated. The initiatives include research in methane reducing feed additives to livestock, more efficient handling of manure in farm and field, and further development of pyrolysis technology, which can transform agricultural residues into fuel and biochar. Moreover, research and development of a farm-level emissions model that will enable accounting and regulation of the emissions of greenhouse gasses from the individual farm is a part of the agreement.

The reform of the EU's Common Agricultural Policy (CAP) offers many new opportunities for a more green agricultural production. A key element in the new CAP reform is a greater focus on green initiatives, where income support to farmers is used to give incentives to switch to more sustainable production and thus support the green transition of the sector.

With the agreement, Denmark fulfils the EU requirement that at least 25 percent of the budget for direct payments goes to green initiatives. Denmark has previously transferred 7 percent from direct support to the rural development program. Overall, almost DKK 27 billion (approximately EUR 3.6 billion), including DKK 4 billion (approximately EUR 0.5 billion) in additional national funds, are targeted towards the green transition of the agricultural sector. Six new support schemes (eco-schemes), as part of the direct payment system, have been established, including organic farming area support.

4.3.7.2.6 Subsidy for conversion of arable land on organic soils to nature

Cultivated organic soils emits large amounts of CO_2. In Demark approximately 73,000 hectares of organic soils (>12% organic carbon) are under agricultural practice in 2020. With reference to the Danish soil classification, which defines soils with 6-12% organic carbon as organic, there is approximately an additional 96,000 hectares under agricultural practise (a total of 169,000 hectares in 2020).

In 2014 the Danish Government adopted a subsidy scheme for conversion of arable land on organic soils to natural habitats under the framework of the common agricultural policy (CAP). This scheme is now a part of the Agreement on the Food and Agricultural Packet.

The objective of the scheme is to reduce agricultural emissions of greenhouse gases from organic soils through less intensive agricultural operations. The initiative also offers opportunities for synergies in relation to reduced discharges of nitrogen into watercourses, lakes and fiords as well as for increased biodiversity. As a part of the Agreement on the Food and Agricultural Packet the scheme was extended to 2020. The scheme was co-financed by the Danish rural development by the European Agricultural Fund for Rural Development (EAFRD).

In September 2019, an Agreement was made on establishing a Multifunctional Land Re-parcelling Fund 2019-2021. The objective was to facilitate re-parcelling of land and thereby obtain synergies between agricultural production and biodiversity, climate, environment, recreation and rural development.

In 2021, the Agreement on a Green Transition of The Agricultural Sector, sat the ambition of restoring and rewetting 100,000 hectares of carbon rich peat soils (from a total of 169,000hectares) before 2030 with the purpose of reducing both greenhouse gas and nitrogen emissions from agricultural soils and forests in Denmark. DKK 4.4 billion (approximately EUR 590 million) has been allocated to restore natural hydrology on 50,500 hectares of agricultural land, including previous political agreements, and another 38,000 hectares for extensive management.

4.3.7.2.7 Political Agreement on Nature

A Political Agreement on Nature (the Nature Package) was reached in May 2016 with the main aim of supporting an increased protection of biodiversity. The agreement states initiatives within the following areas: Biodiversity in forests, continued initiatives for nature (initiatives derived from the former plan Danish Nature Policy), nature and biodiversity, urban nature and outdoors recreation, open land management and the farmer’s role as resource manager of nature areas, modern nature conservation, and simplification of legislation.

As a result of the nature package 10.200 acres of forest is designated as untouched forest and another 3.600 acres is designated as forest in which management primarily is based on biodiversity considerations in state-owned areas. In addition, a government grant scheme has been established to increase areas of untouched forest in private owned forests.

The climate effect of this Agreement has not been estimated.

4.3.7.2.8 Bio-refining

Bio-refining can produce a range of products such as inputs to biogas production, protein and fodder and other higher value products for use in e.g. the chemical and pharmacological industry. As mentioned in chapter 4.3.4, the 1st allocation of the budget under the National Green Climate Fund in June 2017 included an earmarking of 8 million DKK as support in 2017 for pilot-scale bio-refinery projects based on non-food biomass. Commercialization of the bio-refining sector can facilitate demand for crops such as grasses with higher associated environmental and climate benefits than for conventional crops like corn or cereals. In addition, bio-refining is considered to be essential in realizing the bio-economy potential within Danish agriculture and other connected sectors.

In 2019, additional funds have been allocated through the National Green Climate Fund for promotion of green bio refining (see chapter 4.3.4).

In 2021, DKK 260 million (approximately EUR 35 million) was allocated from 2022-2026 to a new support scheme for biorefining of grass in order to develop the production of new sources of plant-based protein for animal feed and human consumption.

4.3.7.2.9 Promotion of precision agriculture, i.e. fertilization.

Since 2021, the use of precision fertilization has been a general measurement in the Danish nitrogen regulation. With the use of high-tech solutions such as remote sensing, high precision positioning systems, sensors and variable rate technologies cultivation is optimized resulting in less nitrogen leaching from the fields. There have been found to be positive climate mitigation effects from precision farming. However, more knowledge beyond the existing initiative is needed in order to quantify the effect.

TABLE 4.21 MEASURES IN AGRICULTURE, FORESTRY AND FISHERIES (SEE ALSO TABLE 4.25 (LULUCF))

Name of mitigation action	Included in with measures GHG projection scenario *	Sector(s) affected	GHG(s) affected	Objective and/or activity affected	Type of instrument	Status of implemen-tation	Brief description	Start year of imple-men-tation	Implementing entity or entities	Estimate of mitigation impact (not cumulative, in ktCO2e)**	
										2020	2030
7-AG-04f: Environmental Approval Act for Livestock Holdings	Yes	5: Agriculture	Methane (CH_4), Nitrous oxide (N_2O)	6_39: Reduction of fertilizer/manure use on cropland, 6_40: Improved livestock management, 6_42: Improved animal waste management systems	Regulatory	Implemented	The measures covered by the Environmental Approval Act for Livestock Holdings are: • 300 m buffer zones around ammonia sensistive areas where no extension of livestock farms can take place if such an extension would lead to increased ammonia deposition in natural areas vulnerable to ammonia. • Demand for reduction of ammonia emissions relative to production facility with lowest ammonia emission norm: 2007: 15%, 2008: 20%, 2009: 25% • Demands for injection of animal slurry on black soil and grass within buffer zones (1 km from vulnerable natural areas). • Demand for fixed cover on most new containers for solid manure and slurry tanks (depending on distance to neighbours and vulnerable natural areas). • Reduced number of Livestock Unit per hectare (LU/ha) when in nitrate vulnerable areas with low denitrification capacity • Regulation of phosphorous surplus on manure spreading areas	2007	The Ministry of Food, Agriculture and Fisheries	NE	IE
7-AG-06: Biogas plants - reporting of annual mandatory leak detection and repair	No	5: Agriculture, 1: Energy supply	Methane (CH_4)	6_42: Improved animal waste management systems, 1_01: Increase in renewable energy sources in the electricity sector, 1_03: Switch to less carbon-intensive fuels	Regulatory	Implemented	In 2019, a targeted effort to reduce methane emissions from Danish biogas plants was initiated. The findings from the project showed higher emissions than formerly assumed from the production of biogas. This resulted in the formulation of new regulation, which was put into effect January 1st 2023. The regulation dictates the reporting of annual mandatory leak detection and repair to the Danish Energy Agency, regular self-monitoring, as well as a 1 % limit on methane loss from upgrading facilities. It is expected that a new campaign to measure the effect of the regulation will take place in 2025.	2023	The Danish Energy Agency	NA	IE
7-AG-13: Agreement on Nature (the Nature Package)	Yes	5: Agriculture, 6: LULUCF	Carbon dioxide (CO_2), Methane (CH_4), Nitrous oxide (N_2O)	6_41: Other activities improving cropland management	Regulatory	Implemented	Political agreement aiming, amongst other goals, towards an increased protection of biodiversity. The agreement states initiatives within the following areas: Converting forests for biodiversity purpose, continued agreements for nature, nature and biodiversity, urban nature and outdoors recreation, open land management and the farmer's role as resource manager, modern nature conservation, and simplification of legislation.	2016	The Ministry of Food, Agriculture and Fisheries	NE	IE
7-AG-15: Pool for the promotion of biogas and other green gases by tender	Yes	5: Agriculture, 1: Energy supply	Methane (CH_4)	6_42: Improved animal waste management systems, 1_01: Increase in renewable energy sources in the electricity sector, 1_02: Increase in renewable energy in the heating and cooling sector	Economic	Adopted	The Climate Agreement introduces an aid scheme for the production of "biogas and other green gasses." According to the Climate agreement, the aid scheme will consist of six successive competitive bidding processes based on clear, transparent and non-discriminatory criteria, where producers of biogas and gasses based on renewable energy sources compete for the aid. The aid will be granted as operating aid for a period of 20 years in the form of a price premium in addition to the market price of the gas produced. The bids will be assessed based on the premium and the offered volume . Fully implemented in 2030 the scheme aims at reducing emmission by 0,7 mil. tonnes CO2e/yearly by producing 10 PJ biogas and e-methane.	2021	The Danish Ministry of Climate, Energy and Utilities	NA	IE
7-AG-16: Separate nitrogen standards for humus soils	Yes	5: Agriculture	Nitrous oxide (N_2O)	6_41: Other activities improving cropland management	Regulatory	Implemented	In 2020 a separate standard has been established for humus soils, which implies that nitrogen standard for crops and grass in rotation is reduced by 25 or 50 kg / N per hectare depending on crop type.	2020	The Ministry of Food, Agriculture and Fisheries	NE	IE
7-AG-17: Adjustment of utilization requirements for livestock slurry and manure	Yes	5: Agriculture	Nitrous oxide (N_2O)	6_41: Other activities improving cropland management	Regulatory	Implemented	In 2020 the utilization requirements in the DK Fertilizer Order has been adjusted, so that a larger share of the amount of nitrogen applied from livestock slurry and manure must count towards compliance with the farmers nitrogen quota.	2020	The Ministry of Food, Agriculture and Fisheries	NE	IE
7-AG-18: Prohibition of fertilization and spraying, etc. on §3 areas (Protected areas)	Yes	5: Agriculture	Nitrous oxide (N_2O)	6_41: Other activities improving cropland management	Regulatory	Adopted	In 2020 a ban of fertilization and spraying on §3 protected areas was adopted. The proposal aims to ensure that spraying, fertilizing and plowing no longer take place on a number of meadow areas with a total area of 37,000 hectares, which are covered by the Nature Conservation Act.	2022	The Ministry of Food, Agriculture and Fisheries	NA	IE
7-AG-19: Subsidy for biogas (for transport and processes)	Yes	6: Agriculture, 1: Energy supply	Methane (CH_4)	6_42: Improved animal waste management systems	Economic	Adopted	The aid scheme for biogas towards transport and process was introduced with the Energy Agreement of 2012. In order to comply with the scheme requirements, biogas sold for direct use in the transport sector can not be produced from energy crops. Furthermore, recipients must live up to national and RED2 sustainability requirements and reporting obligations. As of January 1st 2020, the scheme was closed for new applicants and a production-based cap on potential aid was introduced. The aid scheme can go until 2032 and at least 20 years for the individual scheme recipients.	2012	The Danish Ministry of Climate, Energy and Utilities	NA	IE
7-AG-20: Subsidy for upgrading and purification of biogas	Yes	6: Agriculture, 1: Energy supply	Methane (CH_4), Carbon dioxide (CO_2)	6_42: Improved animal waste management systems	Economic	Adopted	The aid scheme for biogas towards upgrading and purification of biogas was introduced with the Energy Agreement of 2012. In order to comply with the scheme requirements, recipients must live up to national and RED2 sustainability requirements and reporting obligations. As of January 1st 2020, the scheme was closed for new applicants and a production-based cap on potential aid was introduced. The aid scheme can go until 2032 and at least 20 years for the individual scheme recipients.	2012	The Danish Ministry of Climate, Energy and Utilities	NE	IE

TABLE 4.21 MEASURES IN AGRICULTURE, FORESTRY AND FISHERIES (SEE ALSO TABLE 4.25 (LULUCF)) (CONTINUED)

Name of mitigation action	Included in with measures GHG projection scenario	Sector(s) affected	GHG(s) affected	Objective and/or activity affected	Type of instrument	Status of implementation	Brief description	Start year of implementation	Implementing entity or entities	Estimate of mitigation impact (not cumulative, in ktCO2e)** 2020	2030
7-AG-22: Ecological area support (Ecoscheme)	No	Agriculture	CO2, CH4, N2O	6_45: Other agriculture.	Economic	Adopted	The scheme must contribute to both the conversion towards and maintenance of organic farming of agricultural land, in order to support an increase in the organic land, in order to reach a doubling in 2030.	2022	The Ministry of Food, Agriculture and Fisheries	NA	NE
7-AG-23: Environmentally and climate-friendly grass (Ecoscheme)	No	Agriculture	CO2, CH4, N2O	6_45: Other agriculture.	Economic	Adopted	Subsidy for the postponement of the ploughing of grasslands which achieves an environmental and climate effect on the individual area. Furthermore, it contributes to improved microbiology and soil fertility.	2022	The Ministry of Food, Agriculture and Fisheries	NA	NE
7-AG-24: Plants (Ecoscheme)	No	Agriculture	CO2, CH4, N2O	6_45: Other agriculture.	Economic	Adopted	Subsidy to promote greater crop diversity in agriculture by supporting increased crop diversification and the cultivation of rotational crops that is mainly used for food and protein crops.	2022	The Ministry of Food, Agriculture and Fisheries	NA	NE
7-AG-25: Biodiversity and sustainability (Ecoscheme)	No	Cross-cutting	CO2, CH4, N2O	6_45: Other agriculture. , 7_56: Other land use, land-use change and forestry	Economic	Adopted	Subsidy for laying out non-productive agricultural areas to provide more habitats for animals and plants. The subsidy builds on the GLM8 requirement of at least 4 per cent. non-productive areas on arable lands.	2022	The Ministry of Food, Agriculture and Fisheries	NA	NE
7-AG-26: Implementation of "targeted regulation"	No	Agriculture	CO2, CH4, N2O	6_39: Reduction of fertilizer/manure use on cropland, 6_40: Improved livestock management, 6_41: Other activities improving cropland management, 6_42: Improved animal waste management systems, 6_43: Activities improving grazing land or grassland management, 6_44: Improved management of organic soils	Economic	Adopted	The "targeted regulation" is a two-part regulatory scheme related to the objectives of the Water Framework Directive; a voluntary subsidy scheme focused on the reduction of nitrate leaching from agricultural soils through the use of a variety of measures, and - in the event of a lack of voluntary effort - a requirement to establish the measures without compensation will be imposed. The nitrate reducing measures will cause derivative effects on greenhousegas emissions. This encompasses reductions of indirect nitrous oxide emissions and increase of carbon sequestration in soil.	2022	The Ministry of Food, Agriculture and Fisheries	NA	NE
7-AG-27: Restoration of phosphorous wetlands	No	Agriculture	CO2, CH4, N2O	6_45: Other agriculture.	Economic	Adopted	The purpose of the schreme is to reduce phosphorus emmission to water bodies. The projects must be located in sub-areas with at detected need for action, cf. the danish water plans.	2022	The Ministry of Food, Agriculture and Fisheries	NA	NE
7-AG-28: Environmental and climate technology	No	Agriculture	CO2, CH4, N2O	6_45: Other agriculture.	Economic	Adopted	Subsidy for investment in environmentally and climate-friendly technologies on the farm.	2022	The Ministry of Food, Agriculture and Fisheries	NA	NE
7-AG-29: Organic investment support	No	Agriculture	CO2, CH4, N2O	6_45: Other agriculture.	Economic	Adopted	Subsidies for investments in new technologies, in order to improve the competitiveness of organic farming, strengthen efforts to improve the climate, and contribute to the national effort to double the organic area.	2022	The Ministry of Food, Agriculture and Fisheries	NA	NE
7-AG-30: Collective actions measures to reduce nitrogen emissions	No	Cross-cutting	CO2, CH4, N2O	6_44: Improved management of organic soils, 7_54: Prevention of drainage or rewetting of wetlands	Economic	Adopted	Consists of four voluntary subsidy schemes that contribute to reducing nitrogen emissions into Danish waters (restoration of nitrogen wetlands, restoration of mini-wetlands, afforestation and restoration of peatland).	2022	The Ministry of Food, Agriculture and Fisheries	NA	NE
7-AG-31: Generel reduction requirement for cattle	No	Agriculture	CH4	6_40: Improved livestock management	Voluntary Agreement, Information, Regulatory	Adopted	Reduction of greenhouse gas emissions (methane) from cattle via increased fat in cattle feed or use of new measures such as feed additives, e.g. Bovaer.	2021	The Ministry of Food, Agriculture and Fisheries	NA	NE
7-AG-32: More frequent discharge of pig manure	No	Agriculture	CH4	6_40: Improved livestock management	Voluntary Agreement, Information, Regulatory	Adopted	Reduction of greenhouse gas emissions from pig manure via requirements for more frequent discharge of manure from pig barns to an outdoor cooler storage or biogas plant, which reduces emissions.	2021	The Ministry of Food, Agriculture and Fisheries	NA	NE
7-AG-33: CAP-law	No	Agriculture	CH4, N2O	6_40: Improved livestock management, 6_41: Other activities improving cropland management, 6_42: Improved animal waste management systems	Voluntary Agreement, Information, Regulatory	Adopted	Authorization Act that brings together existing legislation and implements EU's agricultural policy from 2023. In the act, authorization is given to determine basic requirements and establish eco-schemes.	2021	The Ministry of Food, Agriculture and Fisheries	NA	NE
7-AG-34: Implementation of EU's agricultural policy	No	Agriculture	CH4, N2O	6_40: Improved livestock management, 6_41: Other activities improving cropland management, 6_42: Improved animal waste management systems	Voluntary Agreement, Information, Regulatory	Adopted	Implementation of the overall milestones in the Danish strategic CAP plan. The strategic CAP plan was submitted to the Commission in December 2021 and approved by the Commision on 31 August 2022.	2021	The Ministry of Food, Agriculture and Fisheries	NA	NE

TABLE 4.21 MEASURES IN AGRICULTURE, FORESTRY AND FISHERIES (SEE ALSO TABLE 4.25 (LULUCF)) (CONTINUED)

Name of mitigation action	Included in with measures GHG projection scenario	Sector(s) affected	GHG(s) affected	Objective and/or activity affected	Type of instrument	Status of implemen-tation	Brief description	Start year of imple-men-tation	Implementing entity or entities	Estimate of mitigation impact (not cumulative, in ktCO2e)**	
										2020	2030
7-AG-35: Conditionality (GLM-requirements)	No	Agriculture	CH4, N2O	6_40: Improved livestock management, 6_41: Other activities improving cropland management, 6_42: Improved animal waste management systems	Economic	Adopted	Good agricultural and environmental conditions (GLM) are the basic requirements (baseline) that a farmer must meet in order not to get his agricultural support received from pillar I reduced as well as area payments from pillar II. The requirements apply from 2023.	2021	The Ministry of Food, Agriculture and Fisheries	NA	NE
7-AG-36: Basic income support for sustainability(BISS)/Basic payment pillar 1	No	Agriculture	CH4, N2O	6_40: Improved livestock management, 6_41: Other activities improving cropland management, 6_42: Improved animal waste management systems	Economic	Adopted	Basic income support for agricultural areas from 2023 (basic payment scheme).	2021	The Ministry of Food, Agriculture and Fisheries	NA	NE

* Here "Yes" means included in the "with measures" projection scenario, in principle. In most cases not based on separate annual estimates for each mitigation action, but either as a result of the assumption that the measure has contributed to the observed level of total Danish greenhouse gas emissions in the most recent inventory year available, when the projection was elaborated and therefore used as the starting point for the projections, or as part of the integrated models used to project the level of annual greenhouse gas emissions in future years.
** See explanatory note under Table 4.26.

4.3.8 LULUCF (Land-Use, Land-Use Change and Forestry)

4.3.8.1 CO_2 – emissions and removals in LULUCF under the Climate Convention

The emission of GHGs from the LULUCF sector (Land Use, Land Use Change and Forestry) includes primarily the emission of CO_2 from land use and small amounts of N_2O from disturbance of soils not included in the agricultural sector.

The LULUCF sector is subdivided into six major categories:

- Forest
- Cropland
- Grassland
- Wetlands
- Settlements
- Other Land

Forests and forestry are important due to CO_2 sequestration and emissions as a consequence of trees growing, respiring and decomposing. Danish forests contain a considerable store of CO_2 absorbed from the atmosphere. When new forests are established, new CO_2 stores are created. Afforestation is therefore a useful climate policy instrument.

The total sector has been estimated to be a net source of 4.3 % of the total Danish emission incl. LULUCF (average 2013-2020 (variation 1.6-7.2 % depending of year). The average emission in 2013-2020 has been estimated to 2145 kt CO_2 equivalents with an emission of 3107 kt CO_2 equivalents in 2020.

Emissions/removals from the sector fluctuate based on specific conditions in the given year. In general, the forest sector is a net sink or around in its equilibrium state, while Cropland and Grassland are net sources. The latter due to a large area with drained organic soils. Emissions from drained organic agricultural soils in 2020 accounts for 9.9 % of the total Danish emission incl. LULUCF. Mineral soils shift between being a sink or a source.

Forest has shown to be a sink for all years since 1990. Since 2013, forest has been estimated to be an average annual net sink of 2980 kt CO_2 equivalents. In 2020, Cropland has been estimated to be a net source of 6.4 % of the total Danish emission incl. LULUCF. Grassland is a net source contributing to 5.0 % of the total Danish emission, also due to a large area with drained organic soils. Emissions from Cropland and Grassland have shown a continuous decrease since 1990. However, large variations occur between years as shown in Table 4.22.

TABLE 4.22 TOTAL GREENHOUSE GAS EMISSIONS IN THE LULUCF SECTOR 1990 AND 2013-2020.
Source: Nielsen at al. (2022a) - Denmark's National Inventory Report 2022 and CRF for 1990-2020.

Total greenhouse gas emissions*	Base year	1990		2013	2014	2015	2016	2017	2018	2019	2020	Change from base to latest reported year
	(kt CO_2 eq)			(kt CO_2 eq)								%
4. Land use, land-use change and forestry	6,874	6,874		1,105	1,816	792	1,886	1,820	3,738	2,893	3,107	-54.8
A. Forest land	-1,229	-1,229		-3,392	-3,958	-4,008	-3,121	-2,570	-2,125	-2,490	-2,172	76.8
B. Cropland	5,298	5,298		2,440	3,563	2,562	2,666	2,226	3,382	3,051	2,851	-46.2
C. Grassland	2,230	2,230		1,847	2,031	2,118	2,149	2,056	2,218	2,132	2,232	0.1
D. Wetlands	105	105		55	65	68	65	47	76	71	72	-31.0
E. Settlements	472	472		248	261	224	302	224	233	214	242	-48.7
F. Other land	NA	NA		NA	NA	NA	NA	NA	NA	NA	NA	0.0
G. Harvested wood products	-2	-2		-94	-147	-172	-174	-162	-46	-85	-118	4869.3
H. Other	NA	NA		NA	NA	NA	NA	NA	NA	NA	NA	0.0

* In this table, the signs for removals in kt CO_2 eq. are negative (-) and for emissions in kt CO_2 eq. positive (+). In the column showing percentage changes, the signs for decrease in emissions or removals are negative (-) and for increase in emissions or removals positive (+).

Forest policies

For more than 30 years climate change has been mitigated through long-term goals and measures for increased forest cover in Denmark.

In 1989, a legislative proposal for a new Danish forest act referred to a long-term goal of doubling the Danish forest cover to approximately 25 pct. of the land area in the course of a tree generation.

In 2002, the first Danish National Forest Programme set out the long-term objective that forest landscapes should cover 20-25 pct. of Denmark in the course of 80-100 years. These objectives and measures relates to Article 3.3 of the Kyoto Protocol. Various measures have been taken towards achieving the goals as shown in Table 4.25. For instance, a government grant scheme has been established as an incentive for afforestation on private agricultural land. Also, the state itself is establishing new forests, and some private individuals are establishing forests on agricultural land without a government grant. Through rural planning and differentiated incentives, afforestation is particularly encouraged in certain priority areas in order to pursue multiple forest functions and values, implementing the water framework directive and including recreation and ground water protection.

In October 2018, the Danish Ministry for Environment and Food launched a new National Forest Programme. It sat out a long-term vision and two long term goals related to expansion of forest cover and biodiversity conservation, 13 strategic orientation lines as well as a number of concrete actions for a multifunctional and sustainable development of Danish forests.

The programme includes a vision for a forest area in growth with healthy and robust forests, which accommodate diversity and provide good opportunities for sustainable timber production and the creation of jobs. The forests should also provide good opportunities for biodiversity, preservation of natural treasures, mitigation of climate change, groundwater protection and offer great outdoor experiences - in new and old forests and for the benefit of both present and future generations.

The programme's long-term goal for forest cover builds on the goal established in the national forest programme of 2002 and reads: “Before the end of the 21st century, forested landscapes will cover 20-25 pct. of Denmark's total area”. Thus, the goal relates to “forest landscapes”, which constitutes all forests and some surrounding areas as well. However, a precise definition of forest landscapes has not yet been developed. The Danish forest area is currently 14.9 pct. of the land cover.

Many strategic orientation lines relate to climate and energy, most notably those below.

Under the header “More forest and less global warming”:

- Increase the Danish forest area and increase the public utility of the new forests.
- Increase the uptake and stocks of carbon in forests and wood products through sustainable management.

Under the header Sustainable production:

- A favourable and clear framework for sustainable production of timber and other goods.
- Increase the demand and supply of documentable sustainable timber.
- Uniform, robust and operational criteria for "sustainable timber".
- Continue the conversion and development of close to nature forestry.

As part of the Common Agricultural Policy Reform 2022-2027, DKK 600 million has been allocated to afforestation. The scheme is expected to contribute to climate change mitigation by reducing greenhouse gas emission and enhancing carbon sequestration, as well as promoting sustainable energy. The scheme is a continuation of the afforestation support scheme in the Rural Development Programme 2014-2020.

In 2022, the government announced in its government platform that it will present an ambitious forest plan for the establishment of 250.000 hectares of new forest in Denmark. Establishment of new forests will contribute to reaching climate neutrality and, in time, net negative emissions. The forest plan shall ensure the greatest possible synergy and balance between the many purposes for new forests and identify key partners and already existing funds as well as consider appropriate means of implementation. This must be done in parallel with the preparation of a vision plan for agricultural development. The forest plan and afforestation will be financed by a newly established green Danish fund, aiming for the largest possible share of contributions to come from private actors and existing grants.

4.3.8.2 CO_2 – emissions, removals and credits from Activities under Articles 3.3 and 3.4 of the Kyoto Protocol

In 2007, a research and monitoring programme for the monitoring and reporting activities under Articles 3.3 and 3.4 was decided with a total budget of DKK 72 million. The results from this programme have been included in the annual reporting of greenhouse gas inventories under the UNFCCC and the Kyoto Protocol since April 2010 and the final results are approved under the Kyoto Protocol with the publication of the inventory review report on 4 February 2015.

A second research and monitoring programme was launched to cover the 2nd commitment period of the Kyoto Protocol 2013-2020.

For the period 2021-2030 a third research and monitoring programme has been launched.

4.3.8.2.1 Article 3.3

In accordance with Article 3.3 of the Kyoto Protocol, emissions and removals from afforestation, reforestation and deforestation (ARD) activities have been included in the accounting of Removal Units (RMUs) in the 1st (2008-2012) and 2nd (2013-2020) commitment period under the Protocol. The total accounted quantity from ARD in the 1st commitment period was a net emission of 255.9 kt CO_2-equivalent. .

In total for the 8 years of the 2nd commitment period afforestation, reforestation, and deforestation (ARD) activities has been estimated to a net source of approximately 61 kt CO_2-equivalent.

No reforestation was recorded in the 1st and 2nd commitment period.

The AR- and D-accounting quantities for the 2nd commitment period are shown in Table 4.24.

4.3.8.2.2 Article 3.4

In accordance with Article 3.4 of the Kyoto Protocol, emissions and removals from forest management (FM), cropland management (CM) and grazing land management (GM) activities have been elected to be included in the accounting of RMUs in the 1st and 2nd commitment period under the Protocol.

Forest management
According to the final estimates for the 1st commitment period (2008-2012) (*Nielsen et al., 2014* and the *Inventory Review Report* published on 4 February 2015), average CO_2 removals from Forest Management amounted to 4050 kt. The included carbon pools were above-ground and below-ground biomass, dead wood and soil. This estimate was much higher than the specified maximum of credits as removal units for Denmark at 183 kt CO_2 (50kt C) annually in 2008-2012.

In 2022 the removal for forest management for the years 2013 to 2020, taking into account the Forest Management Reference Level (FMRL), was estimated to be above the FM cap of 19,822.07 kt CO_2-eq. The accounting quantity for Forest Management in 2013-2020 is therefore 19,822.07 kt CO_2-eq. as shown in Table 4.24.

Harvested wood products (HWP)
Carbon net emissions from harvested wood products (HWP) have been reported since 2013. Denmark has chosen to report under Approach B, the production approach, which refers to equations 12.1, 12.3 and 12.A.6 of volume 4 of the 2006 IPCC Guidelines and the 2013 Supplementary GPG.

The HWP estimation for 2020 is shown in Table 4.23.

TABLE 4.23. HWP IN USE FROM DOMESTIC HARVEST IN 2020 (CRF TABLE 4.GS1).
Source: Nielsen at al. (2022a) - Denmark's National Inventory Report 2022 and CRF for 1990-2020.

	HWP in use from domestic harvest				Net emissions/ removals from HWP in use
	Gains	Losses	Half-life	Annual Change in stock (ΔC HWP IU DH)	
	(t C)		(yr)	(kt C)	(kt CO_2)
HWP produced and consumed domestically (ΔC HWPdom IU DH)					
Total	**152,308**	**-117,693**		**35**	**-127**
1. Solid wood	152,308	-117,682		35	-127
Sawn wood	75,700	-65,339	35	10	-38
Wood panels	76,609	-52,343	25	24	-89
2. Paper and paperboard	NA	-11	2	0	0
HWP produced and exported					
Total	**27,808**	**-30,357**		**-3**	**9**
1. Solid wood	27,808	-30,337		-3	9
Sawn wood	12,117	-11,850	35	0	-1
Wood panels	15,691	-18,487	25	-3	10
2. Paper and paperboard	NA	-20	2	0	0

Cropland management and Grazing land management:
In 2006, the government at that time decided to include removals of CO_2 by soils (Article 3.4 of the Kyoto Protocol) in the calculation of Denmark's climate accounts under the Kyoto Protocol.

From 1990 to the 1st commitment period 2008-2012 Cropland management and Grazing land management has shown a net reduction in greenhouse gas emissions of 7697 Gg CO_2-equivalents or in average 1539 Gg CO_2-equivalents per year.

From 1990 to the eighth years of the 2nd commitment period, i.e. 2013-2020, Cropland management and Grazing land management has shown a net reduction in emissions of 22,053.14 kt CO_2-equivalents per year CO_2-eq. and 2,442.75 kt CO_2-equivalents per year respectively.

Contributions to the Kyoto Protocol under Article 3.4 concern changes to vegetation and soil carbon stocks. Under the Kyoto Protocol, the flows of carbon to and from biomass and soils are stated according to a net-net principle by which the change in net emissions is calculated as the rate of change for the carbon stock in the 1st and 2nd commitment period less the rate of change for the carbon stock in the reference year (1990). As elected land cannot leave an elected activity, emissions from areas, which have been converted from Cropland and Grassland to Wetlands and Settlements in the commitment periods, are included in the accounting. For agriculture, the following potential sources of CO_2 emissions and CO_2 sequestration have been included:

1. Net change in the content of carbon in mineral soils in connection with changed land use and cultivation.
2. Net change in the soil's carbon stock in connection with drainage and cultivation of organic soils or re-establishment of wetlands.
3. Change in the carbon content of wood biomass in wind breaks and fruit farms.

The agricultural mineral soils has shown to be a steady increasing sink. This is primarily due to increased yields, better management, ban on straw burning, statutory requirements for catch crops, etc.

One of the measures with an effect on return of carbon to the soil has been the ban on burning of straw residues on fields as shown in Table 4.25.

The ban has resulted in greater return of carbon to the soil, and therefore increased carbon storage in the soil, as well as increased use of straw as a fuel. Both uses will result in a net reduction in CO_2 emissions. Not burning straw prevents the methane and nitrous oxide emissions associated with the burning. On the other hand, there are some emissions of nitrous oxide in connection with the return of nitrogen to the soil when the straw is mulched.

The measure works by regulating behaviour, and the ban was introduced from 1990. The measure was implemented in the form of a statutory order under the Environmental Protection Act. Ban on field burning is a part of cross compliance under EUs Common Agricultural Policy.

Demands on growing catch crops in the autumn to reduce the nitrate leaching do also sequester CO_2. The area today is approximately 530,000 hectares or approximately 20% of the agricultural area.

Another measure which will increase sequestration in woody biomass is the planting of windbreaks also mentioned in Table 4.25. The objective of planting windbreaks has primarily been to reduce wind erosion and ensure greater biodiversity. Planting of windbreaks has been supported under conditions described in the Statutory Order on Subsidies for Planting Windbreaks and Biotope-improving Measures (Statutory Order no. 1101 of 12/12/2002). Support has been granted under the EU Rural Districts Programme. For the period 2017-2019 windbreaks were established under the political agreement of May 2016 called “Naturpakken” where greater biodiversity was the main objective. Since the end of the 1960s about 1,000 km of tree-lined windbreaks have been planted with government subsidies. It is also estimated that about 30% more has been planted without subsidies. Estimates indicate that planting of windbreaks leads to CO_2 sequestration in woody biomass of about 130,000 tonnes CO_2/year[16].

Total from activities under Articles 3.3 and 3.4

The total amount of net RMU credits from activities under Articles 3.3 and 3.4 is estimated at 8.6 million RMUs (or tonnes of CO_2-equivalents) for the whole period 2008-2012 or as the average per year 1.7 million RMUs.

The total preliminary amounts of net RMU credits under Articles 3.3 and 3.4 has been estimated to 44 million RMUs (or tonnes CO_2-equivalents) for the whole period 2013-2020 or in average 5.5 million RMUs per year.

Further information on the accounting of emissions and removals related to activities under Articles 3.3 and 3.4 under the Kyoto Protocol 2013-2020 is included in Table 4.24.

TABLE 4.24. INFORMATION ON ACCOUNTING FOR ACTIVITIES UNDER ARTICLES 3.3 AND 3.4 OF THE KYOTO PROTOCOL

Source: Nielsen at al. (2022a) - Denmark’s National Inventory Report 2022 and CRF for 1990-2020.

GREENHOUSE GAS SOURCE AND SINK ACTIVITIES	Base Year(2)	NET EMISSIONS/REMOVALS									Accounting parameters	Accounting quantity (4)
		2013	2014	2015	2016	2017	2018	2019	2020	Total(3)		
	(kt CO2 eq)											
A. Article 3.3 activities												
A.1. Afforestation/reforestation		-109.997	-221.211	-287.324	-278.234	-343.141	-484.758	-610.359	-274.987	-2610.011		-2610.011
Excluded emissions from natural disturbances(5)		NA	NA	NA	NA	NA	NA	NA	NA	NA		NA
Excluded subsequent removals from land subject to natural disturbances(6)												
A.2. Deforestation		70.234	170.682	677.880	563.306	44.741	415.572	213.888	514.673	2670.975		2670.975
B. Article 3.4 activities												
B.1. Forest management										-21160.245		-23771.307
Net emissions/removals		-3377.031	-3863.941	-3868.091	-3018.924	-2390.927	-1707.319	-1988.590	-945.422	-21160.245		
Excluded emissions from natural disturbances(5)		NA	NA	NA	NA	NA	NA	NA	NA	NA		NA
Excluded subsequent removals from land subject to natural disturbances(6)												
Any debits from newly established forest (CEF-ne)(7),(8)		NA	NA	NA	NA	NA	NA	NA	NA	NA		NA
Forest management reference level (FMRL)(9)											409.000	
Technical corrections to FMRL(10)											-82.617	
Forest management cap(11)											19822.068	-19822.068
B.2. Cropland management (if elected)	5544.768	2422.066	3560.941	2450.746	2610.041	2208.345	3302.006	2994.153	2756.710	22305.010		-22053.136
B.3. Grazing land management (if elected)	2371.071	1810.941	1953.747	1992.157	2117.880	2058.787	2186.444	2152.203	2254.654	16526.813		-2441.754
B.4. Revegetation (if elected)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA		NA
B.5. Wetland drainage and rewetting (if elected)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA		NA

In Table 4.25 an overview of implemented and adopted relevant policies and measures in LULUCF sector is shown.

[16] Gyldenkærne et al, 2005: Gyldenkærne, S., Münier, B., Olesen, J.E., Olesen, S.E., Petersen, B.M. & Christensen, B.T. (2005). Opgørelse af CO_2-emissioner fra arealanvendelse og ændringer i arealanvendelse. Arbejdsrapport fra DMU.

TABLE 4.25 MEASURES IN THE LAND-USE, LAND-USE CHANGE AND FORESTRY SECTOR (LULUCF)

Name of mitigation action	Included in with measures GHG projection scenario	Sector(s) affected	GHG(s) affected	Objective and/or activity affected	Type of instrument	Status of implemen-tation	Brief description	Start year of imple-men-tation	Implementing entity or entities	Estimate of mitigation impact (not cumulative, in ktCO_2e)**	
										2020	2030
8-LU-01: Ban on burning straw on fields	Yes	Cross-cutting	CO_2	7_55: Restoration of degraded lands, 6_44: Improved management of organic soils	Economic	Implemented	One of the measures with an effect on return of carbon to the soil has been the ban on burning of straw residues on fields. The ban has resulted in greater return of carbon to the soil, and therefore increased carbon storage in the soil, as well as increased use of straw as a fuel. Both uses will result in a net reduction in CO_2 emissions. Not burning straw prevents the methane and nitrous oxide emissions associated with the burning. On the other hand, there are some emissions of nitrous oxide in connection with the return of nitrogen to the soil when the straw is mulched. The measure works by regulating behaviour, and the ban was introduced from 1990. The measure was implemented in the form of a statutory order under the Environmental Protection Act, and compliance is monitored by the local authorities. The objectives are conservation of carbon in agricultural soils and reduction of air pollution.	1989	The Ministry of Food, Agriculture and Fisheries	IE(G1)	IE(G1)
8-LU-04: Public afforestation (state and municipalities)	Yes	Forestry/LULUCF	CO_2	7_46: Afforestation and reforestation	Regulatory, Voluntary Agreement	Implemented	The majority of new public forests are stateowned. The purpose of new state forests is to establish resilient and multifunctional forests, e.g. recreational nature close to cities/users, groundwater protection, carbon storage, nutrient reduction and support biodiversity in generel. The projects are etablished as a collaboration between state, municipalities and (often) waterworks - who each contributes financially. The Dansih Nature Agency etablish approximately 300 hectares each year. On-going implementation through annual budgets.	1989	Ministry of Environment of Denmark	IE(G1)	IE(G1)
8-LU-08: Establishment of the Danish Climate Forest Fund to support climate efforts	Yes	Cross-cutting	CO_2, N_2O	7_46: Afforestation and reforestation, 6_44: Improved management of organic soils, 7_55: Restoration of degraded lands	Economic	Implemented	The Danish Climate Forest Fund is an independent, governmental administrative unit under the Danish Ministry of the Environment. The fund was adopted by Danish law in 2020 and established in 2021. The purpose of the fund is to support the Danish climate policy by cost-efficiently enhancing carbon removal by afforestation as well as by reestablishment of wetlands on organic soils funded by donations from private companies, funds, citizens and government departments.	2021	Ministry of Environment of Denmark	NA	IE(G1)
8-LU-11: Subsidy for restoration of peatland (CAP+national)	No	Cross-cutting	CO_2	7_54: Prevention of drainage or rewetting of wetlands, 7_56: Other land use, land-use change and forestry, 6_44: Improved management of organic soils	Economic	Adopted	Reduction of greenhouse gas emissions from carbon-rich low-lying soils by reverting the soils, herreafter the natural water level will be restored and the wetlands reestablished - which reduces CO_2 emissions.	2022	The Ministry of Food, Agriculture and Fisheries	NA	NE
8-LU-12: Extensification of carbon rich soils (Ecoscheme)	No	Cross-cutting	CO_2, CH_4, N_2O	7_56: Other land use, land-use change and forestry, 6_44: Improved management of organic soils	Economic	Adopted	Promotion of an extensive use of carbon-rich peat soils or associated areas by removing biomass and enforcing a ban on fertilization. Thereby preparing the soils for a possible later rewetting.	2022	The Ministry of Food, Agriculture and Fisheries	NA	NE
8-LU-13: Private afforestation	Yes	Cross-cutting	CO_2, N_2O	6_44: Improved management of organic soils, 7_46: Afforestation and reforestation	Economic	Adopted	The scheme support afforestation on agricultural areas owned by private parties or municipialities. The scheme aims at reducing nitrogene leakage in water bodies and contributes in reducing CO_2 emissions.	2022	The Ministry of Food, Agriculture and Fisheries	NA	IE(G1)
8-LU-14: Temporary reduction in logging	Yes	Cross-cutting	CO_2	7_47: Conservation of carbon in existing forests	Regulatory	Adopted	Temporary reduced harvesting in state owned forest during 2026 to 2031.	2022	The Ministry of Food, Agriculture and Fisheries	NA	IE(G1)

* Here "Yes" means included in the "with measures" projection scenario, in principle. In most cases not based on separate annual estimates for each mitigation action, but either as a result of the assumption that the measure has contributed to the observed level of total Danish greenhouse gas emissions in the most recent inventory year available, when the projection was elaborated and therefore used as the starting point for the projections, or as part of the integrated models used to project the level of annual greenhouse gas emissions in future years.

** See explanatory note under Table 4.26.

4.3.9 Waste

Emissions of greenhouse gases from waste originate from either the general waste sector, or the wastewater treatment sector, with the general waste sector being the most dominant contributor.

The direct contribution of the waste sector (excluding incineration of waste) to greenhouse gas emissions consists primarily of methane from the decomposition of biogenic waste. Out of the total greenhouse gas emissions from the waste sector of 1.2 million tonnes CO_2 equivalents in 2020 – corresponding to 2.7 pct. of total Danish greenhouse gas emissions – the proportion from landfills was 44 pct., from compost production 13 pct., from wastewater treatment 17 pct., from biogas plants 24 pct. and 2 pct. from other minor sources such as accidental fires. Greenhouse gas emissions from wastewater treatment included both methane (26 pct.) and nitrous oxide (74 pct.) in 2020.

In 2012, Denmark produced approximately 10.3 mio. tonnes of waste. 63 pct. was utilized through material recovery, 31 pct. was incinerated, and 4 pct. ended up in a landfill. In 2020, the total amount of waste produced in Denmark increased to 12.1 mio. tonnes, of which 72 pct. was utilized through material recovery, 25 pct. was incinerated, and 3 pct. was landfilled. Both the amount of waste incinerated and deposited has decreased and the material recovery was increased.

Table 4.26 shows the climate relevant measures implemented in the waste sector.

4.3.9.1 CH_4 (methane) and N_2O (nitrous oxide) emissions from biowaste and landfills

Biowaste
Biowaste, which consists of food and garden waste, produces methane and nitrous oxide as it decomposes, both potent greenhouse gasses contributing to global warming. In recent years, Denmark has implemented separate sorting and collection of biowaste nationally. The Danish EPA is currently investigating the best practice for handling garden waste in order to reduce GHG emissions.

Landfills
Denmark has long been one of the frontrunners for reducing the amount of waste landfilled. This includes a regulatory ban on landfilling of incinerable waste and taxes on landfilling. The level of landfilled waste in Denmark is significantly lower than the current EU average and lower than 10 pct. landfilled waste target for 2035 as defined in the Landfill Directive. Despite the low landfilling rate in Denmark, efforts to reduce methane emissions from landfills are ongoing. The Technical University of Denmark has established a viable methodology for documentation of greenhouse gas emissions reductions achieved through the installation of a bio-cover system on landfills. Furthermore, methane generated from waste in some Danish landfills gets collected (to the extent possible) in dedicated gas collection systems and is used for energy generation. A reduction in methane emissions to the atmosphere is thereby achieved.

4.3.9.2 CH_4 (methane) and N_2O (nitrous oxide) emissions from wastewater

Wastewater

The Danish wastewater treatment sector was responsible for 143.499 tons of CO_2e emissions in 2022. The main contribution from the sector is related to the nitrous oxide emissions from the treatment process, which accounts for 68 pct. of GHG emissions from the entire sector. In 2020 it was politically agreed to introduce limit values for nitrous oxide in the sector. The Danish Environmental Protection Agency is in the process of establishing the knowledge basis on which the limit values for the GHG-emissions from wastewater will be established. The emissions from wastewater treatment can be reduced by covering the treatment plants and adjusting and controlling wastewater treatment. Minor contribution to GHG-emissions from the wastewater sector originates from methane emissions from private septic tanks and nitrous oxide emissions from surface water or peripheral sectors such as aquaculture.

TABLE 4.26 MEASURES IN THE WASTE SECTOR

Name of mitigation action	Included in with measures GHG projection scenario *	Sector(s) affected	GHG(s) affected	Objective and/or activity affected	Type of instrument	Status of implementation	Brief description	Start year of implementation	Implementing entity or entities	Estimate of mitigation impact (not cumulative, in ktCO2e)**	
										2020	2030
9-WA-01: A ban of landfill of combustible waste.	Yes	5: Waste management/waste	Methane (CH4)	5_35: Waste incineration with energy use, 5_37: Reduced landfilling	Regulatory	Implemented	In 1996 the Statutory Order on Waste was amended to introduce an obligation for municipalities to assign combustible waste to incineration (corresponding to a stop for disposal of combustible waste at landfills) from 1 January 1997. As a result of this, large quantities of combustible waste that used to be disposed of at landfills are now either recycled or used as fuel in Danish incineration plants.	1997	Municipalities	NE	IE
9-WA-02: The waste tax	Yes	5: Waste management/waste	Methane (CH4)	5_37: Reduced landfilling	Economic, Fiscal	Implemented	A tax is imposed on waste for incineration or landfilling. The taxes are DKK 475 per tonne for landfilling and DKK 60,9/GJ for incineration.	1987	Danish Ministry of Taxation	NE	IE
9-WA-03: Weight-and-volume-based packaging taxes	Yes	5: Waste management/waste	Carbon dioxide (CO2), Methane (CH4)	5_30: Demand management/reduction	Economic, Fiscal	Implemented	Weight-and-volume-based taxes (e.g. on various packaging, carrier bags and PVC film) encourage a reduction in packaging consumption and thus the quantities of waste. The weight-based tax is based on an index that reflects the environmental burden of the materials used.	2014	Danish Ministry of Taxation	NE	IE
9-WA-06: Implementation of the EU landfill directive	Yes	5: Waste management/waste	Methane (CH4)	5_34: Improved landfill management	Regulatory	Implemented	On the basis of the EU Landfill Directive, demands on the establishment and operation of landfills in Denmark have been tightened with Statutory Orders No. 650 of 29 June 2001, No. 252 of 31 March 2009, No. 719 of 24 June 2011 and No. 1049 of 28th of August 2013 on landfills. According to the Statutory Orders on landfills, methane in landfills for mixed waste must be monitored. From landfills where significant amounts of biodegradable waste are disposed of, methane gas must be managed in an environmentally-sound way.	1999	The Environmental Protection Agency	NE	IE
9-WA-09: Subsidy programme for biocovers on landfills	Yes	5: Waste management/waste	Methane (CH4)	5_34: Improved landfill management	Economic	Implemented	Biocovers is a technique that uses compost as a cover on landfills. The microorganisms in the compost increases the oxidation of methane in the top layer.	2017	The Environmental Protection Agency	NE	IE
9-WA-10: Prohibition of free plastic bags and thin plastic bags	Yes	5: Waste management/waste	Carbon dioxide (CO2)	5_30: Demand management/reduction, 5_31: Enhanced recycling	Regulatory	Implemented	As of 1 January 2021, the following carrier bags may not be handed out free of charge at points of sale for goods or products: - Plastic carrier bags with a handle that is thicker than 30 micrometers (eg ordinary carrier bags in supermarkets) - Plastic carrier bags without a handle that are thicker than 30 micrometers - Carrying bags with handles of materials other than plastic In addition, plastic bags thinner than 30 micrometers are completely prohibited. Plastic bags thinner than 15 micrometers with no handle are excempted from the ban.	2021	Ministry of Environment of Denmark	NA	IE
9-WA-11: Triple the tax on carrier bags and disposable tableware	Yes	5: Waste management/waste	Carbon dioxide (CO2)	5_30: Demand management/reduction, 5_31: Enhanced recycling	Economic, Fiscal	Implemented	The tax on carrier bags and disposable tableware was trippled as of January 2020 with the aim of reducing consumption and waste.	2020	Danish Ministry of Taxation	NE	IE
9-WA-12: Requirements for the possibility of direct reuse at municipal recycling stations	Yes	5: Waste management/waste	Carbon dioxide (CO2)	5_30: Demand management/reduction, 5_31: Enhanced recycling	Regulatory	Adopted	All municipal recycling stations are obliged to make a designated spot available where citizens can hand in objects with the purpose of direct reuse of the objects. The objects should be made available first to private agents such as voluntary organisations and citizens.	[2023 /2024]	Ministry of Environment of Denmark	NA	IE
9-WA-13: Streamlining the sorting of business household-like waste	Yes	5: Waste management/waste	Carbon dioxide (CO2)	5_30: Demand management/reduction, 5_31: Enhanced recycling	Regulatory	Adopted	The guidelines and criteria for the sorting of household-like waste from businesses are streamlined nationally and made mandatory and follows the sorting criteria for households for 10 wastefractions. The national wastepictograms for the 10 wastefraction of householdwaste must be used on the collectionbins (the bins collected by the wastecollector). The national guidelines, including the usage of waste pictograms, have been implemented in 2022.	2022	Ministry of Environment of Denmark	NA	IE

TABLE 4.26 MEASURES IN THE WASTE SECTOR (CONTINUED)

Name of mitigation action	Included in with measures GHG projection scenario *	Sector(s) affected	GHG(s) affected	Objective and/or activity affected	Type of instrument	Status of implemen-tation	Brief description	Start year of imple-men-tation	Implementing entity or entities	Estimate of mitigation impact (not cumulative, in ktCO2e)**	
										2020	2030
9-WA-14: Streamlining and mandatory collection schemes for household waste	Yes	5: Waste management/waste	Carbon dioxide (CO2)	5_30: Demand management/reduction, 5_31: Enhanced recycling	Regulatory	Adopted	The guidelines and criteria for the sorting and collecting of household waste are streamlined nationally and made mandatory. The national wastepictograms for the 10 wastefraction of householdwaste must be used on the collectionbins (the bins collected by the wastecollector). The national guidelines, including the usage of waste pictograms, must be imlemented and followed across all municipalities. For the following waste fractions separate collection are made mandatory: Food, paper, cardboard, metal, glass, plastic, textiles (as of 2023), carton packaging from food and drink, hazardouz waste, and general waste. There are possibility for combined collection of some fraction e.g. paper/cardboard, plastic/foodcartons and plastic/foodcartons/metal.	2023	Ministry of Environment of Denmark	NA	IE
9-WA-15: Streamlining with mandatory collection scheme for household textile waste	Yes	5: Waste management/waste	Carbon dioxide (CO2)	5_30: Demand management/reduction, 5_31: Enhanced recycling	Regulatory	Adopted	As of 2023, it has been mandatory for the municipalities to include textile waste as a seperate waste fraction in the provided waste collections scheme. Regarding the implementation of the waste collection of textile waste it is important that voluntary organisations have easy access to textiles able to be reused.	2023	Ministry of Environment of Denmark	NA	IE
9-WA-16: Waste sorting in the public space	Yes	5: Waste management/waste	Carbon dioxide (CO2)	5_30: Demand management/reduction, 5_31: Enhanced recycling	Regulatory	Adopted	Waste sorting in the public space will be improved, especially in the public spaces with most people and most waste. A scheme for the collection of plastic waste in the public space will be implemented. The new and improved sorting and collection of waste in public areas will be implemented no later than january 1st 2025 as part of the forthcoming extended producers responsibility on packaging. It will be analyzed whether or not part of the waste managing in public spaces can be funded through waste fees.	2025	Ministry of Environment of Denmark	NA	IE
9-WA-17: Requirements for the municipalities on tenders for bulky waste schemes with re-sorting with regard to higher real recycling and reuse	Yes	5: Waste management/waste	Carbon dioxide (CO2)	5_30: Demand management/reduction, 5_31: Enhanced recycling	Regulatory	Adopted	Municipalities are required to specify in the tender for bulky waste schemes that a sorting must be carried out in order to achieve a high level of real recycling and preparation for reuse. The sorting will ensure that a lesser part of the bulky waste is incinerated.	2021	Ministry of Environment of Denmark	NA	IE
9-WA-18: Demand for smaller losses in recycling plastic	Yes	5: Waste management/waste	Carbon dioxide (CO2)	5_30: Demand management/reduction, 5_31: Enhanced recycling	Regulatory	Adopted	The Executive Order on Waste stipulates that the municipalities must, as of 1 January 2022, set a requirement of 60 per cent actual recycling of the collected plastic waste when the waste is offered for treatment. The municipalities must ensure a high level of real recycling of all recyclable waste types.	2022	Ministry of Environment of Denmark	NA	IE
9-WA-19: Target of 50% reduction of certain plastic takeaway packaging by 2026	Yes	5: Waste management/waste	Carbon dioxide (CO2)	5_30: Demand management/reduction, 5_31: Enhanced recycling	Regulatory	Adopted	A target of 50 percent reduction of certain plastic take-away packaging in 2026 is set. The goal must initially be sought to be achieved through a binding agreement and collaboration with the restaurant industry. If the goal is not reached by binding agreement, further regulation must be implemented.	2021	Ministry of Environment of Denmark	NA	IE
9-WA-20: National implementation of extended producer responsibility for packaging	Yes	5: Waste management/waste	Carbon dioxide (CO2)	5_30: Demand management/reduction, 5_31: Enhanced recycling	Regulatory	Adopted	The national implementation of the extended producer responsibility for packaging must be introduced no later than January 1st 2025. This will include all types of packaging in all types of materials. The extended producer responsibility must ensure that Denmark achieves the recycling targets for packaging in 2025 and 2030 by creating a strong financial incentive for reducing packaging, reusing packaging, and designing packaging that is easy to recycle and in high quality.	2021	Ministry of Environment of Denmark	NA	IE

TABLE 4.26 MEASURES IN THE WASTE SECTOR (CONTINUED)

Name of mitigation action	Included in with measures GHG projection scenario *	Sector(s) affected	GHG(s) affected	Objective and/or activity affected	Type of instrument	Status of implemen-tation	Brief description	Start year of imple-men-tation	Implementing entity or entities	Estimate of mitigation impact (not cumulative, in ktCO2e)**	
										2020	2030
9-WA-21: Target of 50% sorting of plastic for recycling in the agricultural sector	Yes	5: Waste management/waste	Carbon dioxide (CO2)	5_30: Demand management/reduction, 5_31: Enhanced recycling	Regulatory	Adopted	As an initiative in the Danish climate agreement of June 2020 for a green waste sector and circular economy a sectoral coooperation with the agricultural sector has been established. The goal of the cooperation is to sort out 50% of plastic waste for reuse in 2025 from the aggricultural sector and 80% of plastic waste for reuse in 2030 from the aggricultural sector. As of 2020, approximately 25% of plastic waste from the aggricultural sector is reused. If the sectoral cooperation cannot document the necessary progress by the end of respectively 2023 and 2027 to achieve the goals, new iniatives will be implemented.	2021	Ministry of Environment of Denmark	NA	IE
9-WA-22: Target of 50% sorting of plastic for recycling in the construction sector	Yes	5: Waste management/waste	Carbon dioxide (CO2)	5_30: Demand management/reduction, 5_31: Enhanced recycling	Regulatory	Adopted	As an initiative in the Danish climate agreement of June 2020 for a green waste sector and circular economy a sectoral coooperation with the construction sector will be established. The goal of the cooperation is to sort out 25% of plastic waste for reuse in 2025 from the construction sector and 75% of plastic waste for reuse in 2030 from the construction sector. If the sectoral cooperation cannot document the necessary progress by the end of respectively 2023 and 2027 to achieve the goals, new iniatives will be implemented.	2021	Ministry of Environment of Denmark	NA	IE
9-WA-23: New model for waste management to ensure increased recycling	Yes	5: Waste management/waste	Carbon dioxide (CO2)	5_30: Demand management/reduction, 5_31: Enhanced recycling	Regulatory	Adopted	The new and improved Danish waste inspection will be targeted at the companies with the greatest risk of non-compliance, and where the environmental risk of not complying with the waste rules is the greatest.	2021	Ministry of Environment of Denmark	NA	IE
9-WA-24: Productivity gain on increased recycling of plastics through the synergy effect between a clear framework for the sector, the market gaining access to both household and acquired waste and the increase and streamlining of waste streams	Yes	5: Waste management/waste	Carbon dioxide (CO2)	5_30: Demand management/reduction, 5_31: Enhanced recycling	Regulatory	Adopted	As a result of the Danish climate agreement of June 2020 for a green waste sector and circular econony a productivity gain on the increased recycling of plastics is expected. This is due to an expected synergy effect of the several initiatives in the agreement. This includes a clear framework for the sector, the market gaining access to both household and acquired waste and the increase and streamlining of waste streams.	2021	Ministry of Environment of Denmark	NA	IE
9-WA-25: Ceiling over nitrous oxide emissions from large treatment plants	Yes	5: Waste management/waste	Nitrous oxide (N2O)	5_36: Improved wastewater management systems	Regulatory	Adopted	By political decision, limits for nitrous oxide emissions from treatment plants that treat waste water that is the equivalent of at least 30,000 people's effluent (PE) will be introduced from 2025 onwards. These limit values are introduced to ensure that the total effluent from waste water treatment drops by 50 percent compared to today. Based on preliminary experience, it will, no later than 2025, be discussed by the political parties whether this limit should also be introduced for treatment plants that treat waste water that is the equivalent of less than 30,000 PE. Nitrous oxide emissions from treatment plants is the main source of greenhouse gas emissions from the Danish waste water utilities, but ongoing projects indicate a potential for significant emission reductions by implementing improvement initiatives. This includes adjusting the advanced online control of the aeration and dosing of a carbon source as well as lowering of the specific ammonium loading, taking into account the nitrous oxide emission.	2025	Ministry of Environment of Denmark	NA	IE

* Here "Yes" means included in the "with measures" projection scenario, in principle. In most cases not based on separate annual estimates for each mitigation action, but either as a result of the assumption that the measure has contributed to the observed level of total Danish greenhouse gas emissions in the most recent inventory year available, when the projection was elaborated and therefore used as the starting point for the projections, or as part of the integrated models used to project the level of annual greenhouse gas emissions in future years.

** For the individual mitigation actions included in this table, in the "Estimate of mitigation impact" columns, the notation key NA (Not Applicable) is used in the 2020-column, when the mitigation action was not implemented before 2021, and the notation key NE (Not Estimated) is used in the 2030-column, when the mitigation action was not included in the WEM projection scenario from 2022 ("KF22") - both by matter of principles. The former to signal that there is no effect of an action not yet implemented. The latter to signal that no effect of the action was included in the WEM projection scenario from 2022 ("KF22"). The latter is a matter of principle because WEM projection scenarios in Denmark are not calculated from the sum of the effects of individual mitigation actions, but based on integrated models. Therefore it is not possible attribute the total effect in WEM projection scenarios to all individual mitigation actions included in the projection. The WEM projection scenario from 2022 ("KF22") is described separately in greater detail with focus on future greenhouse gas emission trends from the current level. The estimated effects shown here include greenhouse gas emission increases avoided by implementation and adoption of mitigation actions in the period 1991-2021.

4.4 POLICIES AND MEASURES IN ACCORDANCE WITH ARTICLE 2, OF THE KYOTO PROTOCOL

4.4.1 Denmark's climate efforts – a step on the way to sustainable development

In 2015, the United Nations Member States adopted the 2030 Agenda for Sustainable Development and its 17 Sustainable Development Goals. In 2017, the Danish government published the first "National Action Plan for the 2030 Agenda"[17]. In June 2021, an updated National Action Plan was published, which introduced new policy initiatives to implement the Sustainable Development Goals. For example, the policy of assessing whether and, if so, how new bills are expected to have significant positive or negative impact on the achievement of the Sustainable Development Goals.

In June 2021, Denmark also released its second Voluntary National Review assessing the progress since the first review in 2017[18]. A new approach was applied to document Denmark's progress towards the Sustainable Development Goals as the report included assessments by both the Danish Government and civil society actors of the nation. It also included insights into how various actors of Danish society have worked to support the Sustainable Development Goals.

Efforts to achieve the Sustainable Development Goals are supported by various actors, including Parliament, the private sector, civil society actors, academic institutions, regions, and municipalities.

Denmark's National Action Plan will be updated in 2024.

4.4.2 Efforts for international air transport and shipping

Denmark recognises that the international aviation and maritime transport sectors are large and rapidly growing sources of greenhouse gas emissions and have to be dealt with at all levels. Given the global nature of the two sectors, Denmark believes that the international organisations for civil aviation and maritime transport – the ICAO and the IMO – should decide, develop and implement appropriate global measures to control greenhouse gas emissions from international aviation and maritime transport in line with the 1.5°C long-term temperature goal of the Paris Agreement.

Denmark recognises that the international aviation sector is a large and rapidly growing source of greenhouse gas emissions that has to be dealt with at both national, regional and global level. Denmark further recognizes that the International Civil Aviation Organization (ICAO) has taken measures to reduce greenhouse gas emissions from the aviation sector by introducing the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA) and by adopting a long term aspirational goal (LTAG) for international aviation of net-zero carbon emission by 2050.

However, Denmark emphasizes that the measures taken by ICAO are insufficient and that ambition should be ramped up significantly. This includes by adopting more ambitious definitions and targets for sustainable aviation fuels (SAF) and by strengthening CORSIA. In that regard, Denmark highlights that with the recent Fit for 55-revision of the ETS directive, the EU stands ready to extend the application of the EU ETS to

[17] https://fm.dk/media/24855/handlingsplan-for-fns-verdensmaal_web_a.pdf
[18] https://en.fm.dk/media/24858/voluntary-national-review-2021-denmark_web_a.pdf

departing flights from the EEA to countries outside the EEA from January 2027 if the ICAO Assembly does not by 2025 strengthen the CORSIA scheme in line with achieving its long-term aspirational goal, towards meeting the Paris Agreement objectives, or if countries participating in CORSIA represent less than 70 % of international aviation emissions. Denmark therefore strongly calls on all ICAO member states to agree no later than at the ICAO Assembly in 2025 to significantly ramp up CORSIA's ambition level to meet these criteria.

Denmark welcomes that the IMO in July 2023 adopted the 2023 IMO Strategy on Reduction of GHG Emissions from Ships. The 2023 revision on the IMO GHG strategy significantly increase the levels of ambitions and brings them in line with the Paris Agreement's temperature goal.

Denmark has both in the preparatory work and during negotiations contributed actively to the work on developing of the 2023 IMO Strategy on reduction of GHG emissions from ships. Denmark has drafted submissions for ambitious climate regulation and argued the need for strengthening the levels of ambitions to ensure that international shipping takes its fair share of the global effort to be in accordance with the temperature goal of the Paris agreement. This must be done through global, flag-neutral solutions and regulation that ensure reducing global GHG emissions consistent with the IMO principles.

Denmark will in the coming years contribute actively to the work on implementing the IMO GHG strategy with the aim to develop an effective and enforceable global climate regulation, which ensures delivering on the targets.

Furthermore, Denmark recalls that IMO has in recent years adopted principles for climate regulation, especially the introduction of rules that increase ships' energy efficiency of both new and existing ships and the adoption of a global data collection system that charts the ships' fuel consumption. Denmark contributes actively to the ongoing discussions on the possibility to introduce a strengthened phase 4 of the agreed Energy Efficiency Design Index (EEDI).

4.4.3 Efforts to limit adverse effects in other countries

In connection with Denmark's contribution to international climate efforts, in accordance with the Kyoto Protocol Denmark will endeavour to implement policies and measures under Article 3 of the Protocol in such a way that adverse effects in other countries are minimised. However, Denmark does not consider that its contributions to international climate efforts have adverse effects in other countries as, on the contrary, the reduction of emissions of greenhouse gases in Danish commitments under the Protocol will in fact contribute to limiting dangerous climate change in all countries.

If nothing is done to limit emissions of greenhouse gases, climate scenarios from the IPCC indicate that developing countries in particular will experience the greatest changes in climate.

In its international efforts, Denmark will therefore continue to take the greatest possible account of the special needs and concerns of developing countries and especially least developed countries. This also applies to adverse effects which can already be ascertained from changes in climate. The existing strong Danish focus on the special vulnerability of developing countries to climate change underlines this (see Chapter 7).

4.4.4 Strategies to mitigate climate change cf. Article 10(b) of the Kyoto Protocol

Denmark's Climate Strategy and measures to mitigate climate change are described in sections 4.1, 4.2 and 4.3.

4.5 POLICIES AND MEASURES NO LONGER IN PLACE

In comparison with Denmark's Fourth First Biennial Report (BR4) from December 2019 the reported portfolio of climate relevant policies and measures has changed as shown in Annex B1. From this it can be seen that 26 expired initiatives are not reported any longer and that 96 new initiatives have been added to Denmark's portfolio of climate relevant policies and measures and included in this report (NC8/BR5).

4.6 POLICIES AND MEASURES IN GREENLAND

High basic energy demands and the expected emergence of an industrial sector indicate that Greenland's energy consumption is unlikely to decrease significantly over the coming years. Nevertheless, an existing hydropower plant is to be expanded while a new plant is to be built in the coming years. Government policies aim at reducing energy consumption, where possible, and to improve efficiency in existing energy production and supply.

During the last decades it has been a consistent priority to expand the use of renewable energy and today approximately 66% of the national energy supply is based on hydropower. Concurrently, potentials for wind energy, solar energy and hydrogen-based energy production are being explored on a smaller scale with possibilities for future expansion.

Policies and measures targeting energy production and energy consumption have multiple purposes. In addition to emission reductions, the shift to renewable energy sources is associated with a decreasing dependence on imported fossil fuels and positive effects on the local and regional environment. Improving the efficiency of the current energy production and supply system is cost-reducing and at the same time contributes to reducing GHG emissions. Energy-saving policies, acts and measures are therefore often designed to address a wider range of priorities; of which the reduction of GHG emissions remains predominant.

4.6.1 Policies and acts

A number of energy policies and acts which consider challenges, benefits and initiatives associated with reducing emissions and improving energy efficiency have been introduced:

The Energy Supply Act

Energy supply legislation was first introduced in 1997, when Parliament passed the Energy Supply Act covering the supply of electricity, heating and fuel. In accordance with the Act, the supply of energy must be managed to promote energy saving and be economically sound. It must further improve efficiency of the production and supply system while introducing an environmentally cleaner production of energy.

Framework conditions for the construction, financing and operation of hydropower plants with associated facilities for the supply of Nuuk as well as Qasigiannguit and Aasiaat Act

Legislation regarding the framework conditions for the construction, financing and operation of hydropower near Qasigiannguit in the Disco Bay and expanding the existing Utoqqarmiut Kangerluarsunnguat hydropower plant, was passed in the fall of 2021.

Economic incentives for fuel-efficient behaviour

The Greenlandic Parliament has furthermore passed three acts that create economic incentives for fuel-efficient behaviour:

- Act on Environmental Taxes for Products used in Energy Production is Greenland's first environmental tax on fossil fuels. The Act came into force in January 2011 and constitutes a direct tax of DKK 0.10 per litre of the retail price on most fossil fuels, regardless of end-use, creating an incentive to both reduce fossil fuel consumption and to invest in new and cleaner technologies within the private and public sectors.
- An increase in motor vehicle taxes, primarily targeting heavy vehicles. The Act came into effect in 2013.
- A lower tax rate for electric (EV) and plug-in (PHEV) hybrid.

4.6.2 Past and on-going measures

Hydropower for electricity and heating

The development of hydropower has been central to the national energy supply since the 1970s. Throughout the 1970s and 1980s, systematic studies of possible hydropower potentials were carried out. The 1986 Energy Policy Guidelines stated that hydropower should be a bearing element of the future energy supply system in Greenland.

The first hydropower facility was opened in 1993 and since then the use of hydropower has gradually expanded. With the introduction of the fifth hydropower plant in 2013, the total capacity of the hydropower plants in Greenland amounts to 91 MW, covering around 50% of total supply. In 2020 the five hydropower plants will produce enough energy to save more than 56.3 million litres of oil, cutting greenhouse gas emissions by more than 297,600 tonnes of CO_2 annually.

Residual heat from energy production at the hydropower plants is in some places used for district heating. Surplus electricity production is likewise used for district heating and constitutes an efficient way of making use of energy that would otherwise go to waste. In Nuuk, the capital, the heating supply depends almost entirely on this kind of district heating. A couple of times a year, when the demand peaks, there is no surplus electricity production and temporary use of oil boilers ensures a continuous and steady heating supply.

In this way, hydropower constitutes a significant resource in improving the efficiency of existing energy production and reducing emissions of greenhouse gases in Greenland.

The Greenlandic Parliament, Inatsisartut passed a bill in the fall of 2021, deciding to expand the Utoqqarmiut Kangerluarsunnguat hydro power plant and construction of a new hydropower to supply Qasigiannguit and Aasiaat, called Kuussuup Tasia. The Utoqqarmiut Kangerluarsunnguat expansion includes a new 55 MW power station, which will increase the total capacity of the plant to 100 MW. The Kuussuup Tasia hydropower plant is expected to have the same capacity as the Paakitsoq hydropower plant. Preliminary studies of other potentials continue.

Suspension of all oil exploration activities

In July 2021 the Government of Greenland announced that it suspends all oil exploration activities in Greenland.

Waste Incineration Facilities

Waste management in Greenland is challenged by the vast distances and hence depends on local waste management schemes. In six major cities, incineration plants are in use. Much of the residual heat from these facilities is used for district heating and, in combination with hydropower-based heating, contributes to an energy-efficient heating system. The incineration of waste replaces fuel for heating and reduces emissions of methane that would otherwise occur, if waste was deposited at landfill sites.

Waste management in Greenland is undergoing fundamental change. The Government of Greenland works based on the Waste Management Plan 2020-2031. The Government of Greenland and the municipalities have decided to establish a national waste incineration solution. Greenland is therefore in the process of building two new nationwide, modern waste incineration plants. The new national waste incineration plants are expected to be ready in 2024. The two new waste incineration plants must handle waste from all over the country in an environmentally and health optimal way. Residual heat from waste incineration will supplement existing energy sources in an efficient way in the two cities. When the new waste incinerators are ready, the current six old incinerators will be closed.

Sector Programme for Renovation with Environmental and Energy Effects in Greenland 2000-2003

The objective of the Sector Programme was to ensure that efforts in the renovation of buildings and supply plants would increasingly take into account environmental and energy-saving aspects.

Projects carried out under the Programme included renovation of combined electricity and heat production plants (CHP plants) and supply grids along with renovation of buildings. It also included a revision of the existing building regulations, the preparation of a new energy plan and initiatives for behaviour-regulating measures.

In 2003, an evaluation of the Sector Programme was carried out, estimating a reduction in CO_2 emissions of more than 3,900 tonnes annually. Calculations were based on information from energy statistics provided by the Danish Energy Authority as well as estimates of reductions in the consumption of both electricity and oil.

The Transport Sector

The transport sector is considered a key sector, despite the fact that Greenland has no roads connecting towns and settlements. Even though the market for electric vehicles (EVs) is limited in Greenland, EVs have reached a technological stage of development, where they in some cases can become a realistic alternative to diesel vehicles. In 2021 1.446 of the registered vehicles in Greenland were full electric or plug-in hybrid cars.

The initiative to push forward the introduction of EVs in Nuuk is backed up by several actors represented in a working group on EVs hosted by CSR Greenland; an organisation established in 2010 which promotes the benefits of responsible business and sustainable development in Greenland. The working group on EVs includes representatives from the municipality and the government, local businesses and interested citizens. The national utility company, Nukissiorfiit introduced a public a public charging network for electric cars in 2021. The network had around 500 users in 2021.

Other Initiatives

In 2013 the Ministry of Housing, Nature and Environment launched a national campaign to raise awareness of the effects of GHG emissions. The campaign was published in a number of local newspapers and in one national paper and encouraged energy-saving behaviour.

The Ministry of Labour, Trade, Industry and Energy supports the research in and development of new initiatives within the renewable energy sector.

The programme was designed to support research in hydrogen energy, but today has been expanded to include financial support for a wider range of projects within the field of energy and climate change adaptation. The projects supported under the programme are small-scale, but bring knowledge and practical experience to entrepreneurs and other interested actors in Greenland. As examples, solar panels have been established to supply a folk high school with energy, and in one settlement a micro-hydropower plant has been introduced to supplement energy production from a CHP plant. The programme has furthermore supported pilot projects on wind energy and geothermal energy. All projects provide good experience and useful lessons for entrepreneurs and they contribute to the generation of new knowledge about the opportunities for expanding the use of renewable sources in Greenland.

4.7 POLICIES AND MEASURES ON FAROE ISLANDS

The Climate Convention was ratified by the Realm, and therefore applies for the Faroe Islands. When ratifying the Kyoto Protocol in 1997 the Danish government took a territorial reservation for the Faroe Islands. The Faroese Government decided in 2016 to become a party to the Paris Agreement.

4.7.1 Climate policy and policy-making process

On the initiative of the Minister of Industry and in accordance with the government agreement in 2004, a working group was established to formulate a proposal to a general energy policy. The purpose was to make the country independent from oil by increasing the use of renewable energy sources, and to utilize energy resources more efficiently also regarding economy, supply security, nature, and environment. In 2006 the working group delivered a report with recommendation for a coming energy policy including other relevant information on energy production and consumption in the Faroe Islands. The report presented a recommendation to include these two main goals in the coming policy:

- 20 % of energy consumption on land should in 2015 derive from renewable energy source.
- A 15 % reduction in energy consumption in the fishing fleet, relative to the yield

The report and its recommendation may be considered as the beginning for a Faroese Climate Policy, because in the spring 2008, the Faroese Government started a process formulating the first national Climate Strategy.

In 2008, an Action Plan,[19] listing an arrow of potential measures to reduce emissions of greenhouse gases was published.

The year after, in December 2009, the Faroese Parliament adopted the first Faroese Climate Policy covering the years 2010-2020[20]. The main goal was to reduce the emission of greenhouse gases with 20 % in 2020 with 2005 as base year. All major stakeholders participated in the process of writing the first Climate policy. All the political parties in the Parliament voted for the policy. A description of the national targets set in the policy are contained in Chapter 4.7.2 below and in Chapter VII.C of BR5 (Annex F). The progress in reaching the goals in the policy are yearly published on the homepage of the Faroese Environment Agency.[21]

In 2011 the Ministry of Trade and Industry published an overall plan for electric energy in the Faroe Islands[22] in which you can find a series of conclusions and recommendations on planning of the public electricity sector in the Faroes.

And further, in 2012, the Ministry of Trade and Industry established a working group to draft an Action Plan and a series of recommendations regarding the future electric energy system in the Faroe Islands, which would be based on renewable energy resources. The working group was composed of representatives from the Ministry of Trade and Industry; the Faroese electric utility, SEV; the Faroese Earth and Energy Directorate (Jarðfeingi), and Dansk Energi/ Danish Energy. In this Action Plan, the working group recommends 26 initiatives and seven specific and detailed initiatives within the areas of production, energy storage, consumption, and the electric system.[23] The goal was to provide a solid foundation upon which to build a future energy system that in the main is based on renewable energy, so that the Faroe Islands is less dependent upon fossil fuel.

In 2018 the Ministry of Health and the Interior published a plan for Energy Policy on how to reach the 2025 and 2030 goals[24].

New climate Policy 2022-2032
In 2019, the Faroese Ministry of Health and the Interior presented a proposal for a new Climate and Energy Policy for the Faroe Islands 2020 to 2030.[25] The plan was never politically adopted but worked partly as a foundation for a new working group with members from the Faroese Environment Agency and the Ministry of Environment, Trade and Industry who in 2021 delivered a proposal to a new Climate and Energy Policy, which The Faroese Parliament adopted in May 2022, now covering the years 2022-2032 and containing 25 measures to reduce the emission of greenhouse gasses. Among these are to establish more wind farms and solar energy plants, to reduce the tax on electric cars

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[19] Skjótt syftir seiðir og tunga takið (Easy picking and the long haul). http://www.us.fo/Default.aspx?ID=14087
[20] Climate Policy for the Faroe Islands (Veðurlagspolitikkur Føroya). Ministry of Interior. 2009.
[21] https://www.us.fo/Default.aspx?ID=14240 *In Faroese only.*
[22] http://www.us.fo/Admin/Public/DWSDownload.aspx?File=%2fFiles%2fFiler%2fUS%2fOrka%2fComprehensive+Plan+for+Electric+Energy+2011.pdf - *In Faroese only.*
[23] Action Plan. Report and Recommendations on the future electric energy system of the Faroe Islands. Ministry of Trade and Industry (January 2015). *In Faroese only.*
[24] Plan on Energy Policy. Orkupolitisk ætlan - hvussu vit røkka málunum fram til 2025 og 2030. 2018. Ministry of Health and Interior. *In Faroese only.*
[25] Proposal to a new Climate policy, 2020-2030. Ministry of Health and Interior (2019). *In Faroese only.*

and heat pumps, to ban oil boilers in new buildings and to support the removal of oil boilers in existing buildings. Other measures are the establishment of independent energy advice, to encourage energy-efficient ships and to phase out the use of high-GWP greenhouse gases (F-gases). Table VII.C.3 in BR5 (Annex F), is listing 23 measures in the new policy, some of them also adopted in 2022. The Parliament will revisit two of the proposed initiatives in 2024 – CO_2 tax on oil and tax on f-gases - due to the sudden economic uncertainties in Europe pertaining to the Russia-Ukraine conflict.

With the new Climate and Energy Policy and in accordance with the Paris Agreement the Nationally Determined Contribution (NDC) of the Faroe Island, i.e., the emission reduction target from 2022 to 2032 is defined to be 30 %. This corresponds to around 410,000 tonnes of CO_2 equivalents. The process of preparing the notification of the Faroese NDC to UNFCCC will kick-off in 2023.

A new government came to power in December 2022. The new Ministry of Environment has given the Climate Policy from 2022 high priority.

Climate and environmental policies in municipalities
The municipalities of Klaksvík and Tórshavn as well as some other municipalities on the Faroe Islands have in recent years formulated policies for environment and energy with targets for reduction of emission of greenhouse gases. The goal of the municipality of Klaksvík is to reduce the emission of greenhouse gases 20 % in 2030, with 2005 as the base year. In the Energy Policy 2021-2027 for the institutions in the municipality of Tórshavn the goal is to reduce the emission of greenhouse gases 50 % in 2027 with 2016 as the base year and with focus on 1) reduction in use of fossil fuels to heat institution within the municipality, 2) a shift to more energy saving street lightning and to 3) a shift from fossil fuel cars to electric cars.

4.7.2 Policies and measures and their effect

The Climate Policy for Faroe Islands[26] from 2009 for the years 2010-2020, is the first and only climate policy made before 2020. The Climate Policy addressed three main key action areas: heating of buildings, electricity production and land-based transport. These are described in more detail below. Other areas are ships, aeroplanes and renewable energy resources.

I. Heating of buildings

- ➔ **Target:** In 2020 the oil consumption for heating shall be reduced by 50 % by putting into place energy saving measures and new energy efficient and environmentally friendly technologies.
- ➔ **Measures:** The use of environmentally friendly technologies such as heat pumps, newer and more efficient oil burners and boilers, district heating, solar power and other environmentally friendly and renewable energy sources. To perform regular inspection of the above-mentioned systems to ensure that these are as energy efficient as possible.

Heating of household and other buildings
Historically most Faroese houses are heated with oil boilers. But 15 years ago, it became more normal to install heat pumps, both air to water and ground source heat pumps.

[26] https://d3b1dqw2kzexi.cloudfront.net/media/5522/veðurlagspolitikkur-føroya.pdf *In Faroese only.*

Today, it is estimated that around 15 % or 2000 oil boilers have been phased out and replaced by heat pumps. An average family house use 2,500 litre of heating oil and the emission is approximately 7 ton CO_2 a year. Based on the current power mix (oil, hydro, wind) a heat pump will reduce the emission with around 5 ton. So, the total reduction is around 10,000 ton a year. In 2017 a new technical regulation (BK17) for new buildings was put in place, with stricter rules for use of energy for heating.

District heating

Since 1990, parts of the houses in Tórshavn are connected to the Fjarhitafelagið (District Heating System). The energy originates from waste incineration, waste heat from the diesel engines at Sund Power Station, from Förka biogas plant and from burning of waste oil and partly heating oil. Today 1,700 houses and other buildings are connected. The reduction of CO_2 is estimated to 10.000 ton/year.

Effect of measures for heating

In BR5, Chapter VII.C (Annex F), the effect of the measures in the Climate Policy from 2009 for Heating of buildings is described.

New measures for Heating of buildings

In the new Climate and Energy policy from 2022 new measures regarding heating were presented. These are the measures for heating of buildings:

- Prohibit installation of oil boilers
- Phasing out oil boilers
- Heat Pump – VAT exemption
- Legislation on district heating
- Public energy consulting
- Subsidies to insulation and renovation of old houses

More information about these measures are available in BR5, Table VII.C.3 (Annex F).

II. Electricity production

➔ **Target:** In 2020 about 75 % of the overall production of electricity is derived from renewable energy sources.

➔ **Measures:** In order to significantly increase the production of electricity from renewable energy sources it is necessary to improve the system.

SEV, the Electricity Company, owned by the municipalities, is responsible for production, transmission and distribution of nearly all power in the Faroe Islands.

Altogether, SEV has produced around 300-330 million kWh of electricity yearly from 2014 to 2017. In 2020 the production was 407 million kWh.

SEV uses around 50,000 tonnes of oil annually for electricity production (2018-2020). In 2020 39 % of SEV's overall electricity production was from renewable energy sources (27 % from hydro energy and 12 % from wind energy). Earlier (from 2014-2018) 50% or more of the energy came from renewable sources. Since 2018, the demand and thus the production of electricity has increased significantly and likewise the use of fossil fuel, which again is the reason for the now lower share of renewable energy sources in the production.

The total demand to electric power in the Faroe Islands increases both due to normal economic growth and due the changes in energy usage, which is envisaged within domestic transport and heating when the switch from oil and petrol to electric energy takes place in years to come. Electric energy demand in energy for heating, transport and industry sector is expected to increase from around 390 GWh in 2019 to around 715 GWh (50 % electrification) or 960 GWh (100 % electrification) by 2030.

In 2014 SEV announced a plan to reach 100 % green energy power production by 2030. A hundred percent green power production will reduce the emission of GHG with 150,000 tonnes CO_2 equivalents.

The work to reach 100 % green energy on shore in the Faroe Islands by 2030 is based on three main principles. First, the security of supply must be maintained unconditionally, second, all investments must be financially viable, and third is the consideration for the environment. To make the right decisions at the right time is crucial on the green course. The tangible plan for the green course is a flexible project with the aim to securely and with great care to select the best and least impacting green solutions for the Faroe Islands.[27]

In 2020 renewable energy was less than 6 % of total energy supply in the Faroe Islands, which also covers the relatively large fishing fleet. However, there is unexploited potential, especially in wind and solar power and in a longer perspective in tidal power. The challenge is that wind alone cannot be the sole source of supply; rather the wind needs to be coupled with more stable production sources, such as hydropower and tidal energy.

Wind farms

The Faroe Islands is surrounded by plentiful winds, with an average annual wind above 10 m/s on several locations. Energy production from wind is unstable and closely correlated to the changeable weather patterns in the Faroe Islands.

Wind farms are easy and quick to build, as well as being an inexpensive form of production, and more energy from wind is certainly a part of the renewable energy development plan. This will happen in conjunction with energy storage systems that can store excess wind energy, and then release the stored energy onto the grid, when wind production is low.

The development of wind power in the Faroe Islands started in 2003 when the first wind turbines were installed in Vestmanna. All existing and planned windmills in the Faroe Islands are listed in Table 4.27.

TABLE 4.27 EXISTING AND PLANNED WIND TURBINES IN THE FAROE ISLANDS

Location	**Year**	**Power** *MW*	**Yearly production** *GWh (average)*
Existing			
Mýrarnar Vestmanna	2003	1,98	6
Neshagi/Eystnes	2012	4,5	14

[27] https://www.sev.fo/english/news/tangible-plan-for-the-green-course/

Húsahagi	2014	11,7	35
Porkeri - Heimari partur	2021	6,3	19
Hoyvíkshagi - Gellingarklettur	2022	25,2	100
Flatnahagi	2023	18	64
Total existing		**67,7**	**238**
Planned			
Klivaløkshagi á Sandi	2025	25	100
Glyvrafjall/Junkarahagin	2027	25	100
Total planned		**50**	**200**

The wind farm at Húsahagi has a revolutionary battery system, which in terms of minutes and seconds balances the energy output to the grid. The battery system enables higher yield from wind energy.

Altogether the wind turbines installed until 2020 reduce the annual emission of GHG with 36.850 tonnes CO_2 equivalents.

Solar and tidal energy
SEV established a solar pilot plant on a disused football field in Sumba in 2019 with an expected annual production of about 160 MWh.

In 2020 a test project started with a tidal power plant in Vestmannasund using a Minesto DG100 turbine with an output of 100 kW. Recently it has been decided to continue the test project with a Dragon Class D12 turbine with an output of 1,200 kW.

Effect of measures for Electricity Production

In BR5, Chapter VII.C (Annex F), the effect of the measures (in the Climate Policy from 2009) for Electricity Production of buildings is described.

New measures for Electricity Production
These are the measures for Electricity Production in the Climate Policy from 2022:

- Wind power – development 2023 -2035
- Pump to Storage plant
- Small hydropower plants
- Hydrogen and Power to X
- Small solar power plants
- Medium size sun power plants
- Large sun power plants (> 500kW)

III. Land-based transport

➔ **Target:** In 2020 all gas and diesel fuelled vehicles shall be energy efficient and a significant number of vehicles are to run on renewable energy. The aim is to reduce CO_2 emissions from domestic transport by 50 %.

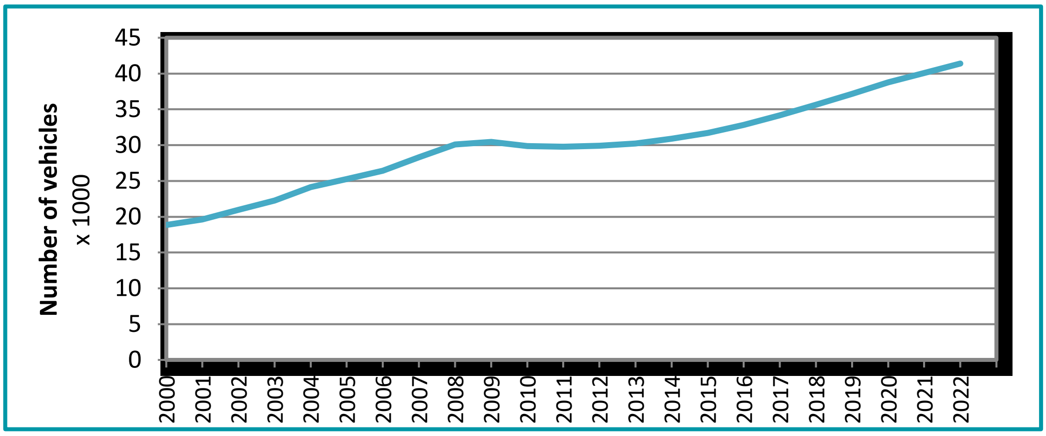
➔ **Measures:**

- Importing more energy efficient gas and diesel vehicles,
- Encourage the use of vehicles that run on renewable energy,
- Biofuels become available when bio fuelled cars are introduced to the Faroese market,
- Public traffic is improved and strategically located junctions provide for easy access.

Although remote and sparsely populated, the Faroe Islands have an advanced domestic infrastructure, both in transportation and digital networks. Paved roads connect all the inhabited villages, and the populated areas are connected by 17 land tunnels. The various islands are connected by two underwater tunnels, in addition to three bridges and seven ferry lines. The transportation links between the different areas in the Faroe Islands are of great importance to local businesses and people alike.

The number of vehicles on the Faroe Islands has been increasing since 2013 and in 2020 38.750 vehicles were regstrated, see Figure 4.4.

FIGURE 4.4 NUMBER OF VEHICLES ON THE FAROE ISLANDS, 2000-2022



Effect of measures for Land-based transport

In BR5, Chapter VII.C (Annex F), the effect of the measures in the Climate Policy from 2009 for Land-based transport is described.

New measures for Land-based transport

These are the measures for Land-based transport in the Climate Policy from 2022:

- Stimulate use of electric cars and hydrogen cars – tax refund
  Buyers of electric cars as well as other green cars, could in 2021 and 2022 apply to get up to 70.000 DKK of the tax refunded. In 2025 and 2026 the amount is 35.000 DKK. This will increase the shift towards greener traffic. Ultimo 2021 around 600 electric cars were registered in the Faroe Islands.
- Environmental tax and ban on use of fossil fuel vehicles
- Green public transport

5

PROJECTIONS AND THE TOTAL EFFECT OF POLICIES AND MEASURES

- AND SUPPLEMENTARITY RELATING TO KYOTO PROTOCOL MECHANISMS

Contents

5 Projections and the total effect of policies and measures

- and supplementary relating to Kyoto Protocol mechanisms

5.1 Projection with existing measures (WEM-scenario)

5.1.1 Projection of total greenhouse gas emissions

In 2022, the 2022 baseline scenario with a projection of Denmark's greenhouse gas emissions 2021-2035 – i.e. a with existing measures (WEM) or frozen policy scenario – was published by the Ministry of Climate, Energy and Utilities in *Denmark's Climate Status and Outlook 2022* - the CSO22-report (*DEA 2022*)[1]. A supplemental documentation report in English was published in August 2022 by DCE, the Danish Centre for Environment and Energy at Aarhus University (*Nielsen et al. (2022b)*)[2].

Detailed results from the 2022 projection are available in Annex C1.

Key facts about the approaches and models used in CSO22 are included in Annex C2.

"Summary of key variables and assumptions used in the projection analysis" and "Information on updated greenhouse gas projections under a 'with measures' scenario" in the required tabular formats, are included in Table 5 and Table 6(a) respectively of Annex F (BR5), Chapter VIII (CTF).

5.1.2 Introduction

Denmark's Climate Status and Outlook 2022 (CSO22) is an account of how Danish greenhouse gas emissions have developed from 1990 to 2020, 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 2035 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

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[1] DEA 2022: *Klimastatus og –fremskrivning 2022*, Ministry of Climate, Energy and Utilities, April 2022 (draft) / June 2022 (final) (in English: https://ens.dk/en/our-services/projections-and-models/danish-climate-and-energy-outlook)

[2] *Nielsen et al. (2022b):* Projection of greenhouse gases 2021-2040. Nielsen, O.-K., Plejdrup, M.S., Winther, M., Hjelgaard, K., Nielsen, M., Mikkelsen, M.H., Albrektsen, R. & Gyldenkærne, S., 2022. Projection of greenhouse gases 2021-2040. Aarhus University, DCE – Danish Centre for Environment and Energy, 131 pp, Scientific Report No. 505 (https://dce2.au.dk/pub/SR505.pdf)

Parliament or the EU before 1 January 2022, or arising out of binding agreements. The policy freeze pertains to Danish and EU climate and energy policy only, and it does not reflect the assumption that developments in general will come to a halt. For example, economic growth and demographic trends are not part of the freeze.

CSO22 thus serves to examine to what extent Denmark's climate and energy targets and commitments will be met within the framework of current regulation. CSO22 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.

Pursuant to the Danish Climate Act of 18 June 2020 (the Climate Act) a climate status and outlook report must be drawn up annually[3].

The Climate Act stipulates that Denmark is to reduce emissions of greenhouse gases by 50-54% in 2025 and 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.

To understand the results in CSO22, it is important to know what emissions are covered in the climate projections, what policy measures, etc. are included and how the projections are made.

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)[4].

The cut-off date for including policy measures in CSO22's modelling for the period 2021 to 2035 has been defined as 1 January 2022. The cut-off date for including policy measures in CSO21 was 1 January 2021. The new policy measures included in CSO22 are the agreement on a green transition of the agricultural sector, the "Denmark Forward" 2035 infrastructure plan agreement, the green transport pool realisation agreement, and the agreement on regulation of the EV charging market, as well as an additional 2GW offshore wind deployment and a technology-neutral tendering procedure for negative emissions (agreed as part of the 2022 Finance Act), and more. For a full list of the new policy measures included in CSO22, as well as a list of the measures that have not been included, either because they have yet to be sufficiently concretised or because it is (currently) not possible to estimate their impact, see the underlying CSO22 memorandum on assumptions 2A[5].

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[3] The Climate Act also requires global reporting on the international impacts of Danish climate efforts. The annual global reporting for 2022 has been prepared and published as a separate publication in parallel with CSO22. References to CSO22 therefore only pertain to Denmark’s national climate status and outlook.

[4] 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 CO_2 emissions). See the underlying CSO22 memorandum on assumptions 2B for further explanation of the emissions covered in CSO22.

[5] https://ens.dk/service/fremskrivninger-analyser-modeller/klimastatus-og-fremskrivning-2023 (under "Klimastatus og – fremskrivning 2022" all memoradas and other backgrond materials used for the CSO22 are available in Danish)

Note that the energy islands decided as part of the 2020 climate agreement for energy and industry, etc. have not been included in the CSO22 basic scenario, because establishment of these islands depends on measures that have yet to be decided, for example measures concerning interconnectors[6]. The agreement on a tendering procedure to promote hydrogen and green fuels (Power-to-X) from 15 March 2022 has also not been included in CSO22. This is because the agreement was concluded after the cut-off date for inclusion of measures in the projections.

In addition to policy measures, CSO22 includes an updated overall assessment of developments based on current market conditions. Amongst other things, this includes actual investment decisions by various players[7]. Note that the assumptions behind CSO22, including assumptions about fuel prices and the CO_2 allowance price, have been established as at the end of 2021, and that CSO22 therefore does not take account of the subsequent developments in Ukraine and any derived effects on energy markets, etc.

CSO22 is a collection of a number of different projections from the Ministry of Climate, Energy and Utilities and the Danish Centre for Environment and Energy (DCE), which the Ministry of Climate, Energy and Utilities has combined with statistical data to produce an overall climate status and outlook report for Denmark. How CSO22 was prepared is described in more detail in the underlying CSO22 memorandum on assumptions 0, 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 2 in the CSO22-report.

It is important to bear in mind that sensitive assumptions and uncertainties affect the key results in CSO22. The projections look more than 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.

CSO22 consists of a main report, underlying sector memoranda and memoranda of assumptions, as well as a number of data sheets. 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 the projections have been documented in several memoranda on assumptions. These memoranda were subject to public consultation in January 2022. For a list of all written CSO22 material, see Appendix 2 in the CSO22-report.

In addition to the main report and the sector memoranda, CSO22 has been 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 presented in Appendix 5.2 in the CSO22-report in the relevant sector memoranda[8].

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[6] See the underlying CSO22 memorandum on assumptions 2C for further explanation of the principles behind the frozen-policy approach in Denmark's Climate Status and Outlook reports.

[7] For a description of how CSO22 deals with collaboration agreements between the government and businesses, see the underlying CSO22 memorandum on assumptions 2C.

[8] The 2020 Climate Action Plan presents several indicators which will in future contribute to the assessment of progress in the transition of individual sectors.

See Appendix 3 in the CSO22-report for further information on this CSO22 data and a list of CSO22 data sheets.

5.1.3 The overall picture

Denmark's climate status: In 2020, total greenhouse gas emissions, including carbon removals and emissions by soils and forests, came to 44.9 million tonnes CO_2e. This means that, in 2020, Danish greenhouse gas emissions had been cut by 43% compared to total Danish emissions in 1990. Note that the Covid-19 pandemic had an effect on activity levels in some sectors in 2020, and that the pandemic therefore also put its mark on energy consumption and greenhouse gas emissions in these sectors. Although 2020 is the most recent statistical year, analyses in CSO22 sometimes use emissions in 2019, in which activity levels must be assumed to represent a fairer basis.

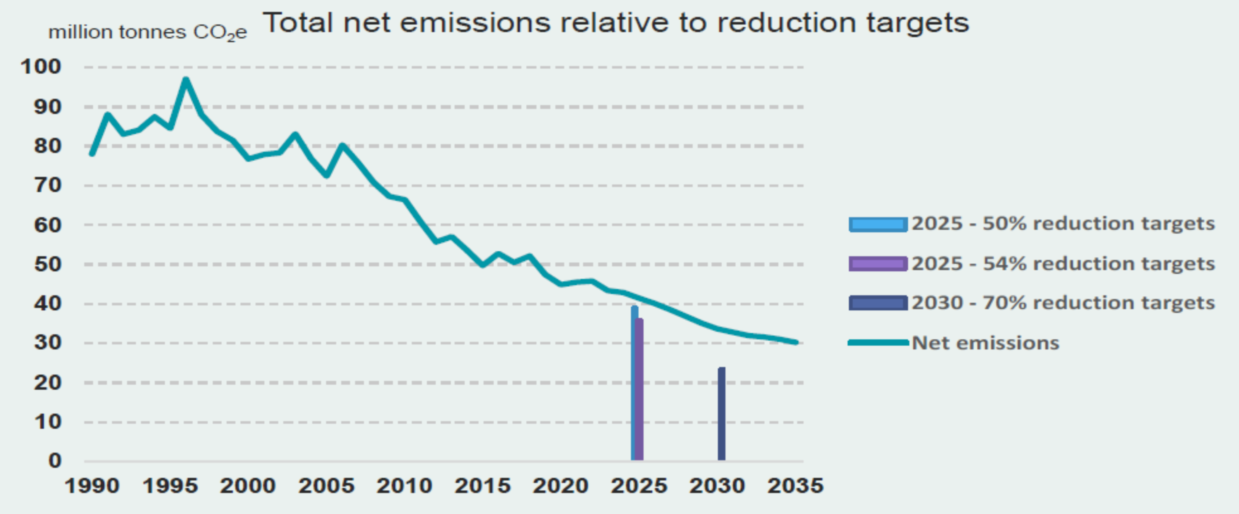
Denmark's climate outlook: based on policies adopted until 1 January 2022, total net emissions[9] are expected to have fallen to 41.4 million tonnes CO_2e in 2025 and 33.6 million tonnes CO_2e in 2030, corresponding to a reduction of 47% in 2025 and 57% in 2030 compared to the 1990 level. Thus, as things stood by 1 January 2022, the CSO22 projections reveal an estimated emissions gap of 3-7 percentage points in 2025 and 13 percentage points in 2030 compared with the reduction targets set out for 2025 and 2030 in the Climate Act. This corresponds to a shortfall of 2.4-5.5 million tonnes CO_2e in 2025 and 10.1 million tonnes CO_2e in 2030. In 2035, total net emissions are expected to have been reduced additionally to 30.2 million tonnes CO_2e.

Naturally, the projections in Denmark's Climate Status and Outlook reports are linked to uncertainty, and the uncertainty in CSO22 is particularly pronounced. This greater general uncertainty is due partly to uncertainty as to the effects of the Covid-19 pandemic and partly the effects of the current uncertainties in the energy markets following from the situation in Ukraine, which, as already mentioned, have not been included in CSO22. These mentioned circumstances could lead to permanent structural changes and permanent changes in consumer behaviour and choice of technology, which are not reflected in CSO22. CSO22 should therefore be interpreted in light of this.

The expected development in net emissions and the emissions gap relative to the reduction targets for 2025 and 2030 are illustrated in Figure 5.1.

[9] The concept of "total net emissions" refers to total emissions (including LULUCF), and after inclusion of CCS. CSO22 has been calculated using the new global warming potential factors (GWPs) from the IPCC's 5th Assessment Report (AR5). The shift from using AR4 GWPs to AR5 GWPs has increased the level of total greenhouse gas emissions with approximately 0.3 million tonnes CO_2e in the projection period, while the effect on the total in 1990 is close to zero.

FIGURE 5.1: TOTAL NET EMISSIONS AND 2025 AND 2030 REDUCTION TARGETS



Note: The extra partial effect of higher allowance prices on emissions from refineries of around 0.08 million tonnes CO2, which has been deducted from the emissions gap for 2030 (cf. table 2.1) is not reflected in emissions estimates in this figure.

5.1.3.1 Status of progress towards reduction targets set out in the Climate Act [10]

Projected total emissions in 2025 and 2030 will be 41.4 million tonnes CO_2e and 33.6 million tonnes CO_2e, respectively, if no new measures are introduced in the climate and energy area after 1 January 2022; the cut-off date for including policy measures in CSO22. This leaves an emissions gap of 2.4-5.5 million tonnes CO_2e compared with the Climate Act's indicative target to reduce emissions in 2025 by 50-54% compared to 1990, and an emissions gap of 10.1 million tonnes CO_2e compared with the target to reduce emissions in 2030 by 70% compared to 1990. The extra partial effect of higher allowance prices on emissions from refineries of around 0.08 million tonnes CO_2 has been deducted from the emissions gap for 2030, see Chapter 5.4 (for further information: see Chapter 7.1 in the CSO22).

[10] See chapter 11 for a status on Denmark's EU obligations for non-ETS emissions and LULUCF, as well as for renewable energy and energy-efficiency improvements.

TABLE 5.1: STATUS OF PROGRESS TOWARDS REDUCTION TARGETS SET OUT IN THE CLIMATE ACT

	1990	2019	2020	2025	2030	2035
CSO22 net emissions (million tonnes CO_2e)	78.0	47.4	44.9	41.4	33.6	30.2
Climate Act reduction target compared to CSO22 (million tonnes of CO_2e)				35.9-39.0	23.4	
Gap compared with reduction target (million tonnes CO_2e)				2.4-5.5	10.1	
CSO22 reduction relative to 1990 emissions	0%	39%	43%	47%	57%	61%
CSO21 reduction relative to 1990 emissions	0%	40%	43%	47%	55%	

Note: Emissions in target years and the remaining emissions gap have been calculated as annual values in the table. The extra partial effect of higher allowance prices on emissions from refineries of around 0.08 million tonnes CO_2 has been deducted from the emissions gap for 2030. However, for technical modelling reasons, the extra partial effect has not been reflected in the other emissions estimates in CSO22.

Pursuant to the Climate Act, the reduction targets in both 2025 and 2030 must be calculated as three-year averages to minimise fluctuations in individual years. Emissions in target years and the associated emissions gap have been calculated as annual values in Table 5.1, among other things because the projection of energyrelated emissions assumes that all projection years are 'normal years'.

The emissions gap for 2025 in CSO22 has increased by around 0.3 million tonnes CO_2e compared with CSO21, while the emissions gap for 2030 has fallen by around 1.7 million tonnes CO_2e. This development is the result of a combination of new policy measures, updated expectations about price and market developments, and an updated data basis[11].

New policy measures included in CSO22

Important new policy measures in CSO22 include[12]:

- Agreement on a green transition of the agricultural sector and Denmark's National CAP Strategic Plan.
- The "Denmark Forward" 2035 infrastructure plan agreement and the agreement on regulation of the EV charging market, as well as the green transport pool realisation agreement, etc.
- Agreement on an additional 2GW offshore wind deployment, agreed as part of the2022 Finance Act.
- Agreement on a technology-neutral tendering procedure for negative emissions, agreed as part of the 2022 Finance Act.

The effect of these agreements on sector emissions are described in brief in section 2.4 and in more detail in the subsequent sector chapters and underlying sector memoranda. As mentioned above, the energy islands have not been included in this

[11] Furthermore, the methodological approach has been updated in some areas, and this may also have influenced someof the results. See appendix 5 for a comparison between net emissions in CSO22 and CSO21 for the entire period 1990 to 2030.
[12] See table 1 in CSO22 memorandum on assumptions 2A.

year's basic scenario, because establishment of these islands depends on measures that have yet to be decided and therefore cannot be included as frozen policy. The agreement from March 2022 on a tendering procedure to promote hydrogen and green fuels (Power-to-X) has also not been included in CSO22, as the agreement was concluded after the cut-off date for including measures in the report.

Updated expectations about price developments

The emissions in CSO22 are also affected by updated expectations about the CO_2 allowance price and fossil-fuel prices. The CO_2 allowance price level in 2021 was more than double that presented in CSO21, and CSO22 therefore assumes a CO_2 allowance price as high as up to DKK 750 per tonne in 2030 (see CSO22 memorandum on assumptions 3B). In the short term, fossil fuel prices are also at a higher level in CSO22 than in CSO21, particularly the price of natural gas (see CSO22 memorandum on assumptions 3A). However, note that the price scenarios for CSO22 have been fixed from end 2021, and that they therefore do not reflect the significant trend in fuel prices during the first quarter of 2022.

Updated expectations about market developments

In addition to developments in prices, updated expectations about market developments also have significance for the development in emissions in CSO22. In this year's report, expectations have been updated about:

- The range of electric cars available in the market, which has significance for the rate at which electric cars and electric vans and lorries replace vehicles with conventional combustion engines in the transport sector.
- Demand on agriculture markets, which is significant for the amount of livestock and crops produced by the agriculture sector.
- The activity level in cement production.

Updated data basis

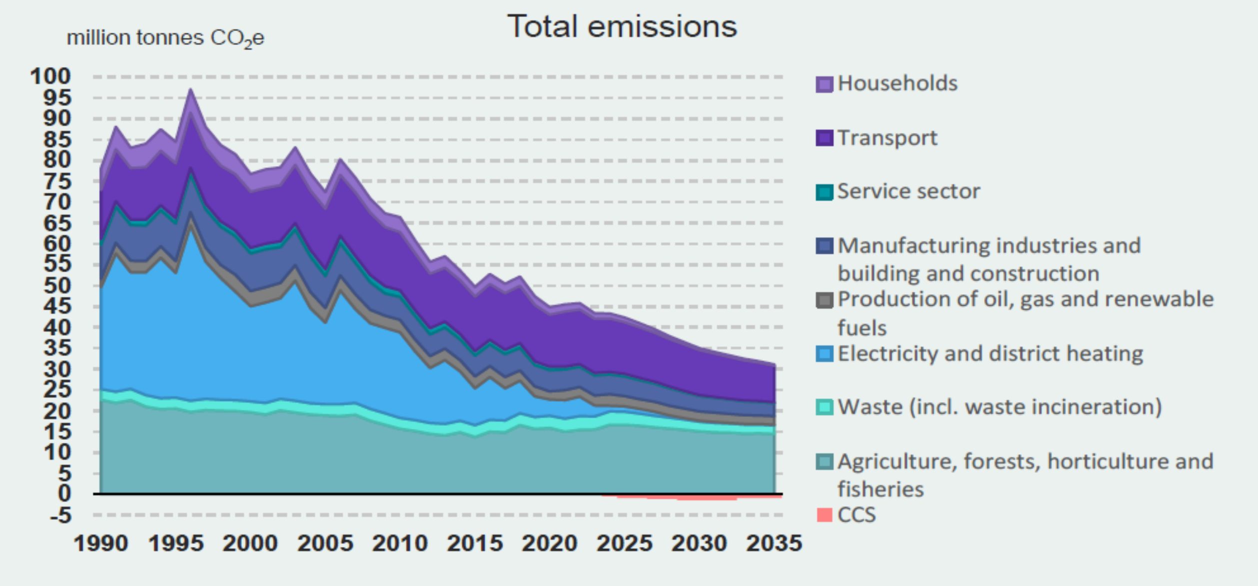
The data basis for projections is updated and improved continuously, and this also has significance for some projections. Important updates to the data basis for CSO22 include:

- A higher future leakage rate from biogas plants as a result of a measurement project (see CSO22 memorandum on assumptions 9B)
- Updated assumptions for calculations, for example in the form of a new assumption about higher future temperatures, which lead to reduced net removals by mineral soils in agriculture (see CSO22 memorandum on assumptions 10C)
- Updated data on the carbon content of and expected removals by forest land, the share of felled trees stored in wood products, expectations about new afforestation, and changed management practices, for example through conversion to virgin forest and nature areas, all of which lead to expected increased net removals

5.1.3.2 Trends in emissions by economic sector

Developments in total net emissions are a result of developments in the various underlying sectors. Figure 5.2 illustrates developments in the individual economic sectors from 1990 up to 2020 and the expected developments in the projection period from 2021 to 2035 for these sectors, as well as for carbon capture and storage (CCS).

FIGURE 5.2: TOTAL EMISSIONS BY ECONOMIC SECTOR, AND CCS



Note: In CSO22, CCS is dealt with as negative emissions not broken down by sectors (see section 2.4).

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 5.2, and in 2020, the sector accounted for only 9% of total emissions. This share is expected to have fallen to 3% in 2025, and in 2030 electricity and district heating (excluding waste incineration) is expected to account for less than 1% of total net emissions[13]. Furthermore, the electricity and district heating sector has seen significant fluctuations in emissions historically. These fluctuations have been due primarily to weather conditions, such as cold winters or fluctuating precipitation in the Nordic countries (affecting Nordic hydropower production). Fluctuations will decrease in future as total emissions from the electricity and district heating sector are reduced as a consequence of phasing-out

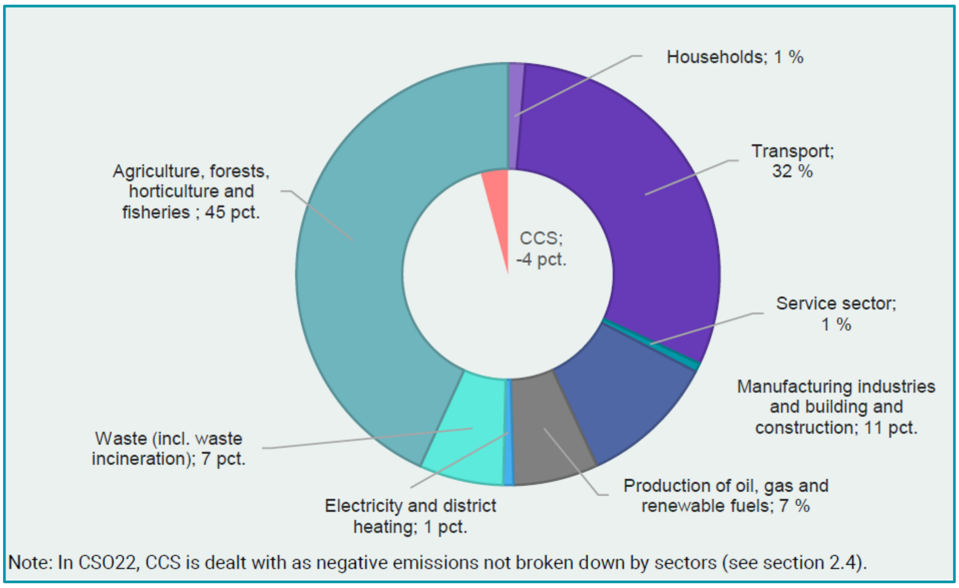
[13] Waste incineration also contributes to electricity and district heating production. If emissions from waste incineration are included with emissions from the electricity and district heating sector, these sectors accounted for 12% of net emissions in 2020 and are expected to make up 7% in 2025 and 3% in 2030. Furthermore, private autoproducers in other sectors also contribute to electricity and district heating production, although emissions from this production are relatively limited (see also sector memorandum 8A).

fossil power plants and transitioning to electricity production based primarily on wind, solar and biomass.

As emissions from electricity and district heating production fall, the other sectors' share of total emissions will increase given that they are not falling to the same extent. Historically, emissions from agriculture, forests, horticulture and fisheries, which include emissions from agricultural processes, agricultural land and forests, as well as energy consumption by the sector, have therefore gone from contributing around 25% of total emissions to contributing 35% of total emissions in 2020. In 2025, this sector is expected to account for 40% of net emissions, while in 2030 the sector's share of total emissions is expected to have increased further to 45%. Similarly, the transport sector's share of total net emissions grew from 15% in 1990 to 28% in 2020, and in 2025 and 2030, 30% and 32%, respectively, of net emissions are expected to stem from the transport sector.

How total emissions in 2030 distribute across sectors is illustrated in Figure 5.3[14]. As can be seen from the figure, emissions in 2030 will be concentrated on relatively few sectors. It is expected that more than 75% of the total net emissions of 33.6 million tonnes CO_2e will stem from either agriculture, forests, horticulture and fisheries or the transport sector.

FIGURE 5.3: TOTAL NET EMISSIONS IN 2030 BY ECONOMIC SECTOR



5.1.3.3 Trends in emissions across types of emission

Greenhouse gas emissions across sectors stem from several different sources and types of activity cf. Figure 5.4. Under the Common Reporting Format (CRF) used for international reporting to the UN and the EU, emissions are divided into five overarching CRF categories: 1) energy-related emissions, 2) process emissions, 3)

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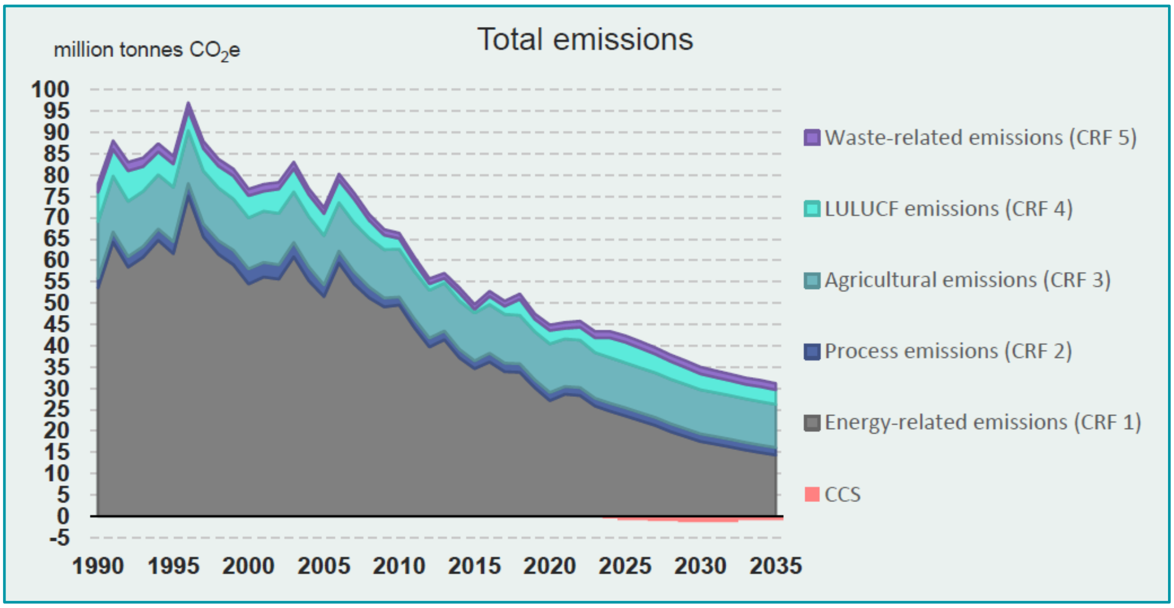
[14] Note that the sectoral divisions in CSO22 have been changed slightly compared to CSO21, in that F gases have been broken down by sectors in CSO22 (see the distribution key for F gases described in CSO22 memorandum on assumptions 9C about F gases). However, this has only very limited significance for the sectors' shares of total emissions in 2030, since F gases will account for only around 0.5% of total net emissions in 2030.

emissions from agricultural processes, 4) LULUCF emissions and 5) waste-related emissions[15].

Almost all emissions from households, transport and production of oil, gas and renewable fuels are energy-related emissions, while the service sector and the manufacturing and building and construction sector have both energy-related emissions and process emissions[16]. Emissions from the waste sector include both energy-related emissions from waste incineration and waste-related emissions from landfills, wastewater, composting and biogas leakage, while the majority of emissions from agriculture, forests, horticulture and fisheries stem from agricultural processes (i.e. digestion by livestock, manure management and fertiliser use), as well as from agricultural land use[17].

FIGURE 5.4: TOTAL EMISSIONS BY CRF CATEGORIES, AND CCS



Energy-related emissions

Up to 2015, total energy-related emissions across sectors have typically constituted between 70% and 75% of total Danish greenhouse gas emissions. However, since then, the energy-related emissions' share of total emissions has dropped, and this trend is expected to continue in the projection period. In 2025, energy-related emissions are therefore expected to account for around 55% of total emissions, in 2030 the share will have fallen additionally to 50%, and in 2035 it will be close to 45%. In future, the majority of energy-related emissions will come from the transport sector, as the transport sector's share of energy-related emissions will have gone from 45% in 2019 to 53% in 2025 and 61% 2030. The transport sector's share of energy-related emissions will increase even though total emissions from the sector are expected to fall during the projection period.

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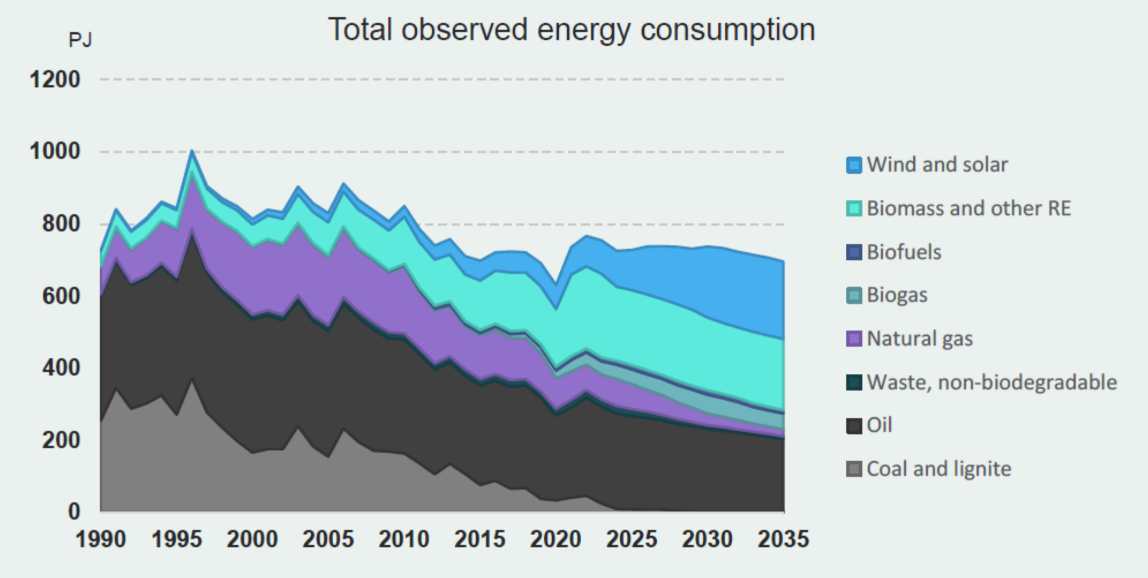
[15] See also Appendix 5.1 in CSO22 memorandum on assumptions 2B.
[16] Process emissions from the service sector comprises F gases, see CSO22 sector memorandum 5A and CSO22 memorandum on assumptions 9C.
[17] Historically, forests have contributed significantly to CO_2 removal, but this contribution will be less significant during the projection period, and during the period 2025 to 2029, small net emissions are expected from forests.

Developments in energy-related emissions depend on total energy consumption as well as on the share of renewable energy in energy consumption. Figure 5.5 shows the energy mix and developments observed in Danish energy consumption from 1990 to today, and onwards up to 2035.

FIGURE 5.5: TOTAL OBSERVED ENERGY CONSUMPTION BY TYPE OF ENERGY (PJ)



Note: The majority of natural gas and biogas will be blended into the gas system and will become mains gas for end consumption.

Renewable energy covers a large number of renewable energy sources, from wind and solar over solid biomass to liquid biofuels and biogas, etc. Some renewable energy sources can be included directly in final energy consumption by the sector, for example wood pellets for space heating and process heat, while other renewable energy sources are used in the production of energy products such as electricity, district heating, mains gas and transport fuels. Biomass burning is considered CO_2 neutral under the UN IPCC methodology, while biogenic energy-related CO_2 emissions are to be reported as a so-called memo item (see memorandum on assumptions 2B).

The biogenic CO_2 emissions from total Danish consumption of biomass for energyrelated purposes are shown in Appendix 6[18].

While emissions associated with electricity and district heating production are ascribed to the electricity and district heating sector and, as far as emissions from waste incineration go, to the waste sector, emissions associated with consumption of mains gas and transport fuels are ascribed to the consuming sectors. Emissions from these sectors are therefore determined by the renewables share in mains gas and transport fuels. As can be seen from Table 5.2, the renewables shares in mains gas and transport fuels will increase during the projection period, for transport fuels, from 6% in 2020 to 9% in 2030, and for mains gas, from 16% in 2020 to 75% in

[18] The corresponding biogenic energy-related CO_2 emissions from the individual sectors are in appendices to the relevant underlying sector memoranda.

2030 and 92% in 2035[19]. Towards the end of the projection period, it is therefore expected there will be relatively few emissions associated with consumption of mains gas.

TABLE 5.2: RENEWABLES SHARES IN ELECTRICITY CONSUMPTION, MAINS GAS AND TRANSPORT FUELS, AS WELL AS TOTAL RENEWABLES SHARE

	2019	2020	2025	2030	2035
Renewables share in electricity consumption (RES-E)	65%	65%	93%	109%	102%
Renewables share in mains gas	10%	16%	38%	75%	92%
Renewables share in transport fuels	5%	6%	7%	9%	8%
Total renewables share (RES) (before sales)	37%	42%	51%	64%	67%

Note: Numbers in the table are rounded. Total RES is calculated before statistical transfers between Denmark and other EU Member States. After statistical transfers, RES was 32% in 2020 (see CSO22 sector memorandum 11B).

The renewables share in transport fuels primarily depends on the national CO_2 displacement requirement for transport fuels and so is only slightly dependent on the total consumption of transport fuels (see also CSO22 sector memorandum 4B). The renewables share in mains gas, on the other hand, will change with changes in the consumption of mains gas. This is because the renewables share in mains gas consists of upgraded biogas, and the amount of biogas produced depends on the demand, assuming that the demand is determined by the relevant subsidy schemes (see CSO22 memorandum on assumptions 7C and sector memoranda 7A and 7B). A reduction in the demand for mains gas would therefore result in a corresponding reduction in the consumption of fossil natural gas. A reduction in the consumption of mains gas in a given sector will therefore also lower emissions from mains gas consumption in other sectors because the renewables share in mains gas increases at the same time.

The renewables share in electricity supply is also projected to increase, from 65% in 2020 to 109% in 2030[20]. Note that meeting the target in the Power-to-X strategy and establishing the energy islands, which have not been included in the CSO22 basic scenario, will significantly increase both the demand and the supply of electricity relative to the levels projected in CSO22.

In CSO22, the renewables share in total energy consumption (before statistical transfers) will increase from 42% in 2020 to 64% in 2030 and 67% in 2035.

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[19] Note that the calculated renewables share in transport fuels differs from the RES-T used in the EU estimates. Amongst other things, RES-T includes the different types of biofuels with different weightings depending on their origin and the type of biomass used, just as it includes electricity consumption by electric road transport and electric rail transport with different weightings.

[20] RES-E is a measure of surplus/shortage of renewables-based electricity production in the Danish electricity system compared to Danish electricity demand, and therefore RES-E can exceed 100%. RES-E was at 97% in 2030 in CSO21. The increase in RES-E for the period around 2030 is largely the result of the increased offshore wind deployment of 2GW decided as part of the 2022 Finance Act.

Emissions from industrial processes, agricultural processes, land and wasteincineration (excluding waste incineration)

Non-energy-related emission types include:

- Process emissions, which are emissions from industrial processes and emissions from use of appliances, etc. (in the form of F gases). Process emissions were 1.8 million tonnes CO_2e in 2019 and are expected to be at the same level in 2030. Process emissions from cement production contribute around 1.3 million tonnes CO_2e annually in the projection period and therefore comprise the majority of total process emissions.
- Emissions from agricultural processes, which include emissions from animaldigestion, manure management and fertiliser use. Emissions from agricultural processes were 11.4 million tonnes CO_2e in 2020 and are expected to have been reduced to 10.3 million tonnes CO_2e in 2030.
- LULUCF emissions, which include emissions and removals by agricultural land and forests, as well as other land and harvested wood products. LULUCF net emissions were 3.1 million tonnes CO_2e in 2020 and are expected to increase to 3.7 million tonnes CO_2e in 2030.
- Waste-related emissions, which comprise emissions from landfills, wastewater and composting, as well as leakage from biogas plants. Waste-related emissions were 1.2 million tonnes CO_2e in 2019 and are expected to increase to 1.6 million tonnes CO_2e in 2030.

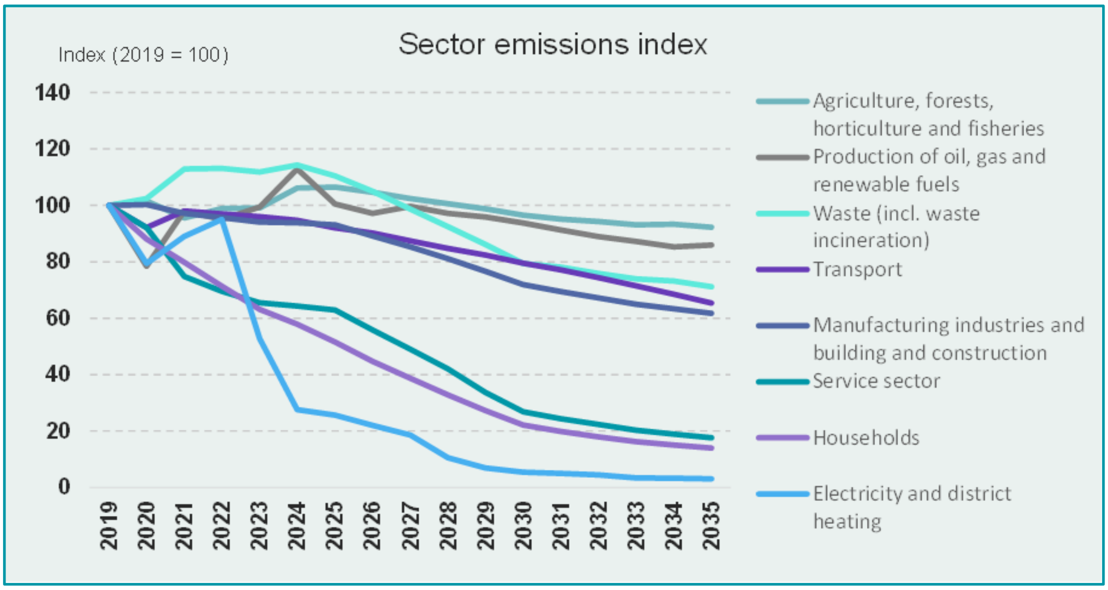
Emissions from agricultural processes therefore account for the majority of nonenergy-related emissions, and emissions from agricultural land also account for the majority of LULUCF emissions. In 2025, emissions from agricultural processes and agricultural land are therefore expected together to account for around 80% of nonenergy-related emissions, and this will also be the case in 2030 and 2035[21]. In step with the general fall in energy-related emissions, the relative significance of non- energy-related emissions will increase, and a significant part of these emissions stem from production processes in agriculture and from agricultural land.

5.1.4 Projection of individual sector emissions 2019-2035

There is not only a difference between how large a share of total emissions can be attributed to the individual sectors, but there are also significant differences in how emissions from the individual sectors are projected to develop during the projection period cf. Figure 5.6. This section describes sector emissions compared to 2019, as emissions in 2020 for some sectors are affected by the Covid-19 pandemic.

[21] Note that total emissions from the agriculture, forests, horticulture and fisheries sector also include the sector's energy consumption, as well as LULUCF emissions and removals by forests, other land and harvested wood products (see chapter 10).

FIGURE 5.6: TRENDS IN SECTOR EMISSIONS 2019-2030 (2019 = INDEX 100)



Note: CCS is not illustrated in this figure, as the technology was not established in 2019.

5.1.4.1 Energy - electricity and district heating (excluding waste incineration)

According to the CSO22 basic scenario, emissions from the electricity and district heating sector will fall from 4.9 million tonnes CO_2e in 2019 to 1.3 million tonnes CO_2e in 2025. In 2030, the sector is expected to emit 0.3 million tonnes CO_2e, and in 2035 just 0.15 million tonnes CO_2e. The background for the significant decrease in emissions is primarily in the phase-out of coal-fired CHP plants, continued wind and solar PV deployments, significant heat pump deployments for district heating production, as well as a reduction in CHP production based on mains gas. Early in the projection period, rising fuel prices will lead to higher electricity prices, which will make it beneficial for Danish electricityproducers to increase their thermal electricity production. In some individual years, this will lead to a higher share of electricity and district heating production based on coal, mains gas and, in particular, biomass, until the share once more falls later in the projection period as a result of competition from increased production of solar andwind power.

The energy islands are not included in the CSO22 basic scenario. Therefore, the system and climate consequences of the energy islands for the Danish electricity and district heating sector have been illustrated in a partial sensitivity calculation, which assumes no change in domestic electricity consumption. In the sensitivity calculation, the energy islands mean that the renewables share in electricity consumption in 2030 increases from 109% to 123%, and in 2035 from 102% to 138%. The energy islands are expected to supply a large surplus of green electricity, which can be used 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 will have very little significance for Danish greenhouse gas emissions, as the scope of fossil electricity production in Denmark will be limited towards the end of the projection period.

5.1.4.2 Energy - production of oil, gas and renewable fuels

Emissions from production of oil, gas and renewable fuels include emissions associated with extraction in the North Sea and emissions from refineries, and in 2019 these made up a total of 2.4 million tonnes CO_2e. Emissions from the sector will peak in 2024 at 2.7 million tonnes CO_2e, after which they will fall to 2.3 million tonnes CO_2e in 2030 and 2.1 million tonnes CO_2e in 2035. The higher emissions during the mid-2020s are due to increased own consumption from extraction activities, and this is linked to postponement of commissioning of the Tyra complex as well as commissioning of a number of other, smaller projects, in which emissions are highest in the start of the operating phase. Furthermore, note that emissions from refineries are covered by the ETS, which means that allowance price developments could have an effect that has not been fully reflected in the sector's emissions in CSO22, because, in CSO22, refineries have been projected to follow a flat curve from the 2019 level (see also chapter 7 and memorandum on assumptions 7B). The extra partial effect on emissions from refineries caused by higher allowance prices is assessed to be around 0.08 million tonnes CO_2. For technical modelling reasons, in CSO22, the extra partial effect is not reflected in the estimate of emissions by refineries; it has, however, been deducted from the emissions gap for 2030 (see section 2.1)[22].

CCS (carbon capture and storage)

In CSO22, CCS is also included as a source of emissions reduction not broken down by sectors. CCS is expected to be realised as a consequence of the CCUS pool (from the 2020 climate agreement for energy and industry, etc.), and the technology-neutral tendering procedure for negative emissions (from the 2022 Finance Act). The expected annual CO_2 emissions reduction effect from CCS is illustrated in Table 5.3 below.

TABLE 5.3: EXPECTED ANNUAL CO_2 EMISSIONS REDUCTION EFFECT FROM CCS

CO_2 (million tonnes)	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
CCUS pool	0	0	0	0	0.4	0.4	0.6	0.6	0.9	0.9	0.9	0.9	0.9	0.9	0.9
Pool for negative emissions	0	0	0	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0	0	0
Total reduction effect	0	0	0	0.5	0.9	0.9	1.1	1.1	1.4	1.4	1.4	1.4	0.9	0.9	0.9

Source: CSO22 memorandum on assumptions 7E: CCS (2022)

CCS can ensure zero emissions from fossil sources or process sources, or negative emissions, if the technology is used to capture biogenic emissions. Due to the large uncertainty about future developments for CCS in Denmark, CSO22 does not include a specific assessment of which sectors will use CCS and will therefore have their emissions reduced. In CSO22, CCS is therefore dealt with as a separate source of negative emissions not broken down by sectors. Because CCS is not broken down by

[22] The possibilities for fine-tuning how emissions from refineries are managed in the models behind the climate projections will be examined before publication of CSO23.

sectors, CCS has also not been included as an integrated part of system calculations for CSO22, and derived effects (e.g. with regard to energy consumption, etc.) will therefore not be reflected in the projected figures.

5.1.4.3 Energy - manufacturing industries and building and construction

Emissions from manufacturing industries and building and construction will fall from 5.1 million tonnes CO_2e in 2019 to 4.7 million tonnes CO_2e in 2025 and 3.7 million tonnes CO_2e in 2030, and are expected to be at 3.1 million tonnes CO_2e in 2035. The fall is due to a fall in energy-related emissions from the sector (from 3.6 million tonnes CO_2e in 2019 to 1.5 million tonnes CO_2e in 2035). Process emissions from the sector, most of which stem from cement production, will increase from 1.4 million tonnes CO_2e in 2019 to almost 1.7 million tonnes CO_2e in 2025 and will stay at this level up to 2035. Amongst other things, this is due to expected increased cement production in Denmark due to an updated assessment on the basis of recent years' production and demand trends, as well as assessments of the total production capacity (see CSO22 memorandum on assumptions 6B).

5.1.4.4 Energy - transport

Emissions from the transport sector were at 13.5 million tonnes CO_2e in 2019. Transport emissions are expected to fall to 12.4 million tonnes CO_2e in 2025 and 10.7 million tonnes CO_2e in 2030, and this fall is expected to continue up to 2035, when transport emissions are expected to have been reduced to 8.8 million tonnes CO_2e, corresponding to a decrease of almost 35% compared to 2019. The fall in transport emissions is projected despite increasing traffic and is due to a combination of transitioning from conventional to electric vehicles, renewable fuels blending and improved energy efficiency for conventional vehicles. With regard to the transition from conventional to electric vehicles, there is projected almost 740,000 electric cars and 270,000 plug-in hybrid cars in 2030, amongst other things due to technological and market developments, including a broader range of electric cars. In 2030, it is expected there will be around 57,000 electric vans and 8,000 plug-in hybrid vans, 2,600 electric lorries and 2,700 electric busses. Outside road transport, the projection period will see increased railway electrification and this will lead to emissions from railways falling from 0.2 million tonnes CO_2e in 2019 to zero from 2031 and onwards.

5.1.4.5 Industrial processes - IPPU

The expected increase in cement production in Denmark despite rising allowance prices should be considered against the backdrop of the rising allowance prices also affecting cement producers in other parts of the EU.

5.1.4.6 Agiculture, forestry, horticulture and fisheries

Emissions from agriculture, forests, horticulture and fisheries were 15.7 million tonnes CO_2e in 2019. Emissions are expected to increase to 16.7 million tonnes CO_2e in 2025, after which they will decrease to 15.1 million tonnes CO_2e and 14.5 million tonnes CO_2e in 2030 and 2035, respectively, corresponding to a fall of 4% in 2030 and 8% in 2035 compared to 2019. Developments in total sector emissions distribute differently across the individual subsectors.

Thus, emissions from agricultural processes will fall from 11.3 million tonnes CO_2e in 2019 to 10.3 million tonnes CO_2e in 2030, amongst other things due to measures under the 2021 agriculture agreement such as reduction requirements for livestock digestion, more frequent slurry flushing, extensification, and set-aside measures for agricultural land, etc.

5.1.4.7 Land-use, land-use change and forestry (LULUCF)

LULUCF emissions will increase from 2.9 million tonnes CO_2e in 2019 to 4.8 million tonnes CO_2e in 2025[23], after which they will fall again to 3.7 million tonnes CO_2e in 2030. The increase up to 2025 is largely the result of forests going from contributing net removals of 2.5 million tonnes CO_2e in 2019 to net emissions of 0.3 million tonnes CO_2e in 2025. The drop in LULUCF emissions from 2025 and onwards is due mainly to set-aside and rewetting carbon-rich soils, as well as to laying out catch crops. Furthermore, emissions from forests are projected to decrease, and from 2030 and onwards forests are again expected to contribute a slight uptake.

5.1.4.8 Waste (including waste incineration)

Emissions from the waste sector were 2.9 million tonnes CO_2e in 2019. Up to 2024, emissions from the waste sector will increase to 3.3 million tonnes CO_2e, after which they will decrease to 2.3 million tonnes CO_2e in 2030 and 2.0 million tonnes CO_2e in 2035. Amongst other things, the development is due to higher emissions associated with methane leakage from biogas plants as a result of a measurement programme having prompted an upwards adjustment of the leakage rate for biogas plants (see CSO22 memorandum on assumptions 9B and sector memorandum 9B). The upwards adjusted leakage rate means higher expected biogas leakage emissions, and these are expected to increase in step with increasing biogas production up to 2030.

Furthermore, a small increase is expected in emissions from waste incineration; from 1.6 million tonnes in 2019 to 1.7 million tonnes in 2024. After this, emissions from waste incineration will fall to 0.7 million tonnes in 2030 as waste incineration capacity is reduced to match smaller Danish waste volumes as a consequence of the 2020 agreement on a climate-neutral waste sector, for example. Increased separation also means that the fossil share in Danish waste volumes will be reduced (see CSO22 memorandum on assumptions 9A and sector memorandum 9A).

5.1.4.9 Uncertainties

As mentioned in chapter 1, it is important to consider the uncertainties associated with the projection when looking at the results presented in CSO22. This applies to the general uncertainty that will always be there when projecting greenhouse gas emissions, as well as the specific uncertainty linked to both derived effects of the Covid-19 pandemic and derived effects of developments in Ukraine.

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[23] However, LULUCF emissions are only 2.4 million tonnes in 2021, amongst other things because 2021 was a relatively cold year, which increases removals by mineral soils.

General uncertainty

The general uncertainty in projections is linked to difficulties projecting the developments in activity in society in general as well as in businesses with considerable greenhouse gas emissions (e.g. cement production and agricultural production).

Another source of general 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 and the technology-neutral tendering procedure for negative emissions (see CSO22 memorandum on assumptions 7E).

Finally, there is general uncertainty associated with the projection's assumptions, including assumptions about economic growth, price developments for resource inputs and technological advances. These factors will also be affected by the Covid-19 pandemic and developments in Ukraine.

The Covid-19 pandemic and developments in Ukraine

There continues to be considerable uncertainty about the potential, permanent consequences of the Covid-19 pandemic, including whether any unforeseen structural or behavioural changes will occur in the long term. Note, in this connection, that 2020 is the most recent statistical year in CSO22 but that, in many cases, the underlying projection is based on 2019, which is assessed to be a more fitting and true projection basis. As CSO22 also reports actual observed emissions for 2020, in many cases, this means that figures and tables show a 'dip' in 2020.

The developments in Ukraine have had significant derived effects on a number of international markets, not least the energy markets. The assumptions behind CSO22 were determined at the end of 2021, and the significant trends in energy prices seen in the first quarter of 2022 are therefore not reflected in the CSO22 results[24].21 The same applies to the government's proposal for a greener and more secure Denmark, *Denmark can do more*, and the green tax reform proposal. These elements cannot be included until in CSO23.

Sensitivity analyses

The following sector chapters include examples of important uncertainties and, in some cases, sensitivity analyses for the relevant sectors. The underlying sector memoranda (in Danish) provide further in-depth descriptions of these. Cross-cutting

[24] However, energy prices had already increased considerably towards the end of 2021 and these increases are reflected in CSO22 fuel price assumptions, see CSO22 memorandum on assumptions 3A.

sensitivity analyses on fossil fuel prices and the CO_2 allowance price has been published in a separate memorandum (in Danish).

5.1.4.10 Progress towards Denmark's non-ETS target for 2021-2030 and other obligations in the EU as of 1 January 2022 cf. CSO22

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 non-ETS sectors. The non-ETS sectors primarily comprise transport, agriculture, non-energy-intensive industries, waste/wastewater, small district heating and CHP plants, and households;
b) provide positive LULUCF climate accounts of emissions and removals by forests, cropland, grassland and wetlands according to specified criteria;
c) meet a number of obligations for the use of renewable energy and energyefficiency improvements.

This chapter contains a status of progress with regard to when these obligations will be met under CSO22[25]. The conclusion in CSO22 is that Denmark will be able to live up to the relevant EU target for climate and energy.

The European Commission has presented the “Fit for 55” package, which involves tightening a number of targets in EU climate and energy legislation. As the proposals from the Commission were still under negotiation within the EU when the CSO22 was elaborated, the CSO22 has not taken into account a specific assessment of the status for these potentially significantly tighter targets. CSO22 shows the status for the targets and commitments as of 1 January 2022 cf. CSO22 is a *frozen-policy by 1 January 2022* projection.

Status of progress regarding climate commitments: Non-ETS emissions and LULUCF

Table 5.4 describes Denmark's EU commitments regarding non-ETS emissions and LULUCF emissions and takes stock of how these commitments could be met as stated in the CSO22 projection report.

Figure 5.8 illustrates the development in non-ETS emissions and status of progress with regard to reduction obligations. As can be seen, in the period 2021 to 2023, non-ETS emissions are expected to be lower than the emission allocations by virtue of the current reduction trajectory. On the other hand, from 2024 to 2030, non-ETS emissions are expected to be higher.

Surplus emission allocations in individual years can be transferred to later years, and, overall, this means there will be an expected cumulative emissions gap of 5.9 million

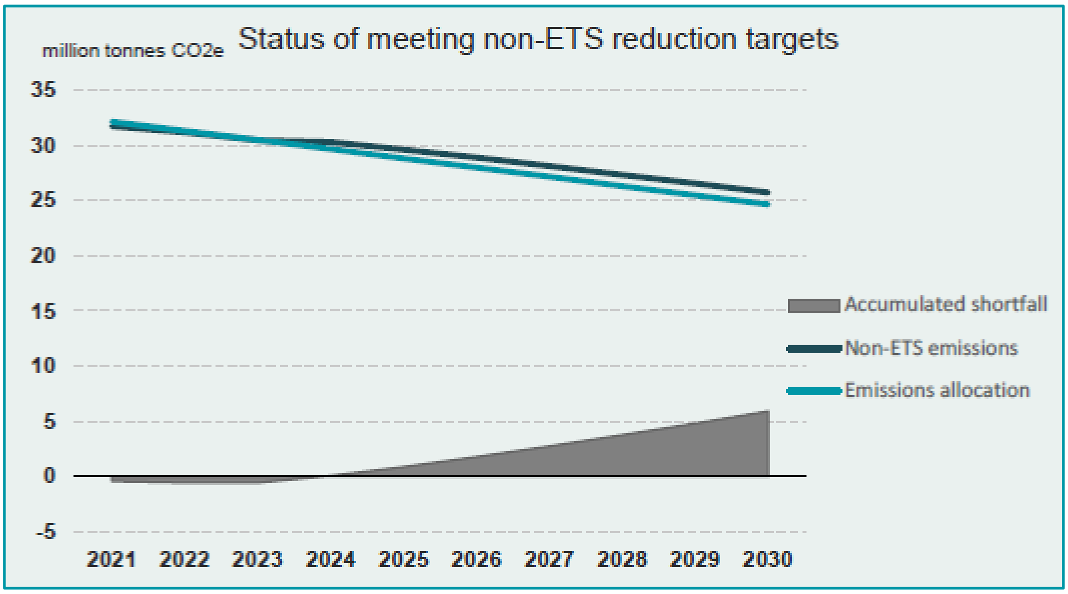
[25] See sector memoranda 11A and 11B for a more detailed description (https://ens.dk/service/fremskrivninger-analyser-modeller/klimastatus-og-fremskrivning-2023 - under “Klimastatus og –fremskrivning 2022” – only available in Danish).

tonnes CO2e in 2030. This shortfall can be offset by implementing further climate measures or by using part of the accumulated LULUCF credits and/or EU ETS allowances.

TABLE 5.4: DENMARK'S PROGRESS TOWARDS MEETING ITS EU COMMITMENTS WITH REGARD TO NON-ETS AND LULUCF EMISSIONS

Indicator	Obligation	Expected status	Primary uncertainty
Reduction of non-ETS emissions	39% reduction in 2030 compared to 2005. The reduction has to follow a given reduction trajectory.	A cumulative gap of 5.9 million tonnes CO_2e is expected in the period 2021-2030. The commitment can be met without new initiatives, if it is decided to make use of LULUCF credits and/or ETS allowances.	Uncertainty relates in particular to the projection of livestock populations in agriculture and emissions from transport, as well as the share of biogas in mains gas. There is a high degree of uncertainty connected with estimating emissions from landfills and biogas plants.
LULUCF credits	The LULUCF sector must deliver positive climate accounts calculated according to specific calculation rules (the no-debit rules)	Met. Cumulative LULUCF credits will correspond to around 29 million tonnes CO_2e in 2030.	There is large uncertainty about estimates of future emissions and removals by forest land older than 30 years, as well as about emission factors for organic agricultural soils and removals by mineral soils in agriculture.

FIGURE 5.8: STATUS OF PROGRESS TOWARDS NON-ETS REDUCTION TARGETS, 2021-30



Status of progress for renewable energy and energy efficiency

Table 5.5 describes Denmark's EU obligations with regard to renewable energy and energy efficiency and gives a status report on the prospect of these obligations beingmet under CSO22.

TABLE 5.5: 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. The renewables share is expected to be 64% in 2030. This clearly exceeds the 55% that was assessed as "sufficiently ambitious" by the European Commission in connection with NECP reporting (2020). The implementation track also 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. RES-T is expected to reach 41% in 2030.	Degree of electrification and RES-E
Advanced biofuels in transport	At least 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 impacts 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. RES-H&C is expected to exceed 60% from 2021, and an annual rate of increase of more than 1.1 percentage points is expected in most years up to 2030.	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.")[42]	See the analysis that is the basis for this expectation

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

Figure 5.9 illustrates the trend in renewables shares.

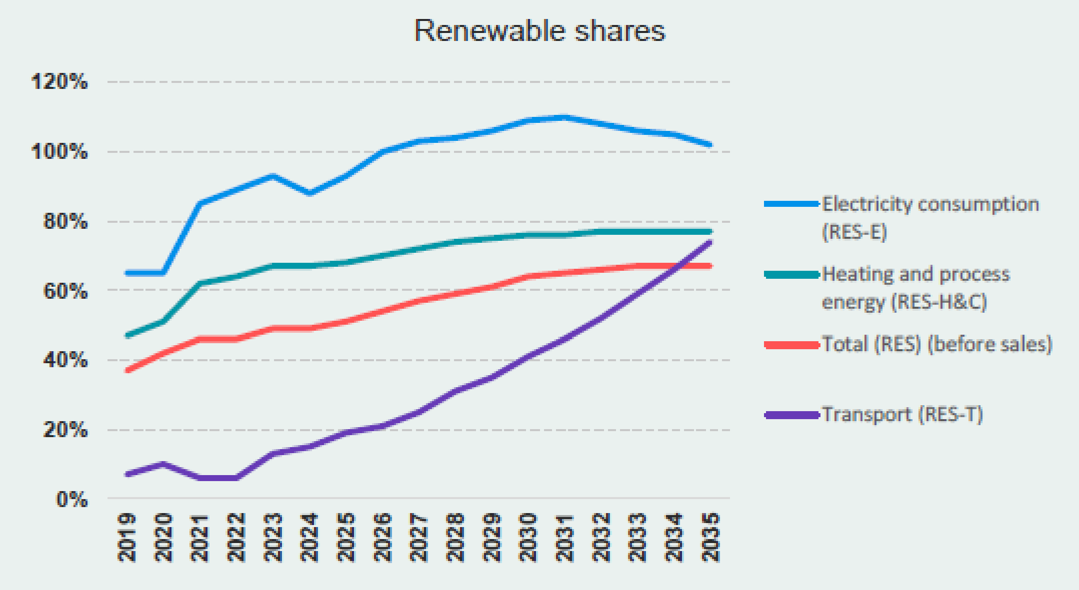
The total share of renewables (RES) is expected to increase from 42% in 2020 to 64% in 2030. This does not include any statistical transfers between Denmark and other EU Member States. After statistical transfers, the total Danish renewables share was 32% in 2020.

The renewables share in electricity consumption (RES-E) is expected to increase from 65% in 2020 to 109% in 2030 and to peak at 110% in 2031. After this, increasing electricity consumption is expected to exceed the deployment of renewable energy in electricity supply such that the renewables share will drop to 102% up to 2035. Contributions from the energy islands are not included in the above, but are dealt with in a partial alternative calculation, see the section below about uncertainty. Similarly, neither does the above include any increase in electricity consumption, e.g. for PtX plant.

The renewables share in heating and process energy (RES-H&C) is expected to increase from 51% in 2020 to 76% in 2030, which will be due in particular to an increasing renewables share in mains gas 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 9.6% in 2020 to 41% 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 5.9: 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. Total RES has been calculated before statistical transfers between Denmark and other EU Member States. After statistical transfers, RES was 32% in 2020.

Uncertainty

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. A partial alternative calculation shows that commissioning the energy islands will increase the renewables share in electricity consumption (RES-E) to 123% in 2030 and further to 138% in 2035 (with unchanged electricity consumption).

Finally, as noted above, 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. The European Commission has subsequently presented its “Fit for 55” package, which involves proposals for tightening the EU's climate and energy legislation. Amongst other things, the proposals entail a tightening of Denmark's climate and energy commitments in the EU. As the proposals from the European Commission were still under negotiation within the EU when CSO22 was elaborated, CSO22 does not assess the status of progress with regard to meeting these significantly tighter targets. However, with the tightening of the above targets for non-ETS and LULUCF, Denmark cannot necessarily be expected to meet these significantly tighter targets with policies and measures adopted until 1 January 2022 – the so-called cut-off date for policies and measures included in CSO22.

5.2 TOTAL EFFECTS OF POLICIES AND MEASURES IMPLEMENTED OR ADOPTED - SINCE THE AGREEMENT ON A NEW DANISH CLIMATE ACT IN DECEMBER 2019

In accordance with the Danish Climate Act, and after the annual agreements on the Finance Act, the Minister for Climate, Energy and Utilities prepares a statement to the Danish parliament with a description of the effects of the government's climate policies and measures.

As the 2022 statement, published in May 2023, was published shortly after finalisation of the draft *Climate Status and Outlook 2023 (CSO23),* the statement included the updated assessment of the reduction shortfalls in achieving the domestic tagets for 2025 and 2030 from the draft CSO23.

Table 5.8 contains the information on the effects policies and measures implemented or adopted since the agreement on a new Danish Climate Act in December 2019, as well as the preliminary updated reduction shortfalls, presented in the statement.

The draft CSO23 projection shows that the climate policies and measures implement-ted or adopted are expected to reduce Denmark’s greenhouse gas emissions with approximately 63 per cent in 2030 compared to 1990. The shortfall for meeting the target of 70 per cent reduction in 2030 equals approximately 5.4 million tonnes of CO_2e, cf. Table 5.8.

An estimate of the shortfall for meeting the target of 50-54 per cent reduction in 2025 was also included the above mentioned statement to the Danish parliament. However, this estimate was made before publication of the result of the first tender of the Carbon Capture, Storage and Utilization (CCUS) subsidy scheme. When this result is taken into account, the shortfall in 2025 is estimated to approximately 0.5-3.7 million tonnes of CO_2e. This is also shown in Table 5.8.

TABLE 5.8 ESTIMATED GREENHOUSE GAS EMISSION REDUCTION EFFECTS OF AGREEMENTS WITH A REDUCTION EFFECT SINCE THE AGREEMENT ON THE DANISH CLIMATE ACT (DECEMBER 2019) AND THE REDUCTION SHORTFALLS IN ACHIEVING THE DOMESTIC REDUCTION TARGETS FOR 2025 AND 2030 IN THE DANISH CLIMATE ACT, IN MILLION TONNES OF CO_2 EQUIVALENTS.

Agreements with a reduction effect since the Danish Climate Act							
The agreements and the annual WEM projections DECO: Denmark's Energy and Climate Outlook CSO : Climate Status and Outlook	**Total greenhouse gas emissions** *(Million tonnes CO_2e)*			**Reduction from 1990** *(pct.)*		**Reduction shortfalls in achieving the domestic tagets for 2025 and 2030** *(Million tonnes CO_2e)*	
	1990	**2025**	**2030**	**2025**	**2030**	**2025**	**2030**
The 2019 projection (DECO19, WEM scenario)	**75.2**	**43.5**	**41.5**	**42.2**	**44.8**	**5.9-8.9**	**18.9**
The decision on phasing out coal on the power plant Fynsværket		-0.5	-0,5				
The agreement on the Finance Act for 2020 (2 December 2019)			-0.5				
Other changes from DECO19 to DECO20 i.a. data correction		+2.6	+2.6				
The 2020 projection (DECO20, WEM scenario)	**77.2**	**45.7**	**43.1**	**41**	**44**	**7-10.1**	**19.9**
The green housing agreement 2020 (19 May 2020)		*-0.03*	*-0.05*				
The climate plan for a green waste sector and circular economy (16 June 2020)		*-0.1*	*-0.7*				
The climate agreement for energy and industry etc. 2020 (22 June 2020)		*-1.3*	*-2.7*				
The agreement on the future of oil and gas extraction in the North Sea (3 December 2020)		*0*	*-0.01*				
The agreement on green transformation of road transport (excluding kilometer-based road tax for trucks) (December 4, 2020)		*-1*	*-1.9*				
The agreement on the Finance Act for 2021 and the agreement on stimuli and green recovery (6 December 2020)		*-0.2*	*-0.2*				
The agreement on a green tax reform (8 December 2020)		*-0.5*	*-0.5*				
Other changes from DECO20 to CSO21		*-1.8*	*-2.0*				
The 2021 projection (CSO21, WEM scenario)	**77.4**	**40.8**	**35.0**	**47**	**55**	**2.1-5.2**	**11.8**
The agreement on the green transformation of agriculture (October 4, 2021)		*-1.2*	*-1.9*				
The sub-agreement on investments in a continuously greener Denmark 2022 (December 4, 2021) and the agreement on the Finance Act for 2022 (December 6, 2021)		*-0.5*	*-0.51*				
Other changes from CSO21 to CSO22		*2.3*	*0.9*				
The 2022 projection (CSO22, WEM scenario)	**78.0**	**41.4**	**33.6**	**47**	**57**	**2.4-5.5**	**10.1**
The agreement on green tax reform for industry etc. (June 24, 2022)		*-1.3*	*-4.3*				
The agreement on kilometer-based road tax for trucks (24 June 2022) and the agreement on kilometer-based road tax for trucks (29 March 2023)		*-0.3*	*-0.4*				
The climate agreement on green electricity and heat 2022 (25 June 2022)		*-0.4*	*-0.4*				
Other changes from CSO22 to the draft CSO23		*+0.3*	*0.5*				
The 2023 projection (CSO23, WEM scenario, draft)	**78.4**	**39.7**	**28.9**	**49.3**	**63.1**	**0.5-3.7***	**5.4**

Note: *This includes the result of the first tender under the CCUS subsidy scheme.

Sources: *Climate programme 2022* (September 2022; https://kefm.dk/Media/638013322993950605/1042399_klimaprogram-a.pdf), *Climate Status, Outlook 2023* (draft April 2023; https://ens.dk/service/fremskrivninger-analyser-modeller/klimastatus-og-fremskrivning-2023), the governments *Annual statement of climate effects 2022* (May 2023; https://www.ft.dk/samling/20222/redegoerelse/R16/index.htm) and the results from the first tender of the Carbon Capture, Storage and Utilization (CCUS) subsidy scheme (https://kefm.dk/aktuelt/nyheder/2023/maj/stort-groent-udbud-er-afgjort-milliardstort-udbud-skal-saette-fart-paa-co2-fangst-og-lagring).

5.3 PROJECTIONS WITH ADDITIONAL MEASURES (WAM-SCENARIOS) AND WITHOUT MEASURES (WOM-SCENARIOS)

In accordance with the reporting guidelines for National Communications, it is also possible to include information on greenhouse gas projections where the expected effects of additional policies and measures that are planned but still not implemented are included (WAM-scenarios) as well as projection scenarios without the effect of policies and measures since an elected point in time (WOM-scenarios).

With the annual update of the WEM scenario projections in accordance with the Danish Climate Act, the window of opportunity for a WAM-scenario in Denmark is often very narrow or not existing. It is not possible to elaborate a scenario with additional measures "which will have a realistic chance of being adopted" and which will not. With the former as the criteria for measures in the planning stage to be included in a "with additional measures" projection, a "with additional measures" projection scenario cannot be made until the government has decided which additional measures Denmark should include in its planning. In Denmark implementation of new measures often starts as soon as a decision on an additional measure has been taken. When a final decision has been taken and implementation has started, the measure will be included in the next annual WEM-scenario following the adoption of the measure.

A WOM-scenario without effects of policies and measures adopted since 1990 was included in Denmark's Seventh National Communication. However, the methodologies used for elaborating WOM-scenarios are under consolidation. New WOM-scenarios might be included in future reporting.

5.4 Supplementarity relating to mechanisms under Articles 6, 12 and 17 of the Kyoto Protocol

According to the Kyoto Protocol, the use of the mechanisms in Articles 6 (JI), 12 (CDM) and 17 (IET) of the Protocol must serve as a supplement to domestic action to reduce greenhouse gas emissions. This was fulfilled in the first commitment period of the Kyoto Protocol 2008-2012. The second commitment period of the Kyoto Protocol 2013-2020 entered into force on 31 December 2020. The Danish Government has not used the Kyoto Protocol mechanisms in the second commitment period and has no plan to do so either during the so-called "true-up period" from 1 June to 5 September 2023. As mentioned in Chapter 3.5, Denmark has achived its targets 2013-2020 under the EU Effort Sharing Decision for the non-ETS sectors – contributing to the EU's achievement of the joint EU target under the 2nd commitment period of the Kyoto Protocol – with existing measures. I.e. there is no need for using the Kyoto Mechanisms.

5.5 Methodology used for the presented greenhouse gas emission projections and comparisons with previous projections

The methodologies used for the presented greenhouse gas emission projections are described briefly in section 5.1.2 and Annex C2. Further information is available in English in the CSO22 projection report[26] and the related documentation report[27].

In Annex C3, a comparison of the 2022 inventory submission with the "with measures" projections of Denmark's total greenhouse gas emissions included in Denmark's first to eighth national communication (NC1-NC8) is shown. As can been

[26] https://ens.dk/en/our-services/projections-and-models/danish-climate-and-energy-outlook
[27] https://dce2.au.dk/pub/SR505.pdf

seen, no clear conclusion can be drawn from a plot of the “raw” projection data reported over the period 1995-2015. However, if the data are normalised to take into account the improvements made in inventory reporting over the same period, and if inter-annual variations in temperature and electricity trade, the latter being sensitive to inter-annual variations in precipitation in Norway and Sweden due to these countries’ hydropower based production of electricity for the Nordic electricity market, is also taken into account, relatively good correlation between the projections until 2005 in NC1 (1994) and until 2010 in NC2 (1997) and the later actual development can be seen. A closer look into the detailed level of sectors and source categories, however, reveals major differences, but outliers in both directions seem to even out each other in the total due to the relatively high number of separately projected sub-categories.

The projections for 2009-2015 in the NC3 (2003), NC4 (2005) and NC5 (2009) show significant deviations from the 2009-2015 inventory data reported in April 2022. The projections for 2012-2015 in the NC6 (2014) are close to the actual inventory data for 2012-2015. This illustrates that projected estimates for years close to the present are more certain than estimates for years more that 3 years into the future.

As a “with measures” projection elaborated at a given point in time only includes the effects of implemented and adopted policies and measures, in many cases also with an end date within the projection period, emissions are projected to increase after the expiration of such policies and measures. The development in the projections shown in Annex C3 can therefore also be seen as an illustration of the main purpose of the WEM projections: to inform governments about future greenhouse gas emissions trends if no new policies and measures are adopted and implemented.

5.6 GREENLAND

Total greenhouse gas emissions in Greenland in 1990, 1995, 2000, 2005, 2010, 2015 and 2020 are shown in Table 5.8.

TABLE 5.8 TOTAL GREENHOUSE GAS EMISSIONS (KT CO_2 EQUIVALENTS) IN 1990, 1995, 2000, 2005, 2010, 2015 AND 2020

Source: Statistics Greenland (2022).

GHG (kt CO_2 Equivalents)	1990	1995	2000	2005	2010	2015	2020
Total (without LULUCF)	652.48	561.71	697.68	679.00	713.53	557.41	575.35
Total (with LULUCF)	652.69	562.10	698.20	679.63	714.95	558.46	576.69

Greenland is likely to experience significant industrial growth over the coming years, which will impact on future emission levels. Possible sources of new emissions includes further growth in the mining industry with the establishment of new mines.

A number of exploration projects are ongoing, however the projected emissions related to these projects are subject to a significant degree of uncertainty and future scenarios have therefore not been included.

According to the latest data from Greenland Statistics the total greenhouse gas emissions with LULUCF is recorded at 576.69 ktons CO_2 equivalent the year 2020[28]. Greenland's economic council has prepared a national economic outlook which projects the 2022 GDP growth rate at 1.6%, while the expected growth rate in 2022 being at 1%.

5.7 Faroe Islands

Figure 5.11 shows a simple projections for the emissions of greenhouse gases in the Energy sector (excl. Transport) in the Faroe Islands, 2022-2035.

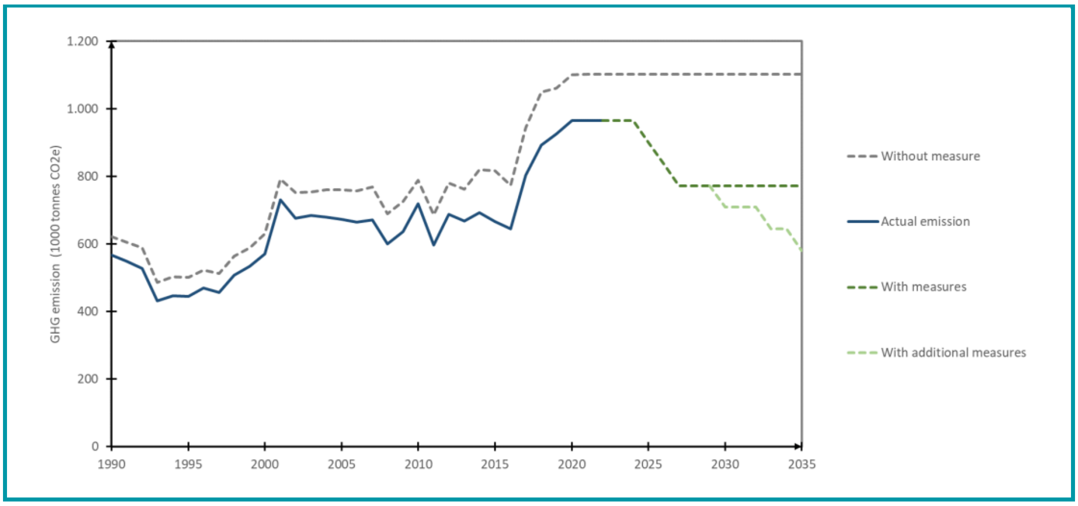
In order to make the projection diagramme the impact of the mitigations effect have been estimated for some of the most effective measures implemented, primarily hydro power and wind power plants, but also district heating and heat pumps have also been included in the estimations of the without measures graph.

The with measures graph, from 1990-2021, is based on actual emissions data (exported from the CRF). The with measures projection 2022-2035 is primariliy based on the estimated effect of the mitigations due to the installation of two new windmill parks, one in year 2025 (25 MW in Klivaløkshagi, Sandoy) and another in year 2026 (25 MW on Glyvrafjall, Eysturoy) and on the assumption that the total yearly emissions in 2022-2035 otherwise is the same as in 2021.

The additional measures graph takes into account the plan to install four windmill parks respectively in 2027, 2030, 2033 and 2035, each with 25 MW, in total 100 MW.

The projections do not compromise estimation of economic growth or other changes in relevant parameters, e.g. population or industry.

Figure 5.11 Faroe Island's Total Greenhouse Gas Emissions in kt in 1990-35. Emissions in 1990-2021 are observed. Emissions 2022-2035 are projected.



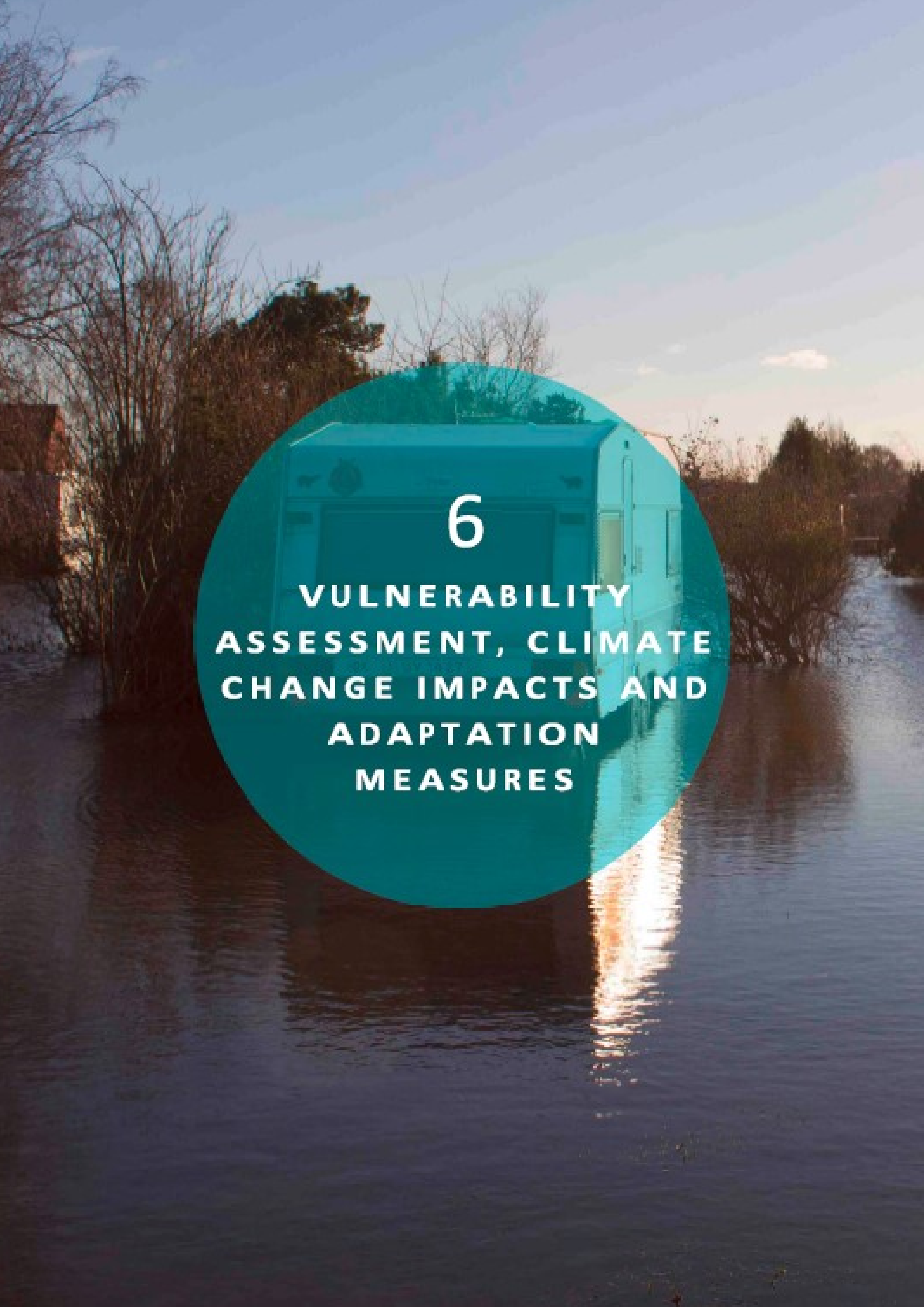
The estimated impact of measures is shown in Table 5.9.

[28] http://www.stat.gl/dialog/main.asp?lang=da&version=201702&sc=EN&subthemecode=t2&colcode=t

TABLE 5.9: RESULTS FROM SIMPLE ESTIMATIONS OF EFFECTS OF MEASURES ON THE EMISSIONS OF GREENHOUSE GASES FROM THE ENERGY SECTOR, 2025, 2030 AND 2035 IN KTCO_2.

Year	1990	1995	2000	2005	2010	2015	2020	2025	2030	2035
With measures	567	445	569	672	718	665	965	900	772	772
Without measures	622	501	629	760	788	817	1,101	1,102	1,102	1,102
With additional measures									708	580

Not included in this projection is the work to establish a Pump To Storage facility at the existing dams in Vestmanna. This will increase the yearly amount of wind energy that can benefit by approx. 60 GWh. If and when all permits are in place, the facility will be completed in 2028, and the reduction of CO_2 emission is estimated to 40 kt yearly.



6

VULNERABILITY ASSESSMENT, CLIMATE CHANGE IMPACTS AND ADAPTATION MEASURES

Contents

6 Vulnerability assessment, climate change impacts and adaptation measures

6.1 Expected impacts of climate change

6.1.1 Climate in the future

The climate is changing, and in all likelihood we will see more changes in the future. In the long term, the future climate is strongly dependent on the future emissions of greenhouse gasses and other substances that influence the climate. The development in greenhouse gas emissions is especially dependent on three factors: demographic development, the rate and spread of implementation of energy-efficient technologies, particularly in the energy and transportation sectors, and the socio-economic development in general. The changing climate with rising temperatures, changing precipitation patterns, an increase in extreme weather events and rising sea levels will have a broad impact on ecosystems and society in general.

Denmark is generally and has historically been a robust country in relation to climate-related incidents. This must, among other things, be seen in the context of geographical conditions, where, for example, Denmark, unlike several other European countries, does not have mountains or large rivers. Agricultural land is well-drained and many farmers are able to irrigate in dry periods. Moreover, the Danish population is aware of, and uses, systematic warning systems of extreme weather events and the consequences of such events.

Overall, Denmark has been able to handle the incidents that have occurred so far. This may be challenged in the longer term, however, if the necessary protective and preventive measures are not taken and/or if effects of climate change become more severe than assumed.

6.1.2 Climate trends in Denmark

6.1.2.1 The latest developments

Since the Ice Age, Denmark has had a temperate maritime climate. This climate, with wet winters and cool summers, is now changing. The latest statistics[1] from the Danish Meteorological Institute (DMI) show that the mean temperature is now around 8.7°C (1991-2020), an increase of about 1.5°C since the end of the 19th

[1] https://www.dmi.dk/vejrarkiv/normaler-danmark/

century. This increase is about double the increase of the global mean temperature for the same period. Today the average winter temperature in Denmark is around 2.0ºC, and the average summer temperature is around 16.1ºC.

The annual precipitation measured in Denmark is now around 759.1 mm (1991-2020). Precipitation has increased by about 15% – or 100 mm – since the first recordings were begun in 1874. Precipitation is highest in the western and southern part of Jutland, with almost 1000 mm annual precipitation, and least precipitation is measured in the eastern parts of Denmark (Zealand and the other eastern islands), where about 600 mm of precipitation is recorded annually. In general wet areas experience the greatest increase in precipitation. Correspondingly, precipitation has increased most in western Jutland, by about 20% in the past 85 years.

The Danish climate has become more maritime in the 20th century. On average, cloud cover has increased by about 5 percent since observations began in 1874. With the clouds, more precipitation has come, there are fewer days with snow cover, and temperatures are higher. The direct consequences, such as decreased need for ice-breaking, shorter winter sport season, earlier pollen season, longer growing season and longer swimming season, is already felt by the Danish population.

The sea level around Denmark has risen over the past 115 years. The maximum observed rise is in southern Denmark, where the water level is rising by about 1.5 mm per year. In the northern-most part of Denmark uplift of the land after the Ice Age is roughly in line with the rise in sea level.

6.1.2.2 Projected climate changes in Denmark

DMI has estimated the expected climate change in Denmark based on the latest Danish and European scenario projections focusing on climate change towards the end of this century. The assessment of future climate change is based on the scenarios used by the Intergovernmental Panel on Climate Change (IPCC).

Climate simulations and understanding of associated uncertainties are constantly being improved. DMI here presents the latest results based on IPCC and the Climate Atlas (www.klimaatlas.dk) hosted at DMI where observations and climate simulations are being combined to provide detailed future projections of expected changes across Denmark. The projections of future climate change are based on an ensemble of climate models, making the estimates more robust and allowing assessments of uncertainties. For specific planning, assessment and risk analysis aimed at climate adaptation, it is important to consider the full range estimate as indicated by the uncertainty interval in the Climate Atlas, instead of simply considering the best estimate.

A key challenge in Denmark, with low elevation and long coastlines, is the ongoing and future sea level rise. Sea level rise is a consequences of melting of snow and ice on land and ocean warming. Aside from being dependent on the level of greenhouse gas emissions, the future amount of melting ice is associated with large uncertainties. Global sea level change, corrected for regional effects and land rise, is presented along with specific statistics on storm surges to illustrate together with scenarios of future sea level rise in the Climate Atlas.

Below, an overview of projected changes for the climate in Denmark is presented. Changes are in relation to the reference period 1981-2010, unless otherwise stated.

- Temperature: The future projection is highly dependent on emissions scenario. By the end of the century (2071-2100) the expected temperature increase in Denmark, relative to 1981-2010 is about 1.8 °C and 1.9 °C for the summer and winter seasons for the RCP4.5 scenario. For the RCP8.5 scenario the expected temperature increase is 3.5 °C for the summer season and 3.6 °C for the winter season.

- Precipitation: Global warming increases the water content in the atmosphere, leading to increased global precipitation. For Denmark, this is also the case. Towards 2100 there is a tendency towards increased precipitation with the largest increase in the winter season. Summer precipitation is expected to increase in Northern Scandinavia and decrease in Central, Eastern and Southern Europe, and Denmark will likely be on the border between these two zones, making predictions of future overall summer precipitation in Denmark rather uncertain. But even with an unchanged total precipitation amount, the summer precipitation will be characterized by longer dry spells and more heavy precipitation events, e.g. an increased risk of cloud burst events (see Table 6.1).

- Wind: Mean wind is not expected to change significantly towards the end of the century in Denmark, but the dominant wind direction is more likely to be from west.

- Sea level: The sea level is currently rising along all Danish coastlines, except in the northernmost Jutland. Further sea-level rise is expected in the future due to climate change. For the period 2071-2100 relative to 1981-2010, the sea level around Denmark is expected to increase by 0.27 (-0.05 - 0.6) m in east Jutland and 0.39 (0.07-0.72) m in southwestern Jutland for the RCP4.5 and 0.44 (0-0.88) m in the northern Jutland and 0.6 (0.17-1.05) m in southwestern Jutland for the high, RCP8.5 scenario. DMI assesses a small risk in the order of 5% for sea level rise in 2100 to be above 2.4 m, due to potential risks of large mass loss from the Antarctic Ice Sheet. In the northern part of Denmark, the sea-level rise will, also in the coming years, be partly compensated by land uplift.

- Extreme events and other climate parameters: Warming, driven by an increased greenhouse effect, generally results in increased frequency, intensity and duration of extreme weather events. Denmark will experience an increase in the frequency and duration of heat waves. Summers will be characterised by longer dry spells and an increase in heavy precipitation events. The occurrence of frost days with sub-zero temperatures will decrease dramatically, while the length of the growing season will similarly increase. The increase in sea level will give rise to increased storm-surge height. Sea level rise will increase the storm-surge height by 0.3 to 0.6 meters towards 2100 depending on location and scenario. This means that a current 20-year event is expected to occur once every year or every second year across Denmark. In Vadehavet outside Esbjerg on the west coast of Jutland, a storm surge event of 4.04 m, which today has a 100-year recurrence interval, is expected to have a recurrence interval of one or two years towards the end of the century. For Copenhagen a 20-year storm-surge event of 1.5 m today is expected to occur more frequent than two times per year if the mean sea level increases by 0.5 m.

TABLE 6.1 FUTURE CHANGES IN PRECIPITATION FOR DENMARK 2081-2100 RELATIVE TO 1986-2005

Precicipation change [%]	RCP4.5	RCP8.5
Annual	7 (0-20)	14 (2-25)
Winter	12 (3-27)	24 (10-41)
Spring	12 (-2-25)	20 (6-37)
Summer	5 (-12-30)	-2 (-17-27)
Autumn	4 (-6-16)	10 (-3-27)

6.1.3 Mapping the impacts of climate change in Denmark

Projections of climate change in Denmark are continuously updated, most recently ultimo 2022, when the Danish Meteorological Institute (DMI) updated its Climate Atlas. The Climate Atlas presents data on the expected future climate following several emission scenarios, calculated in high geographical detail over Denmark.

A review of the significance of climate change up to 2050 for individual sectors and industries shows that Danish society will experience both positive and negative impacts.

There are some positive impacts related to higher temperature, including a longer growing season, increased productivity within the forestry and agricultural sectors and a longer tourist season. Milder winters will moreover reduce energy consumption and construction costs, as well as the costs of winter-weather preparedness.

The negative impacts of climate change relate primarily to an increased risk of flooding from more frequent extreme rainfall (especially during the summer) and persistent rainfall (especially during winter). Coastal flooding risk is increased due to elevated sea level, which also increases the severity of storm surges. Increasing temperature and changed precipitation patterns, result in increased risk of droughts, heat waves, and unprecedented extreme temperatures. Together, these factors can all have adverse consequences for livelihoods, health, the environment, the economy, property, infrastructure and vital societal functions, depending on the level of adaptation to climate change.

Rescue and fire services' response to climate-related incidents have been registered in the Danish Emergency Management Agency's system (ODIN) since 2007. These data can contribute to potential future analyses regarding the frequency and nature of climate incidents seen from a preparedness perspective.

In the following sections, the impacts on individual sectors and industries are further described.

6.1.3.1 Construction and housing

Climate change will have both positive and negative impacts on buildings.

- More extreme rainfall events will lead to more flooding:
  The most important challenge will probably come from increased precipitation. Heavy rainfall may lead to more basements being flooded by intruding rainwater and sewage water. Houses and buildings with entrances at

terrain level may also be exposed. A gradually rising sea level and more frequent storm-surge events, in combination with heavy precipitation, may put low-lying and coastal urban areas at risk, see the section on water. Changes in ground water level may affect a building's foundation (e.g. moisture damage) and stability due to fluctuations in moisture and compaction.
In order to counteract the effects of increased precipitation, measures such as changes to terrain surrounding a given building or perimeter drains, can be implemented. These fall under the responsibility of the building owner.

- Greater air humidity and less frequent sub-zero temperatures are significant for the wear on buildings:
  The lifespan of a building part is (among other things) governed by the twin influences of damage from water, which may cause rot and oxidation, and damage from freezing, where the expansion of water as a result of phaseshift causes mechanical damage. Milder and more humid winters may reduce the life span of individual building components. This can be mitigated through greater focus on management and maintenance. However, less frequent sub-zero temperatures may help reduce the wear and tear on buildings.

- More powerful storms and changes in snowfall may damage buildings:
  Powerful storms may pose a risk of damage to buildings, including damage to roof constructions from storms and greater snow load. There may be a need for increased information, maintenance and in some situations, reinforcement of buildings. Data on storm damage from insurance statistics[2] show that from 2006 to 2021 in Denmark, storm damage on buildings and property was significantly higher in 2013; up to six times higher than in 2014.

- Less demand for heating during winter, but risk of poorer indoor climate:
  Milder winters reduce demand for heating. However, more humid winters may result in a more humid indoor climate providing better conditions for house dust mites and increasing the risk of mould, see the section on human health. A more humid climate may also result in greater demand for maintenance of building envelopes. However, due to greater fluctuations in temperature the need for heating in winter may at times be high. Heating will need to be dimensioned for cold periods rather than the average; the responsibility of which is falls on the building owner.

- Greater risk of overheating:
  Large window sections facing south, and longer periods with warm weather in the summertime may pose a risk of overheating in buildings, which will have to be addressed when designing highly insulated buildings. The problem has already been addressed in the building regulations requirements on maximum indoor temperature. Furthermore, a voluntary datafile containing 2 prognoi ses for weather data based on the IEA EBC Annex 80 Resillient Cooling of Buildings CORDEX project has been made publicly available for use in construction planning. The building owner may have to find ways to

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[2] F&P Stormskader, Udviklingen i antallet og erstatninger for stormskader.

reduce overheating, e.g. through external shading systems or mechanical cooling.

- Changes in productivity in the construction industry:
  A more humid climate, in particular during winter, may mean longer drying times and may pose the risk of damage to building materials, all of which may affect parts of the construction industry. However, the industry can prepare for this by using and further developing methods and materials that reduce the significance of the climate during the construction phase. Climate change could also result in fewer bad-weather days due to milder winters (fewer days with sub-zero temperatures). This will help enhance productivity in the industry.

6.1.3.2 Coasts and ports

Based on future projections of climate change, key consequences for Danish coasts and ports will include:

- Sea level rise increases erosion and coastal recession:
  Sea level rise, resulting in higher storm-surge water levels and more wave impact, will increase erosion and coastal recession. Coastal erosion will be most pronounced for the west coast of Jutland, however other Danish coasts will also suffer coastal erosion in the future. The loss of land due to permanent flooding is estimated at 878 km^2 until 2120, which corresponds to 2.04 % of the land size of Denmark.

- More frequent flooding of low-lying coastal areas:
  Low-lying land not protected by dykes, e.g. in the Limfjord, will be exposed to more frequent flooding. At the same time, the risk of dyke breaching due to higher water levels and wave impact will increase. Urban developments at the mouth of rivers, e.g. in fjords, may come under double pressure: from rising sea levels as well as from increased precipitation and run-off from the catchment area. Overall, the flood risk in coastal areas will increase significantly due to higher and more frequent storm-surge water levels.

- More powerful storm surges will make activity at ports more difficult:
  With more powerful storm surges, harbour areas, e.g. in Esbjerg, will be flooded more frequently, thus interrupting port activities and posing a greater risk of damage to buildings. The same applies to ferry landings. More intense storms will also pose a greater risk of ships breaking their moorings and causing damage to cranes and other equipment at the port.

  The port protection that protects the basin itself will be affected to an increasing extent by the wave impact, and protection will be less effective during high storm surges. Costs for repair and maintenance of port infrastructure will increase in the future, especially at ports located at the west coast of Jutland. In ports where fairways and/or port basins are dredged, the need for dredging will often grow, as higher waves leads to increased sanding.

6.1.3.3 Transport

The key climate-related consequences for different parts of the transport sector in Denmark are described in the sections below.

6.1.3.3.1 <u>Road network</u>

- Higher temperatures reduce construction costs:
  Higher temperatures during winter will mean that periods with heavy frost will be shorter or will all together disappear. This will provide the opportunity to reduce frost protection and the thickness of the bottom-most layers of roadbeds, thus reducing needs for raw materials.

- Higher temperatures reduce the need for winter-weather preparedness and salt application:
  Higher temperatures allow for possible savings on winter-weather preparedness and road salt; this may lead to both financial and environmental benefits. Data on consumption of road salt for the state road network[3], shows a reduction in consumption over the last nine years cf.Table 6.2. The trend indicates milder winters.

TABLE 6.2 CONSUMPTION OF ROAD SALT FOR THE STATE ROAD NETWORK 2012-2021

Year	Consumption of road salt for the state road network	
	Tons total	Kg/m^2
2021	39.322	1,00
2020	15.381	0,39
2019	27.328	0,66
2018	52.412	1,26
2017	49.519	1,20
2016	51.113	1,27
2015	42.833	1,10
2014	41.392	1,06
2013	67.352	1,67
2012	61.352	1,53

- Temperature increases can have both positive and negative impacts on the roadbed:
  Temperature fluctuations around 0 degrees, causing many frost-thaw-cycles, are destructive to the surface of asphalt pavements. Water that penetrates into the small cracks that appear over the years, expands at sub-zero temperatures, causing further cracking. Warmer winters are expected as a consequence of climate change, leading to fewer frost-thaw cycles and reduced cracking.

  On the other hand, higher temperatures on summer days may result in asphalt softening, increasing risk of rutting and requiring further maintenance. Furthermore, an increase in rut-formation may lead to higher risks of hydroplaning. This will further increase in risk due to a higher frequency of heavy or extreme rainfall occurrences as a result of climate change.

[3] Consumption of road salt for state road network

For the underlying gravel and sand layers of the roadbed, the increases in temperature will have a limited but positive effect on the life span.

- Increasing water volume challenges the road network:
  Increased precipitation and rising groundwater level, leading to more flooding events, may negatively affect traffic safety and passability. This will place greater demand on road drainage systems and monitoring of the road network. Flooding not only reduces the carrying capacity of roads, it also shortens life span. Similarly, increased precipitation may cause road banks to become unstable, thereby leading to the risk of landslides.

- Increasing water volume will challenge bridge design:
  For bridges and tunnels, there is a greater risk of reduced carrying capacity of foundations, supporting walls and sheet piles due to higher groundwater levels, regardless of whether this is due to higher sea level or increased rainfall. Particularly construction founded on sand may be affected.

- More frequent storms will pose a challenge for road sign portals:
  More powerful storms will expose road sign portals to greater force.

6.1.3.3.2 Fixed links

- Rising sea level and precipitation may affect Danish fixed links:
  For the fixed links cross the Great Belt and the Sound, an increase in precipitation will enhance pumping requirements from drainage systems in tunnels, railways and roads on the fixed links. Rising sea levels in combination with more powerful storms may enhance the risk of flooding of tunnels, railways and roads on the fixed links and lead to longer periods of interruption. More powerful storms may also mean that bridges will have to more frequently, be shut down temporarily. Current work on protecting the Øresund Bridge will be completed in 2025, with projects aiming to protect the tunnel part of the bridge to withstand a 10,000-year storm surge projected up to 2050[4].

6.1.3.3.3 Rail network

- More water will enhance the risk of flooding and landslides:
  Flooding events and rises in groundwater level will enhance the risk of landslides and embankment failures. A rise in the mean sea level could pose a problem for rail services where embankment and slope drainage systems divert the water into nearby watercourses that are affected by the rise in sea level. Insufficient drainage can thus result in rail sections, tunnels and electrical equipment being flooded or otherwise damaged.

- More powerful storms could lead to interrupted transportation:
  On electrified railway lines, powerful storms and greater wind speeds may lead to greater frequency of breakdowns of overhead wires and to more

[4] Read more on this adaptation case study here.

incidents with trees falling across the tracks. This may result in interrupted train services with consequences for traffic and for the economy.

- Higher temperature may disrupt timetables:
  Higher temperature can affect the track and may introduce a need for adapting maintenance standards. Timetables and transport capacity may be challenged.

6.1.3.4 Water

Based on climate projections for the future, the key consequences for the water sector are described in the sections below.

6.1.3.4.1 Wastewater and flooding

- Increased precipitation will put further pressure on the sewage system:
  Increased frequency of extreme precipitation can result in greater risk of overflow events and subsequent flooding of terrain, buildings and basements, which in turn, poses a risk to human health due to human contact with non-treated wastewater. See more on health related impacts of climate change in section 6.1.3.11. More overflow events will also lead to greater strain from pollution on vulnerable aquatic areas. Furthermore, increases in sea level will deteriorate the drainage capacity of drains close to the coast, resulting in reduced water flow in the sewerage system, potentially leading to local flooding events.

6.1.3.4.2 Groundwater and water supply

- More precipitation means higher annual groundwater recharge:
  The increase in annual precipitation will increase groundwater recharge, in turn increasing the groundwater resource available for water recovery. However, seasonal variations mean that this will primarily be in the winter and there are regional variations between east and west Denmark. Increased groundwater recharge in the upper strata could lead to more local flooding problems, which was observed in February 2020 and 2022. A need for alternative drainage systems may occur as a result of increased seepage to groundwater bodies, as mentioned in earlier sections.

- Long periods of drought may bring water supply under pressure:
  Ever longer periods of drought are expected in spring and summer, which in addition to increased evaporation and resulting reduced infiltration, will put more pressure on the water supply, especially in areas that are already affected by groundwater extraction for larger cities and irrigation. Therefore, in exposed areas it is likely that groundwater extraction will be adjusted to maintain water flow in watercourses and consumers may observe increased competition for the resource.

- Higher temperatures increase bacterial content in drinking water:
  Higher temperatures may mean a slightly higher content of bacteria and

amoeba in drinking water compared with current levels. Today, some waterworks find it challenging to comply with the recommended requirements for the temperature of drinking water; max. 12°C at the tap.

- Higher sea levels may add saltwater to the groundwater:
  Higher sea levels will move the current freshwater boundaries further inland. Locally, this could cause problems with saltwater infiltration into coastal extraction wells and create a need for new wells. The problem is especially serious for smaller Danish islands.

6.1.3.5 Agriculture

The most important effects of climate change for agriculture in Denmark are as follows:

- Longer growing season as a result of changing temperature and rainfall patterns:
  Plant production will primarily be affected by the increased length of the growing season, changing temperature and rainfall patterns. Crop production will also be affected by the interaction between soil quality, water supply and plant protection.

- Longer growing seasons will be favourable for some crops and might change the cropping pattern:
  Crops such as grass, sugar beets and maize will benefit from increases in temperature. Maize and wine grapes are the primary crops that have gained popularity due to climate change, although the area with wine grapes is still insignificant. The effect of longer growing seasons will vary depending on rainfall and temperature during the growing season.

- More CO_2 impacts plant growth:
  Increases to atmospheric CO_2 can increase plant growth for the majority of Danish species. This can lead to higher crops yields, but also increased weed growth. Higher CO_2 concentration will reduce evaporation from plants and thus lower the need for watering, if rainfall patterns are unchanged.

- The main issues for soil quality in Denmark relate to soil organic matter, soil compaction and erosion:
  Generally, soil organic matter content has been decreasing in clay soils and stagnating on sandy soils over the past four decades. Rising temperatures and extended growing season will increase the carbon influx to the soil – this will be counteracted by the increase in carbon turnover, but the overall effects are unknown. An overall carbon loss on Danish soils will lead to poorer soil structure and stability and higher risk of erosion and compaction.
  The risk of soil compaction by heavy machinery will increase with increasing rainfall during the winter period. Soil compaction can lead to poorer drainage, increased nitrous oxide emissions, inhibited root and thereby plant development, erosion and difficulties establishing crops.

  Erosion will increase as a result of increased precipitation and increased frequency of extreme rainfall events. Soil compaction and loss of soil organic matter may also increase erosion.

- Climate change is expected to lead to increasing problems with plant diseases, pests and weeds:
  Higher temperatures could result in more plant diseases and pests. It is very hard to give a clear-cut description of the developments in plant diseases, but the overall assessment is that higher temperatures in the future will be more favourable for a number of plant diseases and pests, which therefore will become more widespread. This will potentially increase the need for use of pesticides, in lack of viable alternatives.

  Some weed species will benefit from a warmer climate, e.g. cockspur and green bristle grass, both of which are relatively new species in Denmark. These species are considered some of the most aggressive globally, but so far they have not been a serious problem in Denmark.

- Higher overall yields for agriculture may give more nitrogen and phosphorus run-off:
  Higher temperatures and winter precipitation will increase the risk of nitrogen and phosphorus leaching and especially run-off into the aquatic environment. The risk of increased leaching is linked to crop and catch crop establishment and growth.

- Increased winter precipitation and increasing water levels mean poorer agricultural exploitation:
  Increased winter precipitation and rising water levels in some areas will lead to flooding or to groundwater levels that are so high, that cultivation security will be difficult to maintain. This may be particularly relevant along a number of fjords and watercourses, but there may also be problems for other poorly drained areas. This could also have a negative effect for production of winter crops, such as grasses, cereals and rape seed.

- Longer periods of drought increases the need for irrigation:
  Longer periods of drought during the summer results in a greater need to water crops artificially, especially on sandy soil. Higher temperatures also increase evaporation, but much of this effect is countered by reduced transpiration due to higher concentrations of CO_2 in the atmosphere. Changing crop types to more maize will also increase the need for irrigation. More irrigation may have an effect on summer flows in water courses. It is not yet accounted for whether increased irrigation in summer months will affect available water resources, or if it will be offset by the increase in winter precipitation.

- Rising temperatures change conditions for exotic diseases in animals:
  Rising temperatures could change conditions for the incidence of animal diseases that are currently regarded as 'exotic' in Denmark. Vector-borne diseases are an example of this, as small changes in temperatures and humidity can enable ticks and mosquitoes to establish themselves in new locations. The vector-borne disease known as blue-tongue was considered an exotic disease some years ago. In just a few years it has spread to most EU countries with consequent comprehensive vaccination programmes.

- Rising temperatures can lead to lower animal welfare and as a consequence, lower production:
  The main climate induced threat to animal welfare is heat stress, which is relevant for both free-range animals and livestock in stables. Higher temperatures and increased precipitation can increase the occurrence of diseases, infections, parasites and insects.

6.1.3.6 Forestry

The most important impacts for forestry are as follows:

- Rising temperatures mean longer growing seasons and larger biomass production:
  Higher temperatures and higher CO_2 content in the atmosphere may cause greater plant growth and thus greater inland biomass production. Because of the warmer climate, the growing season for trees will also be lengthened.

- Increased storm intensity affects wood production and biodiversity:
  Increased storm intensity, as well as increased storm risk, may lead to more trees being blown down (especially conifers, which comprise about one-half of the Danish forest area) and more frequent forest storm damage. This can affect wood production and cause a loss in biodiversity in forests, if forest storm damage occurs in large, cohesive areas.

- Drought stress and storms affect forest trees:
  Forest trees are vulnerable to climate change (drought stress and storms). This also increases their vulnerability to harmful diseases and pests. Pests and diseases can attack trees more easily, weakening the wood and rotting or drying it out.

- Higher summer temperatures increase the risk of more forest fires:
  As a result of the warmer climate, there is a risk of more forest fires, which are already widespread in southern Europe.

- Rising temperatures change the species composition of forests:
  Tree species have different ways of dealing with climate change. Norway spruce, which covers about 13% of Danish forest land, is threatened by temperature increases as the species cannot cope very well with mild winters and summer droughts (other, non-indigenous conifer species such as Sitka spruce will cope with increases in temperature better). In contrast, deciduous forests will have better conditions as a result of rising temperatures.

6.1.3.7 Fisheries

The most important effects for fisheries are as follows:

- Rising sea temperature can have huge impacts on the condition and compostion of fish stocks:
  Fish are generally adapted to a certain temperature interval. Rising temperatures, as well as other climate-related changes, can affect species composition throughout the marine ecosystem and thus change food-chains. It is currently unclear whether these changes will make fish populations and

ecosystems more or less vulnerable to anthropogenic impacts on the ecosystem, such as overfishing and eutrophication, and therefore how the fisheries sector will be affected.

Fish stock composition in Danish waters is expected to change, thereby impacting the fishing resource base. Stocks that have their southern limit in Danish waters can be affected negatively, while stocks preferring higher temperatures will generally be affected positively. Therefore it is likely that there will be an increase in species preferring warmer waters (e.g. sardine and tuna) and species preferring colder waters will retreat (e.g. cod).

- Rising sea temperatures and increased precipitation may cause oxygen depletion:
  Rising sea temperatures, for example in the Baltic Sea and in coastal areas, along with increased precipitation and run-off from watercourses resulting in increased nutrient loading and potential for oxygen depletion (hypoxia), may result in poorer living conditions for fish, with derived consequences for fisheries.

- Rising sea temperatures encourage disease-promoting bacteria:
  Rising sea temperatures can underpin the incidence of new disease-promoting bacteria and toxic algae, which can threaten fish and shellfish stocks as well as food safety.

- Rising sea temperatures can affect production conditions:
  Rising sea temperatures may accelerate the occurrence of populations of invasive species, which may lead to significant changes in ecosystems. This in turn can affect production conditions and therefore fisheries for a number of fish and shellfish species. Similarly, trout production (aquaculture) is very sensitive to increases in temperature, and marine rainbow trout farming may be threatened.

- Rising sea temperatures enable alternative fish farming methods:
  Increases in winter temperatures in particular can in time maybe enable the application of alternative fish farming methods.

- Increases in precipitation and run-off from watercourses lead to a drop in salt concentration in the Danish Belts and in the Baltic Sea:
  Populations of a number of important fish species in Danish coastal waters are demonstrating local adaptation to the existing salt gradient from the Baltic Sea out to the North Sea. Changes in salt concentration may mean changes in the geographical and temporal distribution of the fisheries resources. However, a Danish study of climate effects on river-basin management planning, showed that there has been little change in coastal salinity over the past 100 years.

- Strong winds and precipitation affect the development of marine aquaculture:
  More frequent weather events with strong winds and precipitation may impact the possibilities to develop marine aquaculture and may periodically obstruct shellfish harvests in coastal areas because of discharges of untreated wastewater and consequential problems for food safety.

- Acidification impacts production of a number of organisms:
  Acidification as a result of increasing carbon concentration can affect the production of a number of organisms, including fish and shellfish, because of reduced calcium formation.

- Cumulative effects of climate change:
  There may be cumulative effects from climate change in relation to other anthropogenic impacts. This means that even though the impact of climate change in relation to an organism or ecosystem may be small, the impact may become significant because of other pressures such as increased eutrophication.

6.1.3.8 Energy

Effects for the energy sector are primarily likely to be as follows:

- Milder winters mean less energy consumption:
  With higher average temperature and milder winters, energy needs in the winter will drop. The difference in energy consumption between mild and cold winters is about 20%. However, warmer summers will also mean more needs for cooling, but the effect of this is expected to be less than the effect of milder winters.

- Weather extremes may affect energy-producing facilities:
  More extreme weather with more powerful storms may lead to a need to secure installations against changing weather conditions. The effects are limited however, as wind turbines have been secured against high wind speeds and the vulnerable electricity supply grid is more or less be buried underground. In high winds, wind turbines are cut off which means electricity production will cease.

- More wind gives more output from wind turbines:
  With stronger winds there is a potential for better exploitation of wind turbines for greater electricity generation. The expected increase in average speeds of 1-2% however, will only lead to limited additional production with no significant effect on the economy.

- Changed import/export patterns give lower electricity prices:
  Changed precipitation patterns in Sweden and Norway will mean production of more hydropower. Higher temperatures in Norway and Sweden will also reduce electricity consumption for heating in these countries. Both these factors may reduce electricity prices in Denmark.

- Possibility for more biomass production:
  Higher temperatures and higher CO_2 content in the atmosphere may cause greater plant growth and thus greater domestic biomass production. Biomass production can be incorporated in electricity and heating supply and can replace fossil fuels as well as increase security of supply.

6.1.3.9 Tourism

The most important impacts for tourism are as follows:

- Rising temperatures and more frequent extreme weather events can make Denmark a more attractive destination for a larger part of the year:
  With a warmer climate, Denmark may become an even more attractive tourist destination during the year, as the season is extended. Moreover, popular tourist destinations in the Mediterranean such as Spain, Greece and Turkey may attract less tourists due to rising temperatures, heat waves etc. Especially tourists from the north-western part of Europe are likely to seek alternative holiday destinations in the temperate zone.[5] With its wide beaches and moderate tempertures, Denmark is one of the northern European countries with the best conditions to meet the future tourism demand.[6]

- Higher sea level can make holiday areas along the coast less attractive:
  In the medium term, sea-level rise is likely to make a number of current holiday areas, including holiday centres, holiday homes and camp sites along the coast, inaccessible or less attractive. Holiday homes placed in lowlands near the coast are often without connection to public sewerage systems and are particularly at risk of flooding, mainly in the autumn and winter season. Contrarily, changes in the coastal regions of Denmark, may also create new attractive areas that can be developed for sustainable all-year-round tourism.

- More extreme weather events may increase investment in climate protection:
  More extreme weather events expected in the future summer seasons will affect many of the outdoor activities and attractions that tourists demand. This means that large amusement parks such as Tivoli, Dyrehavsbakken and Djurs Sommerland must adapt their business strategies, products and services in relation to climate change, e.g. by investning in facilities to manage more excessive precipitation and larger storms.

  Many Danish cities, especially those that are highly dependent on tourism, are increasingly investing in climate protection measures. As this becomes increasingly necessary, it is important to exploit the potential of investing in multifunctional climate adaptation solutions that can also be used for recreational purposes. E.g., when creating new natural areas as part of a climate withdrawal strategy, dikes can also be used for hiking or piers and sea locks can be used as viewpoints.

6.1.3.10 Nature

The most important impacts for Danish nature are described in the following sections.

6.1.3.10.1 <u>Aquatic environment</u>

- Changes in rainfall patterns alters flow:
  Increased precipitation enhances flow in watercourses, resulting in higher sea level in coastal areas. Contrarily, longer periods of drought are expected to dry out watercoureses. These changes are expected to impact biodiversity in aquatic ecosystems. For example, increased flow is expected to have a

[5] http://en.klimatilpasning.dk/media/600858/130206_mapping_climate_change_final.pdf
[6] https://climate-adapt.eea.europa.eu/

positive impact, whereas increased frequency of periods with extreme flow, will have a negative impact because the ecosystem cannot adapt to extreme, rapid change.

- More frequent extreme rainfall affects erosion and sedimentation processes: The frequency and size of the extreme runoffs are expected to affect erosion and sedimentation processes in watercourses. An increased supply of sand, silt and humus particles from cultivated fields can bury parts of gravel in the watercourses and thus lead to habitat deterioration for fish and insects.

  The expected increased runoff may increase the leaching of nutrients, pesticides and other environmentally hazardous pollutants and thereby affect the composition of the biological communities in the watercourses. In combination with rising temperatures, this will result in greater algae growth, poorer light conditions, more oxygen depletion and possibly consequential fish death in aquatic environments.

- Warmer climate can change species composition:
  All aquatic organisms have an optimum temperature range, and therefore their fitness and the biological structure of the aquatic environment, is affected by changing temperature. Changes have been observed in the past decades, where warm water fish species, such as thick-lipped mullet, anchovies and European seabass, have become more common in Danish waters. In eastern Denmark, cyanobacteria, that tend to thrive at high temperatures, have become more abundant in inner Danish waters. Furthermore, a modelling study analysing the effects of climate change from approx. year 1900 until now, suggests that climate change and especially increasing temperature, may leed to deeper angiosperm depth distribution and reduced chlorophyll concentrations in Danish coastal marine areas.

- Warmer climate leads to increased substance conversion:
  Biological processes such as microbial processes that facilitate the turn-over of organic matter and nutrients are temperature dependent. A higher temperature will lead to a faster turn-over of substances.

- Increased atmospheric CO_2 can cause acidification of the sea:
  The content of CO_2 in water is in a chemical balance with the content in the air. When the content of CO_2 in the air increases, so does the content in water and this causes acidification of the water with potentially large impacts on aquatic ecosystems.

- Storage of carbon dioxide:
  Climate change affects the distribution of zooplankton in the sea and thus affects planktons' contribution to remove CO_2 from the atmosphere. In the central and eastern part of the North Atlantic today, there are areas with fewer or smaller copepods than earlier, and these changes in biomass have an impact on how much carbon can be transported from the atmosphere to the sea, along with the efficiency of carbon sequestration to sediments.

6.1.3.10.2 Nature and landscapes

- Higher temperatures and increases in the air's content of CO_2 will enhance biomass production:
  Rising temperatures provide for a longer growing season. At the same time, increased contents of CO_2 in the atmosphere lead to more favourable growth conditions. In combination, these factors provide for enhanced biomass production in Danish nature.

- Higher storm-surge water levels will probably lead to the loss of habitats along the coasts:
  As the sea level rises as a result of climate change, more than half of the current salt marshes will be permanently flooded. The beach meadows and other coastal habitats are habitats for birds, amphibians and plants. More species are therefore in risk of disappearing from Denmark during the next 50-100 years.[7]

  Higher sea level and more powerful storms may cause coastal erosion and recession, impacting Danish coastal habitats and reducing available space for habitats such as salt marshes, with consequential negative impacts on their biodiversity. These problems, however, will be limited up until 2050.

- More frequent and more intense rainfall will lead to more flooding of low-lying land areas:
  More frequent flooding events of low lying areas, such as the most valuable fresh meadows, may come under further pressure. Added pressures from the lack of opportunity to spread to other habitats and not enough time to adapt to new conditions, are expected.

- A warmer climate will alter the species composition:
  More non-native species will be able to exploit a warmer climate to expand their natural habitat to include Denmark, affecting the existing ecosystem and very likely supplanting current species.

6.1.3.11 Health
The greatest health-related impacts are expected to increase with changing climate. Some consequences can be linked to extreme weather events such as heatwaves or flooding.

Dehydration and heat stroke during heatwaves:
Heat waves can lead to dehydration and heat stroke, which in their extremity, can be life threatening. People in the northern parts of the world are less used to coping with high temperatures than people who live further south. Particularly vulnerable are the elderly who live alone, young children who do not remember to drink themselves, people with dementia or with mental illness and people whose illness or medication makes it difficult for them to

[7] Ebbensgaard, T.; Frederiksen, L.; Laustsen, K; Flindt, R.M.; Canal-Vergés, P., 2022: Havvandsstigningers betydning for naturen (COWI og SDU).

feel thirsty and sweat.

- Positive as well as negative impacts of staying outdoors:
  The human body creates Vitamin D after only short exposure to the sun, however too much sun exposure can cause skin cancer and malignant melanoma . Spending more time outdoors can have positive effects, e.g. in the form of more outdoor physical activity, fewer problems with indoor climate and less disease transmission in kindergartens etc. However, it may also cause more symptoms in people with pollen allergies and possibly also lead to more people becoming allergic to pollen. Over the recent years there has been an increase in the number of people with allergies in Denmark.

  With a longer pollen season, higher pollen counts and more mould spores in outdoor air, many people will experience more symptoms (asthma and hay fever) and will need intensified preventive treatment. Furthermore, more people are likely to develop allergies (hay fever and asthma). Very allergenic pollen species such as ragweed, have already found a habitat in Denmark. During the pollen season, Asthma-Allergy Denmark sends out daily reports on the air's content of the most important allergenic pollen types.

- Infections and similar when temperatures increase and in connection with flooding:
  Flooding of built-up areas has been documented to increase the risk of infections in connection with e.g. work to clear up basements flooded by polluted wastewater. Weil's disease (leptospirosis) is a disease that can be transmitted from rats to humans. The infection usually occurs through water via the rat's urine. Flooding that affects access to or the functioning of important institutions in society may also affect human health. For example, flooding may cause delays in the treatment of patients.

  Temperature increases and increased risk of extreme weather events will increase the risk of food- and water-borne infections. Outbreaks of a number of tick-borne diseases like tick-borne encephalitis (TBE) and Lyme disease will also be a risk. In the long term, there could also be a risk of mosquitoborne diseases that are restricted to tropical or subtropical areas today. The Danish Veterinary Consortium monitors the occurrence of biting mosquitoes, mites, and ticks in various areas of Denmark and since 2011 has carried out monitoring for West Nile Virus (WNV) and Usutuvirus (USUV), a virus related to WNV. The monitoring shows that outdoor poultry and biting mosquitoes in Denmark are free of WNV/USUV. Between 1-6% of migrating birds from the south are found to be positive in tests for antibodies.

  After longer periods with warm seawater, an increased concentration of certain marine bacteria such as Vibrio vulnificus will comprise an infection risk for fishermen and swimmers, and there may be more incidents of algal blooms and dangerous jellyfish. Vibrio bacteria are found naturally in the Baltic Sea and grow when the water temperature is over 20ºC for several days in a row. The bacteria can cause infection if they come into contact with a wound on the skin or if the water is swallowed. European Centre for Disease Prevention and Control monitors Vibrio growth in the Baltic Sea during the summer using remote sensing data to examine environmental conditions such as sea surface temperature and salinity for Vibrio bacterias (the ECDC Vibrio map viewer).

- More powerful storms and extreme weather events can increase the risk of injury:
  Experience reveals that a greater number of injuries can be linked to e.g. an increase in outdoor activity and more outdoor work in the building and construction industry.

- Warmer summers and more precipitation enhance the risk of damp and mould:
  Expected increases in damp and mould can cause health problems such as asthma attacks and hay fever and may increase the risk of respiratory infections. Furthermore, the existence of a greater number of house dust mites may lead to an increase in symptoms (asthma and hay fever) and intensified preventive treatment in individuals who are allergic to house dust mites. Moreover more people are likely to develop allergies.

- Air pollution:
  Changed temperature and precipitation conditions also result in a change in air quality. Drought leads to dry areas where particles can be released into the air and more forest fires are to be expected as a source of air pollution. The occurrence of ground-level ozone – not to be confused with the ozone layer – will also increase. The climate-related air pollution particularly affects people with reduced heart and lung function and increases the risk of more ailments and reduced quality of life.

  In situations where the ozone levels reach above a threshold value set by the EU (180 micrograms per cubic meter measured over one hour), the Danish Environmental Protection Agency will issue information, so that the population can take their own precautions.

  The environmental authorities must issue an actual ozone warning if the concentration reaches the limit set by the EU (240 micrograms per cubic meter measured over one hour).

6.1.3.12 Cross-sectoral areas

There will be direct physical climate change impacts in three cross-sectoral areas: emergency preparedness, insurance and spatial planning. These cross-sectoral areas, however, are characterised by providing services to other sectors that are more directly vulnerable to changes in climate.

Spatial planning is vital for cross-sectoral preventive efforts within climate change adaptation and has potential to promote solutions with multiple benefits, including measures with values within tourism, recreation, nature, health and so on.

Emergency preparedness aims to prevent or reduce the extent of damage from extreme weather events, whereas the insurance industry provides compensation to those who have suffered damage. Both of these cross-sectoral areas are vital in mitigating the negative impacts of extreme weather events in other sectors and industries.

6.1.3.12.1 Emergency preparedness and fire and rescue services

The effects of climate change are expected to continue to place high demands on national and municipal fire and rescue services. These demands cut across traditional sector lines in dynamic and complex ways.

Incidents involving flooding require several types of responses from Danish national and municipal fire and rescue services. For example, in responding to a storm surge, extreme rainfall, etc. with potential water damage, fire and rescue services work to identify vulnerable buildings, infrastructure, prevent or mitigate flooding using flood containment means and pumping water away from low-lying areas. In other responses, fire and rescue services may also be requested to assist in establishing emergency power supplies. Another important task is protection of health and the environment when flood water becomes contaminated with sewage water or when industrial areas containing chemical substances flood. If flooding leads to contamination of drinking water, Danish fire and rescue services can assist with the distribution of clean drinking water.

Serious transport accidents and other incidents resulting in personal injury due to extreme weather events also create a series of tasks for rescue services. Particularly intense storms, snow storms, and flooding incidents may create a need for the provision of rescue services, including rescuing of people and animals from affected areas and temporary housing and food relief services for those in need (e.g., in the case of evacuation, road or bridge closures and so on).

More frequent and longer-lasting drought periods contribute to the risk of wildfire with the potential to also spread to built-up areas. This may result in a greater volume and complexity of tasks for Danish fire and rescue services, including fire extinguishing and post-extinguishing operations. In addition to risks posed by drought, an increased focus on establishing 'untouched' forests with minimal nature management intervention (e.g., removing dead trees and brush) benefit biodiversity, but simultaneously increase the risk of wildfires.

Furthermore, an increase in the number, duration, and intensity of heat waves during summer months may require increased assistance from the Danish fire and rescue services to health authorities.

Historically, the Danish Emergency Management Agency (DEMA) has been deployed internationally as well as nationally to assist in response efforts to natural disasters, such as floods and wildfires. The increase in number and severity of climate and weather related incidents in other countries, could therefore also place an additional burden on DEMA's capacities.

DEMA and the municipal fire and rescue services' efforts vis-à-vis future climate-related challenges, mainly focus on natural hazard contingency planning and prioritization of relevant equipment purchases such as fire fighting equipment, powerful pumps, water tubes, sandbag fillers, transport and lifting capacity, lighting equipment etc. The scale of the investments required depends however, on preventive measures across many sectors (e.g., regarding land use, design, and dimensioning of buildings, sewage systems and roads, coastal management and protection, and preparedness and contingency planning). The closer the collaboration and coordination, the better effects of climate change can be managed.

6.1.3.12.2 Insurance

Due to the gradual changes in climate, historical statistics of weather and climate events cannot necessarily be used as a reliable prediction of the risk of such events. Insurance companies are therefore less able to accurately predict damage and address risks, unless climate change projections are somehow accounted for. Companies therefore try to minimise uncertainty via the measures described below.

Danish insurance companies are typically re-insured in large international reinsurance companies that also insure against financial losses from earthquakes, tropical storms and other large natural disasters, and to some extent, also from acts of terrorism. The storm Anatol in 1999 made the Danish insurance companies aware of the importance of having sufficient reinsurance capacity. Some insurance companies realized in 1999, that they ran out of capacity, which led a lot of the insurance companies to increase their reinsurance programs. The programs are typically renewed annually. An increase in the intensity of cloudbursts and other extreme weather events in Denmark will lead to an increase in the costs of reinsurance.

For both citizens and enterprises, climate change will entail a risk of higher premiums, lower coverage or the introduction of special terms for taking out insurance. Differentiated premiums (so-called "micro tariffing") might be used more extensively, which means premiums will be determined based on where buildings are located (are they located where the risk flooding is particularly large or small?), the special characteristics and technical design of buildings, as well as their damage history. This will entail that particularly exposed properties may be at greater risk (e.g. if the sewer system is under-dimensioned or if the property is in a low-lying area, and if potential damages cannot be prevented through ordinary preventive measures such as backflow blockers) and therefore cannot be insured or can only be insured against paying extremely high insurance premiums. This, in turn, may affect the sales opportunities of the relevant properties. To adapt to this development, Denmark has introduced the Danish "*National Insurance Scheme for Natural Disasters*" as described in section 6.3.

Transition risks arise in the progression towards a greener economy and derive from extensive political, legal and technological changes, as well as preferential and market changes, such as carbon taxes or changes in consumption patterns in relation to travel, food or the like. These can lead to significant changes in the value of many assets and create changed credit exposures for financial enterprises, as costs and new business opportunities materialise. There may also be reputational risks associated with a lack of or slow conversion to more climate-friendly business models, as well as liability risks for companies that fail to adequately disclose or address their impact on the climate.

6.1.3.12.3 Spatial planning

Climate change is a challenge for both new and existing designation of land. The municipalities need the right knowledge to incorporate climate change in their spatial planning.

The municipal councils are responsible for spatial planning in municipalities. The municipal development plan is an overall plan for land use in the individual municipality. The municipal development plans must not conflict with overall planning and governmental interests. Furthermore, local development plans in the municipality must be in accordance with the overall municipal development plan and with any national planning directives that relate specifically to the area in question.

The Minister of Interior and Housing has the power to intervene in local planning to ensure concepts of national interest by for example, objecting to proposed municipal development plans on behalf of all central-government bodies. Changes in or addition of new land use, for example in connection with adaptation to climate change, can fall under the concept of national interests.

Spatial planning is an effective instrument of control that can contribute to reducing or eliminating the negative effects, as well as exploiting the positive effects of climate change in a number of sectors and industries.

In 2018 new regulations in the planning act were introduced. Their objective is to prevent flooding and erosion when planning for new urban areas, urban densification of existing city, technical facilities or changed to land use and so on. Beside mapping areas in danger of flooding and erosion, it is now compulsory to introduce mitigation or remedial measures, if the planned area is assessed to be exposed to flooding and erosion.

6.2 VULNERABILITY ASSESSMENT

Vulnerability assessments have been an element in the mapping of impacts of climate change in Denmark. To some extent, this area is dealt with in section 6.1.3 and section 6.3.

Nationally funded work on assessments of socio-economic vulnerability, risks and damage is also under development, including initiatives to improve data and modelling. The initiatives aim to ensure risk-based and socio-economically viable climate change adaptation. 3 main projects aim to 1) establish nationally available digital damage costs and models that calculate damage costs on buildings and homes using new data from the Danish trade association for insurance companies and funds; 2) establish improved models for calculation of indirect damage with focus on businesses and production loss and 3) further develop methods and models for intangible consequences and loss from flooding and erosion incidents. These are more difficult to valuate financially, but the aim is to include these in analyses in the foundation for decision-making.

6.3 ADAPTATION MEASURES

6.3.1 Roles and responsibilities

All parts of society must contribute to climate change adaptation in Denmark. Dealing with the climate challenge requires collaboration between authorities, organisations, private enterprises and landowners, regardless of whether the project is maintenance of existing roads, coastal protection, construction, or investments in new infrastructure or materials.

Climate change adaptation is first and foremost based on initiatives at local level and involves municipalities, water utility companies and landowners. These stakeholders know the local conditions best, and are consequently in the best position to make decisions on adaptation. In Denmark, municipalities are the climate change adaptation authority.

Central government itself has a responsibility as the owner of infrastructure, buildings and land. However, the principle role for central government is to establish an appropriate framework for local climate change adaptation by, for example, adapting laws and regulations, but also by ensuring coordination and providing information and guidance for the municipalities. A solid framework for the efforts must support the specific parties involved, so that they can address the challenge in a socio-economically appropriate manner at the right time.

6.3.2 National and municipal adaptation strategies, plans and initiatives

In March 2008, the Danish government launched the first Danish strategy for adaptation to a changing climate.

The strategy was followed by an action plan for a climate-proof Denmark[8], which was launched in December 2012. The action plan is based on the notion that a responsible climate policy must do more than just work towards limiting climate change in the long term. It must also ensure the action necessary right now to adapt our society to a climate that is already changing.

The action plan[9] presented 64 new initiatives and gave at the same time an overview of initiatives already set in motion by the government to ensure that Denmark will become resilient to climate change.

Central to climate change adaptation efforts is a strong interaction between central government authorities and municipalities. In 2012, the government and the municipalities agreed that the municipalities will increase investments in climate change adaptation and that all municipalities carry out a risk assessment and prepare municipal climate change adaptation plans.

From 2012-2014 the Minister of Environment established a task force with specific expertise on local issues as well as web-based mapping of risks of flooding, rainfall and storm surge as a sounding board for the municipalities with regards to their preparation of municipal climate change adaptation plans. All 98 Danish municipalities finalised their action plans by 2014. The objective of this task force was also to ensure up-to-date data and relevant knowledge on the Danish Portal for Climate Change Adaptation www.klimatilpasning.dk.

The Danish web portal, klimatilpasning.dk contains news and concrete cases about climate change adaptation measures. Links to interactive geographic information systems, web platforms and software tools for climate change mapping purposes can be found on the portal. The portal is aimed at municipalities, enterprises and individuals and is updated regularly with casestudies, results from concrete projects throughout the country, relevant workshops and so on. More information and current status on the portal is presented in section 6.5.

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[8] http://en.klimatilpasning.dk/media/590075/action_plan.pdf
[9] http://en.klimatilpasning.dk/media/590075/action_plan.pdf

From 2017-2020 a mobile task force was established, comprised of adaptation, flooding and erosion experts from the Danish Coastal Authority and the Danish Environmental Protection Agency. The goal was to meet needs for guidance on holistic climate change adaptation solutions, with particular focus on flooding and erosion. Annual workshops, seminars and thematic meetings with groups of municipalities, utilities, emergency management groups and other relevant stakeholders were held throughout the country, based on concrete and commonly expressed needs, fostering knowledge exchange and gain.

Out of the 98 municipalities in Denmark, 96 are part of the DK2020-network, that was founded in 2019. In the DK2020-cooperative network, the Danish municipalities take inspiration from C40 initiatives and develop climate action plans, that are compatible with the Paris agreement. Copenhagen Municipality is not a part of DK2020, as the capital is a member of C40 and already has adapted a Paris-compatible climate action plan.

The Danish municipalities involved in the DK2020-network, receive technical support and share knowledge in their development of climate actions plans that live up to the Climate Action Planning Framework defined by C40. The climate action plans focus on all sectors within each municipality's geographical area and define how each municipality plans to obtain climate neutrality and robustness by 2050.

The plans must include descriptions of preparing citizens for the consequences of climate change, for example how to minimise flood-risk. All DK2020-plans are to be finalized by 2023. DK2020 is developed as a cooperative initiative by a Danish philanthropic association (Realdania), the national association of municipalities (KL) and the five regional authorities. CONCITO, the Danish green think-tank, holds the secretariat role and is a knowledge partner along with the C40 cities.

A new Joint Agreement on coastal protection of the Danish West coast for the period 2020-2024 was agreed on between Ringkøbing-Skjern, Holstebro, Lemvig and Thisted Municipalities and the Danish state. The coastal protection is primarily carried out with sand nourishment of larger or smaller quantities along the stretch.

6.3.2.1 Current work on national initiatives for climate adaptation

At the end of 2022, a new Danish government took office. In the new government's work plan for its term of office, it is highlighted that despite significant efforts to counteract climate change, it is also necessary to further secure Denmark against floods and extreme weather. The government will therefore present a national climate adaptation plan, which supports that the necessary measures are implemented in a timely manner, as well as ensuring that the measures are organized as best as possible.

6.3.2.2 New Danish regulation

As focus on adaptation to climate change has increased in the municipalities and among stakeholders, a series of amendments to relevant regulation, along with new regulation, has been implemented. Amendments have been made to the planning act and the coastal protection act and new regulation on wastewater utility's investments in climate change adaptation has been developed. These are covered in more detail in section 6.5.

6.3.2.3 Agreements in the agricultural sector

There is no overall strategy for climate change adaptation for the agricultural sector. However, several political agreements such as the Political Agreement on a Green

Transition of the Agricultural Sector[10] from 2021 have multiple climate mitigating measures with positive climate adaptation effects. The agreement aims to take 100,000 ha of organic soils, including peripheral areas, out of production and rewet them, in order to reduce greenhouse gas emissions. Climate change adaptation is an additional benefit, by adapting production areas to increased rainfall and thus reducing flood-risk on productive land. The Political Agreement on Drought from 2018 has also supported this overall goal.

There is an ongoing crop breeding effort to develop new varieties better adapted to the evolving climate and with better resistance towards existing and emerging pests and diseases. Emerging pests and diseases are monitored and information campaigns are run.

New regulation in the Danish CAP plan will from 2023 allow for support to mixed and more diverse cropping systems such as agroforestry.

6.3.2.4 National Strategy for Sustainable Growth in Danish Tourism

The Ministry of Industry, Business and Financial Affairs works closely with national tourism organisations, including Danish Coastal and Nature Tourism. The organisations support local administrative bodies in implementing local strategic development plans and carrying out projects that demonstrate recreational benefits of climate adaptation measures.

In June 2022, the Danish government launched a new national Strategy for Sustainable Growth in Danish Tourism that sets a common direction for the development of Danish tourism towards 2030. The strategy presents three major goals and 26 initiatives that aim to balance environmental, economic and social sustainability and contribute to the national goal of 70% emissions reductions by 2030. Initiatives focusing on green transition of the tourism industry include areas such as investment in green infrastructure for recreational purposes, distribution of electric charging points and climate-friendly domestic aviation.

The National Tourism Forum will oversee the implementation of the national Strategy for Sustainable Growth in Danish Tourism (2022) and publish annual reports on the progress on goals and initiatives, including those on climate change adaptation.

6.3.2.5 National Insurance Scheme for Natural Disasters

Insurance companies underwriting fire insurance in Denmark are required by law to collect an annual fee of DKK 40 per fire insurance policy. This sum covers the cost of a compensation scheme for damages caused by storm surge, drought, windfalls and flooding from watercourses and lakes. The scheme is administered by a the Danish Natural Hazards Council assisted by the insurance companies.

6.4 MONITORING AND EVALUATION FRAMEWORK

6.4.1 Monitoring effects of climate change on the environment

In 2021, the University of Aarhus produced a report for the Danish Environment Protection Agency on environmental indicators for monitoring effects of climate change on the environment. The report collects and presents exsisting data that can

[10] https://en.fvm.dk/focus-on/the-agreement-on-a-green-transition-of-the-agricultural-sector/

be applied to identify the potential for application of a number of indicators in documentation of the effects of climate change on Danish natural environments.

A list of potential indicators include those applicable in terrestrial, farmland, marine and freshwater environments and are already applied as indicators in the national monitoring programme NOVANA. The report also identifies knowledge gaps toward the development of indicators. Applicability, along with availability of data and analytical methods are discussed and suggestions for potential climate indicators are presented.

The Danish Environment Protection Agency is working on identifying which indicators, or combination of indicators in the NOVANA programme, can be used to monitor effects of climate change on the environment. Indicators used for monitoring coastal waters, including temperature and chlorophyll concentration, have promising prospects for application. Monitoring frequency of some indicators may need to be adjusted for application as climate indicators.

6.4.2 Evaluation of municipal climate change adaptation efforts

In the period February to August 2016, a working group with representatives from the Ministry of Environment and Food of Denmark, the Ministry of Energy, Utilities and Climate and the Ministry of Business and Growth carried out an evaluation of municipal climate change adaptation efforts.

Efforts include climate change adaptation plans, that map the risk of flooding, specify priorities and provide an overview of achievements.

Results of the evaluation of efforts were presented in NC7. These included discrepancies in detail and scoping of topics, identification of financing mechanisms, and indications of successful coordination of climate change adaptation efforts with other spatial planning efforts.

6.4.3 Evaluation of flood risk management plans according to the EU Floods Directive

An evaluation of implementing the EU Flood's Directive in Denmark, shows a positive impact on raising awareness of flood risk. After two cycles, experience shows that the municipalities designated as risk areas and that therefore prepare risk management plans, are further ahead in their climate adaptation compared to other municipalities.

Drawing up risk management plans encourages the municipalities to, within a statutory framework, analyse hazard and risk maps in relation to flooding, set targets for risk reduction, prioritise efforts, identify responsible units and follow up on implementation. Thereby, the municipalities become aware of the consequences of flooding and have to deal with the subject and the dilemmas and challenges that climate adaptation entails, as well as to make plans for how the challenges are to be handled.

6.5 Progress and outcomes of adaptation action

Concrete action has been taken in updating regulation, providing better guidance for municipalities and stakeholders, improving flood warning systems, implementing national support schemes and developing collaborative partnerships.

6.5.1 Regulation

6.5.1.1 Implementation of EU directives in national regulation

6.5.1.1.1 Implementation of the Danish Flood Risk Act (EU Floods Directive)

The Danish Flood Risk Act relates to the Directive 2007/60/EC of the European Union on the assessment and management of flood risks. The purpose of the Directive, implemented in Danish law by the Danish Flood Risk Act, is to identify flood risks and improve preparedness for future flood events and flood risk management.

In Denmark, 10 flood prone areas have been appointed in the first cycle. In nine of the 10 flood prone areas, the source for flooding comes from the sea or from both the sea and rivers. Only one of the areas has an entirely fluvial risk source.

In the second cycle, the methodology of appointing areas of potentiel flood risk was reassessed and updated, in order to simplify risk assessments and improve applicability, including by recognising that flood risk is dynamic and changes over time. The aim was also to rest the national assessments on a more quantitative basis through, for example, formulas and statistics.

Reassessments of national risk were carried out in areas that had experienced increased vulnerability and resulted in the appointment of four additional areas: a total appointment of 14 potential flood risk areas.

In the third step of the act, risk management plans have to be prepared. The risk management plans allow municipalities to prevent, protect and prepare for climate change. They are drawn up on the basis of maps and guidance material from the Danish Coastal Authority.

In autumn 2021, 22 out of a total of 27 designated municipalities had reviewed and adjusted their risk management plans from the first cycle. These plans were adopted in 2015 by the municipal boards and municipalities have since worked to implement measures to reduce risk. 22 municipalities had adopted their updated risk management plan, in which they have given status on the implementation of the measures planned in their first risk management plan. The remaining five municipalities, which were appointed as flood risk areas in 2018, adopted their first risk management plan in autumn 2021.

Based on the municipalities' status in the updated risk management plans, it appears that the 22 municipalities planned a total of 255 measures in 2015. Of these, the municipalities have implemented 135 initiatives and 91 initiatives are in the pipeline. This corresponds to a total of 88.6 % of the planned measures for risk management and climate adaptation have been completed or initiated in the designated municipalities. Of the 226 completed or initiated initiatives, 53 are initiatives within prevention, 78 within protection, 37 are preparedness initiatives and 58 are preparatory work.

An evaluation based on two cycles of implementing the EU Flood's Directive, is presented in section 6.4.3.

6.5.1.1.2 Implementation of the Water Framework Directive

The EU Water Framework Directive (WFD) provides the framework for protection and conservation of watercourses, lakes, transitional waters, coastal waters and groundwater in all EU countries. The directive applies a number of environmental goals and provides the framework for the administrative structure for planning and executing initiatives to meet goals. The WFD is is implemented in Danish law via the law on river basin management planning (LBK nr. 126 of 26/01/2017).

The EU Floods Directive is to be carried out in coordination with the WFD, notably by coordinated flood risk management plans and river basin management plans, and through coordination of public participation procedures and in the preparation of these plans. Denmark is working toward improving coordination and collaboration in these areas.

The public hearing of the proposal for the third Danish river basin management plan was finalised in June 2022. Beyond describing river basin management plans for Denmark, the proposal also outlines the effects of climate change on aquatic ecosystems. These include impacts from higher tempature in surface waters, changes to groundwater levels, increased runoff of nutrients and hazardous substances to aquatic environments and changes to hydrological regimes. The impacts have consequences for hydromorphology, physico-chemical and biological quality indicators and thus the ecological and chemical status of water bodies.

The proposal also identifies that healty aquatic ecosystems in good status are more robust toward anthropogenic impacts and climate change. Robust ecosystems have greater potential to mitigate impacts from drought and flooding. Specifically for watercourses, the proposal describes how many of the mitigation measures implemented to improve physical conditions, also can contribute to climate change adaptation. For example, restoration of river valleys, including re-meandering of watercourses, can help to hold back water, reduce nitrate runoff and nitrous oxide emissions.

6.5.1.2 New Danish regulation

As focus on adaptation to climate change has increased in the municipalities and among stakeholders, a series of amendments to relevant regulation and new regulation have been implemented.

6.5.1.2.1 Amendments to the Planning Act

In June 2012, an amendment to the Planning Act made it possible for municipalities to include climate change adaptation directly in local development plans.

In 2018, new rules in the planning act were introduced in order to prevent flooding and erosion when planning for new urban areas, densification of existing city, special technical facilities or changed land use etc. Beside mapping areas in danger of flooding and erosion, it is now compulsory to introduce mitigation or remedial measures, if the planned area is assessed to be exposed to flooding and erosion. Further guidelines and examples on how and what data to use in local government spatial planning and work on climate change adaptation have been launched.

In June 2022, climate change was included in the statutory objective of the Planning Act, with the goal to strengthen integration of climate change parallel to integration of environment, nature, development and growth interests.

6.5.1.2.2 Amendments to the Coastal Protection Act

In 2017, an amendment to the statutory objectives in the Coastal Protection Act gave property owners greater freedom to select methods of coastal protection. Since September 2018, the administration of legislation concerning coastal protection lies at municipal level.

6.5.1.2.3 New regulation of wastewater utilities' investments in climate change adaptation

In 2021, new rules regulating wasterwater utilities' investments in climate change adaption went into effect. Municipalities can decide to heighten wastewater utilities' service levels in accordance with socio-economic viability, calculated using a defined method. This prevents over-investment.

Wastewater utilities can co-finance with any relevant partner to finance the most efficient climate change adaptation initiative. The wastewater utilities' increased investments in climate change adaptation continues to be within their financial framework, as supplements to their financial frameworks are available, subject to approval by the Danish Water Regulatory Authority. Wastewater utilities are required to report their level of investment and service provided on a yearly basis.

6.5.1.2.4 High groundwater level

In July 2021, the Danish Ministry of Environment and the Danish Ministry of Climate, Energy and Utilities finalised a project with stakeholders from wastewater utilities and municipalities to sketch out potential collective solutions for the handling of excess groundwater in designated areas. Government bodies are currently discussing potential needs for new regulation.

6.5.2 Guidance for municipalities, enterprises and citizens

Central government continuously evaluates the need for guidance on climate change adaptation.

6.5.2.1 Further development of the nationel web portal, www.klimatilpasning.dk

The Danish web portal, klimatilpasning.dk contains news, concrete cases about climate change adaptation measures for knowledge exchange and a number of knowledge products relevant for a large variety of users. Links to interactive geographic information systems, web platforms and software tools for climate change mapping purposes can also be found on the portal. The tools are made available by the Danish Meteorological Institute (DMI), the Environmental Protection Agency, the Coastal Authority, the Agency for Data Supply and Infrastructure, Geological Survey of Denmark and Greenland (GEUS), the Danish Society of Engineer (IDA), DTU Space and other Danish universities. The portal is aimed at municipalities, enterprises and individuals and is continuously updated with new case studies and results from concrete projects throughout the country.

6.5.2.2 National digitalisation strategy – Water from all sides

As part of a national digitalisation strategy, the Danish Ministry of Environment has received funding to ensure better digital support of climate change adaptation action; the initiative is known as "Water from all sides".

The funding is applied to projects that more accurately pinpoint risks and vulnerability, prioritise measures and document effects of climate change adaptation action. The projects will further develop existing data and models (many of which are mentioned in the following subsections), in order to increase the quality and applicability of tools and services made available for municipalities, enterprises and citizens.

Improved risk and vulnerability mapping will support prioritisation of socio-economically optimal climate change adaptation actions. The projects also aim to facilitate standardisation and collection of data across multi-stakeholder levels, helping to make data more publically available.

6.5.2.3 KAMP

KAMP is a screening tool that compares selected national data, calculations and projections and it is aimed, in particular, at planning and environmental employees in municipalities. KAMP is based on the most recent surveys and datasets available at national level.

KAMP shows the areas where possible climate change impacts may require attention. KAMP can also be used to determine how many buildings and kilometres of road, potentially can be affected by flooding, and it can estimate the value of the buildings and constructions that risk damage. A reporting function makes it possible print out relevant data and maps. The tool also contains an option that allows uploading of a QGIS file, allowing further work on the same dataset and mapping in the user's system.

KAMP was developed in collaboration between the Danish Natural Environment Portal and the Danish Environmental Protection Agency in consultation with the national association on municipalities (KL), the Danish Business Authority, Central Denmark Region and a number of selected municipalities. KAMP is available at www.klimatilpasning.dk

6.5.2.4 The Danish Climate Atlas

In 2019, the Danish Meteorological Institute (DMI) launched The Danish Climate Atlas as an regional assessment of IPCC-scenarios, which provides data on municipality, drainage basin and coastal stretch levels showing future changes in temperature, precipitation, extreme precipitation, relative sea level and storm surge heights. It thereby gives an indication of areas with a particular future risk of being impacted by extremes. The tool provides fundamental climate data for planning adaptation.

Data in the Climate Atlas shows the future Danish climate in the beginning, middle and end of the century for different greenhouse gas emission scenarios. The Danish Climate Atlas is an authoritative data set on the projected physical changes in weather and climate, e.g. precipitation until it hits the ground and sea water until it hits the coast. In order to assess e.g. risk of flooding, the data in the Climate Atlas needs to be combined with local data and knowledge on ground water levels, sewers, dikes etc. to complete the full impact analyses of the changing climate conditions.

6.5.2.5 HIP - a Hydrological Information and Prediction system

HIP is an open geodata tool that visualises and provides access to large, free of charge national datasets about hydrological conditions and how they are expected to change with a warmer and wetter climate in the future. Data comprises free public hydrological data and hydrological model simulations that include predictions of future climate change impacts on the depth of the shallow groundwater, river discharge and soil moisture.

HIP was developed under the Joint Government Digitalization Strategy 2016-2020 as a collaborative project between local, regional and national authorities and water utilities in Denmark. HIP comprises more than 5 terrabytes of simulated hydrological data that are visualised at HIPdata.dk using maps and graphs. The aim of HIP is to support screening and collaborations among stakeholders regarding the need for climate adaptation and to provide easy access to data for climate adaptation planning and execution.

HIP-data can also be downloaded and retrieved by webservices to support the development of local solutions for climate adaptation, water management and planning in Denmark. For example, the climate adaptation tool KAMP uses selected HIP-data on shallow groundwater. Housing companies also use HIP-data to inform property owners about the level of groundwater depth.

At HIPdata.dk, a larger range of simulated data, including seasonal variation and statistics are available, and spatial variation in model uncertainties for shallow groundwater and river discharge are visualised to inform (and guide) the users. Simulated water percolation and groundwater flows can also be downloaded to serve as boundary conditions for local-scale modelling by hydrological experts.

6.5.2.6 Kystplanlæggger

Kystplanlægger.dk is a nationwide risk assessment of coastal risks, i.e. erosion and flooding, and also includes suggestions for strategies and specific initiatives that can be applied directly by municipalities in their planning and climate change adaptation efforts along coasts. The risk assessment has been completed for the entire Danish coastline, which stretches 7,300km. Three time perspectives were examined: Today, as well as a 50-year and 100-year perspective up to 2120.

Kystplanlægger is intended to form the scientific basis for future climate change adaptation in Danish coastal areas, at national as well as local level. On the basis of the most recent coastal engineering knowledge, nationwide modelling and comprehensive risk calculations, Kystplanlægger provides a national overview that municipalities can use in their coastal protection efforts, at strategic as well as operational levels.

Kystplanlægger encourages comprehensive solutions across longer stretches of coast; solutions that are not only cost-effective and with optimal impact, but which also benefit the local community in general. Homeowners planning to establish coastal protection can therefore also find ideas in Kystplanlægger, as well as use it as a basis for their decisions.

6.5.2.7 PLASK

PLASK (SPLASH) is a free, excel-based tool that the Danish Environment Protection Agency is making available to everyone who may benefit from calculating the socio-economic benefits of climate change adaptation solutions. The tool is targeted at utility companies and municipalities that develop solutions together. These solutions are often cheaper and result in more benefits than traditional, pipe-based projects. The tool makes it possible to compare up to three different climate change solutions designed to address the same flood risk. The solutions are compared on three parameters: 1) socio-economic benefit – does it pay to adapt to climate change, 2) costs allocation – who should pay and finally 3) what added value does the project provide? PLASK is available at klimatilpasning.dk

6.5.2.8 Others

Other examples include DMI's drought index and a national fire hazard index developed in 2020 by DMI for "Brandfare.dk", which is a collaboration between *DEMA*, Danske Beredskaber (the municipal rescue companies' interest organisation) and the national association of municipalities, KL. The index shows a map of geographic areas in Denmark at heightened risk of wildfire with a 5-day prognosis by combining data on precipitation, humidity, vegetation moisture and wind conditions (similar to the European fire hazard index from Copernicus). This may in turn provide the municipal authorities with a better basis for deliberations on issuing burning bans during droughts, proving risk information to citizens, and for the operational planning of fire and rescue services.

6.5.3 Flood warning in Denmark

In 2022, the Danish government appointed the Danish Meteorological Institute (DMI) as the national authority for flood warning in Denmark. As part of the increased focus on flood warning, Denmark has become a member of the European Flood Awareness System (EFAS).

Due to climate change, Denmark can expect increased sea levels and both more frequent and more extreme cases of dangerous weather, that will increase the risk of flooding. Thus, establishing a national flood warning system in Denmark is of crucial importance for Denmark's ability to prepare for and mitigate the worst consequences of flooding in the future. The risk of flooding includes several types of extreme weather, e.g. storm surges, cloudbursts and prolonged rain. In the past eight out of 10 years, Denmark has been affected by floods as a result of cloudbursts, storm surges or prolonged rain, which has affected critical functions in society.

6.5.4 National Support Schemes

Central goverment continuously evaluates the need for financial mechanisms to allow for climate change adaptation. A number of current mechanisms are presented here.

6.5.4.1 Coastal fund

In the year 2020-2023 the government has established a fund with DKK 400 million earmarked for reinforcement of dikes along the Wadden Sea and municipal projects against coastal protection.

6.5.4.2 Removal of carbon-rich lowland areas from production

From 2020-2022, DKK 600 million has been allocated to removal of carbon-rich lowland areas from production. In 2022 alone, it is expected that approximately 1,100 ha of lowland areas will be removed from production and thus reduce CO_2 emission by approximately 16,000 tons. In addition to climate change mitigation action, the program also focuses on creating synergistic solutions that comply with the EU Water Framework Directive, the Habitats Directive, biodiversity, protected areas, clean drinking water, recreational value, organic farming and climate change adaptation.

6.5.4.3 MUFJO – Multi-purpose landuse distribution

In 2020-2022, a pilot project with the goal of applying multi-purpose landuse initiatives is being applied to realise projects that combine agricultural production with other initiatives. These include improvement of the aquatic environment and drinking water, greenhouse gas emissions reduction, protection of Natura2000 areas and appendix IV species, climate change adaptation, afforestation, biodiversity and nature protection, organic farming and local recreational values. It is expected, that 6-7000 ha of land will be re-distributed. DKK 150 million have been allocated to the project.

6.5.4.4 Projects with nature-based solutions

In 2018, the Danish Minister for Environment granted DKK 34.4 million to fifteen projects in which municipalities will adapt to climate change by implementing nature based solutions. The projects will also focus on reducing the amount of nitrogen to the aquatic environment and recreational solutions. The projects can be followed at klimatilpasning.dk.

6.5.4.5 Environmental Technology Development and Demonstration Program (MUDP)

The program aims at ensuring a better environment as well as strengthening green exports and jobs. The program is a continuation of the Danish efforts since 2007 to promote new environmental technologies, so that Denmark will have a strong position on the global market. In 2022, the government allocated DKK 120 million to new innovative projects. A long list of technologies for climate adaptation is available at www.klimatilpasning.dk.

6.5.5 Partnerships

The Ministry of Environment by the Danish Coastal Authority and Realdania (A Danish philanthropic association) have formed a partnership “Cities and rising sea levels initiative”. The partnership supports the development and realisation of a number of projects with innovative ideas for possible solutions that can combine the need to protect against seawater rise with the need to ensure access to the sea. 18 projects have been selected. DKK 77 million have been earmarked for the initiative.'

In 2020, a large number of public and private organisations chose to gather their effort in a new National Network for Climate Adaptation. The networks unites several former partnerships. During a transitional period, they will consolidate their activities into the new, common network, where they will aim to develop and market innovative Danish climate solutions. The network has created a strong, common framework for a large number of professional activities within three main areas: Research and development, projects, and competence development.

6.6 CLIMATE CHANGES AND ADAPTATION MEASURES IN GREENLAND

6.6.1 Climate changes

Projections of future climate evolution using global and regional climate models[11] for Greenland towards the end of the century compared with 1986-2005 for the RCP8.5

[11] Boberg, F., P. L. Langen, R. H. Mottram, J. H. Christensen and M. Olesen, 2017. 21st Century Climate Change around Kangerlussuaq, West Greenland: From the Ice Sheet to the Shores of Davis Strait. Accepted for publication in Arctic, Antarctic, and Alpine Research

IPCC scenario show general temperature increases of 5-7 °C which is significantly above the increase in mean global temperature. The warming at the east coast of Greenland is expected to be as high as 8-9 °C. The temperature increase is largest in winter, and there will be fewer extremely cold days. Simulations show general increases in precipitation of 50-60 percent; and in Northern Greenland locally up to 350 percent during winter in presently dry areas. The changes result in earlier snow melt and reduced ice cover, especially along the east coast.

DMI has in collaboration with the government of Greenland compiled a new data basis for the Greenland adaptation planning, providing information about future climate change in Greenland in the form of 66 climate indices (DMI Scientific Report 15-04), including reports for each of 6 municipalities. As an example, the length of the growing season in southern Greenland is projected to increase by almost two months from the current extent of about 100 days by the end of the century in the RCP8.5 scenario.

6.6.2 Adaptation measures

The Government of Greenland is initiating projects aimed at mainstreaming adaptation efforts in the management and development of various sectors. A series of assessments of how the public sector can promote adaptation to climate change was launched in 2011. The first assessment focus on 'Opportunities for climate change adaptation in the fisheries and hunting industry' (September 2012). The assessement is conducted on the basis of existing scientific assesments and local knowledge. The assessment report draws up a range of conlusions pointing to the fact that climate change has both direct and indirect consequences, often resulting in significant and unpredictable impacts on the fishing and hunting sector.

Efforts and actions towards the adaptation to climate change should therefore be viewed as a continuous process to be dealt with in close cooperation with the public administration, the scientific community and the industry and various local stakeholders.

The specific assessment of the fisheries and hunting sector addresses the fact that climate changes pose a wide range of challanges to the sector, but also new opportunities are identified. The assessments identify knowlegde gaps as more scientific knowledge about the expected impacts of climate change on natural ressources is needed in order to be able to develop national adaptation strategies and implement systematic approaches.

An integrated adaptation and mitigation assessment of the shipping sector was completed for political deliberation in 2015. Climate change potentially presents new economic opportunities for the shipping sector, most notably due to expected shortened shipping routes, longer navigable periods and increased access to oil and gas resources. However, there are also uncertainties and challenges connected to these opportunities. The assessment focuses on climate-change related challenges and opportunities for the shipping sector, including mitigation efforts.

The latest assessment 'Opportunities for climate change adaptation in the agricultural sector' was completed for political deliberation in June 2017. The assessment describes the consequences of climate change towards 2050 for the agricultural sector with a focus on how climate change can affect livestock, grazz production, crops and watering.

Furthermore, the Government of Greenland has engaged in an Arctic Council partnership with a view to producing an integrated regional assessment of climatic

and antropogenic changes in the Arctic as a tool for future adaptation plans and actions. The Project "Adaptation Actions for a Changing Arctic" (AACA) draws on input from research and government institutions from Denmark, Greenland and Canada and focuses on the Baffin Bay/Davies Strait region.
In addition, a regional overview report was published in April 2017. It presents an overview of the findings of the AACA Baffin Bay / Davis Strait Region pilot study for policy-makers. The scientific report was published in 2017.

The background for the Arctic Council decision to make such an integrated assessment is the observation that the Arctic has experienced substantial climate changes, and over the past decades Arctic climate change and the effects thereof have accelerated. This has led to profound effects and impacts on the physical, chemical and biological conditions of the Arctic and is expected to lead to fundamental changes across the Arctic.

To ensure that the public, the municipalities and the businesses know about the consequences of climate change, the government of Greenland administrates the website http://climategreenland.gl/. The aim of the website is to provide an overview of some of the ways in which Greenland is affected by a changing climate and how this is dealt with.

6.7 CLIMATE CHANGES AND ADAPTATION MEASURES ON THE FAROE ISLANDS

6.7.1 Projected climate changes in the Faroe Islands

The Faroe Islands have an extremely maritime climate, where the differences between summer and winter are relatively small. The future temperature projections are highly dependent on emissions scenario. By the end of the century (2080-2099) the expected temperature increase in the Faroe Islands, relative to 1995-2014 is about 1.4 °C for the SSP2-4.5 scenario. For the SSP5-8.5 scenario the expected temperature increase is 2.3 °C[12].

6.7.2 Expected impacts of climate change

6.7.2.1 The marine environment

The ocean areas around the Faroe Islands are dominated by the North Atlantic Current that brings warm water flowing northeastwards until they meet colder waters from the East Icelandic Current north of the Faroes. This ensures that the upper layers in most of the Faroese economic zone including the shallow parts of the Faroe Plateau and the western banks are continually covered by fairly warm water. Any disruption in the balance between these two current systems may therefore have huge impacts on the temperature. The North Atlantic Current is an integral part of the Atlantic Meridional Overturning Circulation (AMOC), which is projected to weaken during this century (IPCC, AR6-WGI-SPM, 2021). There are, however, large differences between projections for this region based on different climate models and some CMIP6 models even project cooling of Faroese waters by the end of this century for some scenarios (IPCC-AR6-WGI-TS, 2021). In addition to this uncertainty, the strength of the Sub Polar Gyre circulation has a large effect on conditions in Faroese waters and the air temperature is very dependent on wind

[12] CCKP. *World Bank Group, Climate Change Knowledge Portal.*

direction. The Faroese region is therefore especially sensitive to potential changes in the storm track.

Taking all these uncertainties into account, it is difficult to predict with any confidence how the physical conditions in Faroese waters will change, which makes it even more difficult to assess how marine ecosystems and fisheries will be affected. In the pelagic domain, recent years have shown large shifts in the migratory behaviour of economically important fish stocks and changes in the physical conditions are likely to have contributed to these. For the demersal fish stocks, their habitat is highly restricted geographically, which does not allow the stocks much room for relocation if conditions become unfavourable, but responses are likely to be highly species-dependent. Thus, concerns have been raised that strong warming may affect both cod (*Gadus morhua*) and sandeel (*Ammodytes spp.*) negatively; cod during spawning and sandeel during the overwintering period.

Summarizing, the physical conditions, the marine ecosystems, and fishing potential are likely to change in Faroese waters, but the severity and even directions of these changes are difficult to predict at the present level of knowledge.

6.7.2.2 Nature and landscape

The Faroese climate is highly dependent on the stability of ocean currents and wind directions and therefore difficult to predict. If there will be substantial warming, as projected by most climate models, substantial effects may be expected for the natural terrestrial vegetation. In high mountain regions, some alpine plant species are likely to disappear. In the lowlands, new species are likely to find favourable conditions, including highly invasive species. More generally, phenological changes are to be expected. An overall increase in desertification, soil erosion and consequent biodiversity loss can be expected in the higher elevations as a result of increased wind speed and heavier precipitation, as predicted by the latest IPCC report for oceanic areas in NW Europe.

6.7.3 Adaptation measures

So far, no known adaptation measures have been implemented, nor planned in the Faroe Islands.

The University of the Faroe Islands and Tórshavn Municipality have been participants of a now completed project on climate change adaptation in regions in the Nordic countries and with regions in the United Kingdom and Ireland. The programme aimed to tackle Climate Change on local and regional levels by increasing public awareness and using models of best practices to develop Climate Adaptation Plans for local authorities. The project also tested how prepared Faroese municipalities are compared with municipalities in Sweden. See more in chaper 8.2.6.9.

6.8 Assessment of the significance of climate change for the whole Arctic

The Arctic crysosphere (Snow and Ice) is a critically important component of the earth system, affecting the energy balance, atmospheric and ocean circulation, freshwater distribution and storage, sea level as well as the storage and release of large quantities of greenhouse gasses. Further, changes in the arctic cryosphere impact ecosystems, the economy, infrastructure, health, and indigenous and non-indigenous livelihoods, culture and identity.

The Arctic Council and its subsidiary Arctic Monitoring and Assessment Program (AMAP) is regularly releasing syntheses, updates and reports detailing the current scientific understanding and observations for current and future Arctic climate change. Building on the latest extensive assessment report SWIPA 2017[13] (Snow, Water, Ice and Permafrost in the Arctic); AMAP has released updates on the state of the Arctic climate in both 2019[14] and 2021[15]. Valuable contibutions to the understanding of Arctic climate change and effects thereof are based on long term observations and studies as well as other research efforts. Scientists and other experts from the Danish realm have had leading roles in the above work.

Together recent research focusing on arctic climate change and its impacts on the Arctic reports a continuation of cryospheric trends consistent with the rapid warming of the Arctic, and finds that the trends are very likely to continue, with more frequent and stronger extremes and increasing risks of passing of no-return tresholds. The Arctic region is warming faster than the global average, due to several contributing mechanisms, including the ice-albedo feedback, where the gradually darker surface absorps more sunlight than the previously lighter surface. The IPCC[16] concludes that it is virtually certain that the Arctic will continue to warm more than global surface temperature, with high confidence above two times the rate of global warming.

The Arctic sea ice is undergoing a regime shift from multi-year ice to predominately first year ice and the loss of land-based ice –from mountain glaciers and ice caps – is expected to accelerate, and the report finds emerging impacts of Arctic change on mid-latitude weather/climate and global sea level rise. According to the IPCC[17], the Arctic is likely to be practically sea ice-free in September at least once before 2050.

At Physics of Ice, Climate, and Earth (PICE) at Niels Bohr Institute at the University of Copenhagen research from among other things ice-core drillings has contributed significantly to knowledge of past and present climate dynamics and the dynamics of the Greenland Ice Sheet.

The Greenland Climate Research Centre (GCRC) is concerned with the expected impacts of climate change on the Arctic marine environment and on Greenlandic society, including adaptation and prevention strategies. The centre was established in 2009.

A centre for the study of Permafrost, CENPERM, under the University of Copenhagen was established in 2012.

Major institutions in Arctic climate-related reseach and data gathering within the Kingdom of Denmark include: the Danish Meteorological Institute, the University of Copenhagen, the University of Aarhus, the University of Aalborg, the Danish Technical University, the University of Southern Denmark, the National Geological Survey of Denmark and Greenland, the National Museum of Denmark, the Faroe Marine Research Institute, the Greenland Institute of Natural Resources and the Greenland Climate Research Centre.

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[13] AMAP, 2017: Snow, Water, Ice and Permafrsot in the Arctic (SWIPA 2017): Climate Change and the Cryosphere. Arctic Monitoring and Assessment Programme (AMAP), Oslo, Norway

[14] AMAP, 2019: Arctic Climate Change Update 2019 - An update to key findings of snow, water, ice and permafrost in the Arctic (SWIPA), https://www.amap.no/documents/download/3295/inline

[15] AMAP, 2021: Arctic Climate Change Update 2021: Key Trends and Impacts. Summary for Policy-makers. https://www.amap.no/documents/doc/arctic-climate-change-update-2021-key-trends-and-impacts.-summary-for-policy-makers/3508

[16] IPCC 2021: Sixth Assesment Report, Climate Change: The Physical Science Basis

[17] IPCC 2021: Sixth Assesment Report, Climate Change: The Physical Science Basis

7

FINANCIAL RESOURCES AND TRANSFER OF TECHNOLOGY

Contents

7 Financial resources and transfer of technology

- including information under Articles 10 and 11 of the Kyoto Protocol

7.1 Strategies for Danish development assistance and climate change

Denmark is one of the few developed countries that fulfil the UN goal of contributing a minimum of 0.7 percent of Gross National Income (GNI) as Official Development Assistance (ODA).

In June 2021, "The World We Share" superseded "The World 2030" as Denmark's development strategy for 2021-2025. The new strategy confirms Denmark's commitment to provide 0.7 percent of GNI as ODA and makes the fight to stop climate change and restore balance to the planet one of the pillars of Danish development cooperation.

7.1.1 Danish climate finance

Denmark provides and mobilises climate finance to developing countries through a range of channels and instruments. Through development cooperation programmes, Denmark provides climate-relevant ODA with a particular focus on the poorest and most vulnerable developing countries. Climate-relevant ODA comprises bilateral support to a number of countries with whom we have expanded partnerships; support through Danish multi-country programmes and instruments, such as the strategic sector cooperation with other Danish authorities, Danida Sustainable Infrastructure Finance, business instruments, framework agreements with Danish civil society partners and the climate envelope; and support through dedicated climate funds and programmes, such as the Green Climate Fund, the Least Developed Countries Fund, the Sustainable Energy Facility for Africa (SEFA) or the UNEP Copenhagen Climate Centre.

In addition, Denmark mobilises climate finance through various international and multilateral development financing institutions, such as the Investment Fund for Developing Countries (IFU), the World Bank and the African Development Bank.

Denmark seeks to support both adaptation and mitigation related action with a view to contribute to sustainable development. Denmark is committed to a balance of climate finance supporting mitigation and adaptation measures. Danish support to adaptation-related activities and programmes addresses the underlying causes of vulnerability, and contribute to building resilience against crises, natural disasters and the impacts of climate change. The support also assists developing countries in their efforts to integrate adaptation and emissions reduction in their national planning, and policy preparation and implementation, including as part of a country's National Adaptation Plan (NAP) and Nationally Determined Contribution (NDC).

Through both multilateral and bilateral assistance, Denmark supports increased access to sustainable energy in developing countries, improvement in energy efficiency and improved access to climate-friendly technologies. This is done by strengthening national and local knowledge and capacity, by supporting policy development and implementation, and through support to investments in preparation and implementation of specific mitigation projects. Furthermore, Denmark offers technical assistance and advice on development of investment opportunities and by strengthening local businesses in developing countries.

A significant part of Danish climate engagements targets a range of expanded partnership countries, with whom Denmark has a long-term partnership for sustainable development. The Danish representations in partner countries have the primary responsibility for dialogue with the respective partner countries about programming and management of the development cooperation, including support to climate action. Denmark cooperates with national and local government authorities, international agencies, civil society organisations, private companies, research institutions and other relevant actors, and specific projects and programmes are identified and prepared in close collaboration with national partners.

7.1.2 New and additional

According to the reporting requirements, Annex II parties shall clarify how they have determined if resources are new and additional. For the purpose of this report, newly committed (for reporting on commitments) or disbursed (for reporting of disbursements) finance for climate change adaptation or mitigation activities within the reporting period and that were not reported to UNFCCC in previous reports are considered new and additional.

Denmark sees the achievement of climate change and broader sustainable development goals as closely linked and strongly interdependent, and seeks to identify and support activities in developing countries that address multiple objectives as identified in partnership with these countries.

7.2 METHODOLOGY FOR REPORTING

Denmark's Eighth National Communication (NC8) covering 2017-2020 and Fifth Biennial Report (BR5/CTF in Annex F) covering 2019 and 2020, include figures on both commitments and disbursements of climate finance. In the Common Tabular Format (CTF), it has not been possible to upload both commitment and disbursement data electronically to the UNFCCC platform without creating a risk of double counting of individual projects. In the CTF, figures on disbursements are reported.

Tables on both disbursements and commitments of climate finance for the years 2017-2020 are, however, available in Annex D1.

It is important to note that commitments and disbursements describe two different phases in the deployment of climate finance. Climate finance is committed to a specific project, programme or institution when it is finally approved by the relevant

Danish authority and an agreement or similar document is signed with the recipient country or organisation. Finance is disbursed when an actual transfer has taken place to an account of the recipient country or organisation. In some cases, commitment and disbursement takes place in the same year. In other cases, disbursements will take place over a number of years following the commitment. Commitments and disbursements of climate finance are considered as mutually exclusive flows in Denmark's reporting and are not combined within CTF reporting or resulting figures.

Denmark has reported financial figures using the same CTF format as in previous Biennial Reports. This makes it possible to compare figures with the First Biennial Report (BR1) covering 2011-2012, the Second Biennial Report (BR2) covering 2013-2014, the Third Biennial Report (BR3) covering 2015-2016 and the Fourth Biennial Report covering 2017-2018. Denmark's method for reporting to the UNFCCC was changed between BR1 and BR2, as BR1 reported on commitments while BR2 reported disbursements. From BR3 and onwards Denmark has reported on both disbursements and commitments. By providing data on both commitments and disbursements in Annex D1 of Denmark's NC8, it is possible to compare with older reports using both reporting methods.

In the following section, the methods behind the tracking and reporting of bilateral, multilateral and mobilised private climate finance are explained.

7.2.1 Bilateral climate finance

For bilateral public climate finance, Denmark uses the OECD DAC Creditor Reporting System (CRS) database with its Rio markers as the basis for reporting on climate-relevant activities. The Rio markers on adaptation and mitigation are policy markers that indicate policy objectives in relation to each project or programme that is reported to the OECD's CRS. The markers are assigned based on well-defined guidelines and technical eligibility criteria agreed within OECD DAC.

The guidelines for Rio markers are part of the general ODA statistics guidelines[1], which provide concrete examples of Rio marking (Annex 20, Rio Markers). The Rio marker framework is the result of OECD initiatives to improve and develop the DAC reporting methodology related to transparency on public and private climate finance. Denmark has been an active member of an OECD working group refining and improving the Rio marker system to better serve the purpose of being used as the basis for climate finance reporting to UNFCCC.

Rio markers are applied to all bilateral support to developing countries, except general budget support, imputed student costs, debt relief, administrative costs, development awareness-raising, and refugee reception in donor countries. Rio markers are not applied to core contributions to multilateral organisations. For a precise definition of OECD DAC Rio markers see the OECD DAC's Converged Statistical Reporting Directives for the Creditor Reporting System (CRS) and the Annual DAC Questionnaire (including Annex 20 therein).

All Danish bilateral support to developing countries is screened and marked with Rio markers to establish whether the project targets adaptation and/or mitigation as a

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[1] Converged Statistical Reporting Directives for the Creditor Reporting System (CRS) and the Annual DAC Questionnaire, OECD DAC: DCD/DAC/STAT(2020)44/FINAL; DCD/DAC/STAT(2020)44/ADD1/FINAL; DCD/DAC/STAT(2020)44/ADD2/FINAL; and DCD/DAC/STAT(2020)44/ADD3/FINAL

“principal objective”, a “significant objective” or whether these objectives are “not targeted”. The values of a project are attributed according to the extent to which the themes are explicitly addressed at the level of problem analysis (context); objectives and results; and activities as defined in the eligibility criteria.

For single partner projects the climate relevant contribution of a specific project or programme is quantified based on the adaptation and mitigation markers. If a project or programme is marked with Rio-marker 1 ("Significant") for adaptation and/or mitigation, 50% of the project’s associated finance is reported by Denmark as climate-relevant finance. If a project or programme is marked with Rio-marker 2 ("Principal"), 100% of the associated finance is reported as climate-relevant. In order to avoid double-counting, Denmark ensures that in cases where projects or programmes are marked for both adaptation and mitigation, the total amount of climate-relevant finance reported does not exceed the finance associated with the highest Rio marker, which has been allocated. For projects and programmes with multiple partners or contributions to pooled funds and other multi a more granular approach is applied that is based on reports from the recipient entities.

The types of climate-specific support that are reported are “Mitigation”, “Adaptation”, and “Cross-cutting”. In this submission, Denmark has not made use of the “Other” category. The applied Rio-markers are used to distinguish between the different support types. Contributions relating to programmes, projects and activities that are assigned with a positive Rio-marker for either mitigation or adaptation are reported under the relevant heading. Definitions of mitigation and adaptation are in accordance with the definitions by OECD DAC. Detailed information is provided in Annex 20 of the OECD DAC reporting directives referred to above. Mitigation seeks to limit climate change by reducing the emissions of GHGs or by enhancing sink opportunities. Adaptation aims to lessen the adverse impacts of climate change. Contributions to programmes, projects and activities assigned with a positive Rio-marker for both mitigation and adaptation are reported as cross-cutting.

A matrix indicating how climate change mitigation and adaptation Rio markers determine the type of support (mitigation, adaptation or cross-cutting) and the consequential application of Rio marker coefficients is shown in Table 7.1.

TABLE 7.1: MATRIX INDICATING HOW CLIMATE CHANGE MITIGATION AND ADAPTATION RIO MARKERS DETERMINE THE TYPE OF SUPPORT (MITIGATION, ADAPTATION OR CROSS-CUTTING) AND THE CONSEQUENTIAL APPLICATION OF RIO MARKER COEFFICIENTS

Rio marker	Mitigation 0	Mitigation 1	Mitigation 2
Adaptation 0	Not relevant	Mitigation: 50% of finance	Mitigation: 100% of finance
Adaptation 1	Adaptation: 50% of finance	Cross-cutting: 50% of finance	Mitigation: 100% of finance
Adaptation 2	Adaptation: 100% of finance	Adaptation: 100% of finance	Cross-cutting: 100% of finance

The Danish MFA has put in place a system of external quality assurance of all Rio markers in the project portfolio, which is done before their submission to the OECD CRS database and their use for reporting to the UNFCCC. Furthermore, the MFA has internally made an effort to further develop its methods of reporting to the UNFCCC, including by addressing the comments and recommendation by the UNFCCC Expert

Review Team to BR4. Two improvements compared to the method used for the BR4 submission are:

- Further development of the analysis of the climate-specific finance resulting from Danish support provided through multi-project mechanisms and pooled support to Danish NGOs. Such support is provided to: development research activities undertaken by the Danida Fellowship Centre; the strategic partnership agreements between the Danish MFA and Danish NGOs; and to CISU in support of its re-granting mechanisms partnering with small and medium sized Danish NGOs. Climate-specific finance reported from these instruments is based on reporting by those organisations back to the Danish MFA and is based on the actual climate projects implemented using financing sourced from the Danish MFA.
- A more detailed description of the methodology resulting in the sections concerning support for technology development and transfer and capacity building. In particular, these developments regard the process and methodology through which Denmark assesses its development activities and assigns its projects as relevant towards these two objectives.

The in-depth analyses of the multi-project mechanisms and pooled grants supported by Denmark were first included in Denmark's BR4. The further development and expansion of this analysis is a measure taken to consider a larger amount of finance and development partners in more granular climate finance assessments.

The method involves analysing individual projects receiving grants from Denmark's development partner responsible for the multi-project mechanism or pooled fund, using the Rio marker methodology.

7.2.2 Multilateral climate finance

Multilateral climate finance is divided in the CTF into core finance and climate-specific finance.

Core finance is identified by Denmark as funding to select institutions that are marked as "core contributions to multilateral institutions" in statistical reporting to OECD DAC's CRS. Such core funding for multilateral institutions is not marked with Rio markers. This is because any resulting climate finance is better measured as a financial outflow from a multilateral organisation.

The climate-specific finance flowing to multilateral organisations, as included in CTF Table 7 and 7(a) represents one of two things: (1) earmarked, multi-bilateral finance which has been allocated a Rio marker; and (2) core finance to a multilateral organisation deemed as entirely focused on climate change, such as the climate change funds with imputed multilateral shares of 100%, as calculated by the OECD[2].

The funding to multilateral institutions included in CTF Table 7 and 7(a) are the actual amounts of disbursed annual contributions to those organisations.

Again with regards to CTF Tables 7 and 7(a), Denmark reports on core finance and climate-specific as mutually exclusive flows of finance:

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[2] See "Imputed multilateral shares": https://www.oecd.org/dac/financing-sustainable-development/development-finance-topics/climate-change.htm

- Core contributions to “Multilateral financial institutions, including regional development banks” and “Specialised United Nations bodies” are reported as core finance. This includes core funding for the World Bank, the African Development Bank, Asian Development Bank, UNDP and UNEP.
- Core and climate-specific finance to large multilaterals with multiple ‘arms’, such as the World Bank, has been divided into support provided to specific institutions. For example, Denmark’s support to the World Bank is divided into support for the International Development Association,and International Bank for Reconstruction and Development..
- Contributions to “Multilateral climate change funds” are reported as climate-specific. This includes funding to the Least Developed Countries Fund, Green Climate Fund, UNFCCC Trust Fund for Supplementary Activities, and “Other multilateral climate change funds” (including the Multilateral Fund for the Implementation of the Montreal Protocol and the Strategic Climate Fund).
- In 2019 and 2020, core commitments and disbursements provided to: the World Meteorological Organisation (WMO), Intergovernmental Panel on Climate Change (IPCC), Global Green Growth Institute (GGGI) and International Renewable Energy Agency (IRENA), have been considered as climate-specific, based on individual assessments of these contributions. Following this, these projects had their climate objective ("Mitigation", "Adaptation" or "Cross-cutting") assigned after a specific assessment of the objectives of the support.

As referred to above, climate-specific finance channelled through specific programmes and trust funds managed by multilateral institutions is treated in the same way as climate-specific bilateral and regional support. This means the climate-relevance of such activities are identified based on an application of Rio markers. Denmark separates climate-specific bilateral and multilateral funding based on OECD DAC channel codes. Multilateral finance is reported in CTF Table 7(a) while bilateral finance is reported in CTF Table 7(b).

Reporting on climate finance through core contributions to multilateral organisations is a major challenge for Denmark and other donor countries. Aside from those instances outlined above, where an organisation is deemed to be primarily focused on climate change objectives, Denmark’s reporting to UNFCCC does not include any calculations trying to assess the climate-relevant finance resulting from the Danish core contributions to multilateral organisations and development banks. Therefore, Denmark values the annual Joint Report on Multilateral Development Banks' Climate Finance, produced using a commonly agreed methodology among the multilateral development banks (MDBs)[3]. Likewise, Denmark values the reports from OECD on Climate Finance Provided and Mobilised by Developed Countries that estimates the climate finance provided and mobilised by MDBs that can be attributed to developed countries[4]. These report are considered essential for the monitoring of trends and progress in mobilising finance for climate action and

[3] Available at: https://thedocs.worldbank.org/en/doc/9234bfc633439d0172f6a6eb8df1b881-0020012021/original/2020-Joint-MDB-report-on-climate-finance-Report-final-web.pdf

[4] Available at: https://www.oecd.org/env/climate-finance-provided-and-mobilised-by-developed-countries-aggregate-trends-updated-with-2019-data-03590fb7-en.htm

investments in developing countries. The MDB outflows resulting from core support, which can be attributed to Denmark, are not included in this submission.

7.2.3 Private climate finance

In 2015 and 2016, for the first time, Denmark applied Rio markers to private climate finance mobilised through Denmark's Investment Fund for Developing Countries (IFU). Denmark continued to report bilaterally mobilised private finance in its BR4 submission, and continues to do so for 2019 and 2020 in a separate box below. All figures are those provided by IFU to the Danish MFA.

IFU provides equity capital for climate-relevant investments in developing countries using its own resources, while also managing a number of investment vehicles that involve private investors such as the Danish Climate Investment Fund (DCIF) and the Danish SDG Investment Fund.

The total capital commitment to the Danish SDG Investment Fund is close to DKK 5bn. Of which, nearly DKK 3 billion was committed by Danish pension funds and private investors while the remaining DKK 2 billion was committed by IFU, including DKK 100 million from the Danish MFA and a DKK 800 million loan from Denmark's national bank, guaranteed by the Danish state.

In 2017, Danida Business Finance (DBF) was relocated from the Danish MFA to IFU. In January 2020, its name was changed to Danida Sustainable Infrastructure Finance (DSIF), which provides and mobilises finance for sustainable infrastructure projects in developing countries. DSIF offers grants in combination with subsidised loans for infrastructure projects in developing countries with incomes per capita below USD 3,995 (2020). The projects must contribute to sustainable development in the recipient country in line with the UN Sustainable Development Goals (SDG).

Furthermore, Danida Market Development Partnerships (DMDP) brings commercial- and non-commercial actors together in partnerships to promote sustainable business, development and employment opportunities in developing countries, contributing to the SDGs. A number of climate-related activities have been supported, in particular investments in renewable energy and the circular economy.

Danida has also supported 'Partnering for Green Growth and the Global Goals 2030' (P4G) which brings together businesses, governments, and civil society organizations in partnerships to develop and prove market-based green and inclusive solutions to deliver on the SDGs and the Paris Agreement. P4G commenced operations in January 2018. The World Resource Institute (WRI) hosts the Global Hub, which manages P4G.

Private climate finance mobilised through these instruments are not included in this submission or the CTF tables. Private finance mobilised by IFU or IFU managed funds is noted in a separate box this narrative report as supplementary information.

7.2.4 Methodological differences from BR4

The methodology used for calculating Danish climate finance for 2019 and 2020 is generally the same as the methodology used to produce Denmark's BR2, BR3 and BR4 submissions. From 2017-2020, Denmark has reported core funding to a number of institutions which were previously not included in BRs. These include: the Food and Agriculture Organisation (FAO), the International Development Association's Multilateral Debt Relief Programme, the Asian Infrastructure Investment Bank, the Organisation for Economic Cooperation and Development (OECD) and the United Nations Convention to Combat Desertification. These are all reported as core funding only in the CTF tables, and not as climate specific funding.

7.2.5 Final remarks

Denmark provides the information in CTF Tables 7, 7(a) and 7(b) in Danish Kroner and USD. Denmark uses the currency exchange rates published by the OECD DAC[5].

Information on individual Danish development projects is publicly available in Danida's OpenAid database (http://openaid.um.dk), where updated disbursements to individual projects and total sums for disbursements to countries, sectors and implementing organisations can be found.

As an EU Member State, Denmark also reported under the annual EU Monitoring Mechanism (MMR), and now reports under the EU Governance Regulation (GR), which superseded the MMR for post-2020 climate finance reporting. In doing so, Denmark provides annual reporting of information on financial support, capacity building and technology transfer activities to developing countries based on the best available data. To the extent possible, Denmark follows the recommendations made by the European Commission to allow comparable reporting among Member States of the EU.

7.3 OVERVIEW OF DANISH CLIMATE FINANCE FROM 2013 TO 2020

This section presents an overview of Danish climate finance reported to the UNFCCC. The overview includes a breakdown by implementation channel (multilateral, bilateral etc.), an overview of recipient countries, mitigation and adaptation shares, the use of bilateral and multilateral channels, as well as support to LDCs.

Table 7.2 contains an overview of Danish climate-specific finance between 2013 and 2020 for both disbursements and commitments. Denmark's core contributions to multilateral institutions are not included yet are reported separately under the 'Core/general' column of CTF Tables 7 and 7(a), as required by the UNFCCC (see Annex F of Denmark's NC8).

The table shows how Danish climate finance disbursements and commitments have been distributed between mitigation, adaptation and cross-cutting objectives.

It should be noted that commitments may fluctuate significantly from year to year depending on the specific types of commitments made in specific years.

In Denmark's original BR2 submission (covering the years 2013 and 2014), climate finance to organisations like the GCF, LDCF, and GGGI was reported as core finance, and not as climate-specific finance despite the climate-relevance of these organisations. In Denmark's BR3, BR4 and BR5 submissions, finance provided to these organisations was included in CTFs as climate-specific finance. The Figures presented in Table VI.1 therefore differ slightly to those included in Denmark's

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[5] Available at: https://data.oecd.org/conversion/exchange-rates.htm

original BR2 submission, due to the inclusion of finances provided to the GCF, LDCF and GGGI.

TABLE 7.2: DANISH CLIMATE FINANCE BR2-BR5 (2013-2020).

FIGURES REGARDING THE YEARS 2013 AND 2014 INCLUDE CLIMATE-SPECIFIC FINANCE TO THE GCF, LDCF, AND GGGI. THIS FINANCE WAS NOT INCLUDED IN DENMARK'S ORIGINAL BR2 SUBMISSION, YET HAVE BEEN INCLUDED HERE TO ENSURE COMPARABILITY WITH THE METHOD AND FIGURES PRESENTED IN DENMARK'S BR3, BR4 AND BR5 SUBMISSIONS. FIGURES THEREFORE DIFFER SLIGHTLY FROM THOSE INCLUDED IN BR2.

Danish climate-specific finance (DKK Millions)		**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
Commitments	Mitigation	229	471	192	259	376	397	1,015	567
	Adaptation	81	0	89	394	581	462	613	811
	Cross-cutting	1,336	1,257	793	203	304	295	533	658
	Other	0	0	0	2	0	0	0	0
	Total climate-specific	**1,646**	**1,728**	**1,074**	**857**	**1,261**	**1,154**	**2,161**	**2,036**
Disbursements	Mitigation	392	492	296	346	414	587	883	535
	Adaptation	202	171	107	248	355	418	529	683
	Cross-cutting	665	788	762	691	583	470	432	540
	Other	33	33	43	7	0	0	0	0
	Total climate-specific	**1,292**	**1,484**	**1,208**	**1,293**	**1,352**	**1,474**	**1,844**	**1,758**

7.3.1 Danish climate finance reported 2013 to 2020 - disbursements

Total annual disbursements of Danish climate-specific finance, as included in Denmark's original BR2 submission, were 1,207 million DKK and 1,369 million DKK in 2013 and 2014, respectively.

Figure 7.1 below, shows how Danish climate-specific finance disbursements are distributed between mitigation, adaptation and cross-cutting objectives in the period from 2013 to 2020. On average, 34% of finance targeted mitigation, 23% adaptation and 42% cross-cutting. For the year 2019, 48% of climate-specific finance targeted mitigation objectives, 29% adaptation and 23% cross-cutting. In 2020, the shares are 30% for mitigation, 39% adaptation and 31% cross-cutting.

The cross-cutting category can be split equally into mitigation and adaptation to illustrate the balance in finance between the two objectives, with the results shown in Table 7.3.[6]

[6] Here, cross-cutting finance has been divided evenly between mitigation and adaptation. Activities reported by Denmark in the cross-cutting category having the same Rio marker allocated for both mitigation and adaptation objectives (i.e. activities with either two Significant or Principal markers).

FIGURE 7.1: DISBURSEMENTS OF CLIMATE-SPECIFIC FINANCE BY DENMARK BETWEEN 2013 AND 2020. VISUAL PRESENTATION OF THE NUMBERS INCLUDED IN TABLE 7.2.

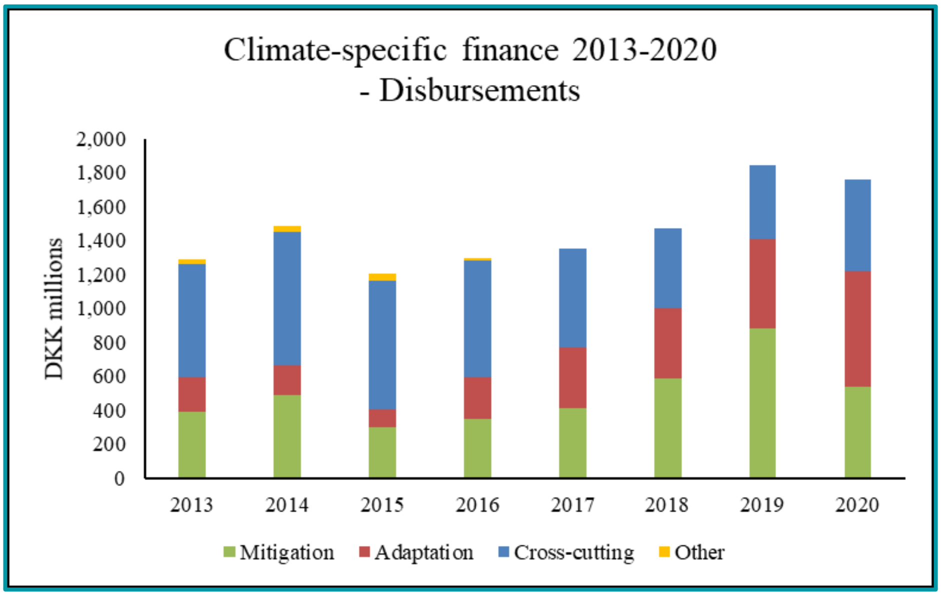


TABLE 7.3: DANISH CLIMATE FINANCE BR2-BR4 (2013-2020). AS TABLE 7.2 BUT WITH THE CROSS-CUTTING CATEGORY EQUALLY SPLIT INTO MITIGATION AND ADAPTATION CLASSIFICATIONS.

Danish climate-specific finance (DKK Millions)		**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
Commitments	Mitigation (% share)	897 (54%)	1,100 (64%)	589 (55%)	361 (42%)	528 (42%)	545 (47%)	1,282 (59%)	896 (46%)
	Adaptation (% share)	749 (46%)	629 (36%)	486 (45%)	496 (58%)	733 (58%)	609 (53%)	880 (41%)	1,140 (54%)
	Other (% share)	0 (0%)	0 (0%)	0 (0%)	2 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
	Total climate-specific	**1,646**	**1,728**	**1,074**	**857**	**1,261**	**1,154**	**2,161**	**2,036**
Disbursements	Mitigation (% share)	725 (56%)	886 (60%)	677 (56%)	692 (54%)	706 (52%)	822 (56%)	1,099 (60%)	805 (46%)
	Adaptation (% share)	535 (41%)	565 (38%)	488 (40%)	594 (46%)	638 (48%)	653 (44%)	745 (40%)	953 (54%)
	Other (% share)	33 (3%)	33 (2%)	43 (4%)	7 (1%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
	Total climate-specific	**1,292**	**1,484**	**1,208**	**1,293**	**1,352**	**1,474**	**1,844**	**1,758**

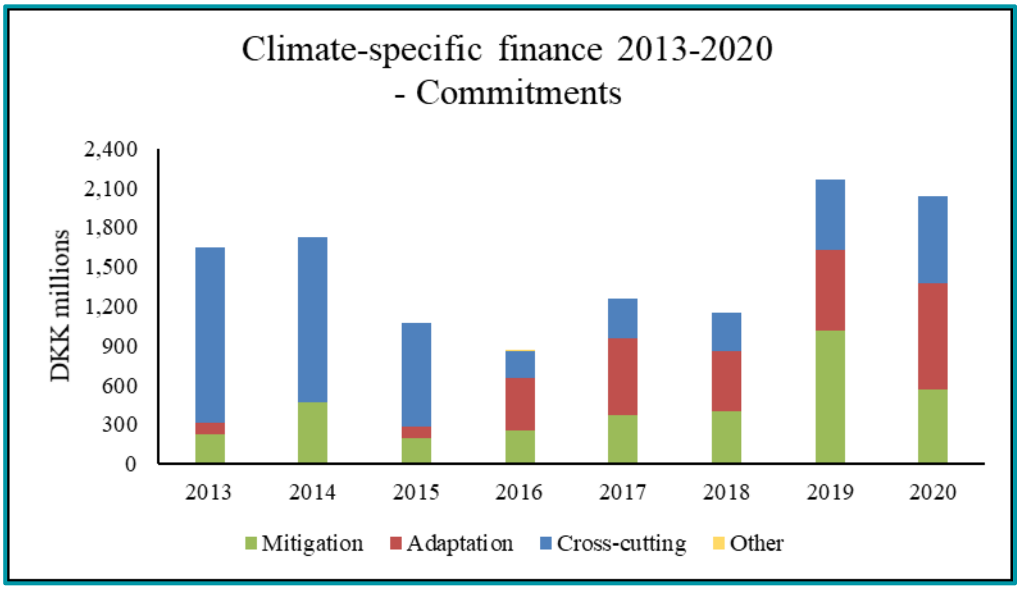
After equally distributing cross-cutting finance between mitigation and adaptation totals, 56% and 43% of Danish disbursements of climate-specific finance targeted mitigation and adaptation objectives, respectively, across the period 2013 to 2020. The shares specifically for the period covered by BR4 (2017-2018) show 54% of climate-specific finance targeted mitigation, and 46% adaptation. The shares specifically for the period covered by BR5 (2019-2020) show 53% of climate-specific finance targeted mitigation, and 47% adaptation.

Total Danish disbursements of climate-specific finance in 2019 and 2020 amounted to 13% and 12% of Denmark's total ODA disbursements in those years, respectively.

7.3.2 Danish Climate Finance Reported to the UNFCCC (2013 to 2020) - commitments

Figure 7.2 shows Danish climate finance commitments between 2013 and 2020. On average, Denmark has committed DKK 1.49 billion annually.

FIGURE 7.2: COMMITMENTS OF CLIMATE FINANCE FROM DENMARK BETWEEN 2013 AND 2020. VISUAL REPRESENTATION OF THE NUMBERS FOUND IN TABLE 7.2.

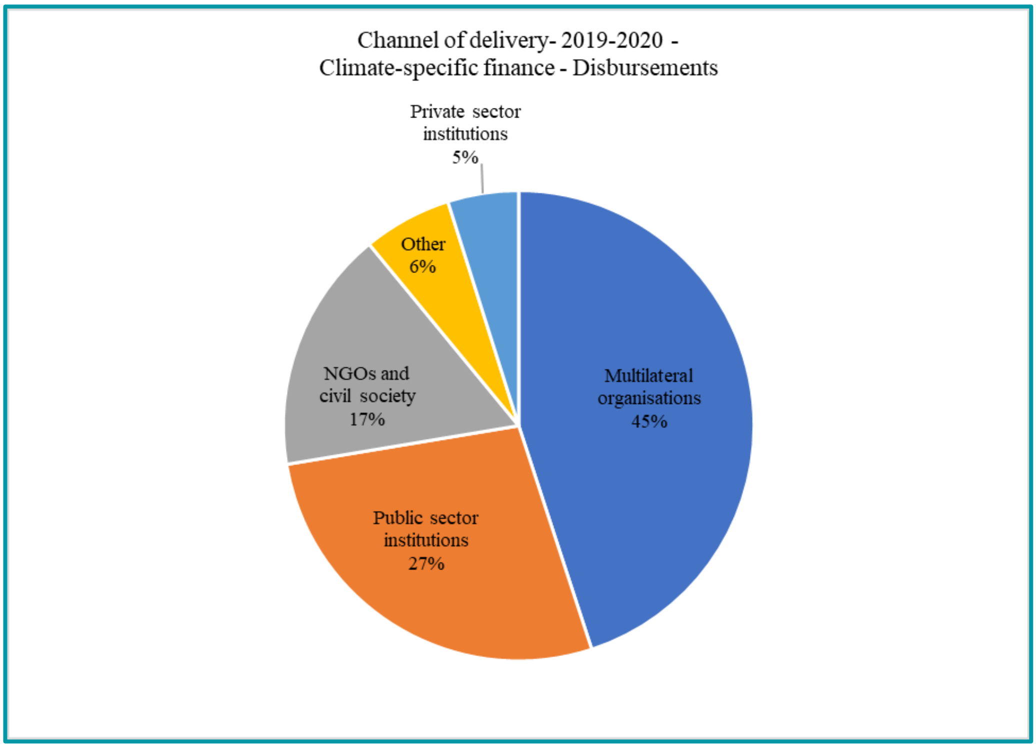


7.3.3 Climate finance by channel of delivery

Figure 7.3 below presents the proportion of Denmark's climate finance being delivered through different partners, or "channels of delivery". The figure highlights the shares of climate finance being disbursed to developing countries through multilateral organisations, public sector institutions, NGOs and civil society organisations, private sector institutions, and through other channels. Figures exclude finance reported as core/general finance in Denmark's CTF tables.

Multilateral institutions used to channel 45% of Denmark's climate finance in 2019 and 2020. The proportion of Danish climate finance channelled through national public sector institutions, NGOs and civil society, and private sector institutions was 27%, 17% and 5%, respectively.

FIGURE 7.3: CHANNEL OF DELIVERY OF DANISH DISBURSEMENTS OF CLIMATE-SPECIFIC FINANCE FROM 2019-2020. FINANCE REPORTED AS CORE/GENERAL FINANCE IN CTF TABLE 7 IS NOT INCLUDED WITHIN FIGURES.



7.3.4 Breakdown by recipient income groups

Based on the activity-level information available in the OECD CRS, it is possible to categorise Danish climate-specific finance according to recipient country income groups. This is illustrated in Figure 7.4, which shows how the Danish climate-specific finance disbursed between 2013 and 2020 is distributed between recipient country income groups used by the OECD DAC (LDC: Least Developed Countries; Other LICs: Other Low Income Countries; LMICs: Lower Middle Income Countries; and UMICs: Upper Middle Income Countries).

The figure excludes funding that is not allocated to a specific recipient country or identifiable income group, for example, finance directed towards a region, spent by means of framework agreements with NGOs or universities, or programmes and contributions to multilateral organisations which target multiple countries.

LDCs received 46% of the bilateral and multi-bilateral country-specific climate finance disbursed by Denmark between 2013 and 2020. In the period 2019-2020, LDCs received 68% of Denmark’s country-specific bilateral and multi-bilateral climate finance disbursements, (78% in 2019 and 45% in 2020).

From 2013-2020, 54% of Danish climate finance to LDCs targeted mitigation and 46% targeted adaptation. For the period 2019-2020, covering BR5, the distribution was 43% towards adaptation objectives, and 57% towards mitigation. Climate finance to middle income countries had a slightly stronger focus on mitigation from 2013-2020, with 55% of finance targeting mitigation objectives.

FIGURE 7.4: RECIPIENT INCOME GROUPS OF DANISH BILATERAL CLIMATE-SPECIFIC FINANCE DISBURSEMENTS FROM 2013-2020. FIGURE INCLUDES ONLY FINANCE WHERE A SINGLE RECIPIENT COUNTRY HAS BEEN SPECIFIED, WITH REGIONAL FINANCE AND FINANCE WITHOUT AN INCOME GROUP SPECIFICATION EXCLUDED. CROSS-CUTTING CLIMATE-SPECIFIC FINANCE HAS BEEN DIVIDED EVENLY BETWEEN ADAPTATION AND MITIGATION TOTALS.

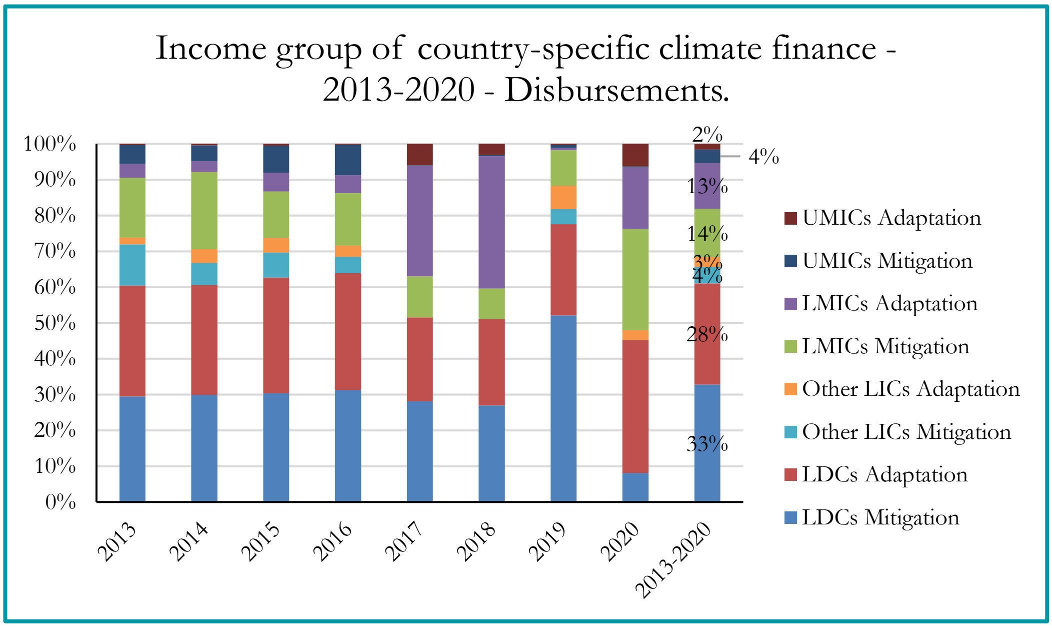
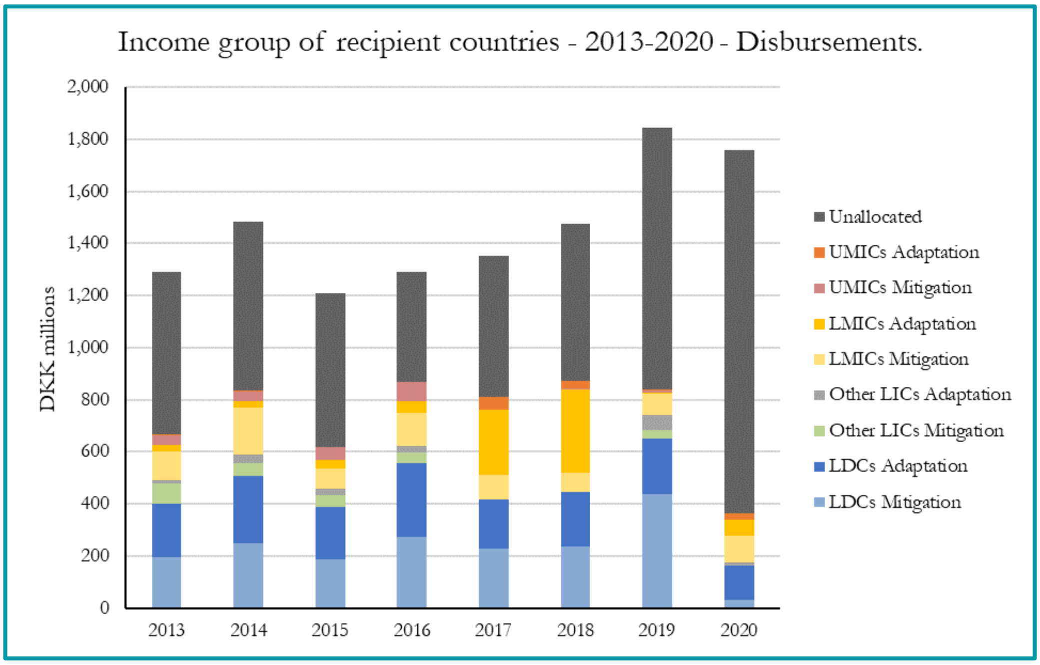


Figure 7.5 presents the absolute amounts of country-specific Danish climate finance disbursed to different income groups from 2013-2020, alongside regional climate-specific finance and finance that is not allocated to a specific recipient country or identifiable income group.

The significant decrease in country-specific climate finance with a recipient country income group allocation in 2020, as compared to previous years, is primarily due to two factors: (1) the increasing share of Danish climate-specific disbursements being channelled through multilateral organisations and institutions; and (2) a large volume of finance being reported with regional recipients in 2020.

FIGURE 7.5: ABSOLUTE AMOUNT OF CLIMATE-SPECIFIC FINANCE DISBURSED TO RECIPIENT INCOME GROUPS FROM 2013-2020. FIGURE INCLUDES COUNTRY-SPECIFIC FINANCE WHERE A SINGLE RECIPIENT COUNTRY HAS BEEN SPECIFIED, ALONGSIDE REGIONAL FINANCE AND FINANCE WITHOUT AN ALLOCATED

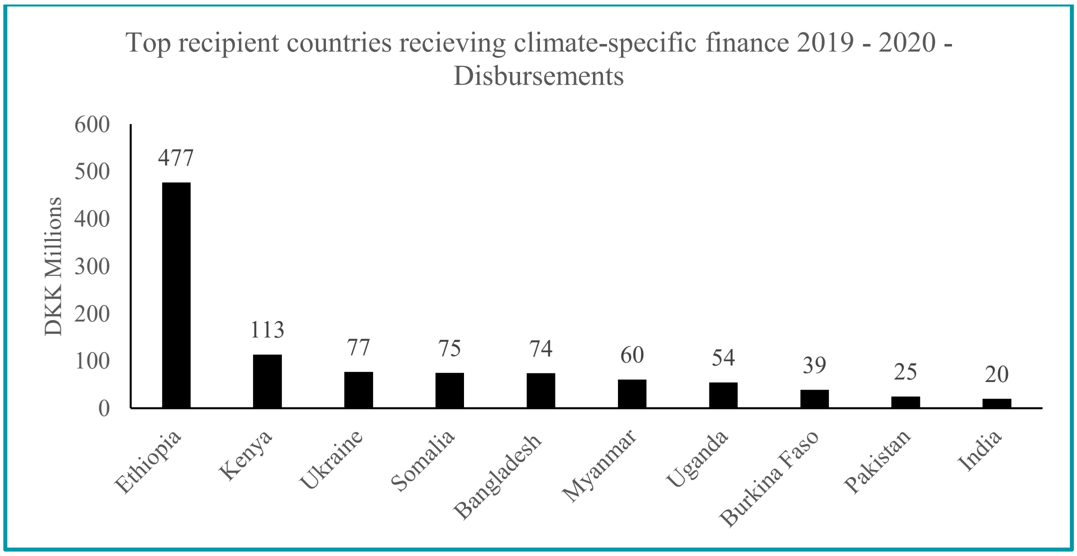
INCOME GROUP SPECIFICATION. CROSS-CUTTING CLIMATE-SPECIFIC FINANCE HAS BEEN DIVIDED EVENLY BETWEEN ADAPTATION AND MITIGATION TOTALS.



7.3.5 Allocation of climate finance to Danida Priority Countries

Figure 7.6 below shows the 10 largest recipient countries of disbursements of Danish climate-specific finance between 2019 and 2020. The largest recipient, by a significant margin over the two years was Ethiopia. This is largely due to the Assela Wind Farm Project and contributions to Denmark's Ethiopia Country Programme 2018-2022.

FIGURE 7.6: TOP TEN RECIPIENT COUNTRIES OF CLIMATE FINANCE DISBURSEMENTS FROM DENMARK BETWEEN 2019 AND 2020.



7.4 MOBILISED PRIVATE SECTOR CLIMATE INVESTMENTS THROUGH IFU

Denmark has established a number of new and innovative instruments to mobilise private finance for climate relevant investments in developing countries as shown in Figure 7.7. The main bilateral vehicle for these efforts has been the Investment Fund for Developing Countries (IFU; Investeringsfonden for Udviklingslande) and the various funds it manages.

FIGURE 7.7: CLIMATE-RELEVANT PUBLIC INVESTMENTS MADE BY IFU, AMOUNTS OF CLIMATE-RELEVANT PRIVATE INVESTMENTS ADMINISTERED BY IFU, AND MOBILISED CLIMATE-RELEVANT PRIVATE INVESTMENTS: 2018-2020.

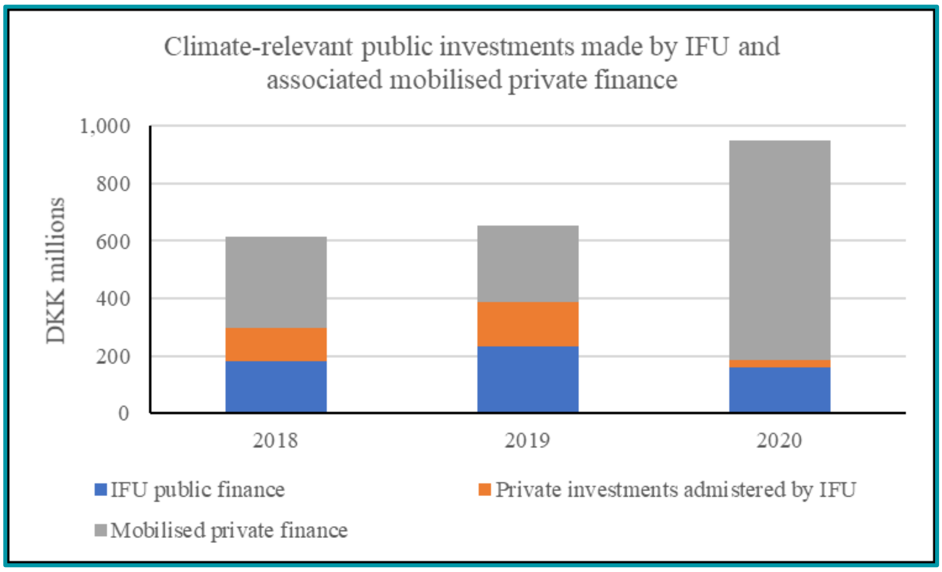


Table 7.4 below presents investments of climate-relevant public finance made by IFU and the Danish MFA from 2017 to 2020, alongside the amounts of private sector investments mobilised through the projects being co-financed. Both the mobilised finance, and the public finance used to mobilise that finance, are presented. DKK 799.9 million, 433.7 million, DKK 420.0 million, and DKK 794.0 million of climate-relevant private investments were mobilised in 2017, 2018, 2019 and 2020, respectively.

The Danish Climate Investment Fund (DCIF) and the Danish SDG Investment Fund (SDG Fund) were involved in 8 (DCIF) and 4 (SDG) of the 22 investment projects from 2017-2020, as listed in Table 7.4. The remaining 10 projects were associated with IFU directly. Both DCIF and the SDG Fund are public-private partnerships managed by IFU.

The SDG Fund was established in 2018 and received a total committed capital of DKK 4.86 billion, involving the Danish State and IFU (DKK 1.94 billion), and Danish pension funds and institutional and private investors (DKK 2.92 billion). Alongside IFU, the 10 contributors to the Fund are: PKA, PensionDanmark, PFA, ATP, JØP/DIP, PenSam, Navest, SEB Life & Pension, Secure SDG Fund, and Chr. Augustinus Fabrikker Akts. The Fund is envisaged to promote investments of at least DKK 30 billion until 2030 and will form the primary vehicle for IFU's equity investment activities. The Fund is an innovative addition to how Denmark will contribute to increasing private investments in developing countries towards the achievement of the SDGs. It will target a number of strategic sectors, such as:

renewable energy, agribusiness, infrastructure, including water and sanitation, industry and service as well as the financial sector.

The DCIF was established as a close-end fund and its investment period ended in early 2018. Up to 2016 it raised EUR 174 million of public and private funds, used to mobilise further private investments at the project level. The public funds were provided by the Danish government and IFU, while Danish pension funds contributed the major remaining part (EUR 104 million). It is estimated that the fund will, in total, generate total investments of EUR 1-1.2 billion. The fund had the opportunity to invest in all developing countries by offering venture capital and advice to climate investors.

The amounts of private finance mobilised have been calculated by IFU, who declare their commitments whilst calculating the level of private finance they have received from pension funds or private investors. Both the public climate-relevant investments made by IFU and the resultingly mobilised climate-relevant private investments are calculated using Denmark's Rio marker methodology.

TABLE 7.4: AN OVERVIEW OF THE CLIMATE-RELEVANT PROJECTS APPROVED BY THE DANISH INVESTMENT FUND FROM 2017-2020, AS REPORTED BY IFU TO THE DANISH MFA.

Year	Extending Agency	Recipient Country	Public finance (DKK thousand)	Private finance administered and mobilised (DKK thousand)	Mitigation Rio marker	Adaptation Rio marker
2017	DCIF	Brazil	29	96,033	2	0
2017	DCIF	Brazil	119,400	23,675	2	0
2017	IFU	Egypt	63,928	391,031	2	0
2017	IFU	Egypt	22,129	7,879	2	0
2017	DCIF	India	19,626	21,444	2	0
2017	DCIF	Mali	2,417	95,408	2	0
2017	DCIF	Mali	39,673	8,965	2	0
2017	DCIF	Mongolia	117,200	105,435	2	0
2017	DCIF	Regional	50,000	50,000	2	0
2018	DCIF	Brazil	64,000	264,988	2	0
2018	IFU	Ghana	5,000	10,431	2	0
2018	IFU	Iran	22,700	68,233	2	0
2018	IFU	Ukraine	42,852	25,780	2	0
2018	IFU	Ukraine	29,800	9,386	2	0
2018	SDG	Ukraine	15,000	54,879	2	0
2019	SDG	Global	68,000	193,000	2	0
2019	SDG	Pakistan	33,000	103,000	2	0
2019	IFU	Ukraine	112,000	121,000	2	0
2019	IFU	Ukraine	20,000	3,000	2	0
2020	IFU	Brazil	130,000	596,000	2	0
2020	SDG	Ivory Coast	18,500	168,000	1	0
2020	IFU	Thailand	9,000	30,000	2	0
Sub-total 2017			**434,402**	**799,870**		
Sub-total 2018			**179,352**	**433,697**		
Sub-total 2019			**233,000**	**420,000**		
Sub-total 2020			**157,500**	**794,000**		
Grand total			**1,004,254**	**2,447,567**		

7.5 TECHNOLOGY DEVELOPMENT AND TRANSFER AND CAPACITY BUILDING

7.5.1 Introduction

Both technology development and transfer and capacity and institutional development are central to effective climate-related development support and the UNFCCC. Capacity building is a foundational entry point for all of Danida's operations and the majority of the climate finance that Denmark provides has capacity building integrated into its operations. Technology development and transfer can be combined with capacity building in an integrated way as an effective form of climate cooperation towards long-term sustainability.

7.5.1.1 Technology development

The Convention notes that all Parties shall promote and cooperate in the development and transfer of technologies that reduce emissions of GHGs. It also urges developed country Parties to take all practicable steps to promote, facilitate and finance the transfer of, or access to, climate technologies to developing countries. Furthermore, the Paris Agreement refers to realizing technology development and transfer for improving resilience to climate change.

Technology development and transfer, as used here, encompasses both "hard" and "soft" technologies. "Hard" technologies include equipment to control, reduce or prevent anthropogenic emissions of greenhouse gases in the energy, transport, forestry, agriculture, and industry sectors, alongside technologies to enhance removals by greenhouse has sinks, technologies to facilitate adaptation and enhanced resilience to climate impacts. "Soft" technologies include capacity-building activities ("know-how"), the provision of and access to information networks, training and research, of relevance to climate-relevant hard technologies.

Transfers of both hard and soft technologies are seen in Danish climate-relevant activities, alongside or in unison with support seeking to enhance and develop the endogenous technologies and capacities of non-Annex I countries. Examples of transfers can be seen in both adaptation and mitigation activities, provided, where appropriate, with the engagement of private-sector actors. The extent of this technology development and transfer and capacity building action is significant and integral to Danish development cooperation.

7.5.1.2 Capacity building

Capacity building activities enhance the capacity and ability of developing country Parties that are particularly vulnerable to the adverse effects of climate change to take effective climate change action. Capacity building can include various instruments to increase local and national capacities to implement adaptation and mitigation actions, and should facilitate technology development, dissemination and deployment, access to climate finance, relevant aspects of education, training and public awareness, and the transparent, timely and accurate communication of information.

Danish climate support inherently seeks to include capacity building elements in its project design, with many projects and programmes also incorporating elements of technology transfer. As outlined in "The World 2030", Denmark's overall strategy for development cooperation and humanitarian action: "*Denmark will support the capacity of local civil society organisations and national and local authorities to deliver local responses to both immediate and long-term consequences of crises*".

Furthermore, it also states: *"Through Danish support to innovation facilities in the multilateral organisations, we will encourage and support the promotion of work with technology and innovation to boost local and concrete results that can inspire new and larger-scale initiatives."*

Regarding the implementation of the UNFCCC, Danish support to capacity building includes a broad spectrum of activities and public, private and civil society partners. Denmark aims to ensure that capacity building support provided to non-Annex I Parties reflects their endogenous priorities and needs through effective development cooperation and, where possible, with the use of prior engagement review and evaluation.

7.5.1.3 Tracking capacity-building and technology transfer elements

An overview of selected projects supported in 2019 and 2020, with technology development and transfer and capacity building objectives are set out in CTF Tables 8 and 9. The projects outlined below are indicative examples taken from those tables, highlighting how Denmark is practicing an integrated approach to capacity building and technology transfer as part of its overall climate support portfolio, within both bilateral and multilateral assistance.

For the present reporting cycle, project documentation for all new Danish climate-relevant commitments in the years 2019 and 2020 have been assessed for technology development and transfer and capacity building relevance. These assessments haves been done in parallel with the existing Danish processes of external review of Rio marker allocations.

Regarding the assessment and marking process, Denmark reviews each project's documentation using a methodology similar to the Rio marker approach. The methodology is used to determine whether technology development and transfer and capacity building elements are included in the project's context, design, and objectives. Markers of "1" and "0" are assigned to each project to indicate whether technology development and transfer and capacity building: a marker of "1" denotes that the objective is a significant or principal objective of the activity; a marker of "0" means neither technology development and transfer or capacity building are significant objectives of the activity (or that they are not targeted at all).

Resultingly, for technology development and transfer and capacity building to have been targeted, they must form at least a "significant" objective within a given development activity. A significant objective is defined in line with the terminology used regarding the OECD DAC's Rio markers. An activity can be marked as having technology development and transfer or capacity building objectives when they are explicitly stated within documentation, however, the objectives do not have to be the fundamental driver or motivation for undertaking and designing a given activity. In the latter case, the activity has other primary objectives but has been formulated or adjusted to help meet the relevant technology transfer and/or capacity building concerns of the recipient.

7.5.2 Examples of projects with technology development and transfer and capacity building components

7.5.2.1 Support to multilateral institutions with technology development and transfer and capacity building components

7.5.2.1.1 *Support to the Climate Technology Center and Network (CTCN) 2020-2022 (adaptation and mitigation, 27.2 million DKK)*

The Climate Technology Center and Network (CTCN), headquartered in UN City Copenhagen, is the implementation arm of the Technology Mechanism of the United Nations Framework Convention on Climate Change (UNFCCC). The CTCN promotes accelerated technology development and transfer, as well as strengthened policy and regulatory environments, at the request of developing countries as they seek to fulfill their Paris Agreement and Sustainable Development Goals. The Center has served over 100 countries since its launch in the fall of 2013, providing targeted mitigation and adaptation interventions that enable countries to make progress in their transition to more climate resilient, low carbon economies.

7.5.2.1.2 *Support to The Africa Commission's Energy Initiative (SEFA) (mitigation, 235 million DKK in 2019; 65 million in 2020)*

The purpose of SEFA is to provide financing through untied grants for technical assistance and investment activities in small/medium sustainable energy projects (encompassing Renewable Energy (RE) and Energy Efficiency (EE)) in Regional Member Countries, in order to stimulate local economic development and job creation. There are three main components of SEFA:

1. Component I (project preparation grants) seeks to support Bank lending to medium-sized RE and EE projects by financing the sponsors’ costs of project preparation from pre-feasibility to financial closure.

2. Component II (equity investments) will provide equity finance and technical assistance for project preparation and business operations through investment in a private equity fund.

3. Component III (public sector activities) will support activities, especially those of the public sector, that create an enabling environment for private investments in sustainable energy in Africa. SEFA will finance (a) institutional, policy and regulatory planning, development and reform and (b) public sector capacity building that enable or promote private sector sustainable energy investment and improve the public sector’s capacity to procure services.

7.5.2.1.3 *Support to the Global Infrastructure Facility (GIF) - Developing Climate Smart Infrastructure Projects (adaptation and mitigation, 75 million DKK)*

The primary objective of the GIF is to increase private investment, particularly long-term finance, in complex infrastructure projects. GIF activities are intended to contribute to the ultimate goals of poverty reduction and inclusive and sustainable growth via improved infrastructure in EMDEs.

The GIF pursued this objective by supporting EMDE governments in bringing high-quality infrastructure projects to market that have been structured with a view to enable the participation of a large number of private-sector investors. In addition to maintaining its "climate smart" eligibility requirement, GIF integrates best and emerging practices to mainstream climate considerations into project preparation activities to minimize carbon contribution and to maximize climate resiliency of EMDE infrastructure.

7.5.2.1.4 *Support to IRENA's SIDS Lighthouses Initiative (mitigation, 50 million DKK)*

The International Renewable Energy Agency (IRENA) supports participating SIDS with assistance in the green energy transition that will mitigate greenhouse gas emissions and strengthen resilience in SIDS' to climate change while improving their energy security. The Lighthouse Initiative therefore contributes to SIDS meeting their NDC targets and to the achievement of the SDGs.

Danish support seeks to: Accelerate the deployment of Renewable Energy (RE) technologies and innovation in RE technologies for SIDS; Develop institutional capacity to strengthen the enabling framework for RE and improve data and information; Strengthen partnerships for knowledge exchange.

7.5.2.1.5 *Danish Contribution to ESMAP 2020-2024 (mitigation, 90 million DKK)*

Denmark is a long-time supporter of the Energy Sector Management Assistance Programme (ESMAP), an assistance programme administered by the World Bank (WB). ESMAP provides analytical advisory services to low- and middle-income countries to reduce poverty and boost growth, through environmentally sustainable energy solutions.

ESMAP builds capacity in client countries through soft technology transfer and targeted technical assistance, knowledge generation and dissemination, pre-investment project preparation, and implementation support. ESMAP tackles questions related to energy in all its forms in both rural and urban settings. It influences billions in loans for development projects, leverages public and private financing, working with global agendas on energy and climate in country partnership programs and beyond. Practically, ESMAP works in every WB client country supporting improved energy sector performance and governance, enhancing access to modern energy services and technology, increasing the efficiency of energy use, and/or promoting renewable energy.

7.5.2.1.6 *Danish Contribution to the Least Developed Countries Fund (LDCF) (adaptation, 150 million DKK in 2019; 210 million DKK in 2020)*

The Least Developed Countries Fund (LDCF) supports the preparation and implementation of National Adaptation Programs of Action (NAPAs) and the National Adaptation Plans (NAPs). The LDCF plays an important role in the climate finance architecture by: a) piloting and demonstrating technologies, techniques, and business models for adaptation; b) supporting policy and strategy frameworks that enable and enhance adaptation and resilience mainstreaming; and c) identifying opportunities for scale-up through other sources of climate and development finance.

7.5.2.2 *Support to multilateral institutions with capacity building components*

7.5.2.2.1 *Support for SEforALL (mitigation)*

The UN initiative, SEforALL, seeks to enable universal access to sustainable energy, and thus the organisation targets SDG 7 (affordable clean energy), including the underlying targets of the goal concerning renewable energy and energy access and efficiency. The stated impact indicators are: (i) global population without access to electricity and clean cooking, (ii) rate of improvement of global energy intensity and (iii) rate of deployment of renewable energy. SEforALL aims to increase access to public and private finance in areas with great need for sustainable energy and is an example of Danish contribution to soft technology dissemination and capacity building through: (a) the creation of more enabling policy environments, (b) the faster scaling and replicating of innovative approaches and business models, and (c) the stronger alignment of country-level initiatives.

Danish contributions to SEforALL support the interventions stated in the SEforALL Workplan: (1) "Electricity for all in Africa"; (2) "Growing Big Markets for Clean Fuels"; (3) "Cooling for All"; (4) "Energizing Finance" and (5) "Gender and the People-Centered Accelerator".

7.5.2.2.2 *Support to the International Renewable Energy Agency (IRENA) (mitigation)*

The strategic objectives of the activity are: to support partner countries in their efforts to achieve low-carbon development, implement the Paris Agreement on Climate Change and realise NDCs; to meet SDG7 target 7.2 and 7.3 by 2030, to increase substantially the share of RE in the global energy mix and to double the global rate of improvement in EE; and to integrate climate change measures into national policies, strategies and planning.

Long-term planning and solid energy scenarios are key to ensuring the right policies and investments,which can speed up the transition to renewable energy. With a mandate from 158-member countries and the EU, IRENA encourages governments to adopt enabling policies for RE investments, provides practical tools and policy advice to accelerate RE deployment and EE, and facilitates knowledge sharing and technology transfer. The project focuses on long term planning, supported by activities producing regional analysis and energy transition system dynamics. The dissemination of this research, and the learnings from it, seek to inform and increased ambitions in RE/energy transition targets. Furthermore, the exchange of best practices among practitioners and policy makers forms an integral part of the project design.

7.5.2.2.3 *Support to the International Work Group for Indigenous Affairs (IWGIA) (adaptation, 8.35 million DKK)*

The World 2030 – Denmark's Strategy for Development Cooperation and Humanitarian Action states that Denmark continues to defend human rights, democracy and equal opportunities as a priority in itself. This endeavour is a precondition for leaving no one behind and achieving the SDGs. Indigenous People (IP) represent 5% of the world population but 15% of the world´s poorest. Promotion and protection of the rights of IPs is an important priority for Denmark working within the framework of the UN including as member of the Human Rights Council.

Danish support to the International Work Group for Indigenous Affairs (IWGIA) is comprised of four goals: Goal 1: Strong international and regional bodies; Goal 2: National policies, institutions and plans adequately account for IPs' rights to land and natural resources; Goal 3: IPs are organised and are claiming and exercising their rights at national, regional and international levels; Goal 4: Indigenous women and youth are actively involved in decision-making related to decisions affecting their lives. As a result, the support will result in the Nationally Determined Contributions of targeted countries referencing IPs' rights and recognising their role and knowledge in climate action.

7.5.2.3 *Bilateral support with both technology development and transfer and capacity building components*

7.5.2.3.1 *The Kenya Bilateral Programme (adaption and mitigation, 170 million DKK)*

Denmark supports a number of Development Engagements in Kenya focusing on both climate change adaptation and mitigation, with significant capacity building components throughout. The four Development Engagements are: 1) Development Through Sustainable Trade; 2) Green Employment in Agriculture; 3) Supporting Climate Technologies and Related Innovative Business Models; and 4) Northern Rangelands Trust: Resilient Communities and Natural Resources.

The Northern Rangelands Trust Development Engagement seeks to increase community resilience and adaptation to climate chnage through sustainable, peaceful use of natural resources. In doing so, project activities seek to build the capacity of communities and local and national government to enable sustainable rangeland, forest and marine managegement systems.

The Supporting Climate Technologies and Related Innovative Business Models Development Engagement seeks to increase the scale-up and uptake of climate solutions contributing to mitigation and adaptation by improving the enabling environment (through policy advocacy, research, access to finance and awareness creation) for innovative business models.

7.5.2.3.2 *Danish Energy Agency Energy Partnership Programme (DEPP) (mitigation, 97.5 million DKK)*

The Danish Energy Agency cooperates with the governments of a number of developing countries on capacity building and technology transfer related to sector energy transition to become a low-carbon economy. The cooperation is primarily focusing on policy improvements in long term energy planning and modeling, renewable energy integration and deployment, energy efficiency interventions and in climate change mitigation, and preparation of specific investments in renewable energy projects and technology transfer.

The "India-Denmark Energy Partnership (INDEP)" and “Danish Energy Partnership Programme III, INDODEPP” projects contain elements of both technology development and transfer and capacity building. The projects looks to build the capacity of the national governments with regards to renewable energy sector planning, integration and policy, while also providing access to Danish renewable energy technology solutions.

Through the development of a Danish-Indian knowledge centre for wind energy development in the country, the INDEP project represents funding for a 5-year partnership programme under the Climate Envelope for 2019. The support exemplifies soft technology transfer and capacity building activities through the development of management systems and tools to better enable the uptake of renewable energy technologies in India.

The support is based on Denmark's long-standing experience on energy transition away from a fossil fuel economy. Furthermore, DEPP builds on a well-tested government-to-government modality of cooperation exemplified through a Memorandum of Understanding outlining: Shared government goals for the cooperation; The provision of technical advisory support including from the DEA and the Danish power system operator; Wider access for counterparts to become acquainted with Danish experience, expertise and technology solutions; Daily programme presences, in-country, through Denmark's embassy and the posting of international Long-Term Advisors with key-partner institutions and; Wider anchoring of programme objectives and results through high-level participation in programme steering and high-level policy dialogues.

The DEPP projects are also part of the country partnerships under the DEA's Centre for Global Cooperation further described in Annex D2.

7.5.2.3.3 *Enabling Environment for Sustainable Energy in Georgia, 2020-2023 (mitigation, 15 million DKK)*

Here Denmark supports Georgia's energy sector reform toward achievement of SDG7 and SDG13 targets, NDC emission reduction goals, and alignment with EU energy market rules. The immediate objectives of the support are: The increased capacity of energy authorities to introduce sustainable energy in George; The provision of tools for long-term energy system planning and modelling and better forecasting technology to help integrate wind energy; Support regarding secondary legislation on appliances and eco-design and the use of experience in energy savings obligations schemes; The strengthening of the enabling environment for implementation of Georgia's green energy transition and related investments.

7.5.2.3.4 *Climate-Smart Agriculture and Market Development for Enhancing Livelihoods of Refugees and their Host Communities in Rwanda (adaptation, 5.4 million DKK)*

Building on the successful implementation of Misizi marshland project, the proposed replication of Misizi project model aims at improving livelihoods and self-reliance for more refugees and host communities, through facilitating access to arable land and agricultural inputs for market-oriented and climate-smart farming.

Danish support includes: The building of governmental and non-governmental capacities to plan and implement climate-smart agriculture activities; The identification of 2-3 feasible value chain in partnership with private sector partners/companies; The training and provision of Agricultural Extension services and business development advisory services; The transfer of productive assets (seeds / inputs / manure / irrigation).

7.5.2.3.5 *Strengthening the Resilience of the Populations of the Zinder Region to Climate Risks (adaptation, 10 million DKK)*

The overall objective of this project is to build the resilience of communities in Korama (Zinder Region) to climate change and natural disasters, and to ensure these communities are economically empowered through the creation of sustainable and meaningful employment opportunities by 2023. Through the provision of Early Warning Systems, Forecast-Based Action and Climate Risk Information Management Systems - alongside capacity building activities to enable the use of the tools and effective adaptation actions - the support exemplified the transfer of hard and soft technologies to enable climate change adaptation.

7.5.2.3.6 *Supporting Biodigester Sector for Green Jobs and Income Generation (adaptation, 9.8 million DKK)*

The overall objective of the project is that Nigerien Civil Society Organisations (CSOs), in partnership with local governments, promote green jobs and income generating activities and enhance the local adaptive capacity and climate resilience of the most climate vulnerable women and youth. The project aims to build capacity of local CSOs and Local Governments to implement locally-led, and gender-transformative adaptation planning. The support provides biodigesters, and the training to use them, to replace charcoal as a cooking fuel while producing an agricultural input enhancing the adaptive capacity of farmers.

7.5.2.4 Bilateral support with capacity building components

7.5.2.4.1 *Support to the Private Agriculture Sector Support Project (adaptation, 10 million DKK)*

Danish support to the Private Agricultural Sector Support (PASS) project will capitalise on the rapidly increasing mobile connectivity in Tanzania. By digitalising PASS products and processes, the project will contribute to significantly accelerate PASS' ability to reach large number of beneficiaries, including small-holder farmers, who will benefit from access to finance.

The project is closely aligned to the objectives of the Danish TechVelopment Initiative. Furthermore, the support will establish a Knowledge Hub (KH), a key avenue where PASS can create awareness on climate change and environmental challenges and notify and educate small holder farmers of green solutions, technologies and approaches, building their capacity to act in the face of change.

7.5.2.4.2 *Support to the Sahel Adaptive Social Protection Programme (adaptation, 40 million DKK)*

Danish support to the Sahel Adaptive Social Protection Programme (SASPP), Burkina Faso's safety net project would be able to reach additional households who are currently suffering from multiple shocks, including food insecurity and other climate related shocks. In addition to expanding payments to new beneficiaries, priorities include strengthening the capacity of the government to plan, implement and oversee adaptive social protection and putting in place the necessary delivery systems, including an early warning system, a social registry and a harmonized targeting methodology.

7.5.2.4.3 *Support for Disaster Risk Reduction in Lebanon (adaption, 20 million DKK)*

Danish support to the French Development Agency's intervention in Lebanon supports the further development of thenational disaster risk management strategy, which is identified as remaining limited in terms of coordination and territorial approach. The strategy builds the capacity of both governmental and non-governmental actors regarding Disaster Risk Reduction (DRR). In addition actors are supported to develop an efficient and replicable river basin Integrated Floord Risk Management model allowing local communities and municipalities to build their resilience and enhance their preparedness, response means and capacities against disasters.

7.5.2.4.4 *Support to Civil Society in Development (CISU): Climate action (adaptation and mitigation)*

Civil Society in Development (CISU) is an independent association with more than 270 Danish civil society organisation (CSO) members. It supports its members by providing training courses, advice, online guidance on all aspects of Civil Society work. Danida has delegated the administration of various funds including:

- Specific fund for environment and climate change actions
- the Civil Society Fund, a fund for Danish CSOs in partnership with CSOs in developing countries

The objective of the activity is to increase climate resilience, particularly for vulnerable and marginalized groups. This will be achieved through capacity building of Danish CSOs, partners, their members and target groups for climate action on the ground and for advocacy towards duty bearers to hold them to account on climate issues. This will be achieved through capacity building of Danish CSOs, partners, their members and target groups for climate action on the ground and for advocacy towards duty bearers to hold them to account on climate issues. To enhance and develop national and community-level climate change policies, planning frameworks and information systems – especially with a view to adaptation, and to increase Danish civil society organisations' capacity to work with climate capacity building and advocacy with partners.

An external review of the fund in 2017 concluded that there is a significant achievement of objectives across the projects supported by CISU. Results feature within advocacy, where projects have promoted the voice of the poor on a variety of environmental and climate challenges, though the actual changes resulting of the advocacy is not captured well by monitoring. Capacity building results are also prominent, for example in the form of enhanced ability of rights-holders to hold duty bearers to account in their constituencies. Strengthened CSOs including their partnerships, networks, target group involvement etc. is another result area.

7.5.2.4.5 *Support to Strategic Partnership Agreements with Danish Civil Society Organisations (adaption and mitigation)*

Through Strategic Partnership Agreements (SPAs) (formerly referred to as Framework Agreements), Denmark contributes to numerous Danish Civil Society

Organisations (CSOs) in four-year agreements. CSOs focused primarily on adaptation include: CARE Denmark, Danish Church Aid and Danish Red Cross. WWF pursue mitigation or cross-cutting targets, primarily relating to sustainable forests and their management in Myanmar and Uganda.

The Ministry of Foreign Affairs (MFA) establishes Strategic Partnerships with professional CSOs that have a focus on strategic alignment and results within Danish development and humanitarian priorities as outlined in the overall Danish Strategy for Development Cooperation and Humanitarian Action. Principally important for climate-related capacity building are those activities undertaken with support from the civil society development budget line of the Danish Finance Act ("Lot CIV" agreements). Lot CIV agreements aim to strengthen civil society in the global South so that it has the independence, space, diversity and capacity to influence and promote the realisation of the Sustainable Development Goals with a particular focus on pro-poor, marginalised and vulnerable groups. The objectives of projects under Lot CIV are:

- Capacity development processes that enable partners in the global South to effectively combat poverty, vulnerability, inequality, build community resilience, crisis preparedness and ability to adapt to climate change and build legitimacy, constituency and internal democracy, and accountability in organisations and movements;
- Promoting an enabling environment for civil society in the global South including i) basic legal guarantees such as the right to assembly, association and registration, ii) appropriate measures for CSOs' financial viability and sustainability and iii) appropriate spaces for participation in local, national and international decision-making processes;
- Global, regional and local advocacy efforts which involve and empower relevant local civil society actors and are informed by evidence and based on knowledge of the processes and stakeholders that need to be influenced. Such efforts include holding duty bearers accountable for implementing the SDGs in priority countries as well as at the global level;
- Strategic service delivery designed to reinforce advocacy, legitimacy of partners in the global South, innovation, learning, and capacity development of change agents and partner organisations in relation to the promotion of the SDGs.

7.5.2.4.6 *Support to Innovative and Gender-sensitive Nature-based Solutions for Resilience and Green Jobs (adaptation, 10 million DKK)*

Focusing on the Rwenzori Mountains in western Uganda, this project will raise awareness of climate change and support communities to restore degraded watersheds and forests prone to climate related flooding and landslides. Communities will be trained in sustainable natural resource management to support their livelihoods. Selected women and youth will receive vocational training and be connected to employers offering green jobs – for example, in sustainable timber production. Local community enterprises, such as those focusing on timber and honey, will be trained and connected to markets to support their growth.

The overall objective of this project is to create and scale green jobs by applying a Nature based Solutions (NbS) approach at a landscape level to harness nature's immense potential to provide for communities' well-being, hereby enhancing their resilience to climate change in the Rwenzori Mountains in western Uganda. Capacity building support focuses on increasing the population's awareness of climate change and available adaptation activities, and through the provision of sustainable resource management training.

7.5.2.5 *Support to engage the private sector in technology development and transfer and capacity building activities*

Alongside select examples of Danish support to multilateral institutions to promote technology development and transfer and capacity building (such as the support to the CTCN, SEFA and IRENA), and which engage the private sector in doing so, the below section provide further examples of Danish support engaging private actors towards these objectives.

7.5.2.5.1 *Support to the Investment Fund for Developing Countries (IFU) High Risk - High Impact Investment in Africa and Climate Investor 2 (adaptation and mitigation, 150 million DKK)*

Denmark's 200 million DKK capitalisation of IFU for the development of its High Risk – High Impact initiative focuses on investments with high development impact in the Least Developed Countries in Africa, where the Danida support allows IFU to take higher risk and have a lower expectation for returns.

In addition, IFU's Climate Investor 2 project, with a financial commitment of 50 million DKK, responds to the large share of the population in developing countries with no or inadequate access to safe water and sanitation. Inadequate water and sanitation systems at all levels in developing countries have a great negative impact on social and economic development, stability and quality of life. The requirements to address these challenges are very demanding in terms of financing, technical capacity, governance and management. A key purpose of Climate Investor 2 is to make use of blended finance, using public funds as leverage for the mobilisation of private capital, technology and know-how of relevance to water and sanitation sectors.

7.5.2.5.2 *Support Beyond the Grid Fund for Africa (BGFA) (mitigation, 37.5 million DKK)*

The Beyond the Grid Fund for Africa (BGFA) aims to incentivize the private off-grid energy enterprises to provide energy access to underserved people in rural and peri-urban areas in Sub-Saharan African countries. This will be done by offering financial incentives to selected private companies to provide high quality and affordable energy services to regions outside the grid. The Danish support to BGFA will support the Uganda window and seek to increase access to primarily off-grid solar home systems. In addition, a Danish priority will be to support technical skills development for the off-grid solar sector in Uganda.

7.5.2.5.3 *Support to The African Guarantee Fund (adaptation and mitigation, 30 million DKK)*

Micro, small and medium-sized enterprises (MSMVs) are the cornerstone of the African economies. This is where local innovation, job creation, green transformation, etc. takes place, but the companies' growth potential is severely limited by insufficient access to loans for necessary investments.

It is estimated that about half of the estimated 44 million formal African MSMVs lack access to loan capital to operate and grow. This is because the banks consider the risk of loans to companies to be too high. The AGF plays a crucial role in providing loan guarantees to African banks so that they can invest and create jobs supporting the green transition and mitigation and adaptation action. The AGF is able to leverage its guaranteed capital by a factor of 8. AGF has guarantee agreements with 160 banks and financial institutions in 40 African countries.

7.5.2.5.4 *Support to The External Investment Plan (EIP) of the European Fund for Sustainable Development (EFSD) (adaptation and mitigation, 75 million DKK)*

The level of investment in many African countries is insufficient to support a sustainable and inclusive growth trajectory, which can ensure employment and income opportunities of a growing labour force. The mobilisation of private capital, technology, and knowhow for SDG investments across Africa is marginal due to a challenging risk-return balance on investments and limited market knowledge. Through the External Investment Plan/European Fund for Sustainable Development, Denmark uses ODA to mobilize private capital, knowhow and technology to have a significant impact on employment generation, reduction of greenhouse gas emission, food production, infrastructure availability, and tax contribution.

7.6 Information under Articles 10 and 11 of the Kyoto Protocol

The steps taken by Denmark to promote, facilitate and finance the transfer of technology to developing countries and to build their capacity described in sections 7.1-7.5 above concern both the UNFCCC and the Kyoto Protocol.

8

RESEARCH AND SYSTEMATIC OBSERVATION

Contents

8 Research and systematic observation

8.1 Climate research and observations in general

Research and observations within climate in the broad sense of the word are going on at a number of institutes and organisations and cover a wide range of disciplines, from natural science to evaluation of policies and measures and societal aspects.

The Danish Meteorological Institute (DMI) carries out observations of climate parameters (atmosphere and ocean) under the World Meteorological Organisation's (WMO) programmes and sub-programmes: the World Weather Watch Programme (WWW), Global Atmosphere Watch (GAW), the Global Observing System (GOS), the Global Climate Observing System (GCOS) and the Global Ocean Observing System (GOOS). DMI also participates in the Network for the Detection of Atmospheric Composition Change (NDACC). Climate monitoring and research has been a key task for DMI for 150 years.

Aarhus University (AU) is part of the Integrated Carbon Observation System (ICOS) monitoring greenhouse gas emissions and concentrations and the Aerosol, Clouds and Trace Gases Research Infrastructure (ACTRIS) providing data on short-lived atmospheric constituents. DCE – the National Centre for Environment and Energy, Aarhus University (AU) is in charge of monitoring the effects of climate change on nature and the environment.

The Technical University of Denmark (DTU) is a founding member and national contact point of the European Climate Research Alliance (ECRA). Denmark is currently active in ECRA's collaborative programmes via DMI (polar research) and DTU (programmes on sea level, hydrology and high impact events, where DTU coordinates the latter). DTU (Space) monitors a significant number of essential climate variables with respect to, in particular, sea ice, sea level, ice sheets, the state of the ocean and large-scale hydrological systems using remote sensing and participates in a large number of international initiatives in this regard.

KU have taken charge of the Danish parts of the three European research infrastructures: Analysis and experimentation on ecosystems (ANAEE), Long Term Ecological Research (LTER) and Integrated Carbon Observation System (ICOS).

Danish research competence concerning the physical expressions of past climate change is particularly at the Geological Survey of Denmark and Greenland (GEUS), the University of Copenhagen (KU) and Aarhus University (AU). GEUS also has competencies in glaciological studies of the Greenland ice sheet and the ice sheet's interaction with climate change, and in the effect of climate change on the water cycle in nature. The Geophysical Department and the Geological Institute at KU and the Department of Ecoscience at AU have very great expertise in palaeoclimate data, and the climate group at KU is known worldwide for its ice core drilling and analyses. The departments of Bioscience and Environmental Science at AU and Department of Biology at KU contribute important research competence in relation to the effect of climate change on ecosystems.

The National Centre for Climate Research at DMI has an extensive international scientific record within regional climate modelling and is the leading national authority on regional climate change projections. Data and knowledge about the future climate in Denmark is presented in the Danish Climate Atlas[1]. The National Centre for Climate Research also operates global climate models in order to investigate interactions and feedback mechanisms between atmosphere, ocean, land surface and ice on a larger scale. In addition to a special focus on the climate in the Kingdom of Denmark, the modelling efforts have a particular focus on the North Atlantic and the polar regions. Several other Danish institutions, notably KU, AU, GEUS and the Technical University of Denmark (DTU) also work in this field or with different aspects of climate research. The Ministry of Science, Technology and Innovation, the Coordination Unit for Research in Climate Change Adaptation and the Ministry of Climate and Energy, published in 2009 a Mapping of Climate Research in Denmark[2].

It is partly on the basis of research competencies in the above areas that Denmark also participates actively in the work of the Intergovernmental Panel on Climate Change (IPCC). Denmark has contributed to IPCC work, for example through contributions to all six Assessment Reports. Experts from several Danish universities and institutions, including DTU, KU, AU, Aalborg University (AAU), Copenhagen Business School (CBS), DMI and GEUS have contributed to Special Reports and Working Group contributions in the IPCC 6th Assessment Cycle. DMI has the role of National Focal Point for Denmark to the IPCC.

Danish research contributes to all six core projects under the World Climate Research Programme: the Climate and Cryosphere (CliC), Climate Variability and Predictability (CLIVAR), Earth System Modelling and Observations (ESMO), the Global Energy and Water Cycle Experiment (GEWEX), Regional Information to Society (RifS) and Stratospheric Processes and their Role in Climate (SPARC).

Danish Centre for Energy and Environment (DCE) – Aarhus University, the Greenland Institute of Natural Resources (GINR) and Asiaq, Greenland Survey are in charge of monitoring the effect of climate change on nature and the environment in Greenland. Greenland Ecosystem Monitoring (GEM) constitutes the main monitoring programme on ecosystems and climate change in Greenland. GEM covers marine, terrestrial, limnic, atmospheric and glacial components of different monitoring sites in Greenland, which also operate as key sites for climate research. The GINR conducts research into Arctic ecosystems and how they are affected by climatic and human impacts. The GINR also monitors the living resources and the environment in Greenland and advises the Government of Greenland and other authorities on sustainable exploitation of living resources and safeguarding the environment and biodiversity.

At Aarhus University, the Interdisciplinary Centre for Climate Change (iCLIMATE) promotes interdisciplinary research aimed at understanding the climate system,

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[1] https://www.dmi.dk/klimaatlas/

[2] *The Ministry of Science, Technology and Innovation, Coordination Unit for Research in Climate Change Adaptation and the Ministry of Climate and Energy, 2009:* Mapping of Climate Research in Denmark (in Danish).

climate change, and human-climate interactions and providing services and solutions to the private and public sectors.

A webportal, Isaaffik Arctic Gateway (isaaffik.org), was established in 2015 in order to facilitate arctic scientific collaboration. It presents an overview of current and future expeditions, research projects and courses. Among other, it enables researchers and institutions to coordinate logistics, which are often costly parts of projects in the Arctic.

In the Faroe Islands, research related to climate and climate changes is primarily conducted on the Faroe Marine Research Institute but also on the Faroe Islands' National Museum and the University of the Faroe Islands. The Faroese Marine Research Institute is also responsible for a series of systematic ocean climate observing systems. Other institutions, The Road Authority and the Faroese Meteorological Office are as well responsible for some systematic climate observations.

8.2 RESEARCH

8.2.1 Research policy and funding

Climate-related research in Denmark has grown within an already existing framework of institutional activities. Danish climate research was mapped in 2009. The mapping showed the picture of a relatively small research field with a strong international position. In an international perspective, Danish climate research has extensive publication activity compared with the rest of the world, and in addition it has significant impact in terms of the number of citations received. The mapping showed that Danish ice core research and palaeoclimatology research are particularly visible in the international context.

In June 2017, the Danish Agency for Science and Higher Education published the research catalogue RESEARCH2025[3]. The objective of the RESEARCH2025-catalogue is to provide a consolidated overview showing the most important research areas of the future as seen from the perspectives of businesses, organisations, ministries, Danish knowledge institutions as well as a wide variety of other stakeholders.

The RESEARCH2025-catalogue will function as a source of inspiration and knowledge and as a basis for prioritizing research investments in various contexts such as political negotiations of the distribution of the research reserve, strategic considerations at Danish knowledge institutions and in relation to Danish participation in international research cooperation.

The catalogue is the result of an extensive mapping and dialogue process and focuses on the research needs within four main areas (1. New technological opportunities, 2. Green growth, 3. Better health and 4. People and society) and 19 different subthemes. The objectives and perspectives for the theme on 'Climate change and adaptation' is the need for research that can strengthen the knowledge base to make decisions in a number of areas of society. The research must create more solid and detailed knowledge about climate processes and changes as well as the effects of climate change. Together with new forms of organization, management tools and financing models this could support climate mitigation and adaptation efforts. The

[3] https://ufm.dk/publikationer/2017/forsk2025-fremtidens-lofterige-forskningsomrader

effort could also support Denmark’s participation in international cooperation activities on climate change, including in connection with knowledge-based international regulation and its implementation. The research should contribute to the development of new, innovative technologies and products in business and robust solutions for the society that addresses the challenges created by a changing climate. The research could address development of new technologies, efficient planning and adaptation within areas such as new crops, water systems, coastal protection, sewerage, construction and construction, fishing, aquaculture, energy, etc. in relation to Denmark's adaptation to climate change. For the arctic parts of the realm, also shipping, tourism and mineral extraction can be added. New innovative solutions and services in the field of climate adaptation are globally sought after and could contribute to Danish exports.

The Innovation Fund Denmark participates (from 2016 as observer) in the European Joint Programming Initiative ‘JPI Climate – Connecting Climate Knowledge in Europe’[4]; an initiative to coordinate and align European research programmes within the area. Denmark is also participating in the extensive 18M ERA4CS Co-Fund action on climate services[5], which was recently initiated, with 5 projects (DTU participates in 2, GEUS, DMI, KU, AU each in one).

In the Faroe Islands, a number of institutions participate in research related to climate and climate changes.

Climate-related research in Denmark, Greenland and the Faroe Islands is described in detail in the following sections.

8.2.2 Climate processes and studies including palaeoclimatic studies

8.2.2.1 DMI

The National Centre for Climate Research at DMI carries out research on atmospheric, oceanic and cryospheric processes and their interactions, all of which are important in connection with global climate change. These process studies also include assessments of natural atmospheric-oceanic-cryospheric interplay on time scales from years to decades, laying the foundation for climate predictions for the coming years. Inhere, ocean circulation processes in the North Atlantic are a particular focus. DMI has developed an Earth System Model that includes a fully interactive ice sheet model which responds to climate variations, and thereby incorporates calculation of how meltwater from the ice sheets may affect the ocean circulation. DMI further uses high-resolution regional modelling over the ice sheets to study the snow and firn processes governing the surface mass balance of the Greenland and Antarctic ice sheets.

DMI works with paleaeoclimate perspectives mainly through ice sheet, regional, and global climate modelling studies, supplemented by statistical methods for reconstructing past climate from proxy data.

8.2.2.2 University of Copenhagen

The Physics of Ice, Climate and Earth (PICE) Department at the Niels Bohr Institute at the University of Copenhagen is strongly involved in studies of climate processes in the research fields of climate, meteorology, oceanography and glaciology. The research

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[4] http://www.jpi-climate.eu/home
[5] http://www.jpi-climate.eu/ERA4CS

includes development of atmosphere and earth-system models to understand the large-scale dynamics of the atmosphere, mapping the natural and anthropogenic climate change and variability, understanding and reducing uncertainty in climate projections, studies of local scale extreme event attribution, studies of how ocean processes contribute to the large climate fluctuations and evolution of the ice sheets and sea level rise. Through drilling deep ice cores through the Greenland ice sheet, palaeo-records of past temperatures, precipitation, greenhouse gas concentrations, solar irradiance, impurities and volcanic eruptions are measured and models are applied to the research subjects listed above with the objective of understanding the governing processes of past and future climate.

Department of Geoscience and Natural Resource Management has through the combined use of field investigations and theoretical modelling of paleoclimate and oceanography expertise to reconstruct past Earth systems and build projections for future environmental change.

8.2.2.3 Technical University of Denmark (DTU)

At DTU studies on climate-processes are mostly focused on wind and precipitation, hydrological systems, changes in marine environments, as well as ice sheet and sea ice dynamics.

8.2.2.4 University of Southern Denmark

Research in climate processes and palaeoclimatic topics is primarily carried out at the Faculty of Science – Department of Biology, within the research group Nordcee and the Danish Center for Hadal Research – HADAL (Center of Excellence).

The research focus is on ocean system science (where some of the work is focused in the Arctic) within topics such as:

- Microbes and element cycles, including for example freshwater & marine sediment biogeochemistry, nitrogen cycle, recycling versus loss in the marine N cycle, and the carbon cycle. Deep-Sea Research (HADAL), including for example transport of particulate matter / marine snow, microbial and viral genomics, and pollutants (https://www.nordcee.dk/greenhouse-gases).
- Co-evolution of Life and Earth, including for example trace metals, biomarkers, and eukaryogenesis.
- Oxygen, including for example oxygen minimum zones, oxygen control on N-cycle and CH4-cycle, oxygen control on sedimentary and benthic community structure.
- Greenhouse gases and climate, including for example microbial diversity, physiology and cultivation, in situ incubation technology, and methane. Sustainability and biotechnology, including for example marine geoengineering, natured based solutions to climate change, electro microbiology, and bioremediation.

8.2.2.5 GEUS

GEUS carries out studies of climate processes related to for example the hydrological system, the cryosphere, ocean and atmosphere circulation, and biodiversity based on present and paleoclimate data as well as modelling.

GEUS studies the effects of climate change in the hydrological cycle, especially in relation to groundwater conditions and the interaction with surface water. The effects of heavy rain and higher temperature on groundwater formation and the quality of the water are addressed in relation to the environment and the drinking water supply. Also the occurrence of flooding and salt water intrusion is studied.

A key research topic at GEUS is the study of mass balance and dynamics of the Greenland ice sheet, including its interaction with climate change and effect on changes in sea level and interaction with ocean circulation variability. This includes the effects of surface albedo variability and refreezing of melted ice on freshwater run-off and the freshwater flux to the fjords and oceans from the ice sheet are measured and evaluated.

GEUS works with reconstructing longer term records of climate and environmental change based on sediment cores in order to assess the magnitude of current changes in the Arctic. Furthermore, the aim is to better understand the complex interactions between the climate, oceans, sea-ice, and the Greenland Ice Sheet. Specifically, GEUS researchers analyse sediment archives from marine and lake environments using sedimentological, biogeochemical, and microfossil proxies to reconstruct past changes in temperature, salinity, ocean current strength, glacier activity, meltwater and freshwater dynamics, sea-ice variability, nutrient status, and primary productivity.

GEUS further studies the development of the coastal regions and their responses to the rapid Holocene sea level rise. These studies provide input to assessments and modelling of the coastal responses to coming sea level changes thus forming part of the science fundament for mitigation of climate changes.

Further, GEUS has mapped and estimated the geothermal energy resources in the Danish subsurface in order to facilitate the utilisation of this renewable energy source. GEUS provides data and advices for the relevant authorities at municipal and national level, as well as consultancy advices to the exploration and exploitation industry.

8.2.2.6 Aarhus University

AU studies the forcing and drivers of the climate system from anthropogenic and natural origins at global, regional and national scales. This includes also the feedback mechanisms that accelerate Arctic warming and the interaction between Arctic and global climate change. The research combines direct in-situ measurements, obtaining and interpreting palaeoclimatic proxies and regional- to global-scale modelling to study greenhouse gases and the processes driving the exchange of gases between the atmosphere and the ecosystems in the oceans, ice and on land; the processes related to transport and chemical transformation of gases and aerosols; and the interaction between changes in ocean-atmosphere and cryosphere.

AU is carrying out research in how, since the last Ice Age, climate change has affected the biological structure of North Atlantic lakes in Greenland, Iceland and the Faroe Islands. Paleolimnological methods are being used to develop projection models.

8.2.2.7 Greenland Institute of Natural Resources (GINR)

GINR houses the Greenland Climate Research Centre, through which most of the monitoring and research on effects of climate changes on the marine habitat is carried out.

GINR investigates marine climate changes and the effects of variability in sea ice cover and temperature-salinity gradients over the past 10.000 years by analysing phytoplankton shells in seabed sediments along West and East Greenland.

GINR is co-leading an interdisciplinary research project using both natural and social sciences to analyse and improve our understanding of long-term climate variability in Greenland. The project is exploring the links between variations in past sea ice, climate conditions, changing environments and Arctic human communities. The links between human activities and changing environments, and sea ice are used to describe settlement patterns in the Nuup Kangerlua. Additionally, through human responses to environmental change, socio-economic patterns may reciprocally be used, supplemented and discussed through the perspective of the natural science, e.g. by understanding sea-ice conditions and changing fjord environments. Here, emphasizing that understanding climate change requires an interdisciplinary perspective is increasingly important. The project provides a detailed reconstruction of changes in climate, environment and sea-ice cover in the inner part of the Nuup Kangerlua.

Climatic records covering the last 5000 years will be constructed, with special focus on the past 1000 years. Investigations are based on marine geological surveys, oceanographic studies, including studies of the rapid changes in relative sea level, variations in the distribution and thickness of sea ice, dynamics of the tidewater glacier, KNS and the general impact of changes on the ocean circulation.

8.2.3 Climate modelling and the climate of the future

8.2.3.1 DMI

DMI is working closely together with research institutions in Europe on analyses of the climatic consequences of an increased greenhouse effect. The main emphasis is on Denmark and the European region, as well as the Arctic, but global research is also being carried out. The funding stems both from the Danish state through the National Centre for Climate Research (NCKF) and from research grants, e.g. from the European Union.

The work includes both development and employment of models for scenario calculations of the climate of the future. The models include:

- Regional dynamic ocean models for calculating changes in ocean and sea ice. The focus areas are the North Sea, the Baltic Sea, Greenland waters, and the Arctic Ocean.
- A regional dynamic atmosphere-climate model for calculating regional/local climate change and variations. The main focus has been on Denmark, Europe, and Greenland, with applications also in Arctic regions, West Africa and India.
- Global Earth System modelling: dynamically coupled models of the atmosphere, ocean, sea-ice, and ice sheets, which are used to study climate change (primarily as a consequence of increased greenhouse effect) and internal variability in the climate on decadal to centennial time scale.
- State-of-the-art models of the surface of the ice sheets, integrated with both global and detailed regional climate models, are used for comprehensive studies of ice mass changes, e.g. applied to study the changes of the Greenland and Antarctic ice sheets in the past, present and future.

Regional climate simulations, currently with resolution down to kilometre-scale, are carried out in connection with national, European and international projects, covering Europe in particular, but also Antarctica, Greenland and the wider Arctic.

With regard to regional simulations, the most important focus areas for Denmark are changes in (extreme) precipitation, drought, and extreme temperatures. These simulations lay the foundation for the Danish Climate Atlas[6] that shares data and information on the future Danish climate with stakeholders and the wider public. For Greenland, changes in simulated snow accumulation, melting and refreezing on the ice sheet are of special interest.

Output from the regional model simulations are made available to all groups of researchers who are studying the effects of climate change, and to decision makers taking part in planning and implementation of adaptation to climate change. DMI contributes to the WCRP CORDEX projects, and hosts and shares climate model data within the so-called ESGF nework. These data are accessible to researchers across the world as well as the general public, and are used as a basis for the assement reports from the UN Intergovernmental Panel Climate Change (IPCC).

8.2.3.2 University of Copenhagen

Research at the Department of Geoscience and Natural Resource Management, the Department of Biology and the Department of Plant and Environmental Sciences at the University of Copenhagen includes experimental/field-related, theoretical, and modelling aspects of vegetation and greenhouse gas emissions and helps to understand how future climate will change.

Researchers at Department of Biology develop process-based ecosystem models by integrating observational patterns from laboratory and field studies and use the developed models to quantify how changes in land ecosystems influence the climate system. Ongoing activities also aim to fully couple vegetation dynamics and plant-emitted volatiles with atmospheric chemistry in order to narrow down model uncertainties in predicting future changes in aerosol and methane concentrations in the atmosphere.

At Department of Geoscience and Natural Resource Management researchers have focus on climatic feedbacks from changes in radiation- , greenhouse gas- and water-balances both in the Arctic and at lower latitudes. At Department of Plant and Environmental Sciences the multi-disciplinary agro-ecological computer model DAISY is developed and used to simulate climate change effects on crop growth, carbon balances, water and nitrogen balances, and the fate of some pollutants such as pesticides.

At the Niels Bohr Institute, the PICE researchers develop atmosphere circulation models, Earth system models and state-of-the-art ice-sheet models to predict the changes in the Arctic regions and how they will influence global and regional sea level rise. The research is done in collaboration with GEUS and DMI and is partly funded by EU framework programmes.

8.2.3.3 Aarhus University

Climate modelling at AU ranges from global to regional scales and focuses both on the physical climate system with a special emphasis on the Arctic and on the interactions between climate, aerosols and atmospheric chemistry. In concert with the monitoring activities, AU develops the model components describing these interactions.

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[6] https://www.dmi.dk/klimaatlas/

Furthermore, climate modelling at AU also aims at understanding the role solar variations play for climate variability.

8.2.3.4 Technical University of Denmark (DTU)

There is at DTU a strong focus on integrated modeling of coastal, pluvial, and fluvial flooding events. As well as on wind systems and hydro-meteorological extremes i.e., droughts.

8.2.3.5 University of Southern Denmark

Research in climate modelling and the climate of the future is primarily carried out at the Faculty of Science, within the research group Nordcee and the Danish Center for Hadal Research – HADAL (Center of Excellence).

The research focus is on Integration and upgrading of oceanic biogeochemical processes into global climate models.

8.2.4 Effects of climate change

The effects of climate change on nature and ecosystems are covered by research at DMI, GEUS, The University of Copenhagen, Aarhus University, The Technical University of Denmark, Greenland Institute of Natural Resources and The Danish Coastal Authority.

8.2.4.1 Aarhus University (AU)

AU is working on the effects of climate change, especially in Greenland, and it is carrying out a standardised biological/ecological monitoring programme covering a broad spectrum of processes, fauna, and flora. In connection with this project, the institute is carrying out research projects aimed at increasing knowledge of basic Arctic ecosystems. These include a strong focus also on physical drivers and feed-back mechanisms like snow modelling and research in the energy- and carbon balance of Arctic ecosystems.

AU is running the High Arctic Zackenberg Research Station, an ecosystem research and monitoring facility in Northeast Greenland (74º28’ N). Zackenberg is owned by the Government of Greenland and is operated by the Department of Bioscience, Aarhus University. The work at Zackenberg is coordinated through the Zackenberg Ecological Research Operations programme with the following institutions as partners: the Department of Bioscience at Aarhus University, Greenland Institute of Natural Resources, the University of Copenhagen, Asiaq - Greenland Survey and the Geological Survey of Denmark and Greenland. The station enables increased research in high-Arctic ice and permafrost as well as the effect of climate change on the high-Arctic sea, air, geology, animals and plants.

AU has since 2014 been running the Villum Research Station at the military outpost Station Nord in high arctic North Greenland (81°36’ N, 16°40’ W). Villum Research Station is owned by the Greenland Government and is being operated by AU in cooperation with the Danish Defense (the Arctic Command). The station hosts individual scientific projects focusing on atmospheric, marine and terrestrial research. In addition to this, the station is also used as a permanent base for an extensive long-term monitoring programme with main focus on atmospheric pollution, but also including effects of Climate Change on arctic marine and terrestrial ecosystems.

The station is open for access throughout the year, and it can host up to 14 scientists at a time.

AU is carrying out research in the effect of climate change on biodiversity and function of the soil environment, in laboratory as well as field conditions. Work includes genetic variations in soil-living fauna, and the fauna's physiological adaptation to extreme climate conditions. AU has research competences concerning tolerance limits for air pollution for particularly sensitive terrestrial ecosystems. In particular, the interaction between climate change, chemical substances and other factors are investigated.

AU has built up competence focused on the function and dynamics of the Arctic marine ecosystem and it is investigating an Arctic fjord system and, within this, relationships between production and nutrient conversion.

Within freshwater, AU has research competence concerning the effect of climate change on nutrient degradation and biological interaction in watercourses and lakes. Studies are being carried out for instance in Arctic, temperate and subtropical lakes, where biological interaction is being studied along climate gradients. Experimental studies are carried out at an advanced test plant at Silkeborg. Models are developed as tools of projection of nutrient transport as well as effects on freshwater ecosystems.

AU is working with climate-change effects across climatic gradients, analyzing, modelling and comparing climate effects at different spatial and temporal levels using an interdisciplinary approach.

AU is doing research on the interactions between climate change and air pollution, including the importance for transport of pollutants such as POP and mercury to the Arctic.

AU is carrying out research on the effects of climate change on marine ecosystems, studying how marine Arctic as well as European ecosystems respond to climate change, in terms of both biodiversity changes and ecosystem structure and function.

AU works with the interaction of climate and agriculture, including effects of climate and atmospheric CO_2 on processes in the soil-plant system. This includes research on how climate change and CO2 affects photosynthesis and crop yields. The research includes both experimental and model based studies. The experimental studies are mostly conducted in controlled environments. A range of crop models are used for studying effects of climate changes on crops and livestock systems. Also, monitoring and experimental data are used in statistical analyses to explore crop-climate interactions. This research is mostly conducted in an international collaboration as part of the European MACSUR knowledge hub and the global AgMIP project. In addition AU has ongoing research collaborations with research institutes in China, Iran, Ghana and Tanzania involving assessments of climate change impacts on agriculture.

The recently started Pioneer center Land-CRAFT (Center for Landscape Research in Sustainable Agricultural Futures) adds to these activities with studies focusing on effects climate change on agriculture using a combination of landscape experimentation, remote sensing information and biogeochemical modelling. Land-CRAFT aims at developing concepts for climate change adaptation, while maintaining productivity and mitigating GHG emissions from the agricultural sector.

8.2.4.2 GEUS

GEUS has competence concerning long-term variations and effects in ecosystems in Denmark and Greenland and on the Faroe Islands caused by the climate. The institute is investigating how the ecosystems react to climate change in vegetation, lakes and marine environments in Denmark and Greenland and in forests in Scandinavia. It also registers changes in sea level and their effect on the water cycle, and conduct research regarding coastal responses to sea level changes.

The formation of groundwater and the effects of climate change on this important resource is being covered by GEUS in several studies. The studies of the hydrological cycle include expected changes in groundwater levels and saline intrusion in the groundwater as well as changes in river discharges and water levels.

Studies have been carried out on the effects of climate change on flooding of urban areas from rivers in Denmark as well as studies of the effects of climate change on pesticide leaching and transport in groundwater and surface water.

Studies of the permafrost in Greenland focus on the consequences of the thawing on the Arctic ecosystems and the mobilization of potentially huge amounts of carbon and nitrogen and release of greenhouse gases.

In the summer of 2017, a natural disaster occurred in Greenland, when a large landslide triggered a tsunami that affected several settlements. As a consequence of this studies of the impact of climate change on bedrock permafrost were initiated as well as studies of the connection between large land slides and climate.

GEUS also works with long-term surveillance of Danish natural woodlands (non-intervention forest reserves), including trees, regeneration, pollen deposition, flora and soil conditions. The studies were initiated in 1948.

8.2.4.3 Technical University of Denmark (DTU)

DTU is widely engaged in research on the environmental and socio-economic effects of climate change events, such as changes in coastal, pluvial, and fluvial flooding due to increasing precipitation extremes and ris-ing sea levels. There is a general focus on adaptation, mitigation, and emergency management, and on the challenges/effectiveness of different policies and renewable energy sources (e.g., wind- and hydropower). DTU has developed a detailed GIS based flood hazard damage cost open source model, which is very widely used in research and in decision making for climate change adaptation.

8.2.4.4 DMI

DMI is hosting the Danish Climate Atlas[7] providing geographically detailed climate change information for planning of adaption and impact modelling. Internationally, the National Centre for Climate Research is a leading contributor to the Baltic Earth Assessment Reports, a project assessing the state-of-the-art knowledge on climate change in the Baltic Sea region, thereby informing e.g. climate adaption in the entire region.

DMI is an active partner in several projects under the COPERNICUS initiative, contribution to the publicly accessible "Climate Data Store". DMI participates in production of regional simulations, development of climate indices and data for storm surge and waves, and in the construction of guidance for users.

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[7] https://www.dmi.dk/klimaatlas/

8.2.4.5 University of Copenhagen (KU)

The effects of climate change on natural and managed ecosystems have a high priority at KU. The research takes advantage of numerous large-scale in-situ infrastructures including long-term experiments, particularly in forests such as an EU-funded infrastructure of climate change manipulation experiments and climate gradients (INCREASE and ANAEE).

Furthermore, the Department of Biology (BIO) and the Department of Geosciences and Natural Resource Management (IGN) have a number of climate manipulation experiments in Abisko (Sweden), Disko and Zackenberg (Greenland), and tropical systems (Costa Rica and Peru) and in Denmark. The research comprises biological processes, ecosystem functioning, organism interactions, biodiversity, exchanges of gasses between land, water and the atmosphere, carbon and nutrient cycling and adaptation of processes and ecosystems to extreme climate conditions and moderate changes. KU is a partner in Greenland Ecosystem Monitoring (www.g-e-m.dk) and delivers together with AU essential inputs to a large database.

KU has competences from both managed and natural terrestrial and aquatic ecosystems, working at scales from molecules to landscape and at different temporal scales. Importantly, KU owns and operates Arctic Station (Disko), which dates back to 1906 but has just been renovated for DKK 18 mill. The station is essential for KU researchers and students (several field courses are performed there every year) as well as function as an international research infrastructure that brings scientists from everywhere to study climate changes.

BIO performs extensive work on climate change effects on plant-atmosphere and plant-soil-microbe interactions, making use of long-term ecosystem manipulation infrastructure as warming, CO_2 enrichment and altered nutrient input and precipitation patterns, mainly in the Arctic but also in temperate and tropical ecosystems. The experimental work spans from physiological processes at fine root and leaf levels to plot and ecosystem scales, and includes work on greenhouse gas emissions, volatile organic compound emissions, nutrient cycling, interactions across trophic scales and vegetation responses. The work also includes upscaling site-level data to regional scale and quantifying ecosystem bio geophysical and biogeochemical feedbacks on the changing climate based on mechanistic modelling.

IGN at the University of Copenhagen is doing research on soil-forming processes in relation to climate and vegetation that are of significance for, amongst other things, the exchange of greenhouse gases between soil and the atmosphere. This is performed on the basis of a wide range of ecological and climatic regions from processes in the Arctic areas, Danish sites and tropical sites e.g. in Africa. At the Center for Permafrost (CENPERM) different scientific disciplines meet to investigate the biological, geographical and physical effects of climate changes with a focus on interacting soil, plant and microbial processes in Greenland and the effects on greenhouse gas exchange as well as carbon and nitrogen budgets. CENPERM combines field experiments in Greenland, Svalbard, northern Sweden and Russia under extreme conditions with experiments under controlled conditions in our laboratories at University of Copenhagen.

Both IGN and BIO also carry out research on the impact on ecosystem function and structure of changed climate and potential for adaptation and mitigation based on management of forests, heathlands and nature areas, changes in plant diseases and invasive species. This includes research in genetic aspects of adaptation and development, and include observations from long-term field experiements (since 1852).

This is further supported by the cooperation, including forest monitoring, performed for the Ministry of the Environment.

IGN and BIO carry out studies of the impact of recent climate change on vegetation productivity at global scale, making extensive use of Earth Observation satellite data. There is also ongoing work exploring the impacts of human-induced changes on terrestrial nutrient cycling on lake eutrophication.

IGN and BIO are both involved in the GEM (Greenland Ecosystem Monitoring), which collects long-term data series in order to quantify variations in biological as well as geophysical parameters in the terrestrial, aquatic and marine environments on a seasonal as well as yearly basis in relation to local, regional and global climate change. MarineBasisDisko has been collecting data since 2018 on physical, chemical as well as biological oceanographic parameters in the Disko Bay. Long term records of physical parameters are available since 1924. GINR monitors the effect of climate change on nature and the environment in Greenland. Since 1995 Zackenberg Research Station in Northeast Greenland (ZERO) has facilitated research and monitoring in the high Arctic (NE Greenland).

The University of Copenhagen, Department of Plant and Environmental Sciences (PLEN), has significant research on the effects of climate change on the production levels of future agricultural biomass (food, feed, fibre, fuels) and the related impacts on soil quality and fertility, as well as feedback mechanisms on environmental emissions e.g. effects on soil carbon sequestration and greenhouse gas emissions.

Mitigation research of climate changes on wetland and dryland crops is also hosted by BIO in collaboration with leading universities in Japan and Australia. Emphasis is on traits in root and shoot tissues that confer flood tolerance of rice and wheat and is supported by a grant from the VILLUM Foundation as well as numerous international grants.

8.2.4.6 Danish Coastal Authority

The Danish Coastal Authority (DCA) is working with projects focusing on the effect of climate change on coastal erosion and flooding and how to adapt the coastal protection in the most sustainable way. DCA is advising the planning authorities in Denmark on how to plan for climate change and has published a report “Guidelines for climate adaptation”. DCA is responsible for implementing the EU’s flooding directive in Denmark.

In different research projects DCA focus on subsidence of coastal areas based on satellite data. The focus is also flood protection assets and the optimum management plan in the light of climate change (Interreg project FAIR). There is a focus optimizing coastal protection measures in todays and futures climate (Interreg project BWN). The Interreg project FRAMES focus on dynamic planning in the future and the society’s recovery phase after a flood event.

8.2.4.7 Roskilde University

Researchers at the Department of Science and Environment, (INM) are doing research on the interaction between climate change and various forms of invasion and/or spread of species with effects on marine ecosystems and human health.

8.2.4.8 Aalborg University

At Aalborg University, research is being carried out on the impact of climate change on society, including regional perspectives on climate change, the impact of climate change on industrial and financial structures as well as human, political and rhetorical implications from the climate change discourse.

Furthermore, studies are being carried out on the effects of climate change on coastal erosion and protection, storm- and rainwater management, energy use in housing, the impact on architecture, building and construction technologies as well as studies on the impact on everyday life and the indoor environment.

Moreover, a great deal of research and demonstration activities at Aalborg University focuses on developing innovative, cost-efficient, and environmentally benign technologies - such as carbon capture and utilization (CCU), power electronic converters as the critical electrical energy infrastructure for the green transition, digital transformation and AI for energy systems, together with life-cycle and techno-economic assessment of such technologies.

8.2.4.9 University of Southern Denmark

At the University of Southern Denmark, we research in the effects of climate change through numerous research disciplines.

At the Faculty of Science, the Center for Population Studies (CPOP) researches on population response to climate change in terrestrial ecosystems.

At the Faculty of Engineering the research includes developing of integration and optimization methods that can be used to find solutions for problems in topics, from energy generation and transport to buildings and agriculture. In the energy sector, system integration and sector coupling are in focus, including analyses, modelling and mapping of the environmental and climate impact.

At the Faculty of Business and Social Sciences, the Department of Law research into the legal effects and consequences of climate change, e.g., rising sea levels and mass climate migration by sea. The department has also established the Centre for Law, Sustainability & Justice, which looks at fair transition and climate justice, in particular societal impacts of renewable energy and transition mineral mining in the Nordic Arctic.

At the faculty of Health Sciences, the effects of climate change are being researched at the Clinical Center for Emerging and Vector-borne Infections that was established in 2014.

Infections and especially vector-borne infections are very susceptible to changes in climate. With increasing temperature, shifts in the distribution of vectors such as ticks and mosquitoes are seen. Thereby, infections can invade new areas, often with great social and health costs.

8.2.4.10 Greenland Institute of Natural Resources (GINR)

As part of the GEM (Greenland Ecosystem Monitoring) GINR is monitoring the effect of climate change on nature and the environment in Greenland. GINR manages the marine monitoring efforts in Zackenberg and Nuuk and the terrestrial/limnic monitoring efforts in Kobbefjord Research Station. GEM is active in national and international climate forums, representing a key Danish-Greenland collaboration on Arctic climate change. The GEM programme collects long-term data series to quantify variations in biological as well as geophysical parameters in the terrestrial, aquatic and marine environments on a seasonal as well as yearly basis in relation to local, regional and global climate change. Kobbefjord Research Station is owned and run by GINR.

GINR conducts annual surveys on marine mammal, fish and shrimp stocks in West and East Greenland offshore areas and in the Disko Bay. The monitoring programme provides unique time-series dating back several decades, thus providing knowledge on the response to natural climate variation and ongoing anthropogenic climate change.

GINR conduct monitoring regarding oceanographic conditions around Greenland and is responsible for the hydrographic monitoring programme. The monitoring program was initiated in 1950 and hydrographic conditions are monitored annually at ten hydrographic sections in June/July across the continental shelf off West Greenland. Additionally, monthly transects are conducted in selected fjords.

GINR provides scientific advice for the Greenland Self-government on sustainable harvest and conservation of marine and terrestrial mammals, birds and vegetation. In this regard, a significant amount of research is conducted on the effects of climate variation, primarily sea ice dynamics, on abundance and behaviour of marine mammals and birds. Moreover, the GINR has developed methods for obtaining oceanographic data in the vicinity of glacier fronts or areas heavily influenced by sea ice by means of tagging diving mammals. Such areas are not easily accessed in traditional oceanographic surveys, but particularly interesting in a climate change context providing invaluable data for understanding the oceanographic feedback processes.

These monitoring programmes also provide a data and knowledge foundation for on-going national and international research projects related to climate change in Greenland.

8.2.4.11 The Faroe Marine Research Institute - (Havstovan)

The The Faroe Marine Research Institute (FAMRI, www.hav.fo) conducts studies of the Faroese marine environment and its living resources, informs the Faroese authorities and public about these conditions and provides advice on sustainable exploitation.

Each year FAMRI informs the Faroese government about the state of fish stocks in Faroese waters and other waters that Faroese fishing vessels use and provides scientific advice and assessments according to the law on commercial fishing. For this purpose, FAMRI performs annual fisheries surveys with the research vessel "Jákup Sverri" and chartered vessels, in addition to analysing catches from commercial fishing vessels.

FAMRI makes regular surveys of the marine environment each year. They highlight the changes from one year to another and help understand the changes in physical conditions and the living resources.

FAMRI carries out a number of experimental fishery projects each year. The Institute also participates in Nordic and international projects in fisheries and marine science of various kinds. This includes monitoring of the oceanic heat transport towards the Arctic, most of which passes by the Faroe Islands, and one of the main overflow branches, returning to feed the AMOC, which FAMRI has monitored for more than two decades.

On-going projects include:

- Joint European Research Infrastructure of Coastal Observatories: Science, Service, Sustainability (JERICO –S3) in 2020-2024,
- Faroese Monitoring (FARMON 2022)
- Dynamics of Calanus species linked to Oceanographic processes, Predation and Sequestration (COPS) in 2022-2024.
- Blue whiting recruitment, distribution and Ocean-climate processes in the North Atlantic Ridge area (BLUE OCEAN) in 2022-2024.
- AMOC and beyond (AMOC-DMI) in 2022.

More information about on-going as well as completed projects is on FAMRIs homepage: http://www.hav.fo/index.php?option=com_content&view=article&id=7&Itemid=111 (in Faroese).

8.2.4.12 The Faroe Islands National Museum (Tjóðsavnið)

The Faroe Islands National Museum (www.savn.fo) is responsible for biodiversity collections from the Faroe Islands, for research in biodiversity, and for presenting the current state of knowledge on biodiversity to the public.

The National Museum is participating in projects on the effects of climate change on the vegetation and selected plant species. Since 2001 an ITEX (International Tundra EXperiment) site was established in alpine area, and the vegetation and phenology of selected plant species have been followed at a regularly basis, though the site has not been active in the last years.

In 2009 a GLORIA (Global Observation Research Initiative in Alpine Environments) site was established on four mountain summits in the Faroe Islands. The aim of the network is to establish and maintain vegetation and temperature data collected at the GLORIA sites for discerning trends in species diversity and temperature. Globally, most sites are investigated at 6–7-year intervals, and the site in the Faroe Islands was monitored for the second time in 2015. For inter-comparison, it is following the same cycle as at the other sites.

FishFAR aims to identify effects of climate change on community structure and trophic ecology of fishes in small subarctic Faroese lakes. Feeding resources, fish diet and fish morphology are compared across the three small subarctic lakes Leynavatn, Saksunarvatn and Toftavatn. These lakes represent contrasting combination of fish species. By studying what fishes eat, where they are found, and if they compete, we can identify how they can affect the whole lake ecosystem. We compare the contemporary data to those obtained in summer 2000 (NORLAKE project), allowing an estimation of contemporary changes in salmonid species in the context of warming. The project started in 2022 and will run to at least 2024.

The National Museum is conducting an inventory of life on the island of Koltur by recording the plant, bird, and invertebrate diversity. This will enable the long-term monitoring of ecological changes, research on species interactions, active nature restoration measures, and the use of Koltur for recreational and educational purpose. In addition, below and above-ground temperature are being recorded throughout the island, and meteorological time-series will be started in 2023.

The National Museum is working on the first large ecological restoration initiative, a project called Lendisbati (Landaid). The aim of the project is to prevent erosion, conserve biodiversity and restore wetlands for carbon uptake. The first Lendisbati project is located on the island of Kalsoy, where a landslide is in the process of being restored. Standard restoration measures appropriate for the Faroese environment are being developed with the aim to utilise the measures on other landslides throughout the islands.

On-going projects include:

- GLobal Observation Research Initiative in Alpine environments (www.gloria.ac.at).
- International Tundra EXperiment (ibis.geog.ubc.ca/itex/).
- Koltur Biodiversity Baseline. An inventory of plants, birds, and invertebrates of the Island of Koltur (2021-2024) (www.tjodsavnid.fo/nature-of-koltur/project-description).
- LIFEPLAN with sites in Tórshavn and Koltur (www2.helsinki.fi/en/projects/lifeplan).
- FishFAR (www.tjodsavnid.fo/landdjoradeild/fishfar-eng).
- Lendisbati (Landaid), the first Ecological Restoration Initiative in the Faroe Islands.

8.2.5 Economic and other research, including evaluation of climate change and possibilities for mitigation

It is important to take account of the economic consequences of the different ways to mitigate greenhouse gas emissions.

8.2.5.1 Technical University of Denmark (DTU)

There is at DTU a general focus on sustainability, circularity, and environ-mental impact of different reduction policies, as well as sector-specific re-search related to food and fisheries, transportation, offshore industry, wind, and energy systems.

DTU is conducting research on energy markets, consumer behaviour, economic instruments and regulatory options.

8.2.5.2 Aarhus University

Research at Aarhus University also covers the judicial, economic and politological aspects of climate policy and legislation at UN, EU and national levels. Cooperating with researchers from the University of Southern Denmark, University of Copenhagen, and a number of partner institutions abroad, and following up cooperation established with the former Centre for Social Science Research on the Environment at Aarhus University, general competence is assured in cross-disciplinary research into law, politology and economics. Research focuses on analyses of effectiveness of specific policy instruments (solely or in interaction with other instruments), both traditional regulatory measures, information measures, economic policy instruments like taxes, quotas and subsidies, and flexible mechanisms (JI and CDM agreements). Decision-making processes and target group behavior/perceptions on climate change are also focus areas for Aarhus University. Moreover, researchers have thorough knowledge of environmental and energy policy and legislation. Such competence forms the basis for cooperation on a Masters degree in Environment and Energy Law, cf. Chapter 9.

AU's Department of Environmental Science has general competence in setting up and evaluating mechanisms for reducing emissions and special competence within the agricultural, energy and transport sectors. In addition, it possesses general knowledge of the different aspects of the Kyoto Protocol, including research competence concerning the Clean Development Mechanism and Joint Implementation. Activities include preparation of guidelines for economic assessment of adaptation to climate change.

AU carries out research on the social and economic dimensions of climate change adaptation, such as how economic analyses are used in the decision-making process, economic modelling of changes in land use. AU carries out research on nature-based solutions, synergies in green, sustainable cities and climate adaptation and sociology research on how private and public actors perceive and react to climate change, and how they participate in climate change adaptation activities.

8.2.5.3 University of Southern Denmark

The Faculty of Business and Social Science is the centre for research within economic research related to the evaluation of climate change.

Examples of research topics and questions are:

- Price regulation and the green transition
- Renewable energy plant and facilities vs. nature protection
- Climate mitigation related finance and social impact assessments
- Fair transition and climate justice, in particular societal impacts of renewable energy and transition mineral mining in the Nordic Arctic
- Governance structure of the environment and the difficulties of management and agreements under climate changes.
- Economic-historical perspective of climate change
- The research programme "Who owns Nature
- Sustainability skills of the small and medium-sized enterprises (SMEs)
- Accounting for the Green Transition, with research on corporate reporting on the EU Taxonomy for Sustainable Activities
- Research contributing to our understanding and knowledge on corporate sustainability.
- Energy Management Research Center - Developing the Green Transition: Sustainable Governance, Organization, and Stakeholder Behaviour in B2C- and B2B-markets.
- Centre of Maritime Health and Society - Develop bio-economic and game theoretic tools to generate improved marine resource governance strategies that preserve and enhance total economic value of marine resources in the Arctic. Avoid biodiversity losses, reductions in Arctic Ocean productivity, and other ecosystem losses from climate change.

Other research, including evaluation of climate change and possibilities for mitigation is being carried out at the Department of Biology, where the Ecology group works with changes in hydrology and nutrient transport in a climate context. There is also work on changes in aquatic communities due to climate change; this work is done in Danish, European and Arctic contexts.

There is also work by the Nordcee group on changes in element cycling (especially N) in oceanic and coastal oxygen minimum zones; these zones are strongly influenced by climate change.

8.2.5.4 University of Copenhagen

At the University of Copenhagen, the social science aspects (economics, law, sociology, anthropology etc.) of adaptation to, and mitigation of, climate change effects is an integrated aspect or a core focus of numerous research activities as well as educational elements. It includes studies of how adaptation to climate change effects enters into decision making for e.g. policy makers, natural resource managers, industry, land owners and households, using economic optimization approaches, environmental sociology and legal regulation as well as anthropological methods. The research addresses the behaviour of decision makers in Denmark as well as in many foreign (developing country) cases, and cases that concern a wide range of topics including e.g. biodiversity conservation under change, land owners' adaptation to changing climatic conditions, rural household livelihood, and transition to greener energy and coping strategies.

Mitigation measures and regulation approaches are thus topics of research, in particular for the economic and legal disciplines, but also others. Apart from focus on e.g. taxes, subsidies and other promoting measures for renewable energy technologies, the ETS and similar regulation tools, there is also emphasis on more general issues like urban industrial and households' decisions on transport, energy consumption etc., as well as global issues like a reliable design of the REDD+ mechanism and reduction of CO2 emissions.

The Department of Food and Resource Economics (IFRO) has a strong focus on climate change adaptation and mitigation and how those affect livelihoods around the globe.

Research on climate change has been ongoing at the Faculty of Law since 2010, and has grown steadily in scope and size with a further strengthening in the past 5+ years.

Three PhD theses have been completed on the regulation of climate change: one on the regulation of greenhouse gas emissions from shipping, one on the legal implications of REDD (*Reducing Emissions from Deforestation and forest Degradation*), and one on the legal implications of the loss and damage provision of the Paris Agreement. Moreover, three PhD theses have been completed clarifying the foundations for sustainability in private law (contract and torts law) and sustainability in trade law. These PhD theses have resulted in a number of academic outputs, including books, journal articles, and paper presentations at conferences worldwide, as well as external funding for new research projects on climate change (included in the list below). In addition, a number of relevant academic outputs have been produced from all academic levels during this period.

Since 2020 climate and sustainability have been defined as strategic focus areas for the faculty. This has – among other things – resulted in the creation of a ***Sustainability Hub***: https://jura.ku.dk/sustainabilityhub/ which functions as a platform for making legal research on sustainability and the green transition visible and useful for the society, and for knowledge sharing between researchers, students, public authorities and private businesses.

Currently, the Faculty of Law hosts 20 larger, externally funded research projects on various aspects of climate change law and governance, both in public and private law, including the interaction between climate change and democracy, economic law (investment and trade), energy, human rights, litigation, public procurement, resilience, vulnerability, supply chains, transport, contracts, and liability.

The following projects are ongoing:

- *Biotrade*: a network project exploring regulation in EU and European countries on protection of biodiversity outside through regulating trade relations, supply chains, and biodiversity. Funded by BiodivERsA and the Innovation Fund Denmark and is hosted at Centre for Private Governance (CEPRI).
- *CirCus*: explores circular supply chains, specifically identifying and allocating legal risks on the challenges of private law and the circular economy. Funded by the Independent Research Fund Denmark (DFF) and hosted by CEPRI.
- *Climate Refugees' in the Nordic Region? Legal and Policy Responses to New Patterns of Human Mobility'*: establishes an interdisciplinary network of scholars working on climate change related human mobility. Funded by the Joint Committee for Nordic Research Councils in the Humanities and Social Sciences (NOS-HS) and hosted by Centre for European and Comparative Legal Studies (CECS).
- *ClimaTIP*: explores tort-based climate change litigation and the interplay between tort law and investor protection law. Partially funded by Orient's Fund and hosted by CEPRI.
- *DIGT: explores* how democracy is affected by, and can in turn affect, efforts to address the impacts of climate change. Funded by DFF and hosted by Centre for International Law and Governance (CILG).
- *EnAct*: explores the role of human rights and economic law in enhancing and enforcing states' mitigation commitments. Funded by DFF and hosted by CILG.
- *ENERGIZE*: explores the role of investment law in the energy transition. Funded by DFF and hosted by Danish National Research Foundation's Centre of Excellence for International Courts (iCourts).
- *GAMES:* explores the societal and legal challenges raised by extreme weather events, studied through the lenses of attribution science, law, and social sciences. Funded by Swedish Research Council for Sustainable Development (FORMAS) and hosted by CILG.
- *ILLECO:* examines environmental crime concerning illegal mining of metals and the dumping of technological waste in Ghana. Funded by DFF and hosted by iCourts.
- *InterAct*: studies the actors involved in international law making processes concerning the climate change impact of shipping. Funded by the Carlsberg Foundation and hosted by CILG.
- *Interfor:* explores how the implementation of forest regulation can be enhanced, in order to better protect forested lands and the people inhabiting them. Funded by an EU Marie Skłodowska-Curie Individual Fellowship and hosted by CILG.
- *NeOGov:* explores international and regional ocean regimes through the lense of climate change. Funded by NOS-HS and hosted by CILG.
- *Of Islands and Ice*: examines climate change adaptation and resilience in Greenland and the Cook Islands in the context of their colonial pasts. Funded by DFF and hosted by CECS.
- *Polar Law and Private Governance*: on the normative systems, including private governance systems, that govern the Arctic and Antarctic in view of climate change. The project is hosted by CEPRI.

- *ProcureGreen*: on legal questions concerning procurement in Denmark as an important element for green transition and a more sustainable economy. Funded by DFF and hosted by Centre for Legal Studies in Welfare and Market (WELMA).
- *PurpLE*: on sustainable public procurement through private law enforcement, studying the interconnections between sustainability, private and public law. The project is funded by the Carlsberg Foundation and hosted by CEPRI.
- *RaR*: studies the European and Danish regulatory systems for the railway as a sustainable means of transportation. The project is partially funded by Banedanmark and hosted by CEPRI.
- *SSH and Sustainable Business*: focuses on building a database for SSH impact on sustainability in private sector companies. The project is funded by the Carlsberg Foundation and hosted by CILG.
- *SAPIENS Network*: Sustainable Tools to Fight Climate Change – Procuring Nature-Based Solutions. Funded by an EU Marie Skłodowska-Curie Doctoral Network grant and hosted by CEPRI.
- *TRAMEREN*: establishes an international network exploring climate change governance generally, in close collaboration with New York University School of Law. Funded by Dreyers Fond and Carlsberg Foundation and hosted by CILG.

8.2.5.5 Roskilde University

At Roskilde University, research is going on concerning scenario building within climate-stabilising policies, together with lifecycle analyses as a tool in economic evaluation of climate-stabilization strategies.

At the university's Department of People and Technology (IMT) research includes participation in the EU project Greeco on territorial potential for a greener economy (http://www.espon.eu/main/Menu_Projects/Menu_AppliedResearch/greecoTPG.html). The development of local and regional mitigation and adaptation strategies to climate change is an important research area which is conducted in cooperation with Danish municipalities. Research also addresses public lighting strategies, transitions to energy-neutral and energy-producing buildings, transitions to public transport and energy-efficient vehicles. The implications for daily life, regional infrastructure planning and transport-related taxation is evaluated.

8.2.5.6 DMI

DMI is involved in various national and international research and networking projects for assessments of climate change impacts on the economy, energy and agriculture sectors. In these projects, DMI develops methodology for downscaling the climate-change projections to the regions of interest, and provides expert advice for other partners of cross-cutting disciplines in the projects on applications of model projections and their uncertainties to assess the climate-change impact and risk on various sectors. Climate projections from the Danish Climate Atlas[8] has been used e.g. by the financial and insurance sectors to assess added risk future changes in extreme weather events and a rising sea level.

[8] https://www.dmi.dk/klimaatlas/

8.2.5.7 Aalborg University

The success of climate mitigation and adaptation options depends crucially on the ability of decision makers to choose the most efficient among the myriad of different actions and pathways by which the global community can reach (or fail to reach) the goals of minimizing global temperature increase and its impacts. One of the largest obstacles causing inefficient or poor decisions and causing delays in communication and implementation is the lack of up-to-date, valid, and trustworthy data with global coverage.

To help solve this problem, Aalborg University is contributing to the development of new global datasets and independent insights made available for governments and the public as basis for whole-of-economy and full value chain centred climate policies and decision making.

The project "Getting the data right" hosted by Department of Planning at Aalborg University will provide a globally unique tool for quantitative assessment of the climate effects of decision alternatives, a so-called 'climate footprint generator', and a mechanism to ensure its continuous updating. The project expands the detail, coverage and applicability of the currently most advanced hybrid input-output database, brings the data up-to-date, and provides public access to work of previous research projects completed as part of several EU FP6 and FP7 projects.

"Getting the data right" is one of five initiatives in the project package Decarbonizing Denmark: 70by30. The project works purposefully to realise Denmark's ambitious climate goal and cement the country's leading position in the climate area internationally.

At Aalborg University, focus of climate mitigation research is in part on how to reduce energy use and carbon emissions from the built environment, especially in relation to the transition of the existing building stock to low energy consumption housing, and the transition of new buildings and constructions to low carbon constructions by increasing use of reused-, waste- and biogene materials. Economic assessment load on energy use in housing and building renovation is prioritized.

Moreover, research is being done on the relations between climate change, design strategies and sustainability of industrial products and sustainable architecture in a new climate using Life Cycle Assessments.

8.2.6 Research and development of technologies and approaches to reduce greenhouse gas emissions and to adapt to climate change

8.2.6.1 Joint actions among the Danish Universities sets the agenda for the green transition of the AgriFood Systems

A successful green transmission of the agriculture and food systems in general is a paramount for addressing the various green challenges. And this can solely be achieved by disruptive changes in our society and business, evidence based on best co-creative science.

The newly established Centre for Sustainable Agrifood Systems (START) is a unique and united intelligence platform by all Danish universities. STARTS contributes to research on green transformation on Agrifood System by exploiting new strategic research collaborations using an integrative, inclusive and interdisciplinary approach. In START researchers from all disciplines e.g. natural, technical and digital sciences to social and humanities sciences explore, co-create and collaborate across research fields and topics.

The START initiative was official formed in November 2021 and was Kick-Off in March 2022. START is currently representing 10 interdisciplinary research hubs advocating the national interdisciplinary collaboration.

The unique assets of the START research community enabling START to strive for realistic future solutions together.

Aarhus University (AU) is heavily involved in all university activities related to the environment, energy and climate-related issues. AU has broad competences within the topics: Future energy systems, Future climate and climate adaptation, and Competitive environmental technologies.

At the Technical University of Denmark (DTU) many Departments are engaged in research and development related to wind and solar technologies, smart energy systems, systems integration and energy system modelling. DTU has also established the Copenhagen Centre on Energy Efficiency as the Hub of the global Sustainable Energy for All initiative. The Centre is engaged in research and country and city level support to implement best practice energy efficiency technologies.

DMI works with solar resource assessment and forecasting and is involved in a Solar-PV development and demonstration project.

8.2.6.2 Energy research

Denmark has a long history of supporting research and development in the field of energy. Chapter 4.3.5.1.6 contains further information on the Danish Energy Technology Development and Demonstration Programme (EUDP) and Mission Innovation.

8.2.6.3 Aarhus University

Research at Aarhus University, DCA – Danish Centre for Food and Agriculture focuses on the agricultural sector's possibilities for adapting to climate change by changing the cultivation system, including changes in fertilisation and the use of pesticides and adapting soil tillage methods. The aim is to develop adaptation options that also reduce greenhouse gas emissions from the sector. Research at AU is also conducted within European and global research projects to address more general concerns for adaptation of agricultural systems to climate change.

At AU, Department of Agroecology and Department of Animal Science conduct a range of research projects aimed at quantifying greenhouse gas emissions from agricultural activities and the effects of management and technologies to reduce these emissions. This covers emissions from soil, livestock and manure, and many different technologies and management systems are being explored. This research is often conducted in collaboration with other European research institutes or as part of the Global Alliance on Agricultural Greenhouse Gases.

At DCA, the world's largest biogas plant for research purposes was commissioned in 2007. It can be used by scientists and private companies - Danish and foreign - for projects in biogas production and slurry separation. Recently, much focus has been given to investigate and up-scale methanisation of the CO2 part of biogas in order to integrate wind and biogas production and increase storage capacity of the renewable energy system. Since 2017, an interdisciplinary AU Centre for Circular Bioeconomy (www.cbio.au.dk) will intensify the research in sustainable and low emission biological production systems on land and in the sea. The centre further investigates the conversion of the biomass into materials and energy to substitute fossil fuels.

AU, DCA has long experience in developing dedicated energy crops with a low environmental impact and high net-emission reduction. Most promising crops are perennial crops such as willow and miscanthus, the latter utilising the C4-photosynthetic pathway, which will become increasingly effective in the warming climate. However, the high content of protein in conventional cut grass and clovers has been intensively studied with the aim of producing a local protein source instead of importing large amounts of soya bean products from other continents. Side-streams from this production are expected to be used for bioenergy, and a demonstration scale plant is expected build in 2018 based on experiences on a pilot plant built in 2015.

Denmark has opted to include detailed accounting of LULUCF as part of its mitigation efforts. Therefore large efforts have been invested at AU (DCA and DCE) to monitor and model changes in soil carbon in both mineral and organic soils. AU has developed the CTOOL model for this purpose, and this model is being applied for national accounting of soil carbon changes. This model has been proved to be reliable, and is currently being considered for application in other European countries.

AU, Department of Environmental Science is working with the main drivers behind greenhouse-gas emissions from the energy sector, the agricultural sector, and the transport sector. The University of Copenhagen, Department of Geoscience and Natural Resource Management has competence in forestry, afforestation, etc. Together, these two institutions cover the aspects of land use in the open countryside for agricultural purposes, forestry and nature. Both institutions are looking at challenges related to use of biomass from agriculture and forestry as an energy source.

AU makes general inventories of atmospheric emissions from all sectors and activities, including the greenhouse gases. The institution has special research competence in inventories from the agricultural sector, the transport sector, the industrial sector, and the energy sector. The University of Copenhagen, Department of Geoscience and Natural Resource Management contributes with inventories of emissions from forestry and changes in land-use in relation to how forests affect the forest ecosystems' carbon sinks and thus the potential binding of CO2 in biomass and soil.

AU has models for projecting greenhouse-gas emissions, based, for instance, on projections of activities in relevant sectors, with the University of Copenhagen, Department of Geoscience and Natural Resource Management providing input on forests.

AU also has research competence in modelling the dispersal of greenhouse gases locally and regionally, with special focus on Denmark, Europe, and Greenland. The Department of Environmental Science has developed a CO2 model (DEHM) for dispersal, transport, and surface movements. The model can be used to determine the size of sources and drains for CO2 in Europe over specific areas and for estimating whether these areas comply with the Kyoto Protocol.

AU's department of Environmental Science has a large research group working on different aspects of climate change adaptation, including eg: risk assessment, economic assessment of climate adaptation measures, user involvement, farmer perception and adaptation to climate change, climate change communication, development of climate services to the public and private sector, sustainable urbanization and nature based solutions.

AU has several research areas of relevance to local climate adaptation solutions related to excess water both in urban and open areas (fluvial, coastal and groundwater). Some of the central research areas are: Groundwater identification and modelling, development of nature based solutions for water retention and development of novel treatment technologies for urban storm waters.

Two new AU interdisciplinary research centres in Climate and in Water Technology will address some of these issues.

AU has several initiatives on the human aspects of climate related risks in the past as well as the present. One of the projects are C3NET – the Climate | Culture | Catastrophe Network with the aim of bringing together an interdisciplinary team of researchers concerned with the human impacts of climate change and extreme environmental events in the past – as well as in the present and future. C3NET aims to create and catalyze a Palaeoenvironmental Humanities research, education and outreach cluster at Aarhus University and beyond.

AU has an interdisciplinary Centre for Environmental Humanities (CEH), that is concerned with re-engaging the environment in disciplines such as history, religion, literature and media, ethics, archaeology, anthropology, education, and artistic practice as ways of understanding and communicating climate change and increasing climate and geo-literacy. Numerous externally- funded projects in archaeology (e.g. EU Life, DFF, Carlsberg) are concerned with past human-environment relations and hence contribute to our understanding of shifting baselines and our stock of knowledge with regards to the diversity of these relations over time.

The Danish School of Education at AU has conducted research on the role of education in relation to climate change and sustainable development.

The newly established centre, Novo Nordisk Foundation CO_2 Research Center (CORC) at Aarhus University has a mission to develop new and innovative knowledge and technology that can be used to capture, convert and recycle CO_2.

8.2.6.4 University of Copenhagen

The University of Copenhagen is involved in a number of research projects related to new technologies e.g. for renewable energy, including biofuels. Furthermore a number of projects and research areas have focus on adaption to and effects of climate change.

The University of Copenhagen is exploring the options for adaptation of cities to climate change by means of blue-green approaches and exploitation of ecosystem services. This research includes principles for redesign of the blue-green infrastructure for storage, infiltration and evaporation of stormwater runoff, for buffering of the urban heat island, and for biodiversity support, as well as the development of new technologies for treatment of stormwater runoff to high quality water for reuse purposes. The research and innovation activities further encompass description and assessment of urban planning concepts for climate-change adaptation in Denmark, China and Africa.

Another research theme at the University of Copenhagen, Department of Geosciences and Natural Resource Management (IGN), is climate-change adaption in the Danish municipalities. Main focus is on performance, drivers and barriers within the following fields: mapping of flooding threats, adaptation policies and planning, implementation and management strategies as well as attitudes and collaboration between the different sectors and stakeholders: politicians and planners from the different authorities as well as the citizens.

Numerous research projects at IGN address issues related to sustainable biomass production, both in forestry and in cooperation with other departments related to agricultural biomass production. The use of biomass, the land use and land use change (including ILUC) is an integrated part of several these projects. Topics related to conversion of biomass to energy – solid or liquid – are directly related to the processes of moving towards a bio-based society and economy.

Department of Geosciences and Natural Resource Management (IGN) in collaboration with Department of Plant and Environmental Sciences (PLEN) is a main collaborator in the newly established pioneer centre on Center for Landscape Research in Sustainable Agricultural Futures (LandCRAFT) which has focus on sustainable developments of the agricultural sector, with emphasis on nitrogen cycling.

The response of tree species to climatic change, the endurance, adjustment and tolerance of species and the resilience of forest ecosystems, as well as the expected influence on productivity and ecosystems services of forests are important research topics at the forest, nature and biomass section of IGN. The implications for development of wise management strategies, including options for sustained and increased biomass productivity and carbon pools, are an important part of the research and development activities. The carbon pools, the dynamics over time and scale are core topics in a number of research projects, including development and testing of efficient inventory and sampling methods, utilizing both field data and remote sensing.

The project SilvaNova (https://ign.ku.dk/english/silvanova/) has focus on restoring soil biology and soil functions to gain multiple benefits in new forests, including increasing the carbon uptake and biodiversity.

IGN carries out research on both mitigation and adaptation in developing countries. Within the framework of an IGN-led EU-funded I-REDD project, the effects of the REDD+ mechanisms are being studied in SE Asia, and in collaboration with UNEP-DTU, possibilities of options for renewable energy have been explored in Mali[9]. In a Danida-funded project, improved adaptation to climate change, making better use of outputs from regional climate modelling and seasonal forecasting, is being studied in West Africa, in collaboration with DMI and AGRHYMET in Niger.

The Department of Plant and Environmental Sciences (PLEN), University of Copenhagen, focuses on developing methods to reduce greenhouse gas emissions from different agricultural production systems, depending on both application of mineral and organic fertilisers, irrigation strategies and choice of crops in both temperate and tropical production systems. A special focus area in a number of research projects is agricultural and urban organic waste recycling technologies, including anaerobic digestion for biogas production and upgrading of residues for biofertilizer production in both intensive and extensive agricultural systems (e.g. http://www.reusewaste.eu, http://biochain.dk, http://www.susane.info). Advanced agroecosystem models and life cycle assessment models are being used to investigate and compare the effects on global warming potential of alternative technologies.

Together, the PLEN and IGN departments play a key role in national and international research initiatives to develop renewable biofuels for climate-change mitigation. The research focuses on sustainable intensification of the productivity and quality of biomass for different bioenergy purposes (http://www.bio4bio.dk). These activities are combined with targeted improvement of biomass feedstocks for new energy

[9] http://www.frsemali.org/

applications (e.g. maritime fuels; http://b21st.ku.dk/) and for use in biorefineries (http://biovalue-spir.ku.dk).

At the Department of Biology, research on freshwater streams and lakes is carried out in the light of increasing temperature as well as changes in precipitation patterns. Issues like increased brownification of freshwaters and also increased nutrient mobility in groundwater and surface waters are covered. The research has lately been supported by the VILLUM Foundation via the Centre for Lake Restoration and Aage V Jensens Naturfond.

Department of Chemistry conducts broad collaborative projects on atmospheric, environmental chemistry and air quality. For example, research on the atmospheric environmental impact of new climate friendly chemical compounds is carried out. These compounds can typically be replacements for SF_6, CFCs, HCFCs and HFCs. The research is performed in collaboration with industry using a smog chamber combined with FTIR spectroscopy. In regard to improving air quality, the department has spawned a couple of startup companies and has collaborations with several industrial partners (*e.g.* Arla, Ambient Carbon, Devlabs, Airscape, and Ford). Research in atmospheric chemistry also aims at removing the greenhouse gas methane from the atmosphere by photocatalytic reactions and at understanding atmospheric radical reactions, properties of atmospheric molecules, their degradations in the atmosphere, and mechanisms of aerosol formation and its influence on climate. Moreover, focus is on the environmental impact of compounds used in the quest for a sustainable future, for example amines used for carbon capture.

The *Center for High Entropy Alloy Catalysis (CHEAC*; Centre of Excellence) at Department of Chemistry focuses on electrocatalysis and energy conversion reactions and on metallic alloys and modified oxides. The aim is to utilize the flexibility of high entropy alloys to discover new (electro) catalyst materials in a combination of theoretical and experimental approaches. Other projects aiming at reducing greenhouse emissions by offering green energy solutions relate to the development of organic molecules for either photovoltaics or energy storage. Other research projects at Department of Chemistry encompass CO_2 fixation and conversion as well as biomass transformations and valorization, *e.g.* methods to convert carbohydrate-based biomass into platform chemicals and biofuel. The department also conducts research on desalination for water purification, which has resulted in a start-up company.

8.2.6.5 GEUS

GEUS is researching impacts on the Arctic environment, and the driving forces for natural climate variations in long-term perspectives.

In cooperation with other countries, GEUS participates in EU-funded projects, in which the possibilities for finding geological storage possibilities near the European power stations and large industrial CO_2 point sources are being studied. Technical-economic models are also being developed in this project for planning and price calculations of different combinations of sources of CO_2 emissions, transport, and types of geological storage. Several geological formations in Denmark are known to be suitable for deposition and GEUS has identified and mapped potential storage sites and estimated the storage volume.

GEUS is also participating in the international research project CO2STORE, a continuation of the SACS project, in which CO_2 deposition from the Norwegian Sleipner gas field is being further developed. GEUS is studying the geological properties of the storage, including the extent of the sand formation, the tightness of the clay seal and the chemical effects of storing CO_2 in the form of carbonic acid at low acidity.

As a significant outcome of the Energy agreement in spring 2012 GEUS has established an open Geothermal Energy portal, where users – including local and national authorities and industry – can find a comprehensive amount of data and information regarding prospective areas, depths and qualities of aquifers. GEUS has further contributed with local geological models assessing the potential in a number of geothermal license areas and has established numerical models for production capacity.

GEUS is investigating the possibilities of using deep-sited aquifers for energy storage for mitigating seasonal fluctuations in production and consumption. Also shallow geothermic energy and heat storage applications are being developed and exploited.

8.2.6.6 Technical University of Denmark (DTU)

DTU is widely engaged in research and development efforts to reduce greenhouse gas emissions. There is an ongoing focus on wind and energy systems research (virtual prototyping, intelligent turbines, and hybrid renewables), a focus on biomass (gasification, bioethanol production, biogas upgrade, biofuels, and biochemicals), and solar energy (photovoltaics, photocatalysis and concentrated solar power). Additionally, there is a focus on energy conversion and storage (power-to-X, carbon capture, thermal energy storage, fuel cells, batteries, etc.), as well as a focus on industrial bio-technology and circular construction.

8.2.6.7 Roskilde University

The university's Department of People and Technology (IMT) is involved in the evaluation of technical, economic and environmental aspects of biofuel production. Research focuses on energy crops and algae cultivation for transformation to bio fuels. The research is based on utilizing sewage water to increase productivity, and it examines effects on CO_2 and nutrient removal. Activities include participation in the Baltic Sea Bio-Energy Promotion Programme (EU Interreg Programme with 36 partners) and in Cluster Biofuel Denmark, which is a technology platform bridging the gap between private enterprises, universities and public authorities.

Another research theme is Climate Change and Innovation in the Building Sector, and this is being conducted in cooperation with the Technical University and many others. In this context, the energy and environmental challenges for building and renovating in the future are being addressed.

At the university's Department of Science and Environment, research is done within energy storage and climate friendly/energy saving surfaces.

8.2.6.8 Aalborg University

In the transformation of low-carbon, renewable energy from alternative to mainstream, Aalborg University has made crucial academic contributions. By 2022, some 400 energy researchers at AAU are engaging a very wide range of academic disciplines in flagship projects within the fields of renewable energy generation and energy islands, sustainable fuels, electrification and energy integration, energy-efficiency, circularity and carbon capture, digital transformation and AI, and smart energy systems. All of these activities are carried out in close collaboration with partners such as private businesses, public organizations or NGO's.

AAU has a long-standing tradition for research paving the way for the smart energy systems of the future and the present, both from a system as well as from a technological perspective. Since 2012 Aalborg University has led the creation and elaboration of the ”Heat Road Map Europe” (funded by FP7 and Horizon 2020), a catalogue of strategies for greener heating and cooling in Europe. Heat Road Map Europe has delivered a host of data, tools, and methods for analyzing energy systems, heat savings, and district heating and cooling on a European level. Considered the main provider of recommendations for these areas by the European Commission, the results from Heat Road Map Europe have been utilized directly in the configuration of EU strategies for heating and cooling.

Closely related to these prominent contributions are a variety of efforts to develop models, strategies, and technological solutions and designs to the integration of heating/ cooling, gas, and electricity. Particularly challenging is the integration of renewables into the energy system which necessitates efficient tools and models for planning, operation management and control of such integrated energy systems. From a technological perspective, projects like SmartC2Net and RemoteGrid (funded by FP7 and the Danish Energy Technology Demonstration Program respectively) have provided groundbreaking progress in these areas. A world-leading ICT research institution for decades, AAU researchers are currently applying insights and know-how from the disciplines of smart cities, artificial intelligence, machine learning and Internet-of-Things on these designs for the smart energy system. Research into energy storage from renewable sources shows great potential as AAU researchers utilize the experiences and competencies acquired from long-term research and development within thermal energy technology, especially fuel cells and hydrogen technology. These new technologies are expected to radically impact the carbon footprint of the transportation sector as they point towards greener fuels.

Research within renewable, low-carbon energy technologies (wind, wave, PV) has in itself been prioritized heavily for decades at AAU. In recent years, however, combined efforts toward the challenge of providing cost-effective and reliable offshore wind energy have been at the heart of many research environments at AAU. In prominent publicly funded research and innovation projects, research is being conducted on the design of the components of the wind turbine system: the blades, the mechanical parts (e.g. nacelle and hub), and the substructure (i.e. various types of foundations). Furthermore, the development of research-based models for leaner and greener manufacturing processes and transportation of components are highly requested by AAU’s business partners. New solutions for grid connection and the control of wind farms are being investigated and validated by AAU researchers. Approximately 100 PhD’s and Post Docs are engaged in wind energy research at Aalborg University.

Enhancing the efficiency and reliability of green energy technologies, power electronics is a crucial part of the green transition. Through large-scale, state-of-the-art research and demonstration projects (“Intelligent Efficient Power Electronics” (2012-2017) and “Center for Reliable Power Electronics” (2011-2016)), AAU has manifested its position as a world-leading hub for the development of power electronics, the part of the energy system where electricity from e.g. wind turbines or PV solar cells is converted to electricity use for households, vehicles etc.. Currently, the X-Power (https://www.xpower.aau.dk/, funded by the Ministry of Higher Education and Science), “Advanced Power Electronic Technology and Tools” (funded by the Innovation Fund Denmark), “REPEPS” (funded by Villum Investigator Program), “AI-Power” (funded by Innovation Fund Denmark) and

“CLEAN-Power” (funded by Independent Research Fund Denmark) projects aim at preparing for a paradigm shift in power electronics that will boost the spread of reliable, smart, compatible and low-carbon, electrical energy systems.

Furthermore, with electrical energy conversion technologies as one of the central research themes, Power-to-X (P2X) is one of AAU's key competencies. Focusing on the electrical power supply as one of the key enablers for P2X realization by coupling renewable energies to other energy sectors as efficient and compatible as possible, AAU is contributing to industrial research and development of P2X through “BioCat” and “eSMR-MeOH” projects (funded by EUDP).

AAU is engaged in a number of EU H2020 projects, among others SATO, PRELUDE and E-dyce, which focus on optimizing energy performance of the whole building and its energy consuming equipment. Information and Communication Technology has reached a level of maturity that allows for cost effective implementation of services, meters and actuators in the building sector giving capability to provide the required information needed for whole building energy assessment and to unlock significant energy savings and energy flexibility. This trend is visible in the development of Smart Buildings, which aim to reduce energy use through a higher degree of automation and operational optimization by combining building and energy system data on a central platform for analysis and optimization of building and energy system operation in order to improve energy efficiency and reduce energy use.

8.2.6.9 University of Southern Denmark

The Faculty of Engineering conducts research into a wide range of solutions for eventually reducing generation and distribution of climate-damaging greenhouse gases. This includes research on various aspects within energy, chemistry, materials, biology, transport, buildings, and food science, but it further includes digitalization and system analysis. At the faculty website the research within climate technologies have been made easy assessable trough this one-point entry: https://www.sdu.dk/en/om_sdu/fakulteterne/teknik/forskning/klima

The key research areas are Renewable energy, Energy efficiency, Climate-friendly transport including maritime transport, Buildings and construction, including circular economy, Agriculture and production of food, Digitalization and informatics as cross disciplinary toolbox and Adaptation to climate change as described below.

Renewable energy
The research is aimed at solutions that lead to a reduction in greenhouse gas emissions through increased use of renewable energy from, among other things, solar and wind. Themes include biogas, bioenergy, biorefineries, photovoltaics based on organic solar cells, new transport (bio) fuels, transport, materials development, conversion (P2X) and storage of green energy. The research also includes integration of renewables into systems and sector coupling with a focus on sustainability analyzes and models, including analyzes and mapping of the environmental and climate impact.

Energy efficiency
Research is being conducted into increased energy efficiency in buildings, food production and industry using IoT, data and artificial intelligence. Examples include energy-efficient greenhouses, whose energy system is intelligently connected to the national energy infrastructure, efficient use, transport, and storage of electrical energy from renewable energy sources and energy-efficient industrial electronics, contributing to a better utilization of the electrical energy from wind and solar sources.

Climate-friendly transport including maritime transport
The research includes digitalization, automation, process optimization and the use of green energy sources (electrification, ammonia, methanol, etc.) for land transport as well as aviation, ship operation

and maritime logistics. The research effort contributes to making transport of passengers and goods more efficient and climate-friendly / sustainable, regardless of whether it takes place in Denmark, Europe or globally. The research includes systems analysis with a focus on sustainability analyzes and models, including analyzes and mapping of the environmental and climate impact.

Buildings and construction, including circular economy
There is great potential in solutions that reduce the climate impact from building construction and production and use of innovative green building materials. Concrete as a building material has a strong climate impact, which is why research into alternative design methods aimed at lighter concrete structures, research into alternative materials and recycling of materials all make important contributions to the reduction of greenhouse gases and research into the ability of concrete structures to absorb CO2 contributes to this. The research also includes circular economy, recycling and up-cycling of building material as well as integration of new functionalities into buildings, such as integrated lighting, sensing and energy generation.

Agriculture and production of food
The research includes climate-friendly production of food, reduction of the emission of climate-damaging gases from stables and other livestock, precision farming with reduced use of fertilizers, automation, and increased use of electric vehicles. New pathways to climate-friendly food production such as the production of healthy and tasty foods and food additives through advanced fermentation technology. Utilization of side streams from food production and agricultural production through research into biorefinery solutions, new value chains and other contributions to support the growing bioeconomy sector. Environmentally friendly and resource-efficient aquaculture is also a research topic. The research also includes system integration and sector coupling with a focus on sustainability analyzes and models, including analyzes and mapping of the environmental and climate impact.

Digitalization and informatics as cross disciplinary toolbox
The research includes developing of integration and optimization methods that can be used to find solutions for problems in all topics, from energy generation and transport to buildings and agriculture. In the energy sector, system integration and sector coupling are in focus, including analyzes, modelling and mapping of the environmental and climate impact.

Adaptation to climate change
The research examines urban resilient transition and addresses the causes and effects of urban climate change, including further effects that result from adaptation to, and mitigation of, climate change - and how risks to climate, environmental and man-made disasters can be reduced. The research also investigates the production, use and discharge of water in urban environments.

At The Faculty of Science, the approaches to reduce greenhouse gas emissions and to adapt to climate change is focused on Nature based solutions (NbS) in aquatic systems – urban, freshwater, coastal. Examples are creation of artificial wetlands, urban vegetated road drainage beds and reestablishment. There is also work on mitigation of ocean acidification via adding alkalinity generation mineral. Further information on research focused on NbS for climate mitigation and adaptation is available here: https://www.sdu.dk/en/forskning/ecology

At the Faculty of Business and Social Sciences research topics within this field is e.g.:

- Globalization of renewable energy technologies; the role of law in facilitating deployment of climate-smart digital technologies in aquaculture.
- Research on how the investments of capital providers (company owners and banks) into companies that implement a sustainable – e.g., carbon neutral – business model can be up scaled.
- Management Accounting tools for sustainability accounting and -management
- The use of Greenwashing in communication.

Further, at the Faculty of Health Sciences a focus on climate friendly procedures is incorporated in the research. One example is a comparison of climate footprint between endoscopic examinations vs. camera examinations of the colon.

8.2.6.10 University of Greenland

Ilisimatusarfik, University of Greenland is managed by a Board of Governors and a Rector under the Ministry of Education, Culture, Research, and Church in the Government of Greenland and is established under Act of Greenlandic Parliament no. 19 of 19 of November 2007 on Ilisimatusarfik.

The Institute of Social Science, Economics & Journalism and the Institute of Culture, Language & History at Ilimmarfik Campus, Ilisimatusarfik, University of Greenland, covers social sciences and humanities. Ilisimatusarfik is involved in a series of activities which include focus on climate change, including specific courses with a focus on climate change offered at BA and MA levels.

The Climate and Society programme
The Climate and Society programme links Ilisimatusarfik/University of Greenland and the Greenland Climate Research Centre (GCRC) and focuses on issues of pressing contemporary concern for society and environment in Greenland. The research and teaching of The Climate and Society programme is at the intersection of social science, climate science and public policy. An important aspect of the work is concern with understanding climate change within the context of other changes and societal and economic transformations in Greenland, including resource development and extractive industries. Rapid social, economic and demographic change, resource management and resource development, anti-hunting campaigns, trade barriers and conservation policies all have significant implications for human security and sustainable livelihoods in the Arctic. In many cases, climate change magnifies existing societal, political, economic, legal, institutional and environmental challenges that people experience and negotiate in their everyday lives.

The research projects nurture new knowledge about human-environment relations, economic activities; environment and climate change in Greenland in both historical and contemporary perspective and contribute to social scientific approaches to climate change more generally.

The Climate and Society programme is a foundation for formal educational links between GCRC and Ilisimatusarfik. It contributes to teaching of undergraduate students and supervision of graduate students at Ilisimatusarfik at both Master's and PhD level.

The Climate and Society programme employs a professor, researchers and PhD students. The current main projects under the Climate and Society programme are:

- Inuit Pinngortitarlu—Nuuk Fjord Monitoring and Mapping Project;
- Climate Change and Extractive Industries;
- Kalaalimernit: Greenlandic Foods, Cultural Identity and Climate Change;
- A Millennium of Changing Environment in the Kangersuneq and the Kapisillit Fjord System, West Greenland;
- Greenlandic Communities, Ice and Living Resources; and
- Climate Change, Policy and Governance.

Major Projects
Researchers at Ilisimatusarfik are involved in the following major projects:

- Marpart (Maritime Preparedness and International Partnership in the High North) is an international research project including nine universities and research institutions in Iceland, Norway and Russia. The main purpose of the project is to assess the risk of the increased maritime activity in the Arctic and the challenges that this increase may represent for the emergency prevention, preparedness and response institutions. The starting point of the project is the increased maritime activity in Arctic waters and the vulnerability related to human safety, environment and vessels or other physical installations at sea. The activities in focus are intraregional and interregional transportation, exploration and exploitation of oil and gas and mineral resources, fisheries and cruise tourism. The challenges in the Arctic for maritime operations are limited infrastructure, low temperatures with ice and icing and a vulnerable nature.
- Qimmeq Greenland's Sled Dog is a Greenland Perspective project under the aegis of the University of Greenland, the Natural History Museum of Denmark and the University of Copenhagen. Today, Greenland holds the Arctic's largest remaining sled dog population and a globally unique traditional dog sled culture. But both the sled dog and the culture that goes with it are threatened by extinction. Even though sled dogs are iconic and dog sled culture plays an essential role in Greenland and despite the subject holding great scientific interest only limited systematic work has previously been done on these matters.
- ARCTICCHALLENGE is an international project focusing on Arctic petroleum development as a challenge to societies: A comparative look at Norwegian, Greenlandic and US case sites. ARCTICCHALLENGE investigates the increased need for energy as a major challenge to society, and therefore to politics, in our time, and the effects on local lives in communities in the Arctic. The project will significantly increase the understanding of the complexities embedded in securing a viable future at the local level in the Arctic, by focusing on local, culturally based perceptions of petroleum development and climate change in shaping such security
- SLiCA (Survey of Living Conditions in the Arctic) is an international joint effort of and a partnership between researchers and indigenous peoples to measure and understand living conditions in the Arctic including the effects of climate change.

Results on climate issues gathered through the ongoing research and monitoring efforts are also communicated in local and international fora.

8.2.6.11 University of the Faroe Islands (Fróðskaparsetur Føroya)

Climate and climate change are included in educational programs at the University. Renewable energy sources, e.g. wind energy, hydro power, and tidal energy potential are part of research and educational activities at the University. Ongoing initiatives are establishment of a genome atlas of Faroese ecology (Gen@Far). One of the ambitions in this initiative is to become able to document potential variations due to climate changes. Another initiative is to expand the observations on the mountain Sornfelli at 750 m altitude, where the Faroese Geological Survey currently is operating a meteorological station, to also include measurements of aerosols and biological content.

The University cooperated with other Faroese institutions in the 1980s and 1990s about meteorological measurements in the central part of the Faroe Islands. At the same time, there was a small project looking into time-series from long-term weather measurements (yearbooks from 1873 and onwards) made in the Faroe Islands by the Danish Meteorological Institute. In recent years relatively substantial research, including PhD and Post-doc projects have been on estimation and clarification of the wind and tidal current energy potentials, and how these renewables might be exploited.

The University of the Faroe Islands seeks to contribute to the understanding of the ocean circulation and ocean surface waves state through numerical simulations including the neighbouring areas beyond the Faroe Shelf as well as on the shelf and into the fjords. The numerical model results are validated towards observation obtained in own projects as well as observations obtained by other domestic and international institutions making observations in the area.

The University of the Faroe Islands has been part of a climate change adaptation project in Nordic regions and regions in the United Kingdom and Ireland. The project aimed to tackle Climate Change on local and regional levels by increasing public awareness and using models of best practices to develop Climate Adaptation Plans and a measure of preparedness for local authorities.

At the project offset, baseline studies were conducted. For the Faroes, climate adaptation was mainly a bottom-up approach as there is a lack of national guidelines and policies. Therefore, climate adaptation is mainly driven by local or regional initiatives. The project looked into how prepared Faroese municipalities are compared with municipalities in Sweden. According to a survey, the participating municipalities were at the lower end of the Swedish ranking of climate change adaptation. Initial risk assessments have been conducted and included flooding, storms, and extreme cold. The project obtained data from municipalities covering 50% of the Faroese population, including Tórshavn municipality (www.torshavn.fo), the biggest municipality with roughly 21,000 inhabitants, equates to about 42% of the total population of the Faroe Islands..

8.3 SYSTEMATIC CLIMATE OBSERVATIONS

8.3.1 Atmospheric climate observations, including measurements of the composition of the atmosphere

DMI carries out continuous monitoring of key weather and climate parameters. In the climate monitoring programme, classic methods of measurement are used and new, satellite-based observation methods are being developed.

DMI operates around 350 automatic measuring stations in the Danish Realm (Denmark and Greenland) with a broad measuring programme ranging from automatic sea level or precipitation stations that measure only one parameter, to stations with a full measuring programme, including automatic cloud height detectors and weather type detectors.

Besides being of use for national programmes, the observations concern Denmark's international contribution in the form of observation components from Danish territory to the worldwide meteorological observation network WWW - World Weather Watch. Other international programmes for mapping weather and climate include the GCOS (Global Climate Observing System), coordinated by the World Meteorological Organisation (WMO). For further details – see Annex E.

The meteorological observations are stored in DMI's databases, and observations from stations in Denmark, Greenland and the Faroe Islands are available in electronic form back to as early as 1872, water level measurements from 1890, and measurements of the surface temperature of the sea from 1931.

The meteorological observation systems that are of most interest in a climate context are:

- The surface observation system
- The radio sounding network
- The weather radar network

- Satellite data
- The ice observation service

Each of these systems are described in the following, together with DMI's stratospheric observations and oceanographic observations.

AU (Department of Ecoscience and Department of Environmental Science) recently joined the ICOS (Integrated Carbon Observation System) with a number of ecosystem monitoring sites and an atmospheric site in Greenland where greenhouse gas emissions and concentrations are monitored and subsequently used for research and input to climate assessments (e.g. SWIPA, IPCC etc).

AU is a part of The Aerosol, Clouds and Trace Gases Research Infrastructure (ACTRIS), a pan-European research infrastructure producing high-quality data and information on short-lived atmospheric constituents. Under ACTRIS-DK, AU is upgrading the AURA atmospheric simulation facility at AU-Chemistry and establishing a new observational platform at Risø (ENVS). This places Denmark in a central position for studying atmospheric processes.

Surface observation network
For historical and practical reasons, the surface observation network consists of many different types of automatic and manual stations Table 8.1 provides an overview of the network. DMI is receiving a growing number of observations from cooperation partners in all parts of the Realm, so these are included in Table 8.1.

TABLE 8.1 THE NETWORK OF SURFACE OBSERVATION STATIONS 1 JANUARY 2021

Source: Danish Meteorological Institute

Type	DMI			Cooperation partners		
	Denmark	Greenland	Faroe Islands	Denmark	Greenland	Faroe Islands
Weather stations	51	23	0	39	53	8
Automatic precipitation intensity stations				186		
Automatic acc. precipitation stations	134	5	0			1
Manual acc. precipitation stations		6				1
Surface radiation stations	28	5				1
Automatic sea level stations	33			approx. 120		
Manual snow observations				72		

In addition, Denmark is a partner in the E-SURFMAR cooperation on collection of weather observations from ships and drifting weather buoys in the North Atlantic, since DMI has strategically well-placed satellite reception facilities in Kangerlussuaq (Greenland) and in Copenhagen. Observations from Denmark, Greenland and the Faroe Islands are also included, and are coordinated with EUCOS (European Coordinated Observation System), which is organised by EUMETNET (European Meteorological Network). As part of the E-SURFMAR programme, DMI has an observation agreement with three ships, which carry out systematic observations (Automated Voluntary Observing Ships) in the waters between Greenland and Denmark.

Since 2018 Denmark has been a member state of the European Research Infrastructure Consortium ICOS which provides exchange and concentrations of greenhouse gases from five stations in Denmark and four in Greenland. This is done as a collaborations between KU, AU and DTU. In Greenland these measurements are done in connection with Greenland Ecological monitoring program, GEM at Disko, Nuuk and Zackenberg.

The radio sounding network
In radio sounding, a small, fully automatic weather station is sent up by balloon. The balloon can reach a height of about 35 kilometres, and all the way up it sends observations of temperature, pressure, humidity, and wind velocity via radio to a receiving station. Radio soundings provide measurement of the atmosphere's vertical profile for use in analyses of the condition of the atmosphere and input data for numerical weather prediction (NWP) models. They also enable measurement of ozone and radioactivity.

DMI operates radio sounding stations in Danmarkshavn, Ittoqqortoormiit, Tasiilaq, Narsarsuaq and Aasiaat in Greenland. One radio sounding station is located in Tórshavn (the Faroe Islands) and is operated by the Faroese Meteorological Organisation. Furthermore, DMI is participating in EUMETNET's E-ASAP (Automated Shipboard Aerological Programme) cooperation. The E-ASAP is collecting radio soundings from data sparse marine areas via ship-borne radio soundings. DMI has an agreement with three ships routing between Denmark and Greenland, thereby covering radio soundings over parts of the North Atlantic.

Weather radar network
With five radars in Sindal, Virring and on Stevns, Rømø and Bornholm, Denmark's network of weather radars provides 100% coverage, which enables comparison with ground-truth data from a network of land-based precipitation stations.

The weather radar network has a high spatial resolution and is therefore able to provide precipitation-climatological information at a very high degree of detail nationally, regionally, and locally. By calibrating radar data against surface-based point-precipitation measurements, the latest research results show that good absolute accuracy can be achieved. The present radar network has a data frequency of 12 data sets per hour and the spatial resolution is 500x500 m^2.

Satellite data
Denmark contributes to space-based observations through membership of the European Space Agency ESA and the European meteorological satellite organisation EUMETSAT, and DMI has facilities for receiving satellite data in Denmark and Greenland.

In cooperation with EUMETSAT, DMI is managing the so-called satellite Application Facility (SAF) for use of GPS data for weather and climate monitoring (ROM-SAF) and is also participating in SAF for oceanography and sea-ice (OSI SAF) and the SAF for atmospheric composition monitoring (AC SAF). DMI is involved in the ESA Climate Change Initiative as a partner and in leading roles. DMI is also involved in EU's Earth observation programme, Copernicus supporting both the space segment and the services.

Ice observation service
DMI is responsible for systematic monitoring of the ice conditions in the waters around Greenland. Observations of the ice conditions have been collected for about 140 years, and there is a very large quantity of data in graphic form such as monthly surveys, ice maps, etc. Since 1959 the waters south of Kap Farvel, in particular, have been intensively monitored with satellites and aircraft for provision of ice information to shipping. Ice maps are prepared and distributed frequently with detailed information on relevant ice conditions. All new ice charts are in vector and

graphic form. Since 1999 weekly maps have been prepared showing the ice conditions all the way round Greenland. All offshore charts are based on satellite data DMI is carrying out research in sea ice modelling, satellite-based iceberg detection and in mapping the extent of sea-ice through the past centuries.

Measurements of pollen and spores
In Denmark the Danish Asthma and Allergy Association (Astma-Allergi Danmark) is responsible for the pollen project and operate two routine stations measuring allergenic pollen and spores in Copenhagen, Zealand, at the DMI (55º43´N, 12º34´E) and in Viborg, Jutland, at Viborg Regional Hospital (56º27´N, 9º24´E). The measurements started in Copenhagen in 1977 and are performed utilising Burkard traps placed 15 and 21 meters above ground level, respectively. The distance between the two stations is about 220 km. In different periods, campaign measurements have been performed at different stations in Denmark.

Aarhus University has since 2014 been running the Villum Research Station at the military outpost Station Nord in high Arctic North Greenland (81°36' N, 16°40' W). Villum Research Station is owned by the Greenland Government and is being operated by AU in cooperation with the Danish Defence (the Arctic Command). The station hosts individual scientific projects focusing on atmospheric, marine and terrestrial research. In addition to this, the station is also used as a permanent base for an extensive long-term monitoring programme with main focus on atmospheric pollution, but also including effects of climate change on Arctic marine and terrestrial ecosystems.

The station is open for access throughout the year, and it can host up to 14 scientists at a time.

8.3.2 Stratospheric observations

Measurements of the ozone layer and UV radiation are made at Copenhagen and Kangerlussuaq (Søndre Strømfjord), using Brewer ozone spectrometers. In Kangerlussuaq is also located a SAOZ spectrometer and an Aeronet Sun Photometer. In order to monitor the ozone depletion in the lower stratosphere in the winter and spring months, and with a view to establishing an ozone profile climatology, since 1989 DMI has been launching ozone probes from a number of stations in Greenland. Since January 1993 ozone probes have been launched on a weekly basis from Ittoqqortoormiit (Scoresbysund) on the east coast of Greenland. Ittoqqortormiit is as of now the only DMI ozone sonde launching station in Greenland. In winter seasons where the polar vortex persist into January and a certain ozone depletion therefore may be expected, the Ittoqqortoormiit Station participates in a Match Campaign run by the Alfred-Wegener Institute (https://www.awi.de/en/) so the number of ozonesoundings may exceed one per week. In Ittoqqortoormiit is also a SAOZ spectrometer, an Aeronet Sun Photometer and a UV broadband instrument installed.

The observatories operated by DMI in Greenland in Kangerlussuaq and Ittoqqortoormiit, are Arctic stations in the Network for Detection of Atmospheric Composition Change (NDACC). This is a worldwide network of measuring stations equipped with standardised instrumentation of verified high quality for monitoring the condition of the stratosphere and the processes that affect the ozone layer. NDACC is supported by the International Ozone Commission (IOC), UN Environment and WMO, and DMI takes part in the NDACC steering committee (http://www.ndacc.org). Besides, the radiosounding station in Narsarsuaq is also hosting an Aeronet Sun Photometer.

The DMI measurements are reported to the NDACC database) and the database of the World Ozone and UV-radiation Data Centre (WOUDC) under the WMO programme Global Atmosphere Watch and are used to validate satellite data as well as to compare with results from climate models. Besides, the Brewer observations at Kangerlussuaq are uploaded to EuBrewNet (http://www.eubrewnet.org/eubrewnet) in near real time, and the SAOZ data from Kangerlussuaq and Ittoqqortoormiit are uploaded to LATMOS (https://www3.latmos.ipsl.fr/index.php/fr/accueil-latmos) on a daily basis. The ozone soundings from Ittoqqortoormiit are uploaded to NILU after each sounding (usually weekly).

8.3.3 Oceanographic climate observations

DMI develops and uses satellite remote sensing of sea surface temperature and height, as well as ice concentration, drift, thickness and surface temperature for climate observations.

DMI cooperates with the Danish Coastal Authority and local authorities to monitor the sea level at a number of Danish localities.

DMI operates operational current-monitoring stations in the Danish Straits.

DMI integrates in-situ observations, satellite observations and ocean and sea ice models to simulate the present oceanic climate around the Denmark, Greenland and the Faroe Islands. The models assimilate observations and/or are validated using observations.

DMI operates at an arctic research infrastructure in NW Greenland, Qaanaaq Winter Observatory, and monitor the ocean, ice and atmospheric conditions there.

In addition, DMI operates several research driven monitoring programs.

Through the research centers Nordcee and HADAL, the Faculty of Science at the University of Southern Denmark (SDU) have observations in polar biology, deep-sea oceans, climate changes, local–regional and global element cycling – e.g. the carbon cycle, nitrogen cycle, and recycling versus loss in the marine nitrogen cycle (https://www.nordcee.dk/greenhouse-gases).

8.3.4 Terrestrial observations related to climate changes

Monitoring of snow cover, sea ice and surface radiation is reported in Sections 8.3.1 and 8.3.2 and observations of the Greenland Ice Sheet in Section 8.3.5. Denmark does not carry out further terrestrial observations that can be related to climate change, but Denmark's climate-related research (cf. Section 8.2) includes monitoring and studying the effect of terrestrial conditions – e.g. the continuous monitoring of forests structure and function performed by the University of Copenhagen for the Ministry of Environment.

As mentioned in Section 8.2.4.10, the Greenland Institute of Natural Resources (GINR), Danish Centre for Energy and Environment (DCE), and Asiaq, Greenland Survey are in charge of monitoring the effect of climate change on nature and the environment in Greenland on the basis of the Greenland Ecosystem Monitoring (GEM). The GEM is also further described in Section 8.2.4.10.

8.3.5 Observations of the Greenland Ice Sheet

GEUS has since 2007 operated the Programme for Monitoring of the Greenland Ice Sheet Margin (PROMICE). Partners are the Greenland Survey (ASIAQ) and the

DTU-Space at the Technical University of Denmark. The objective is to monitor the mass loss of the Greenland Ice sheet.

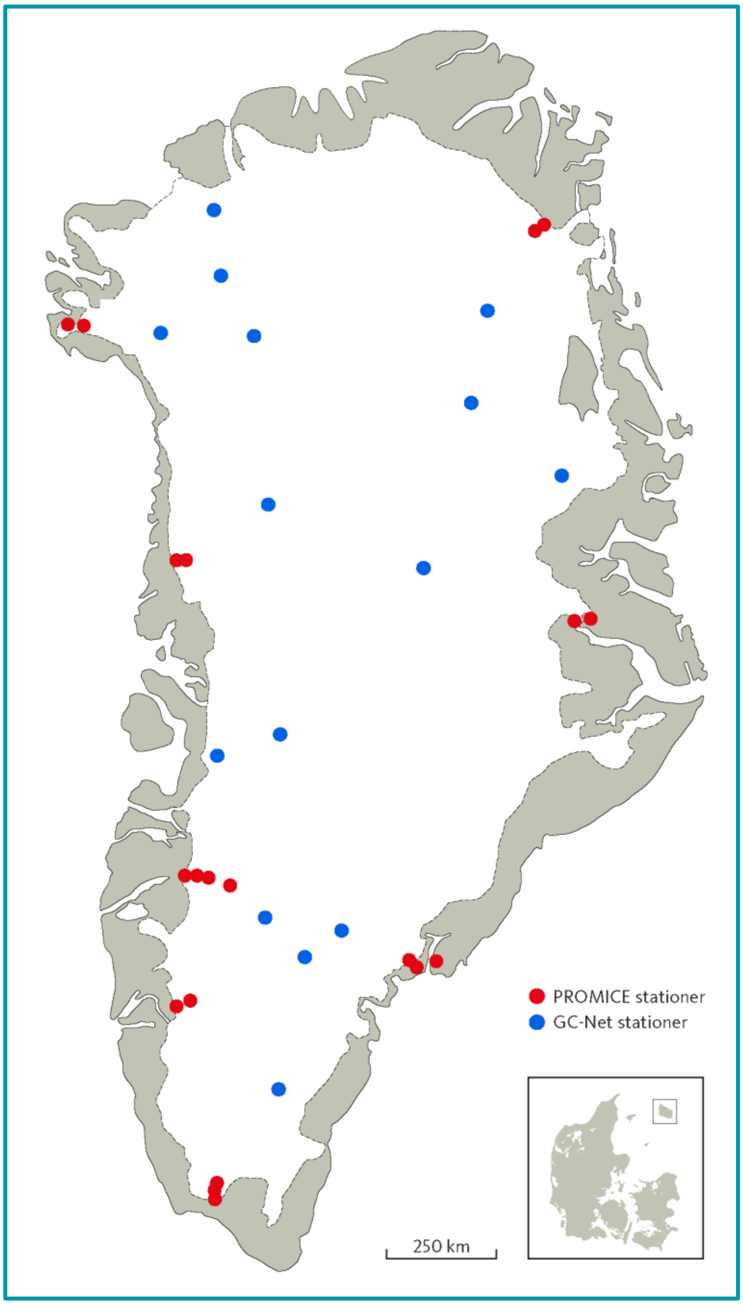
The two major contributors to the ice sheet mass loss are surface melt and a larger production of icebergs through faster ice flow. PROMICE focuses on both processes. Ice movement and discharge are tracked by satellites and GPS. The surface mass balance is monitored by a network of weather stations in the melt zone of the ice sheet.

The Greenland Climate Network (GC-Net) was established in 1995, to obtain knowledge of the mass gain and climatology of the ice sheet. The programme was funded by the USA until 2020, at which point Denmark assumed responsibility for the operation and maintenance of the weather station network. The snowfall and climatology are monitored by a network of weather stations in the accumulation zone of the ice sheet, supplemented by satellite-derived data products.

Together, the two monitoring programmes operate 36 weather stations on the Greenland ice sheet and deliver data about the mass balance of the Greenland ice sheet in near real-time. Data from the programme are available via https:\\promice.org.

FIGURE 8.1 LOCATION OF PROMICE AND GC-NET AUTOMATIC WEATHER STATIONS.

Source: Geological Survey of Denmark and Greenland



GEUS also operates the GlacioBasis monitoring programme at three local glaciers, A.P. Olsen glacier in the Zackenberg region, Freya glacier in the Disko region and Kobbefjord glacier in the Nuuk region within the GEM (Greenland Ecosystem Monitoring) framework, which is a comprehensive environmental long-term monitoring programme.

The PROMICE and GEM sites are included in CryoNet under the WMO programme Global Cryosphere Watch and are used to validate satellite data as well as to compare with results from climate models.

In addition GEUS is involved in a number of project related to satellite based monitoring of the cryosphere funded by ESA and EU Copernicus and research based observations for process understanding.

8.3.6 Systematic observations in Faroe Islands

A number of systematic observations are made in the Faroe Islands in relation to climate, mostly on hydrography (responsibility: FAMRI, see Chapter 8.2.4.11) and on weather stations (responsibility: LV and FMO) cf. Table 8.2.

TABLE 8.2 OVERVIEW OF CLIMATE OBSERVATION SYSTEMS IN THE FAROE ISLANDS.
Source: FAMRI, LV and VØRN/FMO

Observations, type	Responsibility
Hydrography • Conductivity, Temperature and Depth (CTD) measurements are obtained along six standard sections extending out from the Faroe Shelf, typically three times a year. • Current measurements (speed, direction) in the Faroe Current (Atlantic Water inflow) and the Faroe Bank Channel (Nordic Seas overflow). • Annual biological oceanography cruise on the Faroe Shelf. Main observations: chlorophyll a, zooplankton and CTD. • Annual 0-group survey in late June on the Faroe Shelf. Main observations: commercially important juveniles, zooplankton and CTD, chlorophyll a, nutrients. • Coastal station Oyrargjógv: Temperature. • Coastal station Skopun: Temperature, salinity, chlorophyll a, nutrients.	FAMRI
Hydrography • Automatic sea level and temperature measuring stations. • Wave measuring buoys (wave-height, wave period, wave direction and sea temperature).	LV
Atmospheric • Automatic weather-stations measuring: • Wind direction, wind speed, air-temperature, pressure, humidity and rain intensity.	LV
Atmospheric • Weather balloon launches • Automatic weather stations measuring: Wind direction, wind speed, air-temperature, pressure, humidity, rain intensity and sun hours.	VØRN/FMO (DMI until 1/4 -2009)

The Road Authority Faroe Islands
The Road Authority Faroe Islands (LV or LANDSVERK, www.lv.fo) carries out continuous monitoring of key weather and climate parameters. Classic methods of measurement are used.

Landsverk operates 27 automatic weather-measuring stations. Measurements for most of the stations go back to 2006, but for some back to 1998. The weather stations measure wind direction and wind speed (10 min mean wind three sec. Gust), air temperature, pressure, humidity and rain intensity. Many of the stations also measure road temperature, water on road, ice on road and salt on the road. The raw data is used for many purposes. Among others: Building projects, time estimation, evidence in damage, accident incidents, climate investigations, air traffic investigations.

Landsverk operates six automatic sea level and temperature measuring stations and four automatic wave-measuring buoys. The wave-measuring buoys measure among other things: Wave height, wave period, wave direction and sea temperature.

Faroese Meteorological Office (FMO or Veðurstovan, www.vedur.fo)
Apart from conducting inspection on fishing vessels, registrations on catch and other tasks, the Fisheries Inspection (VØRN, www.vorn.fo) has since 2009 conducted a

number of systematic climate observations, formerly done by DMI (Danish Meteorological Institute). VØRN launches weather balloons and is responsible for a number of weather stations.

8.3.7 Development assistance for establishment and maintenance of observation and monitoring systems

DMI has since 2022 participated in the UN Multi-partner Trust Fund 'Systematic Observations Financing Facility (SOFF)'. The aim of the SOFF programme is to enable universal compliance with the Global Basic Observing Network (GBON) standards by increasing the number of surface based and upper air observation stations and strengthen data flows into the global reporting system WIGOS. DMI is participating as peer advisor to (still to be decided) meteorological agencies in the global south. DMI will support gap and capacity analysis and advice on the construction and rehabilitation of basic observation stations.

DMI has since October 1st 2022 established a partnership with Ghana Meteorological Agency funded through the Danish MoFA programme for Strategic Sector Cooperation between public agencies. The project will start with a 12 months inception phase which will guide the development of the partnership's focus areas, methodologies and results framework.

9 EDUCATION, TRAINING AND PUBLIC AWARENESS

Contents

9 Education, training and public awareness

Denmark has a long tradition for involving the public in the environment field. This tradition was followed up by an international UNECE agreement - the Aarhus Convention from 1998 on access to information, public participation in decision-making and access to justice in environmental matters. On climate change, green transition, sustainable development and political action in terms of policies and measures there is and has been an ongoing public debate in the media and elsewhere. Thus, the Danish population is to a high extent informed, conscious and engaged in the political debate about handling climate changes.

A considerable amount of information on climate change and Danish policies is provided on the websites of the Ministry of Climate, Energy and Utilities (www.kefm.dk), the Danish Energy Agency (www.ens.dk), the Danish Meteorological Institute (www.dmi.dk), the Geological Survey of Denmark and Greenland (www.geus.dk) and on the websites of other relevant ministries and the institutions such as the Ministry of Transport (www.trm.dk), the Ministry of Environment of Denmark (www.mim.dk), the Ministry of Food, Agriculture and Fisheries of Denmark (www.fvm.dk), the Ministry of Taxation (www.skm.dk) and the Ministry of Foreign Affairs (www.um.dk).

In 2008 and 2009, numerous new initiatives on education, training and public awareness regarding climate change issues were taken with a view to support Denmark's role as host for the 15th Conference of the Parties to the UNFCCC 7-18 December 2009 in Copenhagen. Although some of these initiatives were project-based and limited in time, several of the initiatives have had impact on an ongoing focus on climate change in a variety of educational institutions.

The recent years, there has been a great focus on integration of education on climate change and sustainable development into the Danish education system among the government, politicians as well as teachers, students and associations. There has been establishments of interdisciplinary educational collaborations and network on education for the future and education for sustainable development and governmental initiatives to inspire to teaching on climate change and sustainable development.

9.1 Education and postgraduate education programmes

The education system in Denmark has a long-lasting tradition and practice in preparing and empowering students to live, learn, work and participate in a society with freedom and democracy. The overall management and democratic learning culture of schools combined with the framework curricula and learning objectives of all subjects provide the basis for pupils and students to develop necessary knowledge and skills to contribute to sustainable development, peace, human rights and global citizenship, in line with the Sustainable Development Goal for quality education for all, SDG 4.

Below further information in relation to education on climate change is provided.

9.1.1 Primary, lower and upper secondary education

Primary and lower secondary education

Climate change and sustainability is integrated in respectively subject purposes, competence areas, knowledge and skill areas and knowledge and skill objectives in the teaching plans (National Common Objectives) of a number of subjects in the primary and lower secondary education: the four natural science subjects (biology, physics/chemistry, geography, nature/technology), social studies, home economics, design, woodwork and metalwork.

It has to be mentioned that Danish primary and lower secondary education is relatively decentralized. Thus, it is up to the individual schools and teachers to decide the specific content of the teaching, which teaching materials to use and which teaching methods to use, and also to initiate school projects, theme weeks, electives, etc. where climate change and sustainability could be a theme.

Inspiration on how to teach about climate change and sustainable development for teachers involved in primary and lower secondary education is available on the national educational website portal under the Ministry of Children and Education (www.emu.dk). The new “Learning Portal” at emu.dk that provides inspiration for including the SDG’s in teaching. For example teaching for sustainable lifestyle, climate footprint and global citizenship. The Learning Portal contains concrete courses, activities and examples from practice as well as general didactic and pedagogical perspectives on teaching within the SDG universe. In addition the website provides examples of collaboration across and between subjects, schools and educational institutions. Futhermore articles have been uploaded on the website to inspire schools to integrate the 2030-agenda in the organizational culture of the school.

Furthermore Denmark has a dedicated network of schools participating in UNESCO's Associated Schools Project Network. The network is partially funded by the Ministry of Children and Education. Following the adoption of the SDGs in 2015 a number of these schools have embarked on a new flagship project, initiated by UNESCO: "A Whole School Approach to Climate Change and Sustainable Development." This project involves both primary, lower secondary and upper secondary schools, teachers and pupils – and their communities.

General upper secondary education

Sustainable development has been a part of Danish general upper secondary education for a number of years. The reform of general upper secondary education, which was launched in august 2017, has a strengthened focus on sustainable development.

The purpose of the education is stated in §1 of the law for upper secondary education. In this paragraph it is stated that “*Students should therefore learn to relate* *reflectively and responsibly to their surroundings: fellow human beings, nature and society as well as their development*".

Aspects of sustainable development appear in the syllabus of several subjects e.g. biology, physics, chemistry, physical geography, geoscience, design and architecture, social science, technical science and it can be included in multi-subject coursework. The Global Goals for Sustainable Development (UN 2015) is specifically mentioned in the syllabus for physical geography.

Inspiration on how to teach about climate change and sustainable development for teachers involved in upper secondary education is also available on the national educational website portal (www.emu.dk), under the Ministry of Children and Education.

Vocational training and education

The 101 vocational education programs represent a large heterogeneity in industries and labor markets where sustainability and green transition constitute a significant area of focus. Climate and sustainability are in different ways included in the education-specific subjects and learning objectives in the practical part of the education course.

For the theoretical part of the education course, resource use and sustainability are included as professional goals in the basic subject called design and in one of the professional subjects which is placed in the basic course.

Furthermore, it has been decided with a political agreement from 2021 that the purpose clause in the Act on Vocational Training must be amended in order to clarify the importance of vocational training's contribution to the green transition.

9.1.2 University of Copenhagen (KU)

Education in climate is an integral part of many educational programmes at the University of Copenhagen. The interdisciplinary two-year MSc programme, MSc in 'Climate Change, that is covering both natural, environmental and social science aspects of climate change has now been running successfully for a decade (http://studies.ku.dk/masters/climate-change/). The programme now includes two specialisations and 20+ courses, offered by departments from the Faculties of Science, and Health. The programme covers a wide range of topics within impacts, mitigation and adaptation of climate change, spanning from geophysical to political science, and including specialist courses in topics such as biodiversity, the ethics of climate change and methods of geoengineering.

Many climate change research groups at KU contribute to teaching, giving the programme a strong research base. Collaboration with other universities, such as Copenhagen Business School (CBS), and research organisations, such as Danish Meteorological Institute (DMI), has been established to ensure the strongest possible research basis of the programme. Students may either follow the programme, leading to a 'MSc in Climate Change', or select individual courses as part of other MSc programmes. The programme has attracted hundreds of students including many from various European and overseas countries. The students mention the interdisciplinary approach and the attractive location in innovative Copenhagen as the main reasons for choosing the programme. A large fraction of the international students find occupation in Denmark after graduation.

A number of courses and educational initiatives run regularly at the Faculty of Law. At the MA/LLM level, the following relevant courses run annually: 'Climate Change and the Law', 'International Energy Law and Sustainability', 'Human Rights and Economic Law for the Green Transition', 'International Environmental Law', 'EU Environmental Law', and 'Transatlantic Climate Change and Energy Law' (EU funded through the Jean Monet programme), and Corporate Social Responsibility.

At the BA level, the following courses run annually: 'Global Challenges in International Law', 'Climate Change, Disasters and Human Mobility', 'Compliance in the Public Sector', and 'Energy Supply in a Contract- and Liability Law Perspective.' The Faculty of Law also offers a specialised LLM programme for professionals, entitled the North Sea Energy Law Programme, which entails collaboration between the universities of Groningen, Aberdeen, Oslo, and Copenhagen.

The Faculty of Law has also established the 'Climate Desk' initiative, where five students per semester writing their MA or BA thesis on a climate change or sustainability-related topic, are given a workspace and integrated into the research environment. In addition, the Faculty hosts the 'Interdisciplinary Seminar Series on Climate, Energy, and Sustainability', where students writing their BA, MA, or PhD thesis on climate change, energy, or sustainability, present their research and receive feedback from a group of scholars. Approximately 100 students from several disciplines and across the world have participated in the seminar.

Other educational programmes with focus on climate are:

- EnvEuro, a two-year Master in Environmental Science, offered by the University of Copenhagen and three other leading European universities within the Euro league for Life Sciences network. The MSc is focused on soil, water and biodiversity and features an introduction to environmental science, three different specialisations, and finally a Master's thesis in environmental science (http://www.enveuro.eu/).
- The University of Copenhagen is hosting the master education in Water and Environment affiliated to the Sino-Danish Center for Education and Research in Beijing. The Master's programme in water and environment focuses on the growing need for innovative and sustainable solutions and better water management systems. Climate and global changes are an integrated part of the teaching, in particular 2nd semester the students acquire the necessary tools to deal with data analysis and processing related to water and environment research at different scales in the context of global change.
- The Earth and Climate Physics specialization of the MSc in Physics programme is offered by the Faculty of Science at University of Copenhagen. The specialization is focused on the Earth System Science and focuses on the physical climate system with emphasis on digital competences that are in high demand. 8-10 courses cover the physical description of the climate system and fundamental geophysical fluid dynamics. The one-year research-based thesis can be done in collaboration with research organizations such as DMI or the Geological Survey (GEUS). The number of students graduating is currently increasing as interest and awareness of the climate system is rising.
- E-learning course in Climate Change Impacts, Adaptation and Mitigation offered by the University of Copenhagen in close cooperation with the DMI, and the University of Natural Resources and Life Sciences in Vienna. The

course offers an introduction to various disciplines within climate change research, focusing mainly on the impacts of climate change and options for mitigation and adaption. The course has been developed by a team of teachers who are international experts within their respective disciplines, including four lead- or coordinating lead-authors on Intergovernmental Panel on Climate Change (IPCC) reports. Through distance learning the course can be followed from anywhere in the world and it is open for MSc students and continuing education students with a relevant BSc background in natural science, social science and economics.

- Global Environmental Governance (GEG) is a cross-faculty specialization, aiming to equip students with interdisciplinary skills which will assist them in dealing with global environmental governance in an international and/or national context. Focus is on the global and international levels of governance, but with a view to how these levels interact with the regional and local levels.
- Climate Solutions is an interdisciplinary course offered by the University of Copenhagen together with experts at DTU, AU and other experts in the field. It is open for MSc students and continuing education students with a relevant BSc background in natural sciences, social sciences, humanities, law, economics and engineering. Students are working together in interdisciplinary teams as consultants for private companies and public institutions to perform accounting of their greenhouse gas emissions and create concrete plans for implementing the most effective and cost-effective solutions for reducing greenhouse gas emissions.
- Summer schools are annually offered by the University of Copenhagen within the area of climate change, often in collaboration with other universities within IARU (http://studies.ku.dk/summer/courses/), and the University of Copenhagen is also contributing to the Climate KIC summer school The Journey (www.journey.climate-kic.org).
- Large and smaller research projects on climate change related topics are continuously initiated and offers summer schools or other educationally related activities as an element of the research plan.
- Climate change is considered as an element in sustainability courses offered by the faculty of Science cf. the University of Copenhagen's course overview (www.ku.dk).
- Furthermore, a number of other individual courses on climate change is available for continuing education students as single subject courses via open education (www.kurser.ku.dk) and may also be taken in combination as a part of a 60 ECTS Flexible Master in Climate Change and Environmental Management cf. the University of Copenhagen's Master's Programmes and Courses (www.ku.dk).

The universities disseminate widely the results of research, with the portals http://climate.ku.dk/ and https://sustainability.ku.dk/research/ as the main entry points. Here, 12 key areas of climate research are listed, including areas of study and contact persons. At the faculty/institute level, a wealth of climate activities within research and education are disseminated, e.g. the Niels Bohr Institute's activities at its dedicated website (https://nbi.ku.dk/english/research/pice/outreach/).

9.1.3 Aarhus University (AU)

There are climate related education programmes at all the faculties. For example there are courses related to the understanding of the climate system and mechanisms of climate change, agricultural production and the impact of this on the climate, courses on tropical ecosystems, management and development, global food production and climate change, global management and manufacturing, and environmental economics and climate change.

AU Department of Law offers a number of courses in climate law or climate mitigation/adaptation-related issues on both bachelor's and master's level. On a bachelor's level a 45-hour course in "Climate-, energy and environmental law" is mandatory for business law students, while a 30-hour elective course in "Renewable energy law" is running every fall. Focusing on exchange students, but also open for Danish students, the Department of Law offers a 38-hours intensive bachelor's course in "Climate law – international and EU law in context" as part of the AU Winter School Programme and a 40-hours course master course in "Climate law", which forms part of the AU Summer School Programme. Moreover, climate law forms an integral part of the "Environmental Law" elective course on the master level. The Department is also taking part in the Peoples University with lectures on the Paris Agreement.

The Danish School of Education at AU has conducted research on the role of education in relation to climate change and sustainable development. DanishIn collaboration with Environmental and Sustainability Learning Centre at Rhodes University in South Africa, they have recently explored how learning can foster change agents and collective agency for climate resilient development.

Climate change issues are highly integrated in the MSc programme on Agroenvironmental Management at Faculty of Sciences and Technology, which contains a course on Carbon Cycling and Climate Change. Climate change is also highly integrated in the Graduate School of Science and Technology and the Agroecology, Biosciences and Environmental Sciences ph.d. programmes at AU.

The Faculty of Business and Social Sciences (BSS) at Aarhus University has set strategic focus on "sustainable growth through innovation" in research, education, communication and cooperation with the business community. More than 50 researchers are working with issues such as regulatory challenges, climate economics, strategies and business models, user behaviour, sustainable supply chain and logistics, responsible investment, CSR etc.

A BScB in Sustainable Business and a BScB in environmental law have been developed.

Department of Archaeology and Heritage Studies offers a MA degree in sustainable heritage management (SHM). The programme provides the students with the knowledge and competencies needed to meet the multiple challenges of contemporary heritage policy, management and research, and taking responsibility for the links between humans, our environment, and the past. Educational programmes in Anthropology also contain elements of environmental studies related to land-use, governance, and political ecology, especially with regards to indigenous peoples.

The AU School of Engineering offers an international graduate programme in Urban Water. The semesters aim at combining traditional engineering skills with environmental process know-how and methods for analysis and engineering of suitable solutions for waste- and stormwater-water management, treatment and discharge, and ground water withdrawal, treatment and distribution. An understanding of the climate and environmental impacts is combined with engineering disciplines in learning how real-life problems of the urban society can be analysed, and how suitable technical solutions can be designed, dimensioned and implemented. The programme is highly relevant in developing practical solutions for water related climate change adaptation.

Aarhus University in collaboration with the Sino-Danish Centre, other Danish universities and the University of the Chinese Academy of Sciences in Beijing offers a Master programme in Water and Environment for Danish and Chinese students in Beijing, China. The programme is focused on finding solutions to the challenge that worldwide freshwater resources are under pressure due to overuse, pollution and climate change.

In addition, Aarhus University carries out a considerable amount of public outreach, including numerous lectures at high schools and primary schools and for the general public. Courses on climate have been organised for school teachers and journalists, and AU has also presented number of papers for the general public, which may be used as teaching material.

9.1.4 Aalborg University (AAU)

Climate change is an integral part of a very large number of educational programs at AAU, reaching from social science through health aspects to technical programs with focus on applications to reduce climate change. Thus, students at AAU generally have in-depth knowledge within a specific (e.g. technical) topic combined with generic knowledge on the wider (e.g. societal) implications. In order to be able to solve the challenges of tomorrow the students need to have knowledge about many aspects of the challenge. This is a key point in our educational programs. This is parallel to the future scenarios for competence building required for the transition to a low-carbon, renewable energy system developed by EUA-EPUE (European platform of universities in energy research and education).

The PBL-based pedagogical model of Aalborg University has become both nationally and internationally recognised by universities, researchers and students as an advanced and efficient learning model. Problem-based learning (PBL) is a student-centered pedagogy in which students learn about a subject through the experience of solving an open-ended problem found in trigger material. Thus, UNESCO has placed its only Danish Chair in PBL at Aalborg University. As of early 2022, all research regarding PBL at Aalborg University has been gathered in the Institute for Advanced Study in Problem Based Learning.

A comprehensive university with both research and education in social science and humanities, health science and medicine, technology and engineering, Aalborg University has more than 25 educational programs covering most aspects of the measures to mitigate climate change as well as the implications of climate change.

Addressing the challenges caused by climate change (e.g. climate adaptation issues or migration), several educational programs offer competences within e.g. societal planning, water & environmental engineering or ICT. A multitude of educational programs also operate within the framework of green energy (low carbon emission energy production, distribution and consumption etc.). Aalborg University offers a variety of specialized energy master degrees, ranging from e.g. sustainable energy planning through thermal energy and process engineering, to mechatronic control engineering. Furthermore, competences achieved through master degrees in more generic engineering disciplines such as structural engineering or bio-technology are very often applied to energy- or climate-related challenges.

Drawing from international experiences and contributing to the development of education and research at a European level, Aalborg University plays an active role in CESAER (the Conference of European Schools for Advanced Engineering Education and Research) – a non-profit international association of leading European universities of science and technology and engineering schools/faculties at comprehensive universities and university colleges.

9.1.5 Technical University of Denmark (DTU)

DTU has incorporated sustainability into study plans and competency pro-files for all undergraduate and graduate degree programs within the univer-sity. Moreover, DTU has introduced a "sustainability carter for engineers" that all students are encouraged to adopt. DTU students are invited also to partake in extracurricular activities such as the running of a sustainable beer brewery at DTU, or the development of energy-efficient vehicles to compete in the Shell Eco-Marathon. Since 2010, DTU has also organized a "Green Challenge", where students present their green projects developed as an integrated part of the educational activities.

9.1.6 Roskilde University

Bachelor studies in natural and social sciences, humanities and technologies at Roskilde University contain climate-related components. Climate science, climate policy modules, energy production and the social dynamics behind such issues are included in the master studies in technological and socioeconomic planning (Teksam), Geography and in the university's new two-year multi-disciplinary, international master's programme in Environmental Risk. Optional courses in the fields of environment and energy with climate-related contents are available to students of these subjects.

Climate-change impacts are also important in relation to the natural science PhD programme, which focuses on how natural stresses (e.g., drought, temperature extremes, diseases) and stress deriving from human activities (e.g., toxic chemicals, habitat destruction) impacting ecological systems.

9.1.7 University of Southern Denmark

Education in climate and sustainability is an integral part of many educational programmes at the University of Southern Denmark and a rising number of courses have a green/sustainable/climate perspective incorporated.

Besides the many course activities, there are also a number of education programs with a main focus/relation to climate (examples):

- At The Faculty of Science there's a Master of Climate Adaptation – a cross disciplinary Masters Programme focusing on sustainable climate adaptation projects.
- At the Faculty of Engineering these following Climate-relevant educations (BSc and MSc) :
  - Product Development and Innovation Engineering: developing sustainable products and processes

- Environmental engineering: designing sustainable, eco-friendly products, solutions and technologies. environmental system analysis, environment and resource efficiency of systems
- Energy Systems Engineering: analysing, developing and integrating existing and new sustainable types of energy systems into the future green energy system.

At the Faculty of Humanities the Centre for Primary and Lower Secondary Education Research (Center for Grundskoleforskning) and the Centre for Upper Secondary School Research (Center for Gymnasieforskning) are located.

The Center for Primary Education Research are experts in primary and lower secondary education research with a particular focus on sustainable development and the UN's World Goals, which are addressed through Goal 4: Quality education. Education for sustainable development, including climate sustainability, is a cross-cutting theme for the centre's activities. The centre's mission is thus to strive for the good life of children through teaching and school development in a sustainable world. With a view to realizing this mission, the center has established a focus area for sustainability from the start.

The Centre for Upper Secondary School Research - In the development of sustainability didactics, the we start from the basic philosophical assumptions underlying education, such as worldview, human view, view of nature, view of learning, perception of what education is and what the purpose should be – and thematize sustainability as an important societal dilemma.

9.1.8 Danish Meteorological Institute (DMI)

DMI presents general information material on www.dmi.dk, offering both current news, basic knowledge on climate and climate-change issues and in-depth topic themes which are widely used in Danish schools.

DMI assists schoolbook publishers with fact-check proofreading, graphics and other consultancy. DMI has taken part in development of specific teaching programmes aimed at elementary and high school students, covering climate change in Denmark and the Arctic.

Together with NOVO LIFE and other external partners, DMI has developed climate related teaching material targeted on high school students. The material consists of a webportal including data and video material as well as hands on exercises. Topic and level is ajusted to the examination requirements.Link: https://life.dk/undervisningsforlob/vandkamp.

DMI also contributes to dissemination of climate knowledge to high school level and beyond in terms of a short movie and a comprehensive theory and exercise book.link: https://lru.praxis.dk/Lru/microsites/virksomhederiundervisningen/dmi_film.html

Data and knowledge on Arctic climate change, e.g. material from Polarportal.dk, is being used as a basis for a teaching programme for elementary and high-school students[1].

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[1]https://via.ritzau.dk/pressemeddelelse/dmi-udvikler-nyt-undervisningsmateriale-om-det-arktiske-klima?publisherId=13559149&releaseId=13606091

DMI also welcomes students from the 9th and 10th grades at state schools in Denmark to participate in a short-term work experience. The programme has a duration of one week and takes place three times a year. Among other things the students learn about climate by using an interactive climate model which is a simplefied version of real climate models.

DMI participates in the education, supervision and training of PhD students, master and bachelor students in collaboration with Danish universities in areas of climate change and related issues. Currently, in 2022, DMI hosts ten PhD students working on climate change projects in collaboration with different Danish universities.

9.1.9 Ministry of Children and Education

The recent years the Danish Ministry of Children and Education has launched a number of initiatives to strengthen a focus on climate change and sustainability in the primary, lower secondary and upper secondary educations.

As a part of the government's action plan for UN's sustainability goals (2021), a website with materials about the SDGs has been initiated on the national educational website portal (www.emu.dk/verdensmaal). The platform accommodates more than 70 inspiration materials addressed pre-school, primary and lower secondary, upper secondary and vocational education and training. The materials consist of didactics, cases, examples, guides and tools on how to integrate sustainability in teaching, management and school operation. The aim is to inspire and provide schools and education institutions with the necessary knowledge and tools to integrate the sustainability goals in teaching and school operation.

As an outcome of the natural science strategy from 2018, several didactic articles were published to promote teaching in the natural sciences as well as the ABC of natural sciences – a compilation of the 10 most basic scientific findings. The ABC of natural sciences has great focus on climate, climate changes and sustainable development. The materials developed as part of the natural science strategy is presented here: https://emu.dk/stx/naturvidenskabsstrategien?b=t6

Another current initiative by the government is an allocation of 10 million DKK annually for an entrepreneurial climate-pool for upper secondary educations. The purpose is to support that youth education is at the forefront of the green agenda, ensure involvement and initiatives of students and provide students with knowledge about the green, sustainable development.

Moreover, the Ministry of Children and Education is working on how to strengthen skills and competences for the sustainable transition in vocational education and training. For example there has been cashed out two pools of funds targeting respectively 1) equipment investments and associated skills development to support green transition and sustainability (57.7 million DKK) and 2) development and testing of teaching courses on vocational training and labour market education focusing on green transition and sustainability (38.3 million DKK). Special "green subsidies" have also been given to providers of technical vocational training (36 million DKK) and a special grant has been given to VET-knowledge centres' work with activities supporting green transition among the vocational schools (54 million DKK). Another example is that funding has been provided for mapping future competence needs in relation to the green transition of five vocational education programs, which are considered to be particularly relevant for the green transition (10 million DKK). Finally, it has been decided to to establish three climate-vocational schools with the aim of establishing strong professional environments of the green transition and sustainability (100 million DKK annualy from 2023-2028 and 30 million DKK annualy thereafter).

The Ministry of Children and Education has also recently granted 0.5 million DKK to the establishment of interdisciplinary educational partnerships on development and integration of education for sustainable development across the education system.

At Denmark's presidency of the Nordic Council of Ministers 2020, the presidency project also had a focus sustainability. The project focuses on how young people's active citizenship can be supported and strengthened in a school context and to what extent environmental sustainability is integrated in teaching plans in the Nordic countries.

9.2 CLIMATE INFORMATION

9.2.1 Ministry of Climate, Energy and Utilities

The websites of the Ministry of Climate, Energy and Utilities (www.kefm.dk) and of the Danish Energy Agency (www.ens.dk) are updated regularly with the latest relevant information within the climate area, either directly in the form of press releases, documents, reports, etc. or through links to relevant professionals.

In accordance with the political Energy Agreement from March 2012, a special effort to develop strategic energy planning and CO_2 calculation tools for Danish municipalities has been initiated by the Danish Energy Agency. The purpose of municipal strategic energy planning (SEP) is to promote a shift towards a more flexible energy system to realize the potential for energy savings and conversion to renewable energy in the most efficient way for society. It is up to the local authorities whether they will develop strategic energy plans. On the basis of previous work and new analyses carried out in 2012 and 2013, the toolbox made available for the municipalities now contains:

- Guidelines regarding mapping methods and data collections, and
- Guidelines regarding system change analyses and scenario analyses.

Furthermore, financial support from a dedicated pool, totalling DKK 19 million for the period 2013 to 2015, was made available for municipalities to apply for in order to promote partnerships for strategic energy planning.

The CO_2 calculation tool for Danish municipalities was also initiated by the Danish Energy Agency and developed in cooperation with *KL-Local Government Denmark* and *Danish Regions*. The tool is called *Energi- og CO_2-regnskabet* (the Energy and CO_2 accounts - see https://sparenergi.dk/offentlig/vaerktoejer/energi-og-co2-regnskabet) and is used by more than half of the municipalities to facilitate the green transition. For example, municipalities can assess the effect on local CO_2-emissions of various initiatives and monitor the historic CO_2-emissions. In 2023, a feature will be added so that it is possible to make projections of local CO_2-emissions.

9.2.2 The Ministry of Environment of Denmark

The websites of the Ministry of Environment of Denmark (www.mim.dk) and of the Danish Environmental Protection Agency (www.mst.dk / www.klimatilpasning.dk) are updated regularly with the latest relevant adaptation information within the climate area, either directly in the form of press releases, documents, reports, etc. or through links to relevant professionals.

9.2.3 Aarhus University (AU)

DCE – Danish Centre for Environment and Energy, Aarhus University prepares regular reports about environmental issues, including climate change. They are published at www.dce.au.dk.

AU also publishes several journals for public outreach. These journals include articles on various subjects within natural science, but climate-related subjects have a dominant role and several volumes of the journals have been dedicated to climate. In addition researchers from AU publish findings of interest to the general public in various public outreach journals as well as on the internet (e.g. www.videnskab.dk).

DCA – the Danish Centre for Food and Agriculture at AU has prepared several reports on 1) greenhouse-gas emissions from agriculture and how these emissions can be reduced, and 2) impacts of climate change on Danish and European agriculture.

Aarhus University interdisciplinary climate center publishes information on the internet (www.iclimate.au.dk).

9.2.4 University of Copenhagen

Dissemination on climate from researchers at the Niels Bohr Institute (NBI) is available on the homepage http://www.isarkiv.dk/, established with support from the Ministry of Research and Education. In addition, KU hosts 50 high school classes every year for climate lessons and view of the Greenland ice cores. On the NBI home page under http://www.nbi.ku.dk/sciencexplorer/, movies on climate and ice core drilling are available and have been accessed by more than 1 million people.

Researchers from NBI have been lead authors on AMAP's assessment of the Snow, Water, Ice and Permafrost in the Arctic (SWIPA: https://swipa.amap.no/) and researchers at the faculty of Science have been contributing authors, or review editors on the IPCC 6th assessment report cycle (AR6) for its working groups one and two.

Currently, the following large NBI-based climate-related research projects are providing outreach information:

- H2020 TiPES on tipping points in the climate system: https://www.tipes.dk/
- H2020 BE-OIC searching for the oldest ice in Antarctica: https://www.beyondepica.eu/en/
- ERGRIP drilling in an ice stream in Greenland: https://eastgrip.org/

As well as:

- IceFlow: https://nbi.ku.dk/english/research/pice/projekt-sider/iceflow/

Both scientific and popular communications are routinely dissiminated from the Greenland Ecosystem Monitoring program (GEM) including annual popular science reports on the measured data from the main observational sites in Disko, Nuuk and Zackenberg. Both IGN and BIO are contributing to the program.

Within the integrated Carbon Observation System (ICOS: https://www.icos-cp.eu/) the European headquarter in Helsinki publish synthesis reports on the European Greenhouse gas emission landscape, aimed for politicians and a broarder public.

9.2.5 Technical University of Denmark

Research results from DTU are published in international journals and con-ferences and are made more widely available via scientific advice, courses, events, industry collaboration, webpages, and national media. Researchers at DTU are encouraged to actively engage in public discourse and to share their findings and insights openly and freely.

9.2.6 University of Southern Denmark

In the beginning of 2022 SDU Climate Cluster was established.The ambition of the SCC is to create optimal conditions for ground-breaking, excellent and interdisciplinary research, education and communication within the climate area.

In autumn 2022 SCC has launched a series of climate lectures 'Climate Thursdays' with researchers from not only SDU but also DTU, AU, DMI and Copenhagen University – a lecture series open and free of charge for both students and the public.

At SDU there is a large focus on knowledge dissemination and we use many different channels to communicate are findings and research within climate.

9.2.7 DMI

DMI disseminates knowledge on climate issues to the general public from an extensive website at www.dmi.dk, offering both current news, basic knowledge on climate and climate-change issues and in-depth topic themes. DMI also communicates through social media, particularly twitter and instragram, popular articles in newspapers and trade journals and more in depth series of reports.

Members of DMI staff give lectures to high-school and university students, teachers, researchers and others. For instance, since 1998 staff members have been taking part in annual national events such as the two annual Science Festivals, *Forskningens Døgn* og *Naturvidenskabsfestival*, giving lectures around Denmark. 150,000 students take part in the events and activities of *Naturvidenskabsfestival* each year, and 75,000 guests from a broad audience visit the science festival of *Forskningens Døgn*. In 2016, 39% of primary schools and 63% of high-schools participated in *Naturvidenskabsfestival*. Since 2020, DMI has further taken part in *Klimafolkemødet*; an annual public event covering climate change from both scientific, political and practical aspects.

On the annual Culture Night in Copenhagen, DMI participates with outreach activities for the general public on climate change and related issues. Finally, employees at DMI often take part in radio and TV interviews, and in interviews for the printed press.

DMI in collaboration with GEUS and DTU display the results of their monitoring of the Greenland Ice Sheet and the sea ice in the Arctic on the webportal polarportal.dk. The main purpose of the site is to make updated information from this monitoring available to the general public, both nationally and internationally. In addition, the site will provide access to scientifically based information resources.

As mentioned in Chapter 6, DMI has developed, and is hosting, the so-called Climate Atlas (www.klimaatlas.dk) where observations and climate simulations are being combined to provide detailed future projections of expected climate change related changes across Denmark. The Danish National Climate Atlas, Klimaatlas, provides Danish society with relevant and easy-to-use information on expected future changes in climate, including changes in atmospheric temperatures, precipitation and derived indices, as well as from the sea surrounding Denmark (sea-level and storm surges).

9.2.8 GEUS

GEUS participates in a number of international research projects, foras and network groups and contributes to the supervision of Master and Ph.D students.

The GEUS website and social media are updated regularly with relevant information and results from GEUS climate research and monitoring. PROMICE maintains a website with data and updated information on the mass balance of the Greenland ice sheet. In collaboration with DMI and DTU Space, GEUS runs the Polar Portal. On this web-site the Danish Arctic research institutions present updated knowledge on the condition of two major components of the Arctic: The Greenland ice sheet and the sea ice. In 2016 GEUS launched an open Geothermal Energy portal[2] providing essential data regarding the geothermal potential in Denmark. GEUS regularly participates in outreach for the general public at events such as Cultural Night and 'Forskningens døgn'. In collaboration with University of Copenhagen and Unioversity of Aarhus GEUS runs the 'Underground channel' which produces videos about geoscience many of them related to climate change. GEUS has extensive field work activities in the Arctic and make an effort to bring journalists into the field to report on climate change and GEUS employees often take part in interviews with national and international media.

9.2.9 University of Greenland

Ilisimatusarfik, University of Greenland, covers social sciences and humanities. Ilisimatusarfik is involved in a series of activities which include focus on climate change. Specific courses with focus on climate change are offered at BA and MA levels.

The Climate and Society programme

The Climate and Society programme connects Ilisimatusarfik, University of Greenland, and the Greenland Climate Research Centre (GCRC) and focuses on issues of pressing current concern for society and the environment in Greenland. The Climate and Society programme carries out research and contributes to teaching at the intersection of social science, climate science and public policy.

The Climate and Society programme complements research in the natural sciences at GCRC and the work aims to improve understanding of the interconnections between climate change, the use of natural resources, non-renewable resource development, and social-ecological systems in Greenland.

Education and communication are central activities. The Climate and Society programme is a foundation for formal educational links between GCRC and Ilisimatusarfik and the Climate and Society programme is contributing to teaching of undergraduate students and supervision of graduate students at Ilisimatusarfik at both Master and PhD level.

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[2] http://dybgeotermi.geus.dk/geotherm/

9.2.10 Greenland Institute of Natural Resources (GINR)

GINR advises the Government of Greenland and other authorities on sustainable exploitation of living resources and safeguarding the environment and biodiversity.

GINR is managed by a Board of Governors and a Director under the Ministry of Agriculture, Self-sufficiency, Energy and Environment in the Government of Greenland and according to Act of Greenlandic Parliament no. 6 of 8 of June 1994 on the Greenland Institute of Natural Resources GINR is obliged to:

- provide the scientific basis for an assessment of sustainable use of the living resources in and around Greenland as well as a scientific basis for protecting the environment and securing biological diversity
- advise the Greenland Government on the work of the Institute
- publish results of its research.

Results on climate issues gathered through the ongoing research and monitoring efforts are also communicated in local and international forums.

GINR are actively participating in expert networks of the Circumpolar Biodiversity Monitoring Program (CBMP), which has been endorsed by the Arctic Council and the UN Convention on Biological Diversity.

GINR also manages the marine monitoring efforts in Zackenberg and Nuuk and the terrestrial/limnic monitoring efforts in Kobbefjord Research Station as part of the Greenland Ecosystem Monitoring (GEM). GEM is active in national and international climate forums, representing a key Danish-Greenland collaboration on Arctic climate change.

9.3 DANISH PARTICIPATION IN INTERNATIONAL CLIMATE ACTIVITIES

9.3.1 DMI

DMI contributes to international climate assessments, notably the IPCC Assessment Reports and assessments by the Arctic Monitoring and Assessment Programme of the Arctic Council, such as regular updates on Arctic Climate Change aimed at policymakers both in the Arctic Council and more widely.

DMI is engaged in communicating the IPCC's reports to the public through dissemination on the DMI website, and DMI has translated key messages of the Summary for Policymakers of the IPCC AR6 Special Reports and Working Group contributions into Danish.

DMI is futher enganged in several european research projects, e.g. funded under the EU Horizon programmes, where policy briefings and information aimed a policy makers and stakeholders are key parts of the research dissemination. Recent examples include the projects Blue Action, EUCP European Climate Prediction, and PROTECT.

9.3.2 GEUS

PROMICE is is part of the AMAP, Arctic Monitoring and Assessment Programme and GEUS provides input to international assessments on climate change such as IPCC AR6 and AMAP Arctic Climate Change Update 2021: Key Trends and Impacts.

GEUS is furthermore involved in climate related work in groups or organisations such as:

- International Arctic Science Committee-Working Group on Arctic Glaciers (IASC),
- World Glacier Monitoring Service (WGMS),
- European Space AngencySA,
- Global Land Ice Measurements from Space (GLIMS),
- EU-Copernicus
- WMO.

In relation to CO_2 storage GEUS participate the following networks:

- CGS Europe,
- CO2GeoNet Association,
- EERA (European Energy Research Alliance) and
- ENeRG (European Network for Research in Geo-Energy).

9.3.3 Aarhus University (AU)

Aarhus University participates at expert level as authors in the IPCC and other climate assesments (e.g. the SWIPA report).

DCA – Danish Centre for Food and Agriculture has contributed with a lead author to recent IPCC assessment reports.

Researchers at AU are actively involved with leading roles in European and international research on quantification of greenhouse gas emissions, quantification of mitigation measures, impacts research as well as evaluating measures and strategies for adaptation to climate change. The results feed into the IPCC emissions inventory guidelines and the IPCC assessment reports.

AU also takes part in numerous international networks and research projects on understanding the climate system, causes for climate change, consequences for the ice sheet and ocean circulation as well as impact on ecosystems and biodiversity.

AU is represented in the Scientific Advisory Board and in the Governing Board of Joint Programming Initiative on Agriculture Food Security and Climate Change (FACCEJPI).

DCE – Danish Centre for Environment and Energy is a member of ‘Partnership for European Environmental Research – PEER’. Through PEER, AU has initiated and participated in several international activities coordinating, developing and dissemination climate change related research.

Researchers under the umbrella of DCA is participating in 1) the UN Task Force on Emissions, Inventories and Projections (TFEIP) Agriculture and Nature Expert Panel, 2) the UN Task Force on Reactive Nitrogen, 3) the annual forum of the Global Alliance on Climate Smart Agriculture, and its working groups on Knowledge Action Group, Enabling Environment Action Group and Investment Action Group, and 4) working groups under the Global Research Alliance on Agricultural Greenhouse Gases.

AU is a member of the European Topic Centre on Climate Change impacts, vulnerability and Adaptation (ETC/CCA) under European Environmental Agency focus on Climate-ADAPT.

9.3.4 Technical University of Denmark (DTU)

DTU participates extensively in international research- and innovation initia-tives. This includes but is not limited to projects funded by the United Na-tions, the European Commission, and the World Bank. DTU offers scientific advice both nationally and internationally and is widely represented in inter-national expert comities and steering groups. In some cases, DTU also formally handles Denmark's monitoring and data collection obligations in relation to international treaties.

9.3.5 University of Copenhagen

The University of Copenhagen is involved in a number of projects in relation to climate change in the tropical regions, focusing on research and outreach.

KU researchers have also played an important role in the work of the IPCC.

PLEN also works with impact models of agricultural crops including extreme events, methods to estimate GHG emissions and combined food and energy producing systems in agriculture. Knowledge of processes in and interactions between soil, water, plant and atmosphere, also covering microclimate, energy and gas exchange between canopy and atmosphere is applied in the development of models (The DAISY model).

Researchers from NBI chair, the climate section of the European Geophysic Union, are members of the climate board CLiC (Climate and Cryosphere; http://www.climate-cryosphere.org/). A number of research projects at NBI are contributing to a better understanding of cryospheric processes of importance for a changing climate (Beyond EPICA: https://www.beyondepica.eu/en/). As an example, the European Reseach Council (ERC) synergy grant funded project ice2ice focus on the role of sea ice as an important mediator of climate change in the Arctic driven by the ocean. One researcher from NBI currently serves as a member of the Joint Scientific Committee (JSC) for WMO's World Climate Research Programme (WCRP).

9.3.6 University of Southern Denmark

SDU participates at expert level as lead author in the IPCC and other climate assessments e.g. chairman of The Danish Council on Climate Change.

SDU is also member of a broade range of international science network with focus on climate related issues.

Through varies research and development projects many of SDU's researchers work together with scientist from all over the world to come up with new research that can pave the way for climate neutrality.

9.3.7 Greenland Institute of Natural Resources (GINR)

GINR is part of numerous international networks and research projects in the Arctic on the effects of climate and climate change on both terrestrial and marine ecosystems.

The GINR research spans from oceanography and biogeochemistry to macroecology, and also includes the aspect of social impacts. Through cross-disciplinary and cross-institutional efforts, GINR aims to improve the understanding of the links between climatic and ecological processes in the Arctic, and the impact of climate change on the human population in Greenland, who rely very much on the natural resources.

9.4 Public campaigns and involvement of civil society

A number of initiatives are being carried out to promote environmentally sound behaviour in companies and households, particularly for climate reasons, and with respect to energy use. Labelling schemes, printed matter, information lines, media spots and similar are used to increase public knowledge of possibilities for action and knowledge about less environmentally harmful technologies.

Since 2019, the involvement of the civil society has been strengthened with the establishment of:

- 13 Climate Partnerships - for cooperation with the business community focused on how businesses and the Government can join forces to address climate challenges in a manner that also supports Danish competitiveness, export, jobs, welfare and prosperity without increasing inequity,
- The Citizens' Assembly - with 99 members selected to discuss dilemmas and solutions associated with citizen centric climate challenges. The assembly had two different phases. One in 2021 and one in 2022. For now, the work has resulted in two reports and a total of 192 recommendations combined. The two phases of the Citizens Assembly will be evaluated during 2023.
- The Youth Climate Council - founded in 2019 with 14 members. The members are appointed for two-year terms and come from all over Denmark with different educational backgrounds and representing different approaches to climate challenges. The Youth Climate Council aims to both infuse innovative thinking into Danish climate policy with input from the Danish youth, and simultaneously to engage and encourage the youth to take part in the debate.