Green National Accounts for Denmark

2015-2016

Highlighting the link between the economy and the environment through environmental-economic accounting

STATISTICS DENMARK

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Green National Accounts for Denmark 2015-2016
Published by Statistics Denmark
February 2018
Printed: 350
Photo: Colourbox

Printed version:
Price: DKK 290.00 incl. VAT. The price is excl. handling and shipping.
Can be bought at: www.schultzboghandel.dk and distribution@rosendahl.dk
ISBN 978-87-501-2291-3

Pdf-version:
Downloadable at www.dst.dk/publ/GreenNatUK
ISBN 978-87-501-2292-0

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Symbols

0 0.0	Less than a half of the applied unit
●	Category not applicable
..	Data too uncertain to be stated
…	Data not available
-	Zero

Due to rounding, the sum of the figures in the tables may differ from the total.

Preface

For many years, the green national accounts – or environmental-economic accounts – and the relationship between the environment and the economy have been the focal point of a number of publications from Statistics Denmark. A three-year appropriation in the 2015 government budget made it possible to increase the effort to draw up a comprehensive statement of green national accounts. Most results of this work were described in a publication in Danish in the beginning of 2017. With this English-language publication, we also want to make the green national accounts available to an international audience. Furthermore, we present results from those parts of the green national accounts that have been added in the course of 2017. This involves extended natural resource accounting for land, fish, forests and the value of the Danish oil and natural gas in the North Sea.

The purpose of the green national accounts is to identify the importance of nature to the economic activities, how economic activities affect the environment, and how nature is part of our national wealth in the broad sense. These are conditions which are important to ensure sustainable development, and which are at the heart of measuring and following up on e.g. the UN sustainable development goals. Accordingly, the publication also includes a special chapter dealing with the development in a number of the indicators defined in connection with the sustainnable development goals.

The green national accounts have been prepared based on the international guidelines provided by the UN and other international organisations in the *System of Environmental-Economic Accounting - Central Framework*. This ensures that the Danish green national accounts are based on a recognised and tested system that also enables international comparisons.

There is still much to be done before the green national accounts have the same prominent position in the public debate as the traditional national accounts. However, my hope is that this publication helps to demonstrate that we have come a long way.

We would like to thank the many contributors outside Statistics Denmark who have participated in and supported the development of the green national accounts and provided data for them. This applies in particular to the Ministry of Environment and Food of Denmark, the Danish Environmental Protection Agency, the Geological Survey of Denmark and Greenland, the Danish Energy Agency, the Danish Business Authority and the Danish Centre for Environment and Energy (DCE), Aarhus University, as well as a number of enterprises.

Statistics Denmark, January 2018

Jørgen Elmeskov, National Statistician

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Summary

Economy and environment

The green national accounts for Denmark supplement the traditional national accounts with information on the connection between the economy and the environment. The accounts include three main types of information. The first type concerns the use of materials, energy and water as well as the resulting residuals in the form of waste, wastewater and air emissions. The second type concerns various aspects of the green economy: environmental protection, output of environmental goods and services as well as environmental taxes etc. The third type of information in the green national accounts concerns Denmark's natural resources in the form of land, oil and natural gas as well as forest and fish.

International guidelines – basis of indicators

The accounts, which are based on guidelines from the UN and other international organisations, are organised so that the information about the environment and natural resources can be logically compared with the economic activities described by the traditional national accounts. This is ensured e.g. by consistently using the same detailed activity classifications as in the national accounts. For this reason, the green national accounts are also well suited as underlying data for some of the SDG indicators defined in connection with the United Nations Sustainable Development Goals. In this way, the green national accounts support the implementation of the SDG indicators in Denmark.

Informing the transition towards a circular economy

There is considerable political focus on the transition of the Danish economy to a circular economy, not least on account of the opportunities this could provide. The green national accounts are instrumental in providing information which sheds light on the possibilities and consequences of such a transition.

Time series

The accounts contain long time series on the environmental pressures of the Danish economy. For production and consumption of energy, the series extend over almost 50 years. For air emissions, data is available for a period of more than 25 years. For areas such as material flows, water, waste and green economy and the Danish resource inventories, the accounts are focused on recent years.

Uncertainty

A great number of calculations, allocations and assumptions have been made in order to establish the green national accounts. In combination with the large variations in source data, it means that much of the information provided is subject to considerable uncertainty. Although many of the results and percentages are presented as being precise with several significant figures this uncertainty should be kept in mind when the numbers and results are assessed and analysed.

Economic growth, environmental pressures and natural resources in 2015 and 2016

Setbacks in some areas – progress in others

Concurrent with the increasing economic activity in 2016, some of the environmental and resource pressures described in the green national accounts also saw an increase. This applies to e.g. the consumption of materials, energy and water as well as the emission of greenhouse gases. In other areas, recent years have seen a significantly smaller environmental pressure; e.g. less waste was generated in 2015 than in 2014. Other developments were also positive. For example, the production and use of sustainable energy increased, as did the turnover of green goods and services.

Economic growth and environmental pressures in 2016

In 2016, gross domestic product (GDP), employment and private consumption all increased. GDP (chained volumes, 2010 prices) increased by 2.0 per cent, employment by 1.7 per cent and private consumption by 2.1 per cent. In 2015, economic growth was 1.6 per cent, while employment and private consumption increased by 1.3 per cent and 1.6 per cent, respectively.

Increasing energy consumption

In both 2015 and 2016, economic growth and increasing private consumption were accompanied by increasing energy consumption. In 2016, however, it was not only economic growth that caused the increase in energy consumption of 5.0 per cent[1] compared to 2015. Part of the increase in 2016 is due to the fact that it was colder than in 2015 and, as a result, more energy was used for heating.

More renewable energy

The consumption of renewable energy has increased in recent years. The increase was 5.7 per cent in 2015 and 5.5 per cent in 2016.

Decline in the oil and natural gas production in the North Sea

Since 2005, the overall output of oil and natural gas from the North Sea has been steadily declining year on year. From 2015 to 2016, the extraction in physical unit terms declined by 7.3 per cent.

At the present extraction rate, Danish reserves of oil and natural gas in the North Sea will be depleted around 2033 provided that the reserves are not adjusted upward in the meantime due to new discoveries etc.

A decline in the physical reserves together with price drops of oil and natural gas meant that the value of the Danish reserves dropped by 27 per cent in the course of 2015, amounting to DKK[2] 151 billion at the beginning of 2016. The value of the reserves in current prices was cut by almost 50 per cent between 2012 and 2016.

Higher greenhouse gas emissions

The total emission of greenhouse gases from Danish economic activities increased in 2016 by 4.0 per cent and the greenhouse gas intensity (emission per DKK of GDP) increased by 2.0 per cent. However, the increases in absolute emissions as well as in greenhouse gas intensity were lower when emissions connected to the refuelling by Danish vessels abroad are excluded. The bunkering etc. of fuel outside the Danish borders explains much of the increase, but the cold weather in 2016 also played a role.

Increase in acidifying emissions and particulate matter

The acidifying emissions from Danish economic activities in Danish territory increased in 2015 by 0.5 per cent compared to 2014. The emissions of harmful fine particulate matter, $PM_{2,5}$, also increased in 2015. The increase was almost 10 per cent.

Declining resource productivity

Domestic material consumption in the form of biomass, minerals and fossil energy etc. was 131 million tonnes in 2016. From 2015 to 2016, domestic material consumption increased more than economic growth – as it did in the period 2014 to 2015. As a result, Danish resource productivity (GDP per kg of domestic material consumption) declined in 2016 and 2015 compared to the previous year. An increase in building and construction activities was an important factor behind this development.

The physical net import of goods in 2016 amounted to 21 million tonnes, which means that Denmark was not self-sufficient in materials.

Decline in the quantities of waste – and higher recycling rate

Despite a higher level of economic activity in 2015 than in 2014, Danish industries and households generated 2.0 per cent less waste in 2015 than in 2014. At the same time, a higher proportion of their waste was recycled. The rate of recycling increased from 67 per cent in 2014 to 68 per cent in 2015. In addition, the quantity of deposited waste in 2015 declined.

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[1] This assessment includes refueling (bunkering etc. of vessels) abroad by Danish transport enterprises. If this part of the energy consumption is excluded, the increase is instead 4.2 per cent.

[2] DKK 100 corresponds approximately to 13.4 Euro and 16.7 USD (February 2018)

Increase in water consumption

A large part of total water consumption goes, with large fluctuations, to agriculture and aquaculture. The abstraction of groundwater increased by 5 per cent from 2015 to 2016. In 2015, on the other hand, the abstraction of groundwater was reduced by 18 per cent compared to 2014. Together industries and households used 741 million cubic metres of water in 2015.

Green economy

Higher turnover of environmental goods and services

The turnover of environmental goods and services increased in 2015 as well as in 2016. Increasing environmental output was accompanied by increased employment. The turnover of environmental goods was DKK 214 billion in 2016. It resulted in 71,000 employees. In 2015, where the environmental turnover was DKK 198 billion, exports of green goods and services amounted to DKK 72 billion.

Increasing environmental protection expenditures in the industry

Industries' environmental protection expenditures increased by 8 per cent in 2016 compared to 2015. They spent a total of DKK 3.4 billion on environmental protection in 2016. In relative terms, increases were particularly significant regarding investments in pollution control and prevention. In monetary terms, the largest increases concerned industries' purchase of environmental services.

Declining public sector environmental expenditures and subsidies etc. for environmental activities

The public sector spent a total of approximately DKK 29 billion on environmental protection in 2016. Compared to 2015, this was a decline of approximately DKK 1 billion. In addition to the direct environmental protection activities handled mainly by public enterprises, the public sector supported environmental activities through subsidies and similar transfers to Danish enterprises and to developing countries. Total environmental subsidies and similar transfers from the public sector declined by 7.1 per cent from 2015 to 2016, following an increase of 12.1 per cent in 2015. Environmental subsides and similar transfers amounted to just over DKK 9 billion in 2016.

No change in environmental tax burden

The expenditure on environmental taxes by industries and households increased in both 2015 and 2016. Environmental taxes amounted to a total of DKK 82.4 billion in 2016. This includes energy and transport taxes. Households paid 57 per cent and industries 43 per cent of the environmental taxes. The environmental tax burden – calculated as environmental taxes in per cent of GDP – has been fairly stable at approximately 4 per cent for a long period of time.

Decreased agricultural area, increased open habitats and forest

The total area of Denmark is 43,000 km^2. The land cover is dominated by agricultural crops, which occupy 61 per cent of the total area. However, the proportion of land covered by agricultural crops dropped slightly from 2011 to 2016. The land previously covered by agricultural crops has instead been used for open habitats such as common pastures, meadows and marshes, as well as forests. From 2011 to 2016, the area of open habitat types increased by 5.7 per cent, and the forest area increased by 1.8 per cent. Roads and built-up areas, which cover 14 per cent of the total area, also take up more space than previously. The increase in these areas was 0.4 per cent in the period.

More forest and growing stock

Looking over a longer period - 2006 to 2016 - the growth in the Danish forest area was 4 per cent, while the growing stock in the forests grew by 15 per cent. In recent years, the growth in the forest area has been declining, and from 2015 to 2016 there was hardly any change in the size of the forest areas. In 2016, the Danish forests contained 75 million m^3 of broadleaves and 57 million m^3 of coniferous wood. The value of this growing stock was DKK 15.3 billion.

Larger fish stock and smaller catches

The Danish stocks[3] of wild fish grew by 7.2 per cent in the course of 2015. The stock at the beginning of 2016 is assessed at 2.5 million tonnes of fish and shellfish. The stock of fish in Danish aquaculture, on the other hand, declined by 3.9 per cent in the course of 2015. At the beginning of 2016, the stock of fish in aquaculture amounted to 21,000 tonnes. Danish fishermen caught just above 672,000 tonnes of fish in 2016, which was 23 per cent less than in 2015. In 2015, 36,000 tonnes of fish were harvested from Danish aquaculture.

Analyses on the basis of the green national accounts

Analyses of developments based on the green national accounts

The national accounts and the green national accounts are closely connected as a result of shared classifications and delimitations. This allows the data contained within the accounts to be used in analyses and model calculations which provide greater insight into the driving forces behind the development of environmental effects.

Decoupling economic growth and greenhouse gases

One of the analyses presented in the green national accounts concerns the development of greenhouse gas emissions resulting from Danish economic activities between 1990 and 2016. This analysis shows the extent to which changes in the Danish energy system, higher energy efficiency as well as changes in the production structure and consumers' demand pattern have reduced Danish emissions of greenhouse gases. Without these changes, the greenhouse gas emissions from Danish industries in 2016 would have amounted to 39 million more tonnes of CO_2 equivalents than in 1990[4]. Instead, they amounted to 19 million tonnes less. The transition to other types of energy and higher energy efficiency in particular contributed to the reduction in emissions. However, the other factors also played a role.

Households generate several millions of tonnes of industrial waste

Another analysis focuses on the correlations between private consumption of various products and the quantities of waste indirectly generated in the manufacturing of these goods. It is shown that 2.2 million tonnes of industrial waste was indirectly generated as a result of private consumption in 2015. By way of comparison, households themselves generated 3.4 million tonnes of waste

[3] The assessment of the Danish fish stocks in the green national accounts is made on the basis of a special calculation based on fish quotas and stocks in the grounds where Danish fishermen are allowed to fish. See chapter 15.

[4] CO_2 emissions from bunkering etc. abroad and from incineration of biomass have not been included in the analysis.

Key figures

Key figures

			2000	2005	2010	2012	2013	2014	2015	2016	2015	2016
											Yearly increase[2] per cent	
	Economy											
1	Gross domestic product, GDP (chained volumes, 2010 prices)	DKK billion	1 677	1 792	1 811	1 839	1 856	1 887	1 917	1 954	1.6	2.0
2	Net domestic product, NDP (chained volumes, 2010 prices)	DKK billion	1 422	1 499	1 490	1 521	1 538	1 569	1 598	1 632	1.9	2.1
3	Private consumption (chained volumes, 2010 prices)	DKK billion	753	841	862	869	871	879	893	912	1.6	2.1
4	Fixed assets, net capital stock (chained volumes, 2010 prices)	DKK billion	4 993	5 312	5 673	5 705	5 737	5 780	5 830	5 893	0.9	1.1
5	Employment	thousand	2 755	2 783	2 788	2 767	2 766	2 794	2 829	2 877	1.3	1.7
6	Population	thousand	5 338	5 419	5 547	5 591	5 613	5 643	5 682	5 729	0.7	0.8
	Energy											
7	Gross energy consumption, incl. bunkering etc. abroad	petajoule (PJ)	1 065	1 256	1 295	1 235	1 183	1 139	1 158	1 216	1.7	5.0
8	Gross energy consumption, excl. bunkering etc. abroad	petajoule (PJ)	813	812	817	746	744	713	719	750	0.8	4.2
9	Energy intensity, incl. bunkering etc. abroad	GJ per DKK GDP	635	701	715	671	637	604	604	622	0.1	3.0
10	Energy intensity, excl. bunkering etc. abroad	GJ per DKK GDP	485	453	451	405	401	378	375	383	-0.8	2.2
11	Extraction of oil and natural gas	petajoule (PJ)	1 085	1 197	837	649	557	526	508	471	-3.5	-7.3
12	Danish output of renewable energy	petajoule (PJ)	80	112	136	144	143	151	165	169	9.0	2.8
13	Danish consumption of renewable energy	petajoule (PJ)	82	125	168	189	188	195	206	217	5.7	5.5
	Air emissions											
14	Greenhouse gas, incl. bunkering etc. abroad (excl. biomass)	Million tonnes CO_2-eq.	92	102	102	92	90	85	84	87	-1.5	4.0
15	Greenhouse gas, excl. bunkering etc. abroad (excl. biomass)	Million tonnes CO_2-eq.	71	66	63	53	55	51	48	50	-4.8	2.5
16	Greenhouse gas intensity, incl. bunkering etc. abroad	GJ per DKK GDP	55	57	56	50	49	45	44	45	-3.0	2.0
17	GHG intensity, excl. bunkering etc. abroad	GJ per DKK GDP	42	37	35	29	30	27	25	25	-6.3	0.5
18	CO_2 from biomass	million tonnes	7	11	15	15	15	15	16	17	5.5	10.7
19	Acidifying emissions	million tonnes PAE	12	11	8	8	8	7	7		0.5	
20	Particulate matter ($PM_{2,5}$)	1,000 tonnes	23	26	26	22	21	18	20		9.6	
	Abstraction and consumption of water											
21	Abstraction of groundwater	million m^3	651	652	686	622	761	780	639	672	-18.0	5.0
22	Abstraction of surface water	million m^3			123	107	249	209	173	70	-17.6	-59.7
23	Industries' consumption of water	million m^3			572	490	764	757	594	531	-21.5	-10.6
24	Households' consumption of water	million m^3			237	238	246	233	217	210	-6.5	-3.4
25	Water intensity	m^3 per GDP million			447	396	544	524	424	379	-19.2	-10.5
26	Water expenditure	DKK billion			7	7	8	8	8	8	3.0	-2.1
	Wastewater											
27	Discharge of wastewater from households and industries	million m^3			521	526	677	639	600	476	-6.1	-20.6
28	Waste water expenditure	DKK billion			11	11	11	12	12	12	1.5	0.4
29	Discharge of water, nitrogen	tonnes total-N						6 883	7 362		7.0	
30	Discharge of water, phosphorus	tonnes total-P						1 014	1 057		4.2	
31	Discharge of water, organic matter	tonnes BOD						12 678	13 355		5.3	

Note: The key figures are a selection from the green national accounts. Many of the above key figures are also available broken down by industry and households.

Source: The data from the Danish green national accounts can be found at www.statbank.dk/2471.

			2000	2005	2010	2012	2013	2014	2015	2016	2015	2016
											Yearly increase [2] per cent	
	Material flows											
32	Domestic extraction of natural resources	million tonnes	130	138	102	112	100	104	108	111	4.4	2.2
33	Imports	million tonnes	53	61	56	61	65	62	61	66	-1.8	8.0
34	Exports	million tonnes	46	49	42	42	42	42	42	45	-0.2	8.0
35	Physical trade balance	million tonnes	7	12	14	18	23	20	19	21	-5.2	7.9
36	Domestic material consumption, DMC	million tonnes	137	150	116	130	123	124	127	131	2.9	3.1
37	Resource productivity (GDP/DMC)	DKK GDP per kg DMC	12	12	16	14	15	15	15	15	-1.2	-1.1
	Waste											
38	Waste generation	million tonnes				11	11	12	11		-2.0	
39	Waste intensity	tonnes per DKK million GDP				5.9	6.0	6.1	5.9		-3.5	
40	Materials recovery percentage	per cent				65	66	67	68		1.1	
41	Deposition of waste	per cent				5	4	4	4		-9.4	
	Green economy											
42	Environmental goods and services, turnover	DKK billion				170	164	174	198	214	13.7	7.9
43	Environmental goods and services, exports	DKK billion				72	69	73	72		-0.3	
44	Environmental goods and services, employment	thousand				60	58	60	69	71	15.1	3.5
45	Environmental protection exp., manuf. industries etc.	DKK billion						3	3	3	6.4	8.0
46	Environmental protection expenditure, public sector	DKK billion	21	27	30	31	33	30	30	29	0.2	-5.9
47	Environmental taxes	DKK billion	64	78	73	75	80	79	81	82	2.2	1.8
48	Environmental tax burden	per cent of GDP	5	5	4	4	4	4	4	4	-0.3	0.0
49	Environmental subsidies and similar transfers	DKK billion	7	5	4	7	8	9	10	9	12.1	-7.1
	Oil and natural gas reserves											
50	Physical stocks of gas reserves (opening stock)	billion Nm^3	139	123	105	95	93	90	85	80	-5.6	-5.9
51	Physical stocks of oil reserves (opening stock)	million m^3	238	260	194	181	174	167	164	160	-1.8	-2.4
52	Value of oil and gas reserves (opening stock)	DKK billion			242	253	294	268	208	151	-22.6	-27.2
	Land cover and forests											
53	Land cover, open habitats [1]	km^2	.	.	.	3 509	.	.		3 710		5.7
54	Land cover, agricultural crops [1]	km^2	.	.	.	26 554	.	.		26 226		-1.2
55	Land cover, forests and other tree-covered areas [1]	km^2			.	5 357	.	.		5 454		1.8
56	Land cover, artificial surfaces (roads, built-up etc.) [1]	km^2	.	.		5 866	.	.	.	5 890		0.4
57	Growing stock in forests (opening stock)	million m^3	.	.	117	120	123	126	130	132	2.7	1.9
	Fish and shellfish											
58	Wild fish (opening stock)	1,000 tonnes			2 117	1 964	1 780	2 174	2 290	2 455	5.3	7.2
59	Fish in aquaculture (opening stock)	1,000 tonnes			18	20	19	21	22	21	5.4	-3.9
60	Fish catch	1,000 tonnes			821	496	662	749	876	672	17.0	-23.3
61	Aquaculture, harvest	1,000 tonnes			33	30	32	35	36		1.5	

[1] For land cover figures stated in the column for 2012 refers partly to the reference year 2011 and partly to 2012.

[2] The yearly increase is the increase from the previous year except for land cover where the increase in per cent refers to the change from 2011/2012 to 2016

1 Introduction

1.1 The background for the green national accounts

Nature is the foundation

Nature is the essential prerequisite in achieving the society we have, both in terms of production and consumption. All enterprises and households in Denmark, without exception, and from both a quantitative and qualitative perspective, depend on nature providing us energy, water and other natural resources. We also depend on nature's ability to offer us general life support, as when e.g. it decomposes the pollution which is the result of our production and consumption. In addition to this, nature enables us to pursue many recreational activities which are traditionally in focus when we discuss the importance of a multifarious nature and a good environment.

Growing realisation

Even though nature and the environment in the broad sense are often left out – or certainly not at the top of the agenda – when we mention the requirements of economic growth and prosperity, the realisation of nature's importance in economic performance has become prevalent. More and more enterprises, many governments and largely all the international organisations take an interest in the relations that exist between the economy and the environment. Examples of this are given in box 1.1.

Natural capital

When conceptualising capital, it is common to think in terms of human capital, social capital, and man-made capital (buildings and machines etc.). The aforementioned realisation of the relationship between the economy and the environment has led nature to, in many contexts, also be referred to as a form of capital. Without sufficiently strong natural capital, nature is unable to provide the ecosystem services it takes for the economy to perform well.

The green national accounts as part of the knowledge base

In order to measure the relationships between the economy and the environment and document the importance of natural capital for economic performance, we need a statistical tool to do so. This is where the environmental-economic accounts – or green national accounts as we call them in this publication - come into play as an extension of and supplement to the traditional national accounts.

Limitations of the traditional national accounts

The national accounts contain information about the production and added value generated by labour and capital. They also contain information about the value of man-made capital in the form of buildings, facilities, machinery and means of transportation as well as research and development.

The value of natural resources such as oil, natural gas, forests and fish have also been included as capital in the guidelines for the accounts. Few countries, however, include this part of the capital in the national accounts. Until now, it has not been included in Denmark, which is why the national accounts fail to explain an essential part of the capital which is the basis for our prosperity and welfare.

The national accounts also do not include information about the impact on the environment caused by economic activities. Accordingly, there is no information about the emission of pollutants from production and consumption.

When it comes to documenting the green economy or green growth, the national accounts are also deficient. Although the economic activities included in the green economy, e.g. production of environmental goods and services, together with e.g. environmental taxes, are included in the national accounts, it is usually not possible to separate these activities from the national accounts.

Finally, the traditional national accounts are deficient when it comes to the ecosystems that nature provides us with. The assessment of production and value added in the national accounts does include the market value of the products produced by the primary industries (forestry, agriculture, fishing, extraction of energy and raw materials) on the basis of nature's services, but the actual extent and value of these services, and the many other services from the environment, are insufficiently documented in the national accounts.

An extension of the national accounts

The green national accounts extend the traditional national accounts by identifying and highlighting the importance of nature to economic activities, how economic activities affect the environment, and how nature is part of Danish national wealth in the broad sense. For this reason, the green national accounts for Denmark are drawn up in close connection with the traditional national accounts. Using the same internationally agreed delimitations, definitions and classifications as in the traditional national accounts, the green national accounts illustrate the relationships between the economy and the environment in a logical way based on industrial and household activities.

Box 1.1 Growing realisation of the importance of nature

Several large foreign and Danish enterprises prepare what are known as natural capital accounting and environmental profit and loss statements, which show land use, energy and water consumption, greenhouse gas emissions and air pollution directly and indirectly attached to the value chains of these enterprises. In so doing, a picture can be created of the extent and the value of all the services provided to these enterprises by nature, of which they are fundamentally dependent[1].

At country level, the COP21 climate agreement is the most significant example of governments worldwide realising that economic activity and the environment are closely related. With the climate agreement, the governments realised the absolute necessity of protecting the natural capital, here in the form of climate, to enable sustainable development. In Paris, December 2015, 195 countries committed themselves to reduce the emissions of greenhouse gases to keep the global rise in temperature under 2 degrees compared to the pre-industrial level and to make an effort to keep the increase under 1.5 degrees. Since then, the remaining countries of the world have joined, so that all of the world's countries have acceded to the Paris agreement, although the United States have since announced their withdrawal from the agreement.

The Montreal protocol, which came into force in 1989, can also be mentioned as an example of widespread international acknowledgement of the need to protect the environment against the adverse effects of certain economic activities. The agreement was made with the purpose of phasing out the emission of substances depleting the ozone layer and has resulted in a drastic reduction in the use of these substances.

The United Nations, the EU, the OECD, the World Bank etc. have all taken initiatives to investigate and focus attention on the relations between nature and the economy. The UN's Agenda 2030 and the global Sustainable Development Goals[2], see also chapter 3, the EU's ´"beyond GDP" initiative[3] and action plan for a circular economy[4], the World Bank's Waves project (Wealth Accounting and Valuation of Ecosystem Services)[5] and the OECD's involvement in green growth[6] are all examples. In these initiatives, nature is a production factor which is essential for growth and prosperity.

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1 See the Danish Environmental Protection Agency, 2014a, 2014b and 2016

2 sustainabledevelopment.un.org/

3 ec.europa.eu/environment/beyond_gdp/index_en.html

4 ec.europa.eu/environment/circular-economy/index_en.htm

5 www.wavespartnership.org/

6 www.oecd.org/greengrowth/

These accounts, on the one hand, enable comparison of an industry's output, value added and employment against the physical use of materials, energy and water required for the industry's output. On the other hand, one can track the amount of waste, wastewater and air emissions caused by the production of the industry. Concerning the actual output of the industry, the accounts allow us to gain an insight into the share of environmentally friendly goods and services, the expenditure incurred by the industry for environmental protection and the amount it pays in environmental taxes. At the same time, the accounts account for the stocks of essential natural resources as well as the development in these stocks.

1.2 The international context: SEEA Central Framework and EU legislation

Based on international guidelines

Denmark's green national accounts are based on international guidelines prepared by the UN in cooperation with the EU, the OECD, the World Bank, the IMF and the FAO, and with expert assistance from a number of national statistical institutions. These guidelines are the *System of Environmental-Economic Accounting – Central Framework* – commonly abbreviated to *SEEA CF* (United Nations et al., 2014). *SEEA CF* was adopted in 2012 as an international statistical standard by the United Nations Statistical Commission.

Statistical standards

A statistical standard in the UN statistical system is characterised by having undergone a process of expert discussions, a global hearing including all UN member countries as well as an approval in the UN Statistical Commission, where statistical institutions from all UN member countries are represented. Even though the countries are not obliged to comply with the UN standards, it is customary for them to do so. Moreover, the standards have an impact on the legislation and guidelines applied in the EU.

Cooperation within the EU and legislation

SEEA CF constitutes the basis for the EU's work on green national accounts (European environmental-economic accounts), and the EU member states must assess and report parts of the accounts to Eurostat in accordance with these guidelines. Consequently, it is possible to keep track of the developments in both individual member states and for the EU as a whole. At the time of this publication, assessments of six modules are reported to Eurostat in accordance with EU regulation no. 691/2011 and the amending regulation no. 538/2014 on European Environmental-Economic Accounting. These involve: energy, emissions to air, economy-wide material flow accounts, environmental taxes, environmental protection expenditure as well as the environmental goods and service sector.

1.3 Elements in the green national accounts

Three main groups of information

From an overall perspective, the information in the green national accounts pertains to one of the following three groups:

1. Flows of natural resources, materials and residuals
2. Aspects of the green economy (environmental production, environmental taxes etc.)
3. Stocks of natural resources

The information in the green national accounts for Denmark within the three main groups is organised in a series of sub-accounts, as shown in figure 1.1.

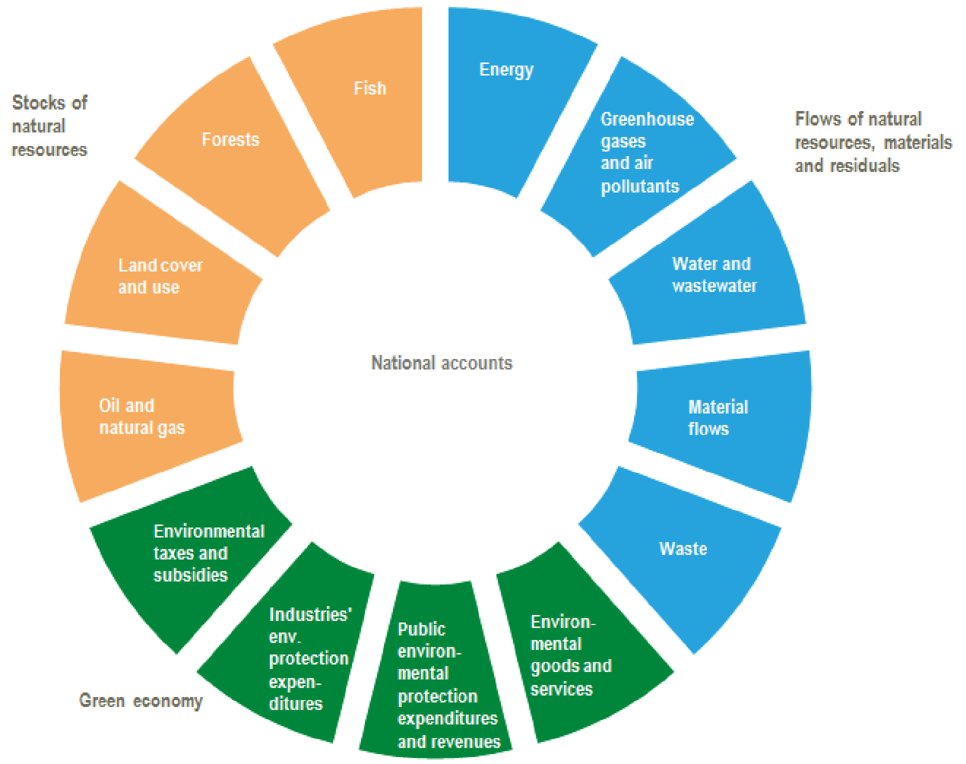
The sub-accounts highlight conditions that have major economic and environmental impact. However, all important conditions have not been incorporated at present. For instance, the green national accounts do not document, for example, nitrogen leaching, changes in ecosystems and biodiversity.

Contents of the following sections and chapters

In the following sections, the individual sub-accounts will be described in brief. Information from the actual accounts will be presented in chapters 3-15. The emphasis in these chapters is on showing some main features of developments in the relevant areas and the structural conditions in the connection between the economy and the environment. In this way, this publication does not provide any detailed account of each of the sub-accounts and the many numbers involved. Instead we refer to www.statbank.dk/2471 and to the associated statistical documentation.

In cases where it is relevant to break down the information by industry, the industry classification from the national accounts is applied with a grouping into 117 industry groups[7]. In this publication, the industry-specific information is at a more aggregate level.

Figure 1.1 Modules in the Danish green national accounts



1.4 Flows of natural resources, materials and residuals

The flow accounts show how the Danish economy is supplied with energy, water and materials through production and import. They also show which parts of the economy (industries and households) use it and what the result is in the form of goods production and residuals. Residuals in the green national accounts refer to greenhouse gases, air pollutants, wastewater and waste etc.

Energy

The energy accounts show how the Danish economy is supplied with various energy products such as crude oil and natural gas, coal, oil products, electricity and heating etc. via Danish production and import. The accounts also show how the energy is used by industries and households as well as how much is exported. The energy accounts are assessed for each energy product in physical units (quantities) and values (basic prices, trade margins, taxes, VAT and purchasers' prices).

You can read more about the energy accounts in chapter 4.

[7] In this publication, the terms industries, industry groups, enterprises and businesses are often used synonymously.

Emission to air

The accounts for emission to air show emissions of greenhouse gases and air pollutants from the energy consumption of industries and households as well as emissions from activities that are not related to the use of energy.

The accounts for emission to air include the below substances

CO_2 – Carbon dioxide	NMVOC – Non-methane volatile compounds
SO_2 – Sulphur dioxide	PM_{10} – Particles < 10 µm
NO_x – Nitrogen oxides	$PM_{2,5}$ – Particles < 2,5 µm
CO – Carbon monoxide	PFC – Perfluorocarbons
NH_3 – Gaseous ammonia	HFC – Hydrofluorocarbons
N_2O - Nitrogen oxide	SF_6 – Sulphur hexafluoride
CH_4 – Methane	

The accounts for emission to air are presented in chapter 5.

Water abstraction consumption and discharge

The water abstraction and water consumption accounts show the abstraction of groundwater and surface water by industries as well as households' total consumption of water – abstracted by themselves as well as by waterworks.

The water accounts also account for the amount of wastewater produced by industries and households. The amount of wastewater produced in the individual regions of Denmark and the content of nitrogen, phosphorus and organic matter in the wastewater has also been assessed.

In addition to a physical assessment of the amounts of water and wastewater measured in cubic metres, the water accounts include an assessment of the water and wastewater expenditure incurred by households and individual industries.

You can read more about water and wastewater in chapter 6.

Material flows

The material flow accounts document the nature, and weight in tonnes, of the goods and materials that are necessary for the Danish economy. In chapter 7, the extraction of natural resources from the Danish environment, import and export of goods as well as the Danish production and use of goods are accounted for through two types of material flow accounts: one type at the economy-wide level and another at a more detailed level. In the latter, a connection is made to the separate accounts for energy, emission to air and waste in order to give a fuller picture of the materials from the moment they enter the economy until they leave it again in the form of residuals.

Waste

The waste accounts in chapter 8 show the quantities of waste produced in different industries and in households. The accounts include a breakdown of the waste into 29 different types (fractions) as well as a breakdown showing whether the waste is characterised as hazardous or non-hazardous. Besides accounting for the origin of the waste, it is also shown how the waste is treated – i.e. how much is recycled, incinerated, deposited etc. Chapter 8 also includes results from an analysis of the link between household consumption and waste generated by industries. Finally chapter 8 includes a section on the economics of waste, which shows e.g. the expenditure incurred by industries and households for waste disposal.

1.5 Green economy

Green economy – environmental accounts

The other main group within the green national accounts consists of accounts documenting the green economy. These include activities such as environmental protection and the production of environmental goods and services. The accounts also include the use of environmental taxes and subsidies and similar transfers.

This is included in the assessment of economic activities in the traditional national accounts. In practice, however, it is difficult or impossible to identify these activities in the traditional national accounts, since the information about the green economy is lumped together with “non-green” activities. For this reason, the green national accounts identify and underline exactly these parts of the national accounts in specific sub-accounts.

Production of environmental goods and services

The environmental goods and service sector (EGSS) accounts concern the goods and services produced for the purpose of protecting the environment or saving resources. Exports, value added and employment are also assessed. The accounts show information about the environmental goods and services for main groups of industry as well as 16 different types of environmental protection and resource saving areas. The accounts show if this incorporates, for example, the protection of soil, groundwater and surface water or whether it involves research and development of resource saving products.

The accounts for the production of environmental goods and services are found in chapter 9.

Environmental protection expenditure by manufacturing industries, etc.

The expenditure on environmental protection incurred by enterprises involved in the extraction of raw materials and manufacturing of products is dealt with in specific sub-accounts. The accounts show the expenditure of enterprises for environmental protection in the form of internal labour costs as well as for purchasing environmental protection products etc. from other enterprises.

Moreover, the industries’ expenditure on environmental protection is broken down according to the environmental area to which the expenditure pertains – if e.g. it concerns protection of air quality and climate or waste management and recycling.

Public sector environmental protection revenues and expenditure

The accounts for public sector environmental protection revenue and expenditure provide information on governmental environmental protection. These are activities aimed at pollution prevention and control as well as activities supporting the development of sustainable technologies. The public sector environmental protection revenue and expenditure are broken down into national, regional, and municipal level. Information pertaining to other state bodies, such as public corporations, is also provided. The expenditure is also broken down by kind of expenditure – i.e. whether it is remuneration of employees, consumption of goods and services, capital expenditure or transfers etc. Correspondingly, the revenue is categorised according to whether it concerns sale of goods and services or capital revenue etc.

The accounts for industries’ environmental protection expenditure and public sector environmental protection revenue and expenditure are presented in chapter 10.

Environmental taxes etc.

The environmental taxes accounts provide a coherent description of how much different industries and households pay in environmental taxes. The individual kinds of environmental taxes are generally broken down according to their relation to energy, transport, pollution or resources. In addition, taxation of what is known as resource rent, i.e. hydrocarbon tax and corporation tax of hydrocarbon activity etc. is presented as a supplement to the statement of the actual environmental taxes.

Subsidies for environmental activities

Correspondingly, the assessment of governmental subsidies and similar transfers for environmental activities provides information on how much is received by industries and households. It also shows how much is paid towards environmental development aid abroad. The assessment includes information about the nature of the support for environmental activities – e.g. whether it is support for environmental activities in agriculture, sustainable energy or recycling plants, and whether it is for the purpose of protecting air, water, biodiversity etc.

The information about environmental taxes and subsidies is available in chapter 11.

1.6 Stocks of natural resources

Inventories and changes in these

The third main dataset in the green national accounts concerns the stocks of natural resources as well as their changes over time, e.g. due to natural growth, new findings, extraction, reassessments and re-evaluations etc.

Oil, natural gas, land, forests and fish

The natural resources accounts include oil and natural gas in the North Sea, the Danish land, forests and fish. For now, the natural resources accounts are only drawn up in physical units, although an economic value assessment has been made for the oil and natural gas reserves in terms of the stocks and the development in these.

The assessments of Danish natural resources are presented in chapters 12-15.

1.7 Key figures and indicators based on the green national accounts

Integral approach to documenting the development

In order for useful indicator systems to be built, e.g. for sustainable development, a cross-functional and integral approach must be taken to the description of the conditions that the indicator systems should document. This implies that correlations and trade-offs between the different areas of development are accounted for.

The information pyramid

When building indicator systems, it is an advantage to use what is known as an information pyramid as a starting point; see figure 1.2. This describes the relationship between basic data, statistics, accounts and indicators: the movement from the large volume of basic data at the bottom of the pyramid towards a small number of indicators at the top of the pyramid, atop statistics and accounts, is based on the gradual selection, processing and condensation of information.

Indicator systems that are systemically built as part of an information pyramid make it simpler to analyse and understand the development in a given indicator, as one is able to move incrementally and therefore retrieve more detailed information. Correspondingly, it is possible to compare different indicators in a consistent way by moving across the pyramid.

Quality assurance and documentation

Basing indicator sets on an information pyramid in the form of a systematised statistics and accounting system further ensures enhanced transparency via underlying protocols, as well as offering criteria on how to provide, quality assure and document the information. It also means that the resulting indicators will be comparable across countries to a greater degree, particularly if the same statistics and accounts are at the core of the indicator systems used by the various countries.

The green national accounts are part of an information pyramid

The traditional national accounts and the green national accounts combined are a major part of an information pyramid. The accounts contain key figures and indicators of fundamental importance in documenting whether development is sustainable. In a number of cases, you can calculate other important key figures and indicators by combining data from different parts of the accounts. This makes it easy to establish whether economic progress goes hand in hand with environmentally sustainable development, or whether the economic development leads to the depletion of resources and environmental deterioration.

Outline of the development in the Danish economy and environment 2015 and 2016

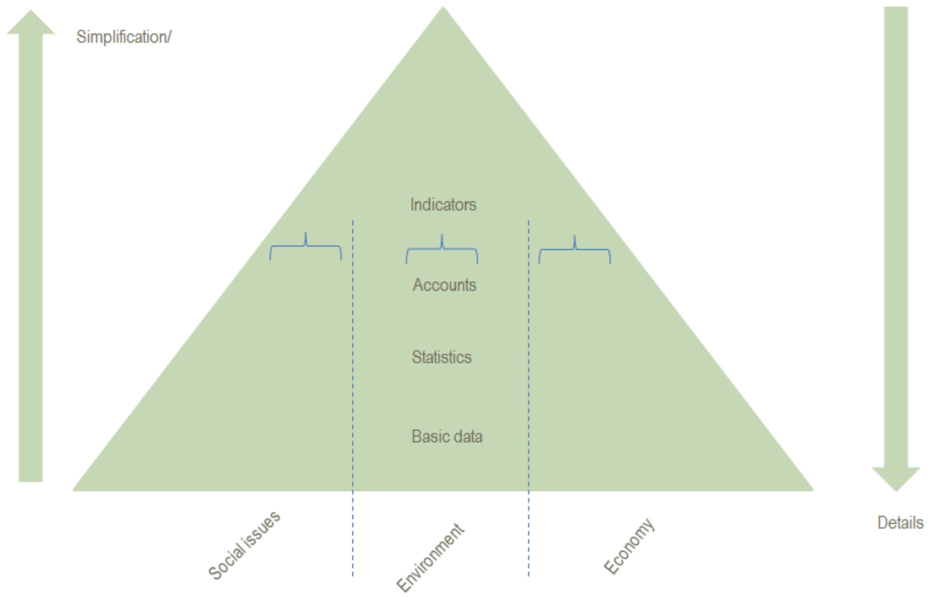
To illustrate, based on *SEEA CF* (see section 1.2), how the green national accounts create the basis for consistent indicators, chapter 2 includes an outline of the Danish economy and environment in the years 2015 and 2016 based on the key figures shown in the table after the summary in the beginning of this publication.

SDG indicators

Furthermore, a number of the indicators established by the UN as part of the monitoring and follow-up of the global Sustainable Development Goals (SDGs) are presented in chapter 3. The indicators have virtually all been established on the basis of the green national accounts.

Figure 1.2

The information pyramid



Source: Pedersen et al. (2002)

1.8 Green GDP

The purpose is not to calculate one bottom line figure

As described in the preceding sections, the green national accounts, in compliance with the international guidelines, *SEEA CF*, are organised as a collection of independent sub-accounts, which are based on common definitions and classifications etc. Implicitly, this means that the purpose of the green national accounts is *not* to calculate a single bottom line figure summarising the development in the economic and environmental area.

Green GDP

Accordingly, the green national accounts are not the same as “green GDP”. The latter is used as a popular and general term for adjusted national accounts indicators calculated by deduction from, and in some cases addition to, the traditional national accounts aggregates – e.g. GDP – to account for environmental factors. The purpose of the green GDP is precisely to summarise the economic and environmental development in a single figure which is based on all environmental conditions also being subject to monetary valuation.

Missing definition

However, the green GDP is not a well-defined or unique indicator, as there are different suggestions as to what to adjust for and how to calculate the adjustments. In fact, the basis for the adjustments is rarely GDP, but more often one of the other national accounts concepts – net national product (NNP) or net savings.

This also means that the exact term for the result of the adjustments varies. E.g. you can come across expressions such as ”depletion-adjusted NNP”, ”depletion and pollution-adjusted NNP”, ”sustainable national income” and ”genuine savings”.

Physical units instead of monetary

In the case of this publication and the green national accounts, far from all environmental impacts and natural resources have been valued and assessed in monetary terms. Instead, physical units such as tonnes have been used, e.g. in the assessment of emissions to air.

Compliance with SEEA CF

The principle that not all environmental conditions should be valued in connection with the green national accounts is compliant with the international guidelines, *SEEA CF*.

The reason that *SEEA CF* does not recommend an exhaustive economic valuation – and consequently does not recommend calculation of a green GDP – is the fact that when developing *SEEA CF*, international organisations and national statistical institutions have not been able to clearly define how a valuation of environmental impacts should be made when prices and values cannot be directly observed and determined by statistical methods.

Green national accounts as a basis for a green GDP

While it is implied in the principles and guidelines behind the green national accounts that they do not lead up to a single bottom line figure, the green national accounts are nevertheless a useful basis for research-based efforts in preparation for the calculation of a green GDP or valuation of environmental impacts in broader terms.

Comprehensive green national accounts offer many of the value assessments on which the calculation of green GDP is based, as well as offering information about environmental impacts measured in physical units. The latter can create the basis of an additional monetary valuation which can subsequently become part of the calculation of the green GDP or similar.

The advantage of using the green national accounts as the basis for the valuation and calculation of "green GDP" is that the classifications, underlying databases, and principles are fully aligned across areas, and are also consistent with the traditional national accounts.

New research project on green GDP set in motion

In accordance with this, the development of a green GDP is the purpose of a three-year research project started by the University of Copenhagen and Statistics Denmark at the end of 2016. The project includes a study of the political administrative processes behind the use of the green national accounts as well as a specific calculation of a green GDP for Denmark based on the green national accounts for Denmark.[8]

1.9 General remarks about the assessments and uncertainties

Reusing data

The green national accounts are mainly based on the use of data from various existing statistics. E.g. the waste accounts are based on the Danish Environmental Protection Agency's system for waste data, ADS, whereas the energy accounts are based on multiple sources, including the Danish Energy Agency's energy statistics and Statistics Denmark's assessment of industries' energy consumption.

Collection of data from enterprises

This means that data is only collected to a limited extent directly from enterprises for the purpose of the green national accounts. However, approximately 2,100 enterprises with more than ten employees contribute data every two years to the statistics on the environmental goods and services sector. In addition to this, data is collected annually from approximately 1,000 mainly large enterprises for the assessment of industries' environmental protection expenditure. This collection of data is due to the collection of general accounting data from enterprises in accordance with an EU directive on Structural Business Statistics, with the collected data subsequently being used for the green national accounts.

[8] The project has been made possible by a grant from the KR Foundation. www.krfnd.org

Reference years and length of the time series

Data in the green national accounts refers to different years depending on the individual accounts consulted. E.g. in the energy accounts, data is available for the years 1966-2016 at the time of publication, whereas data for the overall material flow accounts is available for the years 1993-2015, and for the most detailed material flow accounts only for the year 2009.

The variations in the length of the time series and the punctuality of the individual accounts is partly due to data being retrieved from sources outside Statistics Denmark or from basic statistics in Statistics Denmark. The availability of this data varies in terms of scope and timeliness. In addition, comparing large amounts of source data and incorporating it into the green national accounts naturally takes time. Through continued work with the accounts, however, punctuality in receiving data can gradually be improved, just as the length of time series can be extended.

Comparison of large volumes of data from various sources

The drawing up of most parts of the green national accounts – and also the traditional national accounts – is done by processing and incorporating available data in the accounting framework, including the definitions, classifications and conventions that constitute the mainstay of the green national accounts. This is done while making sure that all parts of the accounts are completed, so that the description is comprehensive in relation to the area in question. This is also done to ensure that the various types of data appear consistent and without incompatibility – across topics as well as across time. See box 1.2.

Assumptions and considerable uncertainty

To achieve this, a number of assumptions must be made. In practice, it means that part of the data is based on calculations, allocations and in some cases also estimates. In combination with the large variation in source data, it means that much of the information is subject to considerable uncertainty and in some cases can be best considered as model calculations indicating the structure and magnitudes rather than very exact figures for the area in question.

Main indicators are more accurate

In general, main indicators and aggregates should be expected to be more accurate than the detailed figures. E.g. the assessment of total energy consumption is often more reliable than the assessment of energy consumption by a specific industry.

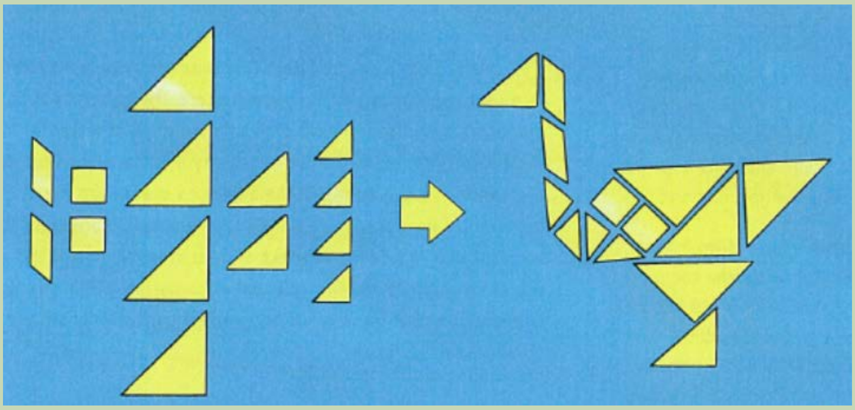
Box 1.2 From statistics to accounts

When drawing up the green national accounts, information from the underlying statistics and data sources (e.g. energy statistics, waste statistics, water statistics) is adapted to the definitions and classifications applied in the accounts. In some cases, this means that more detailed information in the sources is lumped together, in other cases that such information is divided further, e.g. when industry information at an aggregate level must be allocated to several sub-industries. Such allocations are made by retrieving further information or by means of what are known as allocation keys if direct information about the relevant area is not available. An example is when e.g. employment information is used for allocation of the water consumption in certain industries. Naturally, the use of such keys implies that the results are subject to a higher degree of uncertainty. Of course, to the greatest possible extent, efforts are made to ensure that such keys are representative, in order to minimise this uncertainty.

Besides the use of allocation keys, part of the process by which source data is adjusted for use in the green national accounts is dedicated to ensuring that the data reflects the systemic boundaries to which the accounts are subjected according to the international guidelines *SEEA CF*; see section 1.2. An example of this would be the addition of information about Danish transport companies' purchase of fuel abroad to the wider energy statistics pertaining to energy consumption.

The individual parts of the green national accounts (e.g. the energy accounts) are in many cases based on multiple sources. These are often conflicting. For this reason, it is an important task to assess which sources to give more weight to and where, if necessary, to deviate from the underlying statistics. This is critical to producing a reliable and consistent overall picture of the area in question.

From statistics to accounts



Source: UN World Water Assessment Programme and United Nations Statistics Division (2011).

2. The economy and the environment in 2015 and 2016

2.1 Introduction

Economic growth and increasing material consumption

Denmark experienced economic growth in 2015 and 2016. This led to an increase in domestic material consumption. Material consumption increased at a greater rate than would be assumed from the rate of economic growth, partly because the increase in building and construction activities had a significant effect on material use.

Increase in energy consumption and emissions

Energy consumption and emissions of greenhouse gases also increased in 2016. However, this development was not only driven by economic growth, but also by colder weather and greater heating needs. The previous year, 2015, saw an increase in emissions of pollutants that contribute to acidification and particles harmful to health. This marks a contrast with previous years in which economic growth was generally decoupled from energy consumption, greenhouse gas emissions and emissions of air pollutants.

More renewable energy, declining water consumption and greater production of environmental goods and services

On the positive side, 2015 and 2016 saw an increase in the production and use of renewable energy. Water consumption and discharges of wastewater decreased and 2015 saw a decline in waste generation and an increase in recycling compared with the previous year. Production of environmental goods and services increased in both 2015 and 2016, as did the level of employment connected to this area. There were also positive developments regarding fish stocks in areas where Danish fishermen are entitled to fish.

Overview of developments

Section 2.2 presents an overview of these and other developments in 2015 and 2016. This overview is informed by both the aforementioned signifiers and economic indicators, as well as by other information included in the green national accounts. The overview is based on the table of key figures presented on page 13 and 14 in the beginning of this publication. The table of key figures also includes data for the years 2000, 2005, 2010 and for the period 2012-2016. However, data for 2016 is not available for all areas.

Section 2.3 presents the main figures for various economic and environmental factors, as well as an overview of how different main industry groups and households etc. contribute to these factors.

Chapters 4-15 provide more detailed information about the individual areas.

Preliminary figures and uncertainty

Note that in most cases, the 2015 and 2016 figures are preliminary and may be revised in future calculations. Furthermore, it should be noted that the figures are subject to uncertainty, see chapter 1, section 1.9.

Not an exhaustive overview

It should be noted that far from all environmental aspects are included in the green national accounts, and that a reduction in a specific environmental pressure in some years should not necessarily be regarded as expressing a corresponding change in the condition of the environment.

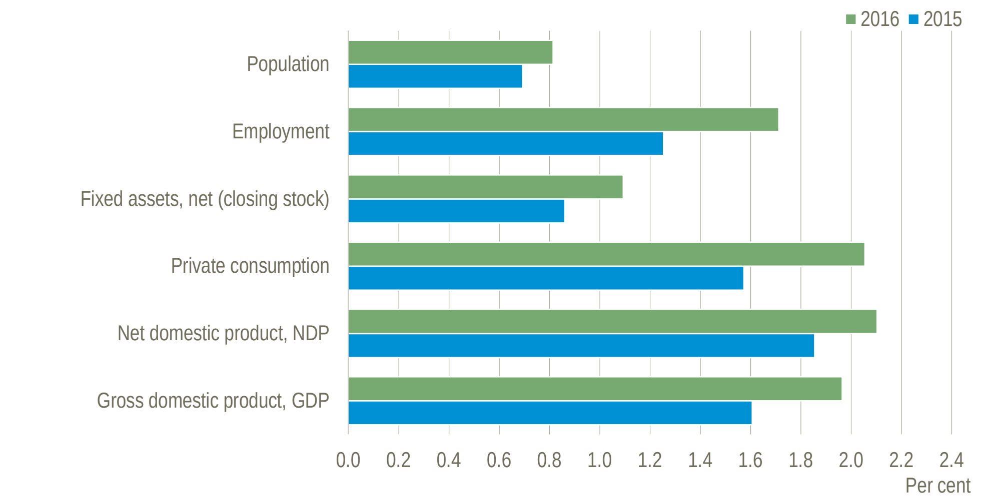
2.2 Developments in 2015 and 2016

The economy

Growth in the Danish economy, measured as gross domestic product adjusted for price developments, amounted to 2.0 per cent in 2016, see figure 2.1. The rate of growth was considerably higher in 2016 than in previous years. In 2015, growth amounted to 1.6 per cent.

Measured as net domestic product, i.e. after accounting for consumption of fixed capital (wear on buildings and machinery etc.), growth was at 2.1 per cent in 2016. In 2015, this figure was 1.9 per cent. In recent years, growth in net domestic product has generally exceeded growth in gross domestic product.

Figure 2.1 Developments in selected economic factors (percentage change compared with previous year)



Note: Growth in GDP, NDP, private consumption and closing stock of fixed assets, net, has been calculated on the basis of chained volumes, 2010 prices

Private consumption increased in both 2015 and 2016. The increase in private consumption more or less followed the rate of GDP growth. Growth amounted to 2.1 per cent in 2016 and 1.6 per cent in 2015.

Closing stock of fixed assets, net, i.e. the value of human-generated capital in society (dwellings and other buildings, installations, means of transport, IT equipment, etc., software and accumulated value of research and development) rose by 1.1 per cent in 2016. In 2015, growth in capital stock amounted to 0.9 per cent.

Both 2015 and 2016 saw an increase in employment. On average, employment was 1.7 per cent higher in 2016 than in 2015. In 2015, average employment rose by 1.3 per cent.

Growth in these economic indicators should be seen in relation to general population growth; Denmark's population was 0.8 per cent larger in 2016 than in 2015. Similarly, in 2015, population growth was 0.7 per cent. Population growth was smaller than the growth in the economic indicators described above, and consequently, all areas have seen a per capita growth, although this was more moderate than the absolute growth figures.

Energy

Economic growth and the increase in private consumption were accompanied by increasing gross energy consumption[1], in both 2015 and 2016, see figure 2.2. This trend can be observed, irrespective of whether bunkering etc. abroad is included[2]. Gross energy consumption, incl. bunkering etc. abroad, increased by 5.0 per cent in 2016. 2015 saw a more moderate increase of 1.7 per cent. The increases were less pronounced in both years if bunkering etc. abroad is excluded. Gross energy con-

[1] Gross energy consumption is a measure of energy consumption used in the Danish green national accounts. The energy content of converted energy types (electricity and district heating, etc.) is not included, but only primary energy quantities (coal, oil, natural gas, etc.), see section 4.3.

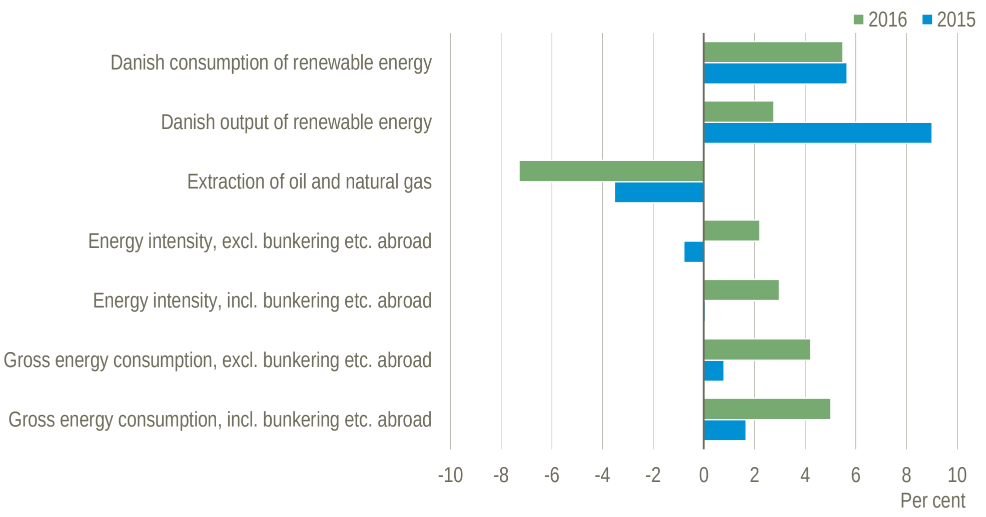
[2] In this context, bunkering refers to refueling ships to ensure their continued operation. Danish-operated ships bunker considerable quantities of fuel abroad. In addition to ships bunkering abroad, Danish-operated aircraft and lorries also refuel abroad.

sumption, excluding bunkering etc. abroad, was 4.2 per cent higher in 2016 than in 2015. In 2015, this figure was 0.8 per cent higher than in 2014.

Part of the explanation for the relatively sharp increase in gross energy consumption in 2016 is the fact that 2016 was colder than 2015, and, consequently, more energy was consumed for heating.

The increase in gross energy consumption in 2016 exceeded economic growth, which means that energy intensity, i.e. energy consumption per unit of GDP, rose. Measured on the basis of gross energy consumption, including bunkering etc. abroad, energy intensity increased by 3.0 per cent in 2016. If bunkering etc. is excluded, the increase amounted to 2.2 per cent. In 2015, energy intensity was at the same level as in 2014, when total gross energy consumption is included. When only domestic consumption is included, i.e. if bunkering etc. abroad is excluded, energy intensity dropped by 0.8 per cent.

Figure 2.2 Developments in the energy sector (percentage change compared with previous year)



Note 1: The indicators in this figure are all based on calculations of energy consumption in joules. Figures for energy intensities are divided by GDP in chained volumes, 2010 prices.

Note 2: Bunkering etc. abroad covers oil and other fuels purchased abroad by Danish-operated ships, aircraft and lorries as part of their international transport activities.

2016 saw a continued decline in the extraction of crude oil and natural gas from Danish reserves in the North Sea. Measured in physical units (petajoules), extraction of oil and natural gas fell by 7.3 per cent. In 2015, the decline was 3.5 per cent. See also figure 2.9 below for details on developments in physical stocks and the value of oil and natural gas reserves.

While North Sea oil and gas production has been on the decline for a number of years, renewable energy production has been increasing. In 2016, production of renewable energy was 2.8 per cent higher than in 2015. 2015 saw an increase in production of 9 per cent. Renewable energy includes wind power, biomass (straw, fuel wood. etc.), biogas, bio oil, heat pumps, solar energy and biodegradable waste.

In both 2015 and 2016 Denmark had a net import of renewable energy, which means that Danish consumption of renewable energy exceeded production. Danish consumption of renewable energy increased by 5.5 per cent in 2016; in 2015, this increase was 5.7 per cent.

Emissions

The higher energy consumption in 2016 was accompanied by a 4.0 per cent increase in total emissions of greenhouse gases from Danish economic activities, see figure 2.3. This calculation includes emissions of greenhouse gases from Danish transport operators' bunkering etc. abroad. These emissions account for approximately two thirds of the total increase in emissions. The other proportion of the increase is related to the fact that 2016 was a cold year with less wind than in 2015. This led to greater consumption of coal for heating, while reduced wind meant that Danish wind turbines produced less power than in the previous year.

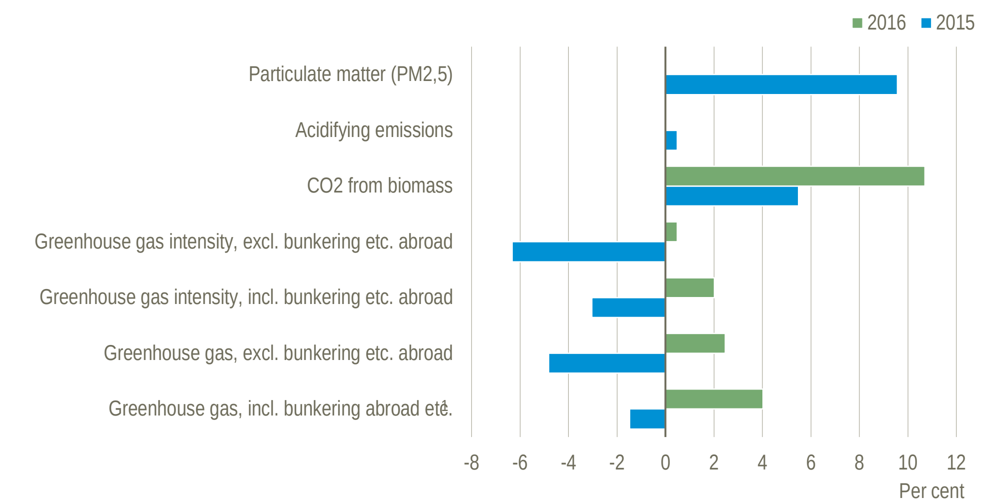
When emissions linked with bunkering etc. abroad are excluded from the calculation, the increase in greenhouse gas emissions was 2.5 per cent.

The increase in greenhouse gas emissions in 2016 broke the long-term downward trend in emissions. In 2015, for instance, emissions fell by 1.5 per cent including bunkering etc. abroad, while they fell by 4.8 per cent excluding bunkering etc. abroad.

The increase in greenhouse gas emissions, including emissions from bunkering etc. abroad, exceeded the increase in GDP in 2016. As a result, greenhouse gas intensity, i.e. emissions per DKK GDP, increased by 2.0 per cent. There was an increase in greenhouse gas intensity of 0.5 per cent when excluding bunkering etc. abroad from the calculation of emissions. However, in 2015, there was a decline in greenhouse gas intensity, irrespective of whether emissions from bunkering etc. are included or excluded. The largest decline is observed when bunkering etc. abroad is excluded from the calculation.

CO_2 emissions from biomass, which are not included when calculating emissions of greenhouse gases, increased by 10.7 per cent in 2016. This increase is related to the increase in the production and consumption of renewable energy, which in 2016 was particularly associated with the use of biomass.

Figure 2.3 Developments in emissions to the air (percentage change compared with previous year)



Note 1: The calculation of greenhouse gas emissions does not include emissions from incinerating biomass.

Note 2: Bunkering etc. abroad refers to greenhouse gas emissions linked to fuels purchased abroad by Danish-operated ships, aircraft and lorries as part of their international transport activities.

Note 3: Data for acidifying substances and particles for 2016 was not available when this publication was prepared.

The emissions of acidifying substances from Danish economic activities in Danish territory, i.e. excluding emissions linked with bunkering etc. abroad, increased by approx. 0.5 per cent in 2015. Acidifying substances include sulphur dioxide (SO_2), nitrogen oxides (NO_x) and ammonia (NH_3).

Emissions of fine particles, $PM_{2.5}$, also increased in 2015. The increase was 9.6 per cent. The increase in total emissions is attributable to an increase in household emissions, especially from wood burners.

Water abstraction and water consumption

In 2016, abstraction of groundwater was 5.0 per cent higher than in 2015, see figure 2.4. However, in 2015, abstraction of groundwater was 18 per cent lower than in 2014. The abstraction of surface water declined in 2015. Preliminary figures for the abstraction of surface water indicate a decline in 2016, but due to major uncertainty when calculating abstraction of surface water in 2016, this figure is not included in figure 2.4.

Water consumption for both industries and households declined in 2015 as well as in 2016, when both groundwater and surface water are measured together. In 2016, water consumption by industries fell by 10.6 per cent[3], while households consumed 3.4 per cent less water. In 2015, the declines were 21.5 and 6.5 per cent, respectively, for industries and households.

Water intensity, i.e. total water consumption per DKK GDP, fell by 10.5 per cent[3] in 2016, and 19.2 per cent in 2015. It should be noted that there are major fluctuations in water consumption and water intensity from year to year due to changing weather conditions and the amount of water used for irrigation in agriculture.

Total water expenditure by households and industries has been more or less stable in recent years. However, there was a small increase in 2015, followed by a slight decrease in 2016.

Figure 2.4 Developments in water abstraction and water consumption (per cent change compared with previous year)

Note: The decline in water consumption and water intensity in 2016 is probably associated with major uncertainty, see footnote 3.

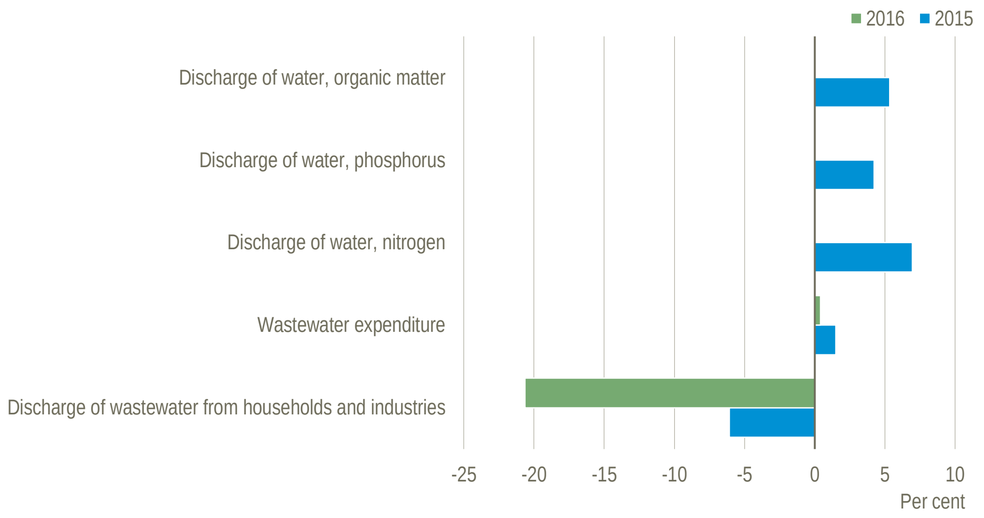
Wastewater

The reduction in water consumption by households and industries in 2015 and 2016 is reflected in lower discharges of wastewater to the sewage system and directly to the aquatic environment from industries and households, see figure 2.5. The reduction in total wastewater discharges to the sewage system and directly to the aquatic environment amounted to 20.6 per cent[3] in 2016, and 6.1 per cent in 2015. Expenditure related to discharges into the sewage system etc. remained

[3] These figures include a major drop in the use of surface water for fish farming. However, this particular figure is associated with great uncertainty, and consequently, it is likely that the final figure for water consumption, and the resulting quantity of wastewater from industries, will reveal less significant declines for 2016.

largely unchanged in 2016 compared with 2015. In 2015, wastewater expenditures increased by 1.5 per cent.

Figure 2.5 Developments in wastewater (per cent change compared with previous year)



Note 1: Discharges of wastewater from households and industries do not include water accidently seeping into the sewage system; nor do they include rain wastewater. Data for discharges of nitrogen, phosphorus and organic matter is not available for 2016, and consequently, the change from 2015 to 2016 is not shown in the figure.

Note 2: The calculation of discharges of pollutants includes discharges linked to percolation into the sewerage system and discharges caused by rain.

The pollutant content of water (the pollutants measured are nitrogen, phosphorous and organic matter) was greater in 2015 than in 2014. Increases from 2014 to 2015 were 7.0 per cent for nitrogen; 4.2 per cent for phosphorus and 5.3 per cent for organic matter.

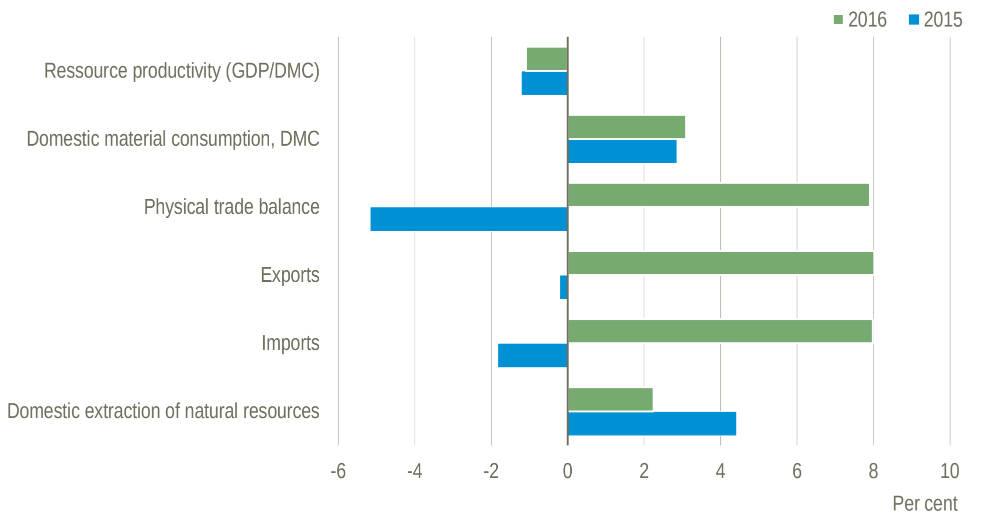
It should be noted that there is no unequivocal correlation between the developments described with regard to water consumption, water expenditures, discharges of wastewater, and payments for wastewater discharges. This is because not all water consumption is subject to charges; not all water is discharged as wastewater (due to evaporation and absorption in products); and no charges are paid for sewage etc. in connection with treatment of wastewater discharged directly into the environment.

Similarly, developments in pollutants may deviate from developments in the amount of wastewater from households and industries. This is because pollutants are measured in wastewater discharged from wastewater treatment plants, which includes water seeping into the sewerage system as well as rainwater which also contains pollutants.

Material flows

Natural resource extraction from Danish territory in 2016 was 2.2 per cent higher than in 2015, when measured by tonnes of materials. This includes crop yields from agriculture, felling in forests, fish catch, gravel, sand, stone etc. as well as oil and natural gas. Extraction of gravel and stone etc. increased in particular, but harvest of biomass and oil and natural gas extraction decreased.

Figure 2.6 Developments in Danish material flows (percentage change compared with previous year)



Note: The calculation of material flows was carried out by determining the weight (tonnes) of all materials (domestic extraction, imports and exports).

The total weight of goods exported by Denmark rose by 8.0 per cent: imports also increased by a corresponding 8.0 per cent. The physical trade balance (weight of imports minus weight of exports) also rose by almost 8 per cent. The physical trade balance was positive (greater imports than exports in terms of weight) in both 2013 and 2014.

Domestic material consumption (DMC) was 3.1 per cent greater in 2016 compared with 2015. This was the second year running that domestic material consumption increased by around 3 per cent. Domestic material consumption is defined as domestic extraction of resources + imports – exports. The indicator shows the weight of all materials used in the Danish economy during the year.

Resource productivity indicates how much GDP is generated during a year in relation to the domestic material consumption (GDP/DMC). In both 2015 and 2016, resource productivity decreased by just over 1 per cent compared with the previous year. Decreasing resource productivity means that a greater quantity of material is required to generate one unit of GDP. An increase in building and construction activities in both 2015 and 2016 was a significant factor in this decreasing resource productivity. This is because building and construction activities require large amounts of gravel, sand and stone.

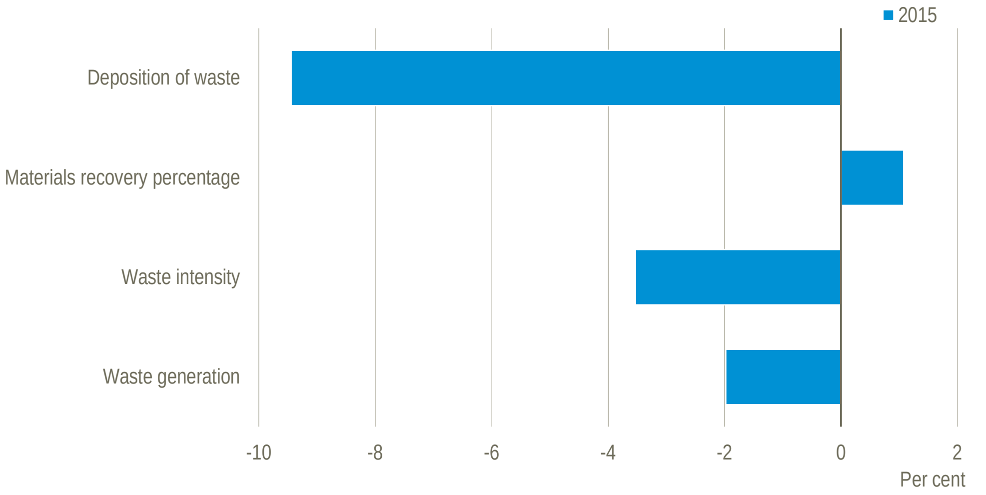
Waste

In 2015, 2.0 per cent less waste was generated than in 2014. This meant that waste intensity, i.e. the volume of waste per DKK GDP, fell by 3.5 per cent. There was thus a decoupling between economic growth and waste volumes.

At the same time, recycling of waste increased. The recycling rate rose from 67 per cent to 68 per cent from 2014 to 2015.

A high recycling rate combined with the incineration of large amounts of waste for heat and electricity production meant that only 4 per cent of total waste was deposited in 2015. 9.4 per cent less waste was deposited in 2015 compared with 2014.

Figure 2.7 Developments in waste (percentage change compared with previous year)



Green economy

Industries' turnover connected to the production of environmental goods and services increased in 2016 by 7.9 per cent, see figure 2.8. Environmental turnover also increased in 2015, by 13.7 per cent[4]. Environmental goods and services are characterised as goods and services that directly protect the environment (for example wastewater treatment and remediation of contaminated soil) or their use results in reduced environmental pressure (for example wind turbines).

The increased turnover in 2015 did not result in a corresponding increase in exports of environmental goods and services: this basically remained unchanged from 2014 to 2015. Figures for exports of environmental goods and services for 2016 were not available at the completion date of this publication.

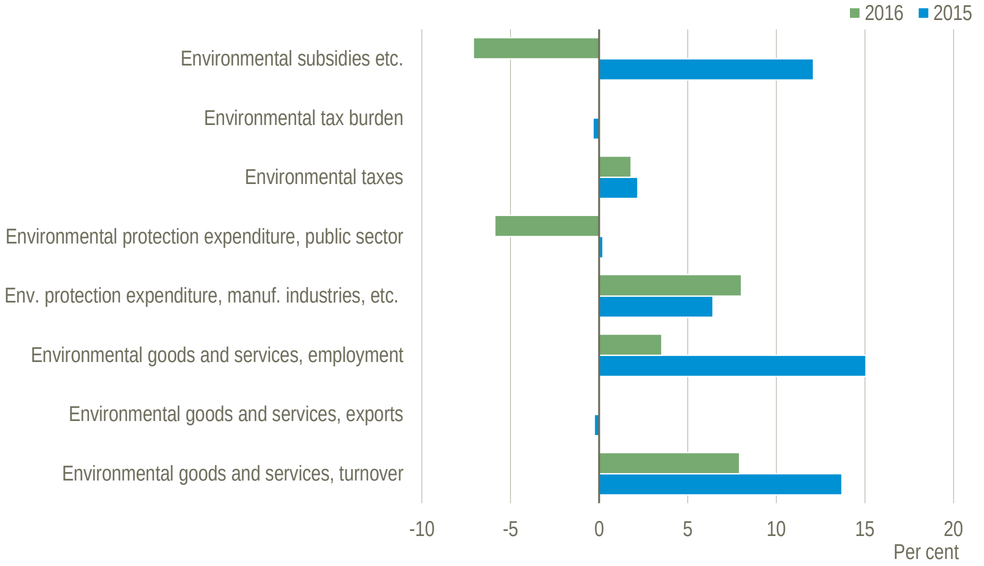
As a result of the increased turnover of environmental goods and services in 2015 and 2016, more people were employed in the production of these goods and services. Employment in the environmental goods and services sector rose by 15.1 per cent in 2015 and by 3.5 per cent in 2016. In 2015, the increase in employment was therefore greater than the increase in turnover, whereas the increase in employment was somewhat smaller than the increase in turnover in 2016.

Regarding expenditure, manufacturing industries etc. had greater expenses for environmental protection in 2016 than in 2015. The increase was 8.0 per cent. Particularly investment in pollution abatement measures and pollution prevention increased in relative terms, whereas the increase in DKK was greatest for purchases of services by manufacturing industries etc. From 2014 to 2015, environmental protection expenditure by manufacturing industries etc. went up by 6.4 per cent.

In 2016, the public sector spent 5.9 per cent less on environmental protection than in 2015. In 2015, public sector environmental protection expenditure was practically on par with expenditure in 2014. Public sector environmental expenditure is particularly incurred by public sector enterprises that then charge the expenditure on to their customers. However, expenditures by central, regional and municipal governments have also been included.

[4] Some of the increase from 2014 to 2015 was probably due to better coverage of the statistics in 2015.

Figure 2.8 Developments in the green economy (percentage change compared with previous year)



Note: This figure is based on calculations of turnover, exports and expenditure etc. in current prices. General price developments have therefore not been taken into account.

In 2016, industries and households had environmental tax expenditure 1.8 per cent higher than in 2015. Environmental tax payments also increased in 2015, and were 2.2 per cent higher than the level in 2014. Environmental taxes are linked to energy, transport, pollution and natural resources. Duties on energy products (including public service obligation tariffs, PSO, see section 11.1) and duties on transport expenditure account for a large part of total environmental taxes. Therefore, factors such as fluctuations in payments of motor vehicle registration duties affect the total proceeds from environmental taxes.

The environmental tax burden, i.e. environmental taxes in relation to GDP, has basically remained unchanged at 4 per cent in recent years, also in 2015 and 2016.

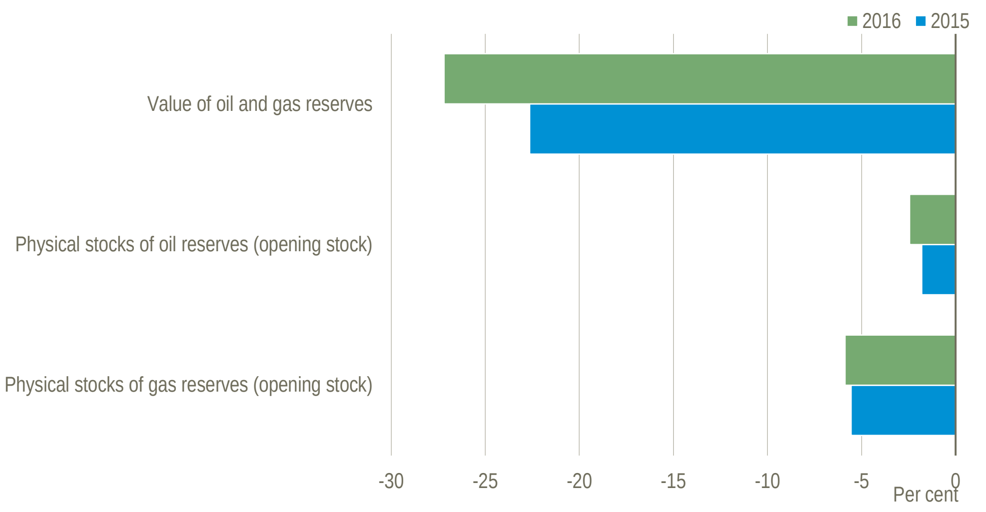
Public sector financial support, in the form of environmental subsidies and similar transfers, fell by 7.1 per cent in 2016 compared with 2015. This fall followed an increase of 12.1 per cent in 2015. This trend is particularly due to changes in the relatively large PSO subsidy which increased in 2015 and then decreased in 2016. Environmental subsidies are generally aimed at activities within energy, transport, pollution and nature management. A proportion of the environmental subsidies are also provided as aid for environmental projects in other countries.

Oil and natural gas in the North Sea

During 2015, oil and natural gas reserves in the North Sea decreased by 2.4 and 5.9 per cent, respectively. During 2014, the decrease was 1.8 and 5.6 per cent, respectively. Danish oil and natural gas reserves decrease proportionally with oil and natural gas extraction. Furthermore, reserves, i.e. the amount technically and economically feasible to extract, can be affected by other factors such as technological developments and energy prices.

In addition to the decrease in physical stocks, the value (calculated in current prices) of oil and natural gas reserves was affected by revaluations due to drops in oil and gas prices. Overall, changes in stocks and prices meant that the value of Danish oil and natural gas reserves in the North Sea fell by 27.2 per cent during 2015. In 2014, the value fell correspondingly by 22.6 per cent.

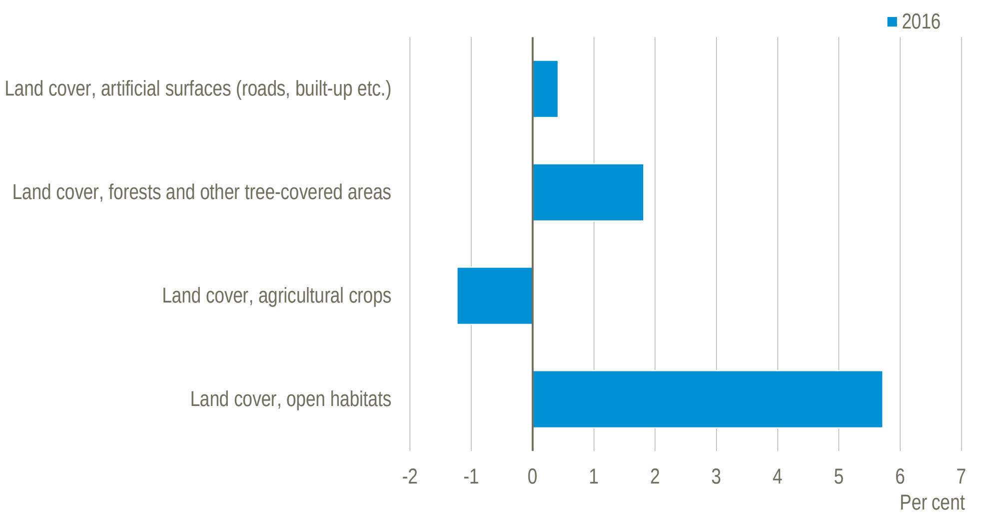
Figure 2.9 Developments in oil and natural gas reserves (percentage change compared with previous year)



Land cover

From 2011 to 2016[5], areas with open habitats and forest increased by 5.7 and 1.8 per cent, respectively, whereas areas with agricultural crops decreased by 1.2 per cent. Areas covered by roads and artificial surfaces etc. increased by 0.4 per cent.

Figure 2.10 Developments in most significant land cover (percentage change 2011-2016)



Fish

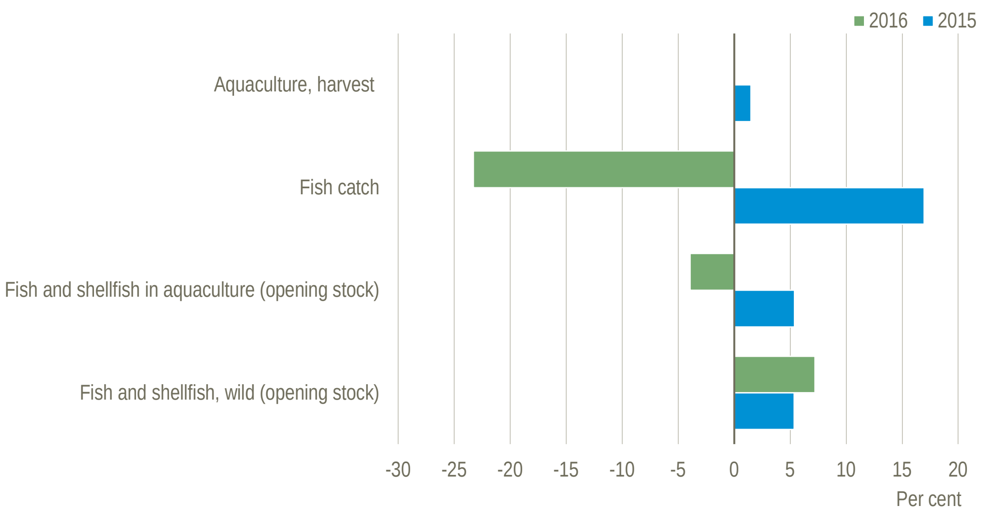
Danish wild fish stocks increased by 7.2 per cent in 2016, see figure 2.11. The stocks were calculated as a percentage of the total stock in the areas in which Danish fishermen are entitled to fish. This percentage corresponds to Denmark's percentage of total allowable catch (Denmark's quotas). In 2015, there was an increase of 5.3 per cent. The stock of fish in Danish aquaculture fell by 3.9 per cent in 2016 following an increase of 5.4 per cent in 2015.

Danish fishermen's catch of fish in 2016 was 23.3 per cent less than the catch in 2015. It is important to note that the catch was at a relatively high level in 2015, as there was a 17 per cent increase in the catch from 2014 to 2015.

In 2015, the harvest from Danish aquaculture was slightly above the level of 2014.

[5] The land accounts in the green national accounts were calculated for 2011 (partly 2012) and 2016.

Figure 2.11 Developments in estimated stocks, catch and harvest of fish (percentage change)



2.3 Economic and environmental profile

Figure 2.12 shows the extent to which households and industries etc. contribute to a number of the aggregates and indicators included in the green national accounts. For simplicity, the figure contains a rough division of industries into four main industry groups. The figure also includes households and "others". The latter group includes other countries, for example. Text in brackets is the absolute volume of the relevant category, whereas the bars and associated figures indicate the percentages of the total.

Note that the other chapters have a more detailed division of the industries, and that www.statbank.dk contains very detailed calculations using the national accounts classification of 117 industries.

Value added

In 2016, industries had a total value added of DKK 1,789 billion (current prices)[6]. Two per cent of this came from agriculture, forestry, fishing, mining and quarrying. Manufacturing and utility services accounted for 17 per cent, trade and transport for 20 per cent and all other industries as a whole for 61 per cent. The latter group includes building and construction, all the service industries, as well as public administration etc.

Employment

Over the course of 2016, an average of 2.8 million people were employed in Denmark. Agriculture, forestry, fishing, mining and quarrying employed 2 per cent of these people, while manufacturing and utility services employed 11 per cent, trade and transport employed 26 per cent, and other industries 61 per cent.

Energy

In 2016, total gross energy consumption, including the large volumes of energy purchased by Danish transport operators abroad (bunkering etc.) in connection with international transport activities, was 1,216 petajoules. Bunkering etc. abroad accounted for 467 petajoules of this total. As a result of this extensive bunkering etc., trade and transport accounted for 48 per cent of total gross energy consumption. Households accounted for 27 per cent, and manufacturing and utility services for 11 per cent.

Industries and households together paid DKK 181 billion for energy in 2015. Households paid 42 per cent and trade and transport 20 per cent. The larger proportion paid by households - as well as other distortions regarding percentages in

[6] DKK 100 corresponds approximately to 13.4 Euro and 16.7 USD (February 2018)

relation to physical energy consumption - can be explained by the fact that duties and trade margins affect the different groups to different extents. Furthermore, prices can vary between customers.

Greenhouse gases

In 2016, total greenhouse gas emissions from Danish economic activities corresponded to 87 million tonnes of CO_2 equivalents. This figure includes 36 million tonnes linked to the large volumes of fuel bunkered etc. abroad. As with gross energy consumption, trade and transport is the most significant industry group in this context, accounting for 49 per cent of greenhouse gas emissions. Manufacturing industries and utilities accounted for 22 per cent, whereas agriculture, forestry, fishing, mining and quarrying caused 16 per cent of total greenhouse gas emissions. Emissions of methane, CH_4, and nitrous oxide, N_2O, from agriculture etc. contributed significantly to this figure.

Waste

A total of 11 million tonnes of waste was generated in 2015. The activities undertaken by the category other industries accounted for a large proportion of this waste, corresponding to 41 per cent. This figure is a result, in particular, of building and construction activities, which generate large volumes of waste. Households also generated large volumes of waste: 30 per cent of total waste generation. A total of 18 per cent of waste came from manufacturing and utility services, and 10 per cent from trade and transport.

Water

Industries and households used a total of 741 million m^3 of water in 2016[7]. Agriculture and fish farms in particular used large volumes of water. Agriculture, forestry, fishing, mining and quarrying accounted for 52 per cent of total water consumption. Households used 28 per cent of the water. Moreover, 13 per cent was used by manufacturing and utility services.

In 2016, water expenditure totalled DKK 8 billion, which was primarily paid by households. Households paid 71 per cent of this total figure. With 52 per cent of the water consumption, agriculture etc. was the largest water consumer. However, agriculture etc. accounted for only 8 per cent of the payments to water suppliers. The reason for this distribution is that agriculture itself extracts large quantities of water, and therefore does not pay waterworks etc. for water supply.

Wastewater

Industries and households discharged a total of 476 million m^3 of wastewater in 2016. 43 per cent of wastewater came from households, whereas 33 per cent came from agriculture, forestry, fishing, mining and quarrying[7]. The latter figure also includes large volumes of water discharged from fish farms. Manufacturing and utility services discharged 13 per cent of wastewater. Note that wastewater is used as a term for all water discharged from industries and households, i.e. all water returned to the aquatic environment, and that it does not indicate anything about the degree of contamination or quality of wastewater.

As is the case with water consumption, households pay the largest proportion of total cost in disposing of wastewater. In 2016, 74 per cent of the total DKK 12 billion paid for wastewater was paid by households. Agriculture, forestry, fishing, mining and quarrying paid 3 per cent and manufacturing and utility services 9 per cent. Some businesses have their own treatment plants and discharge direct to receiving water bodies outside sewerage systems and general treatment plants. Therefore, they do not necessarily pay others to dispose of their wastewater. The costs accrued to industries through their own management and treatment of wastewater were not included in the DKK 12 bn.

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[7] As mentioned in section 1.1, the figure for water abstraction and discharge of wastewater by industries, and particularly fish farms, has probably been underestimated. Thus, the percentage used by agriculture, forestry, fishing, mining and quarrying is also likely to have been underestimated, and conversely the other percentages are likely to have been overestimated.

Land use

82 per cent of Denmark's total area of around 43,000 km^2 is taken up by agriculture, forestry, fishing, mining and quarrying, with agriculture using by far the most. Households' land use for dwellings etc. accounted for 6 per cent of all land use. Manufacturing and utility services used around 1 per cent, whereas the figure was 4 per cent for trade and transport. Finally, 6 per cent of the land was used for other purposes, including roads. This 6 per cent figure also contains land with unknown uses.

Environmental taxes

In 2016, a total of DKK 82 billion was paid in environmental taxes. Households paid 57 per cent of this total. Agriculture, forestry, fishing, mining and quarrying paid 2 per cent, whereas manufacturing and utility services paid 8 per cent, and trade and transport etc. accounted for 9 per cent. Other industries paid 12 per cent, whereas 11 per cent were environmental taxes linked to products for other uses. This category covers investments, changes in inventories and exports etc.

Environmental subsidies etc.

The public sector paid a total of DKK 9 billion in environmental subsidies and similar transfers in 2016. The largest proportion of this total, 27 per cent, was subsidies etc. not directly attributed to receiving industries or households. This category includes transfers linked to exports, investments, and international aid. A further 20 per cent went to households, 27 per cent to manufacturing and utility services, whereas the other three main industry groups shown in figure 2.11 received a total of 26 per cent, relatively evenly distributed across each of the groups.

Environmental turnover, exports and employment

Turnover of environmental goods and services amounted to DKK 214 billion in 2016. 78 per cent of this turnover was generated in manufacturing and utility services. 20 per cent came from other industries, including building and construction and business services. 2 per cent of the turnover on environmental products included organic products from agriculture etc.

Of the DKK 198 billion turnover from environmental products in 2015, DKK 72 billion came from exports. Exports of environmental products were particularly common amongst manufacturing industries: manufacturing and utility services accounted for 91 per cent of these exports.

On the basis of employment related to the production of environmental goods and services, manufacturing industries appear somewhat less dominant. Around 71,000 people were employed in the environmental goods and services sector in 2016. A total of 59 per cent of these were employed in manufacturing and utility services, with 36 per cent in other industries. Finally, 5 per cent of environmental employment was in agriculture, forestry, fishing, mining and quarrying.

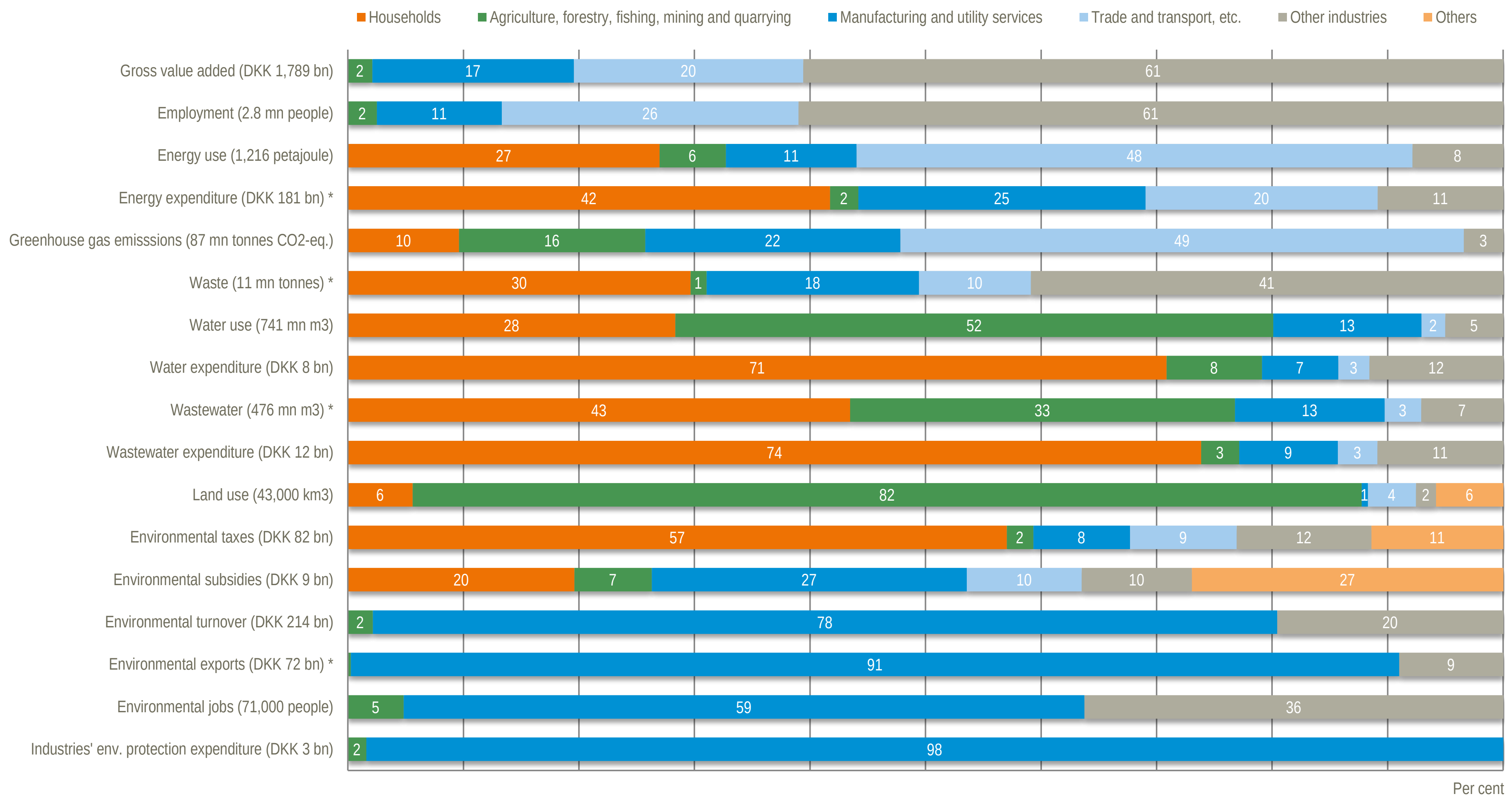
Manufacturing industries' environmental protection expenditures

In 2016, manufacturing industries etc. paid a total of DKK 3 billion for environmental protection. This figure also includes a small amount for environmental protection incurred in connection with mining and quarrying. Calculations of environmental protection expenditures in other industries were not carried out.

Public-sector environmental protection expenditures

In 2016, public sector environmental protection expenditures amounted to DKK 29 billion. A large part of this expenditure was paid by public enterprises. The green national accounts contain no industry breakdown of these expenditures, and therefore these figures are not shown in figure 2.12.

Figure 2.12 Economic and environmental profile for households and main industry groups



Note 1: *Indicates that the figure in brackets and the percentage breakdown are for 2015. Other figures and breakdowns are for 2016.

Note 2: All DKK amounts have been calculated in current price

3. Indicators for the UN Sustainable Development Goals

Sustainable Development Goals, SDGs

In September 2015, heads of state and government from all over the world adopted the United Nations 2030 Agenda for Sustainable Development - commonly referred to as the SDGs (Sustainable Development Goals). The overall aims of the SDGs are to end poverty and hunger globally, reduce inequality, and ensure good education, good health, peace and safety, decent jobs as well as more sustainable growth. By design, the SDGs are universal and as such apply to Denmark.

The goals can only be achieved through an integrated effort that crosses economic, environmental, and social domains. Environmental aspects are therefore included in many of the 17 goals, as well as the further 169 targets into which these goals have been divided. The 17 goals are shown in figure 3.1.

232 indicators to establish if we are moving towards the goals

In order that the SDGs be successfully met, it is crucial that monitoring, on both a national and international basis, can be undertaken as to determine whether development leads towards or away from the goals. To achieve this, the *Inter-Agency Expert Group on Sustainable Development Goal Indicators (IAEG-SDG)* has developed a global indicator framework in collaboration with the United Nations Statistics Division[1]. This was agreed upon at the 48th session of the United Nations Statistical Commission held in March 2017 and has subsequently been adopted by the General Assembly on 6 July 2017. The indicator framework consists of 232 different indicators.

Figure 3.1

United Nations' Sustainable Development Goals

Source: www.un.org/sustainabledevelopment/sustainable-development-goals/

The green national accounts support Danish implementation

The green national accounts developed in accordance with the *SEEA Central Framework*, as presented in the other chapters in this publication, support Denmark's implementation of several of the SDG indicators.

The advantage of using the green national accounts as a basis for the SDG indicators comes from the fact that sound composite indicators should be based on data measured within a coherent conceptual framework. When, for instance, data on the use of energy and air emissions are compared to GDP or other economic aggregates, it is important that the energy and air emissions data reflect the same definitions and delineations as the GDP (see section 1.7).

[1] Global indicator framework for the Sustainable Development Goals and targets of the 2030 Agenda for Sustainable Development. https://unstats.un.org/sdgs/indicators/indicators-list/

SDG indicators for Denmark

Based on the green national accounts, a selection is presented below of targets and SDG indicators for Denmark pertaining to SDG goals 6, 7, 8, 9, 11, 12, 14 and 15. Since the Danish green national accounts do not include all environmental aspects, references are also made to the development in selected other SDG indicators that are closely connected with the green national accounts. The presentation of these other indicators is based on a more comprehensive report on the Danish SDG indicators; see Statistics Denmark (2017b).

However, it must be emphasised that the indicators and their presentation here is not all-encompassing. Furthermore, the indication that in a number of areas Denmark is moving in the right direction towards achieving the goals cannot necessarily be taken to mean that the goals will be achieved.

It should also be noted that the Danish government has established a SDG action plan based on the UN goals and indicators. This comprises 37 political objectives and a number of national indicators which represent the priorities of the government. Objectives and priorities are described in The Danish Government (2017). The presentation of the SDG goals and indicators below only refers to the basic goals and indicators as they are described in the UN indicator framework (see footnote 1 on the previous page).

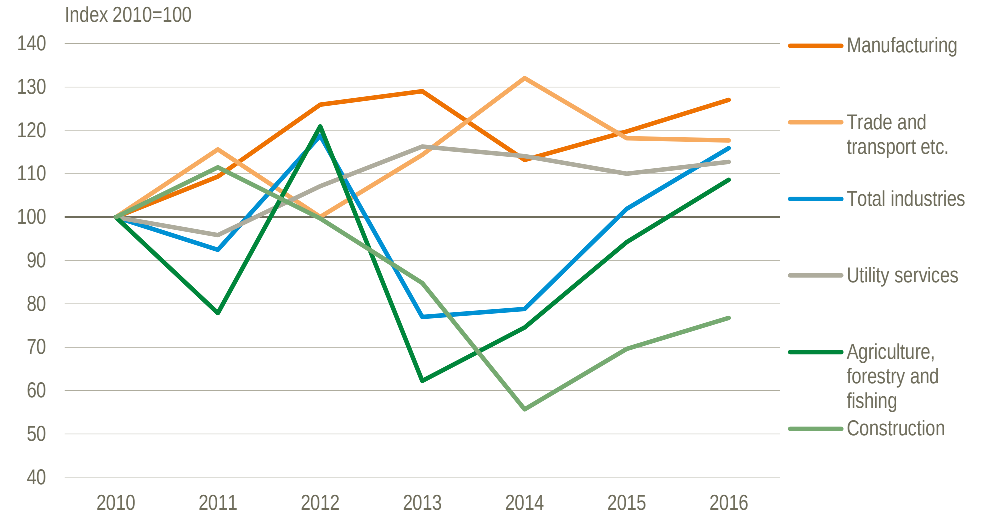
6 CLEAN WATER AND SANITATION

Goal 6. Ensure availability and sustainable management of water and sanitation for all

Information on water abstraction and water use is presented in the green national accounts' module on water, see chapter 6. The water accounts provide information relating to SDG indicator 6.4.1 on water use efficiency, while the land use accounts (see chapter 13) include data that can be used to show developments in indicator 6.6.1 on water-related ecosystems.

Target 6.4 By 2030, substantially increase water-use efficiency across all sectors and ensure sustainable withdrawals and supply of freshwater to address water scarcity and substantially reduce the number of people suffering from water scarcity	Indicator 6.4.1 Change in water-use efficiency over time Indicator 6.4.2 Level of water stress: freshwater withdrawal as a proportion of available freshwater resources

Figure 3.2 Indicator 6.4.1 Water-use efficiency over time



Note: Water use efficiency is estimated as value added (chained volumes, 2010 prices) divided by the quantity of water used

Volatile water use efficiency but improvements for manufacturing industries

The water accounts show that in recent years there have been large fluctuations in water use efficiency – measured as value added (chained volumes) divided by the quantity of water used; see figure 3.2. This applies for industries altogether as well as for separate industries, for instance, the construction and agriculture, forestry and fisheries industries. For agriculture etc., the large fluctuations can be explained by fluctuating irrigation needs due to climatic conditions and crop selection. For the other industry groups shown, there has generally been a slight improvement in the water use efficiency. Despite the volatility in the two most recent years, the trend since 2010 has been an increase in value added compared to water use.

Overall low level of water stress

Indicator 6.4.2 on freshwater withdrawal as a proportion of available freshwater resources can be roughly assessed based on the water accounts and an earlier study of groundwater resources. Henriksen and Troldborg (2003) estimate the Danish total renewable groundwater resources to be approximately one billion cubic metres. Thus, the utilisation rate of available groundwater resources has varied between 60 and 80 per cent in the period from 2010 to 2016. Surface water, which is of less significance in comparison to groundwater in Denmark, is not included in the estimate. A utilisation rate below 100 per cent is a sustainable consumption of groundwater resources. Accordingly, the extraction of water in Denmark appears to be broadly sustainable.

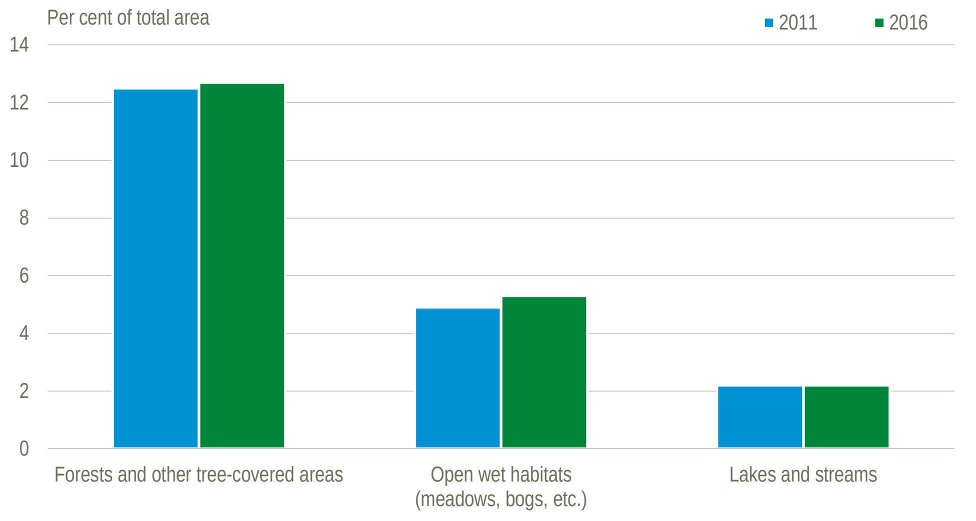
Slight increase in area for some water-related ecosystems

According to the land use accounts, water-related ecosystems like forests and wetlands etc. took up a larger proportion of the total area in 2016 than in 2011; see figure 3.3.

Target 6.6 By 2020, protect and restore water-related ecosystems, including mountains, forests, wetlands, rivers, aquifers and lakes.	Indicator 6.6.1 Change in the extent of water-related ecosystems over time

Figure 3.3

Indicator 6.6.1 Extent of water-related ecosystems over time



Close to 100 per cent fulfilment of the targets for sanitation and hygiene…

Other SDG indicators on water use and sanitation based on other statistical sources than the green national accounts are presented in Statistics Denmark (2017b). They show that Denmark is close to fulfilling target 6.1 on access to safe and affordable drinking water and target 6.2 on access to adequate and equitable sanitation and hygiene.

99 per cent of the Danish population have access to a WC in the dwelling they live in, 97 per cent have access to bathing facilities in the dwelling they live in and 99 per cent have access to a kitchen in said dwelling.

... and wastewater treatment

Indicator *6.3.1 Proportion of wastewater safely treated* aims to show progress towards SDG target 6.3 on improved water quality and untreated wastewater, etc. In Denmark, all wastewater is treated before being led back to the aquatic environment. Almost all treatment takes place at public wastewater treatment plants. However, some dwellings and companies do have their own wastewater treatment facilities. As a result, target 6.3 is very close to being fully achieved in Denmark.

Goal 7: Ensure access to affordable, reliable, sustainable and modern energy for all

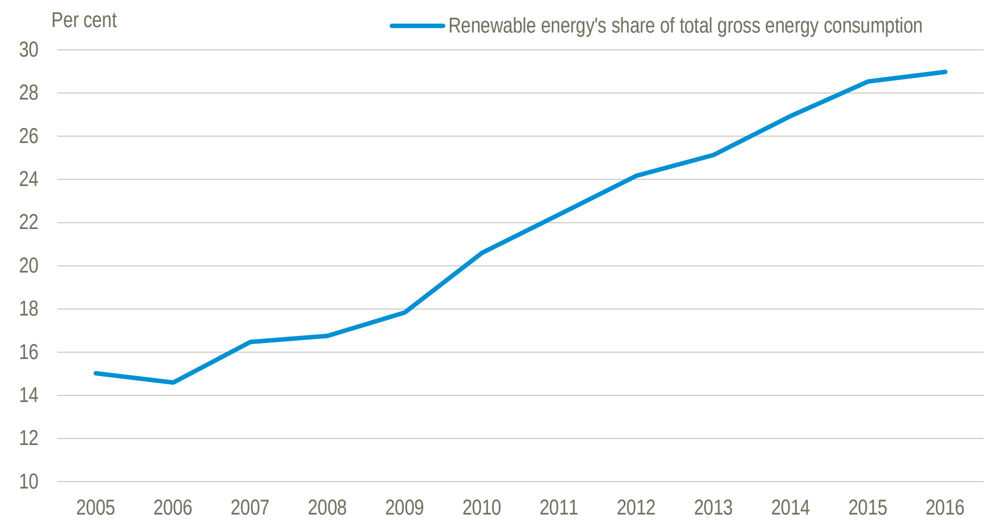
Information on energy production and use is presented in the green national accounts' module on energy; see chapter 4. The energy accounts contain data that can be used in relation to several of the SDG energy indicators.

Increase in the share of renewable energy

According to SDG target 7.2, the share of renewable energy should be increased substantially. Progress is measured by indicator 7.2.1. The renewable energy share of total gross energy consumption can be used as a proxy for this indicator[2]; see figure 3.4.

Target 7.2 By 2030, increase substantially the share of renewable energy in the global energy mix.	Indicator 7.2.1 Renewable energy share of total final energy consumption.

Figure 3.4 Indicator 7.2.1 Renewable energy share of total energy consumption



The share of renewable energy has almost doubled since 2005, so that renewable energy in 2016 accounts for 29 per cent of total gross energy consumption. The change towards a greener energy system accelerated in 2009, and Denmark is progressing towards the SDG target 7.2.

Increase in energy efficiency

A sustainable energy system requires an increase in energy efficiency, and SDG target 7.3 aims to double the global rate of improvement in energy efficiency by 2030.

[2] In Denmark, historically, the difference between the renewable energy share of total gross energy consumption and of total final energy consumption (defined according to an EU-directive on renewable energy) is such that the renewable energy share for the latter is 1-2 percentage point higher.

The corresponding indicator for this target is energy intensity. Figure 3.5 presents two versions of the indicator for Denmark. One is the energy intensity measured as gross energy consumption in relation to GDP for all Danish economic activities. The other is for Danish economic activities exclusive of the fuel bunkered abroad by ships operated by Danish shipping companies. Fuel tanked abroad by aircraft and lorries is also excluded from the second version.

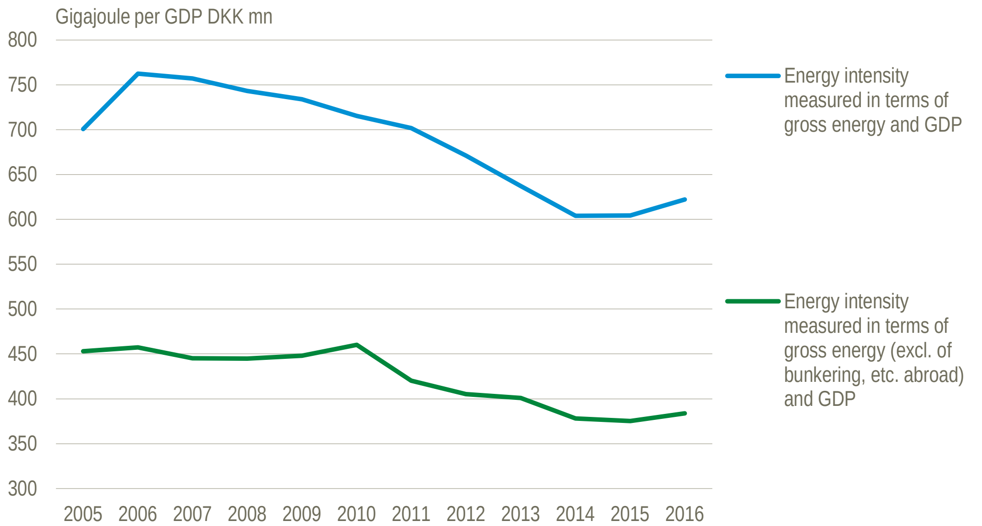
The first version of the indicator is presented since the Danish economy is characterised by a very large shipping industry, which accounts for one third of the total gross energy consumption for Danish economic activities. Thus, the bunkering of fuel alone has a substantial influence on the overall intensity indicator.

The second version of the indicator is in line with the calculation of energy use in relation to greenhouse gas inventories used for reporting to international conventions, e.g. the UNFCCC.

The development over the past decade indicates that the overall energy intensity for the Danish economy is decreasing. Compared to 2005, the energy intensity has decreased by 11 per cent and by 15 per cent if the bunkering abroad is disregarded.

Target 7.3 By 2030, double the global rate of improvement in energy efficiency.	Indicator 7.3.1 Energy intensity measured in terms of primary energy and GDP

Figure 3.5 Indicator 7.3.1 Energy intensity in Denmark



Investments in energy efficiency

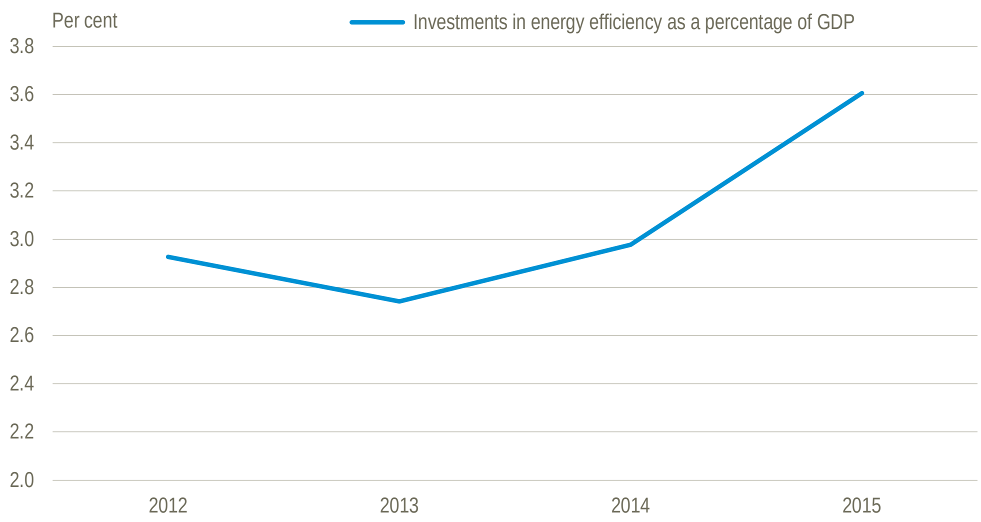
For developed countries, SDG Target 7.b. states that infrastructure should be expanded and technology upgraded in order to supply modern and sustainable energy services for all by 2030. Investments in energy efficiency as a percentage of GDP are used as an indicator.

A proxy indicator based on the environmental goods and services sector accounts, presented in chapter 9, can be used in this context. The indicator is estimated as turnover minus the exports of equipment for production of energy from renewable sources as well as equipment for energy savings and management. The indicator is presented in figure 3.6. It shows that investments in energy efficiency have increased over recent years and that the Danish economy is moving in the right direction apropos goal 7.b.

Target 7.b. By 2030, expand infrastructure and upgrade technology for supplying modern and sustainable energy services for all in developing countries, in particular least developed countries, small island developing States and landlocked developing countries, in accordance with their respective programmes of support	Indicator 7.b.1 Investments in energy efficiency as a percentage of GDP and the amount of foreign direct investment in financial transfer for infrastructure and technology to sustainable development services

Figure 3.6

Indicator 7.b.1 Investments in energy efficiency as a percentage of GDP

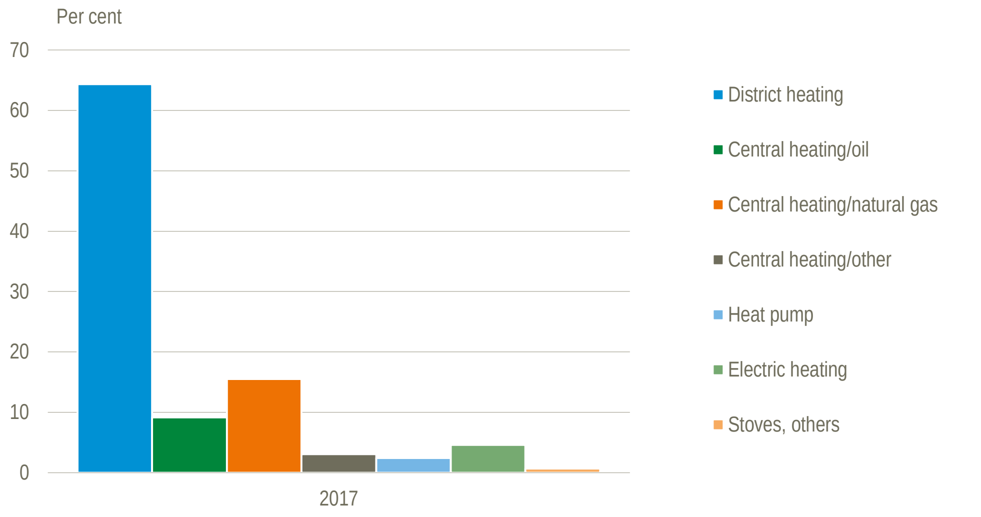


High degree of access to modern energy services

Other targets and indicators for SDG goal 7 are presented in Statistics Denmark (2017b). Regarding target 7.1: *By 2030, ensure universal access to affordable, reliable and modern energy services* and the corresponding indicator *7.1.1 Proportion of population with access to electricity*, Denmark is already operating at a level corresponding to almost 100 per cent. The Danish electricity grid is highly developed and almost all dwellings are connected to the grid.

Figure 3.7

Indicator 7.1.2 Proportion of population using different forms of heating



Source: Statistics Denmark (2017)

Widespread access to clean fuels, but some concerns about use of fuel wood

For indicator *7.1.2 Proportion of population with primary reliance on clean fuels and technology*, the score for Denmark is also relatively high. In 2017, 64 per cent of all dwellings were heated by district heating. Electricity is the main type of energy used for cooking. Gas is also used for cooking, but only to a very limited extent.

However, it is a concern that some dwellings in Denmark also have a wood-burning stove to support their main heating installation. Whilst the use of fuel wood is considered to be neutral in relation to global warming, it nevertheless causes air pollution, which may affect the local air quality in some areas and cause serious potentially life-threatening health problems.

Goal 8: Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all

The material flow accounts module, see chapter 7, are important for the follow-up of SDG goal 8 and the corresponding target on improved resource efficiency. The principal SDG indicator 8.4.2 is based directly on the assessment of domestic material consumption.

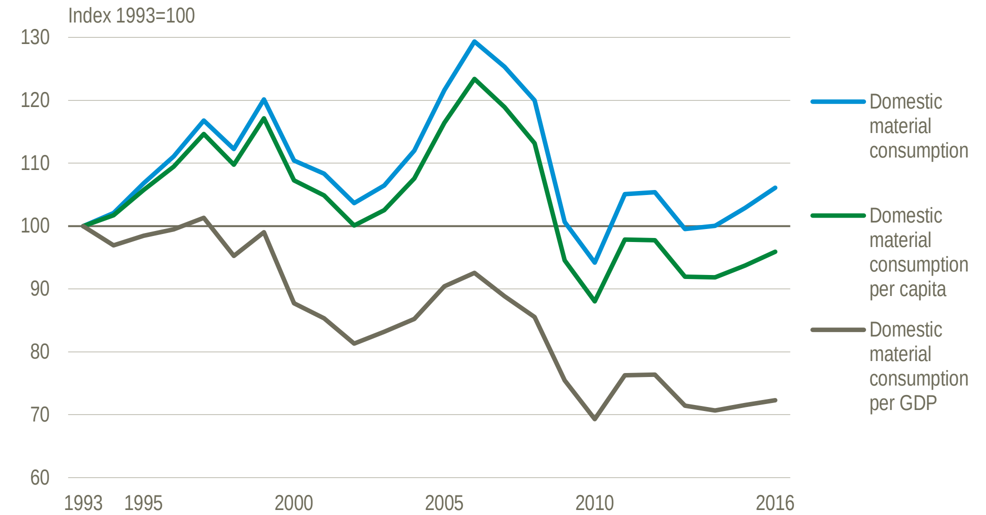
Slight decrease in resource efficiency

Figure 3.8 presents the indicator in its three different forms. The indicators Domestic material consumption (DMC) and Domestic material consumption per capita are roughly at the same level in 2016 as in 1993. DMC in relation to the level of economic activity (GDP) has generally decreased over the period 1993-2016. However, in 2015 and 2016 there was a slight increase in material consumption. All three domestic material consumption indicators are highly influenced by business cycles and construction activities in particular. The latter rely heavily on the use of construction minerals, which, due to their high volumes and weight, strongly influence the domestic material consumption indicator.

Target 8.4 Improve progressively, through 2030, global resource efficiency in consumption and production and endeavour to decouple economic growth from environmental degradation, in accordance with the 10 Year Framework of Programmes on Sustainable Consumption and Production, with developed countries taking the lead.	Indicator 8.4.2 Domestic material consumption, domestic material consumption per capita, and domestic material consumption per GDP

Figure 3.8

Indicator 8.4.2 Domestic material consumption, domestic material consumption per capita and domestic material consumption per GDP



Goal 9: Build resilient infrastructure, promote inclusive and sustainable industrialisation and foster innovation

Target 9.4, pertaining to goal 9, states that by 2030, infrastructure and industries should be sustainable, with increased resource-use efficiency and greater adoption of clean and environmentally sound technologies and industrial processes.

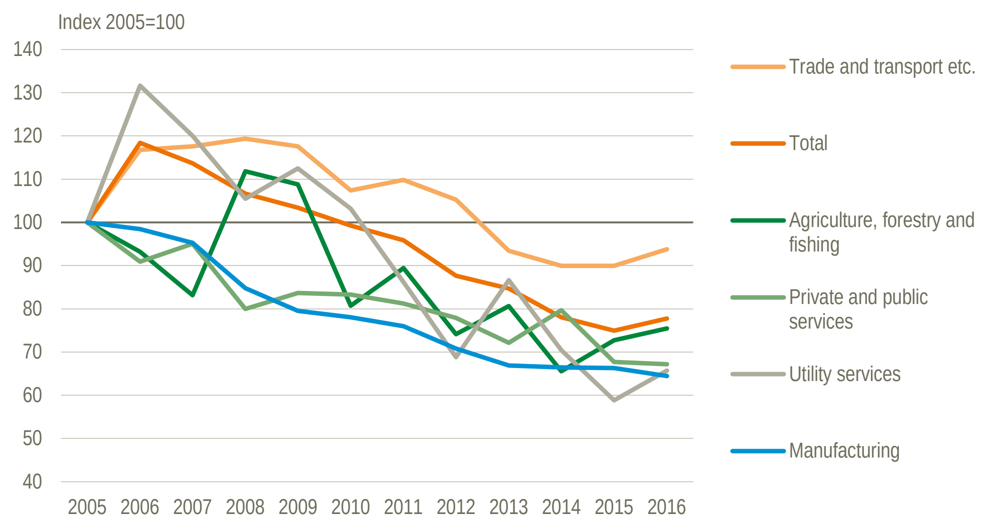
Fall in CO_2 emissions per unit of value added

Figure 3.9, based on the air emissions module of the green national accounts, see chapter 5, presents SDG indicator *9.4.1 CO_2 emission per unit of value added* for all industries as a whole as well as for selected industries. Overall, CO_2 emissions relative to value added have decreased in the period 2005-2016. The main driver behind this development is improved energy efficiency in production and the general shift towards a greener economy with more reliance on renewable energy including biomass.

Target 9.4 By 2030, upgrade infrastructure and retrofit industries to make them sustainable, with increased resource-use efficiency and greater adoption of clean and environmentally sound technologies and industrial processes, with all countries taking action in accordance with their respective capabilities	Indicator 9.4.1 CO_2 emission per unit of value added

Figure 3.9

Indicator 9.4.1 CO_2 emission per unit of value added



Note 1: CO_2 emissions from biomass have been excluded from the indicator

Note 2: Emissions corresponding to use of fuel bunkered/tanked abroad by Danish-operated vessels, aircraft and vehicles are included

Goal 11: Make cities and human settlements inclusive, safe, resilient and sustainable

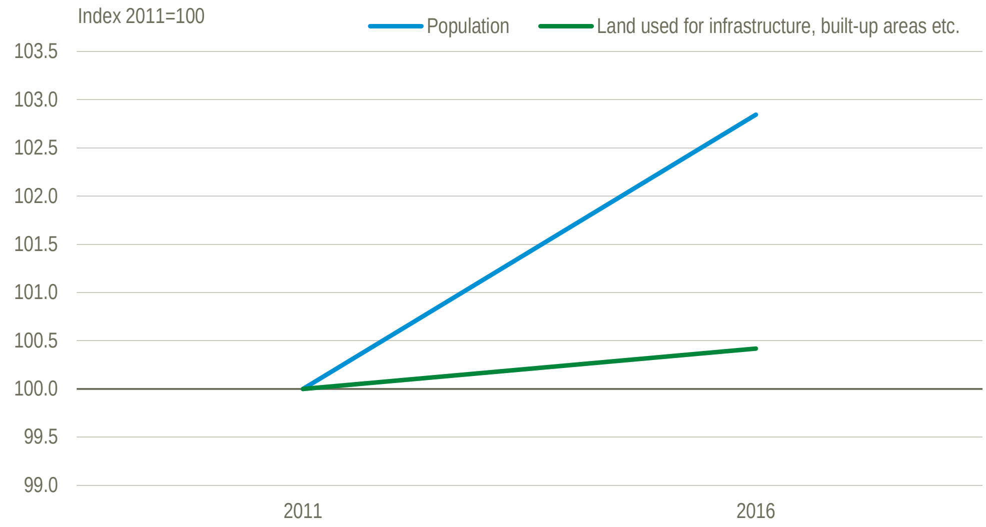
Information related to goal 11 can be found in the green national accounts' module on land use, see chapter 13, and in the module on environmental protection expenditures, see chapter 10.

Urban land use grows at slower rate than the population

The land use accounts are instrumental in the estimation of indicator *11.3.1 Ratio of land consumption rate to population growth rate*. Figure 3.10 indicates that whereas Denmark has seen a population growth of 2.8 per cent from 2011 to 2016, the consumption of land for infrastructure, buildings and the like has only increased by 0.4 percent. As such, urbanisation in Denmark seems not to consume land at the same rate as that by which the population grows.

Target 11.3 By 2030, enhance inclusive and sustainable urbanisation and capacity for participatory, integrated and sustainable human settlement planning and management in all countries	11.3.1 Ratio of land consumption rate to population growth rate

Figure 3.10 Indicator 11.3.1 Land used for infrastructure, built-up areas etc. compared to population



Increase in public expenditure on environmental protection and biodiversity

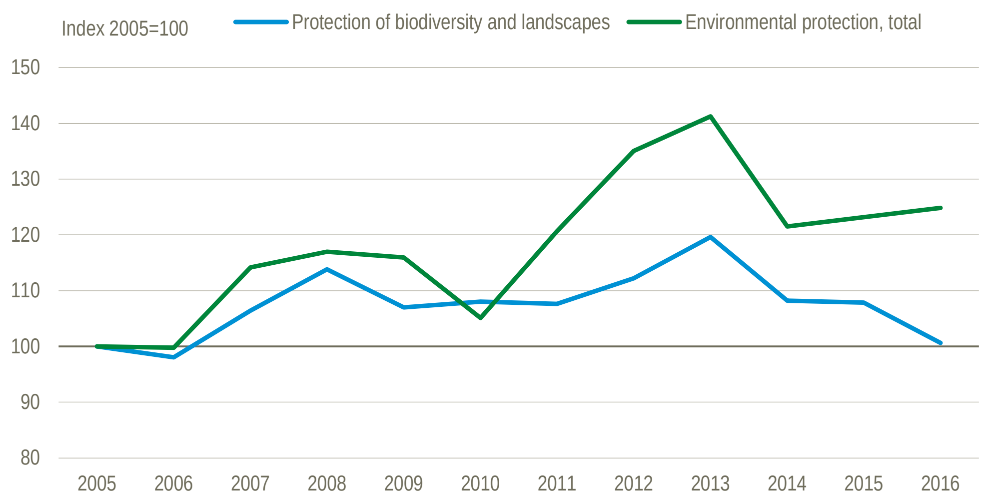
SDG target 11.4 concerns the safeguarding of cultural and natural heritage; the related indicator 11.4.1 measures performance pertaining to this target by looking at per capita expenditure on the preservation, protection, and conservation of this heritage.

As a proxy for that indicator, figure 3.11 presents, based on the environmental expenditure accounts, Danish *public* expenditure on environmental protection and biodiversity per capita.

From 2005 to 2013 there was an increase of 20 per cent in public spending on biodiversity and landscape. In contrast, expenditure fell by 12 per cent from 2013 to 2016. Total environmental protection costs per capita increased by 41 per cent in the period 2005-2013, whereas from 2013 to 2016, total environmental protection costs fell by 16 per cent. For the period since 2005 as a whole, there has been an increase in expenditure on environmental protection and biodiversity. However, it should be noted that the costs are calculated at current prices and inflation has not been taken into account. Furthermore, the indicator only includes aspects of natural heritage, not cultural heritage in a broader sense.

Target 11.4 Strengthen efforts to protect and safeguard the world's cultural and natural heritage	11.4.1 Total expenditure (public and private) per capita spent on the preservation, protection and conservation of all cultural and natural heritage, by type of heritage (cultural, natural, mixed and World Heritage Centre designation), level of government (national, regional and local/municipal), type of expenditure (operating expenditure/investment) and type of private funding (donations in kind, private non-profit sector and sponsorship)

Figure 3.11 Indicator 11.4.1 (proxy) Public expenditure per capita towards environmental protection and biodiversity



Note: Based on expenditures at current prices

High score for collection of solid waste

According to (Statistics Denmark, 2017b), Denmark also has a high score on indicator *11.6.1 Proportion of urban solid waste regularly collected and with adequate final discharge out of total urban solid waste generated by cities*. This indicator is related to SDG target 11.6, which aims at reducing the adverse environmental impact of cities with special attention to air quality and municipal and other waste management.

As a result of both European and Danish laws, the waste treatment sector is highly regulated in Denmark and a very high share of the total urban solid waste is regularly collected and treated.

Goal 12: Ensure sustainable consumption and production patterns

SDG target 12.2 relates to *the sustainable management and efficient use of natural resources*. Progress towards the target is measured by the development in domestic material consumption, estimated from the material flow accounts; see chapter 7.

Target 12.2 By 2030, achieve sustainable management and efficient use of natural resources	Indicator 12.2.2 Domestic material consumption, domestic material consumption per capita, and domestic material consumption per GDP

Slight decrease in resource efficiency

Indicator 12.2.2 is the same as indicator 8.4.2 presented previously in figure 3.8.

According to SDG target 12.4, Denmark should by 2020, achieve the environmentally sound management of chemicals and all waste, and significantly reduce their release to air, water and soil.

No decrease in the amounts of hazardous waste, but more is recovered

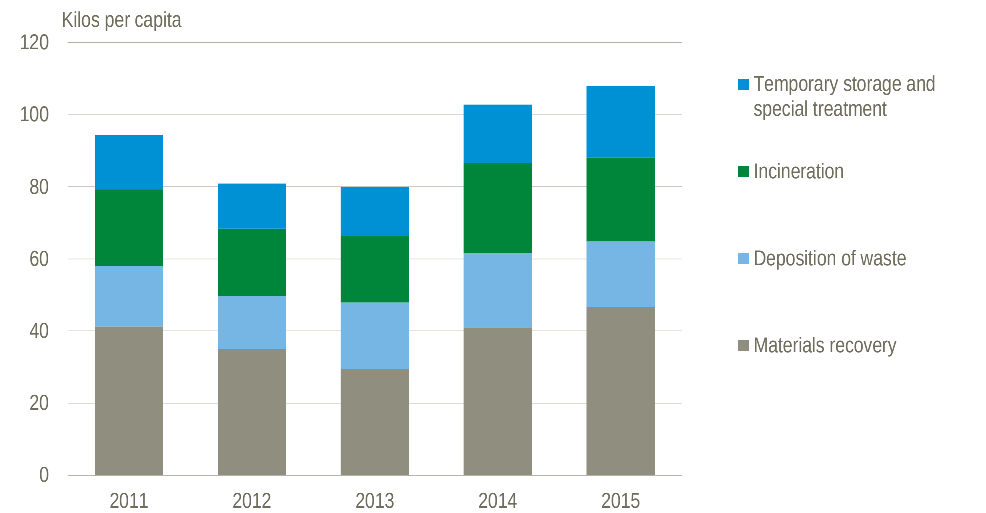
Based on data from the waste accounts module, see chapter 8, figure 3.12 presents indicator *12.4.2 Hazardous waste generated per capita and proportion of hazardous waste treated, by type of treatment.*

The amount of hazardous waste per capita has ranged between 80 and 108 kg in Denmark in the period 2011-2015. Overall, the indicator does not show any progress with regard to reducing amounts of hazardous waste. However, it does show that during recent years there has been an increase in the share of hazardous waste being recovered.

Target 12.4 By 2020, achieve the environmentally sound management of chemicals and all wastes throughout their life cycle, in accordance with agreed international frameworks, and significantly reduce their release to air, water and soil in order to minimize their adverse impacts on human health and the environment	12.4.2 Hazardous waste generated per capita and proportion of hazardous waste treated, by type of treatment

Figure 3.12

Indicator 12.4.2 Amount of hazardous waste per capita by treatment



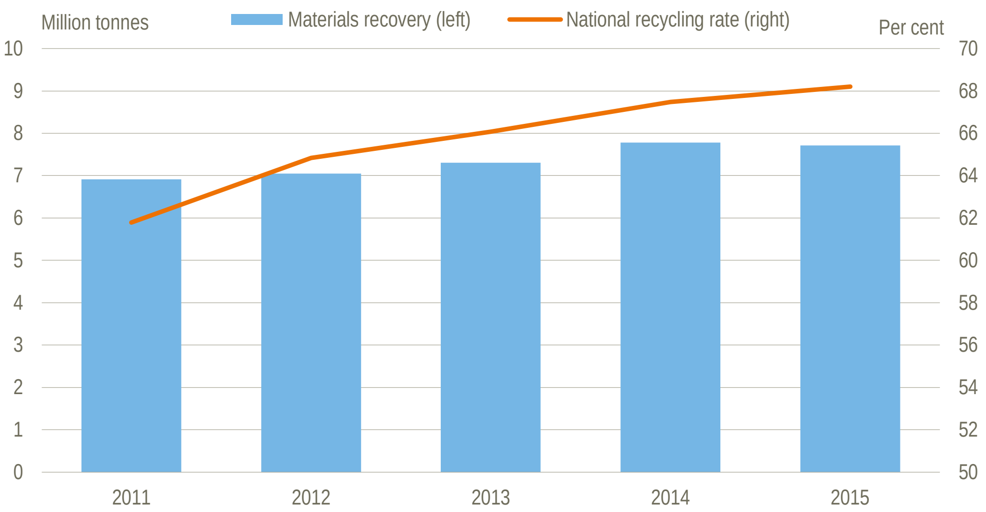
For waste in general, the aim of SDG target 12.5 is to reach a substantial reduction in waste generation through prevention, reduction, recycling and reuse. The corresponding indicator 12.5.1 is estimated based on the number of tonnes of material recycled.

More waste is being recycled

The Danish waste accounts show that 68 per cent of waste was collected for recycling in 2015; see figure 3.13. There has been an increase since 2011 when 62 per cent was collected for recycling. In quantitative terms (tonnes) the trend has also been one of increase, from 6.9 million tonnes in 2011 to 7.7 million tonnes in 2015.

Target 12.5 By 2030, substantially reduce waste generation through prevention, reduction, recycling and reuse	12.5.1 National recycling rate, tons of material recycled

Figure 3.13 Indicator 12.5.1 Materials recovery and national recycling rate



Goal 14: Conserve and sustainably use the oceans, seas and marine resources for sustainable development

As part of goal 14, SDG target 14.4 deals with the challenge of regulating the harvesting of fish and avoiding overfishing in order to restore fish stocks in the shortest time feasible. The corresponding indicator is *14.4.1 Proportion of fish stocks within biologically sustainable levels.*

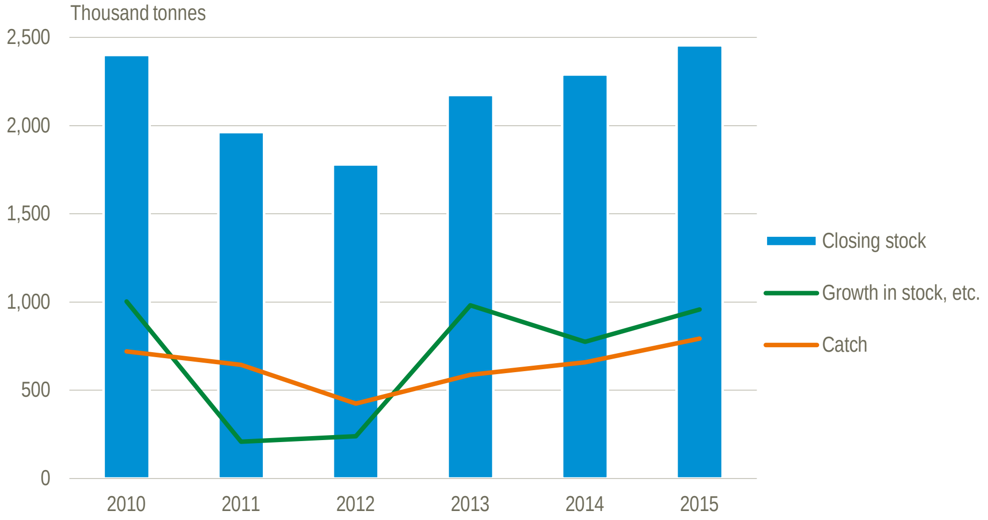
Danish fishing is regulated by the European Union Common Fisheries Policy which determines the total allowable catch and applies a quota system, which aims to ensure that fish stocks are kept within biologically sustainable levels.

Overall increase in fish stocks

Due to the EU Common Fisheries Policy, indicator 14.4.1 makes more sense if assessed for the EU as a whole, instead of for single EU countries. Based on the green national accounts' module on fish, see chapter 15, it is nevertheless possible to indicate if Danish fishing is at a level which imposes a risk to stocks. Figure 3.14 shows the development of an estimated Danish share of fish stocks in areas where Danish fishing vessels are allowed to fish. For the years 2013-2015, the figure shows that the catch has been less than the natural growth in the stock. The effect has been an increase in the stocks. This indicates that for this period, Danish fishing has not jeopardized the fish stocks, at least if the stocks are taken as a whole. It should be noted, however, that a thorough assessment of the sustainability of fishing involves more elements, e.g. an assessment of stocks for individual species. Chapter 15 presents more data and information on Danish fish stocks and fishing.

Target 14.4. By 2020, effectively regulate harvesting and end overfishing, illegal, unreported and unregulated fishing and destructive fishing practices and implement science-based management plans, in order to restore fish stocks in the shortest time feasible, at least to levels that can produce maximum sustainable yield as determined by their biological characteristics	14.4.1 Proportion of fish stocks within biologically sustainable levels

Figure 3.14 Indicator 14.4.1 Danish stocks, growth, and catch of fish



Note 1: The Danish stock of fish is an estimated Danish share of fish stocks in areas where Danish fishing vessels are allowed to fish

Note 2: Closing stock refers to the end-year stock (31 December). Growth and catch are flow measures, i.e. the growth and catch during the year.

Goal 15: Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss

Forests are one of the elements that are in focus under SDG goal 15, relating to life on land. Forests are also the focus of the green national accounts' modules on land and forests; see chapters 13 and 14, respectively. In this way, indicator 15.1.1 regarding forest area as a proportion of total land area can be estimated based on the accounts.

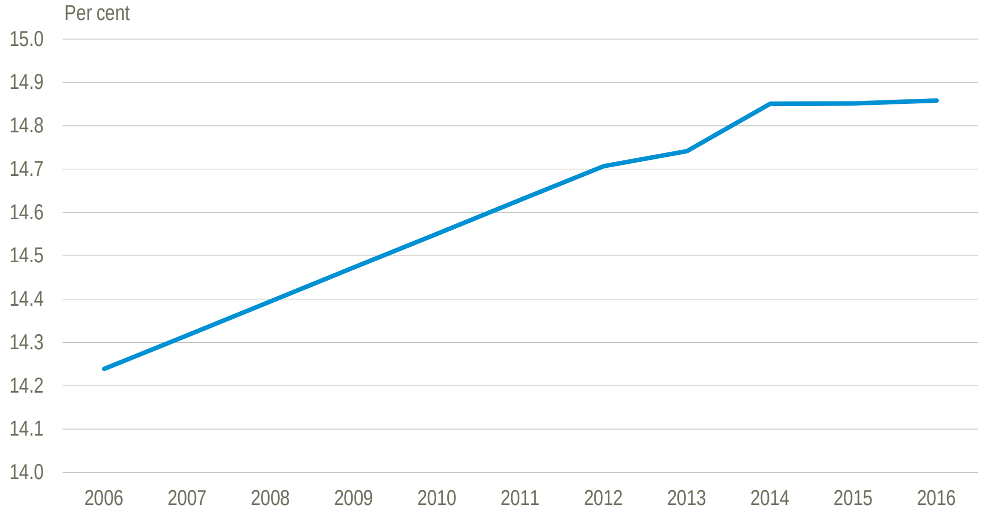
Slight increase in Danish forest area

Figure 3.15 shows Denmark's performance in terms of the forest area indicator. It shows that there has been a slight increase in the forest area in Denmark over the past 10 years. The increase is supported by the Danish Forest Act of 1989, the goal of which is to double the forest area over a period of 100 years.

The indicator as presented here is based on the forest area assessment under the LULUCF part of the Kyoto protocol reporting (see also chapter 14).

Target 15.1 By 2020, ensure the conservation, restoration and sustainable use of terrestrial and inland freshwater ecosystems and their services, in particular forests, wetlands, mountains and drylands, in line with obligations under international agreements	15.1.1 Forest area as a proportion of total land area

Figure 3.15 Indicator 15.1.1 Forest area as a proportion of total land area



Note: Forest area according to the assessment for the LULUCF part of the Kyoto protocol reporting

4 Energy

4.1 Introduction

Energy production and energy consumption play a central role in the economy and in the political objectives for the development of the economy. This is due to energy being an indispensable input in industrial production and household consumption, while the impacts of economic activities on climate, environment and health are significantly related to energy production and consumption through emissions of CO_2, other greenhouse gases and a number of air pollutants.

Supply security

For a number of years, Denmark has produced considerable amounts of oil and natural gas from the North Sea, which has contributed significantly to the energy supply security. The energy production from the North Sea has contributed to Denmark's positive external trade balance, and has resulted in increased tax revenue for the state.

Renewable energy and reduction of the greenhouse gas emissions

The Danish production of electricity from renewable energy sources, especially in the form of biomass and wind power, is central today in the Danish energy system. This is the case both in terms of assuring Denmark's independence from importing energy and in avoiding the associated fluctuations in energy prices. Furthermore, it applies in relation to reducing the Danish emissions of greenhouse gases.

Green transition and competitiveness

The efforts to produce energy from renewable sources and the development of renewable energy technologies, e.g. wind power, have – together with a long-term effort and development of knowledge concerning energy saving and energy efficiency improvements – also been significant factors in ensuring Denmark's strong position within the international market for green energy and energy technology. This has resulted in Danish technology and know-how becoming increasingly sought-after abroad and generating considerable export earnings (see chapter 9 on the environmental goods and services sector).

Objectives for the energy policy in the EU

Denmark has a number of obligations towards the EU in the field of energy. The primary objectives of the EU include specific targets for greenhouse gas emissions (see chapter 5), making renewable energy account for at least 20 per cent of total energy consumption and at least 10 per cent of energy consumption in the transport sector by 2020. In 2030, renewable energy must account for at least 27 per cent of the energy consumption in the EU. The long-term objective means that the energy system in 2050 will have been changed so as to comply with the target of reducing greenhouse gas emissions by 80-95 per cent compared to the level in 1990 (European Commission, 2017).

Danish targets

For Denmark, the EU's objectives for 2020 are translated into renewable energy accounting for 30 per cent of the energy consumption in 2020 and 10 per cent of the energy consumption in the transport sector. By the end of 2018, a new parliamentary energy agreement must be made with targets for the period after 2020. At the UN climate meeting, COP23, in Bonn in November 2017, the Danish government confirmed that coal must be completely phased out of the production of electricity before 2030. The Danish government has as its objective that at least 50 per cent of the energy demand must be met by renewable energy in 2030. The long-term objective for Danish energy policy is for Denmark to be independent of fossil fuels, i.e. coal, oil and gas by 2050 (Danish Ministry of Energy, Utilities and Climate, 2011). This means that by 2050 Denmark must be able to produce sufficient renewable energy to meet the total Danish energy demand (Danish Energy Agency, 2017). A transition of this kind to independence from fossil fuels will impact the supply security as well as Denmark's emission of greenhouse gases.

The contents of this chapter

The Danish production of energy is composed of a mixture of fossil energy extracted from the North Sea and renewable energy sources. Information from the Green National Accounts pertaining to this production is presented in section 4.2 in this chapter.

In section 4.3, an overview is provided of Danish energy consumption and its development over time. Figures are presented for the distribution of energy consumption by various industries and households. Against this background, an overview is also provided of the development in energy productivity. In section 4.4, the development in Denmark's energy self-sufficiency is accounted for.

In section 4.5, focus is placed on the gradually reduced importance of oil products to Denmark in terms of total energy consumption as well as the size of the economy. In section 4.6, figures are presented for the expenditures of the industries and households for the purchase of energy.

Energy-related subjects in the other chapters

In addition to the focus on energy in the strict sense in this chapter, i.e. energy production and energy consumption (measured in units of energy and value), most of the remaining chapters in this publication hold information that is indirectly related to energy. As such, information is provided on emission of greenhouse gases and air pollutants (chapter 5), energy flows in tonnes (chapter 7), waste from energy production and energy production from waste (chapter 8), green products and services as well as environmental protection activities associated with energy (chapters 9 and 10), energy-related environmental taxes (chapter 11) and the reserves of oil and natural gas in the North Sea (chapter 12).

4.2 Energy from the North Sea and Danish production of renewable energy

Extraction of 640 PJ of energy from the environment in 2016

In 2016, Denmark's total extraction of energy from nature, corresponding to the production of *primary energy*[1], was 640 petajoule (PJ)[2] – see table 4.1. The production of fossil energy in the form of oil and natural gas from the North Sea accounted for 74 per cent of this or 471 PJ, whereas the production of renewable energy in the form of biomass and wind power etc. accounted for 169 PJ or 26 per cent.

Fossil energy production

In total, Denmark extracted 6.9 million tonnes of crude oil and 4.4 billion Nm^3 of natural gas from the North Sea in 2016, which corresponds to the aforementioned 471 PJ.

Since the extraction of oil and natural gas from the North Sea gathered pace in the early 1980s, the production of crude oil and natural gas escalated until 2005 where it peaked with a total production of nearly 1200 PJ – i.e. more than twice as much as in 2016 (see also figure 4.5). Since 2005, the production of oil and natural gas from the North Sea overall has been steadily declining year on year. From 2015 to 2016, it dropped by 7 per cent. In 2016, levels of extraction were at their lowest since 1992.

One of the reasons for the decline in production is the fact that the fields with the existing production equipment and given technology yield less as the oil and natural gas is gradually drained. In addition, these ageing fields require more maintenance of wells, pipelines and platforms, which often implies production shutdowns and loss of production.

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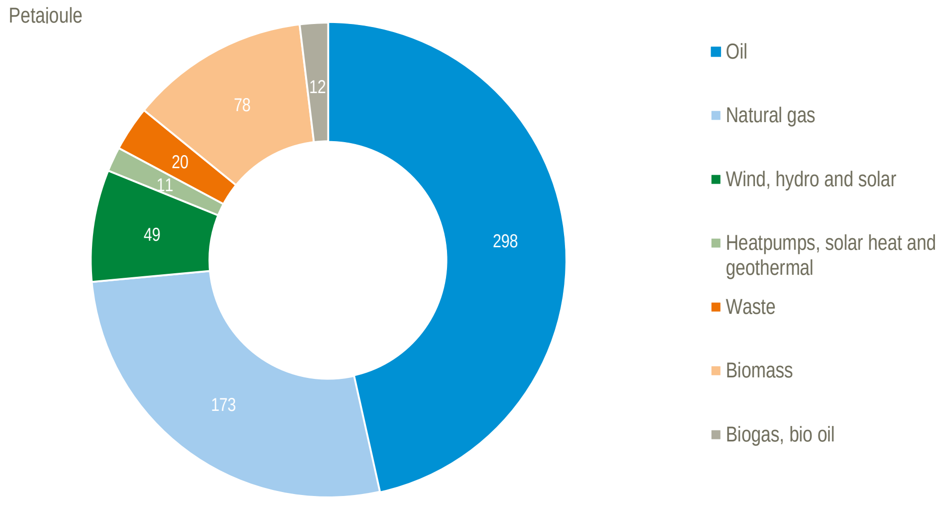
[1] In the following, biodegradable waste has been included as primary energy, while non-biodegradable waste has been excluded. 17 PJ of non-biodegradable waste was used used for energy production in 2016.

[2] 1 petajoule (PJ) = 10^{15} joule

Table 4.1 Danish production of primary energy

	1966	1980	1990	2000	2010	2014	2015	2016
	petajoule							
Total primary production	8	37	422	1 165	974	678	673	640
- crude oil	0	12	256	765	525	350	331	298
- natural gas	0	3	120	320	312	177	177	173
- renewable energy	8	23	46	80	136	151	165	169

Figure 4.1 Danish production of primary energy by type of energy. 2016



In chapter 12 there is an overview of the estimated stocks of oil and natural gas in the North Sea and how these have developed due to extraction and new finds etc. The chapter also contains information about the economic value of the reserves.

Renewable energy

Total production of renewable energy accounted for 169 PJ in 2016. This was an increase of 2.8 per cent compared to 2015, where the production of renewable energy was 165 PJ.

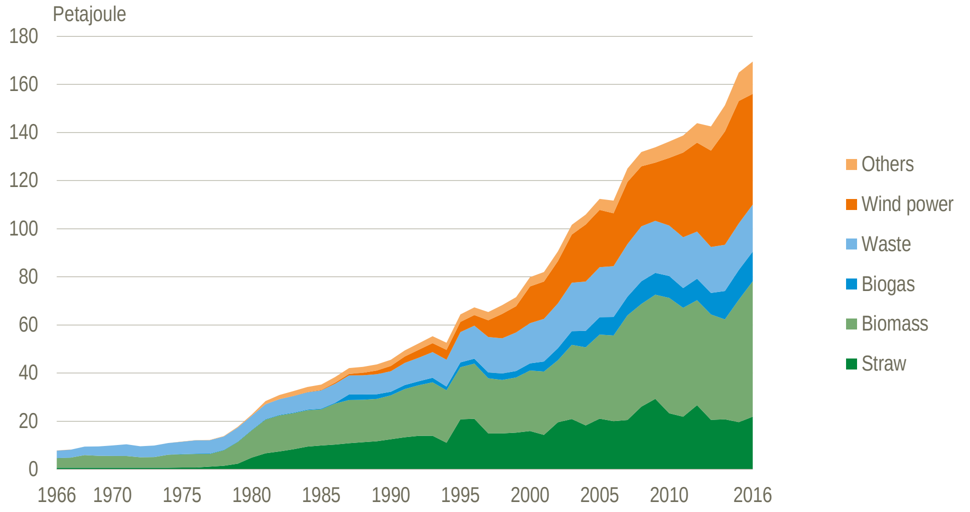
The production of biomass (straw, fuel wood, wood waste etc.) accounted for 78 PJ. The production of wind power accounted for 46 PJ. 20 PJ were produced on the basis of biodegradable waste, whereas heat pumps, biogas and solar energy etc. accounted for 25 PJ.

The Danish production of renewable energy has been growing rapidly over the last 25-30 years. Since 1980, the production of renewable energy has increased almost sevenfold. Wind power in particular has exhibited strong growth from virtually nothing in 1980 to 46 PJ in 2016. In comparison, the total consumption of electricity in industries and households was 111 PJ in 2016, i.e. 41 per cent of the consumption of electricity was covered by the Danish wind power.

Renewable energy in the United Nations SDGs

See also chapter 3 concerning the internationally agreed indicators for the United Nations Sustainable Development Goals. Renewable energy's share of total energy consumption is one of the indicators described in the UN Sustainable Development Goals.

Figure 4.2 Denmark's production of renewable energy



4.3 Danish energy consumption

Increase in the gross energy consumption from 2015 to 2016

Danish gross energy consumption[3] including the energy consumption for international transport activities - i.e. the bunkering of vessels and refuelling of aircraft and lorries abroad - accounted for 1216 petajoule (PJ) in 2016 – see table 4.2. It increased by 5.0 per cent from 2015 to 2016. Deducting international transport activities, the gross energy consumption was 750 PJ, and the increase from 2015 to 2016 was 4.2 per cent.

Industries and households

24 per cent of total Danish energy consumption, corresponding to 328 PJ, was due to household demand. Industries, excluding bunkering etc. abroad, accounted for 422 PJ of consumption; bunkering etc. abroad accounted for a total of 467 PJ. In other words, the energy consumption *solely* from Danish international transport activities was greater than that of all other industries. Of bunkering etc. abroad, the energy consumption resulting from sea transport is particularly significant.

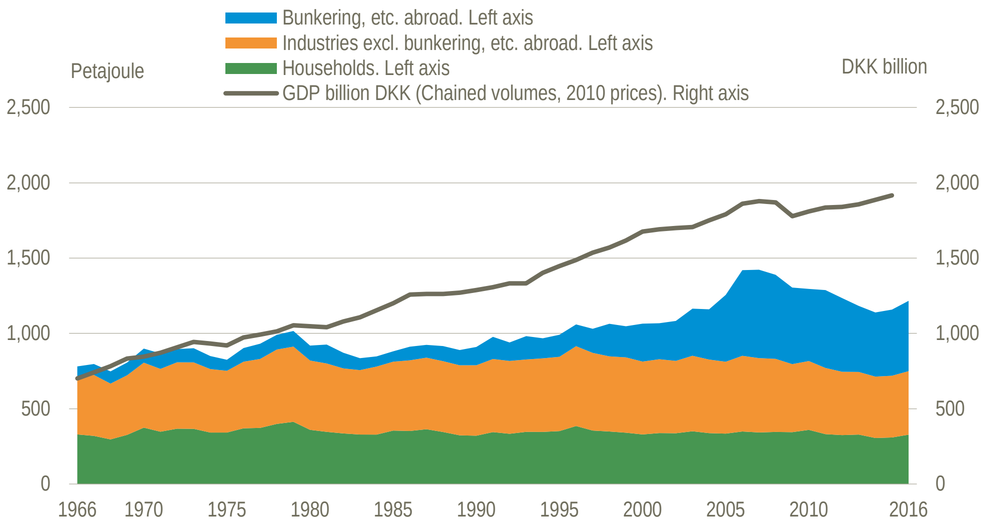
Households' gross energy consumption grew by 6.0 per cent from 2015 to 2016, whereas the growth in industries' energy consumption was 4.7 per cent. The growth in the energy consumption of industries was significantly higher than the growth of 2.0 per cent in GDP (after adjustment for inflation). The growth in households' energy consumption must be viewed in light of the fact that 2016 was a colder year than 2015, and vastly more energy was used for heating, including especially district heating and renewable energy used for heating. Regarding industries, the growth was primarily due to a higher energy consumption in the form of purchase of fuel etc. (bunkering) abroad by Danish vessels and aircraft.

The development from 1966

The gross energy consumption exclusive of bunkering etc. abroad has been at a level in later years corresponding to the level in the latter half of the 1960s. On the whole, Denmark experienced a relatively steep rise from the 60s until the peak in 1979, where the gross energy consumption was over 900 PJ.

[3] Gross energy consumption is an indicator for energy consumption. Only primary energy types (coal, oil, natural gas etc.) are included when calculating gross energy consumption. Secondary types of energy (electricity and district heating etc.) are discounted when calculating this figure. As a result, double counting – including, for example, the energy used to produce electricity, and the resulting electrical energy – is avoided. When calculating gross energy consumption, the consumption of primary energy in the conversion process is distributed on a proportionate basis to the users of the secondary energy types. The consumption of primary energy by conversion industries and the consumption of electricity and district heating by consumers are simultaneously, in the context of this calculation, nullified. Moreover, the net import of electricity for primary energy is converted on the assumption that the technology used for production of electricity abroad is similar to that in Denmark.

Figure 4.3 Danish gross energy consumption and GDP



Subsequently, the consumption dropped for a few years in the wake of the 1979 energy crisis. With a few fluctuations it was then just over 800 PJ until 2008, where the economic crisis set in. Since 2008, there was a steady decline to 713 PJ in 2014, after which the energy consumption has increased over the last years up to 750 PJ in 2016.

The total gross energy consumption peaked in 2007

Gross energy consumption including bunkering etc. abroad was at its all-time high in 2007, when it accounted for 1,423 PJ. Since then, total gross energy consumption has dropped by 15 per cent. The energy consumption of households has dropped by 4 per cent since 2007, whereas the energy consumption of the industries including bunkering abroad has dropped by 18 per cent.

Bunkering etc. abroad

The 18 per cent drop covers a steep decline in the energy consumption of the industry *wholesale and transport etc*. Here a decline in the sea transport bunkering of fuel oil abroad plays a significant role. Bunkering abroad dropped by 20 per cent from 587 PJ in 2007 to 467 PJ in 2016. Danish bunkering etc. abroad had been rising since the beginning of the 80s until the peak of 587 PJ in 2007.

Bunkering etc. abroad is closely related to the Danish export of sea transport services (container traffic etc.) and is consequently highly sensitive to international market conditions. Accordingly, the decline in energy consumption must be viewed in the context of the economic crisis in the years following 2008. In addition to this, total energy consumption in the sea transport industry and transport industry in general is also affected by energy savings and the development of more energy efficient vessels, aircraft and lorries, which – all things being equal – have resulted in reduced energy consumption.

Climatic conditions

The remaining fluctuations can primarily be traced back to climatic conditions in the individual years.

Table 4.2 Gross energy consumption by industries and households

	1966	1980	2007	2014	2015	2016	Change 2007 to 2016	Change 2015 to 2016
	petajoule						per cent	
Total	781	919	1 423	1 139	1 158	1 216	-14.5	5.0
Households	330	360	343	306	309	328	-4.3	6.0
All industries	452	559	1 080	833	849	889	-17.7	4.7
Agriculture, forestry and fishing	43	49	45	39	39	41	-9.9	4.4
Mining and quarrying	4	7	38	29	31	29	-22.9	-6.7
Manufacturing	159	174	157	123	123	126	-19.5	3.1
Utility services	6	6	11	11	11	11	2.3	4.0
Construction	12	13	26	19	21	21	-20.1	0.2
Wholesale and transport etc.	182	230	717	540	554	585	-18.4	5.7
Information and communication	5	6	8	8	7	8	-7.9	5.4
Financial and insurance	3	4	4	3	3	3	-31.4	5.7
Real estate activities and renting of non-residential buildings	2	1	3	2	2	2	-27.8	2.8
Dwellings	1	2	1	1	1	1	-8.6	4.6
Knowledge-based services	6	9	17	13	13	14	-20.7	4.3
Public administration, education, social work	23	51	43	38	37	40	-8.0	6.4
Arts, entertainment and other service activities	6	8	9	7	7	8	-13.8	5.8
Of which bunkering, etc. abroad	71	99	587	426	439	467	-20.5	6.3
Energy consumption total, excl. bunkering	710	820	836	713	719	750	-10.3	4.2

Note: The bunkering of fuel oil, JP1 and diesel of Danish-operated vessels, aircraft and vehicles is included in *Wholesale and transport etc.*

Increasing energy productivity

If we include bunkering etc. abroad, there has been an overall increase in energy productivity of 17 per cent in the period from 1980 to 2016 – see figure 4.4. Energy productivity is assessed as GDP divided by energy consumption, where GDP has been adjusted for inflation. If, on the contrary, energy consumption that can be attributed to bunkering etc. abroad is disregarded, the energy productivity has doubled[4].

Sea transport on the rise

The more moderate increase in energy productivity that appears when Danish bunkering etc. abroad is included in energy consumption reflects in particular how sea transport accounts for a growing share of the total economy in the period overall.

Compositional effects

Compositional effects in the form of relative shifts between highly energy-intensive activities such as sea transport and less energy-intensive activities such as output of services also help to explain the developments in energy productivity. The total energy productivity (including bunkering etc.) of the Danish economy dropped in the years up to 2007, whereas it rose in the years after. In the years up to 2007, transport activities were increasing, and subsequently they declined as a result of the financial crisis.

Improved energy efficiency

In addition to the impact of compositional effects on the total energy productivity of the Danish economy, the improved efficiency of energy use by industries also makes a significant difference. This is equally applicable to transport industries which are affected by technological development and energy savings etc.

Energy intensity and the UN SDGs

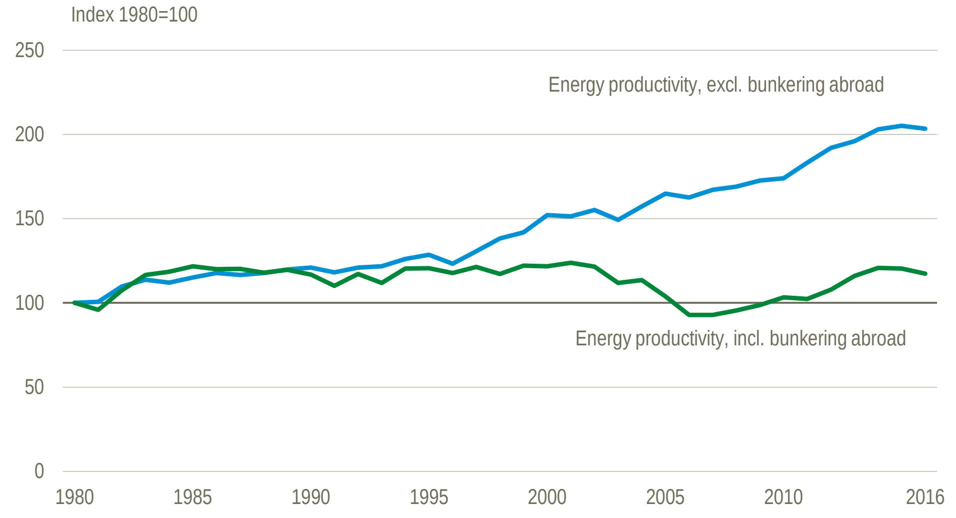
Rising energy productivity corresponds to the fact that energy intensity measured as energy consumption per unit of GDP is falling. Energy intensity and the share of energy consumption accounted for by renewable energy are included as two of the

[4] Note that the assessment of the energy productivity of the industries is based on GDP divided by energy consumption excluding bunkering, must be considered as approximate in the sense that the contribution of international transport activities to GDP have been included whereas, only a minor part of the energy consumption of the transport industries is included.

indicators for the United Nations Sustainable Development Goal 7: *Renewable energy*. In chapter 3, these two indicators are shown in figures 3.4 and 3.5.

Figure 4.4

Index for energy productivity, DKK GDP per gigajoule gross energy consumption



Note: Energy productivity has been calculated here as GDP in chained volumes, 2010 prices, divided by the gross energy consumption of the industries

4.4 Degree of self-sufficiency and foreign trade in energy

Danish self-sufficiency in energy 1998-2012

In the period from 1998 to 2012, the Danish production of primary energy (in the form of oil, natural gas and renewable energy) was higher than gross energy consumption excluding bunkering abroad – see figure 4.5. As such, Denmark was self-sufficient in energy in this period when excluding energy consumption for international transport activities. The degree of self-sufficiency peaked in 2005 - the same year as the production of oil and natural gas in the North Sea was at its highest level. Subsequently, the degree of self-sufficiency quickly declined concurrently with the declining production of oil and natural gas and, in 2013, Denmark once again became a net importer of energy from abroad.

Renewable energy is important to Denmark's degree of self-sufficiency

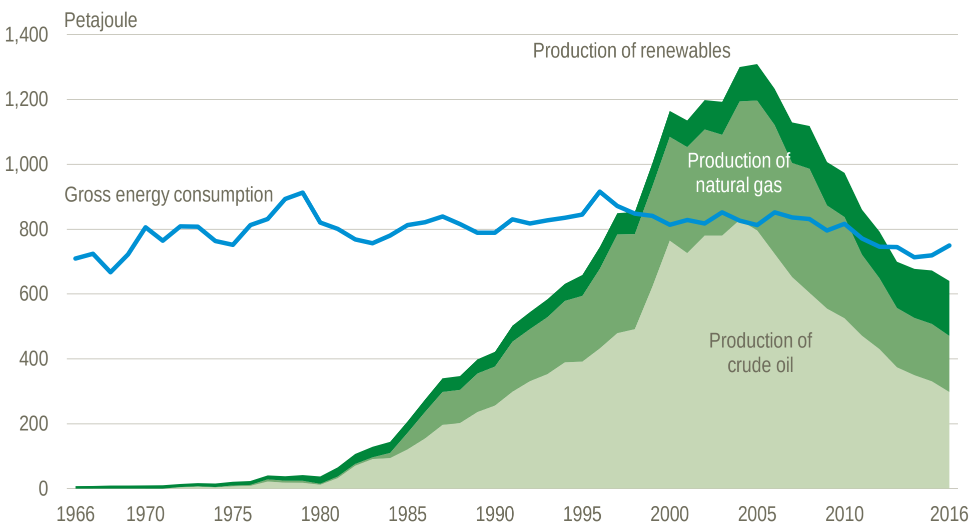
Although it was the extraction of fossil energy from the North Sea in particular that ensured Denmark's self-sufficiency, the production of renewable energy has also contributed substantially. As is shown in figure 4.5, Denmark's dependence on supply of energy from abroad in recent years would have been much greater if it had not been for the production of renewable energy.

If the share of Danish energy consumption accounted for by bunkering etc. abroad is included, the Danish economy has depended on a net supply of energy from abroad throughout the period since 1966, except for the period 2000-2005.

Imports and exports

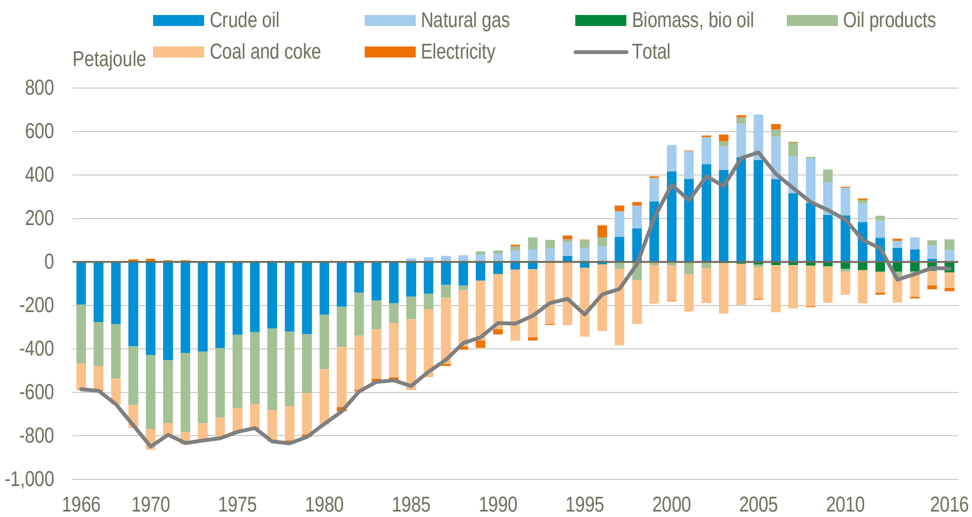
While Denmark was, excluding bunkering etc. abroad, for a long period of time self-sufficient in energy, Denmark has also had a considerable annual import and export of various energy products. Figure 4.6 shows the net export (export - import) of the various energy products. For a long period of time, Denmark has been a net exporter of crude oil and natural gas in particular, while it has been a net importer, particularly of coal, for the production of electricity and heating. Furthermore, the trade of electricity with Norway, Sweden and Germany is extensive. In the period 2014 to 2016, Denmark was a net importer of electricity.

Figure 4.5 Denmark's gross energy consumption and production of primary energy



Note: Gross energy consumption is exclusive of bunkering abroad of Danish-operated vessels, aircraft and vehicles.

Figure 4.6 Denmark’s net export of energy



4.5 The reduced significance of oil to the Danish economy

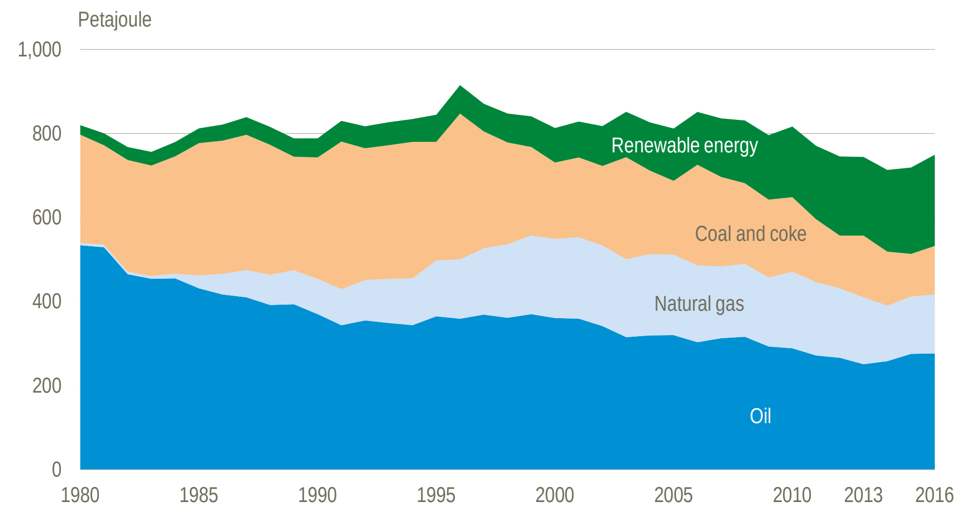
From oil to natural gas and renewable energy

Today, oil products are far less significant for the Danish economy than previously. When oil consumption for international transport activities is disregarded, the actual consumption of oil products (excluding crude oil) accounted for 543 PJ in 1980, which corresponded to 66 per cent of gross energy consumption. Renewable energy and natural gas together accounted for 3 per cent. In 2016, the share accounted for by oil products had dropped to 256 PJ or 34 per cent, whereas the share accounted for by renewable energy had grown to 29 per cent of gross energy consumption, and natural gas to 15 per cent[5]. Domestic oil consumption has plummeted since 1980 and has been replaced by natural gas and renewable energy.

Figure 4.7 shows how the use of renewable energy and natural gas has advanced while the use of oil, coal and coke, has dropped.

[5] The stated figures for consumption of oil, renewable energy and natural gas here only include the energy used in Denmark, and not the energy required for the production of the net import of electricity. The latter, on the contrary, is included in the statement of the gross energy consumption.

Figure 4.7 Gross energy consumption by type of energy



Note 1: Gross energy consumption here is exclusive of the bunkering abroad of Danish-operated vessels, aircraft and vehicles.

Note 2: In the calculation of the gross energy consumption of the individual types of energy, the net import of electricity is converted to the individual primary types of energy on the assumption that the production abroad is similar to that in Denmark.

Sea transport uses a lot of oil

Danish bunkering etc. abroad is considerable, especially for sea transport. If we include these very large quantities of oil bought by Danish carriers abroad, the total consumption of oil by the Danish economy increased by 13 per cent from 1980 to 2016. Consequently, the dependency on oil products is still high when everything is included.

Decoupling

When looking at the development in oil consumption in relation to developments in GDP, it appears that there has been a relative decoupling between economic activity and oil consumption. This applies regardless of whether total oil consumption is included or only domestic c0nsumption. Figure 4.8 shows that the use of oil products for all Danish economic activities including bunkering etc. abroad has increased by the aforementioned 13 per cent and that domestic oil consumption has decreased by 53 per cent. The actual oil consumption exclusive of bunkering etc. has decreased by 47 per cent since 1980. In the same period, GDP has increased significantly by 86 per cent.

Less oil from the North Sea

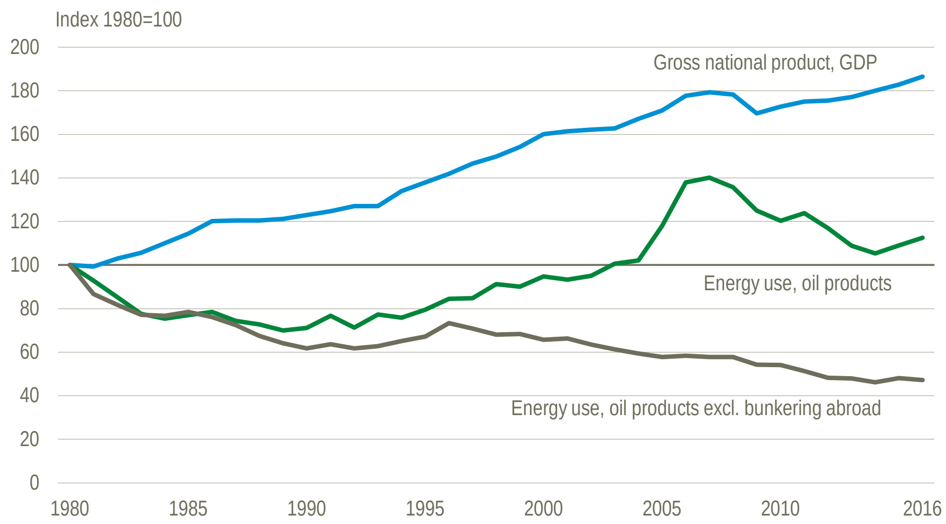
In other ways, the oil plays also a lesser role than previously. As was shown in section 4.2, since 2005 there has been a steady decline in the production of oil as well as natural gas from the North Sea. From 2015 to 2016, the production of oil dropped by 10 per cent and the production of natural gas by 2 per cent.

The value of the production of oil and natural gas in the North Sea was DKK 24.9 billion in 2015. This is DKK 16 billion less than in 2014, and DKK 44 billion less than in 2008 (calculated in current purchasers' prices), where the value of the production peaked. The physical reserves in the North Sea were DKK 151 billion in 2015. Their value has reduced by almost half since 2012, where it accounted for DKK 294 billion (see chapter 12).

Lower revenue to the state

Decreased extraction from the North Sea has caused state proceeds from taxation of said activities in the North Sea, in the forms of hydrocarbon tax, corporation tax from hydrocarbon activities and oil pipeline tax, to fall by DKK 2.8 billion from 2015 to 2016. When looking at the period 2008 to 2016, the fall in the annual proceeds is DKK 24 billion. See also section 11.3 regarding revenue to the state from North Sea extraction activities.

Figure 4.8 Development in the consumption of oil products and GDP



Note: The index of GDP is calculated on the basis of GDP measured in chained volumes, 2010 prices.

4.6 Energy expenditure by industries and households

Purchase of energy is a cost component for all industries. Furthermore the purchase of energy is a significant item in household budgets.

Energy expenditure by industries

In total, the industries' energy expenditure including bunkering etc. abroad was DKK 106 billion in 2015, see table 4.3. In comparison, the total current expenditure by industries for the purchase of goods and services (intermediate consumption) in 2015 was DKK 1,748 billion. This means that energy accounted for 6 per cent of total expenditure on intermediate consumption. However, this figure reflects large variations between different industries. Agriculture, forestry and fishing had expenditures corresponding to 7 per cent of their intermediate consumption and the manufacturing industry was also slightly above average with energy expenditures corresponding to 7 per cent. Utility services had the highest expenditure with 31 per cent, while wholesale and transport accounted for 8 per cent. For a number of service industries, energy expenditure accounted for 1-2 per cent of their total expenditure on the purchase of goods and services (see also figure 7.1).

Households

Households, which accounted for 27 per cent of gross energy consumption in 2015, see table 4.3, had a total energy expenditure of DKK 75.6 billion that year. This means that households paid 42 per cent of the total energy expenditure of DKK 181.1 billion.

From basic prices to purchasers' prices

Table 4.3 shows how the total energy expenditure for industries and households is composed of payments to the producer of energy – i.e. the expenditure broken down into *basic prices*, as well as *trade margins*, *taxes* and *VAT* paid to the supplier and the state. The sum of these is the expenditure in *purchasers' prices*, i.e. the purchasers' total energy expenditure.

Trade margins, taxes and Public Service Obligation

For industries and households as a whole, the trade margins accounted for DKK 6.6 billion or 4 per cent of the total expenditure of DKK 181.1 billion in 2015. The payment to the state in the form of taxes and VAT was DKK 56.8 billion or approximately 31 per cent of the total expenditure. In the assessment of the energy taxes, which is in net terms, the Public Service Obligation (PSO) tariff is included which, in 2015, was DKK 7.3 billion in total, and the Public Service Obligation subsidy which, in 2015, was DKK 8.1 billion. In sections 11.1 and 11.4, there is more information about the PSO tariff and the PSO subsidy respectively.

Trade margins and taxes weigh heavier on the households

Since in a number of cases, businesses, as opposed to households, get a refund of their energy taxes, and since the assessment of the taxes in table 4.3 has been made after repayment, there are major differences in the composition of the energy expenditure of industries and households. For industries as whole, profit margins, taxes and VAT account for 19 per cent of the energy expenditure, whereas the share for households is 57 per cent of their energy expenditure in purchasers' prices.

This difference as to how much the distributors, vendors and the state combined add to the basic energy price - depending on who buys the energy - also explains why households only account for 27 per cent of the gross energy consumption but for 42 per cent of the total payment for energy in purchasers' prices.

Table 4.3 Energy expenditure. 2015

	Basic prices	Trade margins	Taxes[1]	VAT	Purchasers' prices
	DKK million				
Total	117 781	6 580	39 470	17 334	181 164
Households	32 753	3 923	24 474	14 425	75 575
All industries	85 028	2 657	14 996	2 909	105 589
Agriculture, forestry and fishing	3 248	245	666	12	4 171
Mining and quarrying	212	19	29	1	261
Manufacturing	28 714	241	1 846	29	30 830
Utility services	12 990	191	1 018	32	14 230
Construction	1 773	324	1 525	25	3 647
Wholesale and transport etc.	29 686	1 292	4 905	498	36 380
Information and communication	970	18	217	16	1 221
Financial and insurance	316	12	223	121	671
Real estate activities and renting of non-residential buildings	245	23	174	46	488
Dwellings	105	10	71	44	230
Knowledge-based services	1 438	105	913	106	2 562
Public administration, education, social work	4 458	151	2 990	1 822	9 422
Arts, entertainment and other service activities	873	28	418	157	1 476
Of which bunkering etc. abroad:					
Danish ships	15 681	-	-	-	15 681
Danish aircrafts	2 785	-	-	-	2 785
Danish vehicles	1 095	-	-	-	1 095

Note: The bunkering etc. of fuel abroad is included in *Wholesale and transport etc.*

1 Includes the net energy tax, as the power generation subsidy and the PSO subsidy have been deducted. Also net CO_2, SO_2 and NO_x taxes are included.

Box 4.1 About the energy accounts

The energy accounts are assessed for 46 different energy products (coal, oil, natural gas, straw, wind power, district heating, petrol etc.) in different units of quantity (tonnes, cubic metres, joules) and in monetary values.

The accounts assess the supply of each energy product and the use of it. The supply is determined as the sum of production etc. and import, whereas the use is assessed as input in 117 industries as well as private consumption (broken down by five groups of consumption), export, changes in stocks, and cable losses etc.. For each product, supply and use balance. The energy accounts are available from 1966 to 2016. The figures for 2015 and 2016 are preliminary.

More information:
www.statbank.dk/10293
www.dst.dk/en/Statistik/dokumentation/documentationofstatistics/energy-accounts-for-denmark

5 Greenhouse gases and air pollutants

5.1 Introduction

Emissions from energy consumption and processes

The activities of industries and households result in the emission of large quantities of chemical substances into the air. The emissions are generated either from energy combustion or as part of various production processes and the use of, for example, solvents and acids.

Greenhouse gases and air pollutants

Attention is often focused on carbon dioxide (CO_2) and the other greenhouse gases: methane (CH_4), nitrous oxide (N_2O), and various industrial greenhouse gases (CFCs, HCFCs, HFCs, PFCs and SF_6). However, emissions of substances that cause air pollution, and their subsequent effects on human health, are also very significant. This applies to emissions of sulphur dioxide (SO_2), nitrogen oxide (NO_x), and ammonia (NH_3), as well as particulate matter, non-methane volatile organic compounds (NMVOC) and carbon monoxide (CO).

Overview of the chapter

This chapter begins with a general overview of greenhouse gas emissions. Section 5.2 covers global emissions of greenhouse gases. Section 5.3 examines how emissions of greenhouse gases can be determined and calculated using different methods - depending on what is in focus. Section 5.4 presents the green national accounts' estimates of greenhouse gas emissions produced by Danish economic activities. Emissions of CO_2 from biomass incineration are covered in section 5.5. Section 5.6 examines greenhouse gas emissions in relation to developments in economic activity measured in gross domestic product (GDP). Sections 5.7 and 5.8 present the results of model calculations using an input-output model. The calculations show the degree to which private consumption and exports contribute to emissions of greenhouse gases. They also examine which factors have had an impact on reducing emissions from 1990 to 2016.

Finally, section 5.9 deals with emissions of air pollutants, i.e. pollutants that affect the local or regional air quality and that can have various environmental impacts or health implications. This section focuses in particular on pollutants that contribute to acidification and the emission of particulate matter that has harmful effects on health.

5.2 Global emissions of greenhouse gases and climate change

Rising temperatures

Since 1900, the global surface temperature has risen by 1.1 degrees Celsius, a hugely significant increase in relation to the wider global climate. Since 1970 alone, global surface temperature has risen by 0.9 degrees Celsius; see figure 5.1 (right axis).

Other signs of climate change are record high temperatures, melting ice caps and mountain glaciers, declining snow cover in the northern hemisphere, rising sea levels and changes to precipitation patterns. According to the 5th IPCC assessment report, increasing wind speeds have been measured and the strongest hurricanes in the Atlantic Ocean have increased in strength (Pörtner et al., 2014).

Anthropogenic rises in temperature

Emissions of different gases affect the composition of the atmosphere and contribute to what is known as the greenhouse effect, in which an increasing amount of solar radiation is unable to escape the Earth's atmosphere again. According to the Intergovernmental Panel on Climate Change (IPCC), it is very likely that emissions of anthropogenic (man-made) greenhouse gases are mostly to blame for the rise in the global average temperature that has taken place since the middle of the 20th century.

Global emissions of greenhouse gases have doubled since 1970

From 1970 to 2016, global anthropogenic emissions of greenhouse gases, i.e. CO_2, methane, nitrous oxide and halocarbons as a whole, have almost doubled when it is taken into account that these different pollutants have different global warming potentials i.e. different greenhouse effects for each tonne that is emitted. This development is shown in figure 5.1, where the left axis is emissions stated in tonnes of CO_2 equivalents.

CO_2 from fossil energy sources

Approximately 75 per cent of the global warming potential caused by anthropogenic emissions of greenhouse gases in 2012 stemmed from CO_2 emissions caused by burning coal, oil products and natural gas.

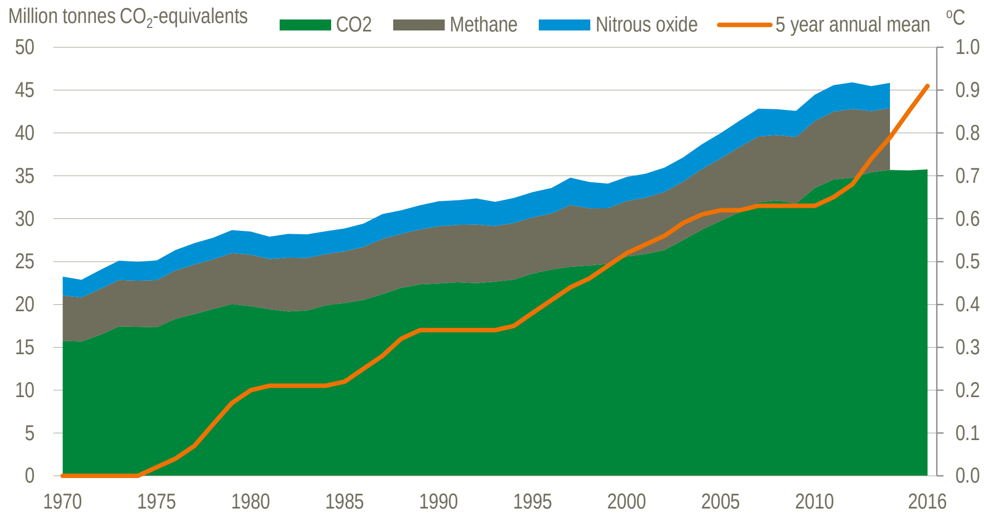
Biomass and land areas

CO_2 is also released into the atmosphere by biomass and soil when biomass is incinerated or degraded as a consequence of e.g. forestry and deforestation. If such emissions are included, global CO_2 emissions currently account for more than 75 per cent of global warming potential from anthropogenic emissions of all greenhouse gases.

Methane and nitrous oxide etc.

Methane, nitrous oxide and halocarbons currently account for almost 25 per cent of global warming potential. Emissions of halocarbons currently generate around 1 per cent of global warming potential.

Figure 5.1 Global anthropogenic greenhouse gas emissions[1] and global surface temperature change[2].



[1] Left axis: CO_2 emissions are exclusive of emissions stemming from the incineration of biomass and land-use, land-use change and forestry (LULUCF). Data on methane and nitrous oxide from 2015 and onwards was not available at the time of publication.

[2] The right axis: Increase in the global five-year mean surface temperature relative to 1951-1980 average temperatures.

Source: EDGAR v.4.3.2 (2017), CAIT Climate data explorer (2017) & NASA/GISS (2017).

The US and China are responsible for 40 per cent of all emissions

Global emissions of greenhouse gases are not equally distributed around the globe. Calculated by country, the biggest emitters in 2014 were China (26 per cent), the US (14 per cent), India (7 per cent), Russia (5 per cent), Japan (3 per cent), and Iran and Brazil (each 2 per cent). The EU-28 as a whole took third place with 9 per cent of total greenhouse gas emissions (CAIT Climate Data Explorer, 2017).

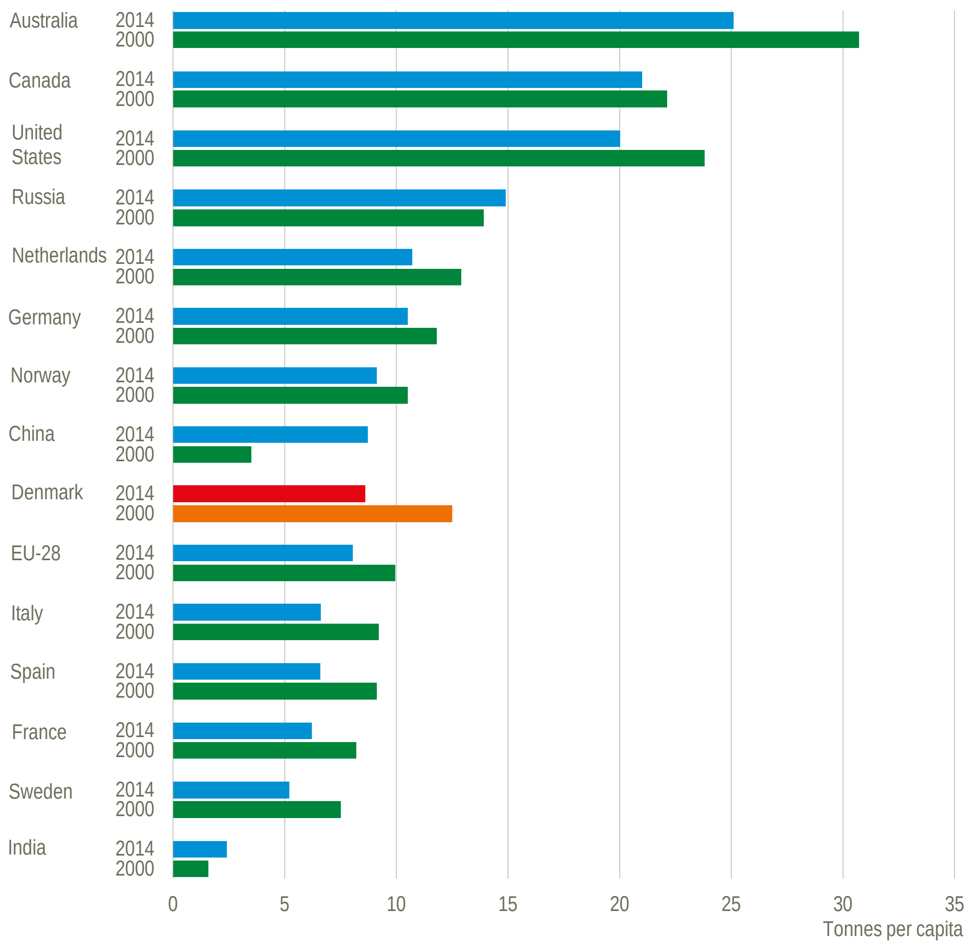
Denmark's emissions are relatively small

Danish greenhouse gas emissions accounted for 0.11 per cent of global emissions. However, emissions from Denmark's international transport activities are not included. These emissions correspond in size to Denmark's other emissions (see section 5.3).

Global per-capita emissions of greenhouse gases

The picture is very different when emissions are calculated per capita. Figure 5.2 illustrates the magnitude and development of greenhouse gases per capita across a few selected countries.

Figure 5.2 Greenhouse gases, tonnes per capita in selected countries



Note: GHG emissions excluding Land-Use Change and Forestry, according to the UNFCCC method, see section 5.3
Source: CAIT Climate data explorer (2017).

High per capita emissions in USA, Australia and Canada

Among countries with high greenhouse gas emissions per capita in 2014, Australia leads with per capita emissions of 25.1 tonnes, followed by Canada with 21.0 tonnes and the United States with 20.0 tonnes. Emissions per capita in Russia and China were respectively 14.9 and 8.7 tonnes.

Low per capita emissions in India

Although India accounted for 7 per cent of total global greenhouse gas emissions, it has one of the lowest levels of per capita emissions at 2.4 tonnes.

Large increases in per capita emissions in China, India and Russia

From the countries presented in figure 5.2, China had the largest increase in greenhouse gas emissions between 2000 and 2014. China more than doubled its per-capita emissions. India also saw a large increase. In Russia, the greenhouse gas emissions per capita increased by 7 per cent between 2000 and 2014.

Sharp decrease in Danish per capita emissions

Danish per capita emissions were 8.6 tonnes in 2014, which was higher than the EU-28 average of 6.4 tonnes. From 2000 to 2014, Danish per capita emissions decreased by 31 per cent, while the EU-28 average decreased by 19 per cent. Both Germany and the Netherlands had similar per capita levels of 10.7 and 10.5 tonnes, respectively, in 2014. The two countries have decreased their level of greenhouse gas emissions by 17 per cent and 11 per cent, respectively, since 2000.

The other EU-28 countries presented in Figure 5.2 - Sweden, France, Spain and Italy - all show lower per capita emissions than Denmark.

Box 5.1 Targets for reducing greenhouse gas emissions

In December 2015, 195 countries entered the COP21 climate agreement and thereby committed to reducing greenhouse gas emissions in order to keep the global temperature increase below 2 degrees Celsius compared to the pre-industrial level and work towards limiting the increase to 1.5 degrees.

According to the IPCC (Intergovernmental Panel on Climate Change), greenhouse gas emissions must be reduced by half by 2050 in order to keep the global temperature increase below 2 degrees Celsius. This means an 80-95 per cent reduction in emissions by the developed world.

Accordingly, the EU has agreed to reduce greenhouse gas emissions by 80-95 per cent by 2050 compared to 1990. In the short term, i.e. up to 2020 and 2030, the EU target is to reduce emissions by 20 per cent and 40 per cent, respectively, compared to 1990 levels.

For individual EU countries, the EU commitments and targets have resulted in the implementation of reduction goals for the ETS and non-ETS sectors. The ETS sector includes the energy sector and the most energy-intensive companies. The non-ETS sector includes transport, agriculture, buildings, waste incineration and other small sources.

Emissions from the ETS sector are regulated at EU level through the EU Emissions Trading System, ETS. The EU also sets targets for the proportion of energy consumption which must be covered by renewable energy.

In order to reach the reduction target for 2030, sectors included in the EU emission trading system must reduce emissions by 43 per cent in 2030 compared to levels in 2005. The non-ETS sector must reduce emissions by 30 per cent in 2030 compared to levels in 2005.

In October 2017, the European Commission set a Danish reduction target for the non-ETS sector of 39 per cent by 2030 compared to 2005 levels. Denmark has the option of using the LULUCF credits. This means that 6 percentage points of the reduction target for the non-ETS sector can be achieved by forestation, converting farmland to set-aside land or by ceasing the drainage of organic soil.

Denmark also aims to be independent of fossils fuels such as coal, oil and natural gas by 2050. A milestone is for 30 per cent of the Danish energy consumption to be covered by renewable energy by 2020; see chapter 4.

The IPCC's (UNFCCC's) principles and guidelines for the calculation of greenhouse gas emissions have been applied in the assessment of the above reduction targets; see section 5.3.

Box 5.2 Greenhouse gases and the greenhouse effect

Greenhouse gases are gases that are able to absorb a proportion of the long-wave infrared radiation from the Earth and send it back as heat. Greenhouse gases are generated by both natural processes and by anthropogenic activity.

The contribution by individual greenhouse gases to the greenhouse effect depends upon their concentration and ability to absorb heat radiation. In order to compare and aggregate the contribution of the various gases emitted, what is known as the Global Warming Potential of the individual gases is taken into account. The Global Warming Potential (GWP) compares the impact of 1kg of the gas in question to the impact of 1kg of CO_2. In this context, the time horizon for assessment of the impact is of importance. A time horizon of 100 years is commonly applied. Over a time horizon of 100 years, the GWP of methane is 25 times greater than the GWP of CO_2. The GWP for nitrous oxide is 298 times higher than CO_2 over the same time horizon. Since the impact of greenhouse gases is measured in comparison to the impact of CO_2, emissions are converted to tonnes of CO_2 (CO_2 equivalents).

Carbon dioxide (CO_2) is produced by incinerating fossil fuels and biomass, as well as by the decomposition of organic substances. Some CO_2 emissions are absorbed by oceans, forests and other ecosystems, but the rest remain in the atmosphere. From 1750 up until today, the concentration of CO_2 in the atmosphere has increased by up to 33 per cent and is now at its highest level in 420,000 years.

Methane (CH_4) is primarily from organic sources. Natural emissions stem from wetlands, ruminants and insects. Anthropogenic emissions stem from coal mining, the extraction and transport of natural gas, as well as from landfills, burning of biomass, rice cultivation and livestock farming. It is estimated that methane has a GWP that is 25 times higher than that of CO_2 on a 100-year time horizon.

Nitrous oxide (N_2O) occurs naturally in oceans and from the decomposition of organic materials. Anthropogenic emissions stem from nitrogenous fertiliser used in agriculture, the burning of biomass and other industrial activities. It is estimated that nitrous oxide has a GWP that is 298 times higher than that of CO_2 on a 100-year time horizon.

Halocarbons (CFCs, HCFCs, HFCs, PFCs and SF_6) are artificially produced carbon compounds that contain fluorine, chlorine, bromine or iodine. The use of CFC (freon) in refrigerators, for example, has been strictly limited by international agreements because - besides being a greenhouse gas - freon also depletes the ozone layer. Other halocarbons are being used to replace CFCs, such as HCFCs and HFCs, which together with PFCs and SF_6 are severe greenhouse gases. For example, the GWP of SF_6 is 22,800 times higher than that of CO_2 on a 100-year time horizon.

Sources:
DMI (2017) and Danish Energy Agency (2017)

5.3 Different estimates of greenhouse gas emissions

The UNFCCC and the green national accounts

Greenhouse gases and other air pollutant emissions can be estimated using different methods. Two of these methods are particularly important in this context: the IPCC or UNFCCC method and the method used when calculating the green national accounts

Large differences for Denmark

For many countries, different methods give broadly similar emission results. For Denmark, however, it makes a big difference, both in assessing the current level of emissions of greenhouse gases and in assessing developments over time.

Estimates based on UNFCCC principles

The emissions categorisations which are set by the Intergovernmental Panel on Climate Change (IPCC) and reported to the UNFCCC (United Nations Framework Convention on Climate Change) are often applied. This calculation method is the basis for assessing a country's reduction commitments according to international agreements, see box 5.1. This calculation method is based on a territorial demarcation and therefore includes emissions generated by production and consumption within the borders of a country.

Transport

In a Danish context, this means that UNFCCC estimates do not include emissions by Danish-owned transport abroad. These estimates do, however, include emissions from foreign-owned ships, planes and cars in Danish territory.

Biomass

In accordance with the UNFCCC principle, the national totals do not include emissions from burning biomass. These emissions are generally considered neutral with regard to their impact on the climate and the greenhouse effect, because it is assumed that a corresponding CO_2 sequestration often occurs when the biomass regrows.

LULUCF

Emissions and sequestration of greenhouse gases through changing land use and forestry (land use, land use change and forestry, LULUCF) are estimated separately in accordance with UNFCC principles and the national totals can be either inclusive or exclusive of these emissions.

The green national accounts

In contrast to UNFCCC estimates, the green national accounts, which are calculated based on the SEEA CF (see chapter 1, section 1.2) international guidelines, include all emissions connected with Danish economic activity, regardless of whether the activity takes place inside or outside of Danish borders. This means that the green national accounts include greenhouse gas emissions from Danish-operated transport activities (ships, planes and land transport) that take place abroad. Emissions from international transport activities are particularly high for Denmark compared with many other countries.

International transport

Including international transport activities in the green national accounts is in accordance with the principles for the National Accounts.

Links to GDP

By using the same principles to calculate greenhouse gas emissions and the impact on GDP, it becomes possible to be consistent when comparing GDP development with developments in the associated greenhouse gas emissions.

Estimating biomass emissions

Another element in the green national accounts, in accordance with *SEEA Central Framework* guidelines, is the estimation of emissions from incinerating biomass. The green national accounts include these emissions in line with other emissions. Over the past few years, Denmark has seen a significant increase in the use of biomass and, therefore, an increase in emissions. These emissions are included because they take place and because they form part of the overall picture that the accounts aim to present. However, this does not include an assessment as to whether all or some of these biomass-related emissions should be considered CO_2-neutral in relation to the greenhouse effect.

Bridge table

The relationship between the estimates for CO_2 emissions pursuant to the UNFCCC principle and the estimates in the green national accounts are illustrated in table 5.1.

The link between the two estimates

Total emissions from Danish economic activity (according to the green national accounts) are calculated by adding together the UNFCCC calculation and the emissions linked to incinerating biomass, emissions linked to bunkering Danish-owned ships abroad, and re-fuelling Danish-owned aircraft and trucks abroad. An addition is also made for other differences from transport and cross-border trade. This includes the bunkering of Danish ships in Danish ports for international shipping.

From 35.7 million tonnes of CO_2 to 86.3 million tonnes

According to the UNFCCC method, Danish economic activity in 2015 emitted 35.7 million tonnes of CO_2, while according to the green national accounts, this activity generated a total of 86.3 million tonnes of CO_2 emissions. As stated above, the difference between these two figures comes from the inclusion of biomass emissions and emissions from international transport activities, etc. If biomass emissions are excluded, as they are often considered neutral with regard to the greenhouse effect, then emissions by Danish economic activity generated 70.6 million tonnes of CO_2.

Greenhouse gas emissions

Figure 5.3 shows the changes in emissions of *all* greenhouse gases (i.e. CO_2, methane, nitrous oxide and industrial greenhouse gases) according to the two calculation methods.

From a decrease to an increase

If emissions are calculated using the UNFCCC method, then total Danish greenhouse gas emissions in the period from 1990 to 2015 fell by 31 per cent. However, if all Danish economic activities are included, as well as emissions from Danish-owned international transport etc. and all emissions from incinerating biomass, then the same period actually saw a 15 per cent increase in greenhouse gas emissions. If biomass emissions are excluded, the increase was 2 per cent.

Table 5.1 Bridge table for CO_2 emissions - UNFCCC method and the green national accounts

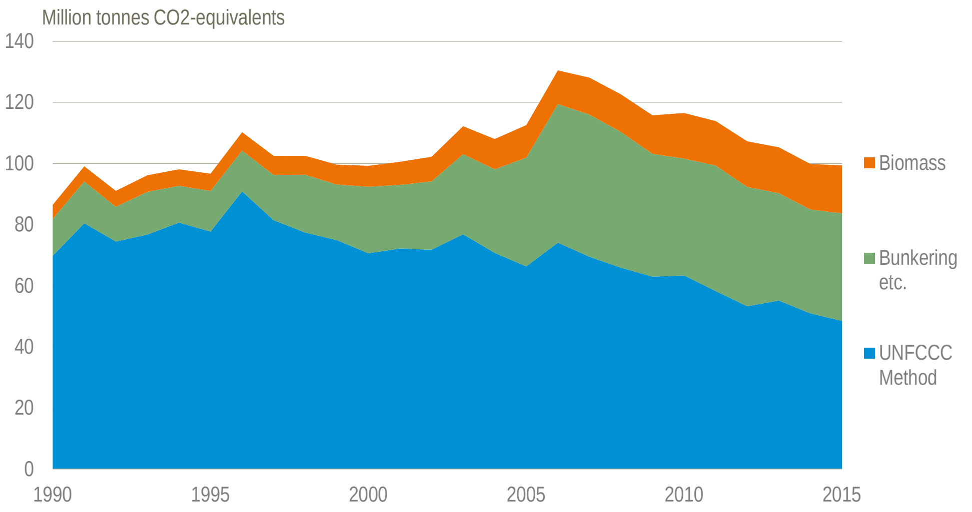
		1990	1995	2000	2005	2013	2014	2015
		million tonnes						
1	Total emissions: UNFCCC method	54.2	62.1	55.0	52.2	42.2	38.0	35.7
2	CO_2 from biomass used as fuel	4.6	5.6	6.8	10.7	15.0	14.9	15.7
3	Total emissions abroad (international transport)	9.4	11.4	19.6	34.4	34.0	33.0	34.0
	Of which: ships:	9.2	10.9	19.1	32.3	30.9	30.0	30.3
	aircrafts:	0.3	0.4	0.5	1.6	1.8	2.0	2.4
	vehicles:	0.0	0.0	0.0	0.5	1.3	1.0	1.2
4	Other differences in emissions from transport and cross-border trade	2.5	1.8	2.0	0.8	0.9	0.7	0.9
5 (=1+2+3+4)	Total emissions from Danish economic activities, incl. biomass	70.7	81.0	83.4	98.1	92.0	86.6	86.3
6	Total emissions from Danish economic activities, excl. biomass	66.2	75.3	76.5	87.4	77.0	71.7	70.6

Note: Emissions are calculated excl. LULUCF.

Source for total emissions reported to the UNFCCC and UNECE is the DCE (Danish Centre for Environment and Energy).

Figure 5.3

Greenhouse gas emissions from Danish economic activities



5.4 Greenhouse gas emissions from the Danish economy

Contribution to the greenhouse effect by pollutant

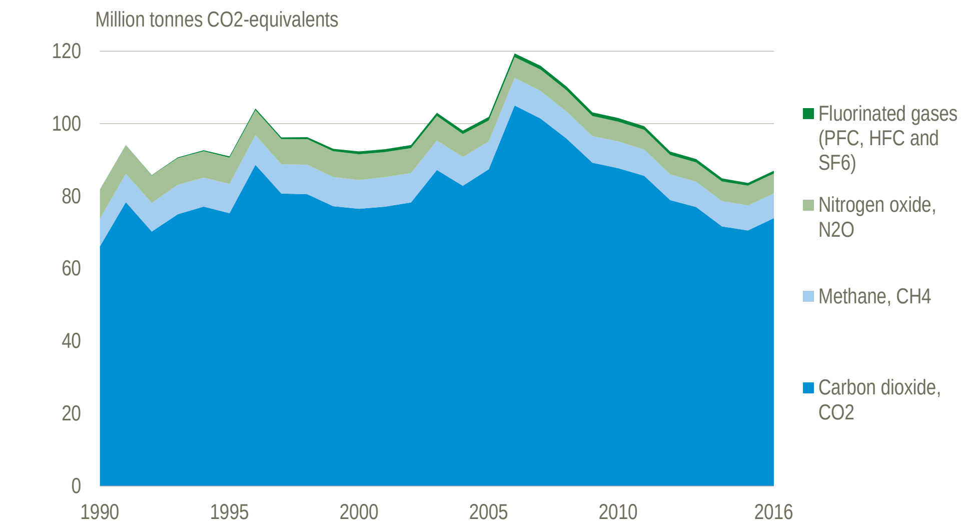
As is the case worldwide, the largest contribution to the greenhouse effect from Danish economic activity is caused by the emission of CO_2, see figure 5.4. In Denmark, CO_2 accounted for 85 per cent of the total contribution in 2016 while methane and nitrous oxide each contributed 8 and 6 per cent respectively. Industrial greenhouse gases made up approx. 1 per cent of the total contribution. Emissions by the individual pollutants have been calculated by their CO_2 equivalents (see box 5.2).

CO_2 from energy; methane and nitrous oxide from agriculture

Emissions of CO_2 stem primarily from the consumption of fossil energy resources, while emissions of methane and nitrous oxide mainly stem from livestock farming and the use of fertilisers.

Figure 5.4

Greenhouse gas emissions from Danish economic activity by type of gas



Note: Emissions generated by bunkering of Danish ships etc. abroad have been included in these calculations but emissions generated by incinerating biomass have not been included. Fluorinated gases emissions are assumed to be the same in 2016 as they were in 2015.

Bunkering etc. included

Note that emissions have been calculated according to the principles applied in the green national accounts, i.e. emissions linked to bunkering Danish ships in foreign harbours and re-fuelling Danish aircrafts and cars abroad have been included.

However, biomass emissions, which are normally considered neutral with regard to the greenhouse effect, have not been included.

Same level in 2016 as in early 1990s

The global warming contribution generated by economic activity was particularly high in the years up to 2007. Emissions decreased in the following years, and by 2016 the global warming contribution from Danish economic activity was at the same level as in the early 1990s.

Fluctuations due to bunkering etc.

Fluctuations in CO_2 emissions are to a large extent connected to corresponding fluctuations in Danish-owned international shipping (bunkering etc. abroad).

Greenhouse effect by industries and households

Figure 5.5 and table 5.2 show the total contribution to the greenhouse effect in 2016 broken down by sources. Industries accounted for 90 per cent of the contribution while households accounted for around 10 per cent.

Trade and transport and Danish bunkering abroad

In 2016, trade and transport alone accounted for 49 per cent of the total contribution to the greenhouse effect. The largest contribution from this industrial group stems from the bunkering of Danish-owned ships and the refuelling of Danish aircrafts and vehicles abroad. Emissions connected to bunkering etc. abroad made up approx. 42 per cent, while domestic trade and transport made up the remaining approx. 7 per cent.

Breakdown of emissions from transport

Emissions from the trade and transport sector include all emissions generated by enterprises providing transport as a service. However, emissions generated by transport activities carried out by other industries and households that use their own cars, vans and lorries are not included. These emissions are instead allocated to their respective industries and to households.

Utility services

In 2016, utility services accounted for 15 per cent of the greenhouse gases, which corresponds to 13 million tonnes of CO_2 equivalents. Emissions related to electricity production and district heating are allocated to utility services industry, while the actual consumption of these energy types by industries and households does not directly generate emissions.

Greenhouse gas emissions generated by utility services can vary greatly from year to year as the production of electricity and district heating varies. This is caused by fluctuations in temperatures from year to year and significant variations in the import and export of electricity. Emissions were relatively high in 1996, 2003 and 2006, years in which a great deal of electricity was produced for export.

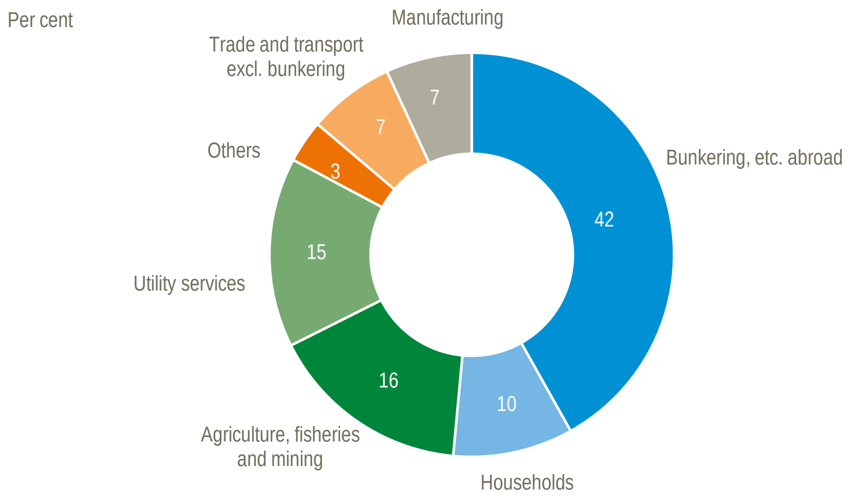
The 51 per cent drop in greenhouse gas emissions by utility services in the period 1990 to 2016 (see table 5.2) was mainly due to the transition towards renewable energy sources, including biomass and wind power.

Agriculture etc.

Emissions generated by agriculture, fisheries and mining and quarrying accounted for 16 per cent of the total greenhouse gases. Emissions by agriculture etc. stemmed mainly from emissions of methane (CH_4) and nitrous oxide (N_2O), which are mainly connected to livestock farming, and fertilising. Emissions of CO_2 by agriculture were less significant.

Emissions of nitrous oxide by agriculture, and thereby the contribution to greenhouse gases, have decreased significantly since 1990 due to changes in fertiliser practices. This has resulted in a 21 per cent drop in greenhouse gases from agriculture etc. in the period from 1990 to 2016.

Figure 5.5 Greenhouse gas emissions from Danish economic activities. 2016



Note: Trade and transport etc. includes postal services and telecom. Others includes Construction, Information and communication, Financial and insurance, Real estate activities and renting of non-residential buildings, Dwellings, Knowledge-based services, Public administration, education and social work, as well as Arts, entertainment and other service activities.

Table 5.2 Greenhouse gas emissions from industries and households

	1990	2000	2010	2015	2016	Distribution in 2016	Change 1990 to 2016
	1,000 tonnes of CO2 equivalents					per cent	
Total air emissions	81 871	92 372	101 587	83 677	87 039	100.0	6.3
Households	10 724	10 651	9 890	8 327	8 354	9.6	-22.1
All industries	71 147	81 722	91 697	75 350	78 685	90.4	10.6
Agriculture, forestry and fishing	15 498	14 017	12 589	12 346	12 301	14.1	-20.6
Mining and quarrying	1 297	2 833	2 204	1 884	1 739	2.0	34.1
Manufacturing	8 493	9 462	6 022	5 854	5 993	6.9	-29.4
Utility services	27 003	26 368	23 771	12 120	13 224	15.2	-51.0
Construction	898	1 102	1 545	1 477	1 479	1.7	64.8
Wholesale and transport etc.	16 349	26 504	43 834	40 189	42 460	48.8	159.7
Information and communication	155	131	112	76	76	0.1	-50.7
Financial and insurance	89	56	66	49	49	0.1	-45.0
Real estate activities and renting of non-residential buildings	44	72	100	82	82	0.1	84.8
Dwellings	50	22	31	35	35	0.0	-29.9
Knowledge-based services	257	298	436	377	373	0.4	45.4
Public administration, education, social work	852	686	815	735	747	0.9	-12.4
Arts, entertainment and other service activities	162	171	171	126	126	0.1	-22.3
Of which:							
bunkering by Danish ships abroad	9 249	19 221	34 416	30 580	32 715	37.6	253.7
bunkering by Danish operated aircrafts abroad	275	521	1 220	2 424	2 606	3.0	845.9
bunkering by Danish vehicles abroad	-	-	1 816	1 266	1 119	1.3	
Total industries excl. bunkering abroad	61 622	61 979	54 245	41 080	42 245	48.5	-31.4

Note: Emissions generated by bunkering of Danish-operated ships, aircrafts and vehicles abroad are included in Trade and transport etc. Emissions of CO_2 from burning of biomass have not been included in the calculation of greenhouse gas emissions.

Manufacturing

In 2016, manufacturing accounted for just below 7 per cent of the total contribution to global warming from Danish economic activities.

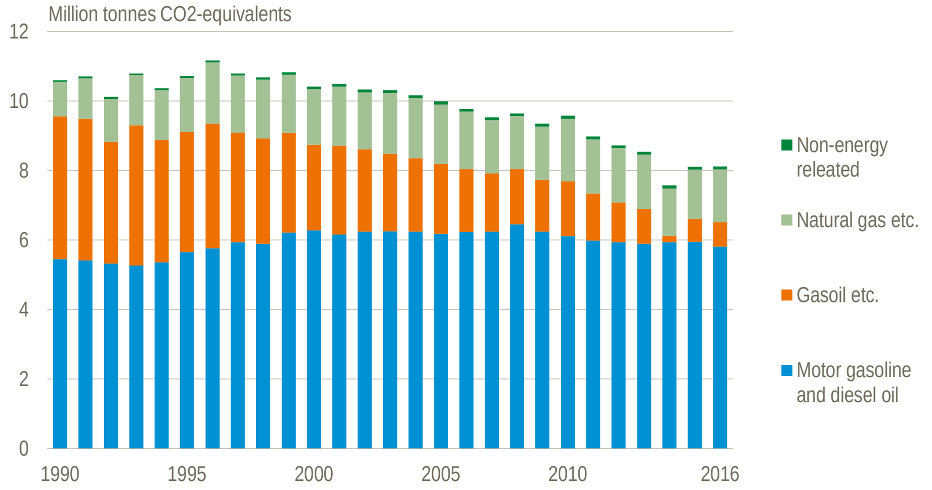
Note that if emissions generated by bunkering etc. abroad are not included (as is the case with the UNFCCC method) then all the above percentages would change. Trade and transport would account for a smaller percentage of emissions, while other industries and households would see their percentage of total emissions increase.

Households

As mentioned previously, households accounted for 10 per cent of total greenhouse gas emissions, corresponding to a little over 8 million tonnes of CO_2 equivalents. Household emissions of greenhouse gases are directly related to energy consumption in connection with heating and food preparation, as well as the use of petrol and diesel fuel for cars, motorcycles, gardening equipment and boats, etc. The breakdown of direct emissions of greenhouse gases by households is presented in figure 5.6.

Household vehicles were responsible for around 6 million tonnes of greenhouse gas emissions; the same level as the early 1990s. Household emissions generated by the use of heating oil and other gas for heating have decreased during the period. This is because the use of heating oil has increasingly been replaced by district heating and the use of wood, wood pellets and other biomass.

Figure 5.6 Direct emissions of greenhouse gases generated by private consumption



Note: Non-energy-related emissions are emissions that are generated by activities that are not connected to energy use, e.g. the use of paint and solvents. Emissions of HFC, PFC and SF_6 are not included in this figure.

5.5 Emissions generated by incinerating biomass

Biomass and carbon neutrality

Emissions generated by incinerating biomass are usually considered neutral with regard to their impact on the climate and the greenhouse gas effect. The rationale is that a corresponding carbon sequestration occurs when the biomass regrows.

However, whether all biomass incineration should be considered carbon-neutral is debatable. This is partly due to the fact that incineration of biomass for energy results in an immediate release of CO_2, while sequestration into the biosphere only begins to occur once the biomass regrows, which can sometimes take decades. Moreover, it also naturally depends on whether corresponding biomass growth actually takes place (Concito, 2011).

The calculations in section 5.4 do not include emissions from biomass, but total CO_2 emissions from biomass are presented in table 5.1 and figure 5.3 in section 5.3.[1]

Substantial increase in biomass emissions

As stated in the energy accounts, see chapter 4, there has been a relatively substantial increase in the use of biomass for fuel. This result is consistent with the rise in emissions generated by the use of biomass stated in table 5.1. From 1990 to 2015, emissions generated by incinerating biomass increased from 5 million tonnes to 16 million tonnes of CO_2. In 1990, this type of emission made up 7 per cent of the 71

[1] Detailed figures on emissions related to biomass can be seen at www.statbank.dk//MRU1

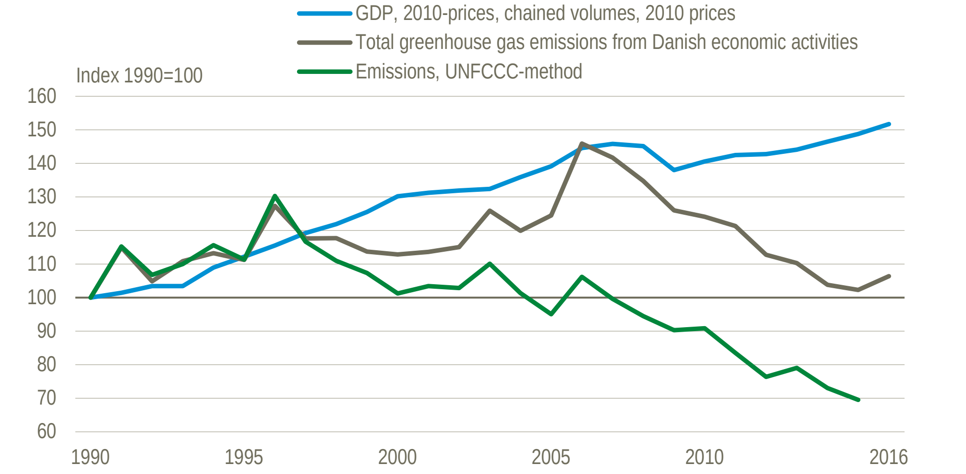
million tonnes of CO_2 emitted that year (including emissions form international transport abroad and emissions generated by incinerating biomass). Emissions from incineration of biomass accounted for 18 per cent of the 86 million tonnes of CO_2 emitted in 2015.

5.6 Decoupling growth and emissions

Decoupling emissions and economic growth 1990-2016

The economic growth which has taken place in Denmark since 1990 has not resulted in a corresponding increase in greenhouse gas emissions when the period 1990 - 2016 is viewed as a whole. Gross domestic product (GDP - measured in chained volumes, 2010 prices) increased by 51 per cent from 1990 to 2016, while greenhouse gas emissions from Danish economic activities in 2016 (excluding biomass emissions) were 6 per cent above 1990 levels.

Figure 5.7 Development in contributions to the greenhouse gas emissions and GDP



Periods with no decoupling

In 2006, for example, when emissions were at their highest level, emissions of greenhouse gases increased more than economic growth. This development was mostly due to significant growth in the shipping industry. In 2006, contributions to the greenhouse effect were 46 per cent above the level in 1990. A steady and rather large decrease has taken place since then.

Greater decoupling according to the UNFCCC method

If emissions from Danish operated international transport etc. are omitted (the UNFCCC method), figure 5.7 shows an absolute drop of 31 per cent in greenhouse gas emissions in the period 1990-2015.

The period overall shows a significant decoupling between economic activity and the Danish contribution to global warming, regardless of whether emissions from international transport are included. That said this decoupling is less significant when emissions from international transport are included.

Reasons for the decoupling

Industries have been able to decouple greenhouse gas emissions from economic growth because, as shown in chapter 4, they have used energy more effectively or have switched to other energy types. The following section will illustrate this relationship by using model calculations based on the green national accounts.

Decoupling and the United Nations SDG Goals

The decoupling of emissions and economic growth is also part of the United Nations Sustainable Development Goal 9 regarding industry, innovation and infrastructure; see chapter 3 on the SDGs.

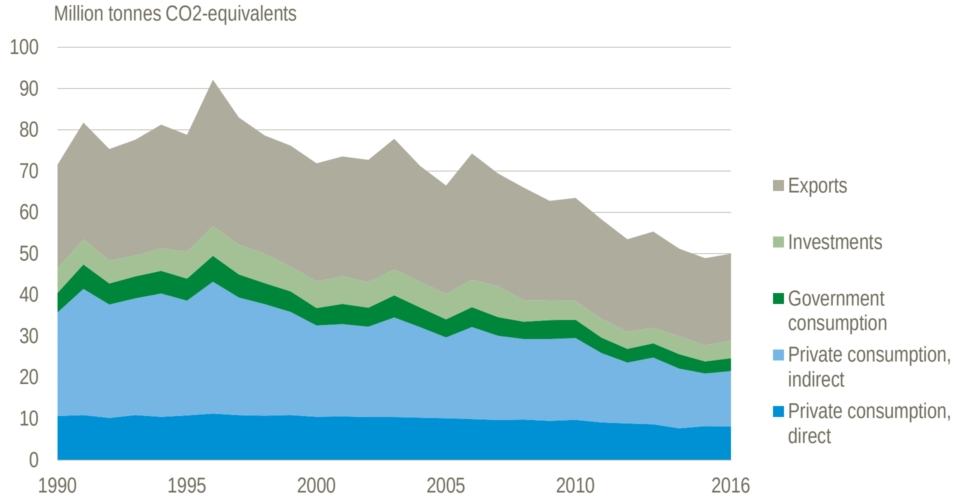
5.7 The impact of exports and private consumption on emissions

Private consumption and exports have the greatest impact

Model calculations based on the green national accounts show that Danish greenhouse gas emissions are primarily generated by household demand for consumer goods and international exports.

In 2016, private consumption and exports accounted for approximately 85 per cent of total greenhouse gas emissions; see figure 5.8. The remaining contributions stemmed from government consumption and investment in buildings, machinery and transport, etc. with each of these two groups contributing about the same amount.

Figure 5.8 Greenhouse gas emissions generated by different types of demand



Note: HFC, PFC and SF_6 are not included in the data for private consumption, direct.

Linkage between industrial emissions and demand

The calculations are based on an input-output model. The model includes both the emissions generated by industries that directly supply demand and the emissions generated by all subcontractors. The consumption of meat can be used as an example. This consumption not only results in greenhouse gas emissions from slaughterhouses, but also from agriculture, energy supply, animal feed mills, packaging factories, transport operators, consultancy services and many other industries.

Increasing significance despite decreased emissions

Relatively, exports have had an increasing impact on greenhouse gas emissions brought about by Danish economic activities. In 1990, exports generated 35 per cent of total greenhouse gas emissions by the Danish economy. This had risen to 43 per cent in 2016, corresponding to 22 million tonnes of CO_2 equivalents.

Exports of transport services

Emissions generated by Danish-operated international sea transport etc. are not included in these figures. The figures only cover emissions generated by domestic activities. If emissions by international sea transport had been included, emissions from exports would have increased from the aforementioned 22 million tonnes of CO_2 equivalents to around 56 million tonnes of CO_2 equivalents.

Private consumption

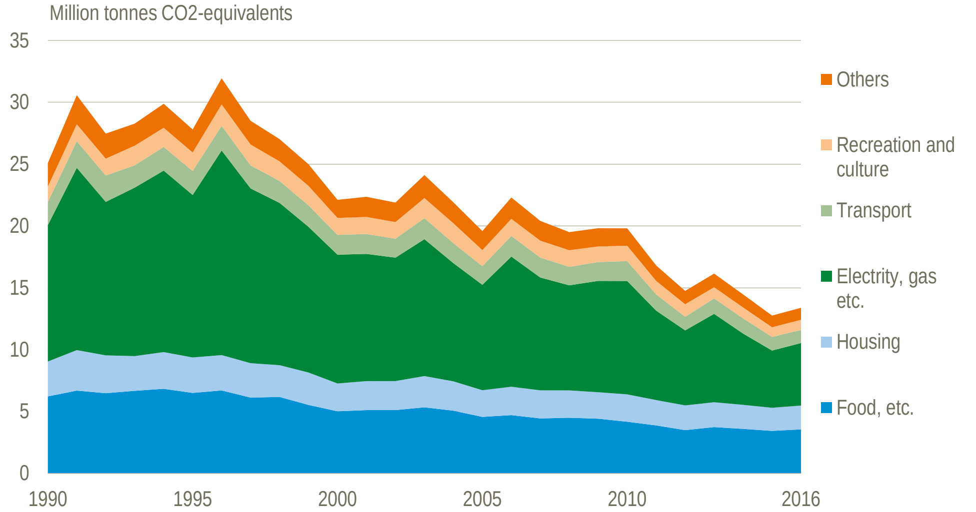
Private consumption in Denmark generated around 22 million tonnes of greenhouse gas emissions, corresponding to slightly less than 43 per cent of total Danish emissions in 2016. More than one third of emissions – more than 8 million tonnes - were direct emissions generated by household consumption of fuel for heating and the use of petrol and diesel fuel for cars (see also figure 5.6). Almost two thirds – close to 14 million tonnes - were indirectly derived emissions from industries as a consequence of the production required to meet household demand for food, clothing, electricity, etc., see figure 5.9.

Food products, transport and housing

In addition to energy consumption, household purchases of food, restaurant visits, transport services (including public transport) and use of dwellings give rise to greenhouse gas emissions by industries. The housing category covers maintenance of dwellings and costs in connection with refuse collection and water, etc.

Figure 5.9

Indirect emissions of greenhouse gases generated by private consumption via Danish industrial production



Note: HFC, PFC and SF_6 are not included in this figure.

The impact of individual consumption categories on derived emissions has been relatively consistent since 1990, although derived emissions from electricity and district heating consumption were slightly more significant in some years and have been considerably smaller in recent years. The emissions from consumption of electricity and district heating was greater in years with high exports of electricity, which require increased use of fossil energy. The relatively higher average emissions for each produced unit of energy are reflected in all consumption categories, as all industries use electricity or district heating to some extent.

5.8 Factors behind the decoupling of economic growth and greenhouse gas emissions[2]

Factors behind the development

A number of factors, including the increased use of renewable energy, have contributed to the fact that the increase in GDP has not resulted in a simultaneous increase in greenhouse gas emissions. As stated in section 5.6, if all emissions generated by economic activities are included then emissions of greenhouse gases increased by around 6 per cent throughout the period from 1990 to 2016, If Danish operated international transport is excluded emissions decreased by 31 per cent up until 2016.

Model calculations

It is possible, through the use of model calculations, to quantify the factors behind the decoupling of economic growth and greenhouses gases which has taken place.[3] These calculations only address emissions generated by Danish industries and not emissions generated by households. As in section 5.7, emissions generated by Danish operated international transport have been left out.

The actual development in greenhouse gas emissions

When this delimitation is applied, emissions of greenhouse gases by industries fell from almost 62 million tonnes of CO_2 equivalents in 1990 to 42 million tonnes of CO_2 equivalents in 2016. This was a decrease of 19 million tonnes of CO_2 equiva-

[2] This section is based on an updated Statistics Denmark Analysis (Andriianets and Rørmose, 2015).

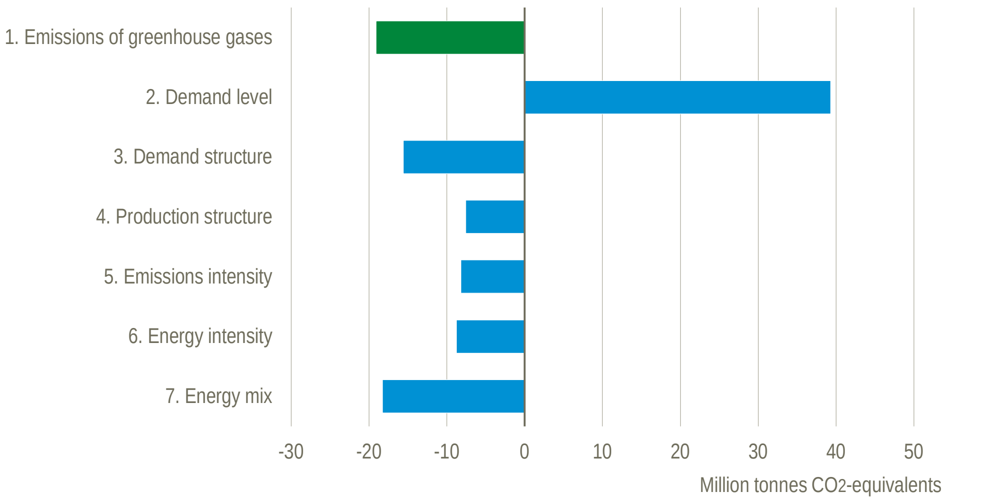
[3] The model calculations are carried out as a structural decomposition analysis based on an input-output model.

lents or more than 31 per cent (see also table 5.2). This decrease in greenhouse gas emissions is illustrated by the green bar in figure 5.10.

Level of demand

The model calculations show that if emissions of greenhouse gases in the period 1990 to 2016 had followed the growth in demand for Danish products from private and government consumption, exports and investments, etc. they would have been 39.3 million tonnes higher than in 1990, instead of decreasing by 19.4 million tonnes of CO_2 equivalents. This increase in the demand level is shown in figure 5.10, in bar 2. The fact that emissions have not increased proportionally to this increase in demand level shows how other factors have pushed greenhouse gas emissions in the opposite direction. All other factors combined have therefore reduced emissions by 58.7 million tonnes of CO_2 equivalents.

Figure 5.10 Changes in greenhouse gas emissions by industries from 1990 to 2016 broken down by underlying factors



Demand structure

Both production and consumption have undergone structural changes in the period from 1990 to 2016 which have made their emissions of greenhouse gases less intensive. The percentage of services compared with physical goods is now relatively higher, and this in of itself helps lower the contribution by industries to the Danish carbon footprint, as the production of services requires less energy than traditional industrial production. At the same time, the percentage of domestic demand covered by imports has increased compared with demand covered by Danish production. Because this analysis is only looking at Danish emissions, this results in lower Danish greenhouse gas emissions. On the other hand, exports have also increased relative to the other demand components. Since production for exports is often more energy-intensive than domestic demand, the positive effect of the changes in the demand structure is curbed.

These structural changes in demand have resulted in a 16 million tonnes reduction of CO_2 equivalent emissions in 2016 compared to 1990. The impact of these structural changes is illustrated by bar 3 in figure 5.10.

Production structure

As with demand, production has also changed. An increasing percentage of the raw materials used in production by industries originate from abroad, and services also account for an increasing percentage of intermediate consumption. Since 1990, for example, industries have increased its use of consultancy and legal services, neither of which generates a large amount of emissions. Altogether, these effects have contributed to an 8 million tonnes reduction in CO_2 equivalents between 1990 and 2016. This is illustrated in bar 4 in figure 5.10.

Emissions intensity

Emissions intensity, bar 5 in figure 5.10, is a factor that represents changes in emissions of the pollutants N_2O and CH_4 in relation to the value of product output from industries. An emissions reduction of around 8 million tonnes CO_2 equivalents is linked to lower emissions intensity and this primarily reflects the fact that agriculture is generating fewer emissions per unit output value.

Energy intensity

Industries have utilised energy with increasing efficiency throughout the period. In 2016, the same production could be achieved by consuming far less energy consumption than in 1990. This effect is estimated to have reduced emissions by around 9 million tonnes in 2016 compared to 1990. Note that energy efficiency is measured relative to the value of output from industries. This can deviate from technical energy efficiency, e.g. energy consumed per kilometre driven. Note also that fluctuations in the economic situation from year to year mean that energy efficiency can also vary a great deal from year to year. The impact is represented by bar 6 in the figure.

Composition of energy consumption

From 1990 to 2016, industries gradually altered their energy mix in favour of cleaner energy types. This primarily refers to the shift away from oil and coal and towards natural gas and renewable energy. Of significance is the increasing use of biofuels such as wood pellets and straw, which in these calculations are considered carbon-dioxide neutral according to IPCC principles. Changes in the composition of energy consumption have resulted in overall savings of approximately 18 million tonnes of CO_2 equivalents in 2016 compared to 1990 and therefore this is the most important individual factor in decreasing emissions. The impact of the changed energy composition is represented by bar 7 in figure 5.10.

The sum of the various contributions

Bar 1 in Figure 5.10 shows the development over the time period: this figure is reached by adding all of the positive and negative contributions to the development in emissions caused by demand, structure, energy and emissions intensities, and energy composition (bars 2-7).

Summary of the development

Considered independently of other developments, the pronounced increase in the demand for goods and services from Danish and foreign enterprises and households in the period 1990 to 2016 would have led to a corresponding increase in emissions of 39 million tonnes of CO2 equivalents by Danish industries. Other developments, however, have mitigated the rise. Particularly important has been the shift away from coal and oil – the most polluting energy types – towards natural gas and renewable energy sources such as wind, solar, and biofuels. Improvements in energy efficiency via the introduction of new and more energy-efficient technologies have also contributed to a decrease in emissions. The structural changes in the Danish economy have also had an impact.

These factors combined have contributed to a reduction in emissions of around 19.4 million tonnes of CO_2 equivalents, instead of an increase of 39.3 million tonnes of CO_2 equivalents.

5.9 Emissions of air pollutants

Local and regional environmental impacts

While emissions of CO_2, methane (CH_4), nitrous oxide (N_2O), and various industrial greenhouse gases have a global impact on the greenhouse effect and climate change, emissions of a number of air pollutants affect local or regional environments. They often also have a negative impact on human health.

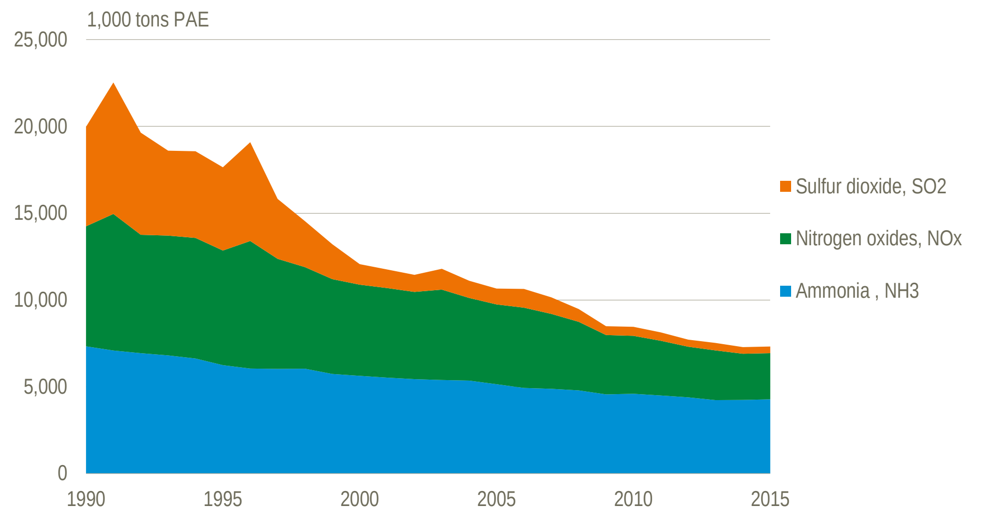
Acidification

Acidification is a problem attached to emissions of sulphur dioxide (SO_2), nitrogen oxides (NO_x), and ammonia (NH_3). It affects the health of forests and the chemical conditions in soil and water bodies. In this way, acidification impacts biodiversity. It can also affect agricultural production and cause damage to buildings and works of art.

Effect of acidification

Emissions of SO_2, NO_x and NH_3 from Danish economic activity can be indexed based on their total acidification effect by attaching weight to the different pollutants according to their acidification impact. The result is expressed in Potential Acidification Equivalents, PAE.

Figure 5.11 Contribution to acidification



Note: Emissions generated by Danish bunkering etc. abroad have not been included. No adjustment has been made for acidic pollutants that are transported in and out of Danish territory by air. PAE, Potential Acidification Equivalent, describes the contribution by various pollutants to acidification (acidification equivalents).

Dramatic drop in contribution to acidification

The contribution to acidification from the Danish economy decreased significantly from 1990 to 2015, see figure 5.11. While GDP increased by 49 per cent, the Danish contribution to acidification decreased by 63 per cent.

The largest contribution from ammonia

This reduction in emissions was achieved, among other things, by the introduction of improved desulphurisation technology in Denmark. As illustrated by figure 5.11, the three pollutants - SO_2, NO_x and NH_3 - each contributed about one third at the start of the period, while by the end of the period the percentage of SO_2 was negligible. The percentage of NO_X has also been decreasing, although it still contributes significantly to acidification. Ammonia (NH_3) now accounts for approximately 60 per cent of the total contribution to acidification by Danish economic activity. Emissions of NH_3 are predominantly generated by agricultural production, see table 5.3[4].

Cleaner fuels and technology

In addition to installation of desulphurisation equipment at power plants and statutory limits on the sulphur content of different fuels, a tax on sulphur was introduced in 1999, see section 11.5. The reduction in NO_x emissions is in part due to the introduction of less polluting car engines as well as the use of cleaner technology and purification at power plants and district-heating plants.

Geographical area

It should be noted that the calculation of acidification contributions above only includes emissions from the Danish geographical area. Emissions linked to Danish carriers' bunkering etc. of oil and fuels abroad have not been included. These emissions are of less consequence for acidification in and around Denmark, although they can affect people and the environment in other countries.

Transboundary pollution is not included

The calculated contribution to acidification does not demonstrate the direct impact on Danish nature and environment. This is because a certain amount of pollutants are transported via air to other countries, just as some acidic pollutants are carried into Danish territory from other countries. Instead, the acidification contribution should therefore be considered an indication of how much Danish economic acti-

[4] Note that the total in table 5.3 includes all emissions from Danish economic activities, incl. emissions related to bunkering, etc. abroad, while the emissions related to bunkering etc. abroad has been excluded from figure 5.11 and 5.12.

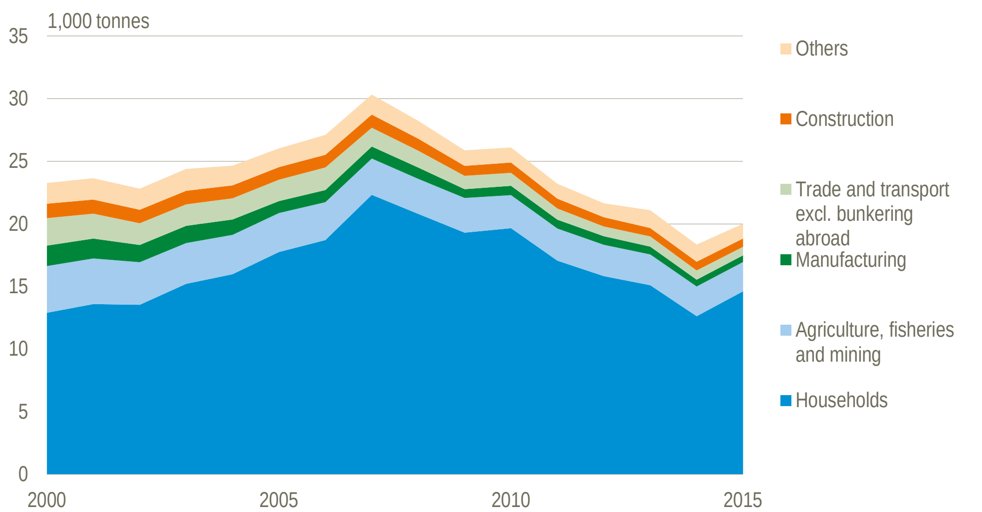
vity potentially contributes to acidification in Denmark and surrounding countries, particularly Sweden and Norway.

Particulate matter is dangerous

Particulate air pollution - especially fine particulate matter, $PM_{2.5}$ - can cause serious health problems in the form of allergies and irritation and in the long term, cancer and cardiovascular diseases.

Figure 5.12

Emissions of fine particulate matter ($PM_{2.5}$)



Note: Emissions generated by Danish carriers' bunkering etc. abroad have not been included. No adjustment has been made for pollutants that are transported in and out of Danish territory by air.

Increased particulate matter emissions

In total, 20.0 thousand tonnes of $PM_{2.5}$ particulate matter were released into the air in Denmark in 2015, see figure 5.12. This was an increase of 9 per cent compared with 2014. The increase in total emissions is attributable to the 16 per cent increase in household emissions.

Particulate matter emissions were increasing up to 2007, particularly due to households. After 2007, households and most industries reduced emissions. The total emission of fine particulate matter in 2015 was around 14 per cent below the level in 2000, where 23.3 thousand tonnes were emitted.

The majority of particulate matter stems from households and agriculture

Even though households and agriculture etc. have reduced emissions significantly over the past few years, they still account for the lowest percentage reduction in particulate matter emissions for the period as a whole. These are also the two areas with the highest particulate matter emissions. In 2015, households accounted for 73 per cent of total emissions, while agriculture etc. accounted for 12 per cent.

Wood burners, cars and ammonia evaporation

The high emissions generated by households are caused by the use of wood burners and cars. In the case of agriculture, particulate matter emissions are generated by ammonia evaporation and, for example, the use of vehicles and machinery.

Break-down by industries and households

Table 5.3[5] shows various pollutant emissions broken down by households and industries. SO_2, NO_x and NH_3 are shown as actual emissions. These are the emissions that were converted in figure 5.11 to acidification equivalents based on the acidification impact of the individual pollutants. Particulate matter emissions are emissions of particulate matter with a diameter smaller than 10µm and smaller than 2.5µm, respectively.

[5] See footnote 4.

Tropospheric ozone

Carbon monoxide (CO) and non-methane volatile organic compounds (NMVOC) can, together with CH_4 and NO_x, create chemical processes that result in the formation of ozone in the troposphere (lower atmosphere). This pollution may compromise our health as well as plant life. Emissions of CO and NMVOC generated on Danish territory (i.e. excluding emissions generated by bunkering, etc. abroad) decreased between 1990 and 2015 by 50 per cent and 39 per cent, respectively. From 2014 to 2015, however, emissions increased by 4 per cent and 3 per cent, respectively.

Table 5.3 Emissions of air pollutants by Danish economic activity. 2015

	Sulphur dioxide (SO_2)	Nitrogen oxides (NO_X)	Carbon monoxide (CO)	Ammonia (NH_3)	Non-methane volatile organic compounds (NMVOC)	Particulate matter <10 µm (PM_{10})	Particulate matter <2.5 µm ($PM_{2.5}$)
	tonnes						
Total	203 223	961 106	430 551	72 789	135 842	47 607	37 072
Households	2 028	18 148	277 726	2 339	26 960	15 410	14 614
Industries (Total)	201 877	946 774	153 224	71 189	107 172	35 435	23 421
Agriculture, forestry and fishing	975	33 868	19 089	69 033	40 688	9 279	2 340
Mining and quarrying	47	5 697	1 256	0	2 997	1 466	294
Manufacturing	4 961	9 323	5 906	501	31 184	768	534
Utility services	2 396	11 141	14 477	745	1 332	815	565
Construction	9	6 355	6 129	56	2 039	1 581	660
Wholesale and transport etc.	192 727	872 399	100 266	75	29 156	17 907	17 742
Information and communication	1	197	298	2	68	14	10
Financial and insurance	1	132	266	2	21	8	6
Real estate activities and renting of non-residential buildings	3	281	342	2	28	16	12
Dwellings	0	123	120	1	12	8	6
Business services	5	1 210	1 625	12	332	83	62
Public administration, education, social work	59	1 853	2 703	15	829	235	213
Arts, entertainment and other service activities	11	380	347	4	196	18	14
Of which:							
Bunkering of ships abroad	190 170	823 731	81 532	0	25 027	16 934	16 848
Bunkering of aircrafts abroad	764	10 459	3 165	0	278	129	129
Bunkering of vehicles abroad	8	4 623	1 947	14	83	82	82
Industries in total excl. bunkering abroad	10 253	104 145	66 181	70 436	83 494	15 053	5 399

Note 1: Emissions related to bunkering of Danish-operated ships, aircrafts and vehicles abroad are included in the Trade and transport etc. These emissions have been excluded from figure 5.11 and 5.12

Box 5.3 About the air emissions accounts

The emissions accounts included in the green national accounts are prepared based on the energy accounts for emissions caused by the energy consumption of oil, natural gas, electricity and coal, divided into the same industries as throughout the rest of the green national accounts. The accounts also use data on emissions coefficients for specific energy products from the Danish Centre for Environment and Energy (DCE). The DCE also provides supplementary data on non-energy related emissions.

The emissions accounts contain data on emissions to the air by different pollutants (CO_2, N_2O, CH_4, PFC, HFC, SF_6, NO_x, NMVOC, CO, PM_{10}, $PM_{2.5}$, SO_2, and NH_3). The data contained in the emissions accounts is continuously adjusted if new sources or new scientific methods lead to altered emissions factors. This also applies to data for years in which the accounts were otherwise considered to be final. The accounts are drawn-up consistently and they are therefore fully comparable over time. There are emissions accounts available from 1990 to 2016.

More information:
www.statbank.dk/10293
www.dst.dk/en/Statistik/dokumentation/documentationofstatistics/emission-accounts

6. Water and wastewater

6.1 Introduction

Large quantities of groundwater in Denmark

In Denmark, groundwater can be used as drinking water with no or limited treatment, and according to the Danish Environmental Protection Agency, Denmark is one of the few countries worldwide to be able to source close to 100 per cent of its supply of drinking water from pure groundwater. However, experiments to soften the water are in progress in certain areas, with the purpose of reducing consumer expenditure on decalcification of pipes and other equipment.

Local differences in the access to groundwater

Access to the groundwater varies locally due to geological conditions. Pollution at the point of abstraction can also affect the availability of pure groundwater. In accordance with the Environmental Protection Act (EPA)[1], groundwater wells for water supply plants are protected by a 25 metre protection zone, which restricts both the use of the area and the use of pesticides in the area. In areas where existing pollution threatens the groundwater, remediation drilling may be set up or wells may be closed as a last resort.

Local differences in prices

Differences in the availability of groundwater and in the water distribution and wastewater disposal networks mean that there are major local differences in the water price as well as in the price for wastewater treatment. The prices of water and wastewater treatment are subject to government regulation - i.e. by the Danish Competition and Consumer Authority, which is continuously aimed at ensuring that consumers are not overcharged, that utilities have sufficient funds and that the utilities continue to enhance the efficiency of their operations[2].

6.2 From water abstraction to wastewater

Scope of the water accounts

The water accounts include information on abstraction of groundwater and surface water, use of water in households and industries (see section 6.3 and 6.4), and water discharged to the aquatic environment via the sewage system or via discharge after local purification (see sections 6.5 and 6.6).

Abstraction by the water supply industry

Figure 6.1 shows the key elements of the physical water accounts. 378 million m^3 groundwater and 3 million m^3 surface water was abstracted by the water supply industry (water works) in 2016. After abstraction the water is supplied to other industries and households. 210 million m^3 of water is supplied to households, 50 million m^3 to agriculture, forestry and fishing, and 93 million m^3 to other industries. In addition the water works has its own consumption of water, and there is also a loss of water due to leakages.

Subsequently, households discharge 198 million m^3 of wastewater to the sewage system. Only a minor part is discharged from households directly to the environment in areas without a sewage system.

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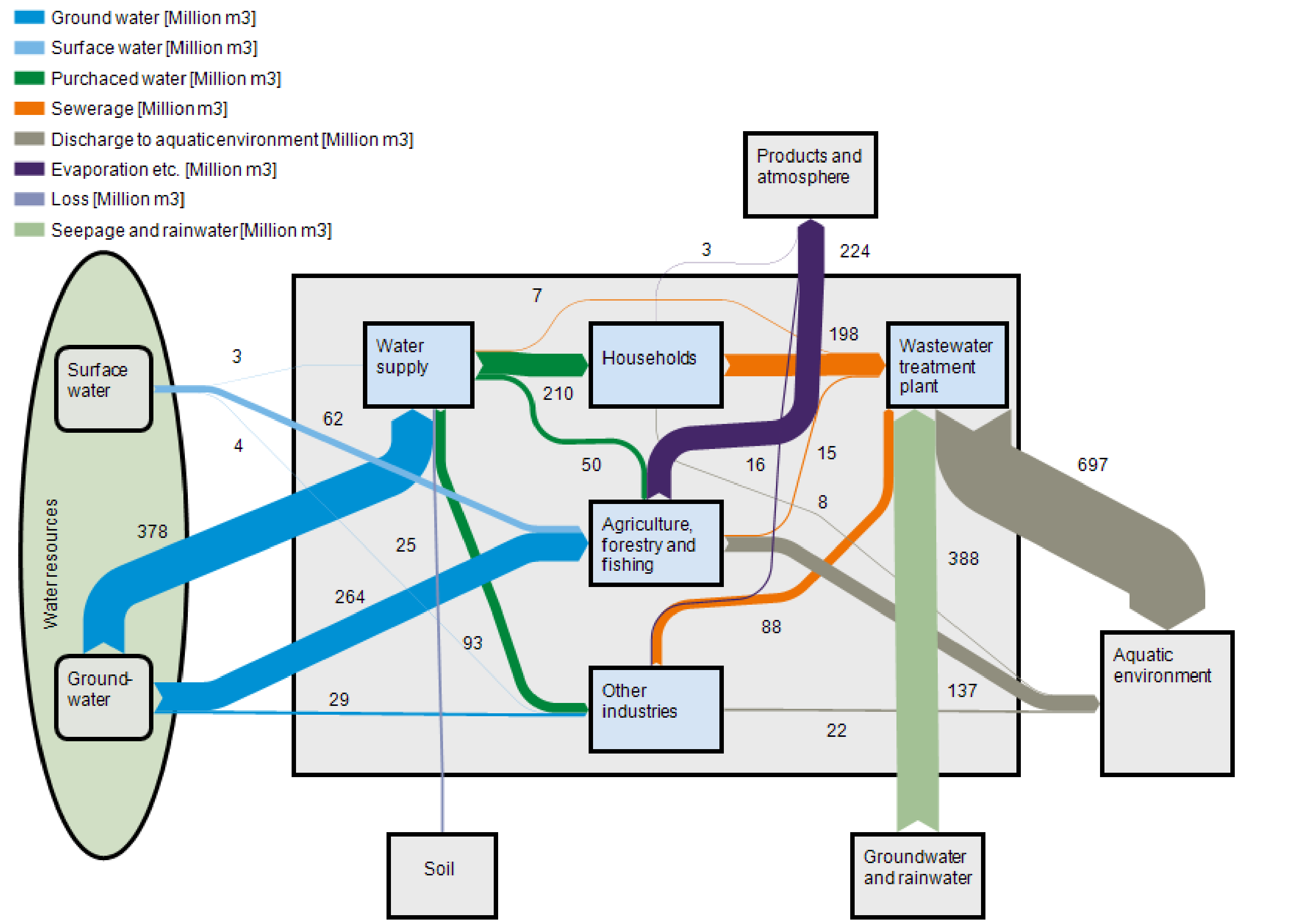
[1] Section 21 b of the Environmental Protection Act (Consolidation Act no. 1189 of 27 September 2016)

[2] The guidelines for this regulation are stipulated in the Danish Water Sector Reform Act no. 469 of 12 June 2009

Figure 6.1 Water and wastewater flows. 2016



Abstraction by agriculture, forestry and fishing	Agriculture, forestry, and fishing abstracted 264 million m³ groundwater and 62 million m³ surface water. 184 million m³ of groundwater was abstracted primarily for irrigation, while fish farms abstracted 80 million m³ of groundwater. Abstracted surface water was primarily used for fish farms.
Evaporation, absorption and returns to the environment	Water used for field irrigation and in fish farms evaporates, is absorbed by products, or is returned to groundwater or rivers. Only a small proportion of the water consumption for agriculture, forestry and fishing ends up in the sewerage and wastewater treatment plants.
Abstraction by other industries	Other industries abstracted 29 million m³ groundwater and 4 million m³ surface water using their own abstraction facilities, in addition to 93 million m³ of water supplied from water works. 16 million m³ of water ends up in products or evaporates. 88 million m³ of wastewater is discharged to the sewage system and 22 million m³ is led directly to the aquatic environment after internal purification.
Discharge from waste water treatment plants	After treatment at the wastewater treatment plants, 697 million m³ of wastewater is discharged to the aquatic environment. A significant proportion, 388 million m³, of the wastewater cannot be accounted for based on the flows of wastewater from industries and households to the sewage system. Instead it can be ascribed to seeping of water into the sewage system and to rainwater[3]. A two-pipe - or separate

[3] These flows are estimated as the difference between the calculated volume of wastewater from industry and households and the discharge of purified wastewater to the aquatic environment from wastewater treatment.

sewer - sewage system is used when attempting to stop wastewater and rainwater coming into contact with one another. Rainwater is channelled to the aquatic environment, whilst wastewater is carried, in a separate pipe, to wastewater treatment plants.

Varying abstraction especially for field irrigation

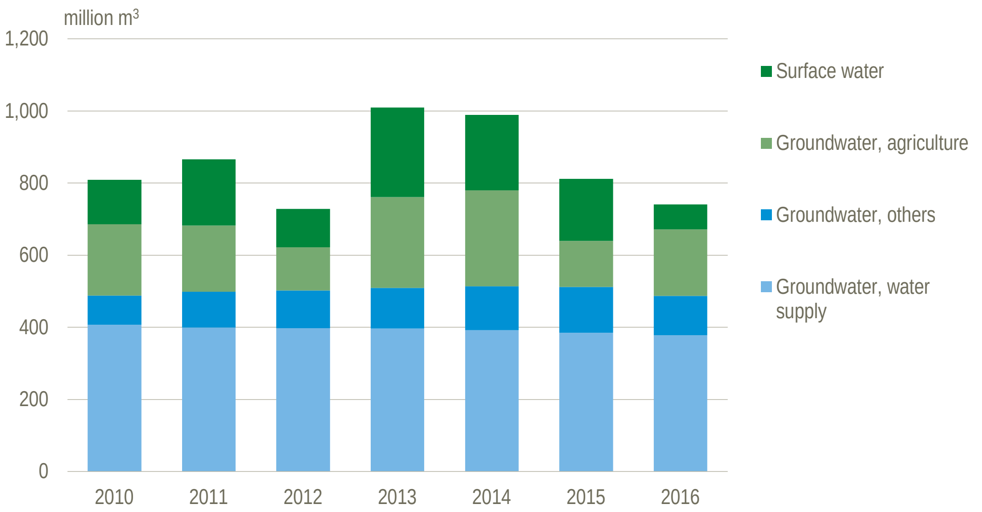
The total abstraction of groundwater and surface water was 741 million m³ in 2016. This is quite low compared to the previous three years, see figure 6.2. The abstraction of water varies over time especially due to varying abstraction of water by agriculture for field irrigation. See also box 6.1.

Decrease in abstraction for water supply

The high abstraction by the water supply industry has been slightly decreasing for a longer period. The abstraction was approximately 7 per cent lower in 2016 compared to 2010.

Figure 6.2

Total water abstraction in Denmark



Note: Abstraction of groundwater, others and abstraction of surface water include abstraction of water for fish farms

6.3 Water consumption by industries and households

Total water consumption includes water bought by industries and households from the water supply industry and water abstracted by industries themselves.

Total water consumption of 741 m³ in 2016

In 2016, the total water consumption was 741 million m³ (corresponding to the total abstraction of groundwater and surface water). Table 6.1 shows the total consumption of water broken down by households and industries. The total water consumption varies especially because of major fluctuations in the consumption by agriculture and fish farms.

Water consumption of households is declining

In 2016, the total water consumption by households was 210 million m³ corresponding to 28 per cent of the total water consumption and to 59 per cent of total water purchased from the water supply industry. This was the lowest level since 2010.

Agriculture and fish farms used half of the water in 2016

Agriculture, forestry and fishing was the industry with the overall highest consumption of water in 2016, accounting for around half of total consumption and corresponding to 377 million m³ of water. Of this total, 237 million m³ was used for agriculture and horticulture, 139 million m³ for fishing (mainly aquaculture) and 0.1 million m³ for forestry.

The consumption of water in agriculture varies from one year to the next because the rainfall pattern impacts the irrigation requirements. See box 6.1 for more information on agricultural irrigation across different municipalities.

Manufacturing used 57 million m^3

The manufacturing industry used 57 million m^3 of water in 2016, the main part of which was water purchased from water works.

Utilities

Utilities (water and energy supply) used 38 million m^3 water in total of which 30 million m^3 was ground water. The consumption of groundwater in utilities has dropped by 32 per cent from 44 million m^3 in 2011. A large share of water consumption attributed to utilities is due to the loss of water (leaking), which happens in the network either between the water well and the waterworks or between the waterworks and the consumer.

Table 6.1 The total consumption of water by households and industries.

	2010	2011	2012	2013	2014	2015	2016
	million m^3						
Industries and households	809	866	729	1 009	989	812	741
Households	237	237	238	246	233	217	210
Total industries	572	628	490	763	757	594	531
Agriculture, forestry and fishing	405	464	333	617	604	439	377
Mining and quarrying	8	8	8	8	6	7	7
Manufacturing	59	58	52	52	60	58	57
Utility services	51	52	47	40	40	39	38
Construction	1	0	1	1	1	1	1
Trade and transport etc.	16	15	17	15	13	15	15
Information and communication	0	0	0	0	0	0	0
Financial and insurance	0	0	0	0	0	0	0
Real estate activities and renting of non-residential buildings	2	3	3	2	2	2	2
Dwellings	0	0	0	0	0	0	0
Other business services	1	1	2	2	2	3	3
Public administration, education and health	19	18	18	17	19	20	21
Arts, entertainment and other services	9	9	9	8	8	9	10

6.4 Expenditure on purchasing water

Water expenditure of DKK 8.1 billion

In 2016, the expenditure for total water consumption amounted to DKK 8.1 billion, see table 6.2. In purchaser's prices, this figure was comprised of payments to the water supply industry (basic prices) of DKK 5.2 billion, corresponding to 64 per cent, water charges of DKK 1.6 billion, corresponding to 20 per cent, and VAT of DKK 1.3 billion, corresponding to 16 per cent. Accordingly, total payments to the state in relation to water consumption amounted to DKK 2.9 billion in 2016

Varying water prices

The average payment to the water supply industry (basic price) for water was DKK 14.80 per m^3 in 2016, and it varied according to local conditions between DKK 5 and 28 per m^3. In 2016, the water charge[4] was DKK 6.53 per m^3. This resulted in an average purchasers' price for households of DKK 27.29 per m^3 (including water charge and VAT). In 2016, the average purchasers' price for industries was DKK 16.51 per m^3.

It should be noted that the payment for water supply and purification of wastewater is usually combined. See also section 6.8 regarding expenditure on the treatment of wastewater.

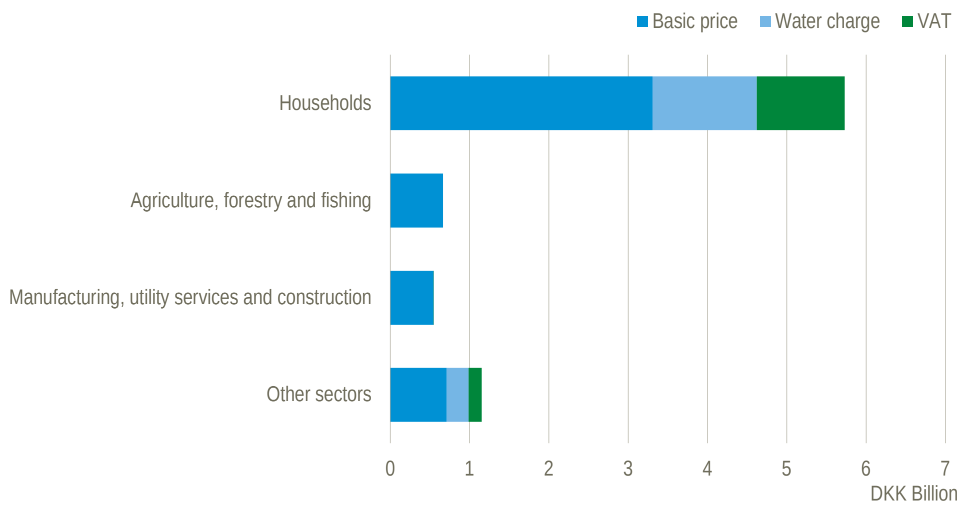
[4] Bekendtgørelse af lov om afgift af ledningsført vand (consolidation act on charge for water from distribution networks, consolidation act no. 962 of 27 June 2013).

A price for the abstraction of water undertaken by industries themselves has not been fixed in the water accounts, and this water is exempt from the water charge if used for industrial purposes.

Table 6.2 Expenditure on purchasing water. 2016

	Basic prices	Water charge	VAT	Purchasers' prices
	million DKK			
Total	5 221	1 595	1 278	8 088
Households	3 305	1 316	1 109	5 731
Total industries	1 915	278	168	2 357
Agriculture, forestry and fishing	666	0	0	666
Mining and quarrying	1	0	0	1
Manufacturing	447	0	0	447
Utility services	87	2	1	89
Construction	8	0	0	8
Trade and transport etc.	206	11	5	217
Information and communication	4	0	0	4
Financial and insurance	8	3	3	14
Real estate activities and renting of non-residential buildings	31	18	6	55
Dwellings	2	0	0	2
Other business services	19	2	1	21
Public administration, education and health	353	209	137	699
Arts, entertainment and other services	86	34	16	136

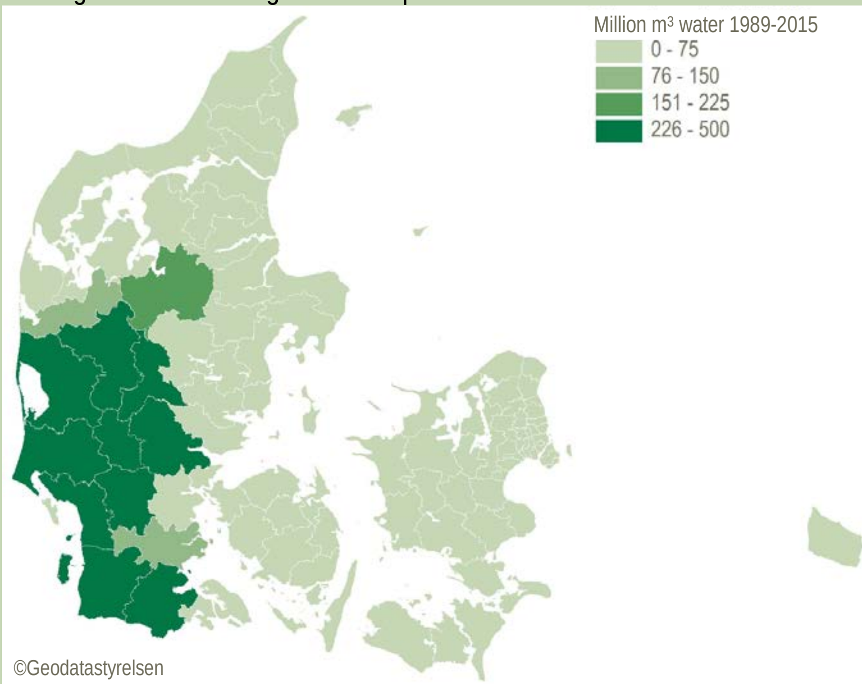
Figure 6.3 Purchase of water by price components. 2016



Box 6.1 The regional distribution of agricultural field irrigation

The farms in the municipalities of Western Jutland use the most water for field irrigation. The municipalities in Jutland which lie to the west of the trimline from the last glacial period have – throughout the period 1989-2015 – had the highest levels of abstraction for field irrigation. The soil is very sandy in this part of Denmark, and there is often a greater need for irrigation. In certain areas, agricultural output can be increased by as much as 40 per cent through irrigation (Videncentret for Landbrug (SEGES), 2011).

Total agricultural field irrigation in the period 1989-2015



In 2015, the Danish national average for irrigation of agricultural land was 52.7 m³ per hectare. For the municipalities with the highest abstraction of water for irrigation, marked by the darkest colour on the map above, abstraction for field irrigation averages 139.1 m³ per hectare. This means that in 2015, these municipalities used nearly three times as much water per hectare as the rest of the country.

6.5 Discharge of water by industries and households

The majority of the wastewater from industries and households is discharged to the sewage system after which it is treated in general wastewater treatment plants. However, households and some industries also discharge wastewater directly into the aquatic environment after they have treated it themselves.

476 million m³ of wastewater

In 2016, 476 million m³ of wastewater was generated by households and industries. 308 million m³ of this water was discharged to sewerage and 168 million m³ discharged directly to the environment; see figure 6.4 and table 6.3.

Households discharged 207 million m³ of wastewater, 96 per cent of which was discharged to the sewage system with 4 per cent discharged via septic tanks etc.

Massive water return flows from fish farms

The total discharge directly to the environment reflects a massive discharge from fish farms of 137 million m³. This is not wastewater in the traditional sense, but water which, after abstraction by the farms, is returned to e.g. rivers.

If the discharge from fish farms is disregarded, approximately 31 million m³ of wastewater was returned to the environment outside the sewage system.

Comparison with the water consumption

The total discharge of water, amounting to 476 million m³, can be compared to the total water consumption of 741 million m³. The difference between the two figures, 265 million m³, is due to water that was discharged in some other manner, mainly via agricultural irrigation and via livestock, but also as water added to products. A share of this water eventually ended up as water vapour.

Figure 6.4

Wastewater from industries and households. 2016

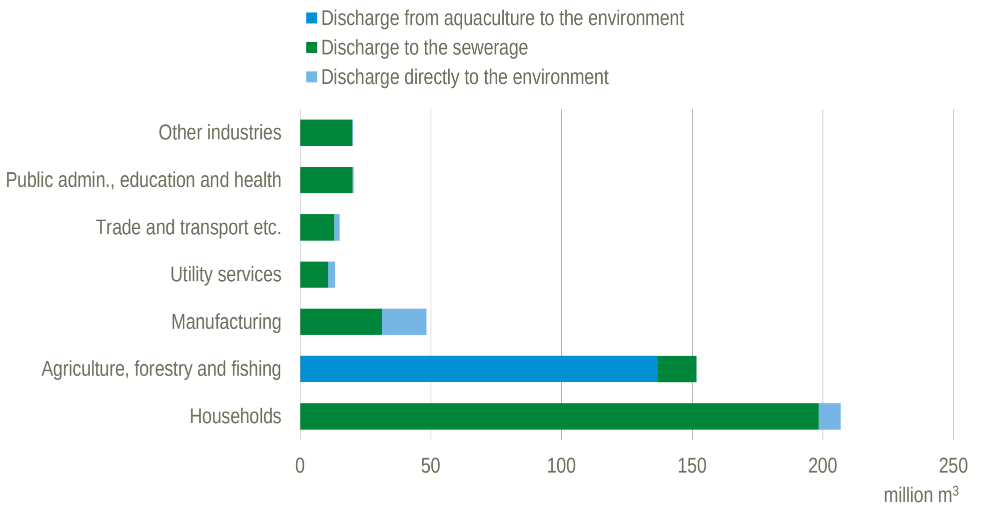


Table 6.3

Generation of wastewater by industries and households

	2010	2011	2012	2013	2014	2015	2016
	million m³						
Industries and households	522	595	526	677	639	600	476
Households	233	234	235	242	229	214	207
Total industries	289	361	291	435	410	386	269
Agriculture, forestry and fishing	167	242	176	326	295	268	152
Mining and quarrying	8	8	8	7	6	7	7
Manufacturing	50	49	44	44	51	49	48
Utility services	17	18	17	15	14	14	13
Construction	0	0	1	1	1	1	1
Trade and transport etc.	16	14	16	15	13	15	15
Information and communication	0	0	0	0	0	0	0
Financial and insurance	0	0	0	0	0	0	0
Real estate activities and renting of non-residential buildings	2	3	3	2	2	2	2
Dwellings	0	0	0	0	0	0	0
Other business services	1	1	2	2	2	3	3
Public administration, education and health	19	17	18	17	18	20	20
Arts, entertainment and other services	7	7	7	6	6	7	7

Note: Generation of wastewater includes discharge directly to the environment and to sewerage.

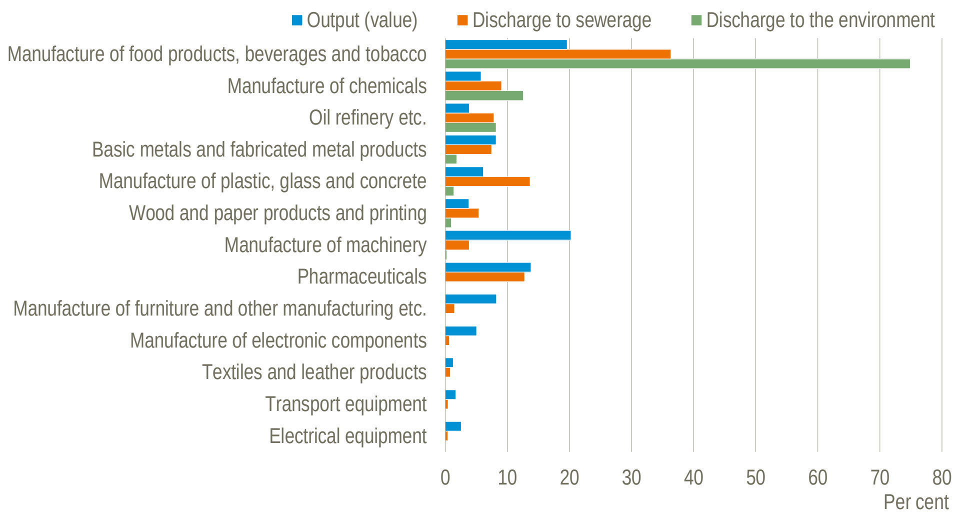
Discharge by manufacturing

The manufacturing industry discharged a total of 48 million m³ of wastewater in 2016: 17 million m³ was discharged directly to the environment and a further 31 million m³ was discharged to the sewage system.

Among the manufacturing industries, the manufacture of food products, beverages and tobacco discharged the most wastewater. This industry accounted for 42 per cent of the manufacturing industry's wastewater to purification plants and 76 per cent of the manufacturing industry's own discharge of wastewater. In comparison, the manufacture of food products, beverages and tobacco accounted for 21 per cent of the manufacturing industry's output value in 2016; see figure 6.5. This means that this industry had a high discharge of wastewater compared to its output.

In contrast, the manufacture of machinery accounted for a similar share of the manufacturing industry's output, i.e. 20 per cent, but was only responsible for 4 per cent of the discharge of wastewater.

Figure 6.5 Wastewater and production (output) of the manufacturing industries. 2016



6.6 Total discharge to the aquatic environment

Discharge from general treatment plants to the aquatic environment

After purification of the wastewater in wastewater treatment plants, the wastewater is directed back to the aquatic environment. In 2016, total discharge from wastewater treatment plants was 697 million m³; see table 6.4. This is significantly higher than the estimated 308 million m³ of wastewater which, according to section 6.5, was delivered to wastewater treatment plants from households and industries. This difference is due to the fact that intruding water flows into the sewage system: via seepage from leaking sewage pipes; and in the form of rainwater in areas without a two-pipe sewage system.

Discharge from industry to the aquatic environment

In 2016, the discharge of purified wastewater from industry-owned wastewater treatment plants accounted for 55 million m³ which was somewhat higher than previous years. Unlike the wastewater volumes mentioned in section 6.5, this figure also includes salt water used in production processes and for cooling.

Discharge from households to the aquatic environment

In 2016, the discharge of wastewater from households in dispersed settlements not connected to the sewage system was 8 million m³. This was somewhat less than the previous years. The 8 million m³ of wastewater corresponds, as mentioned in section 6.5, to 4 per cent of the total volume of wastewater from households.

Table 6.4 Discharge of wastewater etc. to the aquatic environment

	2010	2011	2012	2013	2014	2015	2016
	million m³						
Wastewater treatment plants	706	769	718	644	697	766	697
Industrial discharge	..	53	45	46	46	49	55
Settlements not connected to sewerage	..	11	..	10	10	10	8
Discharge from aquaculture	152	229	163	312	280	253	137
Precipitation-based discharge	..	..	..	..	335	392	313

Note: Industrial discharge includes salt water used in the production and for cooling

Discharge from fish farms

Fish farms discharged 137 million m^3 of water according to the preliminary figures for 2016. This was somewhat less than in previous years. The drop may be a result of a conversion of fish farms to facilities with recirculation or due to uncertainties (delayed reporting to the statistics).

Precipitation-based discharge

Finally, a considerable volume of water flows into the sea, lakes or streams in the form of precipitation-based discharge. The discharge is composed partly of precipitation from separate surface water drains, partly of mixed rainwater and wastewater from combined sewage systems overflowing in connection with cloudbursts etc. In 2016, 313 million m^3 of water was discharged in this way.

6.7 The content of pollutants in wastewater

Nitrogen, phosphorous and organic matter

When discharged to the aquatic environment, wastewater contains a number of substances which could, in excessive quantities, be harmful to the aquatic environment. To assess this pollutant content, the content of nitrogen, phosphorous and organic matter in the wastewater is measured. Nitrogen and phosphorous are nutrients that contribute to eutrophication of freshwater and coastal seas. In connection with wastewater, these are measured and used as indicators for both the effectiveness of wastewater treatment and of the pollution levels from fish farms. BOD (Biochemical oxygen demand) is an indicator used to assess the content of biodegradable organic matter in wastewater.

Increase in all three indicators in 2015

In 2015, the discharge of all three substances increased, BOD in particular; see table 6.5. The discharge of these substances increased as did the discharge of purified wastewater to the aquatic environment.

Table 6.5 Total discharge of wastewater substances.

	2011	2012	2013	2014	2015
	tonnes				
Nitrogen	6 251	5 035	5 696	6 883	7 362
Phosphorus	781	609	749	1 014	1 057
BOD (Organic matter)	9 898	6 164	9 068	12 678	13 355

Note 1: There are breaks in the data series between 2013 and 2014 because more sources were included in 2014.

Note 2: Data for 2016 was not available when this publication was prepared

6.8 Expenditure on wastewater discharge and treatment

Wastewater expenditure of DKK 12.1 billion

In 2016, industries and households paid a total of DKK 12.1 billion for wastewater discharge. Of this amount, DKK 9.9 billion went to the sewerage industry (expenditure in basic prices), DKK 274 million went to wastewater charges, and just below DKK 2 billion went to VAT; see table 6.6.

Households paid three quarters

With an expenditure of DKK 8.9 billion, households paid just below three quarters of the total expenditure incl. charges and VAT. Since households accounted for 44 per cent of the wastewater discharge (see table 6.3), the average price for wastewater discharge and treatment was somewhat higher for households than for industries. In 2016, the average purchase price for households was DKK 45 per m^3 (including VAT), whereas it was just below DKK 29 per m^3 for industries.

Wastewater expenditure of industries

Among industries, manufacturing (DKK 925 million), public administration, education and health (DKK 912 million) and trade and transport (DKK 414 million) contributed the most expenditure towards wastewater discharge.

Price depends on local conditions

The average payment to the wastewater industry (basic price) was DKK 32 per m^3 in 2016, and it varied according to local conditions between DKK 3 and 84 per m^3.

Payment of wastewater charge

The wastewater charge is paid by enterprises and households that are not connected to the sewage system and accordingly discharge wastewater directly into the aquatic environment.

The costs associated with the discharge of wastewater are in most cases charged together with the costs of the supply of pure water, in proportion with the supply.

Table 6.6

Expenditure on discharge and treatment of wastewater. 2016

	Basic prices	Wastewater charge	VAT	Purchasers' prices
	DKK million			
Total	9 870	274	1 967	12 099
Households	7 169	37	1 729	8 936
Total industries	2 700	237	237	3 164
Agriculture, forestry and fishing	394	0	0	394
Mining and quarrying	3	0	0	3
Manufacturing	715	210	0	925
Utility services	95	14	1	110
Construction	15	0	0	15
Trade and transport etc.	406	10	9	414
Information and communication	6	0	0	6
Financial and insurance	65	0	16	81
Real estate activities and renting of non-residential buildings	65	0	7	72
Dwellings	3	0	1	4
Other business services	33	0	1	34
Public administration, education and health	730	3	179	912
Arts, entertainment and other services	171	0	23	193

Total water and wastewater expenditure of DKK 20.2 billion

As was shown in section 6.4, the total expenditure of industries and households on purchasing water was DKK 8.1 billion in 2016. Adding the DKK 12.1 billion for wastewater discharge and purification, the total expenditure is DKK 20.2 billion, of which 60 per cent is associated with the discharge and treatment of wastewater.

Box 6.2 About the water accounts

The water accounts assess the water flows into the economy, within the economy and from the economy to the environment. This involves a balanced statement of the water abstraction and consumption by industries and households on the one hand and the wastewater discharge to sewerage and aquatic environment on the other hand. Data for abstraction of water goes all the way back to 1989, whereas information on wastewater dates back to 2010.

In addition to a statement of the physical volumes stated in m^3, the accounts also include a statement of the expenditure on purchasing water and on disposal and treatment of wastewater.

Data concerning abstraction and consumption of water is based on information from the Geological Survey of Denmark and Greenland (GEUS). Data on the discharge of wastewater comes from the Danish Environmental Protection Agency. Data concerning prices on water supply and wastewater treatment is based on information from the Danish Competition and Consume Authority.

The water accounts only include freshwater; the use of sea water in e.g. the fishing industry and power plants has generally not been included, except in the assessment of industrial discharge. The wastewater assessment is based on e.g. the water consumption by households and industries adjusted for water absorbed in production, water content in products and water evaporation.

The economic figures pertaining to the water accounts explain how the purchaser's price is composed of a mixture of basic prices, which are paid to the water supply or wastewater industry; water and wastewater charges; and VAT, both of which are paid to the state.

The information for recent years is preliminary.

More information:
http://www.statbank.dk/10534
https://www.dst.dk/en/Statistik/dokumentation/documentationofstatistics/water-and-waste-water

7 Material flows

7.1 Circular economy

Denmark is using large quantities of materials

Denmark's economic activities and prosperity are dependent on the supply – to households and industries – of millions of tonnes of natural resources and goods, based on biomass, minerals and fossil energy. On a per capita basis, each inhabitant of Denmark used an average of 23 tonnes of materials[1] in 2016.

Concern about the consumption of resources

Continuously increasing consumption of materials will sooner or later result in the depletion of many of Denmark's natural resources, unless something is done to reduce the drain on these resources. According to a recent governmental report (Advisory Board for Circular Economy, 2017), three Earths would be required to provide the resources for the global population to undertake the same levels of consumption as occur in Denmark.

Need for monitoring the consumption of materials

Besides raising concern as to whether there will be enough natural resources in the future, two factors in particular highlight the need to monitor resource consumption and society's material flows.

The impact on the environment

First of all, the consumption of materials impacts the environment. The extraction of raw materials, for example, changes the landscape and pollutes the surrounding environment. Moreover, the use of materials on the one hand and the production of waste and other residual products on the other are closely interlinked. As such, societies face a choice between harming the environment, or forcing industries, customers, and the public to take the – often costly – action required to avoid or mitigate harmful effects.

Purchasing material is a cost for enterprises

Secondly, purchasing materials in the form of raw materials and goods for intermediate consumption represents a substantial cost component for enterprises. Consequently, efficient use of materials is necessary for enterprises to maintain high productivity and competitiveness. For many manufacturing enterprises, expenditure on intermediate consumption represents a major part of current costs. In the case of the food industry, for example, costs for intermediate consumption constitute more than 70 per cent of total current costs. See figure 7.1, which shows the share for selected industries. In general, intermediate consumption accounts for between 40 and 60 per cent of total current costs for the various manufacturing industries. Intermediate consumption is also significant for the construction industry. In 2014, it accounted for 44 per cent of current costs. It is natural for these percentages to be high, since purchasing and processing goods is the basis of the manufacturing industry. However, the figures indicate that even a small improvement in the utilisation rate will help reduce costs.

It should be noted that for the industry groups shown in figure 7.1, the expenditure on energy only accounts for a minor part of total costs. Expenditure on energy is between five and ten per cent for only two of the industry groups shown. For the rest, it is less than three per cent. For many years, there has been a significant focus on energy saving and energy efficiency to reduce the physical energy consumption and consequently energy expenditure. See also section 4.6 for a more detailed description of the energy expenditure by industries.

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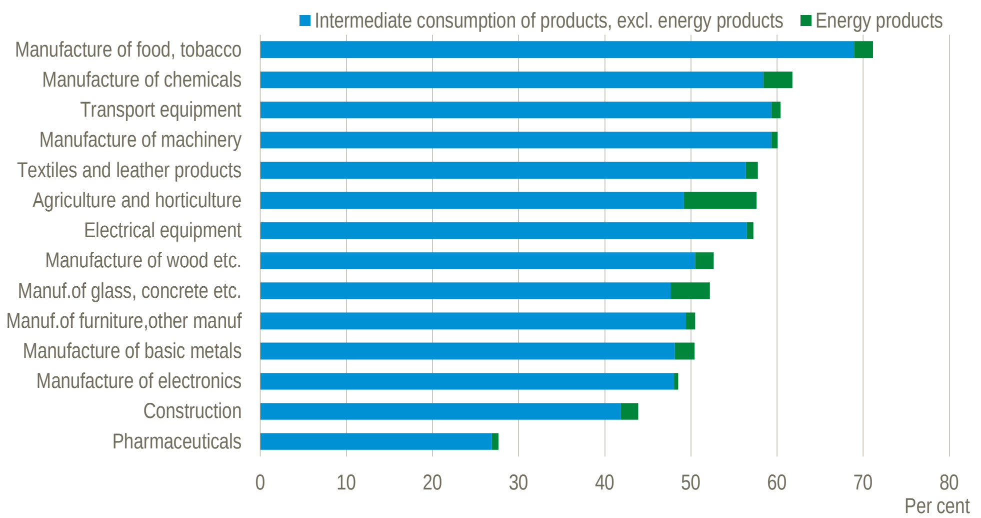
[1] Measured as domestic material consumption, see section 7.3

Figure 7.1 Intermediate consumption as a proportion of total costs – selected industries. 2014



Note 1: Total current costs are calculated here as the sum of the costs for purchasing goods and services, payment of employees and other production taxes minus other subsidies on production.

Note 2: Expenditure on district heating is not included in energy costs.

Materials savings as a competitive parameter

Besides the obvious benefit to an enterprise's bottom line that arises when reducing material consumption, there is also a desire amongst many enterprises to utilise more sustainable manufacturing processes in order to reduce environmental impacts from both the enterprises and their suppliers. Increasing sustainability is also a factor considered by customers, and therefore has significance regarding an enterprise's competitiveness.

Road map to a resource efficient Europe and circular economy package

At the political level, these considerations have been incorporated in the EU's Europe 2020 strategy. One of the flagship initiatives, "Roadmap to a Resource Efficient Europe" (The European Commission, 2011), sets out plans for the sustainable management of all resources by 2050. Building on this, the European Commission has adopted a "Circular Economy Package". The intention is to stimulate Europe's move towards a circular economy in which products, materials and resources are recycled and reused and consequently remain in the economy for as long as possible.

Increased Danish GDP, employment and exports from circular economy

It has been estimated (Ellen MacArthur Foundation, 2015) that even a partial transition to a circular economy in Denmark could result in additional growth in GDP of 0.8-1.4 per cent and generate 7,000-13,000 jobs by 2035. A transition of this kind will also potentially increase net exports by 3-6 per cent whilst simultaneously reducing Denmark's CO_2 footprint by 3–7 per cent and the consumption of new resources for selected materials by 5–50 per cent.

Advisory Board for Circular Economy

In the summer of 2017, the Danish government's Advisory Board for Circular Economy presented a report (Advisory Board for Circular Economy, 2017), that included a vision for Denmark's transition to a circular economy with five concrete targets and 27 recommendations of initiatives to give momentum to the transition.

Vision for circular economy

The vision is that Danish enterprises adopt circular economics as an integral element in their business and strategies, and support this through technological development, circular design, increased resource efficiency, increased recycling and reuse, maintenance, repair, and circular business models. The public sector in turn should support the circular economy by creating good guidelines and incorporating these, for example, in public procurement policy. Finally, citizens should be able to make informed decisions and choose products and services which promote a circular economy.

Targets for circular economy in 2030

The specific targets for 2030 involve, for example: 1) increasing resource productivity (see below) by 40 per cent based on the quantity of materials and 15 per cent based on the value of materials, 2) increasing recycling while reducing waste volume, 3) maintaining Denmark's lead in Europe in developing circular technologies and solutions, and increasing the exports of these, 4) a major share of the population becoming active in the sharing economy, and 5) quadrupling the total turnover of eco-label products and services.

7.2 Assessments of Danish material flows

Two types of material flow accounts

The green national accounts for Denmark include two types of material flow accounts, one with an economy-wide approach, the other with a more detailed approach examining the material flows of households and industries.

Economy-Wide flows, EW-MFA

The Economy-Wide Material Flow Accounts (EW-MFA) hold information on natural resources extracted from nature in Denmark and Danish imports and exports. The commodities and materials are mainly divided into biomass, minerals, fossil energy and others. These are divided further into slightly fewer than 60 different groups. The accounts are described in section 7.3.

Indicators

On the basis of the accounts, indicators are established for domestic material consumption and resource productivity. Resource productivity reflects the output – in the form of gross domestic product (GDP) – achieved per unit resource used. The development in Danish resource productivity is shown in section 7.4.

Water is not included

In accordance with normal practice, the material flow accounts do not include a description of the flows of water. These are described separately in chapter 6.

Detailed accounts broken down by industry and households

As opposed to the economy-wide material flow accounts, the detailed material flow accounts, which are presented in section 7.5, break down the economy in industries and households. This breakdown facilitates detailed analyses of economic activities resulting in the use of materials and resources. The breakdown also allows us to see how the material consumption for these economic activities eventually becomes residuals in the form of air emissions and waste etc.

7.3 Material flows of the Danish economy – from an economy-wide perspective

Tonnes

In the accounts, all material flows are measured in tonnes (weight) per year. As mentioned, water is not included.

Input into the economy: natural resources and imports

The starting point for the material flow accounts is a statement of the physical input into the Danish economy in the form of materials crossing the border between the environment and the Danish economy, as well as between foreign countries and Denmark. This means that extracted Danish natural resources as well as imported goods are included.

The materials from nature and from abroad are used in the economy when they are processed or consumed and when they are accumulated in e.g. buildings and other construction. These materials leave the economy in the form of goods exported to other countries or when pollutants are emitted, e.g. emissions in connection with the incineration of energy.

Output from the economy: exports

In the economy-wide material flow accounts, which are shown in this section, only the export of goods is assessed on the output side of the economy, whereas, for example, emissions to the environment have not been documented. However, in section 7.5 about the detailed material flow accounts, all flows, including flows out of the economy, have been included in the accounts.

Concepts

In addition to information on flows in the form of resource extraction, imports and exports, the accounts include a few derived indicators. The different concepts and terms applied are explained in box 7.1.

Table 7.1 shows the economy-wide material flow accounts with a breakdown on the basis of general material type.

Direct material input

The direct material input in the Danish economy was estimated at 176 million tonnes in 2016 (preliminary figures). Of this, 111 million tonnes or 63 per cent originated from the Danish extraction of natural resources, whereas 66 million tonnes or 37 per cent originated from import.

Danish resource extraction

Of the Danish resource extraction of 111 million tonnes in 2016, the extraction of non-metallic minerals (construction minerals) accounted for 65 million tonnes, corresponding to 58 per cent of the resource extraction and more than one third of the direct material input. The extraction of fossil energy in the form of oil and natural gas accounted for 11 million tonnes whereas the harvest of biomass was 35 million tonnes.

Table 7.1

Danish economy-wide material flows. 2016

	1. Domestic extraction	2. Import	3. Direct Material Input - DMI	4. Exports	5. Domestic Material Consumption - DMC	6. Physical Trade Balance (Net import)
			(3=1+2)		(5=3-4)	(6=2-4)
	million tonnes					
Total	110.5	65.5	176.1	44.8	131.2	20.7
Biomass	35.3	15.2	50.5	12.2	38.3	3.0
Metal ores and concentrates	0.0	6.1	6.1	5.0	1.1	1.1
Non-metallic minerals	64.6	9.4	74.0	5.7	68.4	3.7
Fossil energy materials/carriers	10.6	30.5	41.1	17.1	24.1	13.4
Other products	…	3.3	3.3	2.5	0.7	0.7
Waste	…	1.0	1.0	2.3	-1.2	-1.2

Note: The material categories cover raw materials as well as processed goods. The import is stated including oil products applied by Danish enterprises for international transport activities abroad.

Import

Fossil energy accounted for just below 31 million tonnes or nearly half of the total import of 66 million tonnes. The bunkering and tanking of 11 million tonnes of fuel by Danish transport companies abroad is included in the figure. The import of crude oil and other oil products, including petrol, was just above 13 million tonnes, while the import of coal accounted for more than 3 million tonnes. Imports of waste was 1,0 million tonnes in 2016.

Domestic material consumption

Total domestic material consumption of 131 million tonnes corresponds to the direct material input of 176 million tonnes minus the export of 45 million tonnes. A little more than half of the domestic material consumption consisted of non-metallic minerals, including in particular stone, gravel and sand. The main groups “biomass” and “fossil energy” accounted for 38 and 24 per cent, respectively, of the domestic material consumption in 2016.

Export

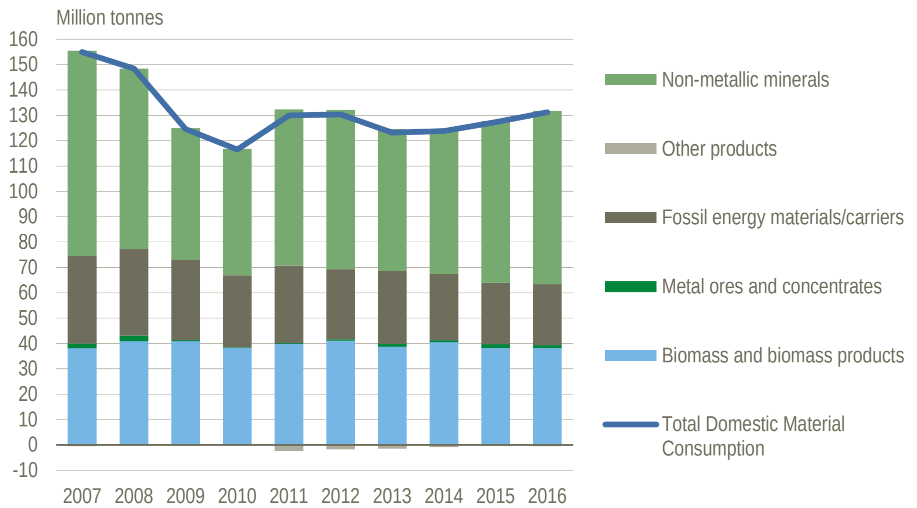
Of Denmark’s exports of 45 million tonnes of goods in 2016, 17 million tonnes were energy products. Crude oil and oil products etc. accounted for 14 million tonnes and natural gas etc. accounted for 2 million tonnes. The export of biomass including animal products accounted for 12 million tonnes. In addition, 2.3 million tonnes of waste was exported from Denmark for treatment abroad.

Physical net import

In 2016, the net import (physical trade balance) amounted to 21 million tonnes.

Figure 7.2

Domestic material consumption (DMC) in Denmark



Note: Domestic material consumption (DMC) is defined as the sum of Danish resource extraction and the import minus the export; see box 7.1

The development in the domestic material consumption

Figure 7.2 shows the development in domestic material consumption in the period from 2007 to 2016. The material consumption was high in the years up to the economic crisis in 2008, after which it decreased significantly. The consumption of non-metallic minerals (sand, gravel etc.) in particular was low in 2009 and 2010. Since then, material consumption has increased to a somewhat higher level, despite a small decrease in 2013. That said, in 2016 it was still at a lower level than in the years leading up to the crisis.

The United Nations Sustainable Development Goals

Domestic material consumption, DMC, is an indicator for the United Nations Sustainable Development Goal no. 8 on decent jobs and economic growth as well as no. 12 on responsible consumption and production; see chapter 3.

7.4 Resource productivity

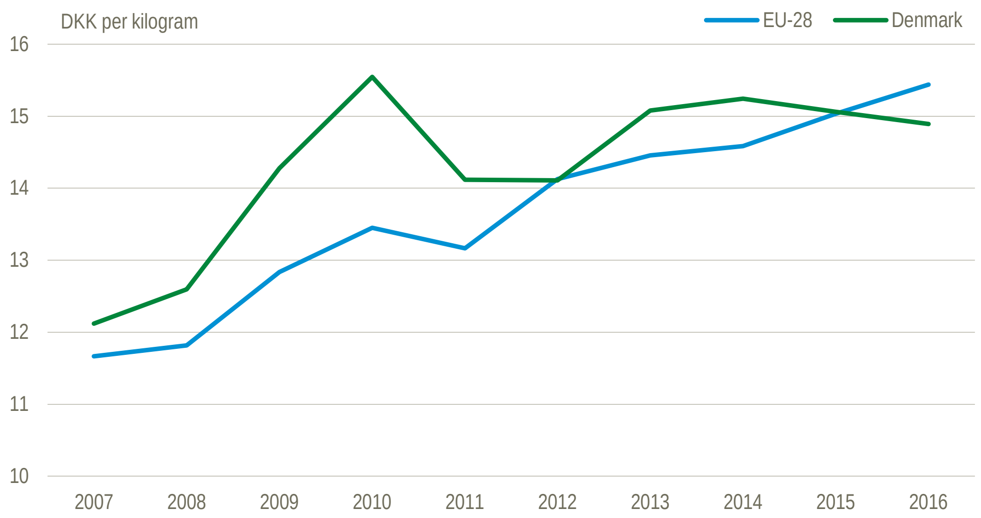
Resource productivity = GDP/DMC

In connection with the EU's flagship initiative and roadmap for a resource efficient Europe (The European Commission, 2011), the concept *resource productivity* is defined as the gross domestic product, GDP, divided by domestic material consumption, DMC, i.e. GDP/DMC. Resource productivity reflects GDP output per resource unit used. The concept of resource productivity is similar to that of labour productivity, in which gross value added is divided by number of working hours in order to demonstrate the amount of value added produced per unit of labour input.

Growing Danish resource productivity

The resource productivity statement based on the green national accounts shows that resource productivity in the period from 2007 to 2016 has gone up from DKK 12.1 to 14.9 per kilogram of material consumption. As such, the Danish economy generally worked more efficiently at the end of the period in terms of the consumption of resources and materials; and the economic growth in the period has taken place without a corresponding growth in the Danish consumption of resources and materials and subsequent generation of waste that must be dealt with at some point in time.

Figure 7.3 Resource productivity in Denmark and the EU



Note: The resource productivity is calculated as GDP in DKK (chained volumes, 2010 prices), divided by the domestic material consumption in kilograms.
Source: Statistics Denmark and Eurostat

Box 7.1 Concepts used in the material flow accounts, EW-MFA

Direct material input, DMI

The total input of materials in the Danish economy is calculated as the sum of the weight of the total *domestic resource extraction* and the weight of the *import*. This input of materials is often referred to as Direct Material Input (DMI).

Domestic material consumption (DMC)

Domestic material consumption is calculated by deducting exports from direct material input. The domestic material consumption is often referred to simply as DMC. DMC is an indicator of the total quantity of materials that has been put into the economy in the period, and which still remains in the geographical area as the materials have not subsequently been exported. DMC can also be seen as an indicator in the broad sense of the waste load (including air emissions etc.) potentially generated in the relevant period or later.

The correlation between the main indicators of the material accounts can be summed up as follows:

Danish resource extraction
\+ Import
= Direct material input, DMI
\- Exports
= Domestic material consumption (DMC).

Resource productivity

Based on the gross domestic product (GDP) and DMC, the resource productivity indicator is calculated as GDP divided by DMC. This is described in more detail in section 7.4.

Physical trade balance (physical net import)

The physical trade balance, or the physical net import, is the difference between import and export stated in tonnes. A positive balance means that the weight of the import is higher than the weight of the export.

In general, Denmark's resource productivity greater than that of the EU

The Danish resource productivity of DKK 14.9 per GDP per kilogram in 2016 was a little below the resource productivity of DKK 15.4 per kilogram in the EU-28 combined. 2016 aside, resource productivity in Denmark has generally been greater than that of the EU-28 more or less every year in the period from 2007. However, increasing resource productivity in the EU in recent years and declining resource productivity in Denmark have eliminated the difference in 2015 and 2016.

The resource productivity across EU member states varies considerably. The DKK 15.4 GDP per kilogram for the whole of the EU is a result of the fact that a number of Eastern European countries have resource productivity rates of less than DKK 5 GDP per kilogram of material consumption. The United Kingdom and the Netherlands, on the other hand, have resource productivity rates around DKK 30 GDP per kilogram[2].

Construction activities is of great significance

As is shown in section 7.3, about half of domestic material consumption consists of non-metallic minerals and derived products. A large share of this is stone, gravel and sand extracted from the environment in Denmark. The extraction is closely connected with construction activities, and fluctuations in construction generally impact the total material consumption more than they impact GDP. As such, declining construction activities will – all things being equal – trigger an increase in the total resource productivity, and vice versa, increasing construction activities will trigger a decline in resource productivity. This explains the major part of the variations in resource productivity, as shown in figure 7.3.

Box 7.2 About the Economy-Wide Material Flow Accounts, EW-MFA

The material flow accounts are set up based on a vast number of primary statistics, e.g. foreign trade statistics and statistics for raw material extraction, agriculture, fishing and forestry. In addition, information from the energy accounts (chapter 4) and waste accounts (chapter 8) is included.

Economy-Wide Material Flow Accounts are developed by Eurostat, amongst others. The accounts can be compared with the material flow accounts set up for other EU countries as a result of the regulation no. 691/2011 on European environmental-economic accounts, introduced by the European Parliament and the Council of Europe

The accounts do not in their present form reflect the considerable amount of natural resources extracted abroad and the environmental impacts they have when producing Danish imports. However, methods have been developed, e.g. under the auspices of Eurostat and OECD, to convert the direct material flows for import and exports into “Raw Material Equivalents, RME”. These methods reflect the global footprint of foreign trade in the form of the weight of the natural resources actually extracted to produce the goods crossing the borders as import or exports.

More information:
www.statbank.dk/MRM2
www.dst.dk/en/Statistik/dokumentation/documentationofstatistics/economy---wide-material-flow-accounts

[2] These comparisons are based on GDP measures at actual exchange rates, i.e. without use of purchasing power parities

7.5 Detailed material flow accounts for industries and households

Danish economy and environment

As opposed to the economy-wide material flow accounts (EW-MFA), which are presented in section 7.3, the detailed material flow accounts for industries and households also hold information on residual flows (e.g. air emissions) from the economy to the environment. The detailed material flow accounts also include information on a vast number of internal material flows in the Danish economy. These are related to the industrial production of goods for intermediate as well as final consumption in the form of private and public consumption, investments and inventories.

Prototype for 2009

At the time of publication, the detailed material flow accounts for Denmark exist as a prototype based on data for the year 2009. In this context, prototype means that the accounts are the first of their kind and that it has not been possible to fully complete the description in all areas. Moreover, all details may not necessarily be fully quality assured or consistent.

Material conservation and the balance of materials

The detailed material flow accounts are based on fundamental principles concerning material conservation and the balance of materials. These principles posit that, whilst materials can be converted into other types of materials, materials cannot disappear. Furthermore, if there is a physical flow into a particular system (production process, enterprise, industry, economy, geographical area, etc.), then a corresponding flow must occur: either an accumulation of materials *in* the system, or a flow *out* of the system.

Approximately 2,000 types of natural resources, goods and residuals

Close to 2,000 different types of natural resources, goods and residuals are included in the detailed material flow accounts. Economic activities are broken down into 117 industries and a large number of types of consumption. This breakdown corresponds to that used in the national accounts and the other sub-accounts in the green national accounts.

Uncertainty

This high level of detail helps ensure the accounts provide a realistic picture. Nevertheless there are major uncertainties associated with many of the details, which must be taken into consideration when evaluating the results. That said, the information provided pertaining to orders of magnitude and structures can be considered to give a true bearing.

When the details of the prototype accounts are assessed in relation to current conditions, it must of course be taken into consideration that the accounts are based on data for 2009, and naturally changes in material consumption have occurred in some areas e.g. due to changed economic conditions, increased recycling etc.

Figure 7.4 shows, in brief, the main features of the accounts. The figure illustrates the supply and use of materials in the Danish economy in 2009.

Supply of materials

The top half of the figure shows the supply of materials to the Danish economy. It consists of extraction of natural resources, import of goods from abroad, industries' production of goods as well as the production of residuals (air emissions, waste etc.) by industries and households.

Use

The bottom half of the figure shows the use of goods by industries and households, for accumulation (investments and changes in inventories) and for exports.

Extraction of natural resources of 107 million tonnes

The top of figure 7.4 shows that the total extraction of natural resources from Danish territory was approximately 107 million tonnes. Of this figure, the extraction of minerals (construction minerals) such as sand and gravel etc. accounts for approximately 49 million tonnes.[3]

The primary industries, i.e. agriculture, forestry, fishing and extraction of raw materials, extract the majority of these natural resources: 101 of the total 107 million tonnes. A minor part, corresponding to a little less than 6 million tonnes, mainly biomass, is extracted by other industries.

From natural resources to goods

After cleaning, if required, and processing, the natural resources, particularly those extracted by the primary industries, become products that are sold to other industries and households or exported etc. The figure shows that the production of goods from the primary industries amounts to approximately 107 million tonnes.

Purchase of goods by primary industries

Alongside extraction, primary industries also have an input of processed goods (intermediate consumption) purchased from other industries. This explains how they produce 107 million tonnes of goods from an extraction of only 101 million tonnes of natural resources. This applies to e.g. the agricultural sector's purchase of fertilisers and imported feed. The total input of goods in the primary industries, including energy used in the production processes, amounts to approximately 20 million tonnes in total. This is shown in the bottom left of figure 7.4.

Residuals from the primary industries

The primary industries also generate a number of residuals weighing altogether a little less than 14 million tonnes. These are e.g. biomass-related residuals in the form of manure and crop remains, as well as air emissions[4] associated with energy consumption as well as livestock and use of fertiliser etc.

Material balance of 121 million tonnes for the primary industries

As mentioned previously, the input and output for each industry must, by necessity, balance. This is also the case for the primary industries as a whole. The total input of 121 million tonnes consists of 101 million tonnes of natural resources and 20 million tonnes of purchased goods. The output consists of 107 million tonnes (88 per cent) of goods and 14 million tonnes (12 per cent) of undesirable residuals - 121 million tonnes in total.

107 million tonnes of goods from manufacturing etc.

Manufacturing, utilities and construction produced a total of 107 million tonnes of goods. This corresponds to the total production of goods in the primary industries, but there is no direct correlation in other respects between these two figures. Broken down by categories of materials, the production included 62 million tonnes of minerals, 14 million tonnes of fossil energy, a little less than 18 million tonnes of biomass as well as 4 million tonnes of iron and metal products.

37 million tonnes of residuals from manufacturing, utilities and construction

In addition to the output of goods, manufacturing, utilities and construction combined generated approximately 37 million tonnes of residuals. A little less than half of this is emission to air from combustion of fossil energy and biomass. Furthermore, the residuals consisted of e.g. sewage sludge as well as regular solid waste of different kinds – including a large quantity of construction waste.

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[3] The stated resource extraction, which refers to the year 2009, does not correspond exactly to the one stated in the economy-wide material flow accounts; see section 7.3. Correspondingly, there are certain deviations in the figures for imports and exports. This is due to the fact that the detailed material flow accounts for industry and households are prototype accounts which are based e.g. on other versions of the underlying statistics.

[4] Air emissions are stated here exclusive of the quantities of oxygen etc. that exist in e.g. CO_2 and SO_2, and which originate from the air that is involved in the combustion processes. This is because the combustion air is not included as an input in the assessment. The air emissions in the material flow accounts are assessed consistently with the emissions that appear from the accounts for air, as described in chapter 4, but it is necessary to adjust for combustion air etc. before the figures can be compared.

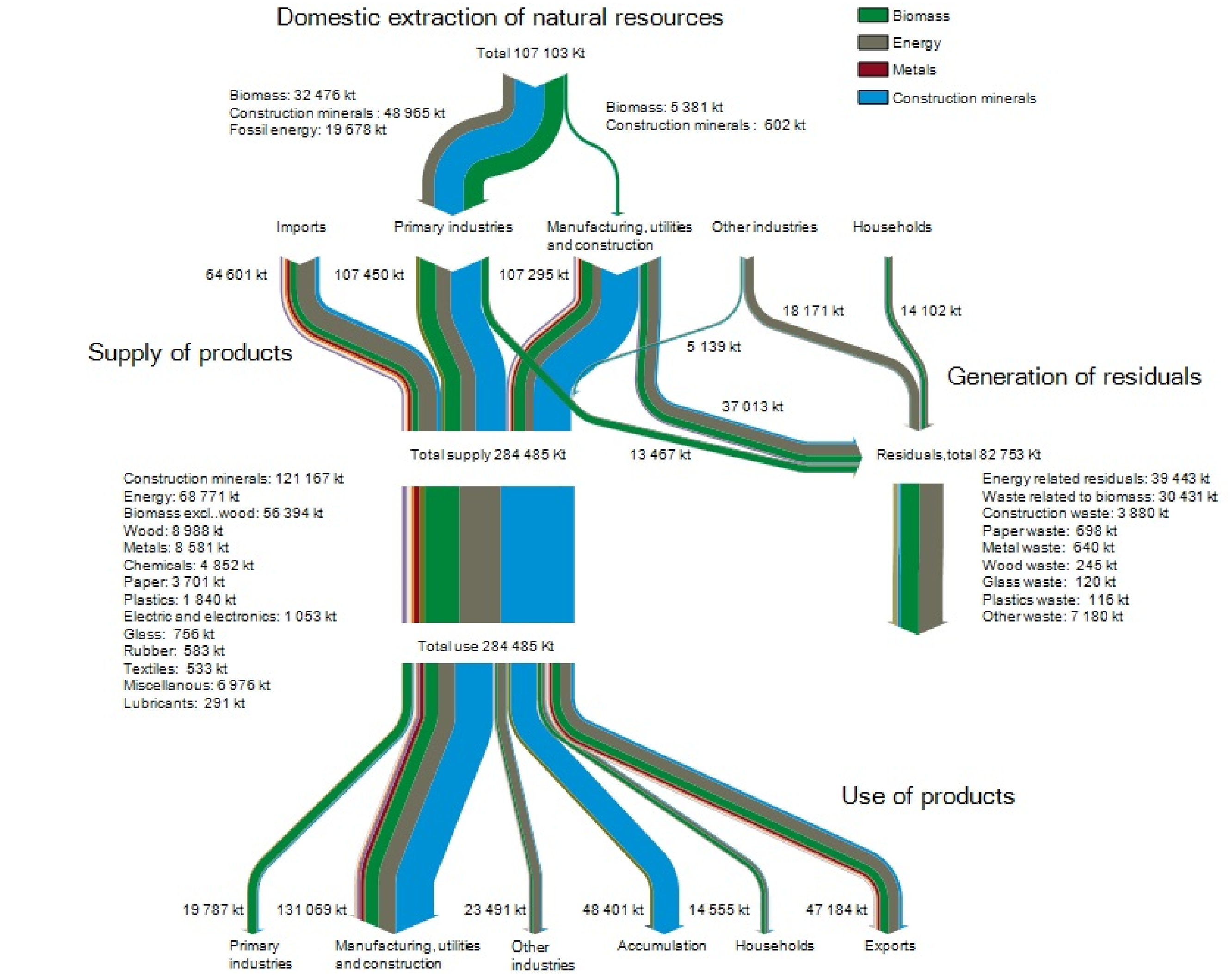
Material balance of 144 million tonnes for manufacturing etc.

With 107 million tonnes of goods and 37 million tonnes of residuals, total output from manufacturing, utilities and construction was 144 million tonnes. From an input perspective, this corresponds to 131 million tonnes of intermediate consumption (i.e. goods used in production), the previously mentioned 6 million tonnes of natural resources extracted by the industries themselves, as well as an input of recycled waste corresponding to approximately 7 million tonnes (not shown in the figure). The intermediate consumption included minerals for construction in particular as well as fossil energy and biomass.

Service industries produce 5 million tonnes of goods and 18 million tonnes of residuals

Other industries, including trade and transport activities, produced 5 million tonnes of goods. These industries mainly produce services. However, industries such as restaurants and hotels, publishing and printing as well as landscape activities, which are included here in other industries, also have a physical output in the form of food and beverages, books and newspapers as well as plants, trees and wood chips. The quantity of residuals was 18 million tonnes, of which a major part, 15 million tonnes, was air emissions. These air emissions were particularly the result of consumption of energy for vessels, planes and cars, including international transport activities abroad. The output – 5 million tonnes of goods and 18 million tonnes of residuals – corresponded to a total input of intermediate consumption of approximately 23 million tonnes.

Figure 7.4 Supply and use of materials 2009. 1,000 tonnes (Kt)



Note 1: The figure is based on a prototype for the detailed material flow accounts.

Note 2: The figures are associated with significant uncertainty.

Accumulation of products

The figure indicates that a great deal of the minerals (construction minerals), which are first extracted as natural resources and then supplied from the primary industries to the construction industry end up accumulated in the economy in the form of buildings and engineering works. The total accumulation of materials is stated as 48 million tonnes in the bottom of figure 7.4.

14.5 million tonnes of goods for household consumption more or less all ended as residuals

Households consumed a total of around 14.5 million tonnes of goods. Of this, food and beverages accounted for 6 million tonnes, energy accounted for 5 million tonnes, and building materials for DIY projects etc. accounted for just under 2 million tonnes. The consumption of these goods led to the creation of an almost equal quantity of residuals, altogether some 14 million tonnes. The household residuals consisted of just over 5 million tonnes of air emissions from energy consumption and regular waste of a little less than 3 million tonnes. The remainder was mainly foods etc, which generally end up in the sewage systems via toilets and sinks etc.

Accumulation in households

The fact that household residuals are 0.5 million tonnes less than the purchase of goods by households indicates a net accumulation of materials in households. This is related to the fact that households buy more durables, e.g. cars, refrigerators, televisions etc. than they dispose of. A certain accumulation of building materials from DIY projects is also part of the explanation.

Imports and exports

A total of 64.6 million tonnes of goods were imported from abroad. Fossil energy accounted for almost half of this, i.e. 30 million tonnes. The export from Denmark was somewhat smaller, accounting for 47 million tonnes of goods. Of this, 18 million tonnes was fossil energy, and 14 million tonnes were biomass-based products.

Total goods balance of 284.5 million tonnes

Overall, the accounts show that the total input of goods in the form of imports and Danish production of goods was 284.5 million tonnes. These goods were used in production as intermediate consumption (174 million tonnes in total) and in households (14.5 million tonnes). In addition, 48 million tonnes were accumulated in the economy, whereas the rest (around 47 million tonnes) was exported.

A total of 83 million tonnes of residuals

In 2009, industries and households combined generated a little less than 83 million tonnes of residuals in the form of air emissions and waste, which is either collected or ends up in the sewage system.[5]

7.6 Supply and use of plastics

An example of the more detailed data included in the detailed material flow accounts would be that concerning the material flows of plastic products and plastics waste. These flows are shown in tables 7.2 and 7.3. Table 7.2 shows the supply of plastic products and plastics waste from specific industries and from households. The table also shows the quantity of plastics imported. Table 7.3 shows the use of plastics in industries (intermediate consumption) and households (private consumption), as well as exports and accumulation in the economy.

2.6 million tonnes of plastics

The total supply of plastics was 2.6 million tonnes. Of this total, 1.8 million tonnes were plastic products, 116,000 tonnes were separate plastics waste, including plastic packaging and other plastics as well as PVC. In addition 608,000 tonnes of plastics were partly contained in products that mainly consist of other types of materials (e.g. electronics, household appliances and machines) and in plastics waste which was not sorted specifically and separated from mixed types of waste (e.g. mixed municipal waste). For households alone, it is estimated based on the

[5] A certain double counting is included in the statement, since a minor part of the waste is incinerated and as a result become air emissions. Correspondingly, double counting exists in the statement of goods production and use, since a part of the goods are used as intermediate consumption for other goods.

accounts that mixed municipal waste contained up to 99,000 tonnes of plastics waste in addition to the 33,000 tonnes that was specifically sorted.

Import of 1.2 million tonnes of plastics

Of the 1.8 million tonnes of actual plastic products, 1.2 million tonnes were imported from abroad, while Danish industries supplied 629,000 tonnes. Of this 629,000 tonnes, more than half was produced by the manufacture of rubber and plastics industry. Its production included a small quantity of raw materials and semi-finished products, e.g. unprocessed polyurethane and plastic tubes, whilst the main part, 260,000 tonnes, was finished products, mainly packaging products in the form of plastic bags, film, boxes, bottles and containers[6]. Among the other industries producing plastics-related products, the textile industry had a significant production of non-woven fabric etc.

Filled plastic packaging from abroad and from Danish industries

Table 7.2 also shows the origin of 326,000 tonnes of plastic packaging which is distributed as filled packaging[7]. The import of filled packages was 139,000 tonnes, while the Danish industries, including the wholesale and retail trade, distributed 187,000 tonnes of filled plastic packages.

Destinations of plastic products

On the use side, the plastic products were distributed, as shown in table 7.3, with 1.2 million tonnes for the industries and 132,000 tonnes for the households (private consumption). In addition, 555 tonnes were exported. Note that use includes 326,000 tonnes of filled plastic packages. The industrial use of plastics includes e.g. 263,000 tonnes of raw materials etc. which the manufacture of rubber and plastics industry uses for its production of plastic packaging and other types of finished plastic products.

Use of separate plastics waste

The 116,000 tonnes of separate plastics waste was fairly evenly distributed amongst exports and intermediate consumption (reprocessing) in the plastics industry etc.

The use of plastics mixed with other products and waste

Part of the 608,000 tonnes of other plastics are used for manufacturing products that mainly consist of other components than plastics (e.g. some types of electronics and household appliances). Another part is included in mixed waste. This has not been further clarified in the accounts. It must be assumed, however, that a major share of the 99 million tonnes of plastics originating from the households (see table 7.2) is incinerated together with mixed municipal waste at the incineration plants.

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[6] In this context also, some double counting of the products is involved, since e.g. plastic packaging is included as empty as well as filled packaging.

[7] Also in this case, there is double counting, as table 7.6 contains empty packaging purchased by Danish enterprises as well as the filled packaging which the enterprises forward to the buyers of the their products.

Table 7.2 Supply (origin) of plastics

	Total	Industries						Private consumption[3]		Imports
		Total	Agriculture, forestry, fishing, mining and quarrying	Manufacture of rubber and plastic products	Other manufacturing	Construction	Other industries	Total	of which semi-durable and durable	
	1,000 tonnes									
Raw materials and semiprocessed products	765	113	-	63	49	-	-	●	●	652
Finished products[1]	749	329	-	260	69	-	-	●	●	420
Filled packaging	326	187	1	16	68	3	100	●	●	139
Plastic produts, total	1 840	629	1	339	186	3	100	●	●	1 210
Waste	116	61	3	27	12	4	15	33	17	22
Others[2]	608	509	1	-	316	74	117	99	21	…
Total	2 564	1 199	6	366	514	81	231	132	38	1 233

Note: Rounding errors may occur

[1] Includes empty packaging

[2] Plastics incorporated in other products, e.g. electronics and household appliances and plastics waste mixed with other types of waste (municipal waste, etc.)

[3] Includes also a negligible amount of plastics related to government consumption

Table 7.3 Use (destination) of plastics

	Total	Industries						Private consumption[3]		Exports	Accumulation	Other products/ mixed waste
		Total	Agriculture, forestry, fishing, mining and quarrying	Manufacture of rubber and plastic products	Other manufacturing	Construction	Other industries	Total	of which semi-durable and durable			
	1,000 tonnes											
Raw materials and semiprocessed products	765	662	1	263	348	29	21	3	1	114	-13	●
Finished products[1]	749	413	1	43	135	45	189	32	23	322	-18	●
Filled packaging	326	60	4	1	27	7	21	97	14	120	49	●
Plastic produts, total	1 840	1 135	6	308	509	81	231	132	38	555	17	●
Waste	116	59	-	54	5	-	1	-	-	57	-	●
Others[2]	608	5	…	5	…	…	…	…	…	…	…	603
Total	2 564	1 199	6	366	514	81	231	132	38	613	17	603

Note: Rounding errors may occur

[1] Includes empty packaging

[2] Plastics incorporated in other products, e.g. electronics and household appliances and plastics waste mixed with other types of waste (municipal waste, etc.)

[3] Includes also a negligible amount of plastics related to government consumption

Box 7.4 About the detailed material flow accounts

The detailed material flow accounts are made from supply-use tables for the Danish economy. This provides a detailed statement of the material flows in and out of the individual industries as well as the material flows connected with imports, exports, private and public consumption as well as investments and changes in inventories.

The accounts are broken down into households and the 117 industries measured in the national accounts.

Moreover, the accounts contain information on approximately 2000 different types of natural resources, goods and residuals. Recycling of various types of waste/products is included in the statement, just as the flows of filled and empty packages have been taken into consideration. Only water added e.g. in connection with the production of beverages or water removed from products through incineration or evaporation is included in the accounts.

The material accounts are set up based on the same underlying statistics as the economy-wide material flow accounts (see section 7.3), but a large amount of additional data is also included. This is e.g. information on the production of goods by enterprises. The national accounts' supply-use tables, calculated in DKK, are a significant source for the breakdown of material consumption by industries and households. The detailed material flow accounts include further data on air emissions and waste etc. from the green national accounts. Via the accounts, these are linked with the use of natural resources and goods. Finally, a number of details are included about packaging and recycling etc. from the environmental projects of the Danish Environmental Protection Agency.

The accounts are based on a great number of assumptions and estimates. These are necessary e.g. to remove the inconsistencies that occur when so many different data sources are set against each other.

At the time of publication, the detailed material flow accounts for Denmark only exist as a prototype based on data for the year 2009.The figures presented in sections 7.5 and 7.6 involve considerable uncertainty, and for this reason many of them only represent orders of magnitude.

8 Waste

In Denmark, approximately two tonnes of waste are generated per inhabitant each year. The vast quantities of waste potentially constitute a huge loss of resources. In addition, the management and disposal of waste involves economic costs, and there are also implications for the climate and the environment.

Good utilisation of waste is important for a circular economy

A reduction in the quantities of waste and an efficient and sustainable use of this waste are key elements in the efforts towards a circular economy. In a circular economy, resource productivity is increased and materials as well as products are kept in the economic cycle for as long as possible, which benefits the environment as well as the economy. Further information about the circular economy is found in chapter 7 on the flow of materials.

Overview of the chapter

Section 8.1 has an overview of the amount of waste generated by the Danish economy, where it is generated, what it is composed of, and how it is processed. Section 8.2 focuses on the recycling of waste in the context of developing a more circular economy, at the national as well as the European level. Section 8.3 looks at Denmark's position in a European perspective when it comes to recycling and Denmark's import and export of waste. Section 8.4 analyses the connections between household consumption and the waste generated by industries making products for consumption in Denmark. Section 8.5 deals with the economics of waste: what is the cost of waste treatment and disposal?

Throughout this chapter, as was the case in chapter 7 on the material flows in general, the physical measurement unit is tonnes. This is in line with the convention for waste statistics and has the advantage that it is a common unit that can be applied to natural resources, products and other residuals as well (see chapter 7). However, one should be aware that the use of tonnes as a measurement unit does not reflect the harmfulness of the waste or the potential value of the waste as a source for recycling or reuse. However, as the waste accounts are detailed with respect to types of waste, specific analysis of almost all types of waste that are of interest from specific environmental and economic perspectives can be carried out.

8.1 Waste – what, from where and how much?

11.3 million tonnes of waste in 2015

The total quantity of waste generated in Denmark was 11.3 million tonnes in 2015. This is composed of 3.4 million tonnes from households, 4.2 million tonnes from the construction industry with the remaining 3.8 million tonnes coming from other industries.

Decrease in 2015

The total quantity of waste generated decreased by 2.0 per cent from 2014 to 2015.

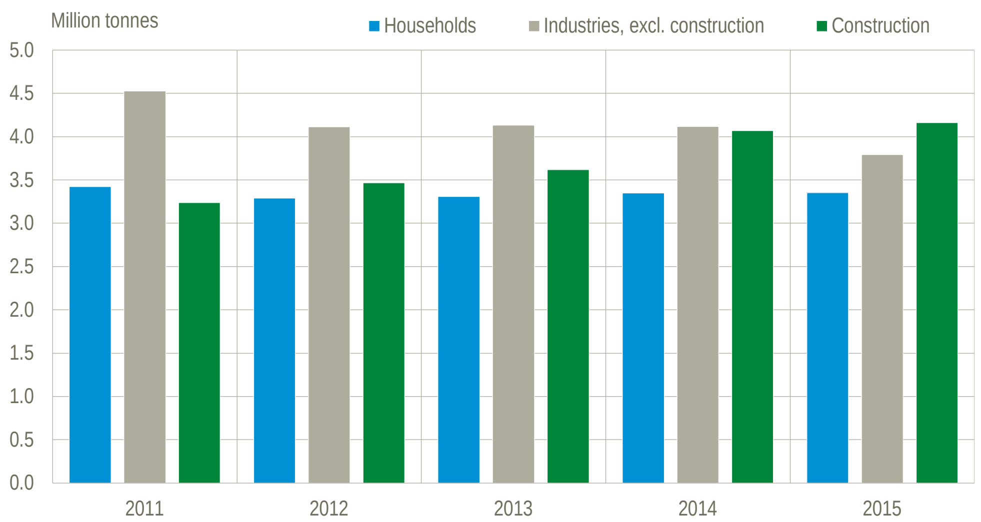
The quantities of waste from households are quite stable from one year to the next. There are greater variations in the waste from industries. Quantities of waste from the construction industry in particular vary considerably from one year to the next as they are linked to the variations in construction activity.[1]

Major differences between types of waste

Figure 8.1 shows all waste, regardless of type. However, the composition of the waste by type is significant for e.g. the hazard degree of the waste, the management costs and the recycling potential. For example, there are major differences between one tonne of mixed municipal waste, chemical waste or construction waste.

[1] Data on soil waste has been excluded from the statistics in this chapter. This is because soil waste from individual construction projects, e.g. metro and harbour projects, can cause variations to the extent that they eclipse the development in all other waste types. In 2015, there were 4.9 million tonnes of soil waste. Figures for other years are available in www.statbank.dk/affald01

Figure 8.1 Waste by source



Construction waste is the most significant type

From the total 11.3 million tonnes of waste, mixed construction waste accounts for the highest share with 28 per cent in 2015, see figure 8.2.

1.4 million tonnes mixed municipal waste

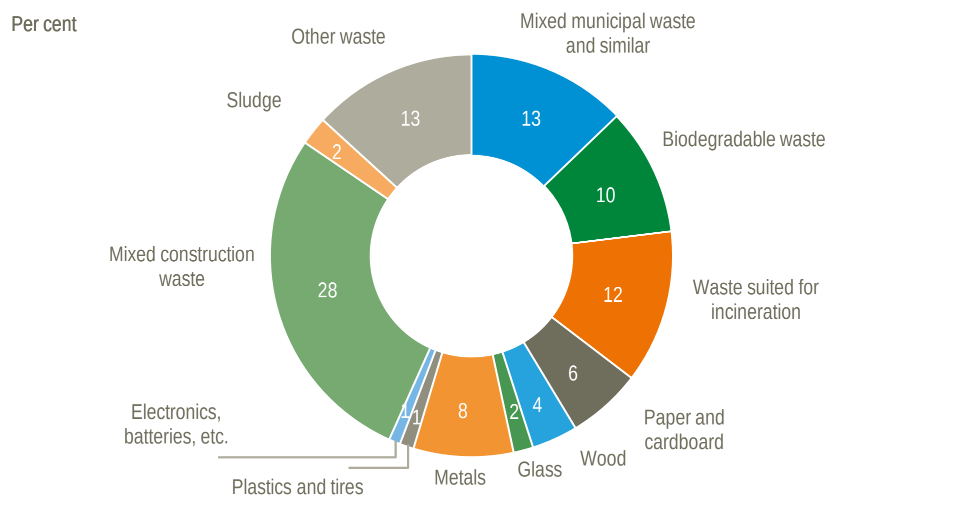
Mixed municipal waste accounts for 13 per cent of the total quantity of waste. Households are the biggest source of mixed municipal waste. Mixed municipal waste accounts for 1.4 million tonnes or 41 per cent of household waste, whereas it only accounts for 74,000 tonnes or approximately 1 per cent of industrial waste. Table 8.1 shows the share of waste types amongst households and industries.

The composition of industrial waste varies significantly between industries. The construction industry, which is the largest contributor to the total quantities of waste, naturally contributes mixed construction waste in particular. Businesses operating in trade and transport tend to generate waste suited for incineration as well as paper and cardboard waste.

The manufacturing industry generates 1.2 million tonnes of waste

The quantity of waste from the manufacturing industry was 1.2 million tonnes in 2015, corresponding to 11 per cent of the total quantity of waste or 15 per cent of total industrial waste. Most of the manufacturing industry waste came from the manufacture of food products, beverages and tobacco (31 per cent), followed by basic metals and fabricated metal products (15 per cent), see figure 8.3

Figure 8.2 The composition of the total quantity of waste. 2015



11 per cent of manufacturing waste is hazardous

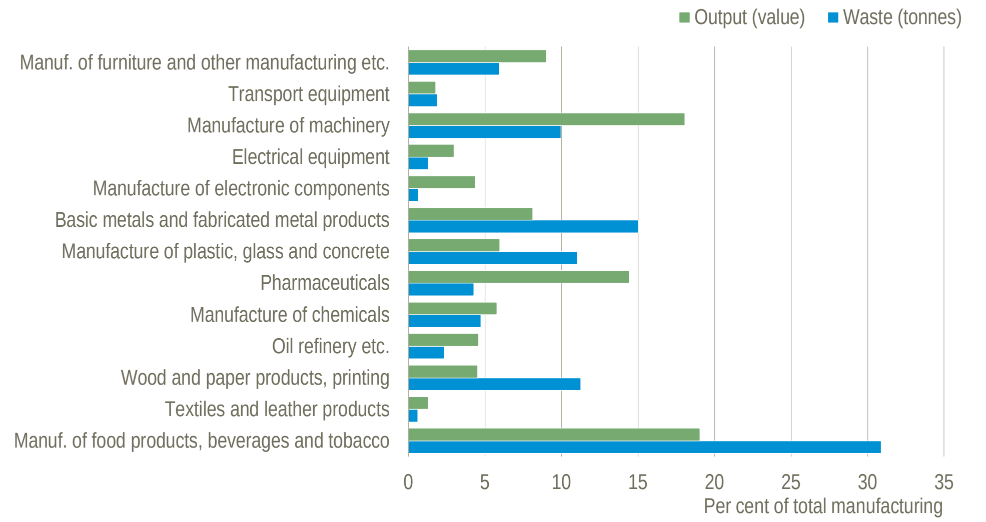
The manufacturing industry's hazardous waste accounted for 136,000 tonnes in 2015. This corresponds to 11 per cent of the total quantity of manufacturing industry waste of 1.2 million tonnes.

Table 8.1. The composition of waste from industries and households. 2015

	Waste, total	Mixed municipal waste and similar	Bio-degradable waste	Waste suited for incineration	Paper and cardboard	Wood	Glass	Metals	Plastics and tires	Electronics, batteries, etc.	Mixed construction waste	Sludge	Other waste
	1,000 tonnes												
All sources	11 307	1 448	1 159	1 394	676	418	179	906	128	104	3 144	259	1 493
Households	3 353	1 374	707	399	247	189	130	140	41	58	-	-	69
Industries, total	7 954	74	452	995	428	229	49	767	86	46	3 144	259	1 423
Agriculture, forestry and fishing	139	2	38	38	1	19	0	7	11	0	-	18	5
Mining and quarrying	16	0	0	1	0	0	0	3	0	0	-	0	11
Manufacturing	1 201	8	154	147	126	50	12	239	32	7	-	78	348
Utility services	878	4	9	22	4	6	1	27	2	2	-	147	653
Construction	4 162	2	46	208	3	120	16	321	5	4	3 144	4	290
Trade and transport etc.	1 095	30	122	372	249	24	17	148	32	19	-	6	75
Other industries	462	27	82	207	45	11	2	23	5	13	-	7	41

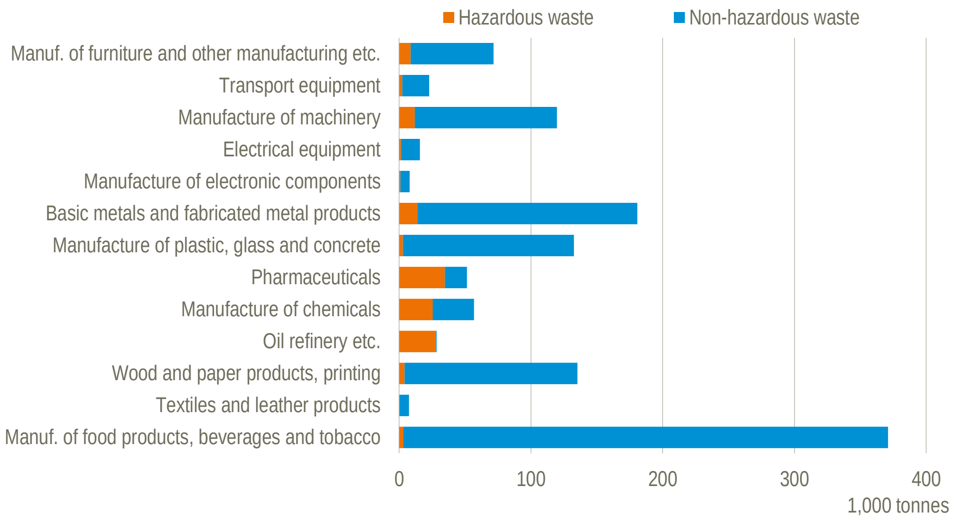
Note: Soil waste from construction is not included.

Figure 8.3 Manufacturing waste and value of output. 2015



The manufacturing industry's hazardous waste comes mainly from oil refineries etc., manufacture of chemicals and pharmaceuticals (see figure 8.4). Together, the three industries generated 88,000 tonnes of hazardous waste in 2015 – corresponding to 64 per cent of all of the manufacturing industry's hazardous waste. Their share of the manufacturing industry's non-hazardous waste is only 5 per cent. Manufacturing of food products, beverages and tobacco generates 35 per cent of the non-hazardous manufacturing waste but only 2 per cent of the hazardous manufacturing waste.

Figure 8.4 The manufacturing industry's waste by hazard degree. 2015



Hazardous waste comes mainly from construction

Only 0.6 million tonnes of the total 11.3 million tonnes of waste generated in Denmark is hazardous waste. Construction is the industry generating the largest quantity of hazardous waste. In 2015, it generated 266,000 tonnes. This includes construction waste containing PCB or asbestos. Hazardous waste accounts for 6 per cent of the total quantity of waste from the construction industry.

8.2 Preventive measures and recycling of waste

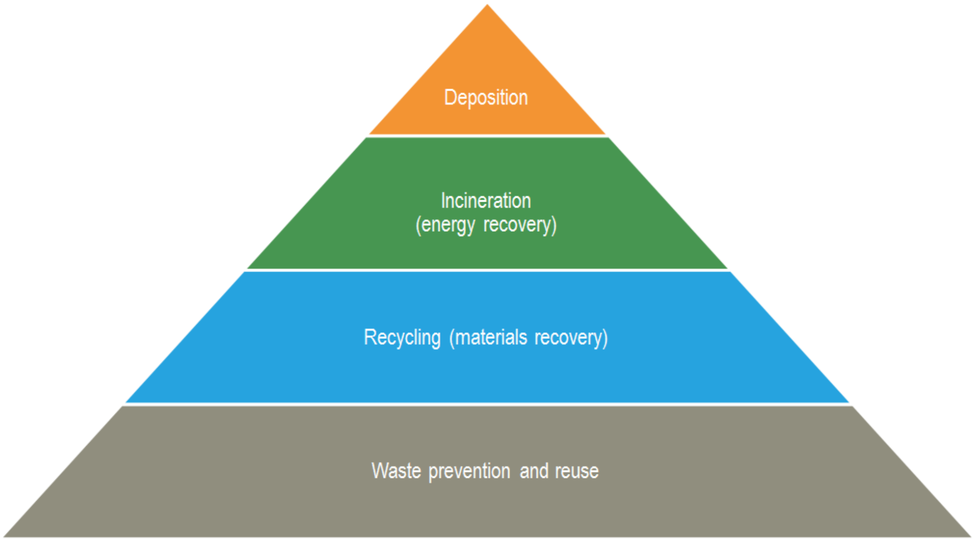
Resource strategy

In 2013, the Danish government then in office adopted a resource strategy "Denmark without waste" which together with a waste management plan for 2013-2018 constitutes the management basis for waste management in Denmark, including the fulfilment of requirements in the EU waste directive. In general, the plan aims to increase recycling and reduce the incineration of waste (Danish Environmental Protection Agency, 2014c).

The Danish objectives concerning waste are linked to the waste hierarchy. The hierarchy can be illustrated as layers in a pyramid, see figure 8.5. In relation to the resource strategy, the layers in the pyramid are prioritised so that the further down a layer is in the pyramid, the more important it is. Accordingly, waste prevention and recycling are the most important objectives of the strategy. Waste prevention can be in the form of e.g. more repairs and pervasive use of products with an extended product life cycle. Reuse is e.g. passing used baby clothes on or selling them instead of throwing them out.

Recycling is the next layer on the way towards the top of the pyramid. The difference between recycling and reuse is that in recycling the waste undergoes processing before it is turned into new products, e.g. paper waste that is converted to new paper pulp, or plastic waste that is converted to granulate. Recycling is also called materials recovery. Energy recovery comes after recycling – here the materials are lost, but the energy created in connection with the waste incineration is utilised. The lowest priority in the pyramid is deposition, which concerns waste stored in landfills etc. In Denmark, it is only legal to deposit waste which cannot be reused or incinerated in any environmentally sound way, such as asbestos and PCB.

Figure 8.5 The waste hierarchy



Waste prevention = less waste

All things being equal, waste prevention and reuse will result in decreased quantities of waste. It must be expected that the increased attention on the circular economy, e.g. via the resource strategy, will eventually lead to decreased quantities of waste compared to a scenario dominated by the "use and throw away" mentality.

Waste prevention has not had a major impact in 2011-2015

Based on the figures available, there is no clear indication that Denmark's waste prevention strategy has had a major impact. The quantity of waste generated has been quite stable in the years 2011-2015.

That said, the total quantity of waste did decrease 2.0 per cent in 2015 compared to 2014. Measured by waste intensity, i.e. the quantity of waste generated per unit GDP, the decrease from 2014 to 2015 was 3.5 per cent.

For industries, an alternative measure of waste intensity is obtained by looking at the waste generated in relation to their economic output. Every year between 2011 and 2015, Danish industries have generated close to 2.4 tonnes of waste per DKK 1 million of output (chained volumes, 2010 prices), meaning no clear sign of decoupling between industrial output and waste generation has been seen.

For household waste, it is more natural to look at waste in relation to consumption. In 2011, 4.0 tonnes of household waste were generated per DKK 1 million of consumption (chained volumes, 2010 prices). This indicator has decreased a little and was 3.9 tonnes in 2015.

However, we recycle more waste

More progress has been made towards increased recycling. In recent years, the percentage of waste recycled has gone up. In 2015, 68 per cent of total waste was collected for recycling. This is an increase on 2011 where the figure was 62 per cent. In 2015, 26 per cent of the waste was sent for incineration, whereas only 5 per cent was deposited or sent for special treatment (figure 8.6).

Recycling from households

The quantity of household waste largely remained unchanged from 2011 to 2015 (see figure 8.1), but a higher share of the household waste is collected for recycling – 1.5 million tonnes in 2015 in contrast to 1.3 million tonnes in 2011. In per cent values, 46 per cent of the household waste was collected for recycling in 2015, in contrast to 38 per cent in 2011.

Figure 8.6 Waste by treatment form

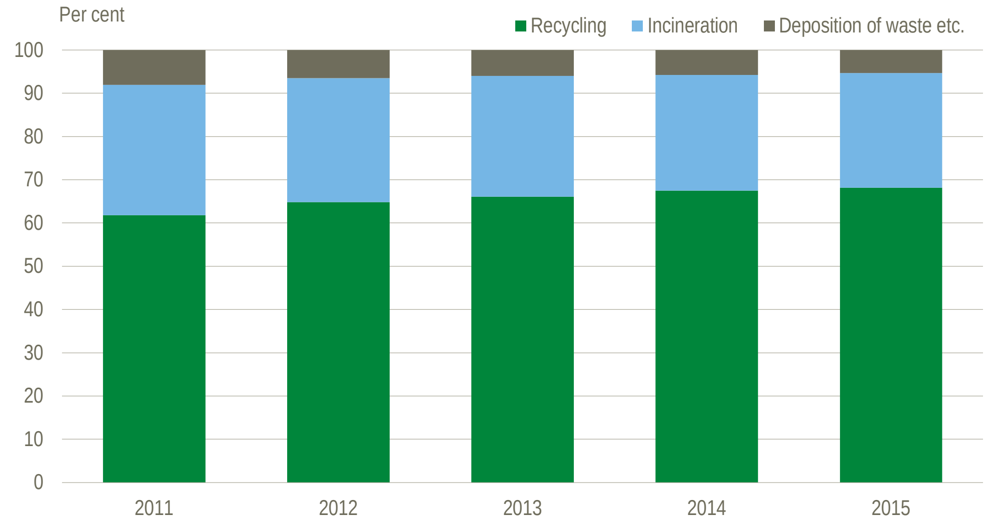
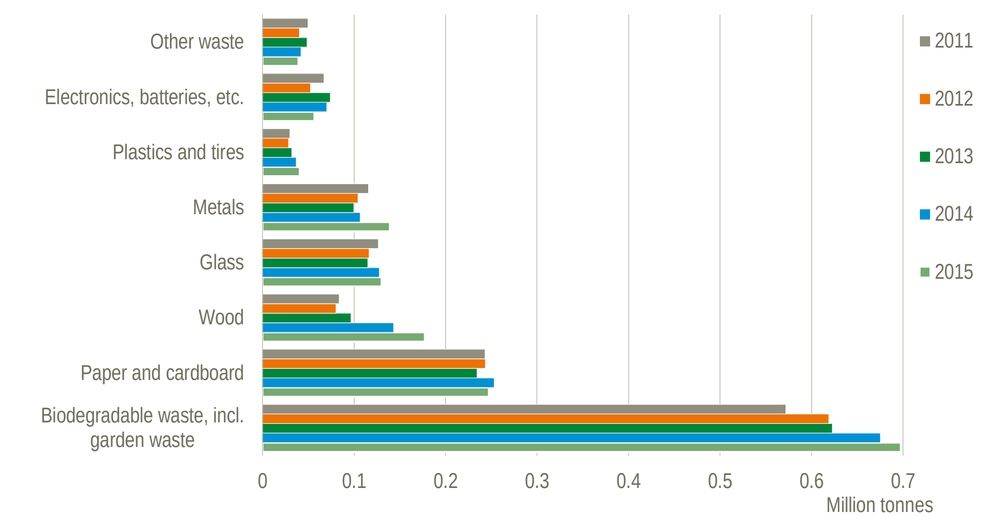


Figure 8.7 shows which types of waste are collected for recycling from households. Garden waste and wood in particular have begun to be collected more frequently for recycling. Paper and cardboard is the second most recycled type of waste. The collected quantities of paper and cardboard have been fairly stable throughout the period.

The household waste that is not collected for recycling (but is primarily incinerated) is mainly classified as mixed municipal waste as well as waste suited for incineration. However, this does not mean that all of the recycling potential has been exhausted. Mixed municipal waste may contain e.g. cardboard or organic waste which could have been recycled if it had been collected separately.

Figure 8.7 Household waste collected for recycling by type of waste



Industrial waste has a higher rate of recycling than household waste

In general, industrial waste has a higher rate of recycling than household waste. For waste from construction, the rate of recycling is 87 per cent, while 67 per cent of the waste from the remaining industries is collected for recycling. The figure covers significant differences between industries. In 2015, 57 per cent of the retail industry's waste was reused. The share is increasing – in 2011, only 42 per cent was reused.

Manufacturing industries with high quantities of waste have high rates of recycling

The five industrial groups in the manufacturing industry that generate the most waste (manufacture of food products; beverages and tobacco; basic metals and fabricated metal products; wood and paper products and printing; manufacture of plastic, glass and concrete; and manufacture of machinery) all have waste recycling rates between 73 and 84 per cent. This is higher than the average recycling rate for the manufacturing industry which is 71 per cent. The manufacture of chemicals has the lowest rate of reuse (22 per cent) within the manufacturing industry. The differences in rate of recycling are due to differences in the composition of the waste, including the amount of hazardous waste generated in the various manufacturing industries (see figure 8.4).

If we look at e.g. waste of paper and cardboard, two types of waste that are collected for recycling on a large scale, it appears from the waste accounts that 339,000 tonnes of waste paper and 336,000 tonnes of cardboard waste were collected in 2015. The sources of the waste paper and cardboard waste are shown in figure 8.8.

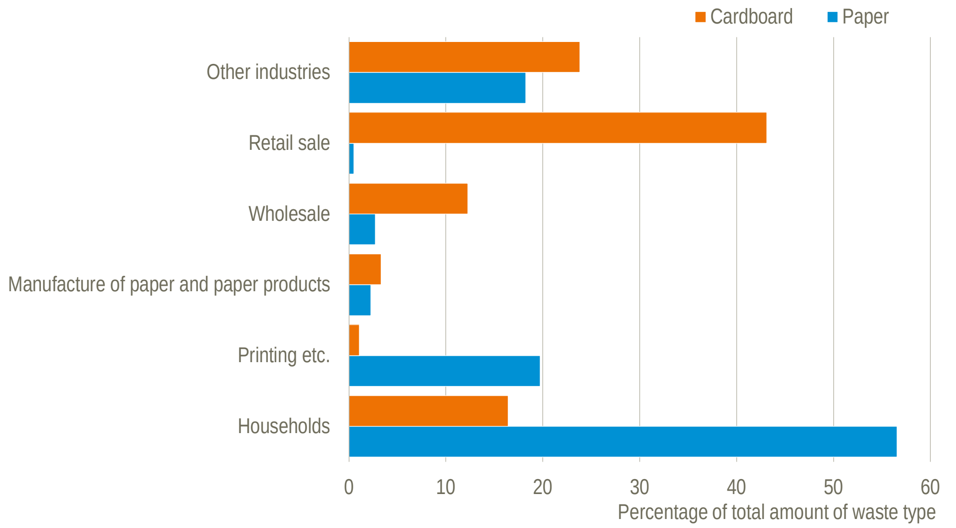
Waste paper from households and printing houses

The waste paper (e.g. newspapers and advertising matter) comes mainly from households (57 per cent), while the printing houses are another significant source of collected waste paper (20 per cent).

Cardboard waste from trade

Cardboard waste is mainly collected from the retail trade – 43 per cent is from shops and stores. Cardboard waste from the wholesale trade accounts for 12 per cent of the total. Accordingly, the wholesale trade and retail trade together account for more than half of the collected cardboard waste. From households, 55,000 tonnes of cardboard waste are collected – corresponding to 16 per cent of the collected cardboard waste in Denmark.

Figure 8.8 Sources of collected waste paper and cardboard waste. 2015



8.3 Recycling in a European perspective and external trading in waste

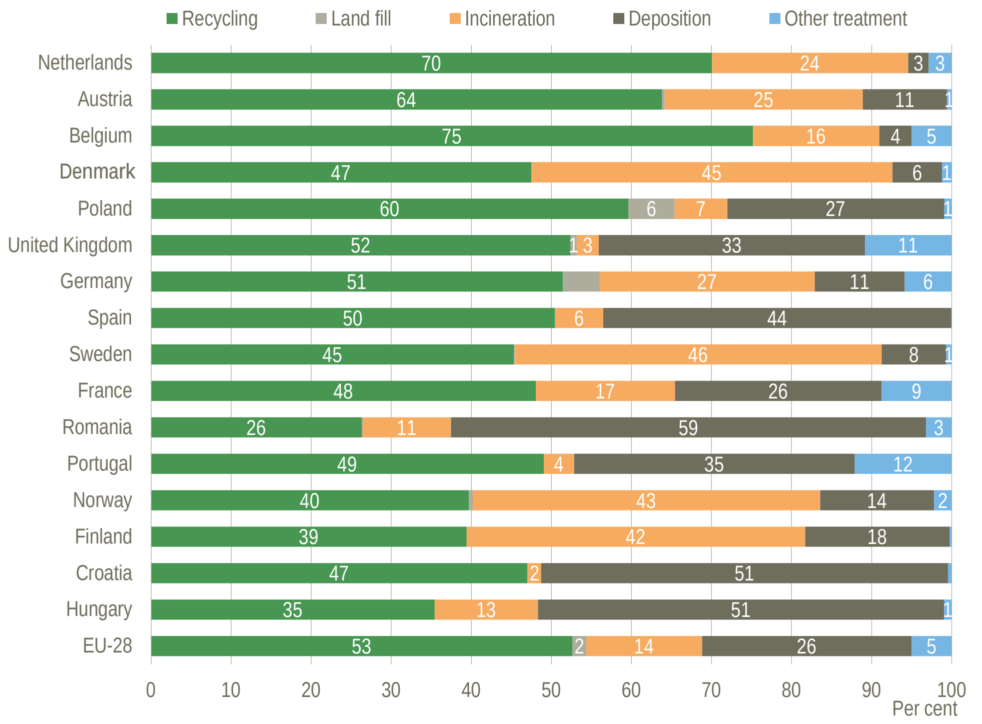
Denmark does not have a high rate of recycling in a European perspective

In 2014, more than half of the waste in the EU-28 was recycled, according to the assessment method used by Eurostat, see figure 8.9. The Danish recycling rate comes to 47 per cent when the Danish figures are assessed by the same method. The difference between the waste accounts and the figures stated above is due to two factors. First, Eurostat calculates waste *treated* in Denmark, whereas the waste accounts calculate waste *produced* in Denmark. Since Denmark exports waste for recycling and imports waste for incineration, the rate of recycling in Eurostat's statistics is lower than in the waste accounts. Second, the figures in figure 8.9 have been calculated without including major mineral wastes. Major mineral wastes are mainly construction waste and mining waste. This is excluded for the sake of comparability between countries.

High rate of incineration and low rate of depositing

Like the other Nordic countries, Denmark has a high rate of waste incineration from a European perspective. In addition, only a very low rate of waste is deposited in Denmark (6 per cent). For the EU-28, the rate of waste deposited is 26 per cent.

Figure 8.9 Waste by treatment form in selected European countries and the EU. 2014



Note: The figure shows "waste, excl. major mineral waste", i.e. soil, mining waste, construction waste etc. has been left out for the sake of comparability between the countries. Accordingly, full consistency is not obtained between the Danish figures in this figure and the figures in figure 8.6. Other treatment forms include also incineration without energy utilisation.

Source: Eurostat

Declining rate of Danish waste is incinerated

The quantity of Danish produced waste that is incinerated is declining. From 2011 to 2015, the quantity of household waste for incineration has declined from 2.0 million tonnes to 1.7 million tonnes. Industries are also sending less waste for incineration: 1.3 million tonnes in 2015 against 1.4 million tonnes in 2011. The Danish quantities of incinerated waste have dropped altogether by 0.4 million tonnes (11 per cent) since 2011.

Import of waste for incineration

From 2011 to 2015, the import of waste for incineration has increased by 0.4 million tonnes. This corresponds roughly to the decline in Danish waste collected for incineration in the same period. In 2015, Denmark imported 1.2 million tonnes of waste in total, half of which was incinerated. In 2011, 0.5 million tonnes of waste was imported, 30 per cent of which was incinerated.

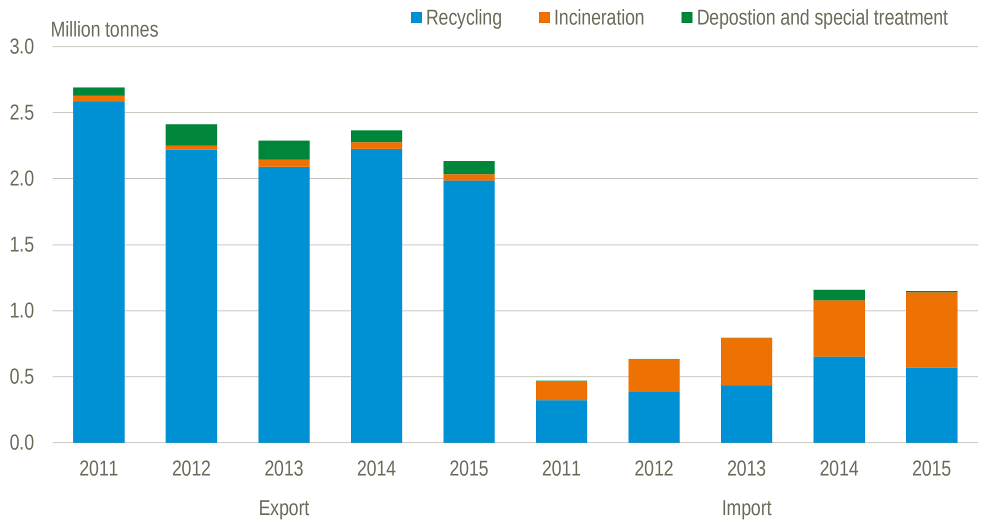
In addition to waste suited for incineration, hazardous waste for special treatment as well as iron and metal and a number of other types of waste for recycling are imported.

Export of waste intended for recycling

Denmark exported 2.1 million tonnes of waste in 2015. The export of waste has been declining from 2011 to 2015. The exported waste is predominantly recycled abroad and includes iron and metal, paper, cardboard and residue from incineration (slag and ash). Export and import of waste is related to the countries' recycling capacities – e.g. Denmark has no steelworks that receive scrap and only a very small paper industry.

Figure 8.10

Export and import of waste



8.4 The connection between household consumption and the quantities of industrial waste

1.1 tonnes of household waste per family

Household consumption results in a great deal of waste. The waste arises e.g. when packaging is tossed away, food scraps are tossed in the bin, and when an old TV is taken to the waste recovery site. In 2015, Denmark generated 3.4 million tonnes of household waste, which corresponds to 1.1 tonnes per family.

The production for our consumption generates industrial waste

Household consumption is also the underlying reason for the creation of large quantities of waste in industries. E.g. when we buy a litre of milk, waste is generated at the dairy, at the supermarket, at the farm which produced the crude milk etc. This list extends to all the other industries providing input for the production and distribution of milk.

On the face of it, the connection between household consumption and the associated quantities of industrial waste cannot be observed. But on the basis of the waste accounts, the connection can be calculated subject to certain assumptions.[2]

0.7 tonnes of industrial waste due to consumption per family

The calculations show that household consumption causes 27 per cent of the industrial waste – i.e. 2.2 million tonnes altogether or 0.7 tonnes per family. However, the largest proportion of total industrial waste (39 per cent) is not due to household consumption but can be put down to investments (capital formation). This is because construction waste is very heavy and that the construction of new buildings is considered to be investment. One quarter (24 per cent) of industrial waste is due to export, while the remaining 10 per cent is the result of public spending, including consumption in non-profit organisations.

Consumption groups and industrial waste can be interlinked

Figure 8.11 shows household consumption distributed over 11 main categories and how much industrial waste is connected with these categories. On the horizontal axis, total consumption is stated in DKK million, whereas the vertical axis shows

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[2] The quantification of the connection between the household consumption and the quantities of industrial waste is made by means of a input-output model. This is described in more detail in a previously published analysis (Vind and Rørmose Jensen, 2016), on which this section is based. The figures have been updated to 2015 for this publication compared to the original analysis, but the method is unchanged.

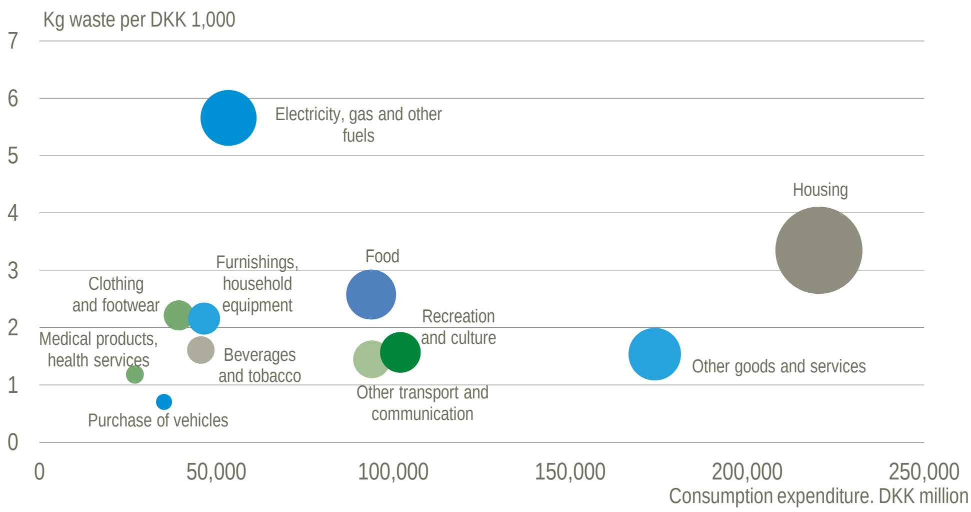
how many kilograms of waste are generated per DKK 1,000 of consumption. The size of each circle represents the total quantity of waste generated by each of the 11 main groups of consumption.

Highest share of waste connected to the use of housing

The largest item of consumption, measured in DKK, is the use of housing, which includes rent (including a calculated rent for owner-occupied dwellings), maintenance of housing, payment of water and wastewater charges and refuse collection. It is also the use of housing that generates the most waste in production (737,000 tonnes). Of particular relevance here is construction waste from repairs and maintenance of owner-occupied dwellings as well as rented housing.[3] Waste in the form of sludge from water treatment plants is included in the consumption category use of housing, as it is connected to our use of the sewerage system (wastewater charges). This waste is also rather weighty.

Figure 8.11

Household consumption and Danish industrial waste caused by consumption. 2015



Electricity, gas and heating generates the most waste per DKK of consumption

Following after the use of housing, it is the use of electricity, gas and heating which causes the most waste in production. In particular, there are large quantities of waste from power plants: slag from incineration and gypsum from flue gas treatment. Consumption of electricity, gas and heating generates 302,000 tonnes of industrial waste. If the quantity of waste is calculated in relation to consumption expenditures, then this consumption category is the most waste-intensive – every DKK 1,000 of consumption generates 5.7 kg of waste.

Waste generated abroad is not included

In total, consumption of housing, electricity and heating is responsible for almost half (48 per cent) of the Danish industrial waste resulting from household consumption. Next is food and the group "other products and services" which includes e.g. consumption in restaurants, hotels and haircuts, as well as purchase of toiletries, jewellery and insurance. Consumption of food results in 241,000 tonnes of industrial waste. This corresponds to 2.6 kg of industrial waste per DKK 1,000 of consumption. Purchase of vehicles results in only 0.7 kg of Danish industrial waste per DKK 1,000 of consumption. This is not because the manufacturing of cars does not generate waste, but because Denmark primarily imports cars and other vehicles. Only waste generated in Denmark is calculated in the waste accounts, and accordingly figure 8.11 does not show the complete global footprint of waste generated by Danish consumption.

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[3] Waste from construction of new houses is not included, since this category is not considered to be consumption but rather to be an investment.

8.5 The economics of waste

Economic activities connected to waste

In addition to the fact that there is a link between the economic activities of industry and households and the physical quantities of waste, waste is also of interest in relation to the economic activities connected to the collection and treatment of the waste.

Businesses and households accrue costs in both the disposal and responsible management and treatment of their waste. These costs, however, provide income to the businesses, municipal companies and municipalities which together represent the Danish waste industry. In other words, physical waste flows are followed by financial flows.

The economics of waste have not yet been sufficiently documented in the green national accounts for Denmark. However, some of the economic transactions connected to waste can be documented based on the Danish national accounts and Statistics Denmark's household budget survey.

Waste collection and treatment worth DKK 14 bn

In 2015, the Danish waste industry produced DKK 14 billion of services linked to waste. The largest part (DKK 11.3 billion) was related to the disposal and collection of waste. Treatment of waste in the form of incineration, depositing and recycling (sorting, crushing, etc.) amounted to DKK 2.7 billion. These amounts are calculated in the national accounts' basic prices, which are exclusive of taxes and VAT.

Households pay DKK 2 per kg of waste

In 2015, a household spent an average of DKK 2,600 (incl. VAT) on refuse collection.[4] Compared to the amount of household waste and the number of households, it means that the households pay an average of DKK 2 per kg of waste they dispose of. This is calculated in purchaser's prices, including VAT.

The implicit price for the management and treatment of industrial waste, which can be calculated based on the above, is significantly lower than for household waste. In addition to a certain price differentiation with the waste management companies and economies of scale, a contributing factor to the industries' lower costs per kg of waste is the fact that a higher share of industrial waste (e.g. iron and metal) can be sold for recycling. To a certain extent, the companies can also defray the waste costs as internal expenses, if e.g. they transport waste for treatment themselves.

Waste is also a source of energy

A substantial part of the waste economy is the use of waste as a fuel for energy production. Accordingly, the waste industry's revenues do not only originate from collection and treatment of waste, but also from the sale of energy. In 2015, the waste sector produced district heating and electricity for DKK 3.3 billion.

Taxes on waste for depositing and incineration

Waste that is deposited is subject to a tax. In 2016, the state's proceeds from this tax were DKK 155 million. Waste for incineration is subject to an energy tax and to taxes on emission of sulphur, NO_x and CO_2. All taxes on waste are included in the assessment of environmental taxes, see chapter 11.

Further documentation of the manufacturing industry's expenses for waste management can be found in chapter 10. Chapter 10 also contains information about public environmental protection expenditure, including expenditure in relation to waste.

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[4] Household Budget Survey, www.statbank.dk/fu10

Box 8.1 About the waste accounts

The waste accounts assess the amount of waste generated in various parts of the economy, the types of waste concerned and how it is treated. The waste accounts are based on data from the Danish Environmental Protection Agency. The data is distributed by Statistics Denmark according to the 117 industrial groups which are used throughout the green national accounts.

The waste accounts for 2014 and 2015 are preliminary.

More information:
http://www.statbank.dk/10294
https://www.dst.dk/en/Statistik/dokumentation/documentationofstatistics/waste-accounts

9 Environmental goods and services

Global and regional targets for green transition

Environmental policy and resource policy targets are generally afforded high priority throughout the world. On a global level, this takes the form of goals for climate protection and sustainability. In a European context, targets have been set in a number of areas, from encouraging more efficient energy consumption and increasingly recycling, to protecting groundwater and surface water, for example.

In many situations, attempts to achieve the many targets are seen solely as a cost and, therefore, an impediment to economic growth. However, in reality, the political targets often result in the creation of new jobs and new products and processes, all of which can drive economic growth.

Environmental goods and services sector, EGSS

The accounts for the *environmental goods and services sector (EGSS)* provide a picture of the economic activity resulting from the transition to a green economy. This economic activity is measured in terms of output, employment, value added and exports, i.e. figures that can be compared with figures for the total economy.

By purpose and industry

Economic activities within the area of environmental goods and services are compiled according to environmental purpose (environmental protection and resource management purposes) as well as industry. Calculating according to environmental purpose helps show e.g. whether concrete environmental targets are being met, while compiling by industry can help show the potential in an industrial policy context.

Environmental protection and resource management

The environmental goods and services accounts describe the economic aspects of the production of environmentally friendly goods and services. In accordance with the international guidelines for these accounts, environmentally goods and services refer to goods and services that protect the environment directly and goods and services designed for natural resource management. Research and development in these fields is also included.

Specific products and cleaner products

Furthermore, a distinction is made between goods and services with a specific environmental purpose (e.g. wind turbines) and products that are cleaner and more resource-efficient compared to other products with the same primary purpose (e.g. water-saving taps). It can be difficult to accurately identify environmental goods and services and these reports are therefore subject to significant uncertainty.

The following sections

Section 9.1 will describe the turnover generated by the production of environmental goods and services in Denmark. Focus is on the environmental purposes and on the industries involved in the production. Section 9.2 will describe how much employment that are involved in production of environmental goods and services. Section 9.3 deals with Danish environmental exports and imports, while section 9.4 compares the turnover from environmental goods and services across countries in the EU.

9.1 Danish production of environmental goods and services

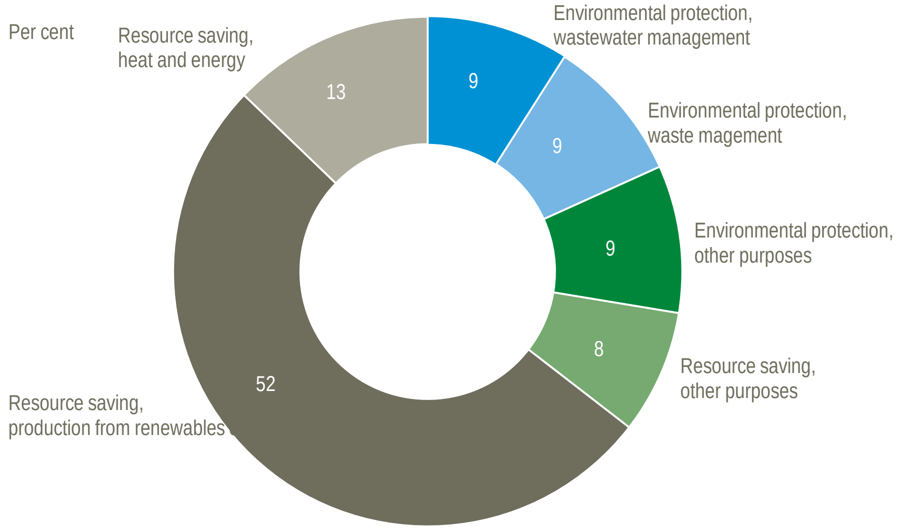
Environmental production in Denmark totalling more than DKK 200 billion

The market for environmental goods and services in Denmark generated a turnover of DKK 214 billion in 2016. Figure 9.1 and table 9.1 show turnover by 16 environmental purposes and 6 types of industry. Goods and services with resource-saving purposes accounted for the majority of turnover, i.e. 72 per cent. Goods and services with environmental protection purposes accounted for the remaining 28 per cent of turnover. When broken down by the nature of the products (i.e. by specific environmental products and cleaner or resource-saving products), 71 per cent of turnover came from specific activities and 29 per cent from cleaner or resource-saving products (see table 9.3).

Production of renewable energy is the most prominent purpose...

The production of goods and services in the field of renewable energy accounts for just over half (52 per cent or DKK 110 billion) of the environmental production in Denmark. This includes the production of wind turbines in particular, but also the construction of biogas plants and the installation of photovoltaic solar cells. The output of electricity and heating from renewable sources are also included.

Figure 9.1 Turnover from environmental goods and services, by environmental purpose. 2016



...but traditional environmental protection purposes also play a significant role

Waste management and *wastewater management* account for major shares of turnover with almost DKK 20 billion and slightly more than DKK 19 billion, respectively. These are predominantly traditional environmental services. There is increasing turnover in both these areas, and this is evidence of increased activity. The large increase in *wastewater management* from 2014 to 2015 is, however, deemed to be the result of improvements made to the questionnaire, which meant that more environmental construction and service activities were included.

Table 9.1 Turnover from environmental goods and services, by environmental purpose

	2014	2015	2016
	DKK million		
Environmental goods and services, total	174 159	198 019	213 705
Environmental protection, total	48 375	57 071	59 017
Protection of ambient air and climate	5 746	7 762	8 358
Wastewater management	14 771	19 344	19 312
Waste management	18 612	19 058	19 745
Protection of soil, groundwater and surface water	6 915	8 209	8 794
Noise and vibration abatement	886	1 013	1 064
Protection of biodiversity and landscape	410	535	536
Environmental research and development	530	416	429
Other environmental protection activities	505	733	778
Resource management, total	125 784	140 948	154 688
Management of water	2 069	2 962	2 839
Management of forest resources	4 015	4 487	4 601
Production of energy from renewable resources	86 694	96 808	110 458
Heat/energy saving and management	24 355	27 343	27 382
Minimisation in use of raw materials	2 834	3 536	3 556
Management of minerals (iron, metals and glass)	1 886	2 200	2 214
Research and development for resource management	2 107	2 221	2 288
Other resource management activities	1 824	1 391	1 350

Note: Developments from 2014 to 2015, e.g., in the area of wastewater, are partly due to the fact that the questionnaire was changed.

Many areas with limited turnover

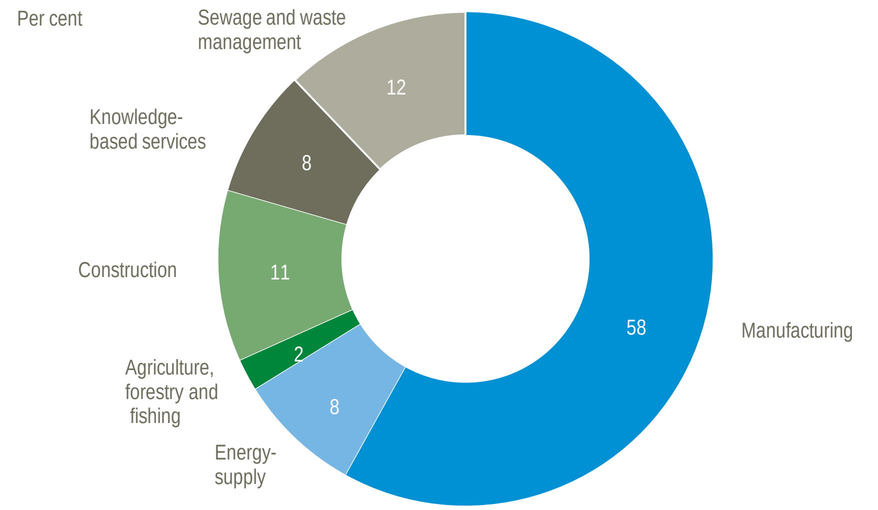
Among the 16 environmental purposes, three have estimated turnover of less than DKK 1 billion, while another seven have been estimated at between DKK 1 and 5 billion. Among the medium-large areas are *protection of ambient air and climate* and *protection of soil, groundwater and surface water* with DKK 8.4 and 8.8 billion respectively in 2016. However, it is important to note that several of the purposes are closely related to one another and that some activities could meet several purposes, and that this is unlikely to be fully reflected in these statistics. The breakdown by purpose can never be entirely accurate.

Contributions from many industry groups

Looking at who produces the environmental goods and services, *manufacturing* accounts for 58 per cent, corresponding to a turnover of DKK 124 billion, see figure 9.2. The products behind this figure are wind turbines in particular, but also a large number of other products that contribute to resource savings or environmental improvements. The second largest industry group is *sewerage and waste management*, which accounts for 12 per cent of total turnover. This includes specialised industries within environmental protection, e.g. wastewater treatment. At 11 per cent, or around DKK 24 billion, *construction* is the third largest contributor to turnover. The smallest contributor is *agriculture, forestry and fishing*. Here, organic farming and certified sustainable forestry together accounted for a turnover of DKK 4.6 billion, corresponding to the bulk of the 2 per cent indicated in figure 9.2.

Figure 9.2

Turnover from environmental goods and services, by industry group. 2016



Many active industries in the area of environmental activities

The *manufacture of machinery* stands out with regard to turnover from environmental goods and services, in that this industry accounts for 41 per cent of total environmental turnover and 71 per cent of total environmental turnover in manufacturing. Within manufacturing, however, there was also environmental production worth DKK 6-9 billion in the *manufacture of chemicals*, the *manufacture of plastic, glass and concrete*, and the *basic metals and fabricated metal products*, respectively, see table 9.2. The industries within *construction* contributed slightly less than DKK 24 billion, while *consultancy etc.* contributed slightly under DKK 15 billion. *Energy supply* is included in the statistics on the basis of its use of renewable energy sources: it contributed DKK 17 billion.

Several industries have limited or no activity

There are also industries with no or limited activity in the production of environmental goods. Furthermore, the name of an industry in the context of the national accounts is not all-encompassing regarding the economic activities undertaken by said industry. For example, the environmental activities referred to under the *manufacture of furniture and other manufacturing* are actually various environmental installation activities, while the manufacture of furniture is not considered an environmental activity.

Table 9.2

Turnover from environmental goods and services, by industry group

	2014	2015	2016
	DKK million		
Total	174 159	198 019	213 705
Agriculture, forestry and fishing	4 208	3 999	4 575
Textiles and leather products	455	390	370
Wood and paper products and printing	3 785	4 635	4 671
Manufacture of chemicals	6 304	7 744	7 065
Manufacture of plastic, glass and concrete	8 343	6 580	6 887
Basic metals and fabricated metal products	7 421	8 291	8 982
Manufacture of electronic components	1 720	2 701	3 137
Electrical equipment	2 635	2 467	2 797
Manufacture of machinery	69 215	75 291	87 926
Transport equipment	1 169	872	889
Manufacture of furniture and other manufacturing etc.	527	1 180	1 328
Electricity, gas, steam and air conditioning supply	16 304	17 483	17 355
Sewerage and waste management	25 786	25 851	25 901
Construction	14 158	22 473	23 850
Consultancy etc.	9 326	15 157	14 964
Scientific research and development	2 637	2 637	2 717
Advertising and other business services	166	269	290

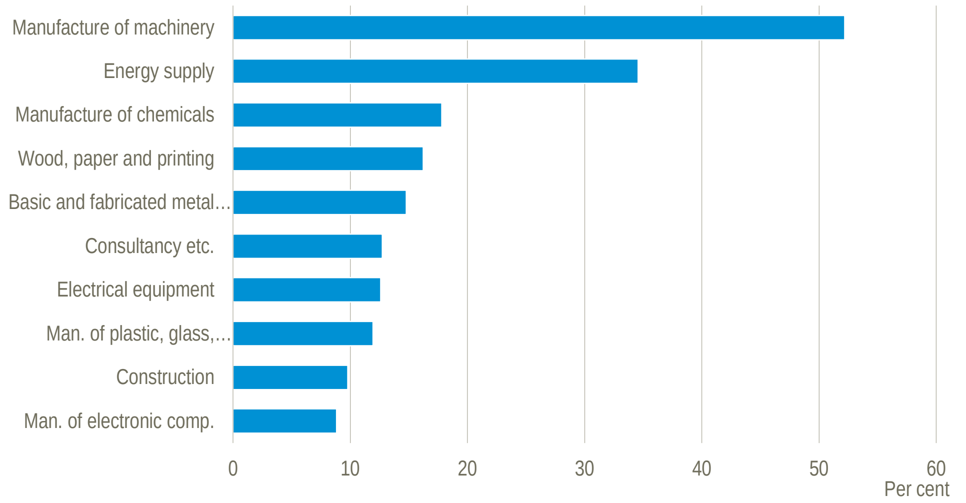
Note: Industries with no environmental production are not included in the table.

Environmental goods and services account for varying shares in the individual industries

The share of environmental production varies considerably across industries. 52 per cent of total turnover in the *manufacture of machinery* came from environmental goods, including wind turbines. At 35 per cent, *energy supply* had the second largest share by virtue of electricity and heating produced from renewable energy sources. Next in line are the *manufacture of chemicals* and industries related to wood and paper. Within construction as a whole, environmental activities account for slightly less than 10 per cent of total turnover.

Figure 9.3

Environmental goods and services as share of turnover by type of industry (selection). 2016



Note: Industries within renovation are not included as they work exclusively with environmental protection.

Industries contribute differently with regard to environmental purpose and product types

The activities of the different industries vary considerably with regard to both environmental purpose and type of activity. Almost half of total turnover comes from specific products within *resource savings*, see table 9.3. At DKK 94 billion, manufacturing accounts for by far the majority of this figure, and within manufacturing, the majority comes from wind turbines for electricity production. A total of DKK

41.6 billion comes from specific activities for *environmental protection*, of which the specific industries in the sewerage and waste management areas account for most. However, there were also considerable contributions from construction and knowledge-based services.

Table 9.3 Turnover from environmental goods and services, by industry group and environmental purpose. 2016

	Environmental protection		Resource saving		
	Specific products	Cleaner products	Specific products	Cleaner products	Total
	DKK million				
Industry, total	41 600	17 417	109 951	44 737	213 705
Agriculture, forestry and fishing	-	4 236	-	339	4 575
Manufacturing	4 511	7 227	93 735	18 581	124 053
Electricity, gas, steam and air conditioning supply	-	-	-	17 355	17 355
Sewerage and waste management	23 741	-	2 160	-	25 901
Construction	7 512	4 233	6 333	5 772	23 850
Knowledge-based services	5 837	1 721	7 722	2 690	17 971

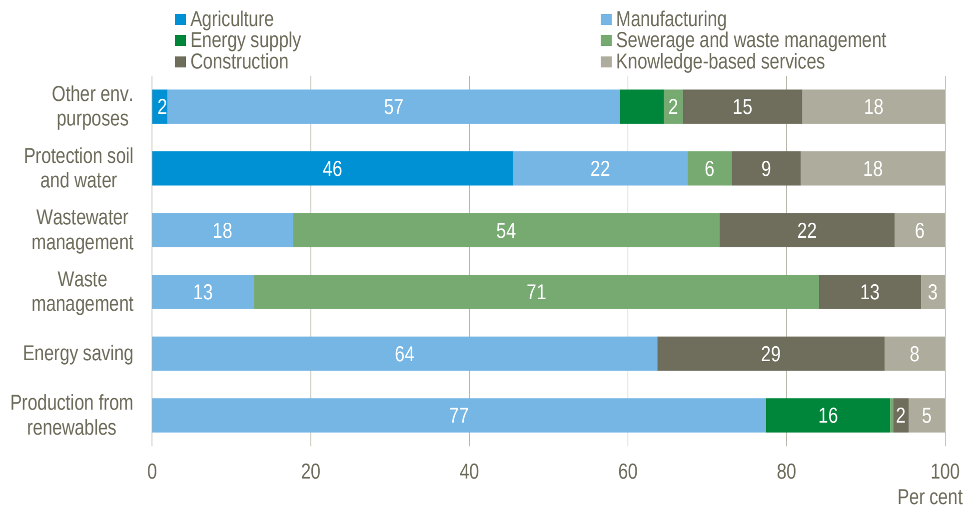
Cleaner and resource-saving activities worth DKK 62 billion

The non-specific activities, i.e. cleaner products, accounted for DKK 62 billion in total and for DKK 45 billion within resource savings alone. Activities covered by this figure are not directly targeted at environmental protection or resource savings, but involve production that leads to cleaner processes with fewer emissions, for example. Manufacturing accounted for DKK 18.6 billion in resource savings in terms of cleaner products, e.g. energy-efficient engines, products based on recycled materials etc. Electricity, gas, steam and air conditioning supply contributed around DKK 17 billion (based on these products being produced in a more environmentally sound way than other electricity and heating). With regard to environmental protection, products manufactured using cleaner technologies accounted for DKK 17.4 billion. This includes the value of organic farming products, as these are produced in a manner that is more protective of soil and groundwater than equivalent products.

Different industry group contributions by environmental purpose

Figure 9.4 shows the proportional contributions of enterprises by environmental purpose. With regard to the largest purpose in terms of turnover, i.e. *production of energy from renewable resources*, manufacturing is the most significant contributor at 77 per cent of the total turnover of DKK 110 billion. At 16 per cent, energy supply accounted for the second largest share. Building and construction contributed considerably with 29 per cent of savings in energy and heating. As is to be expected, the specific environmental protection industries – sewerage and waste management – accounted for the largest relative share when it comes to the environmental purposes wastewater management and waste management. However, there are also contributions from other industry groups, e.g. construction. In this industry group, environmental activities include waste management in the form of demolition tasks or construction of new wastewater and surface water treatment plants.

Figure 9.4 Turnover from environmental goods and services by industry group and by purpose. 2016



9.2 Environmental employment

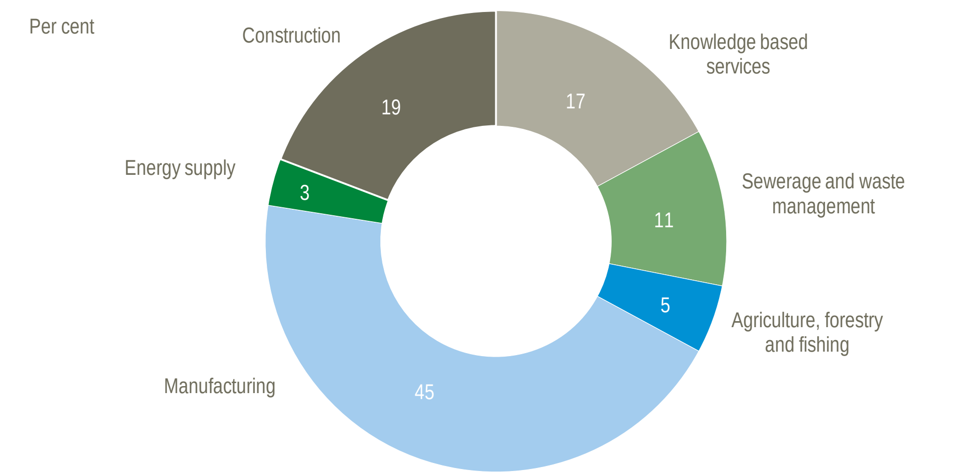
71,000 environmental jobs...

The economic scope of environmental goods and services can also be measured in terms of employment. These figures are based on turnover from environmental goods and on data from other statistics. The number of people employed in the production of environmental goods and services was 71,000 in 2016, in terms of full-time employees. This corresponds to slightly more than 3 per cent of total employment in Denmark.

... 26,000 are within environmental protection and 45,000 within resource management

Employment broken down by purpose shows that around 26,000 people (in full-time equivalent) worked with environmental protection and around 45,000 people worked with resource management. Based on the number of employees, the top five areas in the production of environmental goods and services in 2016 were, as follows: the production of renewable energy, involving 21,000 people; energy savings, involving 14,000 people; waste management and materials recovery, involving 8,300 people; wastewater management, involving 6,800 people; and the protection of soil, groundwater and surface water, involving 5,600 people.

Figure 9.5 Employment in environmental goods and services, by industry group. 2016



Largest employment shares in the labour-intensive industries

The majority of people employed in environmental production (45 per cent) work in manufacturing, while at 19.2 per cent construction makes up the second largest industry with regard to employment share. The labour intensity of the individual industries can be seen by comparing employment figures in the individual industries (figure 9.5) with the breakdown by turnover from environmental goods and services (figure 9.2). Labour intensity is indicative of how much the cost of salaries influences total costs in an industry. Among the industries examined, the most labour-intensive industries are construction (19.2 per cent of employment against 11.2 per cent of turnover) and knowledge-based services (17.1 per cent against 8.4 per cent). Manufacturing (45 per cent of employment against 58 per cent of turnover) and energy supply (3.3 per cent against 8.1 per cent), on the other hand, are not particularly labour-intensive. These two industries are to a higher degree characterised by production plants and goods consumption and are thus more influenced by a range of other costs besides salaries.

Environmental jobs most abundant in the manufacture of machinery

A more detailed breakdown by industry (see table 9.4) reveals that the greatest number of environmental jobs is in the manufacture of machinery, which had 17,600 full-time employees in 2016. Construction comes in second with 13,700 employees followed by consultancy, etc. with 9,200 employees. The fourth largest industry is sewerage and waste management, which had 7,900 full-time employed persons. Note that figures for water supply are not included as this activity is not in itself classified as environmental protection.

Table 9.4 Employment in environmental goods and services, by industry group.

	2014	2015	2016
	number of employees		
Industries, total	59 890	68 914	71 356
Agriculture, forestry and fishing	3 266	3 110	3 438
Textiles and leather products	184	143	152
Wood and paper products and printing	1 794	2 329	2 336
Manufacture of chemicals	2 461	2 817	2 488
Manufacture of plastic, glass and concrete	3 268	2 734	2 741
Basic metals and fabricated metal products	3 152	2 757	2 989
Manufacture of electronic components	945	1 333	1 522
Electrical equipment	1 011	891	872
Manufacture of machinery	15 230	16 268	17 615
Transport equipment	546	434	478
Manufacture of furniture and other manufacturing etc.	329	635	647
Electricity, gas, steam and air conditioning supply	2 077	2 395	2 349
Sewerage and waste management	7 472	7 992	7 854
Construction	9 326	13 142	13 690
Consultancy etc.	6 158	9 045	9 192
Scientific research and development	2 483	2 543	2 619
Advertising and other business services	189	347	375

Note: The relatively large increases in construction and consultancy etc. from 2014 to 2015 are assessed to be due to a more targeted questionnaire.

Many industries with 2-3,000 environmental jobs

The table also shows that a number of industries have 2-3,000 jobs categorised as environmental. *Manufacture of plastic, glass and concrete* and *wood and paper products and printing* are industries characterised by considerable use of recovered materials in new products. This relatively large number of environmental jobs is also found in the manufacture of chemicals, where it relates e.g. to the manufacture of enzymes and environmentally friendly products. It is noteworthy that 2,600 people are employed in environmental protection and resource saving activities within *scientific research and development*.

9.3 Environmental exports and imports

Considerable Danish exports

Denmark has significant exports of environmental goods and services; see table 9.5. The value of these exports has been estimated at around DKK 72 billion, which is 7 per cent of all Danish goods and services exports in 2015. In relation to total turnover from environmental goods and services, export figures show that slightly more than one third of production is exported. The export figures were estimated by assuming that the environmental share of exports by industry is the same as the environmental share of turnover. The statement includes exports of goods as well as services. Exports in 2016 have not yet been calculated, and the figures for previous years may be subject to revision.

Renewable energy the most prominent purpose

When divided according to environmental purpose (table 9.5), more than 60 per cent of exports (around DKK 45 billion) fall under the environmental purpose *production of energy from renewable resources*, to which wind turbines contribute. *Heat/energy saving and management* at around 14 per cent (DKK 10 billion) and *waste management* at 6 per cent (slightly over DKK 4 billion) of the turnover of environmental goods fall in second and third place, respectively.

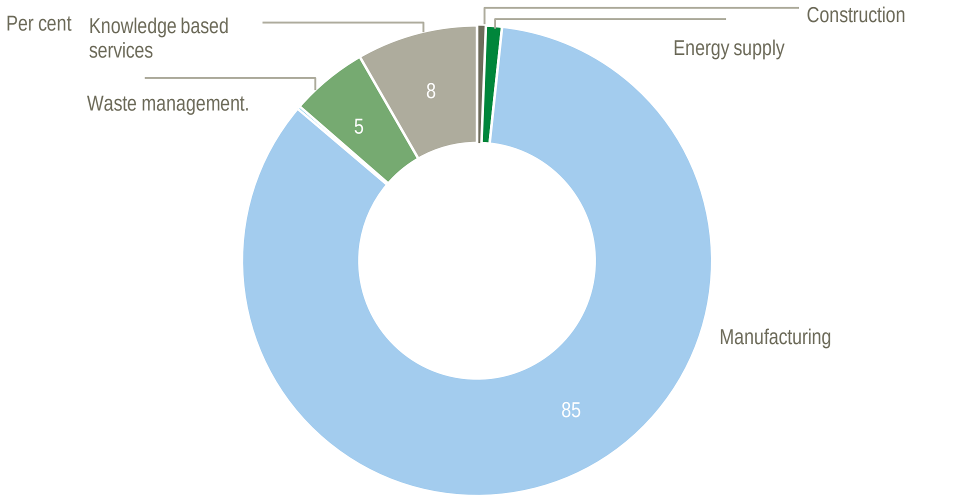
Table 9.5 Danish exports of environmental goods and services by environmental purpose

	2013	2014	2015
	DKK million		
Environmental goods and services, total	69 112	72 613	72 417
Environmental protection, total	11 208	11 937	11 890
Of which:			
Protection of ambient air and climate	2 668	2 454	2 798
Wastewater management	2 047	2 248	2 675
Waste management	4 235	5 317	4 080
Resource management, total	57 904	60 676	60 527
Of which:			
Production of energy from renewable resources	43 255	45 219	44 739
Heat/energy saving and management	9 302	9 659	10 291
Minimisation of use of raw materials	1 226	1 640	1 314

Manufacturing responsible for the vast majority of exports

As can be seen in figure 9.6, the vast majority of the exports of environmental goods and services (i.e. almost 85 per cent) come from manufacturing in the form of goods and equipment. The second largest share comes from knowledge-based services (8 per cent), while there is also a noteworthy contribution from waste management (5 per cent). The contribution from waste management primarily comes from trade in products for recycling. Exports are marginal for the other three types of industry. The reason why there are almost no exports of environmental goods from agriculture, horticulture and forestry is that only unprocessed organic goods count as environmental exports from agriculture.

Figure 9.6 Danish exports of environmental goods and services by industry group. 2015



International trade in environmental goods - based on commodity codes

Calculating on the basis of a list of environmental and partially environmental goods is an alternative, supplementary way of illustrating exports of environmental goods and services. While the results are not entirely consistent with those from the statements presented above, there is nevertheless a considerable degree of overlap. A commodity code analysis can thus provide further information on the exports of environmental *goods*, as well as highlighting information about imports. These statistics do not include services.

Machinery is the largest commodity group

As can be seen in table 9.6, based on the aforementioned commodity code method, exports of environmental goods can be estimated at around DKK 85 billion in 2016. It is also shown that these exports generally increased from 2011 to 2016. Various types of machinery comprise by far the largest commodity group, which is in keeping with the fact that, as noted previously, the manufacture of machinery accounts for the bulk of environmental production and exports. Electrical machinery and instruments come next. Chemical materials and products and plastics also make noteworthy contributions, which tallies with the industry's significance in the area of environmental goods and services. The commodity groups' shares of total environmental exports have remained more or less the same throughout the six years for which figures are provided. The only change is that the significance of the largest commodity group, power generating machinery and equipment, which includes wind turbines, increased considerably from the start of the period until the end of the period.

Table 9.6

Danish exports of environmental goods by type (SITC2) – commodity code method

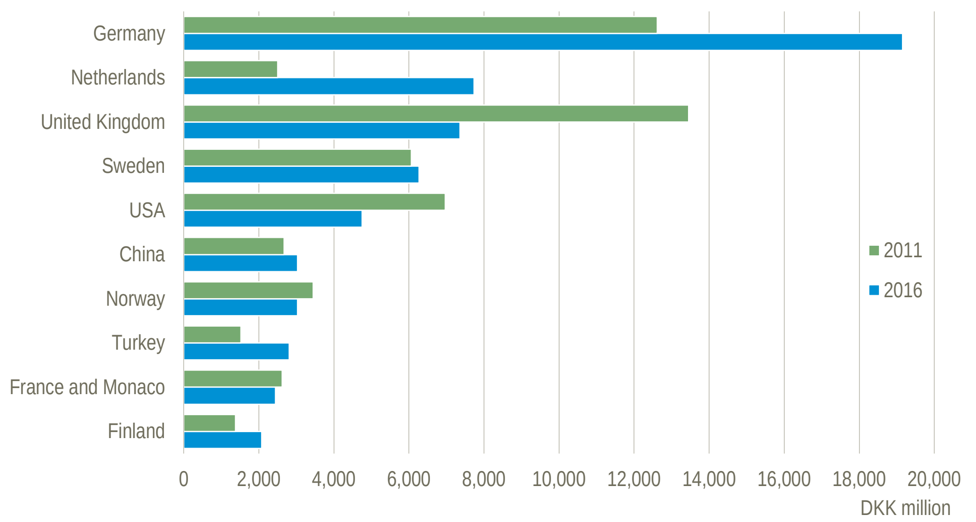
	2011	2012	2013	2014	2015	2016
	DKK million					
Total	78 493	79 798	80 080	85 932	83 942	84 801
Power generating machinery and equipment	19 304	19 349	23 236	30 028	30 396	29 840
General industrial machinery and equipment, and machine parts,	18 639	19 258	18 936	19 115	19 279	18 884
Manufactures of metals,	9 473	9 417	9 060	6 326	5 523	7 820
Professional, scientific and controlling instruments and apparatus,	4 047	4 289	4 388	4 545	4 829	5 207
Electrical machinery, apparatus and appliances, and electrical parts thereof	6 230	6 889	6 332	6 044	5 290	4 288
Metalliferous ores and metal scrap	5 927	4 987	4 256	5 349	3 929	4 088
Nonmetallic mineral manufactures,	3 101	2 813	1 598	1 815	2 004	2 480
Chemical materials and products,	1 877	2 012	2 280	2 767	2 581	2 340
Plastics in non-primary forms	2 110	2 123	2 139	2 165	2 384	2 249
Road vehicles (including air-cushion vehicles)	1 593	1 903	2 053	1 958	1 888	1 780
Miscellaneous manufactured articles,	2 085	2 182	1 966	1 798	1 731	1 664
Machinery specialized for particular industries	1 055	1 466	1 197	1 435	1 538	1 466
Other groups	3 052	3 110	2 640	2 587	2 570	2 695

Germany is a major importer of environmental goods from Denmark

Germany is the dominant importer of environmental goods and services from Denmark; see figure 9.7. Of the total DKK 85 billion environmental goods exports in 2016, DKK 19 billion were exports to Germany. Moreover, it is worth noting that environmental exports to Germany increased by more than 50 per cent from 2011 to 2016, which is due in part to a series of new energy policies adopted in Germany.

The second largest buyers of exported environmental goods in 2016 were the Netherlands and the United Kingdom, while Sweden was fourth, the USA fifth and China sixth. The Netherlands has seen a significant increase since 2011, whereas the United Kingdom has seen a significant decrease. There is a considerable overlap between the largest export countries for environmental goods and for the exports of goods in general.

Figure 9.7 Danish exports of environmental goods by country



DKK billion worth of exports to 17 countries

In 2016, Denmark exported environmental goods and services with a value of at least DKK 1 billion to a total of 17 countries. In addition to those listed in the figure, these countries include Italy, Spain, Ireland, Poland, Austria, Mexico and Russia. Danish enterprises therefore export environmental goods and services to large parts of the world.

Imports of environmental goods

Imports can be analysed based on the same list of goods. However, it should be stressed that the list primarily includes goods that are also produced in Denmark, and results are therefore likely to underestimate imports of environmental goods. A total of DKK 47 billion worth of goods was imported to Denmark in 2016 as opposed to DKK 38 billion in 2011, see table 9.7.

Table 9.7 Danish imports of environmental goods by type (SITC2) – commodity code method

	2011	2012	2013	2014	2015	2016
	DKK million					
Total	38 041	40 686	40 280	40 522	43 152	47 141
General industrial machinery and equipment, and machine parts,	12 499	13 086	13 465	14 570	14 985	16 046
Manufactures of metals,	3 087	3 306	3 479	2 971	3 044	4 487
Power generating machinery and equipment	2 447	2 628	3 517	2 551	3 461	4 316
Electrical machinery, apparatus and appliances, and electrical parts thereof	2 872	4 256	3 260	3 129	4 069	4 047
Professional, scientific and controlling instruments and apparatus,	2 178	2 430	2 476	2 595	2 713	2 997
Non-metallic mineral manufactures,	1 693	1 790	1 765	2 053	2 251	2 848
Plastics in non-primary forms	2 010	2 149	2 178	2 143	2 299	2 313
Miscellaneous manufactured articles,	2 289	2 297	2 124	2 239	2 234	2 264
Iron and steel	1 649	1 602	1 534	1 636	1 654	1 746
Road vehicles (including air-cushion vehicles)	805	858	1 072	1 042	983	912
Rubber manufactures,	752	689	692	767	742	699
Machinery specialized for particular industries	709	745	729	833	765	626
Other groups	5 051	4 850	3 988	3 995	3 952	3 840

Machinery and electrical equipment dominate imports

Imports of environmental goods consist largely of machinery and metals. The largest category - corresponding to DKK 16 billion of the DKK 47 billion - is *general industrial machinery and equipment*, while metals, power generating machinery and equipment and electrical machinery each accounted for imports worth over DKK 4 billion.

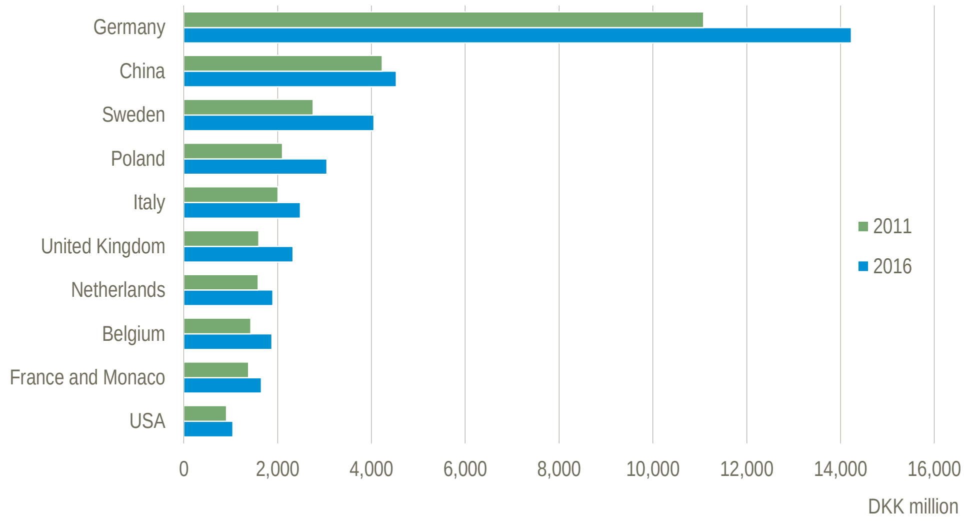
Most imports from Germany and China

Almost one third of imported environmental goods in 2016 came from Germany (DKK 14.2 billion), followed by China (DKK 4.5 billion), Sweden (DKK 4.1 billion) and Poland (DKK 3.1 billion). In general, it is common for there to be a large overlap between significant import countries and significant export countries; this trend applies, too, with regard to environmental goods.

Environmental net exports

The value of environmental goods imports in 2016 amounted to 56 per cent of the value of environmental goods exports. Overall, Denmark is a net exporter of environmental goods with an annual value of around DKK 40 billion. However, as mentioned, import figures are likely to be underestimated, as the underlying commodity list was compiled from a Danish exports perspective and, therefore, may exclude some environmental goods that are not produced in Denmark. These possible shortcomings in the list do not, however, affect the overall picture, which is that Denmark has significant net exports of environmental goods.

Figure 9.8 Danish imports of environmental goods by country



9.4 Environmental goods and services in Europe

Results for Europe

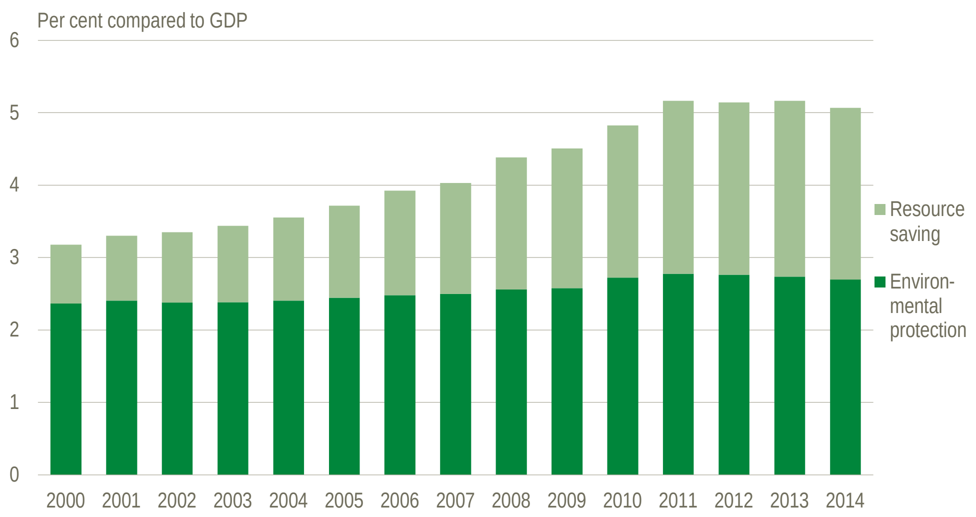
The environmental goods and services accounts are calculated on the basis of internationally-agreed concepts, and the methodology was embedded in an EU Regulation adopted in 2014. Whilst it is a relatively recent development for EU member states to be legally obliged to collect statistics corresponding to this methodology, many countries have been voluntarily collecting this data for a number of years. As such, it is possible for Denmark's results to be compared with those of other countries. However, actual comparisons should be treated with caution, as these statistics are both new and relatively complex.

Increased significance of resource-saving activities

Eurostat has estimated the scale of environmental goods and services for the EU-28 since 2000. As can be seen in figure 9.9, turnover from environmental goods and services accounted for an increasing share of total GDP up to 2011, while the share has remained more or less constant in recent years. Direct environmental protection in the form of clean-up, waste management and similar activities has accounted for an almost constant share, while resource-saving activities have tripled since 2000. Measured in terms of turnover, resource-savings in 2014 were broadly equal to direct environmental-protection activities.[1]

[1] Note that turnover relative to GDP (value added) involves two different economic measures. The development over time can be used as a rough indicator of the development of the environmental goods and services sector, but the actual level of the indicator overestimates the actual share of the sector in proportion to the overall economy.

Figure 9.9 Turnover from environmental goods and services compared to GDP, EU-28

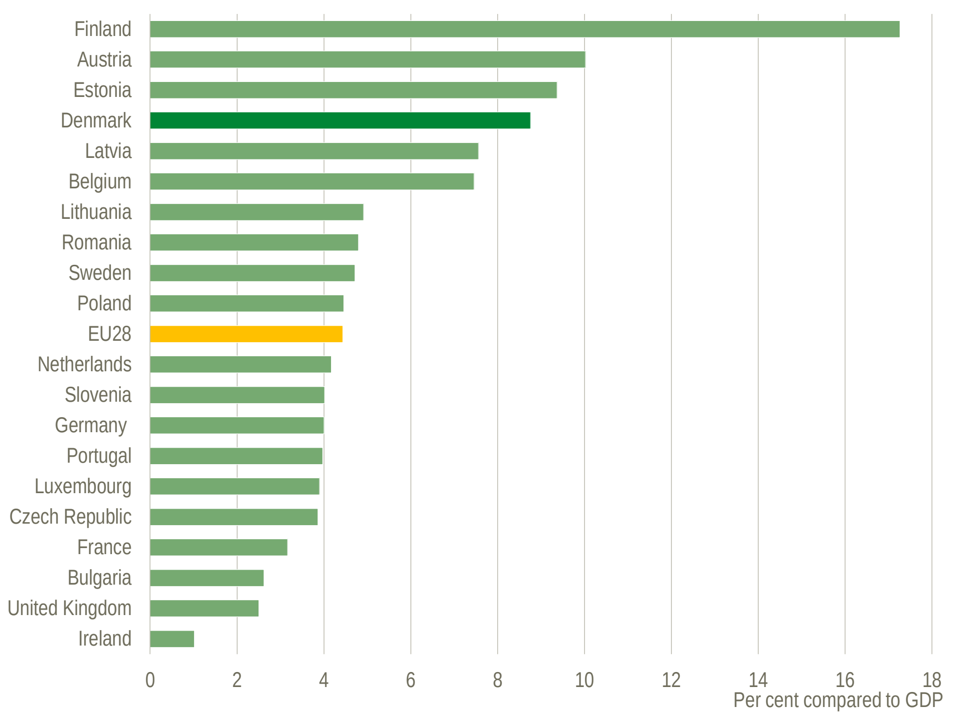


Source: Eurostat

Differences in the scope of environmental goods and services

Denmark has one of the largest shares of environmental goods and services relative to GDP in the EU. Calculated as turnover relative to GDP, market-oriented environmental goods and services amounted to 8.8 per cent in Denmark, surpassed only by Finland (17.3 per cent), Austria (10.0 per cent) and Estonia (9.4 per cent). Latvia is fifth (7.6 per cent) followed by Belgium (7.5 per cent). It should be stressed that the results have been collated on a not fully harmonised basis.

Figure 9.10 Turnover from environmental goods and services. 2014



Note: The results are based on information from the Eurostat database from August 2017 and may have changed since that time. Results are not available for all countries. Eurostat has calculated an overall estimate for the EU-28. Data for Luxembourg, Germany, the Netherlands and Sweden are 2012 data. Data for Belgium is from 2013.

Renewable energy products contribute to the differences

The countries with the largest percentages all share a considerable focus on production from renewable sources, including from biomass. The considerable share of environmental goods and services in Denmark is linked extensively to the production and export of wind turbines and other goods to aid the green transition.

Varying focus on industrial products

When comparing the figures for environmental goods and services across national borders, conclusions should be drawn with caution. Some of the differences in figures are probably due to differences in methodology. For example, an analysis carried out by Statistics Denmark (Statistics Denmark, 2015) revealed that the extent to which industrial products are recognised as environmental differs significantly. The United Kingdom included practically no products, while manufacturing accounted for half of total turnover from environmental goods and services in Denmark and Finland. Finland has since revised its figures and included a very substantial share of construction activities as environmental production. It is expected that the results will be gradually harmonised.

Box 9.1. About environmental goods and services accounts

The accounts follow the Regulation (EU) No 538/2014 amending Regulation (EU) No 691/2011 of the European Parliament and of the Council of 6 July 2011 on European environmental economic accounts.

The Danish accounts cover 2012 and onwards. The 2016 figures are preliminary. The environmental goods and services accounts focus, in particular, on market-related production.

The results are based partly on separate data collection for a number of industries, and partly on existing statistics, where these include relevant information.

The statements are subject to uncertainty because it is difficult to accurately identify the goods and services to be included and because the data from general business statistics is to some extent based on assumptions: e.g. the assumption that if a certain share of the production can be categorised as 'environmental', a similar share of the total number of people employed can be assumed to work with environmental products.

More information:
www.statbank.dk/10520
www.dst.dk/en/Statistik/dokumentation/documentationofstatistics/environmental-goods-and-services

10 Environmental protection activities and expenditure

The growing focus on climate change, environmental pressures and the depletion of natural resources affects procedures in both the private and public sector. Within both sectors initiatives have been implemented with the intention of mitigating the adverse effects economic activities can have on the climate and environment.

Previously, efforts were focused on disposing of wastewater and waste, but over time environmental protection activities have become more comprehensive. Today, focus is also placed on protecting the climate in general and on ensuring healthy ecosystems and high biodiversity.

In this chapter, figures highlighting the expenditure on environmental protection activities are presented. The objective is to make it easier to both identify and monitor measures initiated by society to respond to the challenges related to the effect of economic activity on the climate and environment. Environmental protection expenditure includes all of the costs incurred by industry or the public sector in preventing, restricting and controlling pollution from production and consumption, as well as in facilitating the transition towards green technologies.

Overview of the chapter

In section 10.1, total industrial and public environmental protection expenditure is shown. Section 10.2 deals with the environmental protection expenditure paid by industry, while section 10.3 concerns public sector environmental protection expenditure. In section 10.4, public revenue from environmental protection is presented.

10.1 Total environmental protection expenditure by industry and the public sector

Largest action areas: Waste, wastewater and biodiversity

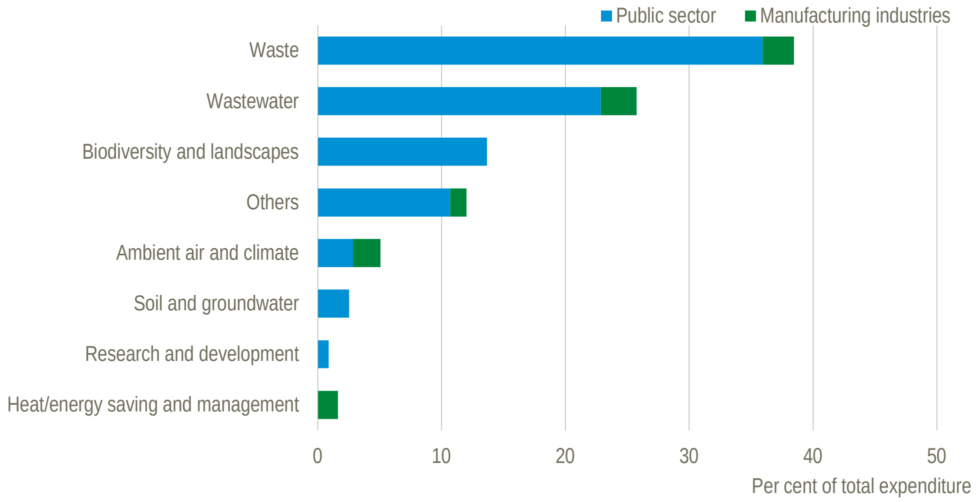
Figure 10.1 shows the total environmental protection expenditure by industry and the public sector in 2016, which together constituted DKK 32 billion. This expenditure concerns three areas in particularly: waste, constituting 38 per cent; wastewater management, 26 per cent; and biodiversity, 14 per cent. The vast majority - 90 per cent - is attributable to public sector environmental protection.

Correlation between environmental protection expenditure and environmental goods and services

Environmental protection activities are divided into two categories: *"characteristic environmental protection"* and *"non-characteristic environmental protection"*. Characteristic environmental protection includes those activities that directly serve an environmental protection purpose, such as waste or wastewater management. Non-characteristic environmental protection includes those activities that produce specially designed products used to serve an environmental purpose, e.g. facilities for renewable energy - installation of solar panels, wind power etc.

Calculations of environmental protection activities undertaken by industry and the public sector in this chapter only include *characteristic environmental protection* activities. However, in the case of industry, the non-characteristic activity "reduced energy and heating consumption" is included in the calculation of environmental protection expenditure by industry (see box 10.1). The calculations of the production of green goods and services, described in chapter 9, include both *characteristic* and *non-characteristic* products, which is the main explanation for the varying calculations within the environmental protection area.

Figure 10.1 Total environmental protection expenditure by environmental purposes. 2016



Action areas for environmental protection expenditure by industry and the public sector, respectively, follow the CEPA classification (see box 10.1), including the addition mentioned above of the CREMA classification for “reduced energy and heating consumption“ in industry expenditure. Regarding industry, “soil and groundwater” as well as “research and development” are included in the category, “others”. The area “Biodiversity and landscape” is only included in public sector expenditure.

10.2 Environmental protection expenditure by industry

Scope of environmental protection expenditure by industry

The calculations identify the degree of explicit expenditure incurred by Danish industries in relation to making their production less environmentally harmful. The calculations include those activities that prevent and control emissions of harmful substances into the environment or those that restore environments damaged by previous activities. Note that expenditure by industry on environmental protection excludes environmental taxes and duties.

The accounts include raw materials extraction, manufacturing industries and the energy and water supply industries, i.e. only a subset of the entire private sector.

The largest proportion of expenditure goes to operating costs

The total expenditure by industry on direct environmental protection in 2016 was DKK 3.4 billion, which is an increase of almost 15 per cent compared with 2014. In 2014, total expenditure on direct environmental protection was DKK 2.9 billion; see figure 10.2 and table 10.1. The total operating expenses and purchases of services increased by 6.5 per cent from DKK 2.1 billion in 2014 to DKK 2.3 billion in 2016.

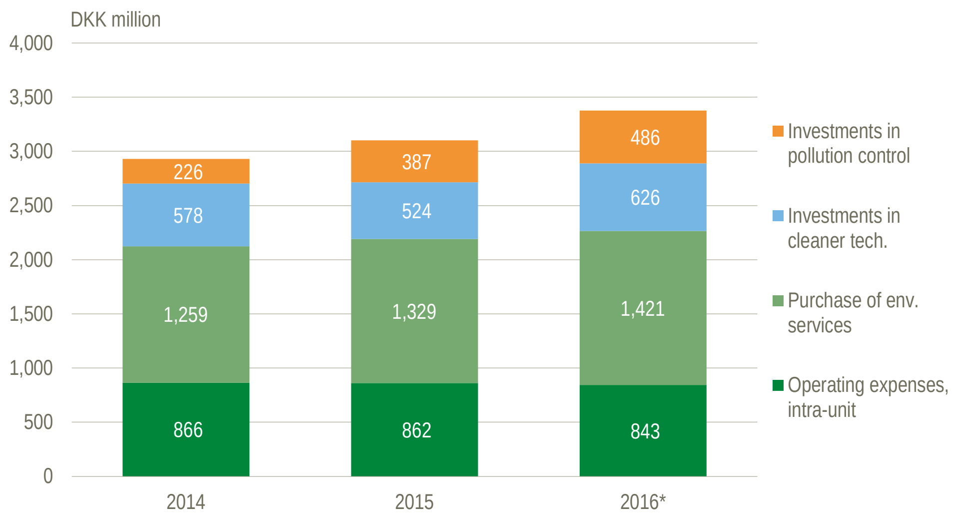
Operating costs for personnel and purchases of goods and services

Operating costs include payroll costs for personnel, certifications, environmental planning etc. In addition, there are purchases of goods and services in relation to e.g. replacement of filters and waste management. Purchases of services alone constituted DKK 1.4 billion in 2016.

Large increase in investments in control measures

Expenditure on investments in equipment for control measures more than doubled from 2014 to 2016, and thus constituted DKK 486 million in 2016 compared with DKK 226 million in 2014. Investments can fluctuate significantly from year to year, and part of the increase in the total expenditure results from just a few large investments. Investment in pollution abatement includes capital goods with a life-time exceeding one year.[1] Investment in pollution abatement includes "end-of-pipe" solutions with the purpose of processing a company's emissions before they enter into the external environment.

Figure 10.2 Environmental protection expenditure in manufacturing, by type of expenditure



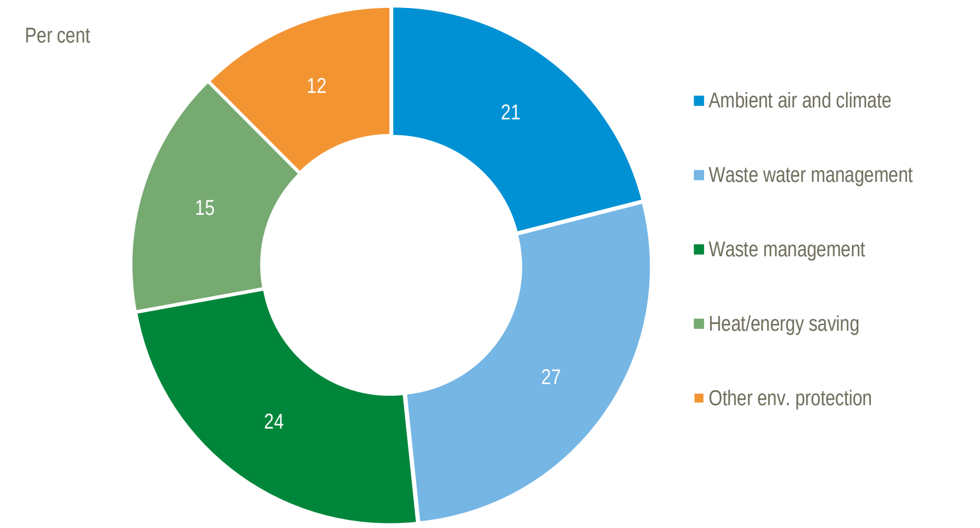
Preventive investments

Preventive investments increased from DKK 578 million in 2014 to DKK 626 million in 2016. Investment in pollution prevention includes investments in what is known as clean technology. These investments concern equipment and measures that make existing or new production installations more environmentally sound.

Major part of expenditure on wastewater and waste management

More than half the total expenditure on environmental protection in 2016 was for *wastewater management (27 per cent)* and *waste management (24 per cent)*, as illustrated in figure 10.3, a largely unchanged share since 2014. The rest of the expenditure on environmental protection is divided into *protection of ambient air and climate (21 per cent)*, *heat/energy saving and management (15 per cent)* and *other environmental protection activities (12 per cent)*.

Figure 10.3 Environmental protection expenditure in manufacturing by environmental domain. 2016



[1] The investments have been calculated as the cost of acquisition in the financial year. The calculation is exclusive of VAT and deductible expenses. Investment grants have been offset against the cost of acquisition.

Looking at types of expenditure in relation to stated environmental purpose the expenditure on *protection of ambient air and climate* and *heat/energy saving and management* were primarily investment costs, whereas costs for *wastewater management* and *waste management* were mainly operating costs.

Distribution by industry

When the environmental expenditure of companies is distributed by industry, it becomes clear that a few industries accounted for the main part of the expenditure in both 2014 and 2016, as shown in table 10.1.

Manufacture of food products, beverages and tobacco has the highest expenditure

Manufacture of food products, beverages and tobacco accounted for 28.1 per cent of total expenditure on environmental protection in 2014 corresponding to DKK 825 million. Its share of total environmental protection expenditure dropped to 27.4 per cent in 2016, but increased in nominal value to DKK 923 million. Despite the change, this industry accounts for environmental protection expenditure twice the value of the second largest industry, *Manufacture of chemicals*. The latter accounted for 15.2 per cent of the total environmental protection expenditure in 2016. Other industries with high expenditure on environmental protection were *manufacture of machinery (8.8 per cent)* and *utility services (11.3 per cent)*.

Table 10.1

Environmental protection expenditure in manufacturing by type of industry

	2014	2016*	2014	2016*
	DKK million		per cent	
Total	2 936	3 372	100.0	100.0
Mining and quarrying	34	53	1.2	1.6
Manufacture of food products, etc	825	923	28.1	27.4
Textiles and leather products	22	29	0.7	0.9
Wood and paper products and printing	114	100	3.9	3.0
Oil refinery etc.	48	146	1.6	4.3
Manufacture of chemicals	496	513	16.9	15.2
Pharmaceuticals	240	216	8.2	6.4
Manufacture of plastic, glass and concrete	295	291	10.0	8.6
Basic metals and fabricated metal products	198	231	6.7	6.9
Manufacture of electronic components	29	37	1.0	1.1
Electrical equipment	27	30	0.9	0.9
Manufacture of machinery	230	298	7.8	8.8
Transport equipment	35	31	1.2	0.9
Manufacture of furniture etc.	66	94	2.2	2.8
Energy and water supply	277	380	9.4	11.3

Manufacture of plastic, glass and concrete accounts for 8.6 per cent corresponding to DKK 291 million, while *manufacture of basic metals and fabricated metal products* accounted for 6,9 per cent corresponding to DKK 231 million of the environmental expenditure by industry. *Pharmaceuticals* accounted for 6.4 per cent of the expenditure, with a value of DKK 216 million. *Transport equipment, textiles and leather products* and *electrical equipment* were at the bottom by 0.9 per cent each, which is, however, related to the relatively small size of these industries in Denmark.

Box 10.1 Environmental expenditure by industry

The accounts identify the level of expenditure by Danish industries for both operations and investments to prevent and control emissions of pollutants into the environment and to restore environmental areas that have been harmed by previous activities. The statistics include industries within raw materials extraction, manufacturing industries, and energy and water supply, i.e. only a subset of the entire private sector.

The calculations are based on data collected from selected companies by means of a questionnaire survey. An imputation for additional companies has been executed in order for the calculations to cover the whole industry. Expenditure by industry on research and development, for example, derive from specific statistics for this area.

The expenditure has been linked to one of the following action areas: "Protection of ambient air and climate", "Wastewater management", Waste management", "Management of energy resources" or "Others". Grouping follows the common European classification system CEPA (Classification of Environmental Protection Activities), including the action area "Management of energy resources", which derives from the CREMA classification (Classification of Resource Management Activities). When establishing the statistics, it was decided that "Management of energy resources" is a natural action area when companies invest in environmental protection initiatives, and it is thus included in the Danish figures.

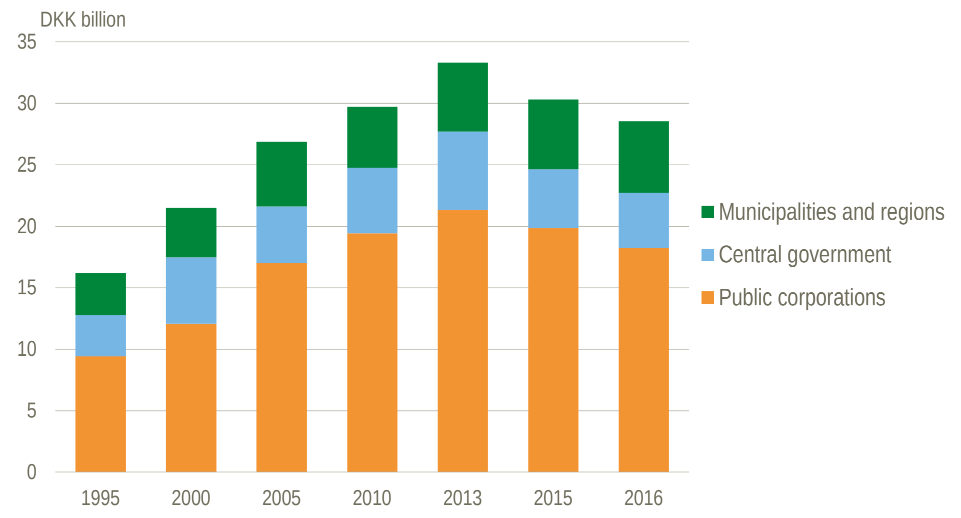
More information:
www.statbank.dk/10520
www.dst.dk/en/Statistik/dokumentation/documentationofstatistics/environmental-protection-expenditures

10.3 Public sector environmental expenditure

Stable level of expenditure

Besides a peak in 2013, total public environmental protection expenditure has been fairly stable in recent years. In 2016, total environmental protection expenditure amounted to DKK 28.5 billion. Public sector environmental expenditure equated to 1.4 per cent of GDP in 2016.

Figure 10.4 Public sector environmental expenditure



In 2013, total environmental expenditure amounted to DKK 33.3 billion or 2.5 per cent of total expenditure within the public sector. The higher level shown for this year is due to climate-change adaptation plans begun in 2013 by the municipalities to safeguard Danish towns against damage caused by flooding in relation to cloudbursts. Public corporations commenced construction projects to cloudburst-proof a number of cities throughout Denmark. Increased expenditure on wastewater management in 2013 is thus attributable in part to initiation of these activities.

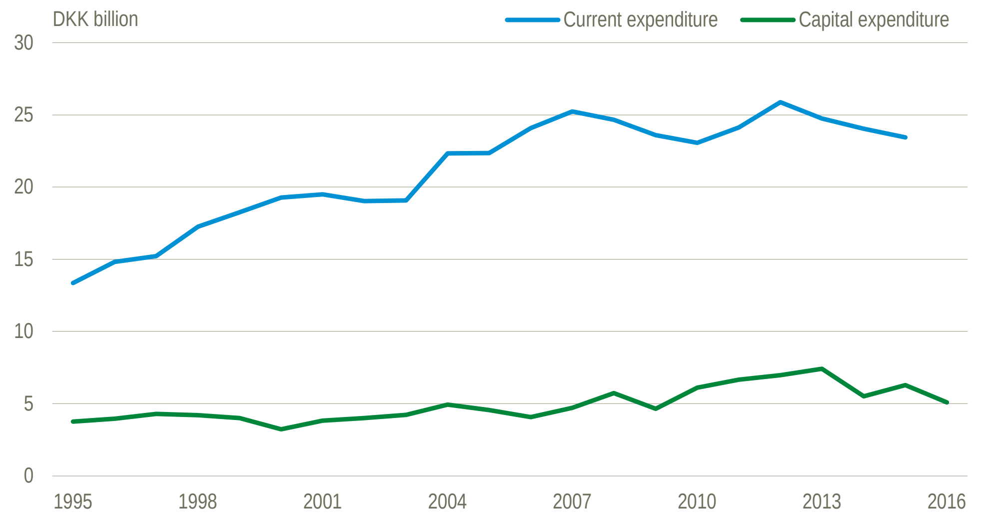
Expenditure on environmental protection is primarily incurred by public corporations, and they are in particular directed toward waste management and treating wastewater. In 2016, public corporations commanded a 64 per cent share of total public sector environmental expenditure, while the state, regions and municipalities were responsible for the rest. Furthermore, public corporations are responsible for a large share of the gradual increase over time; see figure 10.4.

Decrease of DKK 606 million in current expenditure

Current expenditure amounted to DKK 23.4 billion in 2016; see figure 10.5. This was DKK 606 million less compared with 2015. Current expenditure covers pay for employees, purchases of goods and services, interest, taxes on production and subsidies.

Capital expenditure, which primarily comprises investment costs, amounted to DKK 5.1 billion in 2016. Capital expenditure peaked in 2013, when it was approximately DKK 2 billion higher than in 2016.

Figure 10.5 Public sector operating costs and capital expenditure for environmental protection



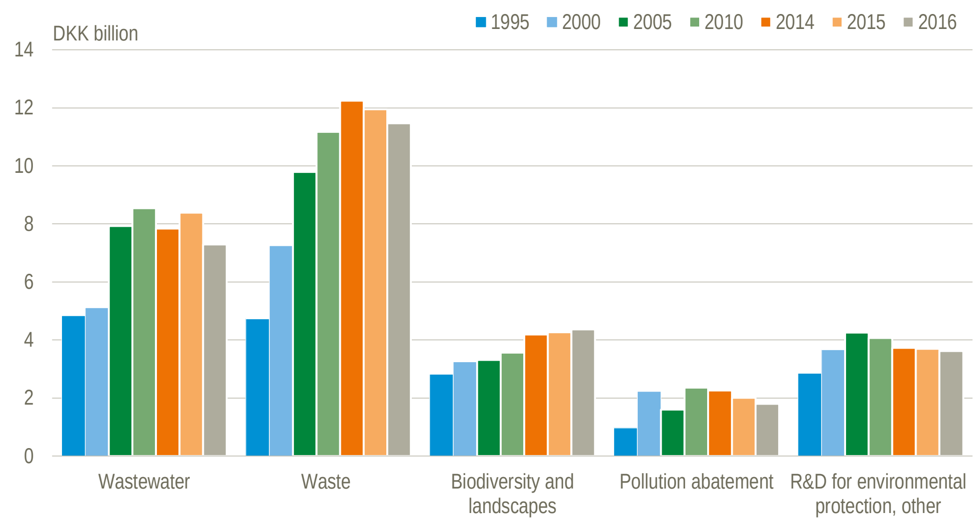
Expenditure on waste and wastewater

Public sector environmental expenditure is particularly focused within the area of waste and wastewater. In 2016, the public sector spent a total of DKK 18.8 billion on waste and wastewater, representing a slight decrease from the DKK 20.3 billion spent in 2015; see figure 10.6. Expenditure on these two areas commanded a 66 per cent share of total public sector environmental expenditure in 2016.

Biodiversity and landscape

Biodiversity and landscape covers environmental expenditure in the areas of coastal protection and sustainable forestry, as well as nature management etc. In 2016, expenditure on *biodiversity and landscape* amounted to DKK 4.4 billion, corresponding to 15 per cent of total environmental expenditure. This area covers environmental expenditure such as measures to limit the use of pesticides in agriculture and initiatives regarding wetlands. This amounted to DKK 0.8 billion in 2016, corresponding to 3 per cent.

Figure 10.6 Public sector environmental expenditure by action areas



10.4 Public sector environmental revenue and net expenditure on environmental protection

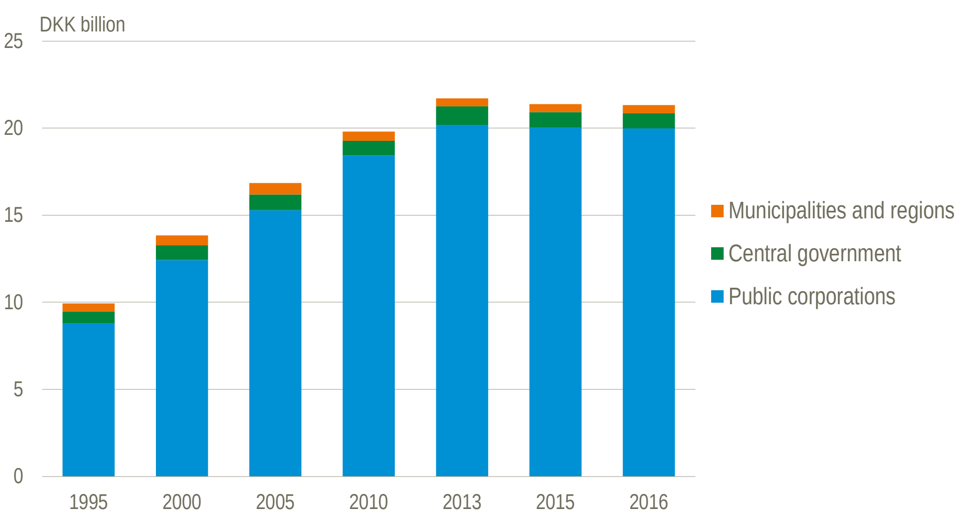
The public sector receives payments from households and companies for the supply of services related to environmental protection. Public corporations in particular receive these payments from households and companies.

Stable revenue in recent years

In 2016, total public sector environmental revenue amounted to DKK 21.3 billion; see figure 10.7. This does not include the environmental taxes that households and companies pay to the state (see chapter 11). Environmental revenue has increased from around DKK 10 billion in 1995 (stated in current prices), but have more or less stabilised in recent years.

Public corporations in particular receive significant environmental revenue: in 2016, they received almost DKK 20 billion. The environmental revenue of the state and the municipalities amounted to DKK 855 million and DKK 455 million in 2016, respectively. The regions received environmental revenue amounting to DKK 31.4 million.

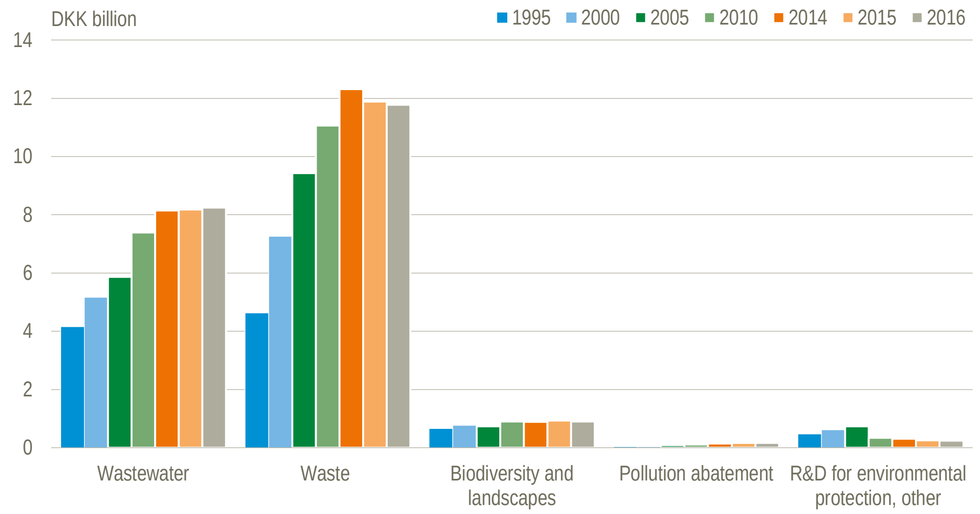
Figure 10.7 Total public sector environmental revenue



Environment areas

Public sector environmental revenue primarily derives from *waste* and *wastewater* management; see figure 10.8. In 2016, environmental revenue from management of *waste* was DKK 11.8 billion, and revenue from management of *wastewater* was DKK 8.2 billion. Together this amounted to a 90 per cent share of the total public sector environmental revenue.

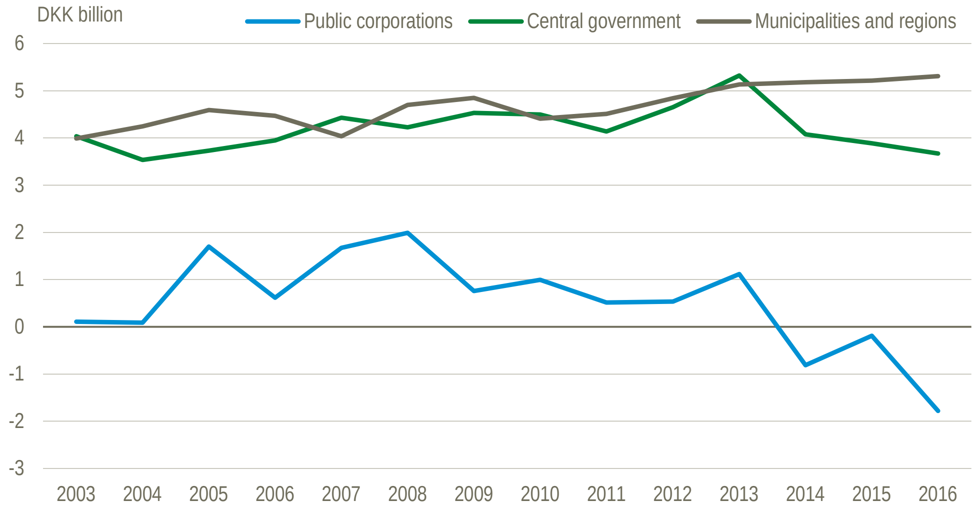
Figure 10.8 Public sector environmental revenue by action areas



Net expenditure

Total public sector net expenditure (expenditure minus revenue) on environmental protection amounted to DKK 7.2 billion in 2016; see figure 10.9. Public corporations received a net revenue of DKK 1.8 billion, while the central government had a net expenditure of DKK 3.7 billion. Municipalities and regions had a net expenditure of DKK 5.3 billion. As mentioned above, revenue from environmental taxes are not included in the calculations of public sector environmental revenue. Therefore, the same applies to net expenditure.

Figure 10.9 Public sector net expenditure on environmental protection



Box 10.3 Public sector environmental revenue and expenditure

The calculations for public sector environmental revenue and expenditure are based on revenue and expenditure concepts that are applied in relation to the public sector figures in the national accounts. The statistics provide information on public environmental protection, namely activities aimed at pollution prevention and control as well as transition to sustainable technologies.

The public sector comprises the general government as well as public corporations. The general government includes the state, municipalities, regions and social security funds. The general government produces non-market public services that are mainly financed through taxes. Public corporations include partly or wholly state-owned companies run under market conditions.

The calculations pertaining to environmental protection are divided into nine environmental domains concerning environmental protection, such as “ambient air and climate”, “soil and groundwater”, “wastewater”, “waste”, “research and development” etc. Groupings follow the common European classification system CEPA: Classification of Environmental Protection Activities.

Figures for 2016 are preliminary and all figures are stated in current prices.

More information:
www.statbank.dk/10520www.dst.dk/en/Statistik/dokumentation/documentationofstatistics/public-sector-environmental-protection-plus-environmental-related-taxes-and-subsidies

11 Environmental taxes and subsidies

Economic instruments play an important role when seeking to encourage producers and consumers to act in more sustainable and environmentally responsible ways. Consequently, environmental taxes and subsidies[1] have attracted increasing international attention.

This chapter focuses on both Danish environmental taxes and environmental subsidies. Section 11.1 will describe the nature of Danish environmental taxes and the extent to which they are levied on industries and households. Section 11.2 will describe how the environmental tax burden in Denmark has developed over time, and how the level of taxes compares with the environmental tax burden in other countries. Section 11.3 will shed light on state revenues from environmental taxes relative to revenues from other Danish taxes and duties. State revenues from taxes linked to the production of oil and gas in the North Sea will also be presented in this section. Section 11.4 deals with Danish environmental subsidies, while section 11.5 looks at the relationship between the industries and activities responsible for emissions of CO_2 and sulphur dioxide and the amount of tax they pay, i.e. whether the polluter pays principle is being adhered to.

11.1 Environmental taxes

What are environmental taxes?

Environmental taxes (environmental related taxes and duties) are based on the idea that the costs associated with the environmental impact of a product should be reflected in the price of the product in order to influence consumers' and producers' choices.

Taxes on environmental impact

Revenues from environmental taxes may be spent on specific environmental initiatives, e.g. waste collection and recycling schemes, but often this is not the case. Thus, the decisive factor in determining whether a tax or a duty should be classified as environmental is not whether the revenue is spent on environmental purposes. Rather, according to the guidelines for environmental-economic accounts, what is essential is whether the tax is levied on a *physical unit (or a proxy of it) of something that has a proven, specific, negative impact on the environment*. It means that it is the potential effect, and not the motive behind the tax that is the decisive factor. Therefore a tax can be classified as environmental even if it has been introduced for purely fiscal purposes as long as the basis of the tax has a negative environmental impact.

In order to facilitate international comparison, the Danish environmental taxes discussed in this chapter are, in practice, delimited according to Eurostat's list of environmental taxes. Eurostat's list includes taxes on renewable energy sources; taxes on wind power, for example, are included, although the environmental impact of this energy type is minimal compared to most others. The inclusion of taxes on renewable energy sources shows there is not a direct correlation between the size of environmental related taxes and the costs of the environmental impacts. The figures presented throughout this chapter should be interpreted with this in mind.

Environmental taxes are divided into four categories depending on whether they relate to energy, transport, pollution or resources.

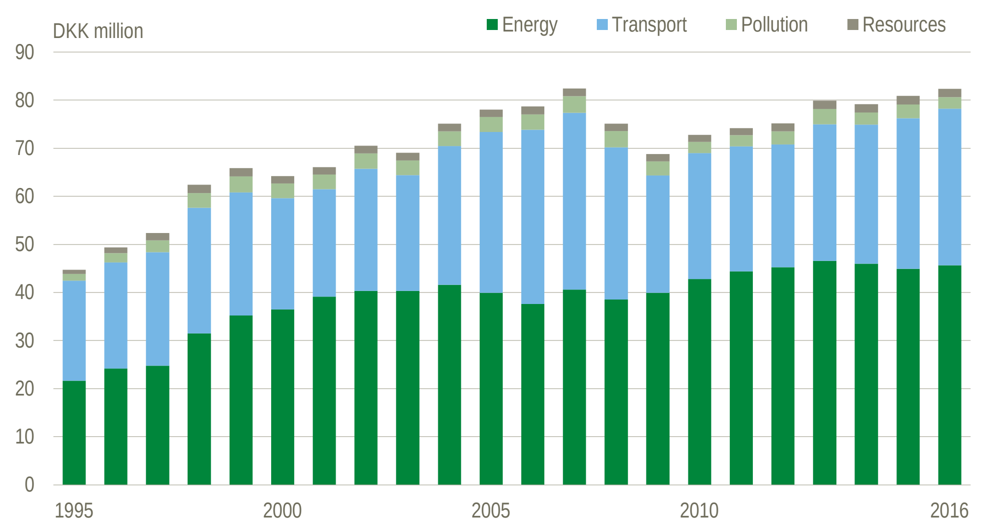
Environmental taxes amounting to DKK 82 billion in 2016

Revenue from environmental taxes in Denmark amounted to DKK 82.4 billion in 2016. This was an increase of DKK 1.5 billion compared with 2015. This increase was in particular due to a higher number of car purchases leading to a rise in envi-

[1] In this chapter "subsidies" is used to cover what are also called "subsidies and similar transfers", see section 11.4

ronmental taxes paid on transport, primarily in the form of motor vehicle registration duty.

Figure 11.1 Environmental taxes by environmental category



Environmental taxes declined during the financial crisis

Figure 11.1 shows developments in environmental taxes since 1995, broken down by the four main categories. Revenues from environmental taxes generally increased until 2007, while in 2008 and 2009, revenues declined as a result of the financial crisis. Subsequently, revenues have once again seen a slight upward trend.

Energy taxes dominate

Throughout the period, energy taxes were the dominant category among total environmental taxes. The most important energy taxes were those levied on electricity, petrol and certain oil products, along with the PSO (public service obligation[2]) tax (see figure 11.2). Energy taxes inclusive of the CO_2 tax amounted to DKK 45.7 billion in 2016. Revenues from the petrol tax peaked at DKK 10.4 billion in 2003. Subsequently, revenues have been declining, and in 2016, they amounted to DKK 7.5 billion. This drop is due to a reduction in the quantity of petrol sold. Revenue from the electricity tax increased steadily until 2014, but then fell to a level of DKK 11.7 billion in 2016.

PSO tax

The PSO tax amounted to DKK 7.6 billion in 2016. During the period 2011-2015, PSO tax revenues almost tripled in current prices. The PSO tax will be phased out in the period 2017-2022.

Transport taxes are second largest

Transport taxes amounted to DKK 32.6 billion in 2016, and consequently constitute the second largest of the main categories of environmental taxes. In 2016, the motor vehicle registration duty accounted for 60 per cent of transport taxes, while the green ownership duty[3] accounted for 33 per cent. The financial crisis had a major impact on car sales, and this was reflected in transport taxes, with the motor vehicle registration duty falling by 46 per cent from 2007 to 2012.

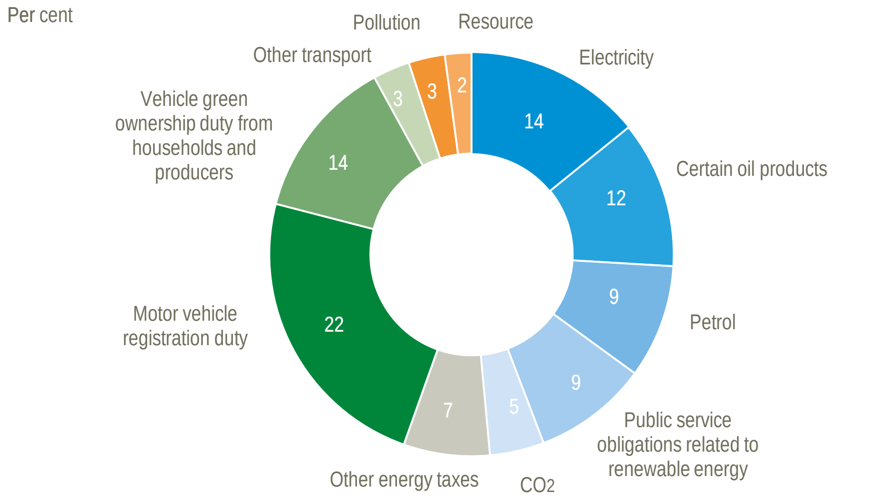
Taxes on pollution and resources play a minor role

The two other main categories, taxes on pollution and resources, are less significant relative to the categories of energy and transport. Combined, they only accounted for 5 per cent of the total environmental taxes in 2016, see figure 11.2. Pollution taxes include taxes on NO_x, pesticides and plastic bags. Taxes on resources cover water charges and taxes on the extraction and import of raw materials.

[2] The PSO (public service obligation) tax is a tax paid by the users of electricity. The revenue is mainly used to subsidise renewable energy, see also section 11.4.

[3] Included is the motor vehicle weight duty paid for older cars. For newer cars the green ownership duty is based on the fuel consumption of the cars.

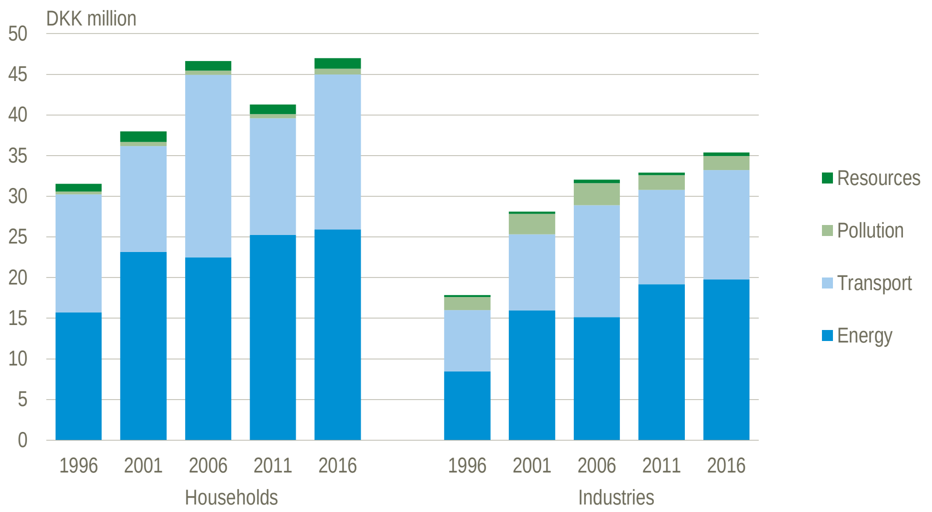
Figure 11.2 Environmentally related taxes by environmental type. 2016



Households pay 57 per cent of environmental taxes

Total environmental taxes and duties amounted to DKK 82.4 billion in 2016, which corresponded to DKK 47.0 billion from households and DKK 35.4 billion from industries, see figure 11.3. The percentage of environmental taxes paid by households thus accounted for 57 per cent of total environmental taxes and duties, whereas payments from industries accounted for 43 per cent. However, the percentage of PSO taxes paid by industries is considerably larger, in that they pay 70 per cent of the total figure. The PSO tax thus accounted for 15 per cent of industries' total environmental taxes, while it only accounted for 5 per cent of payments by households.

Figure 11.3 Environmental taxes distributed among households and industries



Each household paid DKK 17,700 in environmental taxes

Environmental taxes paid by households were predominantly energy taxes (55 per cent) and transport-related taxes (41 per cent). The total revenue from environmental taxes paid by all households was DKK 47.0 billion, which corresponds to DKK 17,700 per household.

Revenues from industries derive from energy consumption

Table 11.1 shows environmental taxes distributed among households and industry types: as can be seen, manufacturing and trade and transport etc. account for the largest proportion of environmental taxes. This is a clear reflection of the energy consumption by businesses in these industries, as energy taxes account for by far the largest proportion of environmental taxes and duties for these industries.

Table 11.1 Environmental taxes distributed among households and industries. 2016

	Environmental taxes			
	Energy	Transport	Pollution and resources	Total
	DKK million			
Total	45 665	32 574	4 137	82 375
Households	25 908	19 092	1 972	46 972
Industries, total	19 757	13 482	2 165	35 403
Investments etc.	0	9 350	57	9 407
Industries	19 757	4 132	2 108	25 996
Agriculture, forestry and fishing	1 212	192	400	1 804
Mining and quarrying	58	6	25	89
Manufacturing	4 769	306	509	5 583
Utility services	1 163	65	92	1 319
Construction	1 274	821	95	2 191
Trade and transport etc.	5 586	1 559	443	7 589
Information and communication	474	71	13	558
Financial and insurance	238	299	7	543
Real estate activities and renting of non-residential buildings	179	64	16	259
Dwellings	56	15	8	79
Other business services	921	548	86	1 555
Public administration, education and health	3 314	120	360	3 794
Arts, entertainment and other services	513	65	55	633

11.2 Environmental tax burden in Denmark and other countries

Environmental tax burden

The environmental tax burden is the term used to describe all environmental taxes as a percentage of GDP. Figure 11.4 shows the environmental tax burden in the period 1995 to 2016. In 2016, the environmental tax burden was 4.0 per cent of GDP, and it has remained stable at this level since 2008. In 1999, the environmental tax burden peaked at 5.3 per cent of GDP.

Denmark's environmental tax burden is high in an international perspective

Denmark has a high environmental tax burden viewed from an international perspective, see figure 11.5. In 2015, the environmental tax burden in Denmark was 4.0 per cent of GDP, which was higher than the environmental tax burden in both Sweden (2.2 per cent) and Norway (2.4 per cent). The environmental tax burden in Sweden and Norway is close to the level in the EU-28 as a whole, where the environmental tax burden is 2.4 per cent of GDP.

But not unique

However, figure 11.5 shows that Denmark's high environmental tax burden is not unique. Countries such as Croatia, Slovenia and Italy are close to Denmark in this respect. Energy taxes in particular account for much of the environmental tax burden in these countries.

Trends since 2005

Over the past decade, environmental taxes as a percentage of GDP have in fact declined in more than half of the countries illustrated in figure 11.5. Energy taxes generally account for the largest percentage of the environmental tax burden throughout the period.

Figure 11.4 Environmental tax burden

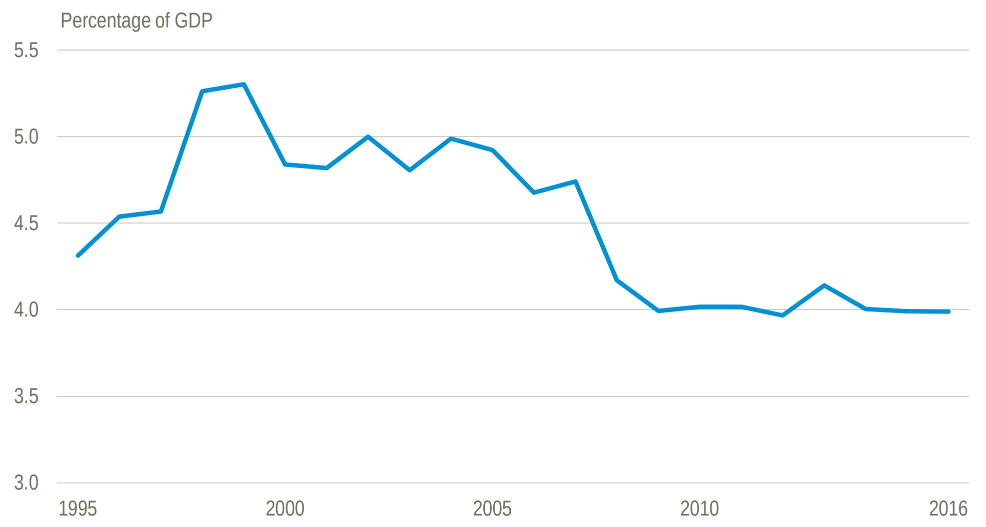
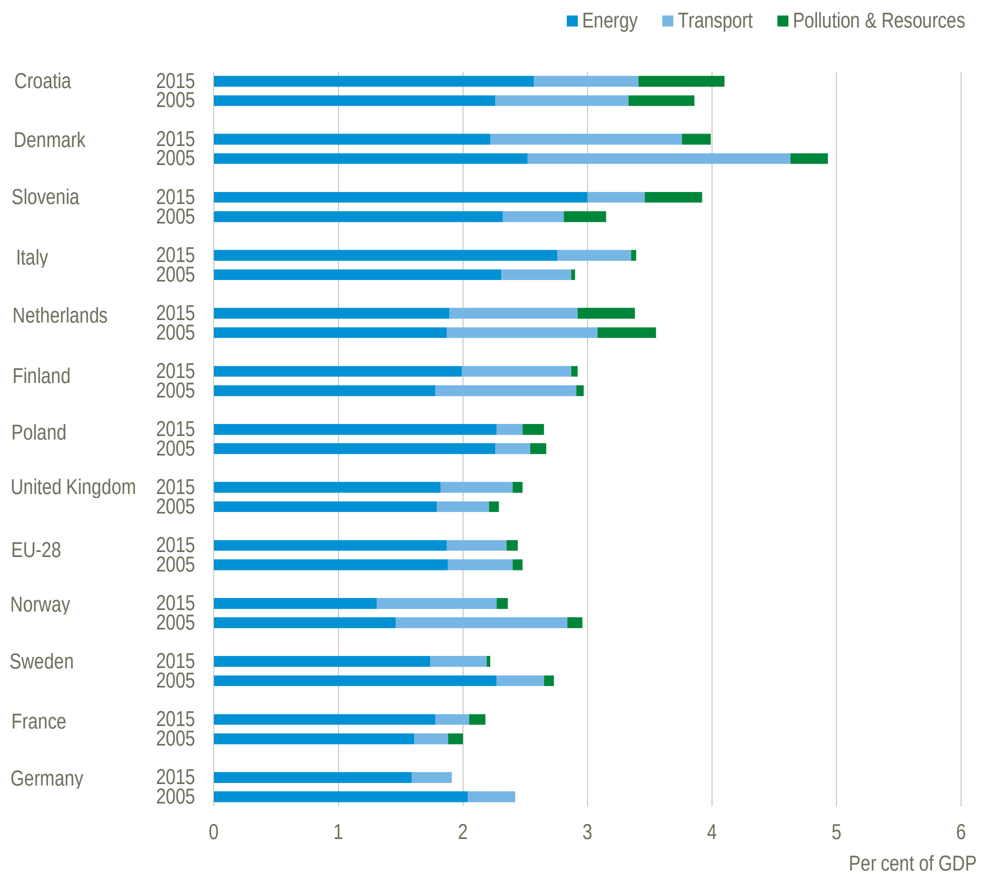


Figure 11.5 Environmental tax burden in selected countries



Source: Eurostat

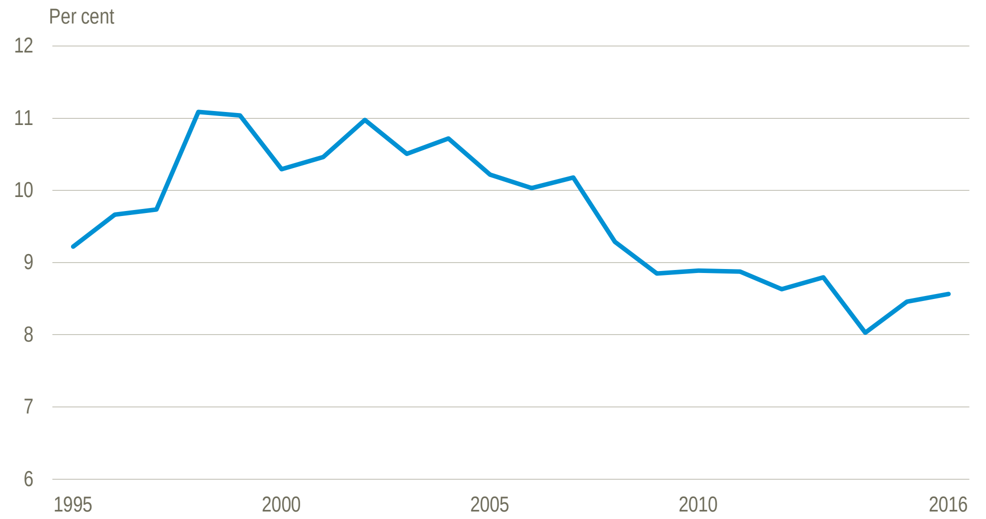
11.3 Revenue from environmental taxes and tax on the North Sea resource rent

Environmental taxes account for 9 per cent of tax revenue

Environmental taxes represent a significant revenue source for the public sector in Denmark. As mentioned previously, environmental taxes amounted to DKK 82.4 billion in 2016, which corresponds to 8.6 per cent of total tax revenue.

Environmental taxes as a percentage of tax revenue peaked in 1998 and 1999 at 11.1 per cent. This was primarily due to the introduction of the PSO tax, combined with an increase in energy tax rates. Since 1999, environmental taxes have experienced a downward trend, see figure 11.7.

Figure 11.6 Environmental taxes as a percentage of total tax revenues



Resource rent

The environmental tax revenue of DKK 82.3 billion described above does not include tax on the resource rent from oil and gas production in the North Sea. Tax on resource rent in this context is composed of hydrocarbon tax and corporation tax on hydrocarbon activities.

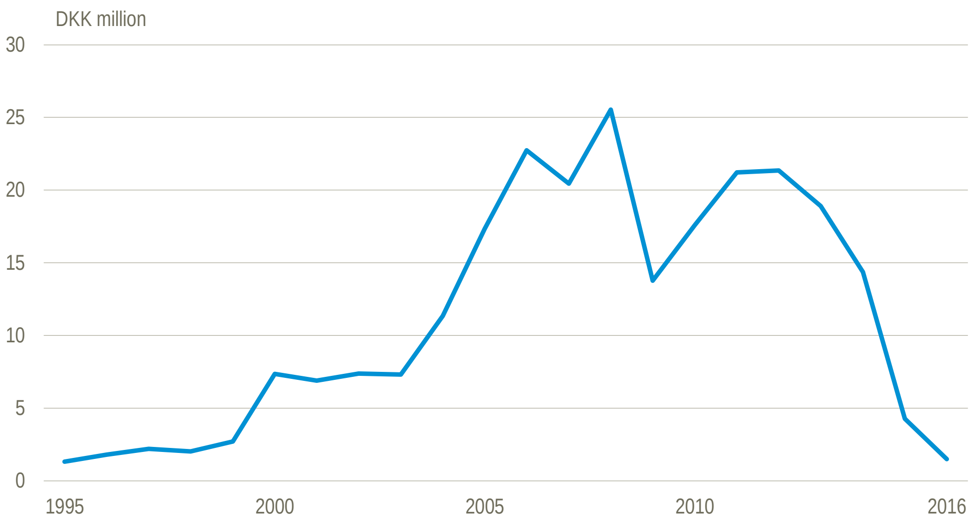
According to guidelines from Eurostat, resource rent tax is not included as a resource tax, although it resembles other resource taxes payable on extraction and consumption of natural resources.

In 2016, resource rent tax was DKK 1.5 billion. Half of this amount came from hydrocarbon tax, and the other half came from corporation tax on hydrocarbon activities. In 2016, the revenue accrued from these taxes was at a low level compared with previous years. Revenues were affected by a decline in production in the North Sea as well as falling oil prices.

66 per cent drop in state revenues from the North Sea

Resource rent tax has seen major fluctuations since 1995, when it amounted to DKK 1.3 billion. In 2004, it increased drastically when hydrocarbon tax was introduced for offshore companies. In 2008, it peaked at DKK 26 billion, but since then it has fallen considerably. In 2008, resource rent tax accounted for 3.2 per cent of total tax revenues, whereas in 2016 it had fallen to 0.2 per cent. Developments in resource rent tax levels have been affected partly by developments in oil and gas production, and partly by fluctuations in oil and gas prices.

Figure 11.7 Environmental tax on the North Sea oil and natural gas resource rent



11.4 Environmental subsidies

Every year, the public sector pays environmental subsidies and similar transfers to businesses, organisations, and households. For simplicity, in the following section *environmental subsidies* refers not only to ordinary subsidies from the government to enterprises related to their current production, but also to other current and capital transfers and investment grants, etc. They can be applied in the context of waste management, soil and groundwater protection, and reductions in the extraction of exhaustible natural resources. A further objective of environmental subsidies is to increase the use of renewable energy resources.

For a tax to be regarded as an *environmental tax*, it has to be levied on a physical unit which has a proven negative impact on the environment (see section 11.1). Environmental subsidies, in contrast, are regarded as such if the introduction of the specific scheme is motivated by environmental concerns. In other words, with respect to taxes it is the *effect* which is the crucial factor, whereas with environmental subsidies it is the *motivation*. These definitions comply with the Eurostat guidelines.

Five main categories

In the Danish Environmental-Economic Accounts, environmental subsidies are divided into five main categories: pollution, energy, transport, nature management and foreign aid. Figure 11.8 shows examples of different types of environment-related subsidies.

Environmental subsidies amounting to almost DKK 9.3 billion in 2016

Danish environmental subsidies amounted to DKK 9.3 billion in 2016, see figure 11.9. This represents a DKK 0.7 billion compared with 2015. Most of the decline from 2015 to 2016 is due to a fall in environmental subsidies for renewable energy.

Energy dominates

Public subsidies related to energy fell from DKK 8.2 billion in 2015 to DKK 7.7 billion in 2016. Energy-related subsidies accounted for 83 per cent of total environmental subsidies in 2016. They consisted primarily of subsidies financed through PSO (Public Service Obligation) for the production, research and development of wind power and other forms of renewable energy.

Figure 11.8 Break-down and examples of environmental subsidies

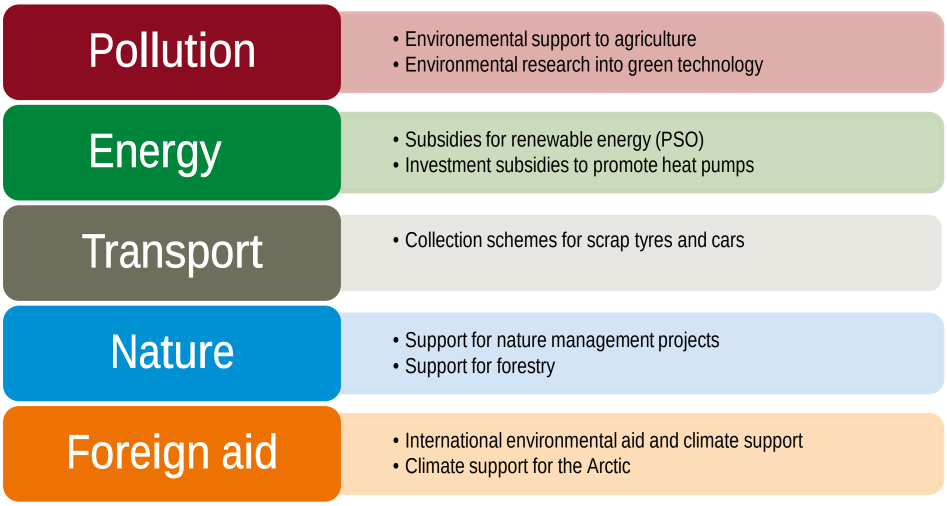
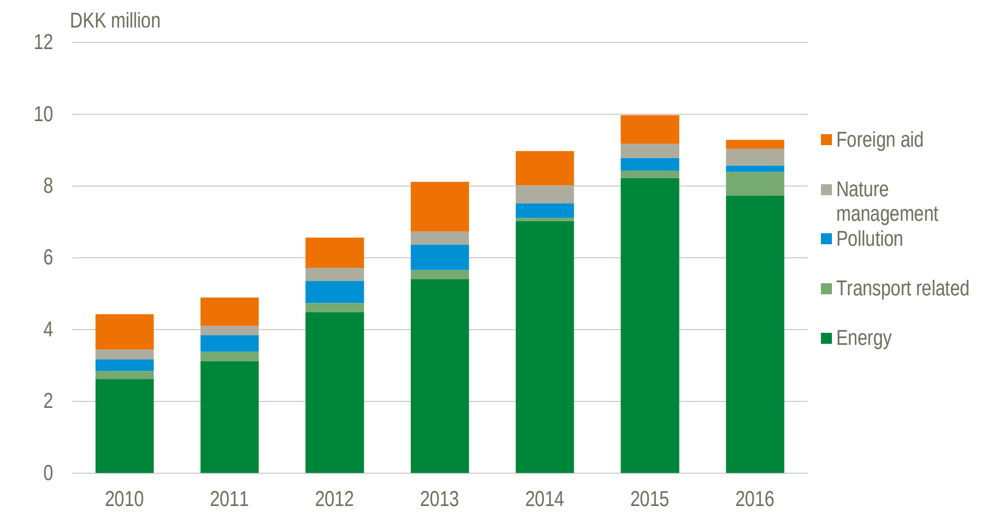


Figure 11.9 Environmental subsidies by environmental category



Especially PSO subsidies

In 2016, PSO subsidies amounted to DKK 7.4 billion. Up to and including 2016, PSO subsidies corresponded to a PSO tax imposed on households and industries via electricity bills see also section 11.1.

Subsidies primarily benefit industries

Of the environmentally subsidies totalling DKK 9.3 billion in 2016, households received DKK 1.8 billion, corresponding to 20 per cent while industries received DKK 7.5 billion, corresponding to 80 per cent, see table 11.2. Most of the environmental subsidies for households are PSO subsidies.

Allocation of PSO subsidies etc. in the national accounts

Electricity consumption is the determining factor, in both the national accounts and the green national accounts, when calculating the allocation of PSO subsidies among industries and households. The assumption is that subsidies for production of renewable energy will result in lower electricity prices, and that, consequently, the subsidies will benefit all users of electricity, including non-Danish buyers of electricity produced in Denmark (exports). Consequently, the allocation of PSO subsidies among households and industries depends to a large extent on the distribution of electricity consumption as documented in the energy accounts, see chapter 4. Similar assumptions about how subsidies affect price have been made with regard to other environmental subsidies linked to specific products.

Households also receive transfers linked to transport, which covers collection schemes for scrap cars and tyres. When comparing different industries, manufacturing, trade and transport etc., agriculture, forestry and fishing, and utility services are the primary recipients of environmental subsidies. Environmental subsidies for industries aim to support initiatives such as green technology, for example.

Foreign aid

Note that in the national accounts, foreign aid is classified as transfers to overseas countries. In table 11.2, foreign aid is categorised under '*Other*' under '*Industries, total*', as it is assumed that most of the funds for foreign aid were initially transferred to businesses and organisations engaged in environmental work abroad. Foreign aid constituted 7 per cent of total environmental subsidies in 2016.

Table 11.2

Environmental subsidies by industry and environmental category. 2016

	Pollution	Energy	Transport-related	Nature management	Foreign aid	Total
	DKK million					
Total	465	7,733	179	252	657	9,286
Households	-	1,671	149	-	-	1,820
Industries, total	465	6,062	30	252	657	7,466
Other	-	1,846	-	-	657	2,503
Industries	465	4,216	30	252	-	4,9
Agriculture, forestry and fishing	29	322	-	252	-	604
Mining and quarrying	-	17	-	-	-	17
Manufacturing	36	1,612	-	-	-	1,647
Utility services	343	512	30	-	-	885
Construction	4	63	-	-	-	67
Trade and transport etc.	30	895	-	-	-	924
Information and communication	-	145	-	-	-	145
Financial and insurance	-	27	-	-	-	27
Real estate activities and renting of non-residential buildings	-	21	-	-	-	21
Dwellings	-	1	-	-	-	1
Other business services	23	100	-	-	-	123
Public administration, education and health	-	415	-	-	-	415
Art, entertainment and other services	-	86	-	-	-	86

Note: The category "Other" includes export, investments etc. It also includes environmental foreign aid to overseas.

11.5 Polluter pays principle

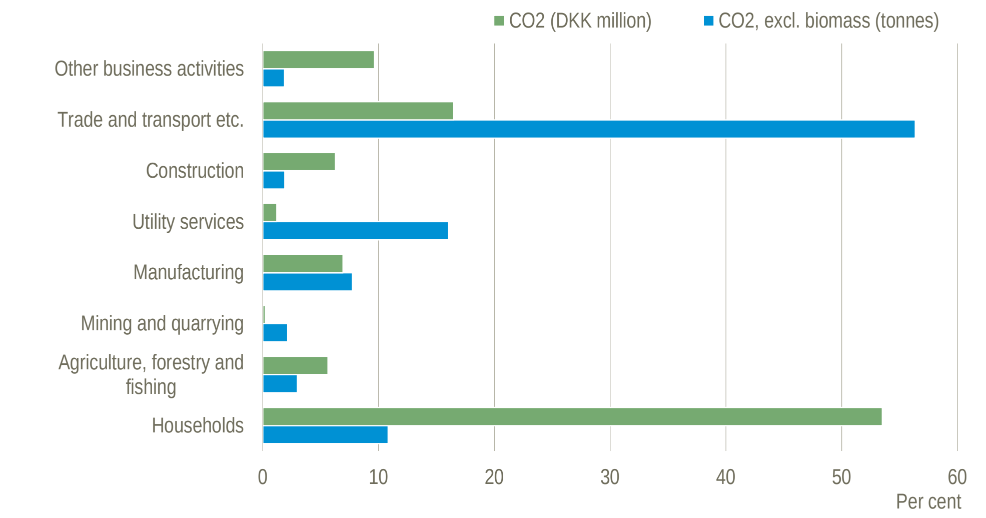
The polluter pays

One of the key principles of sustainable development and environmental policy is that 'the polluter pays'. This means that a business, for example, pays the full cost associated with its production, including the costs of pollution of the environment. One way of ensuring this takes place is to levy environmental taxes on pollution. It can therefore be interesting to juxtapose taxes levied on, for example, specific types of emissions with data pertaining to the same emissions. Below, emissions of CO_2 and sulphur dioxide (SO_2) from industries and households are compared with the taxes paid on CO_2 and sulphur dioxide.

Households pay most of the CO_2 taxes, but are responsible for a smaller proportion of the emissions

Figure 11.10 shows how payments of CO_2 taxes are broken down by industries and households in relation to how much CO_2 they emit. Households pay most of the CO_2 taxes, but are only responsible for 11 per cent of direct CO_2 emissions. One of the explanations for this is that households pay CO_2 taxes in relation to their electricity consumption, while emissions from production of electricity come from the utility services industry. Whilst emissions from international transport are also included, no taxes are currently levied on these activities. This explains why the trade and transport etc. sector is responsible for a much larger proportion of emissions than is reflected in its share of taxes.

Figure 11.10 CO_2 taxes and CO_2 emissions. 2016



Note: The statement of CO_2 emissions includes emissions from Danish bunkering abroad, see chapter 5.

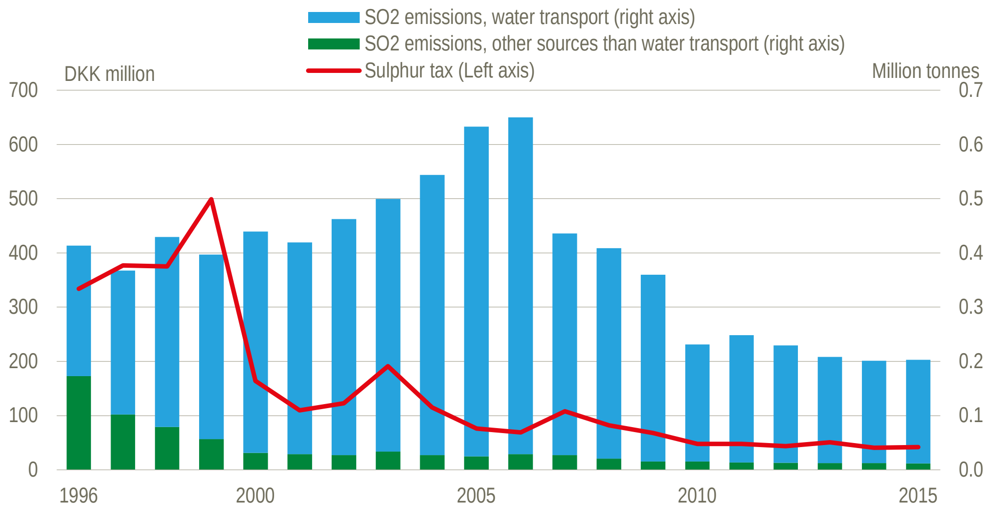
Another way of describing the polluter pays principle is to look at developments in taxes relative to the respective emissions on which these taxes are imposed. Figure 11.11 illustrates the development in sulphur dioxide (SO_2) emissions and the development in revenues from taxes on sulphur dioxide.

The sulphur tax (tax on sulphur dioxide) was introduced in 1996, and tax rates on several energy products were gradually increased, particularly during the years immediately following the introduction of the tax. As a result, until 1999 there followed a sharp increase in total revenues from the sulphur tax. During the same period, there was a drastic fall in SO_2 emissions when excluding emissions from Danish-operated international maritime transport, which has been exempt from this tax. During the period 2000 to 2015, there was also a decline in SO_2 emissions as well as in the related payment of taxes, although the decline was not as pronounced as the decline immediately following the introduction of the tax.

In 2015, SO_2 emissions from sources other than maritime transport only amounted to around 11,000 tonnes, whereas these emissions were around 170,000 tonnes in 1996 (see also chapter 5). As mentioned previously, revenues from the sulphur tax have declined at the same rate as emissions. Thus, in 2016 they amounted to only DKK 38 million, a significant decrease compared to the DKK 499 million of tax revenue in 1999.

International maritime transport is not subject to environmental taxes in Denmark. SO_2 emissions from Danish maritime transport increased until 2006, but since then they have fallen considerably. Since 2005, international rules adopted by the UN International Maritime Organization (IMO) have regulated the maximum permissible sulphur content in marine fuels. The sulphur cap was initially 4.5 per cent. In 2012, it was reduced to 3.5 per cent, and it will be lowered progressively to a limit of 0.5 per cent by 2020.

Figure 11.11 Taxes on sulphur tax (SO_2) and emissions



Note: The statement of SO_2 emissions includes emissions from Danish bunkering abroad, see chapter 5.

Box 11.1 Environmental taxes and subsidies

Calculations of environmental taxes and environmental subsidies (and similar transfers) are based on accounts for the Danish government, municipalities and regions. These are classified in accordance with guidelines from Eurostat. The industry breakdown is based on detailed statements in the national accounts of the use by different industries of products linked to environmental taxes and environmental subsidies.

Environmental taxes are characterised as such when levied on a physical unit with a proven negative impact on the environment. Environmental subsidies are characterised by the motivation for or purpose of the specific subsidies. In practice, this means, for example, that vehicle taxes are included in environmental taxes, whereas subsidies for public transport are not included in environmental subsidies. Figures for 2015 and 2016 are preliminary.

More information:
www.statbank.dk/10520
www.dst.dk/en/Statistik/dokumentation/documentationofstatistics/public-sector-environmental-protection-plus-environmental-related-taxes-and-subsidies

12 Danish oil and gas reserves in the North Sea

12.1 Introduction

Extraction has been of major significance to the Danish economy

Denmark has produced oil and natural gas from the Danish part of the North Sea west of Denmark since 1972. As noted in section 4.4, this led to Denmark becoming energy self-sufficient from the end of the 1990s until 2012. Danish production of oil and natural gas has also had a significant economic impact, on both the Danish balance of payments and the state's revenue.

A significant proportion of the most easily accessible oil and natural has already been extracted: continued extraction will require major investments in infrastructural renewal and expansion. The extraction of oil and natural gas from the North Sea can nevertheless be expected to continue to contribute: both to Danish energy self-sufficiency specifically, and the Danish economy more generally, even if this contribution is on a smaller scale than in previous years.

Gross value added of DKK 29.4 billion in 2014

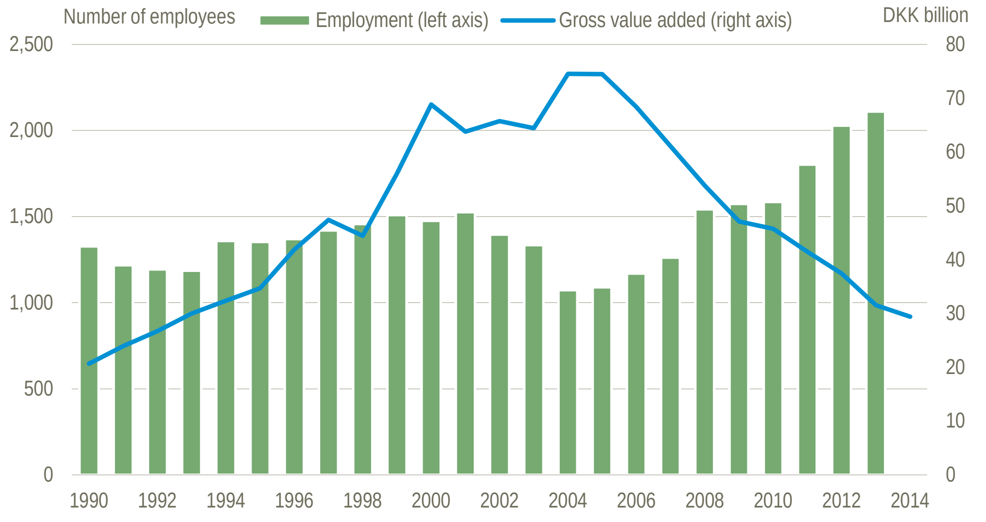
In fixed prices (chained volumes, 2010 prices), the gross value added peaked in the oil and natural gas extraction industry in 2004 at DKK 74.5 billion; see figure 12.1. Since then, concurrent with declining extraction, gross value added has steadily declined. In 2014, it was DKK 29.4 billion in fixed prices (chained volumes, 2010 prices). Stated in current prices, the gross value added in 2014 was DKK 36.4 billion, corresponding to just over 2 per cent of total gross value added in Denmark.

2,000 employees

In recent years the the industry has employed around 2,000 people. This is the highest number of employees in the period since 1990.

Figure 12.1

Value added and employment associated with the extraction of oil and natural gas



Note 1: Value added and employment in the industry 060000 extraction of oil and gas

Note 2: The value added is stated in chained volumes, 2010 prices

12.2 Physical inventory of the oil and natural gas reserves

Decline in Danish oil reserves

Danish reserves[1] of oil in the North Sea amounted to 160 million m^3 at the end of 2015. This was 3.5 million m^3 less than in 2014; see figure 12.2 and table 12.1. The

[1] The term reserves is used in the section in accordance with the term in the former classification system by the Danish Energy Agency. In the Danish Energy Agency's new classification system, a part of these reserves are called contingent resources; see box 12.1.

oil reserves have declined year by year since 2002. At the end of 2015, they were 45 per cent lower than at the end of 2001, where they held 305 million m³.

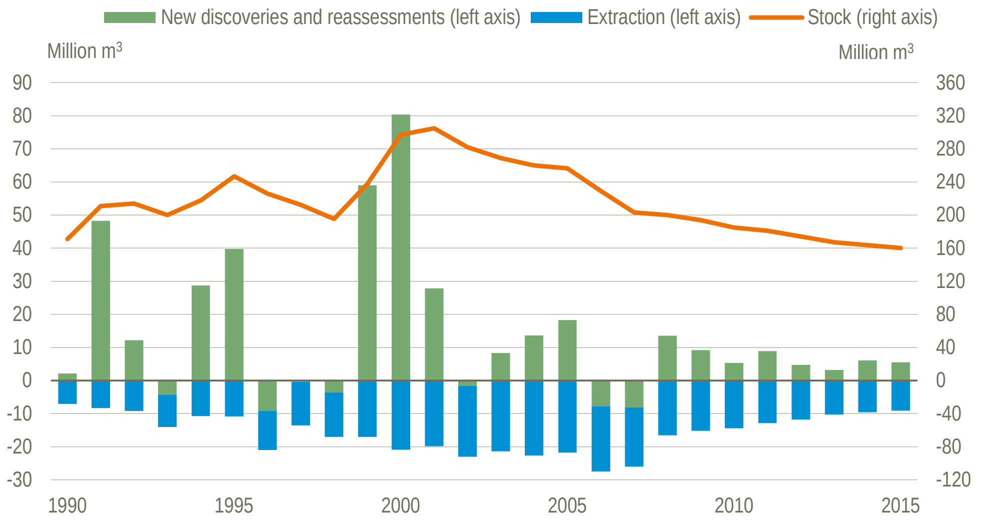
New discoveries and reassessments no longer outweigh extraction of oil...

The decline of 3.5 million m³ in 2015 reflects the extraction of 9 million m³ of oil through the year and an upward adjustment of the reserves of 5.5 million m³. Since 2002, the extraction of oil each year has surpassed the new discoveries and reassessments of the reserves.

... as they did in the 1990s

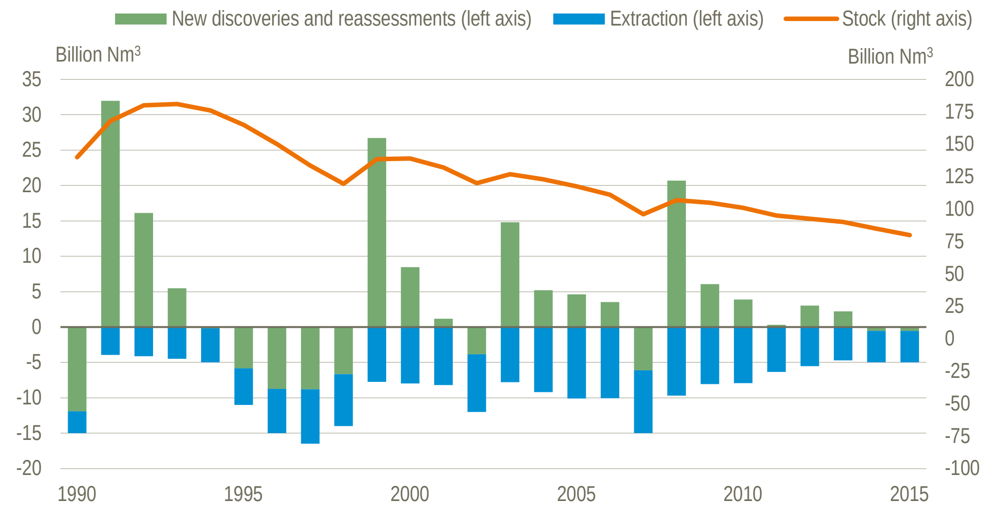
However, over an extended period, 1990-2015, new discoveries and reassessments have to a great extent compensated for the extraction of oil. Despite an accumulated oil extraction of 369 million m³ between the end of 1990 and the end of 2015, the oil reserves were only 6 per cent lower at the end of the period. This is because new discoveries and reassessments – particularly in the 1990s and the year 2000 – were significant, often totalling more than extraction itself. In 2000, the reserves were adjusted upwards by approximately 80 million m³, while the extraction of oil withdrew 21 million m³ of oil from the reserves.

Figure 12.2 Danish reserves of crude oil



Note 1: The reserves are assessed as closing stock, i.e. at the end of the year.
Note 2: The reserve assessment includes contingent resources, which are less likely to be extracted.

Figure 12.3 Danish reserves of natural gas



Note 1: The reserves are assessed as closing stock, i.e. at the end of the year.
Note 2: Extraction is assessed here as net output, i.e. after deduction of reinjection (see box 12.1).
Note 3: The reserve assessment includes contingent resources, which are less likely to be extracted.

More than a 50 per cent reduction of the natural gas reserves since 1993

The reserves of natural gas are also declining. The closing stock for natural gas reserves in 2015 was estimated to be 80 billion Nm^3, which is 5 billion Nm^3 less than at the end of 2014[2]. The natural gas reserves have been declining more or less every year since 1993, where the reserves were at 181 billion Nm^3. This means that natural gas reserves have been reduced by more than 50 per cent from 1993 to 2015. In the years 1999, 2003 and 2008, new discoveries or reassessments exceeded the extraction, so that reserves these years increased a little – only to decline again the following years.

New discoveries and reassessments have not compensated for the extraction of natural gas

While the extraction of oil and new discoveries and reassessments roughly balanced for the period 1990-2015 overall, this was not the case for natural gas The accumulated extraction of natural gas from the end of 1990 to the end of 2015 was 173 billion Nm^3. New discoveries and reassessments accounted for only 113 billion Nm^3. Consequently, the decline in the reserves was 60 billion Nm^3, corresponding to a reduction of 43 per cent during these 25 years.

Steady decline in the extraction of oil and natural gas

Oil extraction peaked in 2004 at 22.7 billion m^3 and the natural gas extraction peaked in 2005 at 10.1 billion Nm^3. Subsequently, the extraction of oil as well as natural gas has declined steadily year by year. In 2015, 9 million m^3 of oil was extracted and 4.5 billion Nm^3 of natural gas. The level of extraction has not been this low since the beginning of the 1990s. The reason for declining extraction is partly a result of the fact that developed fields of oil and natural gas are gradually depleting. However, the decline is also due to the fact that many fields gradually require more maintenance which entails loss of output.

Table 12.1

Accounts of physical oil reserves

	2010	2011	2012	2013	2014	2015	2016
	million m^3						
Opening stock (1)	194	185	181	174	167	164	160
Extraction (2)	14.4	12.9	11.8	10.2	9.6	9.0	8.1
Discoveries and reassessments (3)	5.4	8.9	4.8	3.2	6.1	5.5	…
Closing stock (=1-2+3)	185	181	174	167	164	160	…

Note: The reserve assessment includes contingent resources, which are less likely to be extracted.

Table 12.2

Accounts of physical natural gas reserves

	2010	2011	2012	2013	2014	2015	2016
	billion Nm^3						
Opening stock (1)	105	101	95	93	90	85	80
Extraction[1] (2)	7.9	6.3	5.6	4.7	4.5	4.5	4.4
of which flaring	0.1	0.1	0.1	0.1	0.1	0.1	0.1
own use	0.7	0.6	0.6	0.6	0.6	0.6	0.5
for sale	7.1	5.6	4.8	4.0	3.8	3.8	3.7
Discoveries and reassessments (3)	3.9	0.3	3.0	2.2	-0.5	-0.5	…
Closing stock (=1-2+3)	101	95	93	90	85	80	…

Note: The reserve assessment includes contingent resources, which are less likely to be extracted.

1 Extraction is assessed here as the net output, i.e. after deduction of reinjection (see box 12.1)

Reserves left for another 18 years of extraction

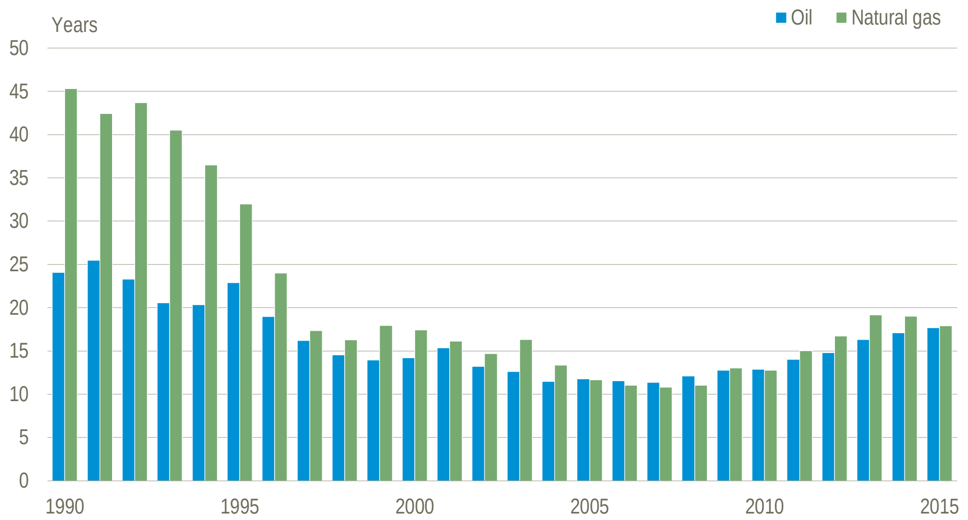
With reserves of 160 million m^3 of oil and 80 billion Nm^3 of natural gas in the end of 2015 as well as annual extraction of 9 million m^3 and 4.5 billion Nm^3, respectively, the oil and the natural gas reserves will be depleted after 18 years - i.e. in 2033. This is assuming that extraction continues at its present pace and that no new discoveries or reassessments of how much oil and natural gas can be extracted from the deposits take place.

2 Nm^3 – normal cubic meter is the volume of natural gas measured under standardised pressure and temperature.

Significantly lower remaining lifespan of the reserves than in the early 1990s

Figure 12.4 applies the aforementioned assumptions for each year across the time period 1990 to 2015. The overall picture is that the remaining lifespan for the Danish oil and natural gas reserves has been severely reduced since the early 1990s, when another 25 years of oil extraction and 40-45 years of natural gas extraction could be anticipated.

Figure 12.4 Remaining lifespan of reserves



Note: The remaining lifespan of the reserves is calculated as the R/P ratio, i.e. the reserves (R) at the end of the year divided by the output/extraction (P) during the year. The R/P ratio indicates how many years the reserves will last if extraction continues at the level of the relevant year and no new discoveries or reassessments of the quantities are made.

High level of extraction reduced the remaining lifespan

As Figure 12.4 shows, it is apparent that the high levels of extraction which took place from the late 1990s until the mid-2000s generally reduced the remaining lifespan of both the oil and natural gas reserves. That said, the remaining useful life of both oil and natural gas has not been declining throughout the whole period: regular – in some years, significant – upwards adjustments of the reserves on the basis of new discoveries and reassessments have been a factor in this development. From around 2005, the remaining lifespan of both oil and natural gas has slightly increased. The fact that extraction has been gradually reduced to a significantly lower level has been a contributory factor to this.

Box 12.1 Assessment of the oil and natural gas reserves

The reserves are the quantities of oil and natural gas which can be extracted under the given economic circumstances using known technology. Accordingly, the reserves are not a static physical quantity, and the reserves only account for a minor part of the total deposits of oil and natural gas resources.

In Denmark, the Danish Energy Agency assesses the physical reserves of oil and natural gas and makes regular adjustments of the estimated extent of the reserves. The figures presented in this section are based on this source.

In practice, there are different approaches to how the reserves (or related concepts) are defined, e.g. based on estimates of the probability that the resources can actually be extracted. For the sake of comparability over time, the reserves are currently defined in the green national accounts in accordance with the classification system formerly used by the Danish Energy Agency. In accordance with this, the reserves include deposits which are instead classified as contingent resources in the new classification system used by the Danish Energy Agency. The contingent resources comprise resources for which the technical or commercial basis is not yet in place for a final decision on extraction. Contingent resources are less likely to be extracted, and parts of them are not included in the forecasts by the Danish Energy Agency for the future extraction.
(See www.ens.dk/sites/ens.dk/files/OlieGas/classificationoilgas.pdf)

The opening stock of a given year is the reserve as assessed on 1 January, whereas the closing stock is the reserve as assessed on 31 December. The opening stock of a year corresponds to the closing stock of the previous year. The closing stock of a year furthermore corresponds to the opening stock of that same year minus the extraction during said year, plus new discoveries and reassessments.

The extraction of oil and natural gas has the effect of gradually depleting the deposits of oil and natural gas, thereby causing the reserves to decline.

Regarding oil, the extraction during a year corresponds to the output for said year and to the sale of crude oil. Regarding natural gas, extraction is gross extraction. For technical reasons, a minor part of the gross extraction is reinjected – i.e. pumped back into the underground. This means that gross extraction minus reinjection equals net output. Some of it is flared off for technical and safety reasons, and some of it is consumed at source by the extractor in connection with the operation of electric power generators and pumps etc. The remaining part of the natural gas is sold.

The reserves are also impacted by new discoveries and other changes in quantities. New discoveries are a result of exploration activities. As new technologies are developed for extraction, a higher share of the deposits that were originally not included in the reserves can be included in the reserves. Also changed economic or socio-economic conditions can affect the share of total deposits included in the reserve. E.g. a change in the oil price will not just impact the value of the existing reserves but also the size of the reserves. This is because the changed price affects the quantity of oil and natural gas that can be extracted at a profit. The impact may be positive or negative.

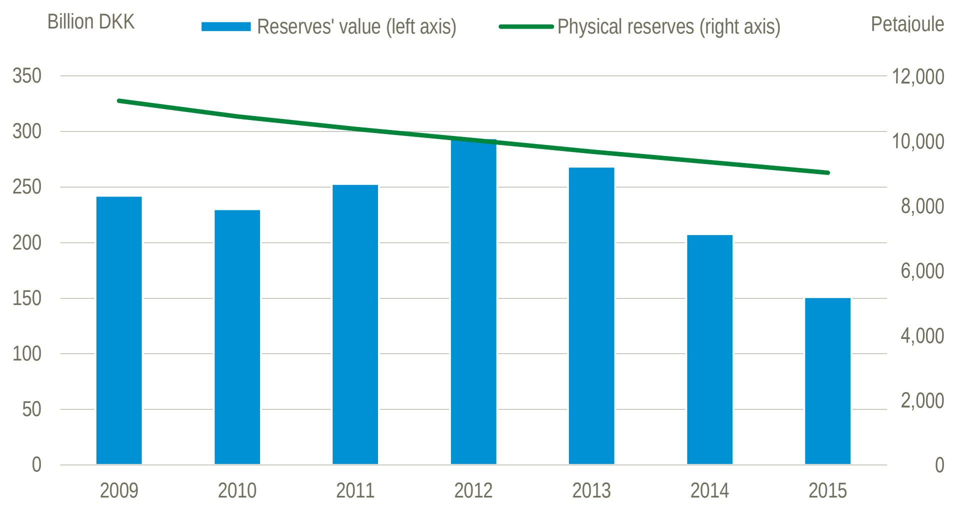
12.3 The value of Danish oil and natural gas reserves

The value of the Danish North Sea reserves has reduced by 50 per cent since 2012

The value of the Danish reserves of oil and natural gas in the North Sea was DKK 151 billion at the end of 2015. This was DKK 143 billion less than in 2012, where the value was DKK 294 billion: this corresponds to the value almost halving. In 2015 alone, the value of the reserves dropped by DKK 57 billion. Between 2009 and 2011, the value of the reserves remained fairly steady between DKK 230 and 253 billion.

Figure 12.5

The value of Danish oil and natural gas reserves



Note 1: The reserves are shown here as closing stock, i.e. as calculated at the end of the year.
Note 2: The figures are stated in current prices.

Decline in the value due to extraction

A minor part of this decline can be explained by quantitative declines in the reserves: in 2015, the physical oil and natural gas reserves declined by 326 petajoule[3], corresponding to 3.5 per cent of the physical reserve. The corresponding loss of value was DKK 2.9 billion. Whilst new discoveries and reassessments added a value of DKK 4.7 billion to the reserves, extraction of oil and natural gas caused a further decline of DKK 7.6 billion, leading to the aforementioned decline in value of DKK 2.9 billion.

Decline in resource rent

The main reason for the decline in the value of the reserves, however, is the revaluation of the reserves' value. In 2013, the values were depreciated due to revaluation by DKK 3.3 billion; in 2014, they were depreciated by DKK 47.3 billion; and in 2015, the values were depreciated by DKK 53.5 billion – a total depreciation of DKK 104.1 billion. The revaluations are primarily linked to a decline in the prices of oil and natural gas and consequently a decline in the net income, also called resource rent (see box 12.2), which the reserves yielded. When the resource rent declines, it affects the expectations of future income and as a result, the market value of the reserve must be revalued.

In 2016, the total net income (resource rent) from extraction in the North Sea was DKK 2.8 billion. In comparison, it was DKK 20.5 billion in 2014 and DKK 7.6 billion in 2015. Per petajoule oil and natural gas extracted, the net income was DKK 6 million in 2016, DKK 15 million in 2015 and DKK 39 million in 2014.

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[3] The physical reserves are assessed here in petajoule as opposed to section 12.1 where the units m^3 and Nm^3 are applied for oil and natural gas, respectively. The common unit petajoule is used here to state oil and natural gas together.

The North Sea taxes withdrew approximately half of the net income

The extraction enterprises' net income, in 2015, of DKK 7.6 billion corresponded to an equal decline in the value of the reserves (i.e. consumption of Danish natural capital).

A part of this value was directly collected by the Danish state via the payment of hydrocarbon tax and corporate income tax on hydrocarbon activities by the extraction enterprises. In 2015, these taxes accounted for DKK 4.2 billion, which corresponds to 56 per cent of the extracting industries' net income (resource rent). For 2016, the preliminary figures show that these taxes constituted DKK 1.5 billion or 53 per cent of the net income of DKK 2.8 billion. See also section 11.3, which deals with the tax payments in connection with North Sea economic activities.

Table 12.3 Monetary accounts for oil and natural gas reserves

	2009	2010	2011	2012	2013	2014	2015	2016
	DKK billion							
Opening stock (1)	336.9	242.2	230.2	252.9	293.9	268.3	207.6	151.1
Extraction (2)	27.9	33.0	39.7	39.1	29.9	20.5	7.6	2.8
Discoveries and reassessments (3)	17.4	9.2	9.5	10.0	7.6	6.9	4.7	...
Revaluation (4)	-84.3	11.8	52.9	70.2	-3.3	-47.3	-53.5	...
Closing stock (= 1-2+3+4)	242.2	230.2	252.9	293.9	268.3	207.6	151.1	...
	petajoule							
Physical opening stock	11 532	11 234	10 747	10 369	10 018	9 662	9 345	9 019

Box 12.2 Valuation of the oil and natural gas reserves

The Danish oil and natural gas fields are not traded in a market, which means that it is not possible to observe a market value. Because of this, the value of the oil and natural gas reserves is determined indirectly via a calculation of the present value of the net income that the extraction yields in the years ahead. The net income is also called the resource rent. It is the share of the output value of oil and natural gas which is left after deduction of all extraction costs. The following is included in the costs: intermediate consumption, wages, other production taxes (net), consumption of fixed assets and a standard return on fixed capital.

The future resource rent (net income from future extraction of oil and natural gas) depends on the quantity extracted and the economic rent per unit of oil and natural gas extracted (unit resource rent). The Danish Energy Agency prepares regular forecasts of the future extraction of oil and natural gas from the North Sea. The forecasts do also include extraction of the contingent resources. The latter are less likely to be extracted, which the Danish Energy Agency takes into account when preparing the forecast.

The estimate of the future unit resource rent, which is used in the calculation of the values presented in section 12.3, is the result of a weighted average of the actual unit resource rent of the last three years and the assumption that the unit resource rent will remain unchanged (in fixed prices) in future. The future income is carried back to the present using a discounted cash flow with a discount rate of 4 per cent for the first 35 years and 3 per cent thereafter in accordance with the recommendations of the Danish Ministry of Finance (Finansministeriet, 2017).

In section 12.4, calculations are presented of the value of the reserves based on other assumptions as to the future resource rent and as to the discount rate.

12.4 Alternative calculations of the value of the oil and natural gas reserves

Assumptions

As mentioned in box 12.2, the value of the reserves cannot be observed and for this reason, the valuation is based on several assumptions. These assumptions concern e.g. the future development in the oil and natural gas prices and the discount rate which is used to weight the future net income.

The future net income

The values of the oil and natural gas reserves presented in section 12.2 are based on an assumption that the future net income per unit of extracted oil and natural gas (unit resource rent) is the same as in recent years measured in fixed prices (chained volumes, 2010 prices). With a discount rate of 4 per cent, it gave a value of the reserves at the beginning of 2016 of DKK 151.1 billion.

Higher prices on oil and natural gas in future

If, instead of fixed prices, on oil and natural gas, it is assumed that the prices on oil and natural gas will go up, it results in a higher expected future net income, and this in turn results in a higher valuation of the oil and natural gas reserves. The higher the expected prices, the higher the calculated value of the reserves.

Based on three scenarios for the future prices of oil and natural gas, which the Danish Energy Agency has prepared (Energistyrelsen, 2017), the value of the reserves can be valued at DKK 208, 402 and 592 billion with a discount rate of 4 per cent. All three scenarios begin with a common starting point in 2016, but subsequently the prices develop at different rates. The lowest increase in prices is in scenario 1 and the highest in scenario 3.

Table 12.4 Alternative values of Danish oil and natural gas reserves, opening stock. 2016

	Constant future energy prices	Price scenarios Scenario 1 Low increase in energy prices	Scenario 2 Medium increase in energy prices	Scenario 3 High increase in energy prices
Discount rate	DKK billion			
0 per cent	198.0	281.8	600.2	901.9
3 per cent	161.6	224.0	442.3	654.1
4 per cent	151.1	208.2	402.3	592.3
5 per cent	141.5	194.0	367.3	538.4

Scenario 1

The lowest value of DKK 208 billion is obtained with scenario 1, which is based on forward prices up to 2020 for natural gas and up to 2022 for crude oil. Subsequently, the prices are assumed to be constant (measured in fixed prices).

Scenario 2

The value of DKK 402 billion in scenario 2 is based on the New Policies scenario from the International Energy Agency (IEA). The scenario takes account of political obligations and future plans announced by countries all over the world.

Scenario 3

Scenario 3, which results in a value of the reserves of DKK 592 billion with a discount rate of 4 per cent, is based on prices for crude oil and natural gas from the IEA's Current Policies scenario from the World Energy Outlook (WEO) 2016. The higher energy prices in this scenario have to do with an assumption that no new energy policies will be adopted in future and that the implementation of existing policies will be slow.

In the calculation of the value of the reserves in accordance with the three scenarios, it is assumed that the costs of extraction remain unchanged.

The discounting

The discount rate is used to carry back the future net income to the present, thus adding less weight to an amount in the future than a corresponding amount in the present. With a discount rate of 0 per cent, the future income carries the same weight as the present income, whereas a positive discount rate means that less weight is added to a future income of DKK 1 million than an income of DKK 1 million here and now. The higher the discount rate, the less weight is added to the future net income.

Alternative discount rates

Table 12.4 shows that the high price estimate in scenario 3 and a discount rate of 0 will lead to a reserve value of more than DKK 900 billion, whereas the lower price estimate in scenario 1 and a discount rate of 5 per cent lead to a value of DKK 194 billion.

Huge impact from prices

Regardless of the discount rate applied, it is clear that the assumption of the price development has a huge impact on the calculated value of the reserves. This is also in keeping with the fact that the price changes that occur from one year to the next give rise to major revaluations of the reserve values; see table 12.3.

The assumption of constant future prices gives low values

The assumption of constant future prices, which was presented above in section 12.2 (table 12.3) was selected on the basis of the international guidelines for the green national accounts, *SEEA CF*; see chapter 1. Compared with the price development in the Danish Energy Agency's three scenarios, the assumption of constant prices appears conservative, and it results in a lower value of the reserves.

Box 12.3 About the resource accounts for oil and natural gas in the North Sea

The accounts document stocks and changes in stocks of oil and natural gas reserves in the North Sea. The reserves comprise the quantities of oil and natural gas which can be extracted under the given economic circumstances using known technology. The assessment is made in physical units (m^3 for oil and Nm^3 for natural gas) and in values.

The physical assessment exists from 1990 onwards, whereas the monetary assessment is made for 2009 onwards.

The accounts are based on information from the Danish Energy Agency including data for the stocks and forecasts for the expected future extraction of oil and natural gas. The main part of the economic data for the income from the oil and natural gas extraction and its costs comes from the national accounts. In addition to this, information is used from the Danish Energy Agency about the expected decommissioning costs, i.e. costs for scrapping and other clean-up operations once the useful life of the platforms etc. has expired.

The accounts for the oil and natural gas reserves are based on the recommendations in the *System of Environmental-Economic Accounting, Central Framework* (UN et al., 2012).

More information:
See also boxes 12.1 and 12.2 concerning definitions of the reserves and the valuation method.

www.statbank.dk/10594
www.dst.dk/en/Statistik/dokumentation/documentationofstatistics/oil-and-natural-gas-in-the-north-sea

13 Land

Land is the foundation of our life

The landmass of Denmark consists of the peninsula, Jutland, which borders Germany, and 394 islands, the largest of which are Funen and Zealand, where the capital city of Copenhagen can be found. Denmark consists of 43,000 km^2 of multifarious land: this is the physical basis for nearly all economic activity, as well as Danish ecosystems and nature.

Increasing demand for land

The total land area of Denmark has remained largely unchanged over time, and the vast majority of this land area is used for various economic activities. At the same time, the demand for land is very likely to change. With today's technology, increased agricultural production to meet growing global demand for food products and energy crops will require more agricultural land. More land is also needed for forests to comply with official Danish forest policy. Organisations such as the Danish Society for Nature Conversation assert that Denmark should have more untouched natural areas.

Water regulation and climate change mitigation may also require more land, while cities and roads take up more and more space. Some land uses can co-exist, but many are mutually exclusive. In a report from 2015 (Arler et al., 2015), researchers at Aalborg University estimated that Denmark would have to be 40 per cent larger to successfully meet all the needs for land. Consequently, Danish land is a scarce natural resource. It is important to account for it, including shifts in *land cover* and *land use* over time.

Land cover

Land cover refers to the bio-physical surface of an area. For example, built-up areas, tree-covered areas or areas covered with crops. The land cover accounts provide information, for example, on the amount of space taken up by Danish cities and roads, and the developments taking place in areas with specific types of nature. Section 13.1 presents selected information from the land cover accounts. Section 13.2 contains information on public and private ownership of land covered with forest, nature and recreational areas. Section 13.3 compares Denmark's land cover with land cover in other EU member states.

Land use

Land use refers to the socio-economic use of land. This refers to how land is used: be that for dwellings, agriculture, retail trade or recreational purposes, for example. Section 13.4 presents parts of the land use accounts, for example, on the proportion of land used for different types of economic activity, and the amount of space taken up by Danish dwellings.

Correlation between cover and use

In some cases, cover and use are closely linked. For example, areas with crops (cover) and areas with agriculture (use) largely overlap. However, not all categories are clearly linked. For instance, a building (cover) cannot be linked directly to a certain type of use, as buildings can be used for multiple purposes.

13.1 Land cover

Agricultural crops are the most important land cover

From the perspective of land cover, Denmark is still an agricultural nation. In 2016, agricultural crops covered 26,226 km^2, or 61 per cent, of Danish land. However, the area of land covered with agricultural crops decreased slightly from 2011 to 2016; the two years for which the land cover accounts were prepared.

Figure 13.1 Land cover in Denmark. 2016

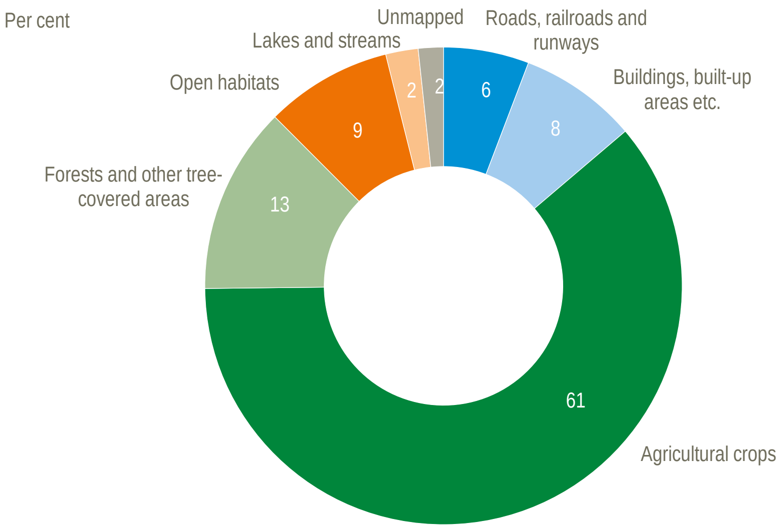


Table 13.1 Land cover in Denmark

	2011	2016	2011	2016	2011	2016
	km²		per cent		m² per capita	
Land, total	42 926	42 926	100.0	100.0	7 720	7 521
Artificial surfaces, total	5 866	5 890	13.7	13.8	1 055	1 032
Roads, railroads and runways	2 463	2 468	5.7	5.8	443	433
Buildings, built-up areas etc.	3 010	3 029	7.1	7.1	541	531
Parks and other recreational areas	393	393	0.9	0.9	71	69
Agricultural crops, total	26 554	26 226	61.9	61.1	4 775	4 595
Herbaceous crops	24 704	23 876	57.6	55.6	4 443	4 184
Woody crops, permanent grass etc.	1 850	2 350	4.4	5.5	333	412
Forests and other tree-covered areas	5 357	5 454	12.5	12.7	963	956
Open habitats	3 509	3 710	8.2	8.6	631	650
Lakes and streams	927	938	2.2	2.2	167	164
Unmapped[1]	713	707	1.7	1.7	128	124

[1] Unmapped refers to areas about which there is no information in the maps used as sources for the statistics.

Cereals and other intensive crops take up most space

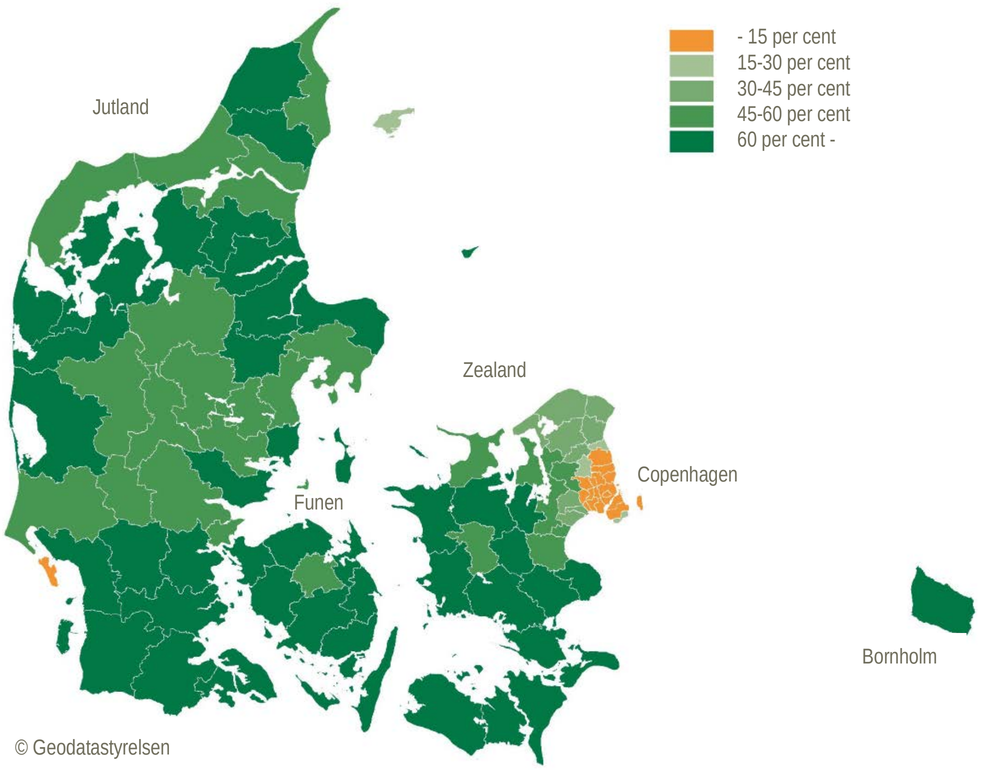
The majority of the agricultural land, 23,876 km² in 2016, was covered by herbaceous crops (e.g. cereals, rape and root crops). This corresponds to 55.6 per cent of total Danish land. Intensive crops took up less space in 2016 than in 2011, when their land share was 57.6 per cent. Areas covered by extensive and permanent agricultural crops, particularly grass and fallow land, increased from 4.4 per cent of the total Danish area in 2011 to 5.5 per cent in 2016. This change can be explained in part by the fact that farming subsidy schemes required the setting aside of land for buffer zones, fallow land and other ecological focus areas.

The map in figure 13.2 shows that agricultural crops account for the largest land cover in the vast majority of Danish municipalities. Southern Jutland, Funen, West and South Zealand are the most densely cultivated areas. Municipalities in the Greater Copenhagen area do not have many crops. Here, the land cover consists primarily of buildings and built-up areas.

Roads and built-up areas etc. cover 14 per cent of the land

A total of 14 per cent of Danish land is covered by artificial surfaces; i.e. it is covered by roads, buildings and built-up areas, including gardens, car parks, parks and other landscaped surfaces. Infrastructure such as roads, railroads and runways cover 5.8 per cent of the land, while buildings and built-up areas cover 8 per cent.

Figure 13.2 Land with agricultural crops by municipality. 2016



Increase in paved area

There was a modest increase in the amount of paved areas, from 5,866 km^2 in 2011 to 5,890 km^2 in 2016. This corresponds to an increase of 0.4 per cent. During the same period, the number of inhabitants in Denmark increased by 2.6 per cent, so the amount of built-up areas and paved areas did not grow at the same rate as the population. The Danish Planning Act divides the country into urban zones and rural zones. Rural zones normally only allow building and construction related to agriculture and forestry. This is to protect the countryside, prevent scattered built-up areas and concentrate urban development in planned areas.

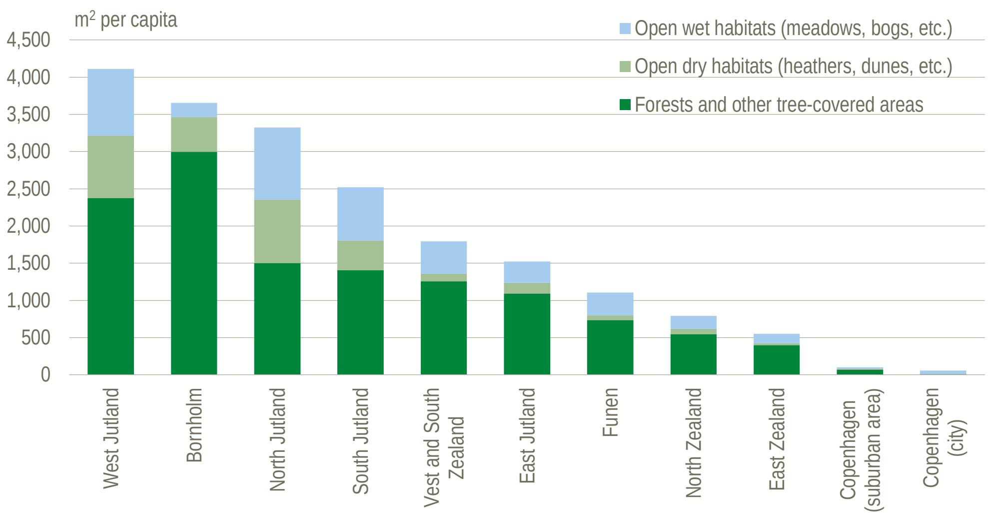
Forests, open habitats, lakes and streams

In 2016, forests took up almost 13 per cent of the land. This was a small increase compared with 2011. Open habitat types also increased between 2011 and 2016. In 2011, they made up 8.2 per cent of the total land cover. In 2016, this figure was 8.6 per cent. Lakes and streams accounted for 2.2 per cent of the land in 2016. This figure was unchanged in relation to 2011.

West Jutland has the most nature per capita

Figure 13.3 shows the amount of land with forests and open habitats per capita in the different provinces. West Jutland has more than 4,000 m^2 of nature per capita in the form of forests and open habitat types such as heaths, dunes, meadows and bogs. The island of Bornholm has the highest per capita proportion of forest, at almost 3,000 m^2 per capita. Not surprisingly, the least nature on a per capita basis is found in the capital city Copenhagen and the surrounding suburban area.

Figure 13.3 Land with forest and open habitats per capita by province. 2016



Box 13.1 Regions, municipalities and provinces.

At the administrative level, Denmark is divided geographically into regions and municipalities. There are 98 municipalities and five regions: the Capital Region of Denmark (Region Hovedstaden); Central Denmark Region (Region Midtjylland); North Denmark Region (Region Nordjylland); Region Zealand (Region Sjælland); and the Region of Southern Denmark (Region Syddanmark). Provinces are not used at an administrative level, but are instead statistical divisions which apply to the EU statistical nomenclature NUTS 3. Denmark has 11 provinces, which are a subdivision of the regions.

13.2 Ownership of forests, nature and recreational areas

Much of Denmarks's forests and open habitats are in private hands

This section examines the ownership of Danish land; a previous analysis (Vind et al., 2017) undertaken by Statistics Denmark, which linked land cover accounts to administrative data on ownership, has functioned as a point of departure in the context of this section.

Of significance are specific land cover categories that can be used recreationally: forests, open habitats, lakes and streams, and parks and other green recreational areas. In the land cover accounts (table 13.1), parks are classified as artificial surfaces. Of course, for many inhabitants in larger cities, parks and other man-made recreational areas represent the most immediately accessible 'green areas'. As such, they are explicitly included in this section.

The greatest proportion of private ownership relates to two land cover types: streams; and wet open habitats, see figure 13.4. These types of land cover often occur on or alongside agricultural land, and as such this land is often owned by farmers.

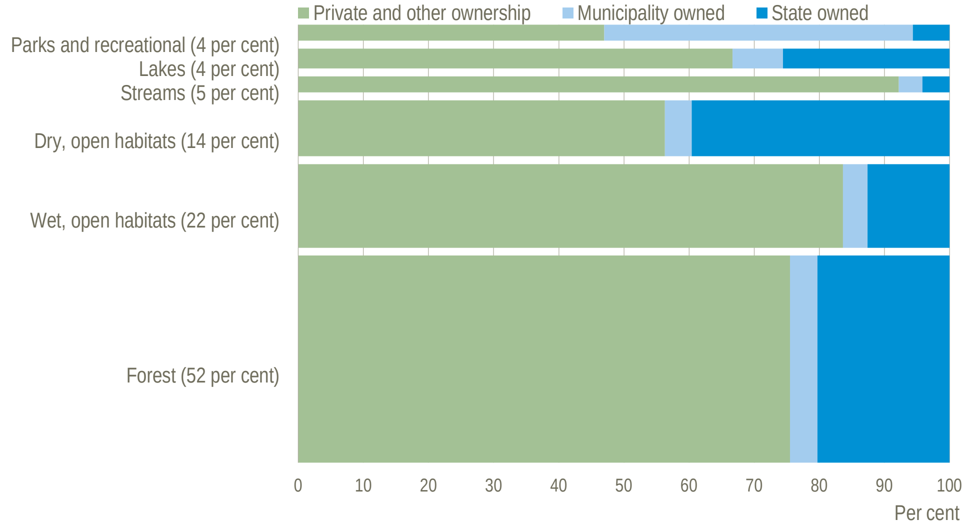
The Danish state owns 20 per cent of the land covered with forest

However, the Danish state also owns large amounts of land. State-ownership is particularly significant for forests and dry open habitats. Almost 40 per cent of dry open habitats are owned by the state, as well as 20 per cent of Denmark's forests.

Municipalities own a smaller proportion (6 per cent) of the land covered with forests, open habitats, lakes and streams. They do, however, own a considerable share of parks and other recreational green areas, primarily in cities and towns.

Private ownership is prevalent amongst other types of land cover not shown in figure 13.4: particularly agricultural areas and built-up areas. Overall, 90 per cent of the land in Denmark is privately owned: the remaining 10 per cent is owned by the state and municipalities.

Figure 13.4 Land cover (selected types) and ownership. 2016



13.3 Danish land cover in a European perspective

Denmark has the highest proportion of arable land

In no other EU member state is such a high proportion of the land covered by agricultural crops: the Danish proportion of land area covered by this type is over 50 per cent[1], which is more than twice the EU-28 average of 22 per cent.

In Denmark's Nordic neighbours, Sweden and Finland, agricultural crops take up less than 10 per cent of total land area. In the European Union, Hungary comes closest to Denmark's high percentage of agricultural area with 44 per cent.

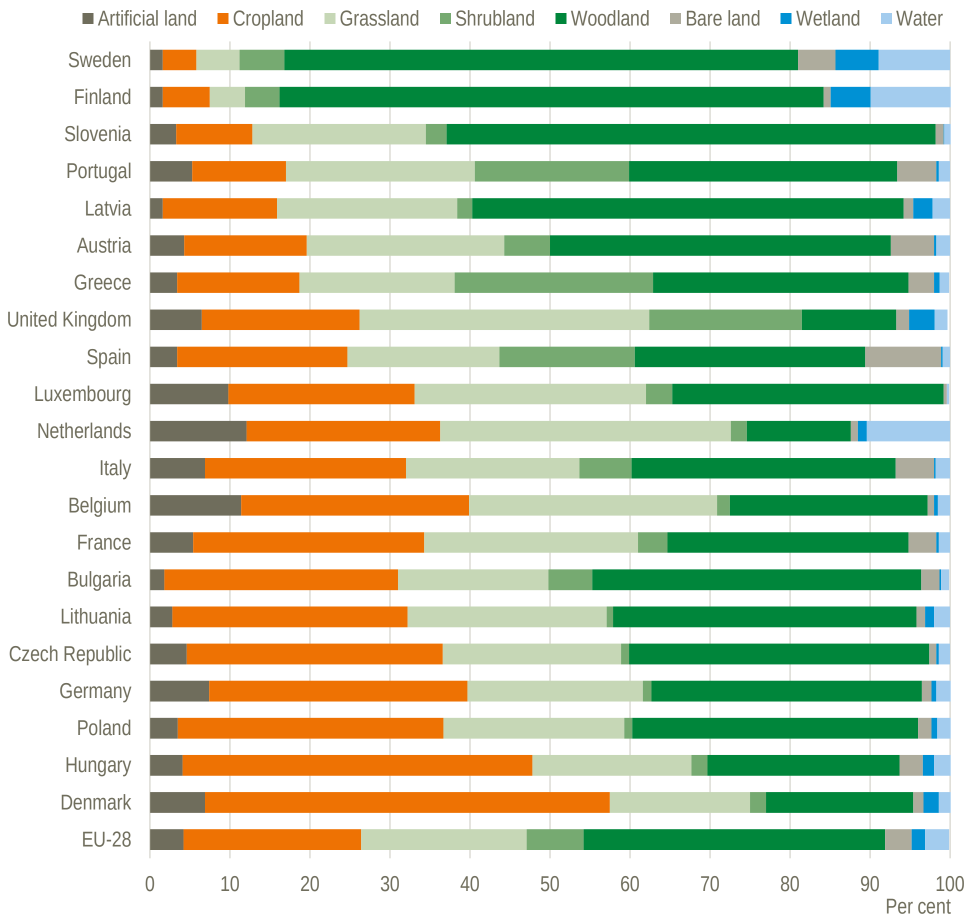
Relatively little forest

On the other hand, the 18 per cent of Danish land covered by forest represents a low figure when compared with most EU member states and the EU-28 as a whole. This percentage is very small compared with Sweden and Finland, where the share of land cover with forest is more than 60 per cent. Sweden and Finland are ten and eight times larger than Denmark, respectively, and have much lower population densities. Denmark has 132 inhabitants per km^2, while Sweden has 24 and Finland 18.[2]

[1] The data and figure presented in this section comes from Eurostat's Land Use and Coverage Area frame Survey, LUCAS. The LUCAS data deviate somewhat from the data presented in the Danish land accounts. For example, the 'grassland' category in LUCAS covers agricultural crops (grass fields) and open nature areas with grass and similar vegetation. Moreover, LUCAS is sample-based, as opposed to the national land accounts, which are based on digital maps.

[2] 2015 figures, source: Eurostat, http://ec.europa.eu/eurostat/tgm/table.do?tab=table&init=1&plugin=1&pcode=tps00003&language=en

Figure 13.5 Land cover in the European Union. 2015



Note: See footnote 1 on previous page.
Source: Eurostat, LUCAS (176)

13.4 Land use

Land is the basis for economic activity

All industries need land. Where they differ is in how *much* land they need, and whether they are able to *share* this land. Agriculture self-evidently uses large areas, while service industries like lawyers, the retail trade, and public administration take up less space, not least due to the fact they are able to share land by occupying, for example, buildings with multiple floors. Some industries can also share land that is partly used for housing: as is the case with mixed office and housing complexes, or in the case of businesses run from home.

The primary industries use 82 per cent of the land

Primary industries (agriculture, forestry, fishing as well as mining and quarrying), which are directly dependent on the land, took up 35,258 km² of land in 2016. This corresponds to 82 per cent of the Danish land area.

Other industries use 3 per cent

Other industries used a total of 1,301 km², corresponding to 3 per cent. Among these, public administration, teaching, and health took up most land (350 km²). Thus, 61 m² of land was used per inhabitant for government buildings, city halls, schools, institutions, hospitals, etc.

5.6 per cent for residential purposes and 1.8 per cent for summer houses etc.

In addition to 36,559 km² for commercial purposes, 2,403 km² (5.6 per cent) of Danish land in 2016 was used for residential purposes; i.e. the buildings lived in by the inhabitants of Denmark and the attached land (private gardens, courtyards, parking spaces etc.). Areas for summer houses, holiday homes, and other recreational facilities took up 790 km² in 2016, corresponding to 1.8 per cent of the total land area.

Large regional differences

The land use accounts also show large differences in how much space is occupied in the different provinces. In Copenhagen, each inhabitant only takes up 54 m² on average for residential purposes, whereas people on the island of Bornholm in East Denmark have the most space: 808 m² of land for residential purposes per inhabitant.

Infrastructure

Finally, infrastructure took up 1,467 km² (3.4 per cent). This figure is somewhat smaller than the corresponding figure for roads and railroads in the statistics concerning land cover (table 13.1). Part of this difference is likely due to the fact that small dirt roads and forest roads in the land use statistics were ascribed to agriculture and forestry rather than infrastructure.

However, part of the difference can also be attributed to statistical uncertainty in the case of both the land use and land cover accounts. The land use accounts in particular are the first of their kind in Denmark to be based on administrative sources. For four per cent of the land, there is no information on use.

Table 13.2 Land use by industry and other use categories. 2016

	km²	per cent	m² per capita	m² per employee
Land, total	42 926	100.0	7 521	-
Primary industries	35 258	82.2	6 177	491 523
Agriculture, forestry and fishing	35 234	82.1	6 173	521 685
Mining and quarrying	24	0.1	4	5 794
Other industries	1 301	3.0	228	464
Manufacturing	153	0.4	27	529
Utility services	81	0.2	14	3 654
Construction	63	0.2	11	352
Trade and transport etc.	321	0.7	56	434
Information and communication, financial and insurance, real estate	98	0.2	17	428
Business services	88	0.2	15	287
Public administration, education and health	350	0.8	61	395
Arts, entertainment and other services	148	0.3	26	958
Other uses	6 366	14.8	1 116	-
Households (dwellings)	2 403	5.6	421	-
Recreational facilities (incl. summer houses)	790	1.8	138	-
Infrastructure	1 467	3.4	257	-
No known or specific use	1 706	4.0	299	-

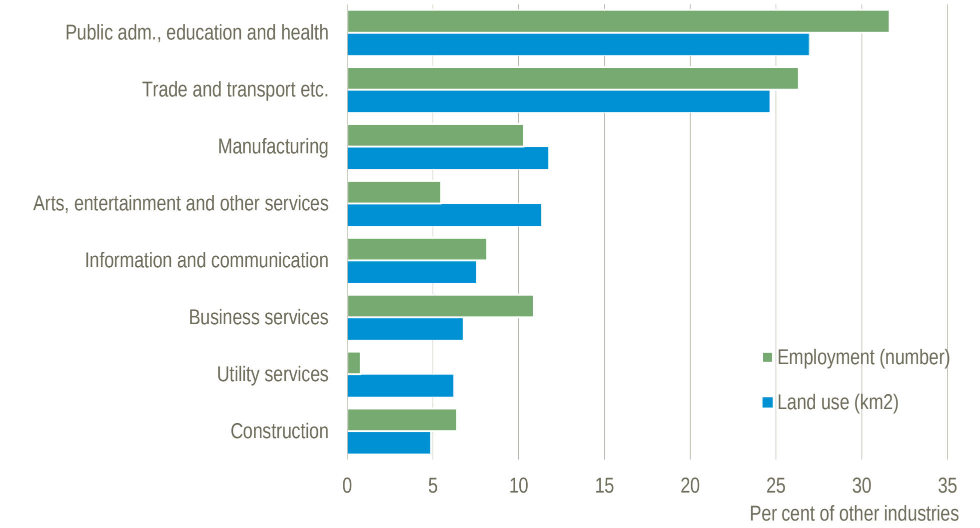
Employment and industrial land use

When considering the relationship between land use and employment, it is the primary industries which require most land in relation to their number of employees. Their land use corresponds to 491,523 m² per employee. Among the other industries, utility services require most land. A total of 3,654 m² land is used for each employee in utility services. Utility services include e.g. waste treatment facilities, power plants and wastewater treatment plants.

The culture, leisure and other services industry group also uses a lot of land, with 958 m² of land per employee. This industry includes e.g. golf courses, sports facilities, amusement parks, cinemas and similar.

All the industries mentioned use more land than that which corresponds to their share of employment. This is shown in figure 13.6, in which primary industries have been left out, however, due to their dominant role in land use. Conversely, industries such as public administration, education and health, business services as well as trade and transport etc. are relatively more employment-oriented than land-oriented.

Figure 13.6 Land use and employment. 2016



Note: The figure shows each industry's percentage of the total land use and employment of all the industries included in the figure.

13.5 Continued expansion of Danish land accounts

Economic value of areas

In the green national accounts, land cover and land use have so far only been calculated in physical units (km^2). A calculation of the value of the area could be an important later expansion of the accounts.

Land accounts as a basis for ecosystem services

Land accounts can also form the basis of accounts for ecosystems and ecosystem services. The land cover accounts for e.g. forests can form the basis of accounts for ecosystem services provided by forests, such as timber production, water regulation and carbon storage.

Box 13.2 About the land accounts

The land accounts assess land cover and land use.

Land cover was calculated in collaboration with the Danish Centre for Environment and Energy (DCE) at Aarhus University. The DCE's work on putting together a consolidated land cover map for Denmark has been documented in a technical report; see Levin et al. (2017). The calculations were based on a number of digital map data from various sources. These figures were first published in February 2017. They include comparable figures for 2011 and 2016.

Land use was calculated on the basis of the Danish cadastral map and a series of administrative registers (the Danish Buildings and Dwellings Register (BBR), the Central Business Register (CVR), the Civil Registration System (CPR) and property-tax assessment information from the Central Customs and Tax Administration (SKAT)) and data on municipal development plans.

More information:
http://www.statbank.dk/10594
https://www.dst.dk/en/Statistik/dokumentation/documentationofstatistics/land-accounts

14 Forest

14.1 Introduction

Forest cover smaller in Denmark than in many other European countries

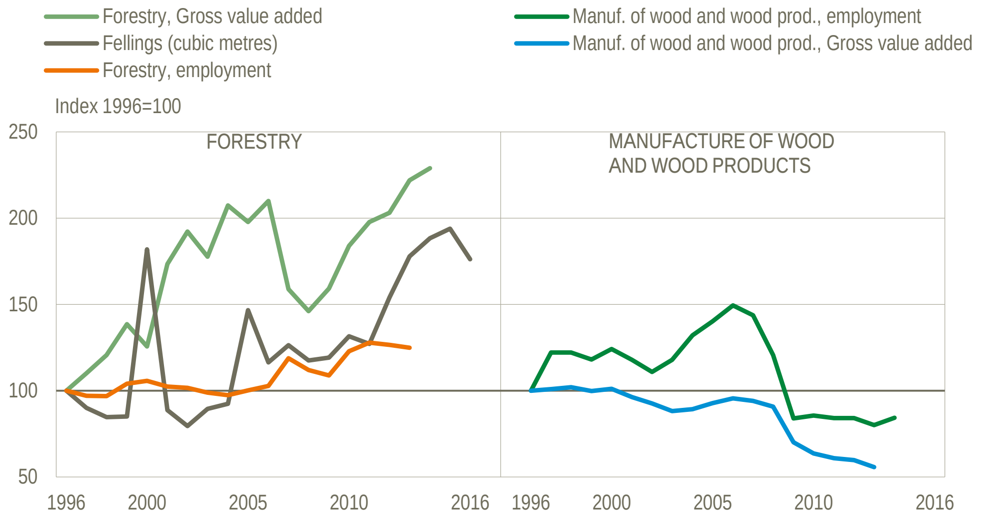
In Denmark, forests cover a smaller proportion of the land than in most other European countries. Approximately 15 per cent of Denmark was covered by forest in 2016. The precise figure depends on the method of assessment (see box 14.1).

Forestry is of little significance to the Danish economy

Even though the vast majority of forests in Denmark are cultivated forests and felling in the forests has been increasing (with high fluctuations, however), forestry is not very significant for the Danish economy in general. The activity in Danish forestry and in the manufacture of wood and wood products combined generated an added value of DKK 5.9 billion in 2016. Primary forestry accounted for DKK 2.1 billion of this, whereas the added value of the manufacture of wood and wood products accounted for DKK 3.8 billion. 5,678 people were employed in forestry, while 8,032 were employed in the manufacture of wood and wood products. The forestry and manufacture of wood and wood products industries combined account for just 0.5 per cent of total Danish employment.

Figure 14.1

Key figures for forestry and manufacture of wood and wood products



Note: The index for gross value added is based on chained volumes, 2010 prices

Import of wood for the Danish manufacture of wood and wood products

The manufacture of wood and wood products in Denmark consists partly of sawmills, which process the primary products of forestry and partly of enterprises manufacturing wooden products such as floorboards, wooden construction materials etc. In many cases, the wood processed in the Danish manufacture of wood and wood products is imported. The paper industry is not included here, since there is no manufacturing of paper from new wood pulp in Denmark.

The added value in forestry, measured in constant prices (chained volumes, 2010 prices), has increased steadily over time. With some fluctuations, the relative contribution of forestry to the economy has been fairly constant for about 50 years, which is the period for which comparable national accounts are available. The significance of the Danish manufacture of wood and wood products has been declining for a number of years, but there is only a limited link between Danish forestry and the wood industry due to foreign trade in wood.

Table14.1 Key figures for forestry and manufacture of wood and wood products in Denmark

	2010	2011	2012	2013	2014	2015	2016
	DKK billion						
Gross value added	5.5	5.8	5.9	6.2	6.4	6.3	5.9
Forestry	1.6	1.8	1.9	2.3	2.3	2.3	2.1
Manufacture of wood and wood products	3.9	4.0	4.0	3.9	4.1	4.0	3.8
Exports	4.7	5.2	5.1	5.4	5.6	..	..
Forestry	0.3	0.3	0.3	0.3	0.4	..	..
Manufacture of wood and wood products	4.4	4.9	4.8	5.1	5.2	..	..
	people employed						
Employment total	14 537	14 363	14 140	13 508	13 749	13 710	..
Forestry	5 537	5 756	5 699	5 628	5 881	5 678	..
Manufacture of wood and wood products	9 000	8 607	8 441	7 880	7 868	8 032	..

The forests are also the basis of ecosystems and biodiversity

Of course, the forests are more than just production areas for forestry. They are important ecosystems which offer services in the form of e.g. recreational opportunities and carbon sequestration. The forests also provide the foundation for some of Denmark's biodiversity, because a major part of Denmark's indigenous animals and plants are linked to the forests.

Biodiversity is measured in the National Forest Inventory

The amount of biodiversity which the various Danish forests are able to support depends on the composition of the forests (tree species, age structure etc.), cultivation methods and the distribution in the landscape. The green national accounts do not include accounts of biodiversity, but in the *National Forest Inventory* (Nord-Larsen et al., 2017) a number of forest biodiversity indicators are assessed.

14.2 Forest area

Aim to double the forest area

In general, the forest area has been increasing for more than 100 years. The increase in the forest area up until the 1970s is mainly due to afforestation of coniferous plantations. The area of broadleaf forest did not increase significantly until after 1990 (Levin & Normander, 2008). In 1989, the Danish Parliament adopted a policy aim for Denmark to double the forest area in the course of the next 100 years.

Declining growth in the area in recent years

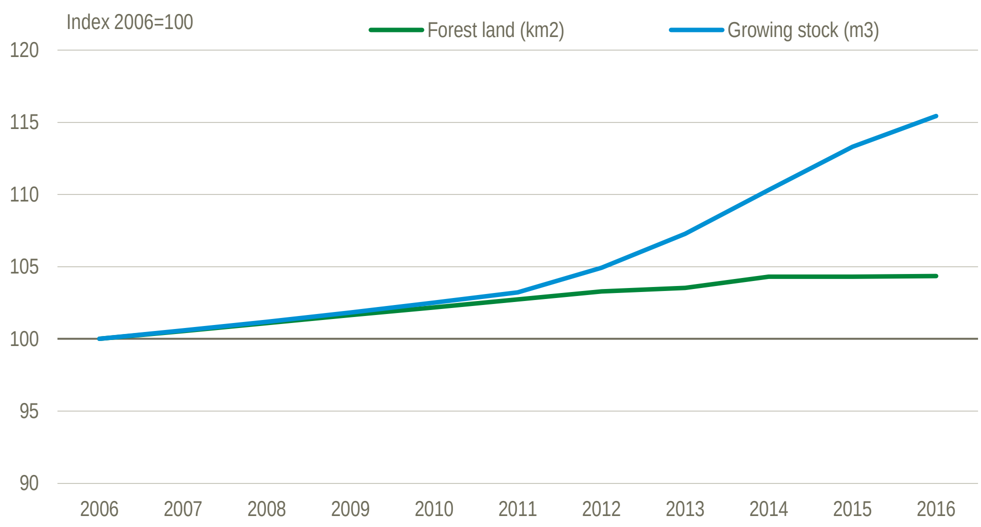
The Danish forest area was 6,378 km^2 in 2016, corresponding to 14.9 per cent of Danish land. This forest area was assessed as part of a report on LULUCF (land use, land use change and forestry) under the Kyoto protocol[1]. From 2006 to 2016, the forest area grew by 4 per cent; see figure 14.2. In recent years, however, the growth in the forest area has been declining, and from 2015 to 2016 there was hardly any change in the size of the forest area. See also SDG indicator 15.1.1 for the forest area in chapter 3.

In 2015, approximately 30 km^2 were afforested, while 26 km^2 were deforested. In comparison, the afforestation was approximately 40 km^2 in 2010, while the deforestation was less than 7 km^2.

[1] See box 14.1 about the difference compared to the forest area in the land cover survey in chapter 13.

Figure 14.2

Forest land and growing stock



Note: The forest land has been assessed in accordance with the LULUCF (land use, land use change and forestry) guidelines under the Kyoto protocol; see box 14.1.

Most forest is privately held

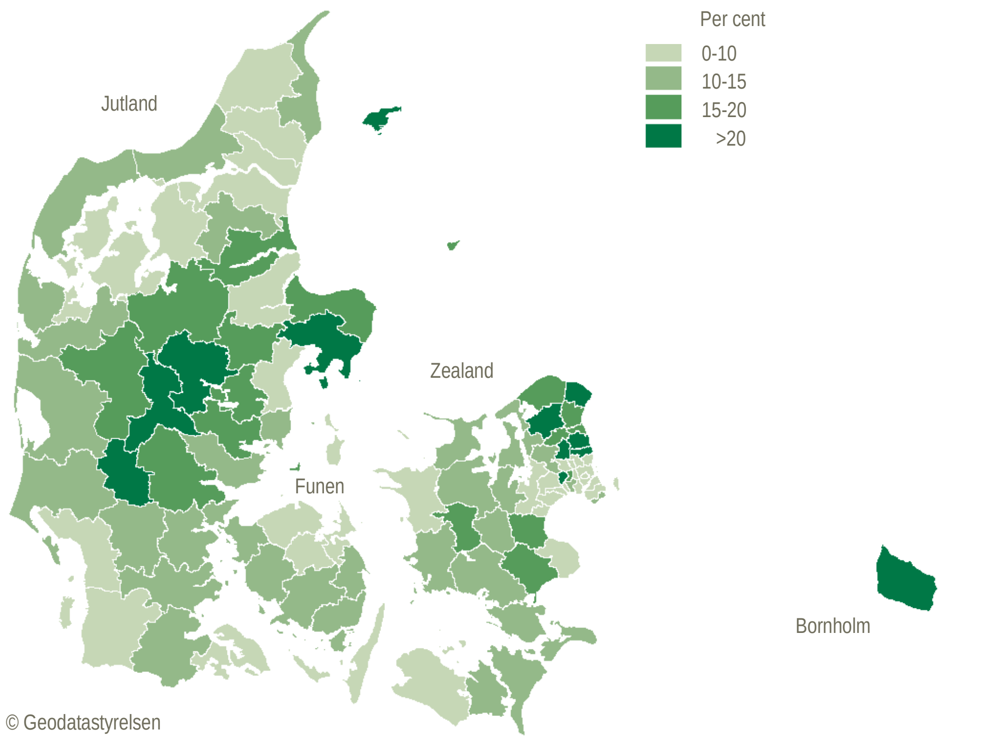
About one quarter of the Danish forest areas are owned by the public, primarily the state. The rest is privately held, i.e. owned by enterprises, private individuals, foundations and institutions. The state forests are run for several purposes – commercial forestry is not the only operational consideration. Private land owners who are also subject to the Forestry Act (see below) may apply for subsidies for afforestation under different schemes targeted at e.g. ground water protection and biodiversity.

Uneven geographical distribution of the forest

The geographical distribution of the forest area is shown in figure 14.3. The majority of the forest land is in central Jutland and North Zealand. In the forests of Jutland, conifers are most widespread, whereas broadleaves are most common in Zealand. This is very much due to the cultivation conditions, e.g. the soil.

Figure 14.3

Forests by municipality (share of total area). 2016



Source: Vind et al. (2017)

No virgin forest, a little undisturbed forest and a lot of protected forest

The Danish forests are generally all planted forests; there is no virgin forest in Denmark. However, some forest areas are designated untouched forest and accordingly these are no longer affected by felling and other forestry activities. In 2016, 6 per cent of the forest area was designated undisturbed forest (Nord-Larsen et al., 2017). However, the majority of the Danish forests are protected by the Forestry Act, since they are defined as forest reserves.

A forest reserve is an area of forest in which it is legally stipulated that the land cover must remain forest: in other words, whilst economic activity can occur – in contrast to untouched forest – the forest itself cannot be changed to e.g., artificial surfaces. A further requirement of forest reserves is that sustainable forestry, as described in the Forestry Act, is undertaken.

Box 14.1 Different assessments of the forest area

There are various assessments of the Danish forest area, and comparisons of the development of the forests over time may be affected to some extent by the method applied.

The resource accounts for forests include the forest area reported by Denmark under the Kyoto protocol's section on land cover (LULUCF) (Nielsen et al., 2017). This assessment was used because it has a high degree of comparability over time. The reporting also includes changes, i.e. afforestation and felling. The Danish forest area was 6,378 km^2 in 2016, corresponding to 14.9 per cent of the Danish land.

According to the land cover assessment (section 13.1), Denmark had 5,454 km2 of forest in 2016. This corresponds to 12.7 per cent of the land. The purpose of the land cover accounts is to create a consolidated view of all of the Danish land at a given point in time.

The difference between the two assessments is partly due to uncertainties in both assessments, partly to differences in the definitions, sources and method. The land cover accounts shown in chapter 13 include Christmas trees, forest roads, fire breaks, auxiliary areas etc. in the forest area. The delimitation differences do not fully explain the difference between the two methods of assessment. Some of it can also be attributed to methods and source basis. E.g. differences in the resolution (level of detail) of the map layers on which they are based.

14.3 Growing stock

Forests measured as growing stock

In addition to measuring the extent of forest land, the forests can be measured by the amount of tree they contain. When trees are living and standing in forests, they can be referred to as growing stock. The growing stock is the total cubic content and is measured in cubic metres. In practice, the growing stock is estimated via a combination of measurements of trees in sample plots and model calculations which take into account the typical growth of various trees as well as the relationship between diameter, height and growing stock[2].

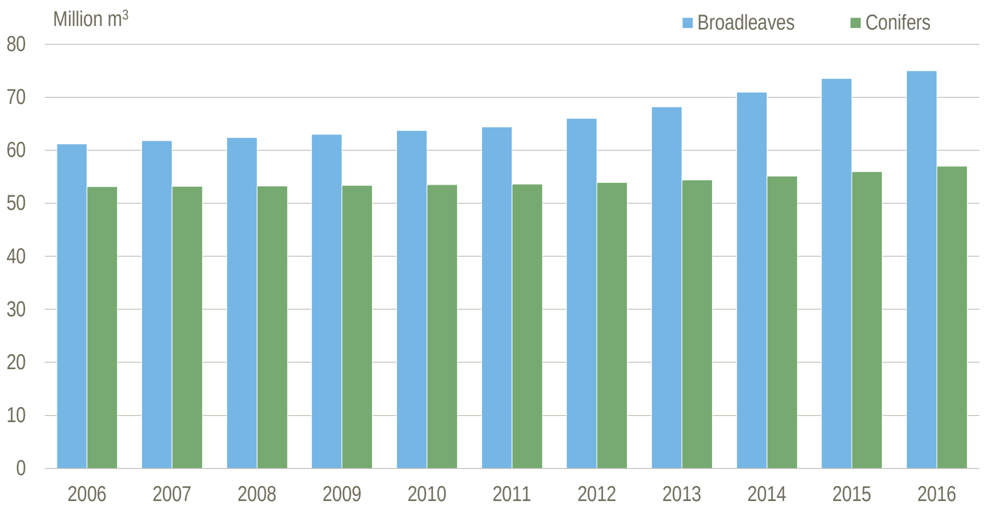
In 2016, Danish forests contained trees with a total growing stock of 132 million cubic metres. Broadleaves accounted for 75 million cubic metres of growing stock in 2016, whereas conifers accounted for the remaining 57 million cubic metres; see figure 14.4.

In 2016, the growing stock was 15 per cent higher than in 2006; see figure 14.2. In the ten years from 2006 to 2016, the growing stock of broadleaves grew the most by 23 per cent, whereas the growing stock of conifers grew by 7 per cent.

[2] The assessment of growing stock is made in Denmark by the Department of Geosciences and Natural Resource Management at the University of Copenhagen.

The most significant species of broadleaves in the Danish forests is beech, which accounts for a little less than half of the growing stock of broadleaves. Other wide-spread species of broadleaves are oak, ash, birch and sycamore maple. The most important species of conifers is Norway spruce, which accounts for 42 per cent of the growing stock of conifers. Other widespread species of conifers are Sitka spruce, pine and fir.

Figure 14.4 Growing stock, opening stock by species of wood



The annual growth of conifers is highest, but the felling is correspondingly high

Figure 14.5 and table 14.2 illustrate the annual physical changes in the growing stock for broadleaves and conifers. The growing stock grows each year due to natural growth, in which the individual trees grow bigger and new trees are planted or reseed themselves. At the same time, a reduction takes place of the growing stock each year. This is primarily due to felling, but tree death and windfall also reduce the growing stock. The difference between the growth and the reductions constitutes the net growth, which determines the change in the stock.

The growing stock of broadleaves has increased, because the growth of the trees has been greater than the reductions in the growing stock every year throughout the period. The gross growth in the growing stock of conifers is higher than that for broadleaves almost every year. At the same time, however, a reduction of the growing stock of conifers takes place every year by felling. This is why the growing stock of conifers is only increasing a little.

When the growing stock is reduced, this is particularly due to felling. The trees felled in Danish forests are primarily used as firewood and energy wood (wood chip). The felling has been increasing through the past 10 years. The highest increase has taken place in the felling of trees for use as firewood and energy wood, whereas the growth in the felling of timber has been somewhat more modest; see figure 14.6.

Figure 14.5 Changes in growing stock by species of wood

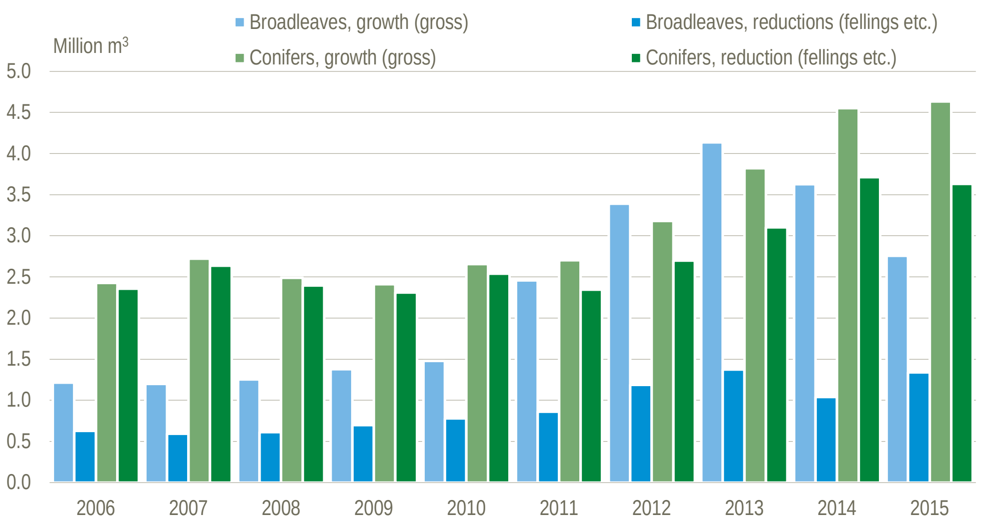
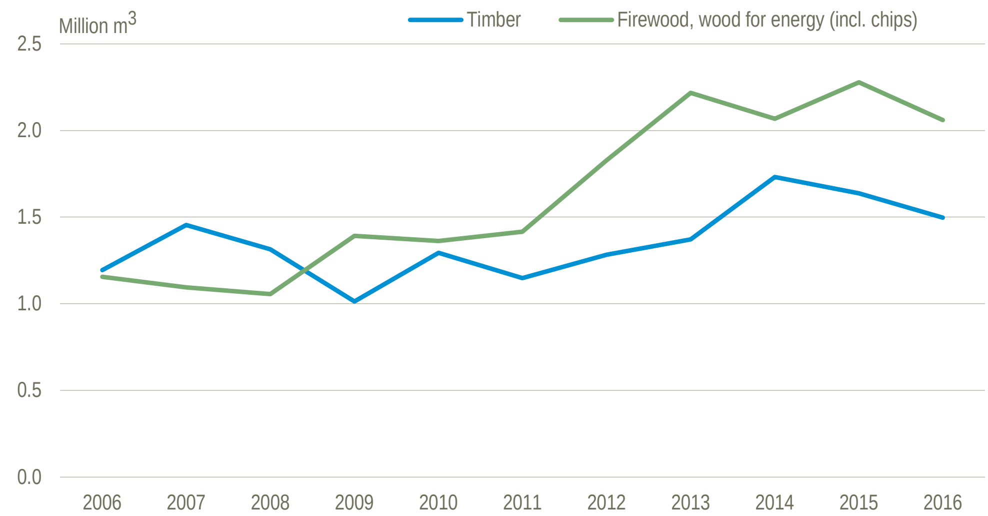


Figure 14.6 Felling by type



Source: www.statbank.dk/skov55

The growing stock has a monetary value of DKK 15.8 billion

The growing stock has a monetary value which can be estimated based on the prices of lumber, firewood and wood chip and a number of assumptions. In the green national accounts, the value of the growing stock in Danish forests has been assessed at DKK 15.8 billion in 2015. The amount is distributed with DKK 9.6 billion worth of broadleaves and DKK 6.2 billion worth of conifers. Broadleaves account for 61 per cent of the growing stock value. In comparison, broadleaves constitute 57 per cent of the physical stock. The valuation is based on the 'stumpage price method', see box 14.2.

The total value of the growing stock has increased from 2006 to 2016. The value of the conifers in particular has increased, which is mainly due to price changes (revaluation). The growing stock of broadleaves has also increased in value, but this is mainly due to the increased physical volume. The prices of broadleaves have been stable or declining from 2006 to 2016. There is probably a connection between the prices of the broadleaves and the cautious felling of broadleaves.

Table 14.2 Growing stock by species of wood (physical balance)

	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
	million m³									
Broadleaves										
Opening stock (1)	61.2	61.8	62.4	63.0	63.7	64.4	66.0	68.2	71.0	73.6
Growth (gross) (2)	1.2	1.2	1.3	1.4	1.5	2.5	3.4	4.1	3.6	2.8
Felling, losses and other reductions (3)	0.6	0.6	0.6	0.7	0.8	0.9	1.2	1.4	1.0	1.3
Closing stock (=1+2-3)	61.8	62.4	63.0	63.7	64.4	66.0	68.2	71.0	73.6	75.0
Conifers										
Opening stock (1)	53.1	53.2	53.3	53.4	53.5	53.6	54.0	54.4	55.2	56.0
Growth (gross) (2)	2.4	2.7	2.5	2.4	2.7	2.7	3.2	3.8	4.6	4.6
Felling, losses and other reductions (3)	2.4	2.6	2.4	2.3	2.5	2.3	2.7	3.1	3.7	3.6
Closing stock (=1+2-3)	53.2	53.3	53.4	53.5	53.6	54.0	54.4	55.2	56.0	57.0

Table 14.3 Value of growing stock by species of wood (monetary balance)

	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
	DKK million									
Broadleaves										
Opening stock (1)	7 955	8 018	7 796	8 141	8 087	8 565	8 828	9 025	9 480	9 654
Growth (gross) (2)	158	156	157	178	188	327	453	548	484	362
Felling, losses and other reductions (3)	81	77	77	90	99	115	159	182	139	176
Revaluation (4)	-14	-300	265	-143	390	52	-98	89	-172	-408
Closing stock (=1+2-3)	8 018	7 796	8 141	8 087	8 565	8 828	9 025	9 480	9 654	9 432
Conifers										
Opening stock (1)	3 093	3 545	4 037	4 917	5 232	5 719	6 249	6 333	6 312	6 226
Growth (gross) (2)	141	181	189	222	260	288	368	445	521	515
Felling, losses and other reductions (3)	137	176	182	213	248	250	313	361	425	404
Revaluation (4)	447	486	873	306	475	492	28	-104	-182	-420
Closing stock (=1+2-3+4)	3 545	4 037	4 917	5 232	5 719	6 249	6 333	6 312	6 226	5 916

The many other values of forests

As mentioned previously, forests and their growing stock have value in many ways besides the purely market-oriented value of growing stock as lumber. The value of their biodiversity is significant, as are the ecosystem services such as carbon storage, recreation, and groundwater protection. The green national accounts do not yet contain any assessment of these services or their value.

Box 14.2 About the resource accounts for forest

The most important data source of the resource accounts for forest is the National Forest Inventory of Denmark, which is produced by Skov og Landskab (Forest and Landscape) at the Department of Geosciences and Natural Resource Management, University of Copenhagen. Furthermore, the data sources include, among others, felling statistics, produced by Statistics Denmark, and data from Denmark's reporting under the Kyoto protocol's section on land use and land use changes (LULUCF) (Nielsen et al., 2017).

The valuation method used for the monetary balance of growing stock is the stumpage price method. This is a simplified net present value method (see chapter 12) where the value of the stock is obtained by multiplying the current volume of standing timber by its stumpage price, assuming the rate of discount is equal to the natural growth rate. The stumpage prices are estimated from road side market prices, deducting costs of felling and transport.

The resource accounts for forest initially only include a valuation of the growing stock. The market value of the forest areas is not included due to insufficient data basis. Nor have the non-market values of the forest been included, because these can only be valued by experimental methods.

More information:
http://www.statbank.dk/10594
http://www.dst.dk/en/Statistik/dokumentation/documentationofstatistics/forest-accounts

15 Fish and shellfish

15.1 Economic significance of Danish fisheries

With an extensive coastline and easy access to the sea, Denmark has a long tradition of fishing. Even though fisheries have not been a significant part of the Danish economy since the Middle Ages, catching and processing fish has consistently had considerable local influence. This applies in particular to northern and western Jutland, where the majority of fishing and fish processing takes place.

Today, the Danish fishing activities comprise two specific industry groups. The fishing industry comprises wild fish and shellfish caught from Danish vessels, as well as the farming and harvesting of fish and shellfish in aquaculture. The other relevant industry group is the processing of fish: for both human consumption and for reduction for the production of fish meal and oil.

Value added of DKK 4 bn. and 5,000 employees

Activities in fishing and processing of fish annually generate gross value added close to DKK 4 billion, and together the two sectors employ around 5,000 people. Total gross value added and employment are more or less equally distributed between the two sectors. Aquaculture is included in the figures for value added and employment in fishing.

Fish make up 3 per cent of Danish goods exports

The Danish production of fish and fish products is primarily exported. Total annual Danish exports from fishing and processing of fish amount to DKK 21-22 billion, corresponding to just over 3 per cent of total Danish goods exports. The fishing industry is responsible for around one quarter of these exports. A proportion of the fishing industry's exports occur as a result of fish landed by Danish fishermen in foreign ports. The processing of fish accounts for the remaining three-quarters of exports.

Table15.1 Key economic figures for fishing and processing of fish in Denmark

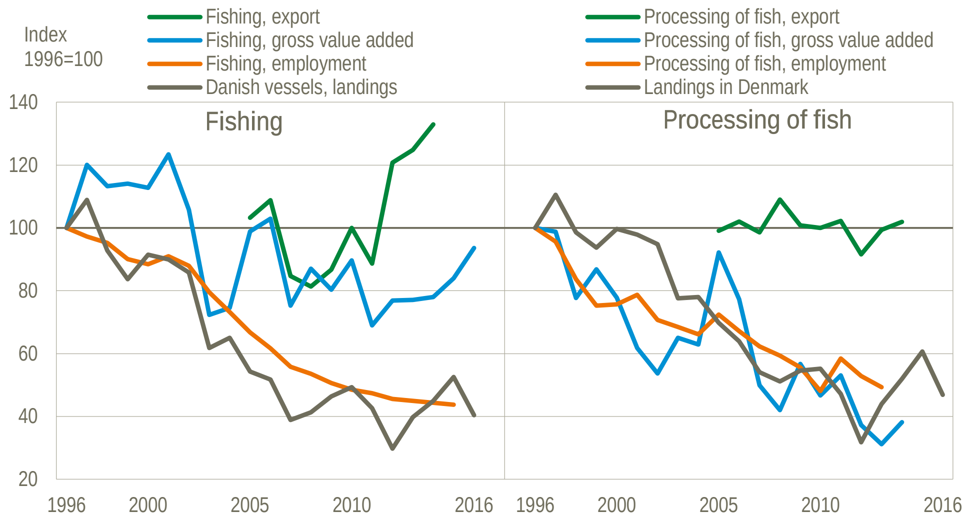
	2010	2011	2012	2013	2014	2015	2016
	DKK billion						
Gross value added	3.6	4.1	3.9	3.9	3.9	..	..
Fishing	1.9	1.9	1.9	2.0	1.9	2.5*	2.9*
Processing of fish	1.6	2.1	2.0	1.9	1.9	..	..
Exports	17.8	19.3	19.6	21.2	21.5	23.5*	25.5*
Fishing	3.3	3.3	4.7	5.0	5.2	..	..
Processing of fish	14.5	16.0	14.9	16.2	16.3	..	..
	persons						
Employment	5 222	5 708	5 305	5 085	..	..	..
Fishing	2 670	2 609	2 505	2 472	2 438	2 408	..
Processing of fish	2 552	3 099	2 800	2 613	..	..	..

Note: The figures in this table come from the Danish national accounts.

Reduction in quantities of fish landed

Landings by Danish fishermen in Danish and foreign ports are currently around 60 per cent lower than 20 years ago, see left part of figure 15.1. The decline in fishing has meant that gross value added and employment in fishing have been generally declining in this period. However, gross value added rose again in the last part of this period, and now it has almost returned to the level in 1996.

Figure 15.1 Developments in fishing and processing of fish



Note 1: Total landings by Danish vessels (left figure) include landings in Danish and foreign ports. Landings in Denmark (right figure) include landings in Denmark by Danish and foreign fishermen.

Note 2: The trends in gross value added and exports were calculated on the basis of chained volumes, 2010 prices.

Larger vessels and increased efficiency in fishing

The increasing gross value added and decreasing employment which have occurred in recent years indicate that the Danish fishing industry has become more efficient. It is probable that this is a result of the fact that fishing has become more concentrated, with fewer, but larger, fishing vessels. The number of fishing vessels has fallen by 19 per cent since 2010, whilst the tonnage (a measure of the cargo-carrying capacity of seafaring vessels) has remained broadly stable. Between 1996 and 2006, the number of fishing vessels fell from 4,830 to 2,273 vessels. The remaining vessels include many smaller ancillary vessels or inactive vessels that are not used for commercial fishing.

Box 15.1 International regulation of Danish fisheries

Danish fisheries are subject to the European Union's Common Fisheries Policy (CFP), which aims to ensure that fishing and aquaculture are environmentally, economically and socially sustainable. This is done by regulating fishing fleets in the European Union and limiting the catch to maintain fish stocks at a sustainable long term level. Moreover, the CFP aims to give all European fishing fleets equal access to EU waters and fishing areas.

According to the CFP, each coastal state has the right to manage natural resources in its Exclusive Economic Zone, but under the CFP, the fishing area of all EU states is considered one zone (see map above).

Fisheries in the European Union are regulated on the basis of recommendations from the International Council for the Exploration of the Sea (ICES). On the basis of assessments of fish stocks, the ICES makes recommendations on the total allowable catch (TAC) for a series of commercially important species divided into geographic fishing areas.

The European Union sets quotas for Member States and allocates quotas between the European Union and adjacent countries, such as Norway, in bilateral negotiations. EU Member States can also negotiate exchanges of quotas between themselves or with third-party countries such as Norway.

More fish landed abroad

The concentration of fishing on larger vessels coincides with a changed landing pattern. This means that 20-25 per cent of the landing value now comes from landings abroad. This helps explain why exports from fishing have risen in recent years.

Reduction in the processing of fish...

Landings by Danish and foreign fishermen in Denmark, which contribute to the processing of fish industry, fell by 53 per cent from 1996 to 2016. From 2010 to 2016 alone, landings by Danish and foreign fishermen in Denmark fell by 15 per cent, see right part of figure 15.1. The gross value added and the number of employees in Danish fish processing fell accordingly.

…but not in exports

The value of exports from the processing of fish, calculated in fixed prices (chained volumes, 2010 prices), has remained fairly constant from 2005 to 2014.

15.2 Danish catch of wild fish

Landings of 672,000 tonnes of fish

In 2016, Danish fishermen landed a total of 672,000 tonnes of fish and shellfish in Danish and foreign ports.

Landings of fish for reduction by Danish vessels vary considerably. In recent years, the catch has been particularly low. In 2012, the total catch amounted to 217,000 tonnes, and in 2016, it amounted to 335,000 tonnes, see table 15.2. Landings of fish for consumption such as codfish, flatfish and mackerel have remained at more or less the same level since 2010. However, landings of the consumption fish caught in the greatest volumes (herring) have risen from 77,000 tonnes in 2010 to 146,000 tonnes in 2016. Landings of crustaceans and molluscs have risen from 43,000 tonnes in 2010 to 72,000 tonnes in 2016. In 2016, fish for reduction and consumption fish each accounted for about half of total landings at 672,000 tonnes.

Table 15.2

Landings of fish and shellfish by Danish vessels in Denmark and outside Denmark

	2010	2011	2012	2013	2014	2015	2016
	1,000 tonnes						
Total	821	709	496	662	749	876	672
1. Codfish[1]	35	34	35	29	30	33	31
2. Flatfish[2]	24	26	27	29	27	30	32
3. Atlantic herring	77	86	125	141	136	121	146
4. Atlantic mackerel	41	35	36	33	42	46	41
5. Fish for reduction[3]	597	475	217	370	438	552	335
6. Crustaceans and molluscs[4]	43	50	52	56	71	79	72
7. Other fish	3	3	3	4	6	14	17

[1] Codfish includes: cod, haddock, hake, pollock, etc.

[2] Flatfish includes: plaice, dab, lemon sole, etc.

[3] Fish for reduction includes: sand eel, sprat, Norway pout, etc.

[4] Crustaceans and molluscs includes: common mussel, Northern prawns, Norway lobster, etc.

Source: www.statbank.dk/fisk2 and Statistics Denmark (2017a).

Landing value of DKK 3.7 billion

The value of fish and shellfish landed by Danish fishermen has increased over the last few years: from DKK 2.9 billion in 2010, to DKK 3.7 billion in 2016. The value of landings of herring has increased most markedly: in 2010, the total value of landings of herring was DKK 237 million, which increased to DKK 736 million in 2016. The value of landings of flatfish increased by 47 per cent during this period, whilst the value of landings of crustaceans and molluscs increased by 44 per cent.

Table 15.3 Value of fish and shellfish landed by Danish vessels in Denmark and outside Denmark

	2010	2011	2012	2013	2014	2015	2016
	DKK million						
Total	2 948	3 168	2 916	3 025	2 914	3 392	3 665
1. Codfish[1]	483	510	500	432	450	526	533
2. Flatfish[2]	358	416	399	374	351	430	527
3. Atlantic herring	237	373	647	528	443	484	736
4. Atlantic mackerel	337	425	265	273	311	290	302
5. Fish for reduction[3]	941	795	456	777	701	953	681
6. Crustaceans and molluscs[4]	495	551	549	538	558	566	712
7. Other fish	98	99	99	103	101	144	174

Note: 1.– 4: see notes to table 15.2

Source: www.statbank.dk/fisk2 and Statistics Denmark (2017a).

Box 15.2 Fishing areas for Danish fishermen

Danish fishermen primarily fish in the Norwegian Sea, the North Sea, the English Channel, the Skagerrak, the Kattegat, the Sound and the Belt Sea as well as the Baltic Sea. The total landings in 2016 were 672.000 tonnes.

[1] Other areas include The Norwegian Sea, the English Channel, the Sound and the Belt Sea.

15.3 Developments in wild fish stocks

Many conditions influence fish stocks

The developments in wild fish stocks are a result of a complex interaction of many factors. The fishing pressure on different species, the relationship between predatory fish and prey fish, food sources, climatic conditions and impacts from, for example, oil and gas installations as well as wind turbines in marine areas[1] are all factors which can influence stocks.

Danish fish stocks

Fish typically move in and out of the Danish exclusive economic zone. Moreover, because of the European Union's Common Fisheries Policy, there is no unequivocal link between countries' exclusive economic zones and the areas in which said countries are entitled to fish, see box 15.1.

Danish stock statistics based on assumptions

As such, it does not make sense to assess a "Danish fish stock" on the basis of the fish in Denmark's exclusive economic zone. Instead, Danish quotas and the Danish catch of fish can be compared to the stock and the natural growth of fish stocks in the fishing areas where Danish fishermen are entitled to fish. Therefore, as part of the green national accounts, a Danish stock (or rather: a percentage of the stock) was calculated on the basis of Denmark's percentage of the total allowable catch (TAC, see box 15.1) in the relevant fishing areas. Denmark does not have exclusive ownership of this stock, but is entitled to fish from the stock.

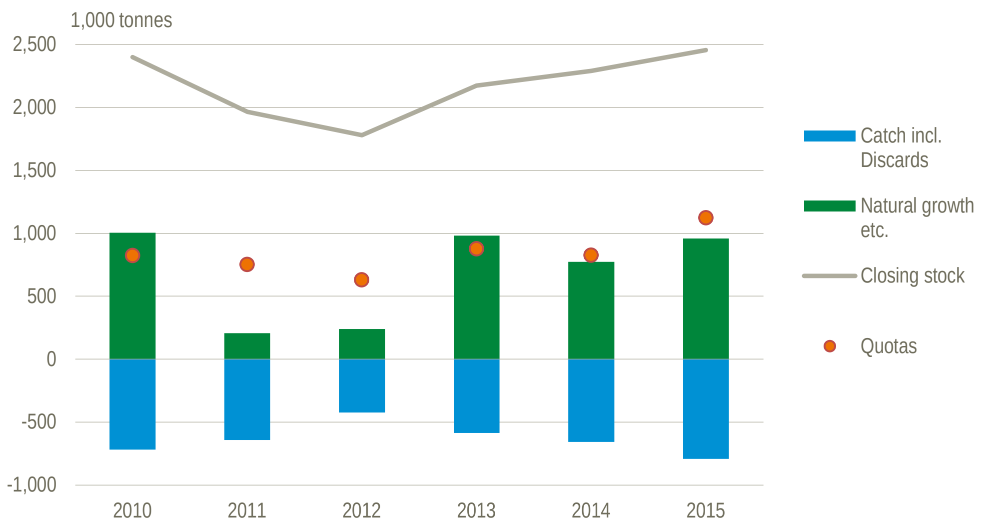
Figure 15.2 shows developments in the calculated Danish stock of fish and shellfish from 2010 to 2015. The calculation comprises around 90 per cent of the fish species landed by Danish fishermen in 2015. Table 15.4 shows the stock in 2015 broken down by fish for reduction and various species of consumption fish, etc.

Danish stock of 2,455,000 tonnes of fish

At the end of 2015, the calculated Danish stock amounted to 2,455,000 tonnes of fish. Of this figure, 1,150,000 tonnes was fish for reduction, whereas herring (747,000 tonnes) and plaice (253,000 tonnes) constituted the largest proportion of the stock of fish for consumption.

The calculated stock fell every year between 2010 and 2012, but it has been increasing since then. The increase from the lowest point in 2012 to 2015 was 38 per cent.

Figure 15.2 Danish stocks of wild fish and shellfish. End of year



Note 1. Stock is calculated as a percentage of the total stock in the areas in which Danish fishermen have access to fish according to agreements with the European Union and third-party countries. This percentage corresponds to Denmark's percentage of total fish quotas in the relevant areas. Natural growth etc. is calculated as a residual.

Note 2: The stock accounts comprise around 90 per cent of fish species landed by Danish fishermen in 2015.

[1] A detailed description of the dynamics of fish and shellfish stocks in the North Sea is available in ICES (2016).

Natural growth higher than catch in 2013-2015

The catch in 2011 and 2012 was greater than the natural growth in the Danish fish stock. Conversely, in each of the years 2013, 2014 and 2015 the catch was smaller than natural growth, etc. A prerequisite for sustainable fishing and the conservation of fish stocks is that the catch does not exceed the natural growth etc. At the same time, increasing fish stocks will usually result in greater annual natural growth etc.

Also important to consider stocks of individual fish species

It is important to note that the description of the developments provided above does not necessarily provide an exhaustive picture of these developments from the perspective of sustainability. This is because reduction in the stock of some species may affect developments in the stock of other species. The increase in the stock of fish for reduction as a whole overlooks the fact that the stock of several species of fish for reduction, such as horse mackerel, capelin and sand eel, has decreased in some years.

Table 15.4

Danish stocks of wild fish and shellfish. 2015

	Total	Atlantic cod	Other codfish	European plaice	Atlantic herring	Atlantic mackerel	Fish for reduction
	1,000 tonnes						
1. Opening stock	2 290	83	39	203	693	197	1 075
2. Natural growth etc.	957	33	9	75	194	35	610
3. Catch	784	28	9	24	141	47	536
4. Discards	8	5	1	1	0	0	0
5. Closing stock (= 1+2-3-4)	2 455	83	38	253	747	185	1 150

Note 1: Stocks are calculated as a percentage of the total stock in the areas in which Danish fishermen have access to fish according to agreements with the European Union and third-party countries. This percentage corresponds to Denmark's percentage of total fish quotas in the relevant areas. Natural growth etc. is calculated as a residual.

Note 2: The calculation comprises around 90 per cent of Danish fishermen's landings in 2015, and the figures for the catch in the table are therefore a subset of the figures shown in table 15.2.

Slightly more than one-third of the stock caught in 2015

Overall Danish fishermen's catch including discards[2] accounted for 35 per cent of the Danish stock in early 2015. For plaice, this figure was 13 per cent, whereas catch and discards accounted for 50 per cent of the stock of fish for reduction.

Discards

Average discards for all fish constitute between 1 and 2 per cent of the catch, with variations between the different species.

Utilisation of quotas

Danish fishermen's catch is regulated by the European Union's quota system, see box 15.1. Danish fishermen's quotas are not being fully utilised. For example, Danish fishermen in 2015 caught plaice corresponding to only 63 per cent of Denmark's total quota.

15.4 Aquaculture

218 aquaculture facilities

In 2015, there were 218 active aquaculture facilities. These included 138 traditional fish farms, 33 more eco-friendly model farms with recirculating water, 20 sea farms, five eel farms, 12 shellfish farms and ten other facilities (Danmarks Statistik, 2017). The fish farms are primarily located in Jutland, whereas the sea farms are located in Danish coastal waters such as the Little Belt and the Great Belt.

49,000 tonnes of fish from farms in 2015

In 2015, the 218 facilities had a production of 49,000 tonnes with a value of DKK 1.1 billion[3]. In comparison, Danish fishermen landed 876,000 tonnes of fish in 2015 with a landing value of DKK 3.4 billion; see section 15.2.

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[2] "Discarding is the practice of returning unwanted catches to the sea, either dead or alive, because they are undersized, due to market demand, the fisherman has no quota or because catch composition rules impose this." As a result of the European Union Common Fisheries Policy, rules for discarding have been laid down for specific species and specific fishing areas. (EU, 2013).

[3] http://statbank.dk/akv1

Table 15.4 shows the different types of addition and reduction of fish from aquaculture facilities in the individual years from 2010 to 2015, and how these movements have affected the quantity of fish in the farms at the beginning (opening stock) and end of the year (closing stock).

Slightly increasing stock of fish in aquaculture

The stock of fish in aquaculture has slightly increased over the period. However, there was a slight decrease in the stock during 2015. The stock at the end of 2015 was 21,000 tonnes of fish.

Table 15.5

Stock of fish and shellfish in aquaculture

	2010	2011	2012	2013	2014	2015
	1,000 tonnes					
1. Opening stock	18	19	20	19	21	22
2. Natural growth	35	36	33	36	41	37
3. Other additions	7	8	8	10	10	11
4. Harvest	33	32	30	32	35	36
5. Other reduction	8	11	11	13	15	13
6. Closing stock (=1+2+3-4-5)	19	20	19	21	22	21

Additions and reductions

Additions to the fish stock at the farms during the year are primarily a result of natural growth. The majority of reductions are a result of the harvesting of fish. In the period considered, figures for natural growth and harvest were similar, although growth was generally slightly higher. In 2015, growth was 37,000 tonnes, whereas harvest was 36,000 tonnes. Other additions and reductions of fish account for the fact that fish is traded between different farms[4] and used in "put & take" lakes. Furthermore, there is some loss due to disease and escaped fish. The net impact on the stock from other additions and reductions was 2,000 tonnes in 2015.

Trout and salmon are the most important products in Danish aquaculture

Trout and salmon are by far the most important products in Danish aquaculture, see table 15.6. The harvest from fish farms was 27,000 tonnes, whereas the harvest from sea farms totalled around 6,000 tonnes. A total of 93 per cent of the harvest from aquaculture consisted of trout and salmon.

Table 15.6

Stock of fish and shellfish in aquaculture by type. 2015

	Total	Trout and salmon[1], aquaculture	Other fish[2] and shellfish	European eel	Trout and Salmon, sea farms	Mussels, shellfish farms
	1,000 tonnes					
1. Opening stock	22	16	0.07	1.7	3.0	1.7
2. Natural growth	37	33	0.05	0.5	2.0	1.5
3. Other additions	11	7	0.00	0.0	4.5	0.0
4. Harvest	36	27	0.02	1.2	6.3	1.2
5. Other reduction	13	13	0.02	0.0	0.3	0.0
6. Closing stock (=1+2+3-4-5)	21	15	0.07	1.0	3.0	2.0

[1] Trout and salmon include: brown trout, Arctic char, golden trout, brook trout, salmon, sea trout and rainbow trout.

[2] Other fish and shellfish include: perch, Ray's bream, common whitefish, crustaceans, carp, pike-perch and sturgeon.

The value of fish in aquaculture

Table 15.7 shows the value of the stock of fish in aquaculture and changes herein, including the value of the harvest from aquaculture. The values have been calculated on the basis of average prices paid to fish farms for fish sold for consumption.

The value of the harvest from aquaculture has steadily increased from DKK 735 million in 2010 to DKK 846 million in 2015, corresponding to a 15 per cent increase. The value of other reductions, i.e. sales to other facilities, rose from DKK 148 million to DKK 266 million in the period.

[4] In the statistics presented here, fish transferred from one farm to another farm were included first as reductions and then as additions. When all farms are considered as a whole, reduction and additions balance and in this way they do not influence the overall balance.

The harvest of fish with a total value of DKK 846 million in 2015 was only partly counterbalanced by a natural growth corresponding to DKK 834 million. As the value of other reductions (transfer, loss etc.) was greater than other additions, this meant that the value of the stock of fish in aquaculture decreased during 2015. The decrease was countered to a lesser extent by a positive revaluation of the stock due to an increase in the average price during the year.

Table 15.7 Value of fish and shellfish in aquaculture

	2010	2011	2012	2013	2014	2015
	DKK million					
1. Opening stock	376	411	471	488	539	545
2. Natural growth	759	866	866	917	937	834
3. Other additions	132	159	211	237	202	227
4. Harvest	735	774	765	798	811	846
5. Other reductions	148	219	282	288	308	266
6. Revaluation	26	26	16	-17	-14	13
7. Closing stock (=1+2+3-4-5+6)	411	471	488	539	545	506

Box 15.3 About the stock accounts for fish and shellfish

The stock accounts for fish and shellfish concern both wild fish and fish in aquaculture. The wild fish and shellfish accounts include around 90 per cent of "Danish stocks", whereas the aquaculture accounts include the entire Danish stock.

The wild fish and shellfish accounts are based on information on stocks and total allowable catch (TAC) from the International Council for the Exploration of the Sea (ICES) as well as information on Danish quotas and catch from the Danish Agricultural Agency (the former Danish AgriFish Agency). The accounts include the following species: cod, codfish (haddock, hake and pollock), mackerel, plaice, herring, and fish for reduction (sand eel, sprat, blue whiting, horse mackerel, capelin and Norway pout) which constitute around 90 per cent of fish landed within Danish quotas.

Note that it is not possible to calculate a specific Danish stock of wild fish and shellfish, as Denmark is subject to the European Union's Common Fisheries Policy and shares fishing waters with the European Union and third-party countries. The Danish stocks presented in section 15.3 are thus calculated as a percentage of the total stock in the areas in which Danish fishermen have access to fish. This percentage corresponds to Denmark's percentage of total fish quotas in the relevant areas. Moreover, natural growth etc. is calculated as a residual on the basis of the opening stocks and closing stocks, other catch and discards etc. The purpose of calculating the stock and natural growth in this way is to arrive at figures that can be used to put the Danish catch of fish into perspective.

The accounts for fish and shellfish in aquaculture are based on information on quantities and prices from individual facilities gathered by the Danish Agricultural Agency. The accounts include the following species: trout and salmon (brown trout, Arctic char, golden trout, brook trout, salmon, sea trout and rainbow trout), eel, common mussel and other fish (perch, Ray's bream, common whitefish, crustaceans, carp, pike-perch and sturgeon).

The accounts were calculated using assumptions and estimates, and many of the figures are associated with considerable uncertainty.

More information:
www.statbank.dk/10594
www.dst.dk/en/Statistik/dokumentation/documentationofstatistics/stock-account-for-fish-and-shellfish

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