STATISTICS DENMARK

Documentation of statistics for Climate footprint (experimental statistics) 2021

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1 Introduction

The purpose of the statistics is to measure the global emission of greenhouse gases from the supply chains for Danish final use (Danish consumption, investment and export). It illustrates correlations between Danish final use and emissions of greenhouse gases from Danish and international production. Global emission of greenhouse gases from Danish consumption and investment constitutes Denmark's Climate Footprint. The statistic is experimental and have been prepared since 2021 in collaboration with the Danish Energy Agency, which uses it for the annual publication "Danmarks Globale Klimapåvirkning – Global Afrapportering".

2 Statistical presentation

The statistics show the amount of greenhouse gas that has been emitted in the supply chains for Danish final use annually from 1990 onwards. The emissions are distributed by type of final use, emitting industries and countries, as well as by supplying industries.

2.1 Data description

The statistics show the amount of greenhouse gas that has been emitted in the supply chains for Danish final use. The emissions are distributed by type of final use, emitting industries and countries, as well as by supplying industries.

The calculation of the climate footprint uses 100-year Global Warming Potentials from the IPCC's fourth assessment report (AR4) to convert tonnes of a given greenhouse gas into tonnes of Co2 equivalents.

The supply chain for a type of final use is defined in these statistics as *all the production activities in Denmark and the rest of the world that have been necessary to produce the products for final use*. The supply chain behind e.g. milk includes both raw milk production and further processing, the production of dairy cows and feed for them, the production of electricity to run the stables and dairies, as well as steel and wood to build the stables and dairies, etc.

The emissions are calculated in tonnes of CO2e (CO2 equivalents) and include the greenhouse gases CO2, CH4 (Methane), N2O (Nitrous oxide) and F-gases (SF6, HFC-gases and PFC-gases). In relation to LULUCF (unfccc.int) the climate footprint only includes emissions from land use in the agricultural sector.

The statistic has five variables: - Types of use: The type of Danish final use whose supply chain led to the greenhouse gas emissions. - Supplying industry: The Danish industry that formed the last link in the supply chain for the final use. Imports from foreign industries directly for final use are entered under the item "Imports for final use" so that the statistics are fully comprehensive. (Supply industry is only included in the AFTRYK2 table) - Emitting industry: The industry where the production that emitted the greenhouse gas took place. - Emitting country: The country where the production that emitted the greenhouse gas took place. - Year: The year of final use.

For example, in table AFTRYK1 you can see that – according to the climate footprint model – the agricultural industry in Italy emitted 46,290 tonnes of CO2e greenhouse gases in 2021 as part of the supply chains for Danish food consumption.

In table AFTRYK2, you can see that – according to the climate footprint model – the electricity supply in China emitted 4,908 tonnes of CO2e greenhouse gases in 2021 as part of the supply chains for the Danish pharmaceutical industry's production for Danish final use.

When looking at the emissions from emitting industries, you must be aware that the figures only

include emissions from the industry's own production. This means, for example, that the agricultural industry as a emitting industry includes emissions from, among other things, cows and tractors, but not from the production of the electricity that the agricultural industry buys from the electricity supply industry. These emissions are listed as emissions in the electricity supply industry. The industry breakdown of output industries is calculated in the same way as in the Emissions account

When looking at the emissions from supplying industries, one must be aware that the emissions belonging to a supplying industry are not the emissions from the industry's total production and its supply chains, but only from the production that the industry itself supplied for final use, as well as from the supply chains for this production.

For example, the emissions from agriculture as a "supplying industry" only constitute a small part of the total emissions from agriculture as an "emitting industry". This is because the supply chains for household demand for food to a very large extent start with slaughterhouses and dairies, which refine agricultural products and make them ready for consumers. Only a few consumers buy milk, eggs and meat directly at the barn door. So consumer demand for meat does not go to agriculture, but to the slaughterhouse. On the other hand, the emissions from "supplying industries" show all emissions back into the supply chains, including also in other industries both domestically and abroad. To use the example from before, emissions from slaughterhouses as a "supplying industry" will include both emissions from the slaughterhouse itself, from Danish agriculture, from emissions from the electricity supply in Denmark, from foreign producers of soy protein that is used as animal feed in Danish agriculture, etc.

2.2 Classification system

Types of use and industries are divided according to classifications that are also used in the national accounts In the table AFTRYK2, the final use is simply divided into domestic final use (which make up the Climate Footprint) and exports. In table AFTRYK1, domestic final use is further divided into private consumption, NPISH consumption, public consumption and investment, and private consumption is divided into 11 subgroups as follows COICOP the classification.

The industries are divided according to the national accounts' 117 industry classification. This corresponds – with a few deviations – to the 127 industry classification in the Danish Industry Code 2007 (DB07). DB07 is a Danish version of the international nomenclatures EU's NACE, Rev. 2 and the UN's ISIC, Rev. 4, and contains a number of standard groupings: the 127, 36, 19 and 10 groupings. The national accounts' 117 industries can be aggregated to the other standard groupings in DB07.

The country breakdown comes from EXIOBASE and consists of 44 individual countries and five groupings for the rest of the world.

2.3 Sector coverage

The Climate Footprint covers all sectors of the economy.

2.4 Statistical concepts and definitions

Climate footprint: The amount of greenhouse gas emitted in the supply chains for the Danish domestic final use, which includes household consumption, consumption in institutions etc. (NPISH), public consumption and investments.

Supply chain: The term supply chain is used somewhat interchangeably and has varying definitions. In this statistic, the term supply chain is used to illustrate the network made up of all the production activities in Denmark and the rest of the world that have been necessary to produce the products in the final use. The term supply chain thus includes both direct and indirect, derived production in Denmark as well as abroad. In the calculations, emissions of greenhouse gases are linked to the production activities in the supply chains. The supply chain behind e.g. milk includes the production of raw milk in the agricultural sector, the transport to and further processing in the dairies, the production of feed for dairy cows, the production of electricity to run the barns and dairies, steel and wood to build the barns, tank truck and dairies, etc.

2.5 Statistical unit

The units in the national accounts are resident companies, households or other units that are characterized by being able to make independent financial decisions and enter into financial transactions with other resident or non-resident units.

2.6 Statistical population

Danish domestic final use (household consumption, NPISH, government consumption and investment)

2.7 Reference area

Denmark

2.8 Time coverage

The statistics covers the period from 1990 and onwards

2.9 Base period

Not relevant for this statistics.

2.10 Unit of measure

Tonnes of CO_2 equivalents.

2.11 Reference period

01-01-2021 – 31-12-2021.

2.12 Frequency of dissemination

Annual

2.13 Legal acts and other agreements

Legal authority for data collection is found in § 8 subsection 1 in the Act on Denmark's Statistics, cf. Legislative Decree No. 610 of 30 May 2018 in as well as Regulation No. 691/2011 of the European Parliament and of the Council on European environmental economic accounts.

2.14 Cost and burden

The statistic is based on information from existing statistics. There is therefore no direct reporting burden in connection with the calculation of this statistic.

2.15 Comment

Other information can be found on the statistics Subject page or can be obtained by contacting Statistics Denmark.

3 Statistical processing

The climate footprint is calculated with a multi-regional environmental economic input-output (MRIO) model that links data from Statistics Denmark on Danish production and greenhouse gas emissions with data from the international database EXIOBASE on international production and greenhouse gas emissions.

3.1 Source data

The calculations of greenhouse gas emissions from Danish production to Danish final use use Statistics Denmark's input-output tables, which have been prepared in accordance with the "System of National Accounts 2008" (SNA08) Chapters 14 and 28 of the manual outline the framework for setting up supply-use tables and how these are used for setting up input-output tables.

In addition, the emission accounts from Statistics Denmark are used.

Information from the statistics "Foreign trade in goods" and "Balance of Payments" are used to split Danish imports by country of origin.

Data from EXIOBASE, version 3.8.2, is used to calculate greenhouse gas emissions from the production of the imports that are included in Danish production, as well as from the production of imports directly for Danish final use.

EXIOBASE is a database of global, multi-regional, environmental economic IO tables constructed by collating national IO tables, macroeconomic aggregates and trade statistics and balancing them against each other. EXIOBASE's sector- and country-distributed greenhouse gas emissions are calculated by combining data on economic activities with emission factors from the TEAM model. Further details are described in the article Stadler et al, 2018. The development and maintenance of EXIOBASE is handled by a consortium consisting of NTNU (Norwegian University of Science and Technology), TNO (Netherlands Organization for Applied Scientific Research), SERI (The Sustainable Europe Research Institute), Universiteit Leiden (Vienna University of Economics and Business) and 2 .-0 LCA Consultants.

3.2 Frequency of data collection

The sources from Statistics Denmark (the input-output tables and the emissions account) are based on data that is collected continuously, typically with an annual frequency.

EXIOBASE 3.8.2 is originally a time series of annual environmental economic IO tables from 1995-2011. In these years, each table is made with annually collected data. From 2011-2021, EXIOBASE has projected their tables themselves by balancing them against annually collected macroeconomic aggregates, trade statistics and emissions data (see details in readme.txt in EXIOBASE 3.8.2's Zenodo repository). However, these data were only available as projections for 2020 and 2021, when EXIOBASE 3.8.2 was compiled in 2021. No updates have been made available since then. From 1990-1995, the calculation of the climate footprint uses EXIOBASE data from 1995.

3.3 Data collection

The sources from Statistics Denmark (the IO tables from the national accounts and the emissions accounts) are drawn from Statistics Denmark's internal databases, but are also publicly available via Statbank.

EXIOBASE 3.8.2 is downloaded from this Zenodo repository.

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3.4 Data validation

The output from the climate footprint model is validated by assessing the reasonableness of levels and developments in aggregates, such as Denmark's total annual climate footprint divided by exporting countries. In addition, it is checked that the total emissions from each Danish industry are equal to the industry-distributed emissions in the emissions account.

3.5 Data compilation

The climate footprint is calculated with the multiregional environmental economic IO model (MRIO), which links data from Statistics Denmark on Danish production and emissions with data from EXIOBASE on international production and emissions. First, the Danish IO table is used to calculate the Danish production to supply the various types of Danish final use, as well as the imports to supply this production. Next, industry-distributed emission intensities from the emissions accounts are used to calculate the emissions from this Danish production. Next, the imports are transformed into EXIOBASE's industry and country dimensions, after which EXIOBASE's IO table is used to calculate the global production of imports to Danish production of Danish final use, as well as of imports directly to Danish final use. Next, EXIOBASE's sector- and country-distributed emission intensities are used to calculate the emissions from this global production.

The climate footprint model is described further in this report to Eurostat

The statistic is compiled based on a so-called attributional method. This means that the statistics link parts of the actual global greenhouse gas emissions in a historical year to different parts of the actual Danish final use in that year. An input-output model calculation based on the attributional method is best suited to analyze the effects of marginal interventions in the economy that do not require significant structural changes to be implemented. It will therefore be problematic to use the statistics to analyze how the emissions from production to Danish final use would have been different if Danish final use had been significantly different. This means, for example, that it is problematic to use the statistics to say that if Danish consumers had bought X percent less food, then the Danish climate footprint would have been Y percent lower, where X is a significant change in food consumption.

Alternatively, you can work with a so-called consequential method, where the calculation aims to model some of the adaptations in the production structure that would actually occur if demand changed significantly. For example, the need for electricity that would come from a significantly increased demand in the Danish economy today would probably be met with new wind turbines or solar parks, and not with an average of the total electricity supply as it looks today. Schaubroeck et al, 2021, provides further explanation of the differences between an attributional and consequential methodological approach.

3.6 Adjustment

Not relevant for these statistics.

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4 Relevance

The climate footprint is relevant for everyone who is interested in relations between Danish consumption and investment and global emissions of greenhouse gases. The climate footprint is prepared in collaboration with the Danish Energy Agency's Center for System Analysis, which uses it in their annual report "Danmarks Globale Klimapåvirkning – Global Afrapportering".

4.1 User Needs

The climate footprint is compiled in collaboration with the Danish Energy Agency's Center for System Analysis, which uses it in their annual report "Global Afrapportering". In addition, the statistics can be used by other users who are interested in relations between Danish consumption and investment and global emissions of greenhouse gases. For example, there has been demand for the statistics and the underlying model from analysts in the central administration, industry organisations, municipalities, research institutions, NGOs and consultancy companies.

4.2 User Satisfaction

The Contact committee for environmental economic accounts and statistics (KMØRS) holds at least one meeting a year. The committee is for key users of the statistics, the list of members and meeting materials can be found on Statistics Denmark's website. Information on user satisfaction is not collected separately, but users' needs and satisfaction are discussed in this contact committee.

4.3 Data completeness rate

Not relevant for this statistic, as is voluntary and not subject to any Eurostat regulation or guideline.

5 Accuracy and reliability

The overall precision of the statistics is not as high as other statistics from Statistics Denmark, which are based on directly observable data. The majority of the figures in this statistic are the result of calculations with Danish and international input-output models. The international input-output model in particular is uncertain because it is a compilation of figures from many countries of uneven quality. However, it is assessed that the precision is as good as it can be at the present time, when available sources and methods are taken into account.

5.1 Overall accuracy

The overall precision of the statistics is assessed as lower than most statistics from Statistics Denmark, including most environmental and macroeconomic statistics. However, it is assessed that it is currently not possible to calculate Denmark's consumption-based climate footprint with significantly higher precision. This is because the statistics cover greenhouse gas emissions in global supply chains, and at present there is only data on this, where the precision is lower than Statistics Denmark's typical level. In addition, the attribution of greenhouse gas emissions in the global economy to types of Danish final use also requires more modeling than is typical for Statistics Denmark's statistics.

The uncertainty could be made more transparent by carrying out sensitivity analyzes of how the results of the statistics depend on the different parts of the data base and the modelling. These analyzes have not yet been prepared specifically for Statistics Denmark's climate footprint model. The article Tukker et al, 2020 reviews more general sensitivity analyzes of multiregional IO climate footprint models, including the sensitivity to using EXIOBASE versus others environmental economic, multi-regional IO databases.

5.2 Sampling error

Not relevant for these statistics.

5.3 Non-sampling error

The uncertainty in the climate footprint stems from the uncertainty in the sources and in the model's assumptions.

The sources for the climate footprint are IO tables and the emissions accounts from Statistics Denmark and multi-regional, environmental economic IO tables from EXIOBASE. As described in the documentation for the IO tables and the emissions account, these sources have considerable uncertainty. EXIOBASE is based on a compilation of IO tables and emission modeling for EXIOBASE's 44 countries and 5 rest-of-the-world regions. Thus, EXIOBASE will accommodate both uncertainty from the national sources, as well as from the method used to balance these national sources against each other. All in all, the sources of the climate footprint therefore contain a high degree of uncertainty. For the past few years, there is further uncertainty linked to the fact that data in EXIOBASE has been created by projections, rather than actual updates of the source base.

The model behind the climate footprint is a multi-regional, environmental economic IO table (MRIO). The model's calculations are thus based on industry and country-divided averages for inputs to industries' production and for greenhouse gas emissions per production (read more in Miller and Blair, 2022.The more precisely these averages describe the conditions in the actual supply chains for Danish final use, the more truthful the results of the calculations be.

5.4 Quality management

Statistics Denmark follows the recommendations on organisation and management of quality given in the Code of Practice for European Statistics (CoP) and the implementation guidelines given in the Quality Assurance Framework of the European Statistical System (QAF). A Working Group on Quality and a central quality assurance function have been established to continuously carry through control of products and processes.

5.5 Quality assurance

Statistics Denmark follows the principles in the Code of Practice for European Statistics (CoP) and uses the Quality Assurance Framework of the European Statistical System (QAF) for the implementation of the principles. This involves continuous decentralized and central control of products and processes based on documentation following international standards. The central quality assurance function reports to the Working Group on Quality. Reports include suggestions for improvement that are assessed, decided and subsequently implemented.

5.6 Quality assessment

The climate footprint is relevant for everyone who is interested in connections between Danish consumption and investment and global emissions of greenhouse gases, and the statistics contribute to the ongoing debate about Denmark's climate goals. The figures are consistent with other statistics on greenhouse gas emissions from Statistics Denmark, while it is more difficult to judge the consistency in relation to other countries' emissions of greenhouse gases, which are influenced by Danish final use. The statistics are partly comparable to similar statistics from other countries, but this is an experimental statistic, and other countries are also experimenting with methods and data bases. There is a great deal of work underway internationally with a view to harmonizing the data basis for calculations of this type, which over time will lead to better comparability and coherence in calculations of this type for different countries.

It is important to keep in mind that these are partly model calculations which are based on a number of assumptions. The statistics are therefore considered to be more uncertain than most statistics from Statistics Denmark. With the methods and data currently available, it is estimated that it will be difficult to raise the quality further. The nature and size of the uncertainty could be made more transparent to users by preparing sensitivity analyses.

In relation to relevance and precision, the statistics will be improved by using an industry classification that subdivides the industries in the national accounts' industry classification that contain products with very different emission intensities. An example is dividing the agricultural industry into sub-sectors, such as plant production, dairy cattle, beef cattle and pig farming. It is planned that the next publication of the climate footprint will be calculated and published with the industry classification, where it is possible to reflect the differences in the industries' emissions of greenhouse gases to a greater extent.

5.7 Data revision - policy

Statistics Denmark revises published figures in accordance with the Revision Policy for Statistics Denmark. The common procedures and principles of the Revision Policy are for some statistics supplemented by a specific revision practice.

5.8 Data revision practice

The calculation of the climate footprint is experimental statistics and revisions are therefore to be expected, not only on the basis of revised source data but also as a result of methodological and model development. With each publication, the climate footprint is recalculated for all years back to 1990, so that the statistics are comparable over time.

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6 Timeliness and punctuality

The climate footprint is an experimental statistic and does not yet have a fixed publication time. When a publication date is determined, it is published in Statistics Denmark's publication calendar.

6.1 Timeliness and time lag - final results

The climate footprint is an experimental statistic and does not yet have a fixed publication time. When a publication date is determined, it is published in Statistics Denmark's publication calendar. The climate footprint does not have final figures, as the entire time series is revised with each publication.

6.2 Punctuality

The statistics are published without delay in relation to the pre-announced publication time in the publication calendar.

7 Comparability

The statistics are compiled for 1990 and onwards and are comparable over time. The statistics have been produced in collaboration with the Danish Energy Agency and are used for the Danish Energy Agency's report "Danmarks Globale Klimapåvirkning – Global Afrapportering". there will therefore be full agreement between results published by the Danish Energy Agency and Statistics Denmark.

As there is not yet full international agreement on methods and data bases for calculating climate footprints, there will not necessarily be full comparability with the calculations of other institutions or other countries.

7.1 Comparability - geographical

Environmental economic, multi-regional IO models are a scientifically recognized and widespread method for calculating countries' consumption-based climate footprints (cf. e.g. the article Tukker et al, 2018)). The method behind these statistics is also used by other national statistical agencies that prepare consumption-based climate footprints. For example, the national statistics agencies in England and Sweden have made such calculations, where their methods are reminiscent of the method behind the Danish climate footprint. However, there are still no official international standards for national statistical agencies' calculations of consumption-based climate footprints. Therefore, attention should be paid to whether there may be significant methodological differences when comparing climate footprint calculations from different organisations, including different national statistical agencies.

7.2 Comparability over time

The climate footprint is fully comparable over time from 1990 onwards.

7.3 Coherence - cross domain

The statistics have been produced in collaboration with the Danish Energy Agency and are used for the Danish Energy Agency's report "Danmarks Globale Klimapåvirkning – Global Afrapportering". Thus, the figures in the Statistics and "Danmarks Globale Klimapåvirkning – Global Afrapportering" are consistent with each other.

The starting point for the Danish Energy Agency's publications and publications from Statistics Denmark is thus completely the same, but since this is data material of a very significant size, there may be differences in how the data is combined or split up, and it is therefore essential to adhere to the texts which help to present and explain the figures.

There is not full comparability between data from the GHG protocol, Scope1-3 and the climate footprint. Scope1 emissions come from a company, and are defined as *direct greenhouse gas emissions from sources owned or controlled by the company* GHG protocol, p. 25. The calculation principles are not completely comparable, as industries are not groupings of institutional units, such as companies, but of local professional units. A company can therefore belong to several industries.

7.4 Coherence - internal

When compiling the statistics, it is ensured that the data is internally consistent.

8 Accessibility and clarity

In the Statbank, the climate footprint is published under the subject Energy and emissions in the tables AFTRYK1 and AFTRYK2.

8.1 Release calendar

The publication date appears in the release calendar. The date is confirmed in the weeks before.

8.3 User access

Statistics are always published at 8:00 a.m. at the day announced in the release calendar. No one outside of Statistics Denmark can access the statistics before they are published.

8.2 Release calendar access

The Release Calender can be accessed on our English website: Release Calender.

8.4 News release

No separate news release (Nyt fra Danmarks Statistik (in Danish only)) is published for these statistics.

8.5 Publications

Not relevant for these statistics.

8.6 On-line database

The statistics are published in the statistics bank under the subject Energy and emissions in the tables: - AFTRYK1: Climate footprint (experimental statistics) by types of use, emitting industries and emitting countries. - AFTRYK2: Climate footprint (experimental statistics) by types of use, supplying industries, exporting industries and exporting countries.

8.7 Micro-data access

The climate footprint is published at the most detailed level for the countries and industries, but there is the possibility of further breakdown of the types of final use.

8.8 Other

The climate footprint is described and analyzed in the Energy Agency's annual report "Danmarks Globale Klimapåvirkning – Global Afrapportering".

8.9 Confidentiality - policy

Data Confidentiality Policy for Statistics Denmark is applied.

8.10 Confidentiality - data treatment

These statistics are published at a level of detail that does not require further discretion.

8.11 Documentation on methodology

The method behind the climate footprint is also described in the report to Eurostat Compilation of a consumption based greenhouse gas account for Denmark using coupled models.

8.12 Quality documentation

Results from the quality evaluation of products and selected processes are available in detail for each statistics and in summary reports for the Working Group on Quality.

9 Contact

The administrative placement of these statistics is in the division of National Accounts, Climate and Environment. The contact person is Peter Rørmose Jensen, tel.: + 45 4013 5126, and e-mail: PRJ@dst.dk.