Denmark

Quality Assurance and Quality Control (QA/QC) in Denmark's National GHG inventory

Good practice summary

[Results/insights]

Denmark annually produces a national GHG inventory in line with UNFCCC requirements and related requirements at EU-level. The GHG inventory is produced by the Danish Centre for Environment and Energy (DCE) at Aarhus University. Quality of the compilation process is ensured by a quality assurance and quality control (QA/QC) plan, which sets out well-structured and transparent data management processes with integrated checks along every step of the pathway from collection of raw data to data compilation, modelling, documentation/archiving and final reporting.

Scope covered

Functions

☐ Measuring ☒ Reporting ☒ Verification ☐ Accounting

Administrative scope

☒ National ☐ Regional ☐ City-level ☐ Policy/programme/project ☐ Corporate/Facility-level

Legal basis

[policies, regulations and commitments that the case study has to comply with]

Directive 2003/87/EC[1]: Decision of the European Parliament and of the Council of 13 October 2003 establishing a scheme for greenhouse gas emission allowance trading within the Community and amending Council Directive 96/61/EC.

Decision 2004/156/EC[2]: Commission Decision of 29 January 2004 establishing guidelines for the monitoring and reporting of greenhouse gas emissions pursuant to Directive 2003/87/EC of the European Parliament and of the Council.

Decision 280/2004/EC[3]: Decision of the European Parliament and of the Council of 11 February 2004 concerning a mechanism for monitoring Community greenhouse gas emissions and for implementing the Kyoto Protocol (KP).

Commission Implementing Regulation (EU) No 749/2014[4]: Regulation of the Commission of 30 June 2014 on structure, format, submission processes and review of information reported by Member States pursuant to Regulation (EU) No 525/2013 of the European Parliament and of the Council.

There is no national lawing regulating the institutional arrangements for the National Emissions Inventory. The Danish legal culture does not require legislation for this type of work.

Operational since

The QA/QC system was implemented in 2005; the first manual was published early 2006.

[1] http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32003L0087
[2] http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32004D0156
[3] http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32004D0280
[4] http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32014R0749

How is this related to accounting?

[The following is based solely on the consultant's opinion]

» What kind of measures, policies, or commitments are a) monitored and included in an accounting system, b) only monitored, but not included in an accounting system, or c) not even monitored?

The national GHG inventory is a key input to tracking progress towards the common European Union (EU) INDC target. Denmark's QA/QC approach ensures high-quality inventory data is generated which can be used as input to the accounting process.

Case description

Background

» What was the need, pre-conditions, and/or experiences that motivated the country to develop this system?

Articles 5 and 7 of the KP require that Annex I Parties shall have in place a national system for the estimation of their anthropogenic GHG emissions by sources and removals by sinks and report on these annually[5]. On this basis, Denmark as a Party to Annex I of the KP and the Doha Amendment, has to compile national GHG inventories on an annual basis as a means to track progress towards the targets set under these agreements. This will also apply for tracking progress towards the common EU-wide INDC target[6].

Denmark needed a National GHG Inventory System, including QA/QC approaches in compliance with the National System requirements under the Kyoto Protocol (KP) by the beginning of the first Commitment Period of the Kyoto Protocol, i.e. 2008. Therefore, Denmark developed a QA/QC system which it implemented in 2005. The QA/QC system was designed to meet the requirements of the Conference of the Parties serving as the meeting of the Parties to the Kyoto Protocol (CMP) decisions, the guidance in the IPCC GPG and inspired by ISO standards.

General description of the system

[Questions below should be answered only when applicable]

» General definition/description of the system
» What are the main types of action that mitigate GHG emissions?
» What linkages to other systems/ system elements of environmental information (including adaptation to climate change or emissions trading schemes) do exist and why were they established? What linkages exist to other statistical/ monitoring systems?
» Which platforms are used to transport information and are they specific to the purpose of usage MRV information?

DCE is elaborating the emission inventory for mainland Denmark for all sectors with the exception of Fluorinated greenhouse gases and forestry. These two sectors are covered by PlanMiljoe and Copenhagen University respectively.

Figure below shows a schematic overview of the process of inventory preparation. The figure illustrates the process from the first step of collecting external data to the last step, where the reporting schemes are generated for the UNFCCC and EU (in the CRF format (Common Re-porting Format)) and to the United Nations Economic Commission for Europe/Cooperative Programme for Monitoring and Evaluation of the Long-range Transmission of Air Pollutants in Europe (UNECE/EMEP) (in the NFR format (Nomenclature For Reporting)).

The inventory is compiled on an annual basis and submitted on January of every year to the European Commission, in accordance with the Regulation (EU) 525/2013, for the preparation of the EU-wide GHG inventory, and to the UNFCCC Secretariat by the April 15th deadline.

[5] http://unfccc.int/resource/docs/convkp/kpeng.pdf
[6] http://www4.unfccc.int/submissions/INDC/Published%20Documents/Latvia/1/LV-03-06-EU%20INDC.pdf

Detailed information on the compilation of the national GHG inventory and the QA/QC approaches is provided in the following section.

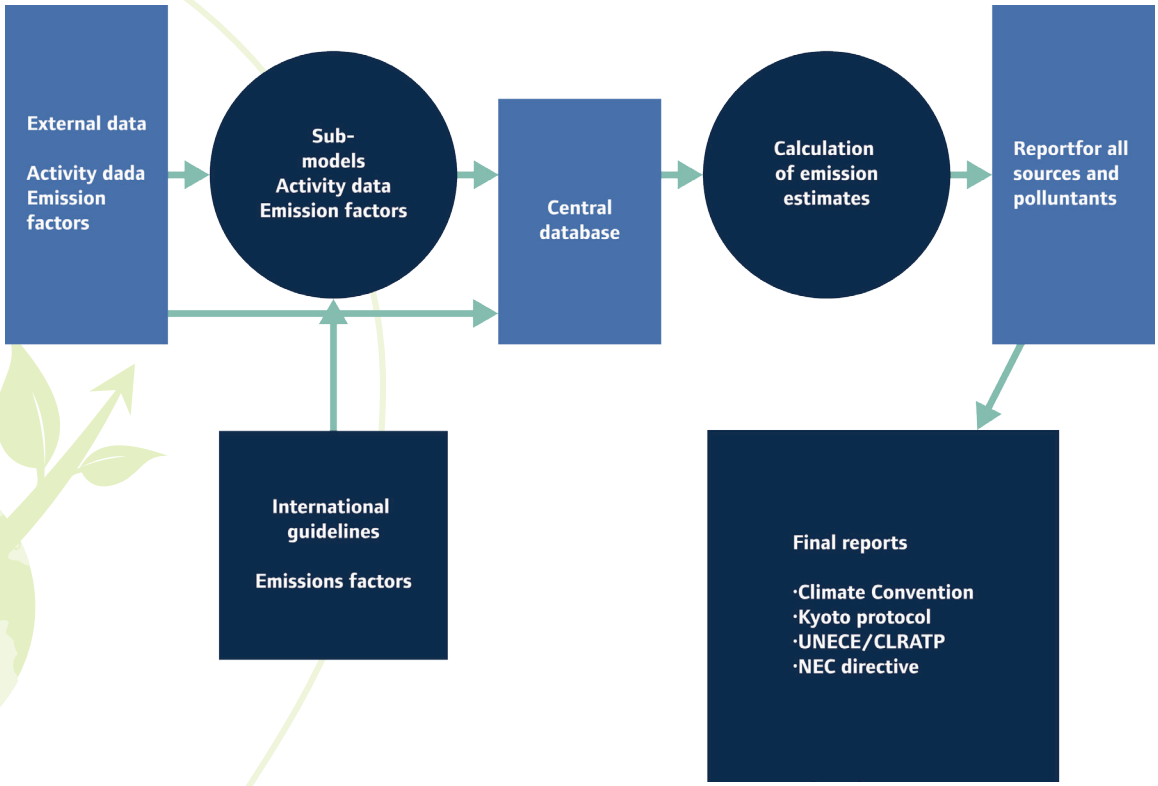

Figure 1: National al GHG Inventory

MRV and accounting systems, processes and procedures

[Questions below should be answered only when applicable]

» How is information generated, communicated, integrated, and verified at each stage of the MRV chain?
» What information needs to be gathered in order to quantify the effect of these actions?
» How is such information gathered or estimated? By whom?
» How is this information reported? How is it verified?
» In what areas information is shared among accounting and MRV systems?
» What kind of agreements are used to establish the relevant institutional roles?

Data collection

For the energy sector, the key dataset are the energy statistics compiled by the Danish Energy Agency. Data for the industrial processes

and product use sector (IPPU) is received, among other, from industry statistics, supplied by Statistics Denmark, and directly from the installations, e.g. from environmental reports and, where applicable reports submitted under the EU ETS. Data related to agriculture, land-use, land-use change and forestry is obtained mainly from Statistics Denmark. Waste sector data is generated through models using data from the Danish Environment Agency for solid waste and the energy statistics provide information related to waste incineration. Information on data suppliers and the information supplied is presented in Denmark's National GHG Inventory Report[7].

Data requests are annually sent to the data providers. Formerly, the provision of data was on a voluntary basis, but more formal data agreements in the form of Memoranda of Understanding have been put in place. The data agreements specify the data to be provided, confidentiality requirements (where applicable) and the deadlines for its provision. The formats for data provision are adapted to and agreed with the specific data suppliers and will be used every year to ensure the same data in the same format is received (unless adjustments are necessary, e.g. where new sources of emission appear). Mostly Excel-sheets are used. DCE receives the data from suppliers via email.

Data processing

The processing of data is structured into three levels: compiling of external data, calculating emissions, and calculating aggregated parameters. Both inputs and outputs of data processing are stored, leading to four levels of data storage. Figure 2 provides an overview of the data flows and levels of data processing and storage.

At the first level input data for the emission inventory is prepared based on the external data sources. Some external data may be used directly as input to the data processing at level 2, while other data needs to be interpreted using models.

At the 2nd level, the emission for every subcategory is calculated, including the uncertainty for all sectors and activities. The summation of all contributions from sub-sources makes up the GHG inventory.

At the 3rd level, a number of aggregated parameters are calculated which need to be included in the final reporting, e.g. implied emission factors.

For data handling, the software tool CollectER (Pulles et al., 1999) is used. The data processing is carried out using mathematical operations or models, mainly spreadsheets (MS Excel) or databases (MS Access).

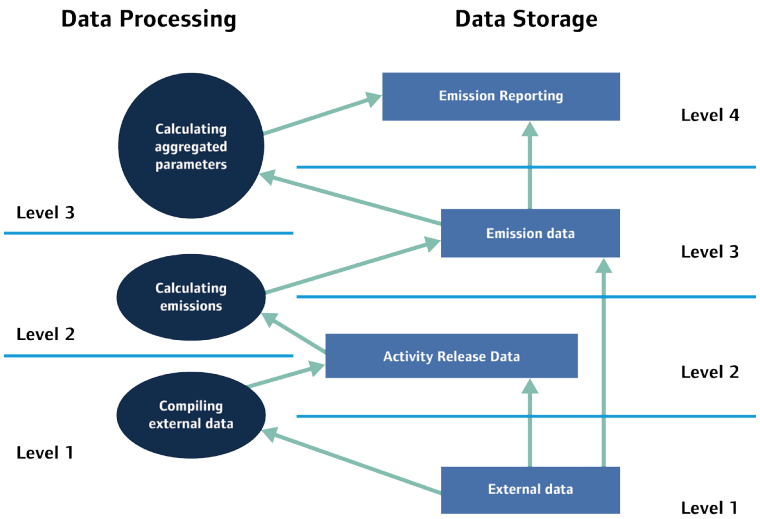

Figure 2: Data processing and storage levels in the compilation process

[7]For the 2015 report, see http://unfccc.int/files/national_reports/annex_i_ghg_inventories/national_inventories_submissions/application/zip/dnk-2015-nir-15nov15.zip

Overall QA/QC approach

As part of the national system, the DCE has developed a manual for the quality assurance and quality control of the emission inventories[8]. The manual complies with the guidelines provided by the UNFCCC (IPCC, 1997), and the Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories (IPCC, 2000). The ISO 9000 standards are also used as important input for the plan.

The QA/QC manual defines what is considered as quality with regard to the national GHG inventory compilation process, defines the data process and storage levels presented above and defines so-called critical control points. These can be seen as principles which have to be complied with in order to fulfil the quality objective. As critical control points the manual defines the UNFCCC GHG inventory principles accuracy, comparability, completeness, consistency, transparency, complemented by two additional principles, robustness and correctness[9]. In order to allow assessing whether these principles are fulfilled, the manual furthermore provides a list of so called points of measurement, specific action to be taken at a specific data processing or data storage level. For easier reference, each point of measurement has an ID number. Points of measurement exist both for the general level, i.e. applicable to all sectors as well as specific to a sector/subsector. The manual only lists the general points of measurement, while the sector-specific points of measurement are listed in the National GHG inventory report. Table 1 presents examples for general points of measurement related to data storage level 3.

Level	Critical control point	ID	Description
Data Storage Level 3	1. Accuracy	DS 3.1.1	Quantification of uncertainty
	5. Correctness	DS 3.5.1	Comparison of inventories of the previous years on the level of the categories of the CRF as well as on SNAP source categories. Any major changes are checked, verified, etc.
		DS 3.5.2	Total emissions, when aggregated to CRF source categories are compared with totals based on SNAP source categories (control of data transfer).
		DS 3.5.3	Checking of time series of the CRF and SNAP source categories as they are found in the Corinair databases. Considerable trends and changes are checked and explained.

Table 1: Example points of measurement

Additionally, the manual describes structure and responsibilities with regards to the compilation of the national GHG inventory, quality assurance procedures as well as verification procedures. All of these will are presented in the following subsections.

Responsibilities related to QA/QC

For each sector, one or several experts – depending on the size of the sector – have responsibility for the sectoral quality control measures.

The general QC checks and all checks performed at an aggregated level are the responsibility of the team leader. The inventory compilation team has a data management expert, who, in cooperation with the team leader, works to ensure the highest possible degree of automatism in the QC checks. The team leader also manages the contact and dialogue with the external organisations that are directly contributing to the greenhouse gas inventory.

[8] http://www.dmu.dk/pub/SR47.pdf
[9] For definitions of each of the principles, see section 5 of http://www.dmu.dk/pub/SR47.pdf
[10] See for example chapter 7.2 on forestry.

Quality control procedures
QC procedures are the implementation of the points of measurement laid down in the QA/QC manual and the NIR. Where elements of the national GHG inventory are compiled by other institutions, these carry out QC checks according to their own procedures, which are also listed in the NIR.[10]

To a large extent QC checks are carried out automatically in databases or spreadsheets were outliers are flagged for follow-up. This is done both in terms of emission trends and emission recalculations. Work is ongoing to automate the time series of implied emission factors and to automatically flag large inter-annual fluctuations.

Quality assurance procedures
The objective of QA procedures is to ensure an independent qualified review to assess the quality of the inventory and to provide suggestions for further improvements. The QA procedures for the Danish greenhouse gas inventory can be separated in two main activities: international reviews of the whole inventory and reviews of the single sectors or subsectors of the inventory.

The Danish greenhouse gas inventory is annually subjected to reviews under both the European Union (EU) and the UNFCCC. As a very important part of the QA activities methodological reports are prepared for each sector/subsector. These reports are written for all emission sources and document the data and calculation methods used in a detailed manner. The methodological reports prepared for sectors/subsectors are peer reviewed by either a national or international expert within the field that has not been involved in the preparation of the Danish emission inventory. This practice has been occurring in Denmark for several years in particular for the most important source sectors, i.e. stationary and mobile combustion. As a general rule, the reports should be updated and reviewed at least every three years. However, there are other considerations that can affect the schedule, e.g. major changes in methodology will prompt the need for an updated sectoral report. On the other hand if no methodological changes have occurred, updating is not required.

Comments received under the above mentioned reviews are incorporated in the annual inventory submissions as part of the improvement processes and documented both in the NIR and in the subsequent sectoral reports.

Another QA activity carried out on parts of the Danish inventory is the publication of papers in peer-reviewed journals documenting the country specific methodologies developed for certain subsectors. These include country-specific methodologies for non-road machinery (Winther & Nielsen, 2007), navigation (Winther, 2008), Danish emission inventory for solvents used in industries and households (Fauser 2010) and uncertainty calculations (Fauser et al., 2011).

Verification procedures
The IPCC Good Practice Guidance describes a number of verification approaches, which can help evaluate the uncertainty in emissions estimates. These approaches are based on comparing GHG inventory data to independent sources of data, i.e. data which have not been used for the GHG inventory compilation. Table 2 below shows a number of verification approaches used by DCE[11]

[11] The full list of verification approaches can be found in chapter 10 of the above mentioned QA/QC manual for the GHG inventory compilation.

Verification Approach	Implementation with regards to the Danish national GHG inventory
Comparison with national scientific and other publications	DCE continuously monitor the publication of relevant information by other Danish institutions. This includes e.g. the publication of research papers and dissertations from Danish universities and research institutions. Also technical reports elaborated for e.g. the Danish Energy Agency or the Danish Environmental Protection Agency are examined for any knowledge that can be used to verify or improve the Danish greenhouse gas emission inventory.
Bottom-up, top-down comparisons	Some checks of this nature are done annually as part of the mandatory reporting requirements. This is for instance the case for the comparison between the reference and sectoral approaches for CO2 emissions from fuel combustion.
Comparisons of national emission inventories with independently compiled international datasets	There are available global databases of emissions. Examples are the CO2 emissions estimates from combustion of fossil fuels that are compiled by the International Energy Agency (IEA) and the Carbon Dioxide Information and Analysis Centre (CDIAC). Potentially, these comparisons can assist in checking completeness, consistency, source allocation and accuracy to within an order of magnitude. However, it must be noted that the data sources are not independent. As a consequence of this weakness this area has not been prioritized for the Danish verification activities.
Comparisons of activity data with independently compiled datasets	Checks can also be made concerning activity data, e.g. using IEA data for fuel consumption or FAO data for number of livestock. In the Danish case checks can also be made using data published by Eurostat that is the statistical office of the European Union.
Comparisons of emission factors between countries	This activity covers three main aspects: direct comparison of applied emission factors, comparison of implied emission factors (IEFs) and comparison with IPCC default values. Comparing emission factors directly is difficult due to few countries reporting the applied emission factors. Therefore, the most feasible verification is to compare IEFs from the CRF reporting made by countries to the UNFCCC. In the future it will be considered to include comparison of IEFs for key categories between countries as part of the verification of the Danish inventory.

Table 2 – Selected verification approaches used by DCE

Archiving

The background data (activity data and emission factors) for estimation of the Danish emission inventories is stored in central databases located at the Department of Environmental Science (ENVS), Aarhus University. For each submission, databases and additional tools and sub-models are frozen together with the resulting CRF-reporting format. This material is placed on central institutional servers, which are subject to routine back-up services. Material, which has been backed up, is archived safely.

Correspondence relevant to the national GHG inventory, e.g. with the UNFCCC Secretariat, the EU Commission and review teams, is documented and archived in the official journal system at DCE.

Design and set-up

[Questions below should be answered only when applicable]

» How was the system designed?
» What was the overall process to set-up the system?

The inventory compilation process including the QA/QC processes was designed by DCE staff not involved with the GHG inventory compilation with inputs from the GHG inventory compilation team. Key considerations in designing the QA/QC processes were as follows:

» The strategy for the set-up was based on a process oriented principle (ISO 9000 series)
» The data flow should support the QC/QA in order to facilitate a cost-effective procedure. Data flow had to take place in a transparent way by making the transformation of data detectable. Finding the original background data for any calculation and tracing the sequence of calculations from the raw data to the final emission result should be easy.
» Computer programming for automated calculations and checking (including automated value control) was to enhance the accuracy and minimize the number of miscalculations and flaws in input value settings. Especially manual typing of numbers needs to be minimized. The quality of the programming had to be verified to ensure the correctness of the automated calculations.
» The QC/QA should be supported as far as possible by the data structure.

The QA/QC system was developed in 2005 and used for the compilation process from the 2006 compilation cycle onwards.

Improvement over time

» Is there an internal evaluation of the systems established aiming to enable improvement over time?

The data documentation and QA/QC systems are under constant improvement. The improvements are either initiated by the DCE or result from recommendations received from external reviews. As an example, areas with room for improvement with regards to completeness and accuracy were identified based on comparisons with the national GHG inventories of other countries. The improvements have been numerous and range from updating single emission factors and changes of methodological approaches, to providing more information on the methodologies used or presenting data in a more transparent way. Furthermore, the QA/QC system was updated to take into account the 2006 IPCC Guidelines.

The improvement over time is also reflected in the quality manual for the Quality Control (QC) and Quality Assurance (QA). The quality procedure is continuously improved as part of the on-going process of improving the emission inventory. As indicated above, the QA/QC approach and manual were developed in 2005 and applied from then onwards, the first QA/QC manual was published in early 2006. In 2013, a revised version of the manual was published, taking into consideration lessons learned. Updates include extended descriptions of QA procedures and adjustments (addition, deletion, and redefinition) of points of measurement. The changes made reflect the experiences gained by the emission inventory team during the past seven years as well as input received during external reviews as foreseen under the QA processes. The manual will be continuously reviewed and updated as necessary.

Institutions involved

» What institutional arrangements allow for the flow and integration of this information?
» What types of entities take a role in the above structures?

Lead: On behalf of the Ministry of the Environment and the Ministry of Climate, Energy and Building, the DCE is responsible for the calculation and reporting of the Danish national emission inventory to EU and the UNFCCC and UNECE CLRTAP conventions.

Institutional arrangements: DCE has set up Memoranda of Understanding with relevant data providers[12].

Case learning

Why is it good practice

This case study is considered as a strong example of data collection and QA/QC system, tools needed for an accurate accounting.

Barriers that have been overcome

[barriers that have been overcome till date]

Information: Confidential information from industrial facilities. A large share of the plant-specific information that the inventory receives is confidential. By now, the inventory team has long-standing experience on protecting confidential data and has a strong working relationship with data providers so that they trust the inventory team to be able to maintain the confidentiality of the data. As a practical matter, all data related to the emission inventory is stored on a secure server where only the members of the emission inventory team have access to.

Barriers to overcome

[barriers that are still present and needed to overcome]

Capacity: The task of finding suitable reviewers for the sectoral reports is challenging. Experts with the knowledge to evaluate the methodologies used in the inventory and to contribute with constructive criticism of the choices made by the inventory compilers are required and need to have a substantial amount of time available for the review. In some cases it is not possible to find a reviewer suited to review all aspects of the sectoral report, e.g. for mobile combustion activities vary from aviation to road transport and different non-road machinery. In these cases different approaches have been used: having the report has reviewed by more than one reviewer or, having subsequent versions of a sectoral report by reviewers with different areas of expertise, so that all aspects of the given sector are reviewed over time.

Quantitative information

Funding obtained

The work on national GHG inventories is funded by the Ministry of Environment and Food and the Ministry of Energy, Utilities and Climate. For the last years there has been funding for 6 man years for the national GHG inventory, and 2 man years for the air pollutant inventory.

[12]A list of relevant data providers can be found in Denmarks National GHG inventory report submissions. For the 2015 report, see http://unfccc.int/files/national_reports/annex_i_ghg_inventories/national_inventories_submissions/application/zip/dnk-2015-nir-15nov15.zip.

Funding required

N/A

Staff

[Number of staff involved in the design and implementation of the case study]

When the national GHG inventory system was first set-up, nine people were involved with the emission inventory compilation at Aarhus University, Department of Environmental Science. Currently the team at consists of 11 staff members (not all of them fulltime).

Time

[Time required to get to this stage]

Around 600 working hours were needed for the design and implementation of the QA/QC system.

Further information

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References

Fauser, P. 2010: Danish Emission Inventory for Solvent Use in Industries and Households. National Environmental Research Institute, Aarhus University, Denmark. 47 pp. – NERI Technical Report no. 768. Retrieved from: http://www.dmu.dk/Pub/FR768.pdf

Fauser, P., Sørensen, P. B., Nielsen, M., Winther, M., Plejdrup, M. S., Hoffmann, L., Gyldenkærne, S., Mikkelsen, M. H., Albrektsen, R., Lyck, E., Thomsen, M., Hjelgaard, K. & Nielsen, O-K., 2011: Monte Carlo (Tier 2) Uncertainty Analysis of Danish Greenhouse Gas Emission Inventory. Greenhouse Gas Measurement & Management. 1(3/4), pp. 145-161.

Nielsen, O.-K., Plejdrup, M.S., Winther, M., Nielsen, M., Gyldenkærne, S., Mikkelsen, M.H., Albrektsen, R., Thomsen, M., Hjelgaard, K., Fauser, P., Bruun, H.G., Johannsen, V.K., Nord-Larsen, T., Vesterdal, L., Møller, I.S., Caspersen, O.H., Rasmussen, E., Petersen, S.B., Baunbæk, L. & Hansen, M.G. 2015. Denmark's National Inventory Report 2015. Emission Inventories 1990-2013 - Submitted under the United Nations Framework Convention on Climate Change and the Kyoto Protocol. Aarhus University, DCE – Danish Centre for Environment and Energy, 911pp. Scientific Report from DCE – Danish Centre for Environment and Energy. Retrieved from: http://dce2.au.dk/pub/SR171.pdf

Sørensen, P.B., Illerup, J.B., Nielsen, M., Lyck, E., Bruun, H.G., Winther, M., Mikkelsen, M.H. & Gyldenkærne, S. 2005: Quality manual for the greenhouse gas inventory. Version 1. National Environmental Research Institute. - Research Notes from NERI 224: 25 pp. Retrieved from: http://www2.dmu.dk/1_viden/2_Publikationer/3_arbrapporter/rapporter/AR224.pdf

Nielsen, O.-K., Plejdrup, M.S., Winther, M., Gyldenkærne, S., Thomsen, M., Fauser, P., Nielsen, M. Mikkelsen, M.H., Albrektsen, R., Hjelgaard, K., Hoffmann, L. & Bruun, H.G. 2012. Quality manual for the Danish greenhouse gas inventory. Version 2. Aarhus University, DCE – Danish Centre for Environment and Energy, 44 pp. Scientific Report from DCE – Danish Centre for Environment and Energy No. 47. Retrieved from: http://www.dmu.dk/Pub/SR47.pdf

Winther, M., 2008: New national emission inventory for navigation in Denmark. Atmospheric Environment – Volume 42, Issue 19, June 2008, Pages 4632–4655.

Winther, M. & Nielsen, O.-K., 2007: Fuel use and emissions for non-road machinery in Denmark 1985- 2020. In: ISP's Proceedings, Vol. 316, 2007, pp. 352-361. Retrieved from: http://www.trafikdage.dk/program/Artikelsamling_2006.pdf

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