The carbon footprint of central government procurement

Evaluating the GHG intensities of government procurement in Norway

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1. Summary

1.1 English summary

In this project we derive the Carbon Footprint (CF) of an important part of public service provision; the state administration. This is a significant part of government activities and includes the activities of ministries, agencies and directorates in Norway, corresponding to a total procurement of approximately 98 billion NOKs. Our results show that the CF of the procurement made corresponds to about 2,4 million tonnes of CO2 equivalents (tCO2e).

The largest contributions are a result of building and infrastructure activities. Especially the Norwegian government's agency for railway services (Jernbaneverket) and The Norwegian Public Roads Administration (Statens vegvesen) have large contributions of together more than 1 million tCO2e, making The Ministry of Transport and Communications and its subordinate agencies by far the most important ministerial area regarding the emission of GHG gases (47 % of the total CF). In contrast, the Ministry of Climate and Environment accounts for only 1,7 % of the total CF.

The CF structure of the different ministries differ significantly. The assessment in this project should be considered as a first overview on the size and structure of CF contributions to help ministries, agencies and directorates identify their most important target areas in reducing their CF. The results are however considered to be too uncertain to track the effect of specific action, e.g. changes made at the product level.

1.2 Norsk sammendrag

Vi har i dette prosjektet beregnet klimafotavtrykket til en viktig del av offentlig tjenesteyting: statsforvaltningen. Dette er utgjør en viktig del av de offentliges oppgaver, og inkluderer blant annet departementer og direktorater. Til sammen bidrar disse med innkjøp på nær 98 milliarder NOK. Resultatene fra analysen viser at dette innkjøpet bidrar til nærmere 2,4 millioner tonn CO2 ekvivalenter (tCO2e).

Det viktigste bidraget til klimafotavtrykket i analysen finner vi innen bygg, anlegg og eiendom (BAE). Jernbaneverket og Statens vegvesen har spesielt store bidrag på til sammen mer enn 1 millioner tCO2e, noe som gjøre Samferdselsdepartementet til det desidert viktigste departementet (47 % av totalen) når det kommer til klimafotavtrykk. Klima- og miljødepartementet på sin side bidrar med kun 1,7 % av totalt klimafotavtrykk i analysen.

Vi ser at strukturen i klimafotavtrykk varierer mellom departementene. Denne analysen bør sees på som et første overblikk på størrelse og struktur av klimafotavtrykk, for å hjelpe de ulike aktører å identifisere sine fokusområder for reduksjon av klimagasser. Resultatene er imidlertid *for* usikre til å benytte dem til å måle effekten av spesifikke tiltak på produktnivå.

2. Background

2.1 From Rio to the green shift and a new public procurement law

The United Nations Framework Convention on Climate Change (UNFCCC) was negotiated at the Earth Summit in Rio de Janeiro in 1992, and entered into force 1994. The UNFCCC objective is to:

"*stabilize greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system*".

The framework set no binding limits on greenhouse gas emissions for individual countries and contained no enforcement mechanisms. However, it laid the groundwork for future international treaties ("protocols" or "Agreements") to set binding limits on emissions. The first one, the Kyoto Protocol, has been effective since 2005, with legally binding obligations for developed countries to reduce their greenhouse gas emissions in the period 2008-2012. The latest, the Paris Agreement, was negotiated in 2015. In October 2016 the requirements for the agreement to enter into force was met, and it has been in effect since November 2016.

While the UNFCCC to a large part governs the global climate policy development, countries and groups of countries are developing their own policies within the framework set by the convention. One example is the EU emissions trading system (EU ETS), operating in all 28 EU countries plus Iceland, Liechtenstein and Norway. EU ETS is the largest carbon market in the world, and it is also an important instrument for shared obligations between the participating countries. Among many other measures and instruments, governments in many countries recognize that public procurement plays an important role in greening the economy, due to its sheer market power and the corresponding potential to change commodity standards and dominant market trends.

A new public procurement law passed the Norwegian parliament in June 2016. This was as an important step to conform national legislation to the three new EU-directives on public procurement. The new law also goes further than required by EU-legislation and the EEA Agreement, as reflected in § 5. Environment, human rights and other societal considerations, which requires “state, county and municipal governments and statutory bodies to use their procurement practices to reduce harmful environmental impacts and promote climate friendly solutions where applicable. One method of ensuring this will be for the contracting authority to take account of life cycle costs.

In appendix 3 we provide a short introduction of the new EU public procurement directives and the European emission trade system, for more background in the potential of green public procurement and its interactions to other policy measures.

2.2 Organizational carbon footprint initiatives

In addition to the international published studies on environmentally extended input-output analysis (EE-IOA) methodology mentioned in the methods section of the appendix 4, there have been several national and international studies, initiatives, tools, standards and methods aiming at analysing the carbon footprint with an organizational focus.

Internationally there are several methodologies, tools and standards that somehow relate to the calculation of organizational carbon footprints. They do vary in the system boundaries they use (whether or not they aim at including some or all indirect emissions). This includes the GHG-protocol[1], in which reporting of so-called "scope 3"-emissions[2] is voluntary. There are guidelines for calculation of the scope 3 emissions, that recommend performing an initial screening to identify most important contributions, and then to refine the method in the most important areas.

The life cycle initiative has published a guideline on how to do an "organizational LCA" (Martínez-Blanco et al., 2015). The guideline describes a detailed method of combining top-down, and bottom-up approaches to obtain a broad, and at the same time specific in the most important areas, coverage of the environmental footprint of an organization. The guideline applies to other impacts in addition to climate impacts. Organizational carbon footprint is also covered in the ISO 14064 standard, which provides guidance on how to calculate the footprint on the enterprise level, as well as guidelines on good reporting practice, communication, data quality etc. The EU has an initiative called "Product environmental footprint" PEF, in which there is a parallel organizational-version (organizational environmental footprint, OEF). The method is currently undergoing testing, and preliminary guidelines for footprint calculations are available on the website[3].

For the Nordic countries the total footprint of final demand was investigated in a 2010 study (G. Peters & Solli, 2010)[4] with a follow up report "Global environmental footprints" (Glen P. Peters, Andrew, & Karstensen, 2016)[5]. This report does not quantify emissions down to individual components of final demand, such as state entities, but demonstrates clearly how important the emissions embodied in imports are for the Nordic countries in total. The report also discusses the policy relevance of different types of environmental footprints (material, water and carbon). One of the findings discussed in the report is that global problems such as climate, are better informed by the footprint approach than more local types of issues, like water use and local pollution. Uncertainty is also addressed, and the report generally recommends some degree of cation in using environmental footprints. Although the aggregated uncertainty seems to be low, application of the footprint on very specific areas or product groups has a higher degree of uncertainty.

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[1] http://www.ghgprotocol.org/

[2] Non energy related indirect emissions.

[3] http://ec.europa.eu/environment/eussd/smgp/ef_pilots.htm

[4] http://www.diva-portal.org/smash/record.jsf?pid=diva2%3A701599&dswid=4697

[5] http://tinyurl.com/j2rulgk

The UK health services has used the full carbon footprint[6] for management and measurement purposes, and has specified targets for the reduction of their total carbon footprint by some 80 % by 2050. Reporting of the development in the footprint is done very elegantly, broken down on activity increase, changes in the volume of goods consumed, and changes in the emissions intensity of the goods consumed. Further, the EU JRC[7] and the European Commission[8] have compiled overviews of methods for organizational footprints.

National footprint initiatives and tools aimed at the organization level include the previous Difi project "Climate neutral state"[9] where selected state entities calculated their carbon footprint. This initiative did not include all scope 3- emissions (some included a few, such as transport services), but focussed more on scope 1 (direct) and -2 (indirect from energy) emissions.

For the municipal sector[10], Asplan Viak has developed KLIMAKOST, a footprint calculation tool, based on the same method as the one used in this report. A large number (~50) of Norwegian municipalities have used this tool to get an overview of their total carbon footprint. There are many other providers of footprint calculations for organizations available on the web (companies, government entities), but few seem to include the full carbon footprint, including scope 3 emissions. Most reporting tools seem to rely on physically reported scope 1- and scope 2 inputs, with a small selection of scope 3 contributions. It is outside the scope of this study to investigate all available tools related to the subject.

2.3 About the project

In a previous work from 2015, the Agency for Public Management and eGovernment (Difi) gave Asplan Viak the task to calculate the Carbon Footprint (CF) of all governmental activities in Norway[11]. The years 2008-2013 were covered, and all municipal and central governmental service provision was included. During the period 2008-2013 the CF of governmental activities increased from 10,3 to 11,9 million tonnes of CO2 equivalents (tCO2e.) In 2013 this corresponded to 14 % of the total CF of all final consumption in Norway.

An important finding of the project was the significance of indirect emissions associated with goods and services procured by municipal and central governmental entities. In table 1 we summarize the CF structure found, indicating a high fraction of the scope 3 indirect emissions described earlier.

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[6] http://www.sduhealth.org.uk/policy-strategy/reporting/nhs-carbon-footprint.aspx

[7] http://ec.europa.eu/environment/eussd/pdf/Deliverable.pdf

[8] http://ec.europa.eu/environment/pubs/pdf/ERM_GHG_Reporting_final.pdf

[9] https://www.difi.no/artikkel/2011/08/pilotprosjektet-klimanoytral-stat

[10] www.klimakost.no

[11] https://www.anskaffelser.no/sites/anskaffelser/files/klimafotavtrykk_for_offentlig_virksomhet.pdf

Contributions	ktCO2e.
Direct emissions (scope 1)	1 074
Food and beverages	430
Consumables	2 278
Energy (scope 2)	1 894
Water and renovation	163
Infrastructure (operation)	695
Transport services	827
Purchases of services	1 195
Infrastructure (investments)	1 123
Transport material	701
Other investments	1 492
SUM	**11 871**

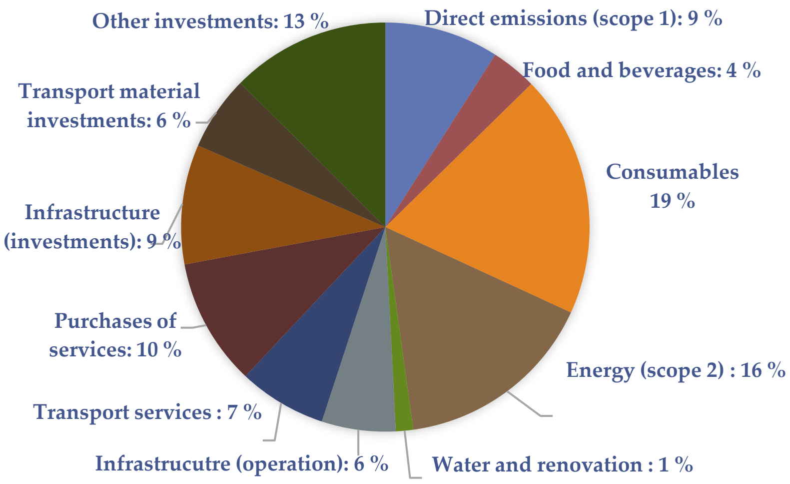

Table 1: The Carbon Footprint of all governmental activities in Norway, 2013 (Difi-project, 2015)

Table 1 are derived directly from the governmental final demand category in the national input-output models, and therefore provide only limited details on the specific products and services purchased, and no details on the composition of the service provided.

In 2016, however, Difi published statistics covering important parts of central government procurement[12]. Here, information on the procurement of each ministry, and their subordinate agencies, is provided in a standardized format. Advance knowledge of carbon intensities is a necessary prerequisite to use Public Procurement as an effective instrument to reduce greenhouse gas emissions. Additionally, this knowledge can be useful in the development of climate related strategies and carbon risk management.

This project, initiated in 2016, demonstrates how CF calculations can be applied to this new statistic. More specifically; to allocate CF intensities to all relevant categories of purchased goods and services. Pros et contras regarding use of carbon intensities as part of climate policy tools are outside the scope of the report.

Further, the purpose of this report is to:

- contribute to the scientific basis for future assessments and priorities for national statistics development related to public procurement (acquisitions) and climate.
- constitute the basis for prioritizing specific areas for Difi guidance on climate and environmental standards in public procurement.
- serve as an educational tool to illustrate the government's role as a market player in the green shift.

[12] https://www.difi.no/rapporter-og-statistikk/nokkeltall-og-statistikk/innkjop

3. Methodology

3.1 Carbon footprint and carbon intensities

The carbon footprint is often defined as the total amount of greenhouse gas emissions caused by an individual, event, organisation or product, expressed as CO_2e.[13] The Greenhouse Gas (GHG) Protocol[14] describes the carbon footprint using three *scopes*:

Scope 1 Direct GHG Emissions	Direct GHG emissions occur from sources that are owned or controlled by the entity itself. An example is GHG emissions from vehicles owned by the entity.
Scope 2 Electricity Indirect GHG Emissions	GHG emissions from the generation of purchased electricity consumed. Scope 2 emissions physically occur at the facility where electricity is generated.
Scope 3 Other Indirect GHG Emissions	All other indirect emissions. Scope 3 emissions are a consequence of the activities of the entity, but occur from sources not owned or controlled by it. Some examples of scope 3 activities are extraction and production of purchased materials and fuels, transport-related activities in vehicles not owned or controlled by the reporting entity, air travels, outsourced activities, and waste disposal.

The separation of GHG emissions into scopes is designed to avoid double-counting of emissions, and can be useful when categorizing GHG emissions into those that an organisation can *control* (e.g. Scope 1) versus those that can only be influenced to varying degrees (e.g. Scope 2 and 3). As buyers, for example, we (usually) cannot control energy use in all modes of transportation, but we can choose to travel by train, and video-conferencing can be an alternative to air trips.

Flawless calculations of the total carbon footprint are possible in some cases, but lack of data often prevents this. However, for groups of products and services, statistical methods can generate useful data without large costs. Data are often generated as *intensity factors*, quantifying amounts of emissions in relation to amounts of money spent. These intensities can be valid as average estimates, but even within groups of seemingly identical producers and products there will be differences due to variations in production technology, electricity systems, national legislation etc. As a consequence

[13] Where CO_2e is the *carbon dioxide equivalent,* reflecting long term global warming potential (GWP100).
[14] The Greenhouse Gas (GHG) Protocol is developed by World Resources Institute (WRI) and World Business Council on Sustainable Development (WBCSD), and serves as the foundation for most GHG standards in the world.

of this, intensities must be used carefully in decision making: They can be useful to establish the big picture; to realise where the combination of estimated intensities and actual money spent indicates a large (part of the total) carbon footprint, but they cannot be used to identify the best product or producer within these areas. The latter requires product and/or producer specific intensities.

For final demand in Norway, whether from private or public entities, a large part of the carbon footprint is linked to physical emissions in other countries, originating from production of goods imported to Norway. Thus, reducing the carbon footprint may lead to reduced direct emissions in another country.

Many procurement decisions, for example the construction of a new office building, generate two different sets of emissions: The first one, following the investment decision, is related to the construction phase, and results mainly from conditions that are well known. These emissions occur in recent past, now or in near future. The second set consists of future emissions related to the operation phase. These future emissions are calculated using projected intensities, which are outside the scope of this report.

3.2 The footprint calculation model

The model used for calculation of the governmental footprints has been built to utilize information already contained in the detailed governmental accounts on public procurements. It is based on the same methodology as the existing Klimakost[15] method. An overall objective has been to include total direct and indirect (so-called life cycle) emissions. The traditional life cycle assessment approach (LCA), based on product specific process descriptions, does not match well with the available information in the accounting system. Hence, an alternative method of estimating value chain emissions has been used.

Procurement data from the governmental accounting are available for approximately 120 different categories of purchases/cost items. To make this resolution useful, we therefore need emission factors for every NOK spent on each cost item classification. This has been accommodated by constructing an environmentally extended input-output model (EE-IOA), and connecting this emissions model to the accounting data of the state (government).

An EE-IOA-model makes it possible to characterize the structural effects of different kinds of demand in on one or more economic sectors. The input-output model is supplied by Statistics Norway. The model contains information about interrelations between all sectors in the economy; how, and to what extent they typically trade services and products between them (expressed in monetary terms). Emissions data for each sector are collected from statistics, and a model that enables the calculation of total direct and indirect emissions from the final demand of 1 NOK from any given sector, or any mix of sectors, can be constructed.

[15] www.klimakost.no

A number of adjustments are required to connect this underlying emissions model to the economic accounting data of the state. This includes:

- Estimation of taxes, trade- and transport margins contained in the state purchases (cost category by cost category)
- Re-allocation of trade and transport margins to the relevant sectors
- Adjusting prices so they have the same base year (cost category by cost category)
- Treatment of imports (to industry sectors and directly to state entities)
- Treatment of the use of fixed capital in the production sectors of the economy
- Matching between the cost categories in the state accounts and the sector classification used in the EE-IOA-mode

More details about methods and models can be found in Appendix 5.

4. Results

In this chapter we will present selected results on both deriving GHG emission intensities and applying them to governmental procurement categories and the different ministries.

4.1 Overall findings

When matching the governmental procurement categories to the Klimakost model as described, we are able to derive a set of GHG intensities for all 120 entities. The results are summarized in appendix 1. Table 2 shows the top 20 GHG-contributors, with their respective codes from the accounting system. These results include State administration purchases of close to 97,8 billion NOKs. Important exclusions are the hospital sector, the university sector, and defence expenditures. In total, the 97,8 billion NOKs contribute to a carbon footprint of more than 2,39 million tonnes of CO2e (tCO2e.). As illustrated in Table 2 an important part of this footprint is embodied in the use of subcontractors (0,5 mill) and entrepreneur and consultancy services (0,29 mill). Other important contributions are infrastructure developments (0,29 mill), travels (0,25 mill) and energy (0,2 mill, code 634/620) and GHG emissions embodied in the renting of property (0,15 mill, code 630/631). The mentioned contributions cover more than 70 % of the total CF investigated. Some large GHG contributing elements identified are a result of the sheer amount of money used. The use of subcontractors, entrepreneurs, and consultancy are not especially GHG intensive, but the amount of money spent on these elements (close to 40 billion NOKs) trigger a high GHG contribution. On the other hand, energy and transport related expenses are substantially smaller. A high carbon footprint intensity, however, make these elements important regarding GHG emissions.

Art	Navn	Category	Mill NOK	kgCO2e/NOK	Tonn CO2 e.	%
450-454	Subcontractors	B & I	26 307	0,018	505 538	21,1 %
487	Infrastructure investments	B & I	11 487	0,026	293 774	12,3 %
678-679	Entrepreneur and consultancy	Services	13 400	0,017	290 054	12,1 %
713	Travels	Transport	2 079	0,117	250 585	10,5 %
634	Light and heat	B & I	590	0,180	106 133	4,4 %
630	Renting of property	B & I	6 658	0,016	103 615	4,3 %
620	Electricity	B & I	543	0,180	97 672	4,1 %
779	Misc.	Misc.	4 562	0,017	76 085	3,2 %
400-403	Intermediate goods	Misc.	983	0,071	69 492	2,9 %
631	Renting of property, Statsbygg	B & I	2 580	0,016	40 154	1,7 %
700	Fuel for transportation	Transport	130	0,250	32 445	1,4 %
715	Food expenses relating to travels	Transport	492	0,057	28 163	1,2 %
671	Development, ICT	ICT	2 499	0,010	25 876	1,1 %
625	Gasoline, diesel	Transport	100	0,250	25 066	1,0 %
672	Operation, ICT	ICT	2 257	0,010	23 367	1,0 %
710	Car allowance	Transport	279	0,079	22 074	0,9 %
686	Meetings	Communication	423	0,047	20 013	0,8 %
687	Employee training and development	Competence	596	0,033	19 538	0,8 %
591	Canteen expenses	Personal	183	0,105	19 191	0,8 %
493	Transport vehicles	BAE	406	0,045	18 410	0,8 %
---	All other contributions	---	21 244	0,153	325 533	13,6 %
All	**All contributions**	**All**	**97 796**	**0,245**	**2 392 777**	**100 %**

Table 2: Segment of GHG intensity table, illustrating the top 20 contributions

Results can also be divided into more general categories, as those applied by Difi, illustrated in Figure 1. The building and infrastructure (B & I) category cover more than half of the CF and is therefore broken down in more detail to the right. Other important categories are services (12 %, mainly entrepreneur and consultancy service) and transport and travels (17 %). The other categories have less significant contributions.

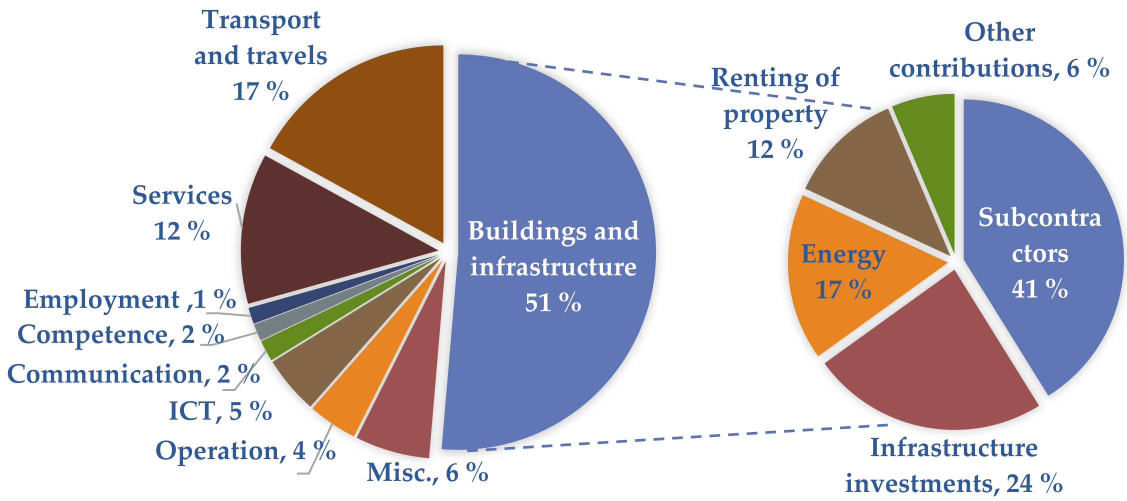

Figure 1: Dividing the Carbon Footprint into different categories

When applying the CH intensities to each ministerial sector, we find the structure illustrated in Figure 2. Because of the importance of The Ministry of Transport and Communications (SD), the Norwegian government's agency for railway services and The Norwegian Public Roads Administration have been separated out. These two agencies contribute to a CF of approximately 368 000 and 700 000 tCO2e., respectively. The Ministry of Justice and Public Security also contribute significantly with about 375 000 tCO2e., This ministry include important services areas such as the National Police Directorate.

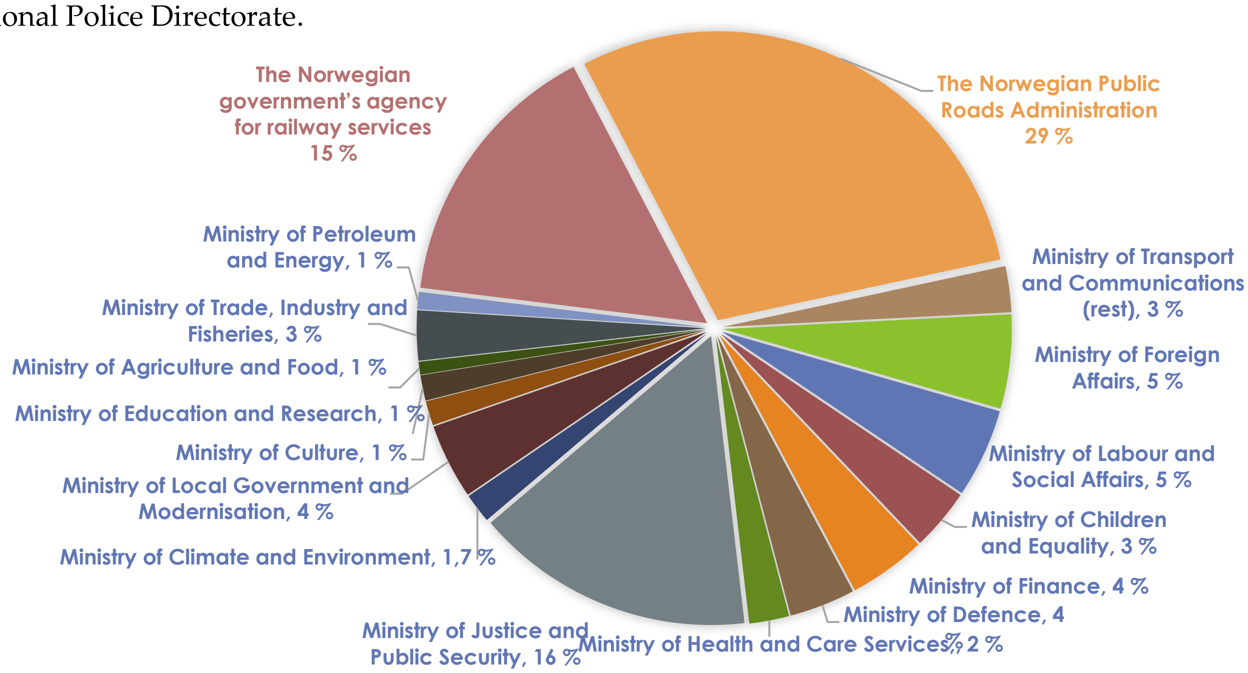

Figure 2: Dividing the Carbon Footprint into different departments (in Norwegian)

4.2 Application to the Ministry of Climate and Environment

As part of this project, GHG intensities are applied to one selected ministerial sector in more detail. The selected sector is that controlled by the Ministry of Climate and Environment (Klima og miljødepartementet, KLD). Results show that the ministry's expenditures of GHG contributing elements generate a carbon footprint of 39,7 kt CO2e. This is about 1,7 % of the total CF.

In Table 3 we highlight the 20 most contribution elements to the GHG inventory of KLD, covering 92,8 % of the total CF. Entrepreneur and consultancy is the highest contribution element, with more than 1/3 of the total CF. Further, the ministry has high GHG contributing elements relating to travels and transport.

#	Code	Name	Category	tCO2e	%
1	678/9	Entrepreneur and consultancy	Services	13 537	34,1 %
2	713	Travels	Transport	7 632	19,2 %
3	476	Rights and licences	Competence	4 771	12,0 %
4	630	Renting of property	B & I	1 738	4,4 %
5	634	Light and heat	B & I	1 142	2,9 %
6	715	Food expenses relating to travels	Transport	1 057	2,7 %
7	631	Renting of property, Statsbygg	B & I	869	2,2 %
8	646	Renting means of transportation	Transport	861	2,2 %
9	700	Fuel for transportation	Transport	775	1,9 %
10	689	Other office expenses	Operation	755	1,9 %
11	686	Meetings	Communication	576	1,5 %
12	668	Repair and maint. of ships, airplanes	Transport	493	1,2 %
13	687	Employee training and development	Competence	476	1,2 %
14	710	Car allowance	Transport	434	1,1 %
15	672	Operation, ICT	ICT	387	1,0 %
16	591	Canteen expenses	Personal	370	0,9 %
17	642	Renting of computer systems	ICT	280	0,7 %
18	499	Other supplies	Operation	264	0,7 %
19	497	Tools etc.	Operation	234	0,6 %
20	680	Office supplies	Operation	230	0,6 %
		Rest	-	2 855	7,2 %
		SUM	**-**	**39 737**	**100,0 %**

Table 3: Top 20 contribution to the CF of the Ministry of Climate and Environment

In Figure 3 the CF of KLD is broken down to the standardized categories used by Difi. It highlights the importance of services and transport/travels. To the right, we compare the structure of the KLD CF to the average structure of all departments, both inclusive and exclusive the important Ministry of Transport and Communications (SD). This further identifies a need to focusing on transport and travel related GHG emissions for the ministry. On the other hand, a much lesser fraction of the CF is related to buildings and infrastructure. More detail on the carbon footprint of the different ministries are provided in appendix 2.

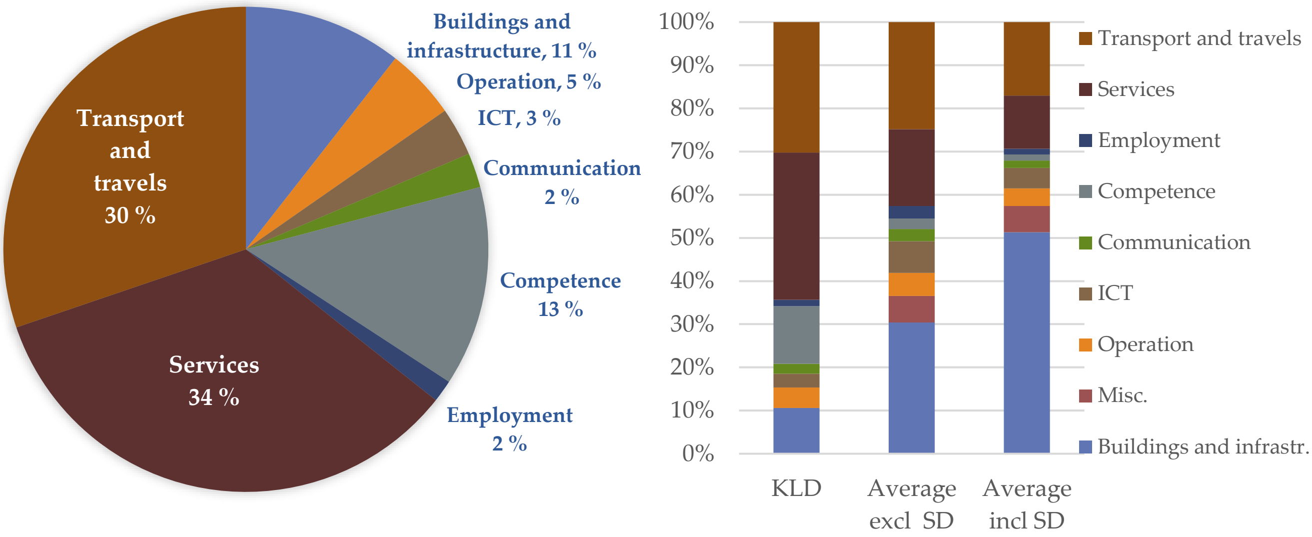

Figure 3: Dividing the KLD carbon footprint into different categories

4.3 Carbon Footprint structure

Several possible illustrations of the CF calculated are possible. One is the scope-distribution as illustrated in Figure 4. Direct - scope 1 – GHG emissions only account for 3 % of the total CF. The contribution at 83 kt CO2e. should however still be considered significant as these emissions are from sources owned or controlled by the reporting entity. The use of fuel for transportation is now by far the largest scope 1 contribution, as fossil fuel for heating is becoming less common. The purchase of energy further contributes to 9 % of the total carbon footprint, a contribution of slightly more than 200 kt CO2e., assuming a Nordic mix of electricity at 128 gCO2e/kWh. This leaves the vast majority of the CF to be counted as Scope 3 contribution; indirect GHG emissions from the purchase of goods and services. The use of subcontractors, purchase of entrepreneur and consultancy services, air travels are all examples of important scope 3 elements. In total this contributes to more than 2,1 million tonnes of CO2e., corresponding to 88 % of the total CF.

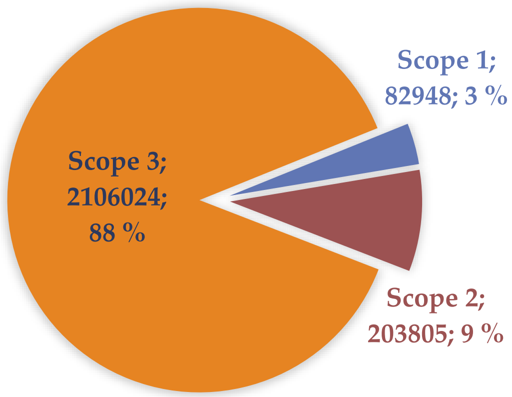

Figure 4: Scope distribution of the CF

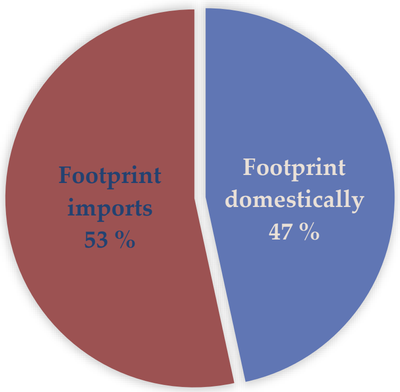

Figure 5: Domestic-import-fraction of CF

The CF can also be distributed to each of the sectors in the EE-IO- model, in a “where do emissions occur” manner. This also enables a domestic-import distribution of the results, as indicated in Figure 5. As we see, GHG emissions are quite evenly distributed on domestic and import sectors, with slightly more allocated to imports. Note that imports are a combination of products purchased directly from abroad, but more important; imported emissions embodied in the purchase of goods and services domestically.

4.4 Sensitivity

In the assessment made, we have assumed a Nordic mix of electricity at 128 gCO2e/kWh in the domestic economy, and a EU28 average for the import economy. Both assumptions influence the results. A sensitivity assessment has therefore been performed to identify the significance. In Figure 6 five scenarios are investigated. The scenario relates to the different energy assumptions, ranging from Norwegian energy (domestically) and EU energy (imports) to the left, to EU (domestically) and China (import) to the right. Compared to the base case (Nordic energy mix domestically combined with EU mix for imports), the Norwegian-EU scenario reduces the total CF by 10 %. Assuming a EU mix both domestically and for imports ("free flow of energy in the EU"), on the other hand, increases the CF by 7 %.

It could also be argued that the EU technology is cleaner compared to the average import mix to Norway. Therefore, we also substitute the energy mix in the import technology to US and China technology, increasing the CF by 10 and 14 % respectively. The sensitivity analyses show that the assessment done is quite robust. The sensitivity to especially import assumptions are surprisingly low, but could be explained by that some large contributions are not too influenced by electricity mixes, in particular transport and travels, and also to some degree: construction of buildings and infrastructure. Also, only the electricity intensity has been modified in the model, and a complete use of an e.g. Chinese import model would further differentiate the results.

Norwegian-EU	Nordic-EU	EU-EU	EU-USA	EU-China
2161	**2393**	2570	2631	2738
90 %	**100 %**	107 %	110 %	114 %

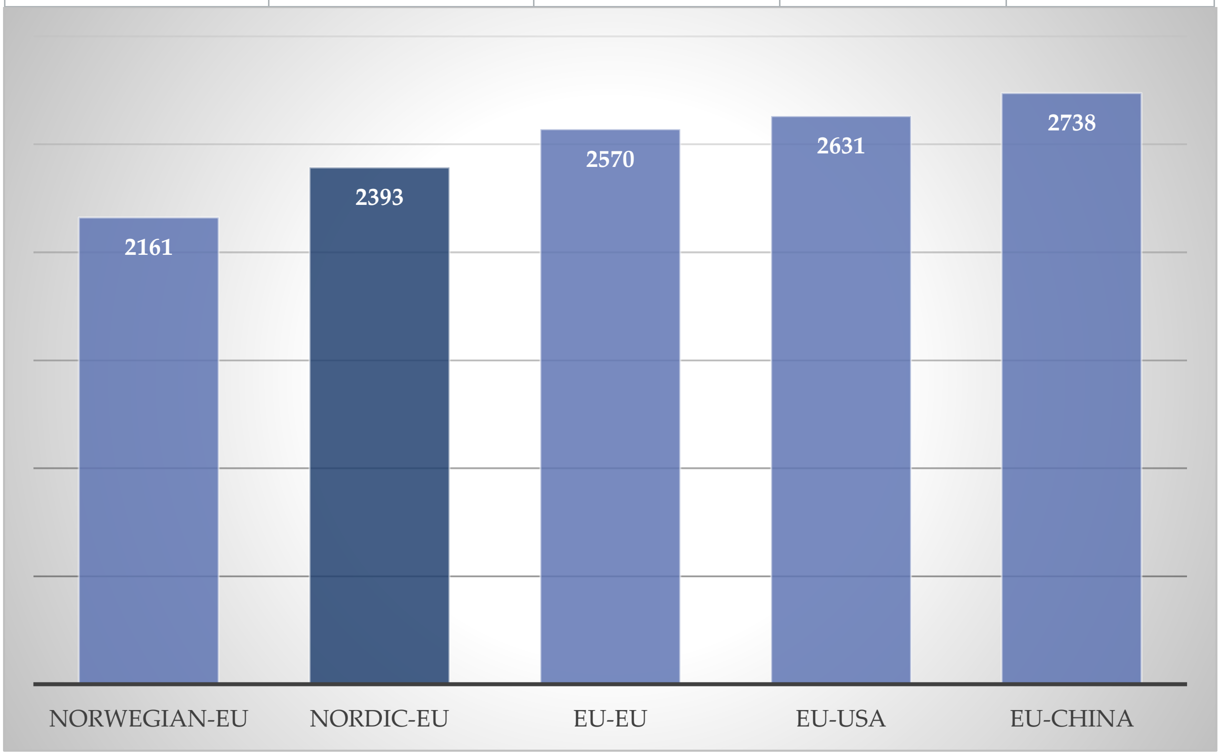

Figure 6: Sensitivity of different assumptions on energy generation (kt CO2)

4.5 Application of GHG emissions factors

The methodology (EE-IOA) and model (Klimakost) have in this project proven its usefulness; we are able to derive time-efficient GHG intensities that cover all 120 procurement categories in the State administration account. Using a well-developed methodology further enables a standardized procedure in both improving and update the intensities derived. However, the GHG emissions intensities derived in appendix 1 should be applied with care. Uncertainties are found both in the economic background data and in the model developed. In particular, the matching matrix converting the procurement categories to EE-IOA sectors should be revised as soon as more accurate procurement data becomes available. One element that could significantly improve the quality of the data is the use of company level procurement data that more easily could be assigned to the correct EE-IOA sector. Also, the model could be developed further including more multi-regionality. However, in order to make use of such an improvement, more data on the origin of procurements need to be provided. Presently, the information and detail available in the financial statistic on procurement fits quite well with the detail of the EE-IOA-model described.

Some of the largest elements in the GHG inventory, however, are difficult to model emissions of. Obviously, the inventory elements: subcontractors (450-454), infrastructure investments 450-454, entrepreneur and consultancy (678-679) are not specific enough to model with sufficient accuracy. In some cases, more details on the composition of these elements were collected. From the Norwegian government's agency for railway services we found that a large fraction of infrastructure investments 450-454 are investments in railway infrastructure. Other contributions were also investigated in more detail to improve the matching. In general, roads, railways and transport caused much of the climate load from government procurement. These spend areas should be analysed in more details as potential candidates for "Green Innovation", e.g. Low-Carbon construction. For other "non-transport" intensive ministries we find that the climate profile varies widely. Carbon mitigation activities should be targeted accordingly in order to maximise effect.

Due to the points made above and the general limitations of EE-IOA, we recommend that the GHG emission factors are applied to ministries, agencies and directorates to indicate their respective carbon footprint size and structure. The implementation of these factors should, however, not in any way be used to tract the effect of very specific actions, such as buying one type of food ahead of another. For this, more specific Life Cycle Assessments (LCAs) and Environmental Product declarations (EPDs) are necessary. From a societal perspective it is important to keep in mind what the carbon footprint can and should be used as. Given that the purpose is to describe historical emissions, i.e., to give a picture of the carbon footprint from public procurements last year (or alike), it is advisable to use intensities reflecting average technologies, as the one presented in this report. But if the purpose is to use carbon intensities or carbon footprints as an instrument when designing public measures or policies they should be, preferably, based on the marginal technology, i.e. the technology that most likely will be affected when introducing the new policy.

5. Appendices

5.1 Appendix 1: GHG emission factors (in Norwegian)

artkode	artnavn	kategori	mill NOK	kgCO2e./ NOK	tonn CO2e.
400	Innkjøp av råvarer og halvfabrikater	Diverse	983,2	0,071	69492
403	(Innkjøp av råvarer og halvfabrikater - Tas i bruk ved	Diverse	0,3	0,071	22
406	Frakt, toll og spedisjon	Diverse	1,0	0,020	19
450	Fremmedytelse og underentreprise	Bygg, anlegg og eiendom	26306,8	0,018	475929
451	(Fremmedytelse og underentreprise - Tas i bruk ved behov	Bygg, anlegg og eiendom	44,8	0,018	810
452	(Fremmedytelse og underentreprise - Tas i bruk ved behov	Bygg, anlegg og eiendom	1486,8	0,018	26898
453	(Fremmedytelse og underentreprise - Tas i bruk ved behov	Bygg, anlegg og eiendom	14,9	0,018	269
454	(Fremmedytelse og underentreprise - Tas i bruk ved behov	Bygg, anlegg og eiendom	90,2	0,018	1632
470	Forskning og utvikling	Kompetanse	363,4	0,017	6191
474	Programvarelisenser	IKT	203,2	0,011	2319
476	Andre rettigheter	Kompetanse	382,7	0,012	4771
480	Bygninger	Bygg, anlegg og eiendom	341,4	0,024	8263
481	Beredskapsanskaffelser	Bygg, anlegg og eiendom	35,9	0,026	917
482	Bygningsmessige anlegg	Bygg, anlegg og eiendom	11,7	0,026	300
484	Jord- og skogbrukseiendommer	Bygg, anlegg og eiendom	0,0	0,001	0
485	Tomter og andre grunnarealer	Bygg, anlegg og eiendom	345,9	0,012	4066
486	Boliger inkl. tomter	Bygg, anlegg og eiendom	2,8	0,017	46
487	Infrastruktureiendeler	Bygg, anlegg og eiendom	11486,6	0,026	293774
488	Nasjonaleiendom og kulturminner	Bygg, anlegg og eiendom	6,3	0,005	29
489	Andre anleggsmidler	Bygg, anlegg og eiendom	0,8	0,029	23
490	Maskiner og anlegg	Drift	165,9	0,034	5658
492	Skip, rigger, fly	Transport	158,9	0,035	5641
493	Biler	Transport	405,6	0,045	18410
494	Andre transportmidler	Transport	8,2	0,035	293
495	Inventar	Drift	192,1	0,037	7148
496	Fast bygningsinventar med annen levetid enn bygningen	Bygg, anlegg og eiendom	111,6	0,035	3949
497	Verktøy og lignende	Drift	12,9	0,038	487
498	Datamaskiner (PCer, servere m.m.)	IKT	747,6	0,015	11533
499	Andre driftsmidler	Drift	292,0	0,029	8428
590	Gaver til ansatte	Personal	48,1	0,027	1310
591	Kantinekostnad	Personal	183,1	0,105	19191
592	Gruppelivsforsikring	Personal	114,1	0,007	821
593	Yrkesskadepremie	Personal	59,0	0,007	425
596	Velferdstiltak	Personal	148,1	0,022	3279
599	Annen personalkostnad	Personal	-251,9	0,020	-4988
610	Frakt, transport og forsikring ved vareforsendelse	Transport	34,7	0,069	2389
611	Toll og spedisjon ved vareforsendelse	Diverse	0,8	0,029	25
619	Annen frakt- og transportkostnad ved salg	Transport	28,6	0,085	2422
620	Elektrisitet	Bygg, anlegg og eiendom	542,6	0,180	97672
621	Gass	Bygg, anlegg og eiendom	10,5	0,250	2627
622	Fyringsolje	Bygg, anlegg og eiendom	1,6	0,375	601
624	Ved	Bygg, anlegg og eiendom	0,1	0,022	2
625	Bensin, diesel	Transport	100,3	0,250	25066
626	Vann	Bygg, anlegg og eiendom	0,0	0,022	0
629	Annet brensel	Bygg, anlegg og eiendom	0,7	0,200	133
630	Leie lokaler	Bygg, anlegg og eiendom	6657,8	0,016	103615
631	Leie lokaler fra Statsbygg	Bygg, anlegg og eiendom	2580,1	0,016	40154
632	Renovasjon, vann, avløp o.l.	Bygg, anlegg og eiendom	83,3	0,069	5708
634	Lys, varme	Bygg, anlegg og eiendom	589,6	0,180	106133
636	Renhold, vakthold, vaktmestertjenester	Bygg, anlegg og eiendom	797,8	0,017	13244
639	Annen kostnad lokaler	Bygg, anlegg og eiendom	793,2	0,017	13169
640	Leie maskiner	Drift	70,8	0,028	1970
641	Leie inventar	Drift	10,4	0,021	214
642	Leie av datasystemer (årlige lisenser m.m.)	IKT	901,2	0,016	14371
643	Leie av datamaskiner	IKT	86,9	0,018	1550
644	Leie av andre kontormaskiner	Drift	49,4	0,026	1305
645	Leie av biler	Transport	238,9	0,033	7995
646	Leie av andre transportmidler	Transport	111,0	0,029	3164
649	Annen leiekostnad	Bygg, anlegg og eiendom	323,3	0,030	9591
650	Maskiner	Drift	17,8	0,034	606

651	Verktøy og lignende	Drift	104,6	0,038	3952
652	Programvare (anskaffelse)	IKT	218,5	0,011	2309
654	Inventar	Drift	226,4	0,023	5266
655	Datamaskiner (PCer, servere m.m.)	IKT	527,7	0,015	8100
656	Andre kontormaskiner	IKT	47,4	0,025	1174
657	Arbeidsklær og verneutstyr	Drift	150,5	0,020	2991
658	Annet driftsmateriale	Drift	16,5	0,024	398
659	(Annet driftsmateriale - Tas i bruk ved behov)	Drift	376,5	0,024	9063
660	Reparasjon og vedlikehold egne bygninger	Bygg, anlegg og eiendom	91,4	0,021	1927
661	(Reparasjon og vedlikehold egne bygninger - Tas i bruk ved behov)	Bygg, anlegg og eiendom	10,0	0,021	210
662	(Reparasjon og vedlikehold egne bygninger - Tas i bruk ved behov)	Bygg, anlegg og eiendom	1,9	0,021	41
663	Reparasjon og vedlikehold leide lokaler	Bygg, anlegg og eiendom	283,7	0,021	5982
664	Reparasjon og vedlikehold infrastruktureiendeler	Bygg, anlegg og eiendom	306,5	0,026	7838
665	(Reparasjon og vedlikehold infrastruktureiendeler - Tas i bruk ved behov)	Bygg, anlegg og eiendom	28,3	0,026	724
666	Reparasjon og vedlikehold maskiner og anlegg	IKT	366,9	0,028	10230
667	(Reparasjon og vedlikehold maskiner og anlegg - Tas i bruk ved behov)	Bygg, anlegg og eiendom	72,4	0,028	2019
668	Reparasjon og vedlikehold skip, rigger, fly	Transport	92,3	0,028	2573
669	Reparasjon og vedlikehold annet	Drift	752,3	0,024	17736
670	Regnskaps-, revisjons- og økonomitjenester	Prof. tjenester	64,9	0,010	640
671	Kjøp av tjenester til utvikling av programvare, IKT-løsninger mv.	IKT	2498,9	0,010	25876
672	Kjøp av tjenester til løpende driftsoppgaver, IKT	IKT	2256,6	0,010	23367
673	Kjøp av tjenester til organisasjonsutvikling, rekruttering mv.	Prof. tjenester	278,5	0,006	1804
674	Innleid personell fra vikarbyrå o.l.	Prof. tjenester	298,4	0,008	2276
678	Kjøp av andre fremmede tjenester	Prof. tjenester	3934,3	0,017	65834
679	(Kjøp av andre fremmede tjenester - Tas i bruk ved behov)	Prof. tjenester	13399,5	0,017	224220
680	Kontorrekvisita	Drift	240,6	0,046	11184
682	Trykksak	Kommunikasjon	167,0	0,032	5266
683	Annonser, kunngjøringer	Kommunikasjon	166,1	0,019	3239
684	Aviser, tidsskrifter, bøker o.l.	Kompetanse	188,6	0,012	2351
685	Aviser, tidsskrifter, bøker o.l. i bibliotek	Kompetanse	26,8	0,012	334
686	Møter	Kommunikasjon	423,5	0,047	20013
687	Kurs og seminarer for egne ansatte	Kompetanse	596,4	0,033	19538
688	Kurs og seminarer for eksterne deltakere	Kommunikasjon	265,0	0,033	8680
689	Annen kontorkostnad	Drift	198,9	0,031	6245
690	Telefoni og datakommunikasjon, samband, internett	IKT	984,0	0,013	12409
694	Porto	Drift	636,9	0,020	12483
700	Drivstoff	Transport	129,8	0,250	32445
702	Vedlikehold	Transport	130,6	0,028	3641
704	Forsikring	Transport	18,9	0,007	136
709	Annen kostnad transportmidler	Transport	29,4	0,037	1081
710	Bilgodtgjørelse	Transport	278,6	0,079	22074
713	Reisekostnad	Transport	2078,9	0,117	242685
714	(Reisekostnad - Tas i bruk ved behov for ytterligere underkontoer)	Transport	67,7	0,117	7901
715	Diettkostnad	Transport	492,3	0,057	28163
716	(Diettkostnad - Tas i bruk ved behov for ytterligere underkontoer)	Transport	12,5	0,057	714
719	Annen kostnadsgodtgjørelse	Transport	6,4	0,080	510
730	Salgskostnad	Kommunikasjon	8,8	0,015	129
732	Reklamekostnad	Kommunikasjon	152,2	0,019	2968
735	Representasjon	Kommunikasjon	96,6	0,010	952
740	Kontingent	Personal	720,3	0,016	11822
741	Gave	Kommunikasjon	14,7	0,027	390
750	Forsikringspremie	Drift	23,4	0,007	168
756	Servicekostnad	Drift	5,4	0,025	134
760	Lisensavgift og royalties (ikke programvarelisenser, jf. 642)	Drift	57,0	0,014	775
761	Patentkostnad ved egen patent	Prof. tjenester	0,1	0,017	2
762	Kostnad ved varemerke og lignende	Drift	0,0	0,018	0
771	Styremøter	Drift	0,6	0,024	14
775	Eiendoms- og festeavgift	Bygg, anlegg og eiendom	17,1	0,013	231
777	Bank- og kortgebyr	Drift	59,5	0,006	385
779	Annen kostnad	Diverse	4561,7	0,017	76085

Table 4: CF intensities all procurement codes

5.2 Appendix 2: Carbon Footprint of the different ministries

Tall i kilotonn CO2 ekv.	**Bygg, anlegg og eiendom**	**Diverse**	**Drift**	**IKT**	**Kommunika-sjon**	**Kompetanse**	**Personal**	**Prof. tjenester**	**Transport og reise**	**SUM**
Arbeids- og sosialdepartementet	32	1	20	14	6	1	3	20	22	119
Barne-, likestillings- og inkluderingsdep.	12	0	4	3	3	1	1	45	14	83
Finansdepartementet	33	4	7	14	2	3	4	6	30	104
Forsvarsdepartementet	65	0	2	3	1	7	1	2	8	88
Helse- og omsorgsdepartementet	14	2	3	8	4	1	2	7	12	53
Justis- og beredskapsdepartementet	98	6	15	24	5	5	7	101	115	375
Klima- og miljødepartementet	4	0	2	1	1	5	1	14	12	40
Kommunal- og moderniseringsdep.	56	0	5	8	4	2	4	6	15	101
Kulturdepartementet	9	0	2	2	2	1	1	3	13	33
Kunnskapsdepartementet	7	0	1	4	4	1	1	6	10	34
Landbruks- og matdepartementet	3	0	1	2	0	0	1	3	6	17
Nærings- og fiskeridepartementet	18	1	2	5	1	1	9	3	27	67
Olje- og energidepartementet	8	0	1	1	1	0	1	4	7	23
Samferdselsdepartementet	845	68	29	20	6	3	-5	71	94	1130
Utenriksdepartementet	25	62	3	3	2	1	2	5	22	126
Ymse utgifter	0	0	0	0	0	0	0	0	0	0
SUM	1229	146	97	113	42	33	32	295	407	2393

Table 5: Carbon Footprint of the different ministries

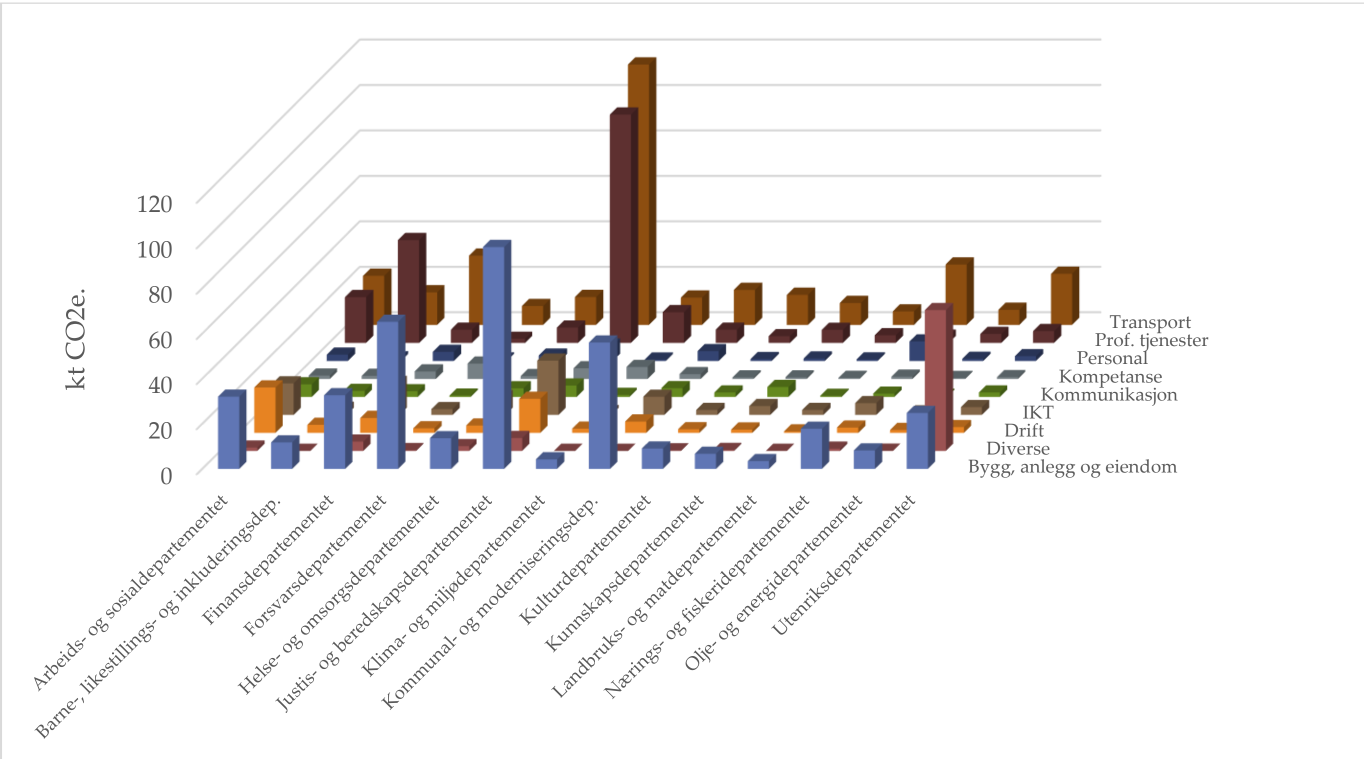

Figure 7: Illustration of the CF of the different ministries

5.3 Appendix 3: EU public procurement directives and Interaction with EU ETS

Three new EU public procurement directives

More than 250 000 public authorities in the EU spend around 14 % of GDP on the purchase of services, works and supplies. In many sectors public authorities are the principal buyers. EU law sets out minimum harmonised public procurement rules, which organise the way public authorities and certain public utility operators purchase goods, works and services. Non EU members of the EEA (the three EEA EFTA states), Iceland, Liechtenstein and Norway, have agreed to enact legislation similar to that passed in the EU in the areas of social policy, consumer protection, environment, company law and statistics. Therefore, these three new EU public procurement directives are of direct relevance for public procurements in Norway:

- Directive 2014/24/EU on public procurement
- Directive 2014/25/EU on procurement by entities operating in the water, energy, transport and postal services sectors
- Directive 2014/23/EU on the award of concession contracts

The new Directives were adopted by the European Parliament and the Council of the European Union on 26 February 2014, and 18 April 2016 was the date by which EU countries must have put in place national legislation conforming to the directives. One of the common premises for all the three directives when they were adopted, was that:

> *"..with a view to the better integration of social and environmental considerations in the award procedures, contracting authorities or contracting entities should be allowed to use award criteria or performance conditions relating to the works, supplies or services to be provided under the contract in any respect and at any stage of their life cycles from extraction of raw materials for the product to the stage of disposal of the product, including factors involved in the specific process of production, provision or trading of those works (etc, etc) or a specific process during a later stage of their life cycle, even where such factors do not form part of their material substance."*

In terms of Green Public Procurement, the Commission points out that the following sections of the directives are worth drawing attention to:

- Defining the requirements of a contract: Defining technical specifications is guided through Article 42 and Annex VII of Directive 2014/24/EU; and Article 60 and Annex VIII of Directive 2014/25/EU.
- Use of labels: Conditions for using labels are laid out in Article 43 of Directive 2014/24/EU; and Article 61 of Directive 2014/25/EU.
- Lowest price award and life-cycle costing (LCC): Awarding public contracts on the basis of the most economically advantageous tender is provided as part of Article 67 of Directive 2014/24/EU; and Article 82 of Directive 2014/25/EU.

- Innovation partnerships: Where a contracting authority wishes to purchase goods or services, which are not currently available on the market, it may establish an innovation partnership with one or more partners. This allows for the research and development (R&D), piloting and subsequent purchase of a new product, service or work, by establishing a structured partnership. The procedure for establishing an innovation partnership is set out in Article 31 of Directive 2014/24/EU.
- Consulting the market: The procurement directives specifically allow for preliminary market consultation with suppliers in order to get advice, which may be used in the preparation of the procedure. Article 40 of Directive 2014/24/EU.

Thus, the new directives can be instrumental[16] in the transition towards products and services that contributes significantly to reduced negative consequences for climate and the environment.

Interaction with other policy measures and instruments

When interpreting the impact of carbon intensities used as a climate policy tool in public procurement, there are several considerations to keep in mind, among these the possible interactions with other policy measures, especially the EU Emissions Trading System (EU ETS). Within EU ETS a cap is set on the total amount of certain greenhouse gases that can be emitted by installations covered by the system. Emission reductions related to specific measures within the system are difficult to quantify, since they will be "offset" by increases elsewhere in the system. However, they may influence carbon prices and the pace by which future caps are reduced. Sectors included in the system are oil and gas, energy, (manufacturing) industries and aviation. For other sectors and emissions, agreements with and within EU are aligned to reduce total emissions with 30 per cent in 2030 compared to 2005, but the national obligations are not yet set.[17] In further developments of the carbon footprint method as a climate policy tool in public procurement, it might be useful to distinguish between emissions included in EU ETS and emissions who are not.

[16] Norwegian public procurement law also facilitates for these options.

[17] https://www.regjeringen.no/no/aktuelt/ny-klimaforpliktelse-for-norge/id2394737/

5.4 Appendix 4: Consumption based accounting

Emissions accounting can be based either on a so-called production perspective, or a consumption perspective. The difference lies in how emissions are allocated across actors in the value chain. Under a production perspective, emissions are simply allocated to the entity (company, region, etc.) that physically emits the gases. In contrast, a consumption perspective allocates all emissions required to deliver a final demand, to the end consumer. There are also other, in-between methods for emissions allocation, such as allocation based on value added shares, or shared producer and consumer perspective (Manfred Lenzen, Murray, Sack, & Wiedmann, 2007).

For this study, the purpose has been to derive emission metrics useful for calculating the (consumption based) carbon footprint of state entities, and the following sections will explain the methodology in more detail.

The public sector delivers services to the population of Norway. It has a relatively low share of national direct emissions, but a high share of the economic activity. This is mainly because the services produced are labour intensive (like health care) and based on inputs from other sectors, such as infrastructure production and service inputs. Figure 8 shows the public share of total emissions as well as the share of total production value. The 0,8% share of emissions contrasts the 17% share of production value.

It can be expected that the majority of consumption based emissions related to the public sector is connected to indirect emissions occurring in other sectors that provide the materials and services required in public service provision.

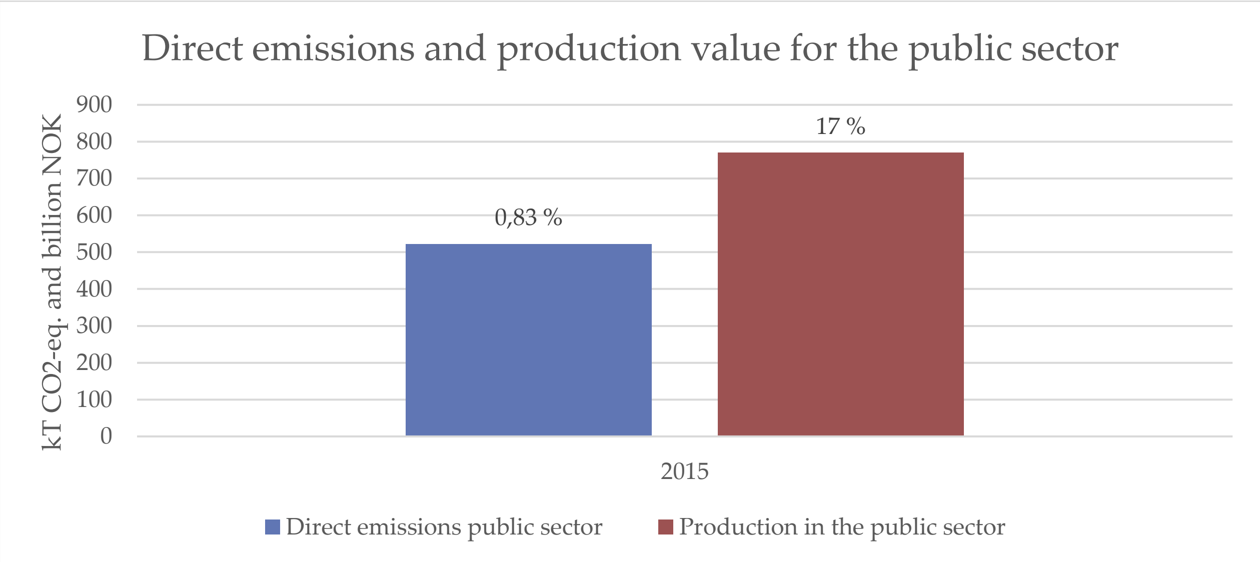

Figure 8: Direct emissions and production in the public sector. Numbers in kT CO2-eq. and billion NOK. Percent values on top of the bars indicate share of total national emissions and share of total national production value. Source: Statistics Norway.

There are two main approaches for consumption based emissions accounting; process based life cycle assessment (LCA), and environmentally extended input-output analysis (EE-IOA).

Process based LCA

Process based LCA has its roots in the late 60'ies and is the method normally referred to by the term "LCA". LCA is the assessment of environmental impact throughout the life-cycle of product systems. The cornerstone to the life-cycle approach is the understanding that environmental impacts are not restricted to specific locations or single processes, but rather are consequences of the life-cycle design of products and services. The product life-cycle covers all processes from extraction of raw material, production, use, and final treatment or reuse (Baumann & Tillman, 2004). The combination of a quantitative approach and a holistic perspective leads to trade-offs being clearly demonstrated in LCA results. It is a systems tool well-suited for environmental decision making. Having been referred to by many names through its development, LCA has, in the last four decades, evolved from the idea of cumulative resource requirements into a scientific field that includes emission inventory assessment methods (Heijungs & Suh, 2002) and environmental cause-consequence modeling (de Haes et al., 2002).

The LCA methodology has been standardized step by step. The SETAC working groups[18] and other institutions have been vital in this process. The development of international standards has been an important driver for defining the methods of LCA. The first set of standards were published by the International Organization for Standardization in 1997, with a revised version complete in 2006 (ISO, 2006). For a more thorough description of the historical development of LCA, see Ayres (Ayres, 1995) and Baumann and Tillman (Baumann & Tillman, 2004).

Process-based LCA is a bottom-up method, requiring input and emission data to be collected for all processes involved in the supply network required to deliver some pre-defined function of product. Since this task would be overwhelming to repeat every time one conducts an LCA, databases have been developed that contains generic data for common processes that can be used to model the background parts of the production system under study. The Ecoinvent database[19] is the most comprehensive database available within the field.

LCA is labour and data intensive, but offers detailed insight into the footprint of different products, choices or development scenarios. On the other hand it has a systematic cut-off in that it often overlooks the importance of service inputs. Some authors report that up to 50% of the footprint may be ignored by applying process based LCA to products from certain sectors (M Lenzen, 2001). EE-IOA offers more completeness at the expense of specificity.

EE-IOA

Input-output analysis (IOA) was initially developed by Leontief (W. Leontief, 1936) as a method to study the interrelations between the sectors in an economy. In the beginning of the seventies, he formulated a framework to extend the analysis with environmental information (W. W. Leontief, 1970). The basis of this analysis is to use information contained in national economic statistics, in

[18] http://www.setac.org/

[19] www.ecoinvent.com

combination with data on emissions from the various sectors in the economy, to calculate all of the direct and indirect emissions occurring from an arbitrary final demand placed upon the system.

The economic activity induced by spending 1 NOK on, for example, gasoline, may be calculated and traced through all of the interconnected sectors of the economy in an infinite, yet converging, series of demands between the sectors. Once the economic outputs required to support the production of this 1 NOK purchase of gasoline have been calculated, the resulting vector of economic activity in each sector may then be multiplied with emissions intensities for each sector to give the total (life cycle) emissions occurring in the production of 1 NOK worth of gasoline.

Recent developments are numerous: on multi-regionality (Hertwich & Peters, 2009; M Lenzen, Wood, & Wiedmann, 2010; G P Peters & Hertwich, 2008), hybridization (Nakamura & Kondo, 2002; Strømman & Solli, 2008; Suh et al., 2004; Treloar, 1997) and sub-national levels (Hogne N. Larsen & Hertwich, 2009; H. N. Larsen, Pettersen, Solli, & Hertwich, 2013; Manfred Lenzen et al., 2007; Manfred Lenzen & Peters, 2010; Wiedmann, Lenzen, & Barrett, 2009), A thorough overview of the different IOA applications to environmental analysis is provided by (Minx et al., 2009).

There is a large body of literature concerning emissions embodied in trade, and several multiregional models have been developed and are available to various degrees. These include the GTAP MRIOA model (R. M. Andrew & Peters, 2013), the EORA[20] model (Manfred Lenzen, Kanemoto, Moran, & Geschke, 2012; Manfred Lenzen, Moran, Kanemoto, & Geschke, 2013), the OECD tables[21] and the Exiobase[22] (Tukker et al., 2013; Wood et al., 2014). These models include a large number of countries, as well as a varying degree of sectorial aggregation.

Compared to LCA, EE-IOA is usually much less data intensive to use (once the underlying emissions model has been constructed), and includes all types of economic activity, including service inputs. It therefore offers more complete footprints with less effort. However, EE-IOA is less able to capture product specific changes in emissions due to very specific actions, and to give detailed advice on which types of goods that are more climate friendly compared to alternatives. For instance, EE-IOA can tell us how important food as a consumption category is, but in order to find out if we should consume apples or pears, more specific analyses such as LCA are required.

The strengths from both process based LCA and EE-IOA can also be combined in various hybrid frameworks (Strømman & Solli, 2008; Strømman, Solli, & Hertwich, 2006).

20 http://www.worldmrio.com/

21 http://www.oecd.org/sti/ind/input-outputtablesedition2015accesstodata.htm

22 http://www.exiobase.eu/

5.5 Appendix 5: The Klimakost model

The model used for the calculation of the state footprint in this study is based on the Klimakost[23] method previously developed by MiSA, now Asplan Viak. Klimakost uses the economic accounts of an organization to estimate its carbon footprint. The structure of the carbon footprint will hence follow the available economic reporting structure in the organization. The underlying emissions model in Klimakost is primarily an environmentally extended input-output model, with some modifications introduced in areas of particular interest or importance, and/or areas with better information available than the economic accounts of an entity.

Computational structure

We will give a short description of the computational framework for calculating emissions based on a given final demand, using an EE-IOA model. We start by defining our system of production processes, economic sectors, or both (in hybrid analyses) as a matrix Z, containing the flows of energy, materials, money etc. between the different entities (from now on referred to as "industries").

$$\boldsymbol{Z} = \begin{pmatrix} \boldsymbol{z}_{11} & \cdots & \boldsymbol{z}_{1j} \\ \vdots & \ddots & \vdots \\ \boldsymbol{z}_{i1} & \cdots & \boldsymbol{z}_{ij} \end{pmatrix}, \quad \boldsymbol{x} = \begin{pmatrix} \boldsymbol{x}_1 \\ \vdots \\ \boldsymbol{x}_i \end{pmatrix}$$

Each element z_{ij} of the matrix denotes the flow of the product from industry i into the production of output from industry j. In addition, we have information on the total output from the system, x. If the total output from each industry is described by the vector x, a normalized system may be constructed by dividing each column in Z by the corresponding total outputs:

$$A = Z\hat{x}^{-1}$$

We then can define a final demand by the vector:

$$y = \begin{pmatrix} y_1 \\ \vdots \\ y_i \end{pmatrix}$$

Setting up a balance we know that the total output of the individual industries subtracted the amounts consumed by themselves, should equal the final demand y.

$$\overbrace{x}^{total\ output} - \overbrace{Ax}^{consumed\ by\ industries} = \overbrace{y}^{final\ demand}$$

The total output x from each industry needed to fulfill the final demand, in addition to all the intermediate demand from other industries, can then be calculated by

$$x = \overbrace{(I-A)^{-1}}^{Leontief\ inverse}\ y$$

The Leontief inverse, L, is a matrix describing multipliers for all industries in the system, so that a column j in L gives the total direct *and indirect* outputs in all other industries in order to deliver a unit

[23] www.klimakost.no

final demand from j. Similarly, emissions can be treated the same way where the matrix S is total emissions and where an element s_{kj} contains the emissions of substance k from industry j.

$$S = \begin{pmatrix} s_{11} & \cdots & s_{1j} \\ \vdots & \ddots & \vdots \\ s_{k1} & \cdots & s_{kj} \end{pmatrix} \rightarrow F = S\hat{x}^{-1}$$

Normalization by dividing of total node output (x) gives a matrix F of emission intensities per unit output from each industry. The total emissions, e, occurring due to an arbitrary final demand from the industries can now be calculated by:

$$e = Fx = F(I - A)^{-1}y$$

Model construction

For the purpose of this assessment the pure EE-IOA-model has been modified with an option to choose electricity mix at two levels (direct input to the state entities and electricity in the domestic background), as well as an expansion enabling estimation of direct emissions, by estimating direct emissions from combustion of fuel from data on fuel purchases.

The underlying basis of the model is the 64 industry[24] domestic input-output table as published by Statistics Norway[25], as well as emissions of greenhouse gases by industry as reported to Eurostat[26]. We have used to most recent data for Norway, which is 2014 for the Z-matrix and 2013 for emissions. A large number of adjustments and adaptations are made in order to create an A-matrix (previous section) suitable for the purpose of this assessment, as well as deriving a conversion path from the economic accounts data, to a final demand vector y (also previous section) expressed in the same classification as the A-matrix.

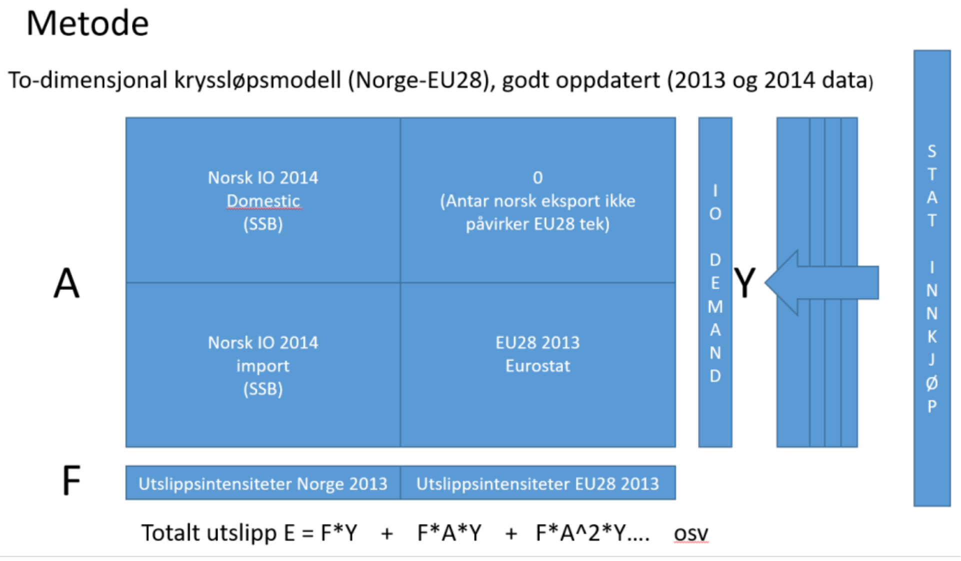

Figure 9: Overview of the model used in this project

[24] Using the 2-digit NACE rev.2 classification: http://ec.europa.eu/eurostat/web/nace-rev2
[25] https://www.ssb.no/en/nasjonalregnskap-og-konjunkturer/tables/supply-and-use-and-input-output
[26] http://ec.europa.eu/eurostat/data/database

Imports

Although multi-regional models exist and have been made available to the public, we have chosen to treat imports in a simplified manner, where we assume all imports to domestic final demand or industries, is produced by the average EU technology. The input-output matrix for EU28 (base year 2013) has been downloaded from Eurostat, as well as sectorial emissions. The imports to industries are reported in a separate Z-matrix from Statistics Norway.

One of the reasons for this approach is that available multiregional models are quite old (Exiobase 2 has base year 2007), as well as being large and potentially more complex to work with. In addition, there is no information in the state accounts of the country origin of the purchases. Better regional coverage would therefore not be as useful as if this information was logged. There are plans of making more updated multi-regional models available (Exiobase 3), so later developments may explore the use of such models. If we compare the results of our model to the national totals from multi-regional models, our approach seems to slightly underestimate emissions from imports.

The EU28 emissions model is combined with the domestic model via the Z-matrix for imports to form a model for Norway with imports. For imports to final demand a splitting has been made. The import share of the final demand has been estimated by summing the purchases of the three major public sectors and using the average domestic/import shares from these sectors as a proxy for the import shares of state purchases. The import split vector is included in the excel appendix. Some purchases are almost exclusively done domestically, such as trade services, sewage and construction, while others are mainly imported, such as for instance computers, textiles and furniture.

Capital

Capital is treated in two different ways. For capital investments *done by the state entities*, the emissions are counted when the investment occurs (i.e. not smeared out by depreciation). For the use of capital equipment *in the industries in the background economy*, the consumption of fixed capital (from the input-output table) has been added to the interindustry requirements matrix (Z). This makes sure that emissions from replacing wear and tear of equipment and buildings used for producing goods and services to support the state final demand, is included in our estimates. In lack of better information, the *structure* of the consumption of fixed capital has been assumed to be identical to the structure of the total capital formation (from the input-output table) for the base year.

Price adjustments

The accounts data are from 2015 while the base year of the emissions model is 2014 for the domestic economy and 2013 for the import part of the model. Prices therefore need to be adjusted to the base year in the emission model. This is done by using the relevant price index on a product category level, published by Statistics Norway[27]. Price adjustment data used is included in the excel appendix.

[27] https://www.ssb.no/priser-og-prisindekser/nokkeltall/priser-og-prisindekser-oversiktstabeller

Taxes, trade- and transport margins (TTM)

For every NOK logged as spent within a cost item category in the state accounts (in *purchaser prices*), a certain share goes to cover taxes and trade- and transport margins. After subtracting these items, the remaining NOK is in *basic prices*, corresponding to the valuation used in the underlying emissions model.

Taxes are just removed, without any emissions associated. Trade and transport margins however, are redistributed to the trade and transport sectors. The TTM shares that are used are included in the excel appendix, as well as the mix of trade and transport sectors matched up with the use of trade and transport margins. An example: For every NOK spent on bread, eventual taxes on bread are removed. A fraction of the remainder is purchased from (a mix of) the trade and transport sectors. The remainder is finally purchased from the sector "bread" is matched with (next section), which in this case is the food production sector.

Matching

One of the key elements in using EE-IOA for calculation of the carbon footprint of an organization, is to construct a matching between the accounting system and the NACE classification used in the national accounts. Basically this procedure is to come from the account data used in the state institutions' accounting system, to a final demand vector y that can be fed into the emissions model.

The accounting system has its own categorization of cost items (see excel appendix). The procedure of matching these categories to the categories in the emissions model, is done by a somewhat eclectic procedure. Initially the names of the cost items are mapped to one or more of the industry classification categories in the NACE classification. For cost items with names that are hard to interpret, additional investigations have been made to find out what type of expenses are actually categorized under the cost item. Finally, a balancing action has been performed in order to ensure that when applying the matching to all state accounts, the resulting final demand vector in NACE classification mimics the totals given in the national accounts. The resulting matching matrix is included in the excel appendix. The matching matrix is constructed on a basic price level, so preceding the matching of cost items to sectors, price adjustments and corrections for taxes, trade- and transport margins have to be done.

Uncertainties, strengths and weaknesses with the approach

The method used in this assessment is strong in that it offers a doable way of estimating the total footprint of state activities, and break this down on organizations and cost items. It also covers all indirect emissions, without the cut-offs commonly associated with bottom-up approaches (M Lenzen, 2001).

However, the ease and simplicity of the approach comes with a cost. Since the information contained in the accounts- and the corresponding sector aggregation in the emission model, is quite coarse, the method is less able to assess the consequence of actions taken to reduce the footprint, and provide more insight into the largest contributing items *within* a cost category. For this type of use other more detailed, bottom up models need to be developed.

The strengths and weaknesses are thus connected to the intended use of the information and the necessary precision.

A few uncertainties related to the technical construction of the underlying emissions model should be mentioned:

- Uncertainty in the input-output model (possible errors in national statistics for emissions and sector interdependence)
- Uncertainty in the price adjustments (basic prices and yearly adjustments) and redistribution of trade-and transport margins
- Uncertainty in the capital goods consumption of the industries
- Uncertainties due to the highly aggregated sector level in the underlying model
- Uncertainties due to the simplified import assumption (import to production sectors)

The overall uncertainties related to the underlying emissions model/ methodology has, by other authors, see for instance the recently published study on environmental footprint of the Nordic countries (Glen P. Peters et al., 2016) been discussed in the context of using the information for national footprint calculations. The general evaluation is that for this purpose these uncertainties are not so large, but that some uncertainty aspects may have been systematically underestimated in previous studies.

The aspect of regional aggregation has been discussed in the literature (R. Andrew, Peters, & Lennox, 2009; Su & Ang, 2010). However, whether or not the regional aggregation is a problem or not, is mainly connected to the intended use of the analyses. If the intended purpose is to highlight the importance of international trade patterns, regional aggregation may cause issues. If the focus is to find out which product groups are associated with emissions, a high level of regional aggregation may not pose a big problem. The approach used here, with imports assumed to be represented by an EU28 proxy answers the latter question fairly well, while giving an estimate of total emission shares that can be expected to occur abroad, due to Norwegian state activity.

For sectoral aggregation this is also a commonly debated issue (Su, Huang, Ang, & Zhou, 2010) and again the issue connected to this is the intended use of the model. Some input-output models have a large number of sectors (such as the 500 sector US input-output table published every 5 yrs), while others, such as the one used in this analysis, are simpler and include ~34-190 sectors. LCA-databases on the other hand, contain data for several thousand processes. Since our purpose has been to use a model in combination with the accounts data of the state entities, the sector aggregation is not a major problem. The coarse categorization that the cost items in the state accounts represent, actually fits quite well with the granularity available in the IO-based emissions model. Improved sector aggregation would not provide any improvement, but could offer more options in refinement of the method.

For the application in this study the uncertainties in the underlying emissions model may not pose a large problem, since the applied method still estimates footprints with a rough degree of precision that allows us to say something useful about which state entities, and which activities and purchases, that cause the largest contribution to the footprint. Further use of the model for other purposes, may however be limited without adding more specificity and detail.

There are some uncertainties that are not related to the underlying emissions model, but relate to the available input data used as a basis for the calculations. This includes:

- Uncertainties in the cost classification scheme in the state accounting system and how well this differentiates the different products and services the state purchases.
- Uncertainty toward how the accounting classification system is used in practice across the different state entities
- Uncertainties caused by the aggregation of cost items and the matching of these to the emissions model
- Uncertainty connected to varying practices in accounting book-keeping at the state level
- The simplified treatment of imports (import share of consumption basket of the state entities)

The uncertainties introduced due to differences in the use of the cost item code in the state accounts are not very well understood at the time of this analysis. Dialogue and discussions with procurements- and accounting personnel may help identify how large this problem may be. As mentioned above, the granularity and categories in the cost classification actually fits quite well with the corresponding NACE-classification in the emissions model. There are some exceptions, especially connected to purchasing of construction services.

For the use of identifying the largest footprint contributors, the uncertainty in the import treatment does not pose a large problem. The absolute figures may be slightly different to those of a full MRIO-model, since using the EU28 as a proxy for the weighted average of all imports may underestimate total emissions. Differences could be larger for certain product groups that to a large degree are imported from either a very clean or dirty region.

Possible developments and improvements

Further development of the footprint methodology depends on which direction one wants to go in terms of using the information. For national policy discussions, one could argue that improved coverage of imports with a better country resolution could prove useful. There are plans to publish a publicly available multi-region model with good sector- and country resolution (Exiobase 3) and very recent base years, but it is not yet clear when this will happen.

If the intention is to go in the direction of using the information to inform green public procurement strategies and/or to be used in environmental management as a tool to evaluate the effect of specific improvement actions, other developments could be more useful. In particular, this relates to the hybridization of the model to accommodate more detailed information on certain (important) areas, such as for instance energy, fuels, transport and construction materials. The available information used as data input must then be improved with similar detail. This means that the footprint cannot rely on the economic accounts alone, or at least that the account categories need refinement and specification on the most important areas. The use of results from such a refined model in environmental management, green procurement org to evaluate the effect of concrete actions could prove feasible.

Another way of utilizing the "big data" power of using economic account data for footprint calculations could be to collect information on a supplier level (if this exists in the accounts). Several automated, or semi-automated methods could then be applied to provide both the possibility of getting more precise matching data (based on the supplier sector classification) and for calculating the footprint on a supplier level, enabling the state entities to address its largest contributors to the footprint directly.

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