Climate intensities of public procurements

Quantification of life cycle emissions from public procurements in Norway

Direktoratet for forvaltning og økonomistyring (DFØ)

(The Norwegian Agency for Public and Financial Management)

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Summary

The public sector has a central role in the green shift, and it is crucial that the public sector reduces its carbon footprint. Green procurements are an important tool for reducing the footprint. In order for the public institutions to be able to get an overview of their purchase related emissions and identify important emission drivers, and in this way be enabled to implement efficient measures and targeted procurements, there is a need for data on the emissions associated with the various purchasing categories. The Norwegian Agency for Public and Financial Management (DFØ) therefore requested NIRAS, in cooperation with Richard Wood and Menon Economics, to create tables with climate intensity data for all relevant three-digit GL accounts used in the state public accounts.

The climate intensity tables have been prepared using a *coupled* model, where data from Norwegian input-output tables and emission statistics are used to calculate emissions associated with purchases from domestic production, while the acknowledged environmentally extended input-output database EXIOBASE has been used to calculate emissions associated with imports. This approach ensures higher quality results than if only EXIOBASE had been used, while the use of EXIOBASE ensures a high degree of coverage throughout the value chains. The calculation model has been prepared using Excel and MATLAB.

The results, presented in tables with climate intensities for the various general ledger accounts, are split according to which emissions in the value chain occur in Norway and the rest of the world, respectively. The results are also distributed to the three Scopes, i.e. (1) direct emissions, (2) indirect emissions associated with electricity and district heating and (3) all other (upstream) indirect emissions. The results show that the most emission-intensive purchase categories are *621: Gas* ("Gass"), *629: Other fuels* ("Annet brensel"), *625: Petrol, diesel* ("Bensin, diesel") and *700: Fuel* ("Drivstoff"), with climate intensities of 415, 299, 239 and 239 tonnes carbon dioxide equivalents per million Norwegian kroner, respectively. Transparency with regard to data sources and methodological choices is emphasised in the project to ensure verifiability and facilitate regular updates of climate intensities. The possibility to update the model using limited resources is important, as changes in factors due to climate policies and rapid technological changes are expected in the coming years.

Norsk sammendrag

Det offentlige har en sentral rolle i det grønne skiftet, og det er avgjørende at offentlig sektor reduserer sitt karbonfotavtrykk. Et viktig virkemiddel for å redusere fotavtrykket er grønne anskaffelser. For at de offentlige virksomhetene skal kunne få oversikt over sine innkjøpsrelaterte utslipp og identifisere store utslippsdrivere, og på den måten settes i stand til å iverksette effektfulle tiltak og målrettede anskaffelser, er det behov for data om utslippene forbundet med de ulike innkjøpskategoriene. Som et viktig verktøy har NIRAS for Direktoratet for forvaltning og økonomistyring (DFØ) utarbeidet tabeller med klimaintensitetsdata for alle relevante tresifrede artskontoer som brukes i statsregnskapet.

Klimaintensitetstabellene er utarbeidet ved å benytte en *koblet* modell, der data fra norske kryssløpstabeller og utslippsstatistikk brukes til å beregne utslipp forbundet med kjøp fra innenlandsk produksjon, mens den internasjonalt anerkjente miljøutvidede kryssløpsdatabasen EXIOBASE beregner utslipp forbundet med import. Denne fremgangsmåten sikrer resultater med høy kvalitet for norske utslippskilder, og EXIOBASE sikrer høy dekningsgrad gjennom verdikjedene. Beregningsmodellen er utarbeidet ved bruk av Excel og MATLAB.

Resultatene, i form av tabeller med klimaintensiteter for de ulike artskontoene, er inndelt etter hvilke utslipp i verdikjeden som skjer i henholdsvis Norge og resten av verden, samt fordelt på de tre *Scopene*, det vil si (1) direkte utslipp, (2) indirekte utslipp forbundet med elektrisitet og fjernvarme og (3) alle andre (oppstrøms) indirekte utslipp. Resultatene viser at de tre mest utslippsintensive innkjøpskategoriene er *621: Gass*, *629: Annet brensel*, *625: Bensin, diesel* og *700: Drivstoff*, med klimaintensiteter på henholdsvis 415, 299, 239 og 239 tonn karbondioksidekvivalenter per million kroner. Transparens med hensyn til datagrunnlag og metodiske valg er i stor grad vektlagt i prosjektet for å sikre etterprøvbarhet og muligheten til jevnlige oppdateringer av klimaintensitetene. Muligheten for å oppdatere modellen med enkle ressurser er viktig, da det fremover forventes endringer i faktorer som følge av klimapolitikk og raske teknologiske endringer.

Contents

List of figures

List of tables

Abbreviations, acronyms and definitions

CF	Carbon Footprint. Total greenhouse gas emissions caused by an entity.
CH_4	Methane. A greenhouse gas.
CO_2	Carbon dioxide. A greenhouse gas.
CO_2e	Carbon dioxide equivalents. Common unit used for summing global warming contributions of all GHGs. The conversion is done using GWP100 factors from the latest IPCC assessment report (AR5).
DEFRA	Department for Environment, Food & Rural Affairs. British department that publish yearly emission factors for fuels, among other things.
DFØ	The Norwegian Agency for Public and Financial Management *(Direktoratet for forvaltning og økonomistyring* in Norwegian).
EE-IOA(T/A)	Environmentally Extended Input-Output (Table/Analysis). Top-down macroeconomic and quantitative table/analysis method with basis in the interdependencies between sectors and supply and use of goods and services within an economy, extended with environmental data.
EXIOBASE	EXIOBASE is a highly acknowledged global EE-MRIO database. The tables include 44 countries and 5 "rest-of-the-world" regions, and offer a great level of detail with 163 sectors and the GHGs CO_2, CH_4, N_2O, SF_6, HFCs and PFCs.
EE-MRIO(T/A)	Environmentally Extended Multiregional Input-Output (Table/Analysis). Top-down macroeconomic and quantitative table/analysis method with basis in the interdependencies between sectors and supply and use of goods and services within a multi-regional economy, extended with environmental data.
GHG	Greenhouse gas. Gas contributing to global warming.
GL	General Ledger. Set of numbered accounts to systemise e.g. incomes, expenses and assets.
HFCs	Hydrofluorocarbons. Group of greenhouse gases.
IO(T/A)	Input-Output (Table/Analysis). Top-down macroeconomic and quantitative table/analysis method with basis in the interdependencies between sectors and supply and use of goods and services within an economy.
kg	Kilograms. Unit of weight.
LCA	Life Cycle Assessment. Bottom up environmental impact assessment method taking into account emissions in all steps of the value chain of the product or system being analysed.

MNOK	Million NOK.
MRIO	Multi-regional input-output.
N_2O	Nitrous oxide. A greenhouse gas.
NACE	Statistical Classification of Economic Activities in the European Community (from French "Nomenclature statistique des activités économiques dans la Communauté européenne"). Standard industry classification system used in the EU.
NO	Norway.
NOK	Norwegian Kroner. Monetary unit of Norway.
PFCs	Perfluorinated compounds. Group of greenhouse gases.
RoW	Rest of World.
SF_6	Sulfur hexafluoride. A greenhouse gas.
SSB	Statistics Norway (*Statistisk sentralbyrå)*. The Norwegian statistics bureau.
t	Tonnes. Unit of weight, corresponding to 1000 kg. Also known as metric ton.

1 Introduction

1.1 Background

There is an increasing focus on the carbon footprint (CF) of the public sector in Norway, i.e. the total greenhouse gas (GHG) emissions they are contributing to. The Norwegian Government highlights more green public procurements as a crucial instrument to reduce the footprint and stimulate the green market. The Norwegian Agency for Public and Financial Management (DFØ) plays an important role in the work to escalate the use of green procurement strategies, as highlighted in the recently published "Action plan for increased share of climate- and environment-friendly public procurements and green innovation" (Direktoratet for forvaltning og økonomistyring, 2021). DFØ's responsibilities include providing knowledge, tools and other means to assist public authorities in assessments of the climate impacts of their procurements and to facilitate the implementation of efficient climate mitigation measures.

As part of this work, DFØ and procuring agencies need good data sets on the life cycle emissions associated with public procurements. The climate impacts should be quantified per spent monetary unit (NOK) in different purchase categories – so called climate intensities. The climate intensities currently used are outdated and lack transparency. DFØ has therefore requested an update so that the datasets better represent the current situation and thus are suitable for use in decision-making related to climate measures. NIRAS, with subconsultants Richard Wood and Menon Economics, were assigned the task of developing the updated climate intensity tables for DFØ.

1.2 Aim and scope of the project

The aim of the project is to develop robust, updated and representative climate intensity tables for all relevant purchase categories as defined in the standard chart of accounts ("standard kontoplan"). A key aspect of DFØ's needs is transparency regarding databases and methods, to ensure verifiable results. This implies that the calculations are based on publicly available data as far as possible. The project deliverables include (a) climate intensity tables (Appendix A and Appendix B), (b) a report including thorough method descriptions (this report, Appendix C and Appendix D), code used for calculations (Appendix E) and guidance to the code (Appendix F) and (c) a workshop with DFØ for transfer of competence.

The climate intensities cover emissions in the whole value chain of the procurements, excluding downstream emissions related to the end-of-life of the purchased goods in following years. Emissions associated with the purchase of waste treatment services in a given year are however accounted for. The intensities include emissions of the most important GHGs. Emissions from land use, land use change and forestry (LULUCF) and biogenic CO_2 are not included, due to the many ongoing discussions regarding the magnitude of the releases at global level (low data availability) and the extent of the potential global warming effect (carbon neutrality or not). As such, these emissions are excluded from the present project in order for the emission intensities to be developed based on robust data.

1.3 Previous work

Carbon footprints can be calculated using different methodologies, and a range of models and guidances on how to do it have been developed. Which method is the most suitable will depend on the subject of the CF analysis (a country, organization, business, project or product) and the purpose of the work. For organizational CFs, methodical standards and guidelines include the GHG Protocol (Greenhouse Gas Protocol, n.d.), several ISO standards (ISO 14064, ISO 14067), *Guidance on Organizational Life Cycle Assessment* from Life Cycle Initiative (Blanco, Finkbeiner, & Inaba, 2015), and the *Organisation Environmental Footprint (OEF) Guide* from the European Commission (Pelletier, Allacker, Manfredi, Chomkhamsri, & Souza, 2012). Furthermore, The Nordic Council of Ministers has published a guide focusing on consumption based environmental footprints at a national level (Peters, Andrew, & Karstensen, 2016). The method used in this project is based on environmentally extended input-output analysis (EE-IOA), see section 2.2, which is a recognised approach for calculation of organizational carbon footprints.

In recent years there has been an extensive development within the EE-IOA field, and the methodology has been used to calculate the consumption based climate footprint of the UK (Wiedmann, et al., 2010), Sweden (Steinbach, et al., 2018) and Denmark (NIRAS A/S, 2021). In Norway, the CF of public procurements has been calculated based on EE-IOA in several projects, the latest being from 2019 (Asplan Viak and Oslo Economics, 2019). This calculation used an EE-IOA model based on the previously created model KLIMAKOST, which was developed for the Norwegian municipal sector. The KLIMAKOST model was also the basis for the project in which DFØs former climate intensities were calculated. The methodology and results from this project are summarised in the report "The carbon footprint of central government procurement. Evaluating the GHG intensities of government procurement in Norway" (Larsen, Solli, Grorud, & Ibenholt, 2016). Differences between the modelling in that project and the current are described in section 2.4.3.

The model developed in this work is based on a so-called coupled model approach as documented in Wood (2018) and Palm, et al. (2019). The approach derives from earlier work on respecting national statistical data within a multi-regional input-output (MRIO) framework in a so called Single-country National Account Consistent (SNAC) approach (Edens, et al., 2015). However, instead of the approach described by Edens et al., which requires a full rebalance of the MRIO tables, it simply uses a relaxation of the widely used domestic technology assumption with MRIO data on technology used to produce imports. As such the coupled model uses Norwegian data for the Norwegian input-output tables and environmental pressures, while import related emissions are calculated using an environmentally-extended multiregional input-output (EE-MRIO) database. The coupling together of the domestic model with the coverage of imports is what defines the coupled model, further described in section 2.4.

1.4 Contents of the report

The rest of the report starts with chapter 2 explaining the method used for the development of the climate intensity tables, including a concise introduction to the concept of environmentally extended multi-regional input-output (EE-MRIO) models as well as a description of the calculation model developed by NIRAS' team. Chapter 3 presents the results of the work, while a discussion of the results follows in chapter 4. This part will touch upon subjects like uncertainties in the results and weaknesses in the calculation model, recommendations on the use of the results as well as for future work. The report rounds off with a conclusion in chapter 5.

2 Method

2.1 Climate intensities

The climate intensities developed in this project are consumption based, meaning that they include emissions in the whole value chain of purchases in the respective purchase categories. This implies that emissions in all *Scopes*, as defined by the GHG Protocol, are included. The three Scopes are explained in the below info box.

Scope 1	Direct GHG emissions occurring from sources that are owned or controlled by the public institutions. An example is GHG emissions from vehicles owned by the entity.
Scope 2	GHG emissions from the generation of purchased electricity and district heating consumed. Scope 2 emissions physically occur at the facility where electricity and district heating is generated.
Scope 3	All other indirect GHG emissions, associated with the purchase of goods and services by the entity. 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 emission intensities account for emissions of fossil CO_2, CH_4, N_2O, SF_6, HFCs and PFCs. All GHG emissions are aggregated in CO_2e using the global warming potentials (GWP100) from the latest IPCC assessment report (AR5). LULUCF and biogenic CO_2 emissions are not included. For each purchase category the intensities are broken down to show how they distribute to the three Scopes as described above. There is also a split between emissions that happen in Norway and abroad for the Scope 2 and 3 emissions, while Scope 1 emissions are assumed to occur in Norway.

2.2 Environmentally extended multiregional input-output analysis (EE-MRIOA)

Input-output analysis (IOA) is an economic analysis method used to investigate the interdependencies between sectors in an economy and the relationship between final demand in one sector and production in other sectors (ScienceDirect, n.d.). The method is based upon input-output tables (IOTs), which are statistical tables quantifying trade flows between sectors in an economy (Peters, Andrew, & Karstensen, 2016). When more than one region is included in the IOTs, they are called multiregional input-output (MRIO) tables.

The MRIO tables can be used in environmental footprint calculations by relating environmental data to the economic data, performing so-called environmentally extended multi-regional input-output (EE-MRIO) analysis. EE-MRIO analysis (EE-MRIOA) is a top-down approach aiming at full coverage of emissions, distributing the emissions to the final demand in different economic sectors. This is in contrast to life cycle assessment (LCA), which is a bottom-up approach calculating environmental footprints based on the emissions related to the different steps in value chains of the processes and products being studied. While LCA is usually relating emissions to physical units (L, kg, kWh), EE-MRIOA is often relating them to economical units (NOK, €, £). EE-MRIOA is suitable for calculation of climate intensities of public purchases because of the comprehensive coverage and also because of the format of the data basis for the analysis, i.e. the Norwegian standard chart of accounts. Due to their extensive scope, EE-MRIO models are however less suitable for identifying more detailed aspects of emission drivers within each purchase category.

The computations in IOA (and EE-MRIOA) are typically done through matrix calculations, making it possible to derive inputs required to fulfill a given final demand. EE-MRIOA can be used to produce average emission multipliers or emission intensities (e.g. in kg CO_2e per NOK), representing the average cradle-to-gate emissions related to the purchase of goods and services from each sector of the economy. These multipliers can be further decomposed through the supply chain to identify where emissions are occurring in the production value chain (e.g. combustion of fuels during transport vs. construction of vehicles vs. extraction of fuels). The characteristics of the method makes it possible to identify required inputs and associated emissions in different "layers" in the production value chain. The layers begin with the direct inputs, i.e. inputs required from all sectors to produce the final demand, and go backwards through the indirect input layers, i.e. the inputs required from all sectors to produce the intermediary inputs at the given layer in the value chain. Such disaggregations are possible in the MATLAB script, but for feasibility of reporting, only the difference between domestic and imported emissions are reported in the output here.

2.3 Accounts included in the tables

The purchase categories in DFØ's system are defined by general ledger (GL) accounts ("artskontoer") that are characterised by number codes and names. This project includes all three-digit accounts considered relevant for carbon footprinting purposes, i.e. accounts associated with an actual consumption of goods and/or services. Emission intensities were produced for all sectors included in the previous study by Asplan Viak, and the relevance of any additional accounts has been thoroughly assessed in the project through close dialogue between NIRAS' team and DFØ. Purchase categories which appear not to be used in the *statsregnskapet* (e.g. 623 "Coal") are excluded from the present project. The included accounts cover those related to purchases of goods, services and land areas, while accounts related to wages, taxes, incomes etc. are excluded as they are not related to purchases with associated emissions. Overall, 155 purchase accounts were selected for developing emission intensities in this project. The full list of included accounts/purchase categories can be found in Appendix A.

2.4 Calculation model

The general approach to calculate the climate intensities, including the data sources used for the different Scopes, is schematised in Figure 2.1 and described in the next sections. Section 2.4.2 describes the data treatment that has been necessary and section 2.4.3 provides a short discussion concerning differences between the current model and the model used in the previous project calculating climate intensities, i.e. Larsen, Solli, Grorud, & Ibenholt (2016).

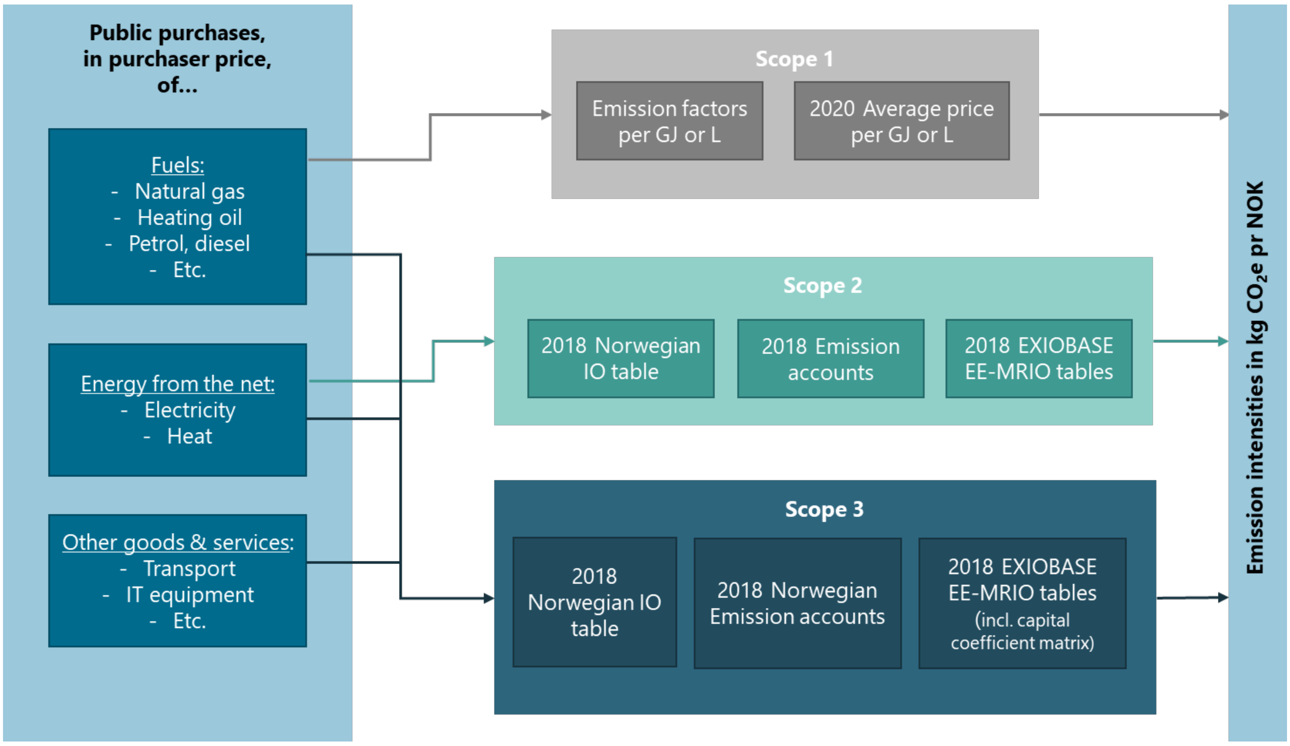

Figure 2.1: Illustration of the general approach to calculate the climate intensities of public procurements

In this project, the climate intensities have been calculated creating a *coupled model* where Norwegian IOTs and emissions data are coupled with an EE-MRIO database to calculate Scope 2 and 3 emissions from domestic and imported products and services. Here, using Norwegian specific data is advantageous since Norwegian Statistics' existing high-quality timely air emissions accounts and input-output tables can be used as input, providing a more accurate model than if based on an existing EE-MRIO table alone. Environmental pressures arising outside of Norway due to demand in the Norwegian economy (i.e. due to imports) are then calculated using the EE-MRIO database EXIOBASE. Such a coupled model is also easier to update with new statistics than if the Norwegian IOTs were directly integrated in an EE-MRIO model. The Scope 1 emissions are calculated separately using average prices of fuels and emission factors on a per physical unit basis.

2.4.1 Data sources

2.4.1.1 Scope 1

For Scope 1 emissions, the emissions data per physical units have been taken from DEFRA (DEFRA, 2021). DEFRA publishes yearly updated emission intensities for a range of energy carriers. The emission intensities are converted from physical units to monetary units using average prices of the fuels relevant for this project. These are gathered from different sources, as summarised in Table 2.1.

Table 2.1: Average prices of relevant energy carriers.

Energy carrier	Price	Unit	Source	Comment
Petrol	14,69	NOK/L	(Statistics Norway, 2021a)	Average price for 2020.
Diesel	13,86	NOK/L	(Statistics Norway, 2021a)	Average price for 2020.
Wood	1	NOK/kWh	(Norsk Varme, 2021), (Huseierne, 2021)	Estimate based on several sources. Assuming wood logs (not pellets).
Heating oil	23,22	NOK/L	(Circle K, 2021)	Assuming biobased heating oil due to the prohibition of fossil based heating oils for heating of buildings from 01.01.2020. 2021 price as it was the only one publicly available.
Gas	0,62	NOK/kWh	Median of a range of sources, please refer to Appendix D.	Assuming propane.
Marine gas oil	11,79	NOK/L	(Skarbøvika Tankanlegg AS, 2021)	2021 price as it was the only one publicly available.

2.4.1.2 Scope 2 and 3

For Scope 2 and Scope 3 emissions the Norwegian IOTs are supplied by Statistics Norway (SSB) (Statistics Norway, 2020a). To date, the most recent IOTs are the 2018. Statistics on the emissions from Norwegian economic activity are also published yearly by SSB. To be consistent with the IOTs, the 2018 emissions are used (Statistics Norway, 2021b). It should be noted that this emission data corresponds to a "production account" rather than a "territorial account". Territorial accounts are what is commonly reported to the United Nations Framework Convention on Climate Change, however exclude the emissions of residents abroad. The latter includes embassies, but more importantly activities such as water transport through international water by Norwegian ships. The production account used in this work as a basis for the Scope 2 and 3 emissions includes these sources.

The national emissions accounts as provided by SSB are only 48 sectors, in contrast to the 64 sectors in the Norwegian IOTs (which correspond to the NACE codes). Some tests were performed to disaggregate the 48 sectors to 64 (including using EXIOBASE data), but it was ultimately decided to use gross output from the IOTs to disaggregate the aggregated SSB data to the separate categories in the IO tables. This ensures that the total emissions are the same as in the SSB data and that all disaggregated sectors would have the same direct emission intensities. The sectors impacted are mostly service sectors. Since most of the carbon footprint of these sectors are in their supply-chains, and not due to direct emissions, this assumption should not have a major effect on resultant multipliers.

For the imports associated emissions, EXIOBASE is used. EXIOBASE is a highly acknowledged global EE-MRIO database developed by a consortium of a range of European research institutions and financed by European research framework programs. In October 2021 the Norwegian University of Science and Technology (NTNU) publicly released EXIOBASE v3.8.2, which includes time series for the entire period 1995-2022[1]. The tables include 44 countries and 5 "rest-of-the-world" regions, and offer a great level of detail with 163 sectors. Emission data covers all GHGs included in the project (CO_2, CH_4, N_2O, SF_6, HFCs and PFCs)[2].

2.4.2 Data treatment

2.4.2.1 Scope 1

The Scope 1 climate intensities were calculated in Excel using the information from the data sources listed in section 2.4.1. Scope 1 emission intensities are only relevant for fuels, i.e. purchase categories 621 ("Gas"), 622 ("Heating oil"), 624 ("Wood"), 625 ("Petrol, diesel"), 629 ("Other fuels"), and 700 ("Fuel"). Some assumptions have been necessary with respect to fuel types included in the different purchase categories. These include:

- Type of gas
  It is assumed that the gas purchases are of propane. The gas GL account might be used for purchases of gas used for cooking, heating, transport, industrial purposes like welding etc. Natural gas is in Norway mainly used in larger industrial facilities. Governmental institutions are therefore assumed to purchase very limited amounts of natural gas, and rather propane, which is a commonly used gas for cooking etc.
- Type of heating oil
  As of 01.01.2020 using fossil heating oil was prohibited in Norway (with a few exceptions). Thus, it is assumed that the purchases in GL account 622 are solely of biobased heating oils. This gives significantly lower Scope 1 emissions than if fossil heating oil was assumed, due to zero fossil CO_2 emissions[3] and only limited CH_4 and N_2O emissions.
- Type of wood
  It is assumed wood logs (not pellets). Although wood is a biomass, Scope 1 emissions are not null due to the emissions of biogenic CH_4 and N_2O, which must be included according to the GHG protocol.
- Split between petrol and diesel
  Based on statistical data on sales of petroleum products to the sector "Public administration, defence, education, health and social services", it is a assumed a split between petrol and diesel of 17% and 83% respectively, measured in monetary units (Statistics Norway, 2020b). The split is based on the 2019 amounts of auto diesel and petrol due to lacking data for 2020 (confidentiality reasons).
- Content of "Other fuels"
  Based on information on purchases of other types of fuels by governmental institutions (provided by DFØ), it is assumed that this GL account is used for purchases of marine gas oil.
- Content of "Fuel"
  In the study by Asplan Viak, purchase categories 700 ("Fuel") and 625 ("Petrol, diesel") have the same

[1] Part of the data in the time series is now-casted and/or forecasted based on macro-economic projection.
[2] The data is downloadable at https://zenodo.org/record/5589597#.YbbStq8zY-c
[3] Biogenic CO_2 emissions are not part of the Scope 1 emissions according to GHG protocol, but can be reported separately from the Scopes.

emission intensities. Data provided by DFØ also specifies that at least 18% of the expenses in purchase category 700 are "petrol, diesel and fuel", while the rest is showed as fuel with no further specification. All expenses under category 700 are thus assumed as petrol or diesel, thus with the same emission intensities as purchase category 625.

2.4.2.2 Scope 2 and 3

Calculation of the emission intensities for Scope 2 and Scope 3 required several modelling steps to be executed. First, a comprehensive matching job was performed. The matching work comprised the following:

a) A matching of the 64 Norwegian sectors with the 163 EXIOBASE sectors.
b) A matching of the public purchase categories with the 64 sectors in the Norwegian IOTs.
c) A matching of the public purchase categories with the 163 EXIOBASE sectors.

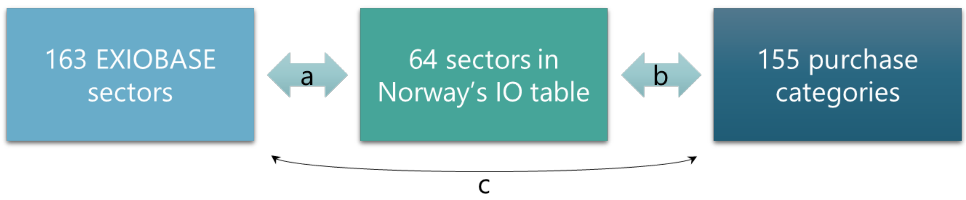

Figure 2.2: Illustration of the matching approach

Matching a) was carrying out by the NIRAS team building on its experience from the Danish coupled model. Several sectors in the Norwegian IOT have a one-to-one match with the sectors in EXIOBASE, due to the common use of the NACE classification as a building block. Sectors related to agriculture, food production, electricity production and waste treatment show a higher level of disaggregation in EXIOBASE than in the Norwegian IOTs, but the purchase categories are not detailed enough to make use of such a sectorial resolution. Matching c) between the purchase categories and the EXIOBASE sectors was thus done indirectly, using the sectors from the Norwegian IOTs as an intermediate.

Matching b) builds on a matching matrix provided by DFØ, based on the analysis of a dataset of governmental purchases with NACE classification of the suppliers. It is estimated that this dataset covers approximately 40% of the governmental organizations, and less than 20% of the purchases. NIRAS performed several manual adjustments to correct among other things for the use of supplier information and the aggregation of chemical sectors in the IOTs as developed below.

Several purchase categories showed a strong match with the wholesale and retail sale sectors in the Norwegian IO tables, while these are almost exclusively used for the allocation of margin on products in the IOTs. Although governmental organization may indeed buy goods from supermarkets and other retailers (thus the match with these sectors), the purchase category should be matched with the sector representing the purchased goods themselves (e.g. fuel, furniture, etc) in order to provide more accurate emission intensities. The share of the expenses which were automatically matched with the wholesale and retail sale sectors were thus manually reallocated to other manufacturing processes, based on the guidance to the standard chart of accounts (DFØ, 2021) and the list of the top suppliers for each purchase category.

Likewise, the purchase of electrical equipment from a company that might be associated with the IO sector for electricity production might be matched to the wrong sector based on the supplier information alone. Any purchase from the sector "Electricity, gas, steam and air-conditioning" in the Norwegian IOTs is associated with Scope 2 emissions in the results, whereas the purchase of goods should not be associated with any Scope 2 emissions. Any partial match with this sector for purchase categories other than 620 ("Electricity"), 621 ("Gas") and 634 ("Light and heat") were thus reallocated to the IO sector "Electrical equipment".

Some purchase categories cover a wide range of goods and services, where it proved difficult to manually allocate the purchases to several sectors in the Norwegian IOTs (e.g. 430: "Consumption of purchased goods and services"). In these cases, data regarding the "final consumption expenditure by government" and the intermediate consumption expenditure by "Public administration and defence" were extracted from the 2018 Norwegian IOTs and used to calculate a distribution of expenses over the relevant sectors.

In the Norwegian IOTs, the data from the sectors "Coke and Refined petroleum products" and "Chemicals and chemical products" are aggregated with the sector "Basic pharmaceutical products and pharmaceutical preparations". Any share of purchase category which was matched with one of these sectors was thus reallocated to the sector "Basic pharmaceuticals products and pharmaceutical preparations". The whole process for matching b) was executed in close dialogue with DFØ. Details from the matching work can be found in Appendix C.

With the matches completed, the Scope 2 and 3 emission intensities were calculated in MATLAB through matrix calculations, including the coupling of the Norwegian and EXIOBASE IO tables, additional data treatment and the exporting of the results to an Excel workbook. In particular, the following activities were part of the required data treatment for the Scope 2 and Scope 3 emission intensities:

- Conversion from purchaser price to basic price
  In general, IO tables are computed in basic prices while public purchases are recorded in purchaser prices, which account additionally for taxes and trade and transport margins. Spent data and associated emissions thus needed to be converted in purchaser price to be compatible with the valuation used in the coupled model. There are two steps to this process: 1) ensuring that the emissions associated with trade and transport margins are allocated to the goods that these margins apply to, and 2) rebasing the expenditure data (and thus the multipliers) from basic to purchaser price. Step one was done by extracting the value of trade and transport margins applied to goods from the Norwegian IO tables (reported in the Supply table). Percentages were calculated that showed the percentage of margin commodities that were due to the margin component (the transport and trade of other goods) and the non-margin component (trade and transport directly used). The application of these percentages to the footprint of the trade and transport margin sectors shows the total amount of emissions associated with trade and transport margins. The value of these trade and transport emissions are then distributed across all goods and services based on the percentage of trade and transport margins used in each sector. Finally, in step 2, the rebasing of the pricing of consumption (the denominator in the multiplier) was done by calculating the relative value of purchaser price to basic price and adjusting the denominator of the multiplier accordingly.
  In this way, all trade and transport margins are aggregated and assigned based on the total margins used by each sector, rather than using any margin specific information, or any specific information that show how government purchases differ from the rest of the economy. This is due to the available data in the most recent IO tables available. Margin and sector specific data is sometimes available in benchmark IO tables

when the Use tables are disaggregated by margin commodity. Whilst this data is common internationally at least every 5 years, it was not available from SSB.

- Disaggregation of the electricity supply chain to isolate Scope 2 emissions
  Scope 2 emissions comprise emissions from the generation of electricity. The upstream emissions associated with the potential extraction of energy carriers or the consumption of other resources in the power plant for operational purposes, as well as transmission and distribution losses, are however included as part of Scope 3. Yet, all of these air releases are part of the same supply chain and integrated in the Norwegian and EXIOBASE IO tables. It was thus necessary to disaggregate the supply chain for electricity consumption in order to isolate the Scope 2 emissions. Two sets of results are hence displayed: Scope 2 emissions, which are simply the direct emissions from electricity generation per MNOK of consumption of electricity, and Scope 3 emission multipliers which are full supply chain emissions per MNOK, *excluding Scope 2 emissions*. For the use of multipliers, Scope 2 and Scope 3 multipliers are thus additive in the final work.
  Scope 2 emissions were calculated due to the purchase of domestic electricity from the Norwegian IO tables. Such a result is simply the emissions from the electricity sector, divided by the output of the sector. For direct purchases of imported electricity, EXIOBASE data was used, with the direct emissions of foreign produced electricity per unit of imports included.
  Of note is that the Norwegian IOTs aggregate electricity with gas, heat and cooling in the sector called "Electricity, gas, steam and air-conditioning". In the model, the emissions associated with what are here defined as the Scope 2 emissions hence also include emissions beyond pure electricity and district heating. This was because no data was available to disaggregate the sector into pure electricity emissions and output (both emission and production) value, consistent with the IOTs would have to be disaggregated.
- Disaggregation of Scope 3 emissions in Norway (NO) and in the rest of the world (RoW)
  Scope 3 emissions were calculated both for domestic Norwegian emissions and for emissions embodied in imports. The delineation of the calculation is a feature of the coupled model, and is described in detail in Appendix F. The Norwegian IO and emissions data was the inputs required for the Norwegian Scope 3 emissions, whilst the EXIOBASE data and the Norwegian IO tables are required to allocate emissions embodied in imports to final goods and services in Norway.
- Capital goods endogenization
  Emissions associated with capital goods are included in the intensities using a capital coefficient matrix from EXIOBASE. The calculation builds on earlier work in EXIOBASE, and uses data updated to the most recent year. The capital use matrices available show the amount of capital used in each sector of the economy. These are converted into coefficients based on the relative amount of consumption of fixed capital reported in EXIOBASE for the import multipliers, and that reported in the Norwegian IO table for the domestic calculation. An adjustment is then made for the direct coefficient matrices used (both domestic and imports) to include these capital coefficients. Note an assumption here is that the emission intensity of capital consumed is the same intensity of the corresponding capital good in the current year (2018) even though the capital would have been produced in a different year. More details on the endogenization are given in the MATLAB script.
- Quality assurance
  Scope 3 emission intensities calculated with the Norwegian coupled model were tracked through multiple modelling steps, and is available in the Excel files included in Appendix E. A comparison was made to results obtained directly from the EXIOBASE dataset at the level of classification of the Norwegian IO tables. These results are available in the workbook Multipliers_NO_bp_w_Capital_Comparison.xlsx in Appendix E and are in basic price values. The check shows a reasonably good match, with most differences as expected due to the

different nature and data used in the coupled model. The main difference occurs in the agricultural sector, where the Norwegian data clearly shows higher (roughly double) emissions than EXIOBASE.

In the model, some assumptions have been required due to the characteristics of the Norwegian IOTs. First, sectors 19, 20 and 21 *(19: Manufacture of coke and refined petroleum products*, *20: Manufacture of chemicals and chemical products* and *21: Manufacture of basic pharmaceutical products and pharmaceutical preparations*) are aggregated in the IO tables, probably due to confidentiality aspects of dominant suppliers. In the model, the emission multipliers related to these sectors are therefore considered equal for the Scope 2 and 3 emissions, while the Scope 1 multipliers are calculated separately (only relevant for *Manufacture of coke and refined petroleum* products, see details on the Scope 1 calculations earlier in the section). In theory, the Scope 3 multipliers associated with imports in these three sectors could be different, since EXIOBASE distinguishes between them, but to be consistent with the domestic part, it was decided to have one multiplier also for the imports. The error caused by this necessary assumption is likely not large, as the EXIOBASE emission intensities of these sectors only vary with 10–15%.

Second, the Norwegian IOTs provided by SSB are defined as product by product, but they are reported and treated as equivalent with industry by industry tables. Emissions data are usually reported by industry, but due to the classification used in the IO tables, the SSB convention is followed, treating the product and industry dimensions as equivalent (i.e. that each industry produces one product).

Furthermore, the data on public procurement does not include information regarding the origin of the goods and services, i.e. whether they are domestically produced or direct imports. Therefore, the emission intensities do not make this distinction either. In the calculation model, it is assumed a reasonable distribution between direct imports and domestically produced goods and services for each DFØ purchase category. The distribution is based on the average split for Norwegian purchases from different sectors. The data on this is provided in the Norwegian IO tables.

The MATLAB code and associated input and output files can be found in Appendix E, and the guidance on how to understand the code is found in Appendix F.

2.4.3 Differences compared to previous model

The emission intensities previously used by DFØ were calculated as part of a project carried out in 2016, when the availability of environmentally-extended multi-regional input-output (EE-MRIO) models was still limited. Emission intensities were thus based on the 2015 Norwegian IO tables and 2014 Norwegian emissions data for the domestic part of the supply chain, while all imports were modelled using an average IO table for EU28 in 2013 from Eurostat.

Compared to the previous emission intensities, the intensities resulting from the current project present the following improvements:

- Updated IO and emission data
  Emission intensities build on updated IO tables and carbon accounts from 2018, which was the last year with complete data at the time the project was started. The resulting updated emission intensities are thus more likely to reflect current market conditions (e.g. share of domestic products vs. imports) and production technologies (e.g. with lower emission intensities) than in the previous model.
- Better representation of imports
  In the previous study, all imports were modelled using average European data, although some products in the value chain might have been imported from non-European countries such as China, Brazil or the United States of America. In the current project, the Norwegian statistics are coupled with EE-MRIO tables from EXIOBASE, which includes 43 countries and 5 "rest-of-the-world" regions. As such, the coupled model can

better account for country-specific production technologies (e.g. regarding electricity generation), and is thus likely to provide more accurate emission intensities for the imports.

- Classification in Scopes, and in domestic emissions vs. aboard emissions
  While aggregated emission intensities were provided in the previous study, these are shared in Scope 1, 2 and 3 according to the GHG Protocol, and further disaggregated between emissions occurring in Norway and abroad. This classification will facilitate the reporting of the carbon footprint from public authorities, as well as eventual comparisons with national targets focusing on domestic emissions alone.
- Methodological consistency with carbon footprints from neighbouring countries
  The carbon footprint of Sweden and Denmark have recently been calculated using coupled models combining their national statistics with EXIOBASE. The Norwegian coupled model built in this project can be further developed to calculate the carbon footprint of the entire country (i.e. not only public purchases, but the final demand from households, government, etc.) according to a method consistent with the one used in neighbouring countries, thus allowing for more reliable comparisons.
- Future updates of emission intensities
  The coupled model is easy to update due to the simple matrix computations, and relies on data sources which are typically yearly updated (IO tables, GHG emission accounts). Using the commented MATLAB script, DFØ should thus be able to update the emission intensities using latest available data, using limited resources.

3 Results

Table 3.1 shows the climate intensities in tonnes CO_2e per NOK for the 20 most climate intensive purchase categories. The full climate intensity table is given in Appendix A (alternatively in Appendix B for the Excel version).

Table 3.1: Climate intensities of public procurements in three-digit purchase categories (GL accounts, "artskontoer") in tonnes CO_2e per MNOK for the 20 most climate intensive categories.

Climate intensities in Scopes [t CO_2e/MNOK]		Scope 1	Scope 2		Scope 3		Sum
#	Name of GL account ("artskonto")	Norway	Norway	RoW	Norway	RoW	
621	Gass	375	14	0	6	20	**415**
629	Annet brensel	235	-	-	20	44	**299**
625	Bensin, diesel	176	-	-	20	44	**239**
700	Drivstoff	176	-	-	20	44	**239**
619	Annen frakt- og transportkostnad ved salg	-	-	-	114	41	**155**
632	Renovasjon, vann, avløp o.l.	-	-	-	44	25	**69**
400	Innkjøp av råvarer og halvfabrikater	-	-	-	20	45	**65**
403	Innkjøp av råvarer og halvfabrikater, fortsettelse	-	-	-	20	45	**65**
622	Fyringsolje	2	-	-	20	44	**65**
658	Annet driftsmateriale	-	-	-	15	47	**62**
659	Annet driftsmateriale, fortsettelse	-	-	-	15	47	**62**
610	Frakt, transport og forsikring ved vareforsendelse	-	-	-	33	25	**58**
146	Innkjøpte varer (ferdigvarer) og driftsmateriell	-	-	-	14	39	**53**
147	Innkjøpte varer (ferdigvarer) og driftsmateriell, fortsettelse	-	-	-	14	39	**53**
122	Skip, rigger, fly	-	-	-	3	49	**52**
492	Skip, rigger, fly	-	-	-	3	49	**52**
657	Arbeidsklær og verneutstyr	-	-	-	1	47	**48**
124	Andre transportmidler	-	-	-	2	40	**43**
494	Andre transportmidler	-	-	-	2	40	**43**
710	Bilgodtgjørelse	-	-	-	26	15	**41**

Fossil fuels are among the purchases with the highest emission intensities, due to the high releases of greenhouse gases through combustion, mostly categorised as Scope 1 emissions. While fuel oil (account 622) was associated with the highest emission intensity in the study by Asplan Viak, it displays a medium to lower emission intensity in the current project due to the ban of fossil fuel oil since January 2020, and the fuel thus being modelled as biofuel HVO.

The transport services show relatively high emission intensities (Scope 3), due to the high use of fuels within the sector – both water transport and air transport are emission intensive. There is considerable variation in fuel use dependent on type of ship used in water transport however, so further efforts to disaggregate this multiplier into passenger and freight, and low and high speed would be useful (both in the IO tables and the purchase data).

Due to the high share of renewable energy (e.g. hydropower) in Norway, the Scope 2 emissions from electricity generation are relatively low. The model shows indeed, that nearly 65% of emissions from electricity purchases are classified as Scope 3, highlighting the need for accounting for upstream emissions to correctly capture the impact from electricity consumption.

Overall, the Scope 3 emission multipliers are higher for more basic goods than manufactured goods or services. This is partially due to the lower levels of value added (and thus the lower cost) of these basic goods. It would be expected that there would be relatively less expenditure on these goods, compared to manufactured goods. A clear example here is agriculture, which has a relatively high emissions multiplier. However most agricultural goods, are processed at least simply before consumption, and the corresponding multiplier for food manufacturing is roughly half that of agricultural goods. This effect can also be seen in the intensities in Table 3.1, where for example 400: "Innkjøp av råvarer og halvfabrikater" (Purchase of raw materials and intermediate goods) has a higher intensity than 122: "Skip, rigger, fly" (Ships, rigs and aircrafts).

In terms of emissions released in Norway versus abroad, there is a predominance of emissions embodied in imports for the basic and manufactured goods and even services (with some notable exceptions for example for paper products and non-metallic minerals). It is mainly the fuel using sectors such as transport, and the waste treatment sectors which have relatively high domestic emissions (see e.g. 619 Annen frakt- og transportkostnad ved salg, and 632 Renovasjon, vann, avløp o.l.).

4 Discussion

4.1 Implications of the results

The results show which purchase categories are the most and least climate intensive per NOK spent, which purchase categories are dominated by Scope 1, Scope 2 and Scope 3 emissions, respectively, as well as which categories cause emissions mainly abroad or in Norway. When applied to public purchases the intensities may be used for different kinds of analyses of consumption-based environmental impacts, as explained in section 4.3. These results may then again be applied to identify and implement efficient measures and policies to reduce GHG emissions.

4.2 Uncertainties and limitations

Some necessary assumptions due to the format of the IO tables, as explained in section 2.4.2.2, give rise to uncertainties in the results that users should be aware of. First, three sectors in the Norwegian IO tables are assigned the same Scope 2 and 3 emissions multipliers for both domestic purchases and imports because they are aggregated in the IO tables. This concerns sectors 19 *Manufacture of coke and refined petroleum products*, 20 *Manufacture of chemicals and chemical products* and 21 *Manufacture of basic pharmaceutical products and pharmaceutical preparations*). These sectors are disaggregated in EXIOBASE and the associated emission multipliers show little variation. It is thus NIRAS' evaluation that the error caused by this assumption is relatively small.

Second, the sector including electricity in the Norwegian IOTs and in the Norwegian emission accounts also include manufactured gases (not natural gas) and heating/cooling. The Scope 2 emissions defined in this report thus also include activities beyond pure electricity emissions (and is a result of the difficulty in disaggregating combined heat and power). This implies that production of electricity and district heating are associated with the same direct emissions in terms of CO_2e in the Norwegian IOT, and the intensity also includes manufactured gas production, which is not included in Scope 2 according to the GHG protocol. The purchases from this sector are nevertheless assumed to be dominated by electricity, implying that this is causing a minor error. It is still worthwhile mentioning that the coupled model results in a Scope 2 emission intensity for electricity which cannot be expected to directly correspond to other sources like NVE[4], due to differences in terms of system boundaries and uncertainties related to the fluctuating price of electricity.

Furthermore, the additional assumptions required in the MATLAB modelling, like the capital goods being produced the same year as the final demand, the assigning of trade and transport margins based on the total margins used by each sector and the split between purchases of domestically produced and imported goods and services being the

[4] https://www.nve.no/energi/energisystem/kraftproduksjon/hvor-kommer-strommen-fra/

same as for the Norwegian economy in general, are all sources of inaccuracies in the results. Some assumptions are however inevitable in EE-MRIOA, and the results are still considered to give good representations of the emissions associated with each purchase category.

The robustness of the emission intensities in Scope 2 and Scope 3 also depends on the quality of the matching. As described in section 2.4.2.2, the matching began with a matrix provided by DFØ as the starting point. This matrix was generated by DFØ using accounting data from different governmental institutions. Even though this matrix was thoroughly reviewed and manually revised, errors in this original matrix could cause consequential errors in the results. For example, the purchase data on which the matrix was based only covered about 40% of governmental organizations and around 20% of total purchases, possibly giving an unrepresentative picture of the purchases as a whole. Further, the dataset did not include period 13, which is an "extra" period where corrections to the 12 actual periods are listed, nor did it include the balance sheet accounts (accounts 104-147). The manual review of the matrix revealed quite a few incorrect/doubtful matches that were adjusted, nevertheless the content of some of the purchase categories was unclear, and users of the intensities should be aware of this possible source of error.

Additionally, upon applying the climate intensities to public purchases, the accuracy of the calculated carbon footprints naturally depends on the correct accounting and use of the GL accounts. If purchases are registered in the wrong account, the wrong intensity will be applied.

Regarding the split of domestic versus imported emissions, all results correspond to Norwegian economic activity, rather than whether they are on the Norwegian territory or not. This is in line with the distinction between territorial accounts and production (and henceforth consumption, which are based on the production) accounts (see section 2.4.1.2). Hence, any direct emissions from fossil based heating of embassies and military facilities abroad, as well as fuels used for transportation by Norwegian entities abroad, are Scope 1 emissions that are released by Norwegian "residential entities" even if they occur outside the Norwegian territory. A full discussion of the difference between territorial accounts and production accounts is available at Usubiaga & Acosta-Fernández (2015).

Further, sections 2.4.1.1 and 2.4.2.1 describe how the Scope 1 emission intensities are calculated separately from the MATLAB modelling using information on direct emissions from the different energy carriers and their prices. The Scope 1 emissions are therefore sensitive to any price variations, and because the robustness of the prices used in the calculations as listed in Table 2.1 vary, inaccuracies in the Scope 1 emission intensities depend on the deviation of the actual prices from the assumed prices. A sensitivity analysis shows that a 50% decrease in fuel price gives a doubling of the Scope 1 climate intensity, while a 50% increase in price gives a 33% reduction in the intensity. For the fuels with high Scope 1 emissions, like 621 ("Gas"), 625 ("Petrol, diesel"), 629 ("Other fuels"), and 700 ("Fuel"), price variations thus have considerable impacts on the final intensities. Please refer to Appendix D for details on the sensitivity analysis.

The Scope 1 emissions are also based on assumptions related to the content of the different purchase categories, as listed in section 2.4.2.1. How well these assumptions reflect reality will affect the correctness of the Scope 1 results. For example, it is assumed that the GL account 629 "Other fuels" only consists of marine gas oil (MGO) only, while in practice other fuels might also be registered here. Thus, the accuracy of the Scope 1 intensities and consequently the total carbon footprint might vary between governmental institutions depending on the amount they purchase of the different fuels.

When it comes to limitations, as mentioned in section 2.2, EE-MRIO is, due to its high coverage, less suitable for analysing the emission intensities in detail within the purchase categories, as the intensities are necessarily calculated based on sector averages as provided by EXIOBASE. This means that the model and results cannot be used directly to analyse the effects of green procurements, nor details of specific goods and services within the same purchase category. Furthermore, the MRIO data does not include downstream Scope 3 emissions related to end-of-life of the purchased goods, which means that these emissions are not included in the intensities either.

The exclusion of LULUCF emissions and carbon absorption in the modelling is also a limitation, as these emissions and uptakes might be considerable. There is currently ongoing research on techniques for better measurements of these emissions, and when improved data is available, it might be relevant to expand the climate intensity model to account for these emissions as well. This would, among other things, require the LULUCF emissions to be disaggregated by sector and data to be available for all countries in the MRIO table.

4.3 Recommendations

The climate intensities resulting from this project can be used by individual public institutions to identify climate intensive purchase categories in order to prioritise green procurements where they are most efficient. The intensities may also be used in a larger context to calculate the carbon footprint of public procurements in Norway, both totals and specific for different public bodies, which then can be compared. The intensities may be used by all public institutions are covered by the state public accounts.

With respect to future work, the Norwegian IO tables and emissions data are updated yearly, and EXIOBASE is also updated regularly, meaning that the climate intensities should be continuously updated to best reflect the current situation. The MATLAB code (Appendix E) and the associated guidance (Appendix F) explains how to do these updates. Future work could also include efforts to improve the quality of the data basis for the model, in order to reduce the uncertainties discussed in section 4.2. Here it is NIRAS' recommendation to prioritise purchase categories which have high climate intensities, and/or have high purchase volumes (in monetary terms), thus contributing to a large share of the final carbon footprint when applying the intensities to the public purchases.

NIRAS also suggests to prioritise improvements in the Scope 1 data basis, as the emissions here are very dominant for the fuel related purchase categories and also highly price sensitive as section 4.2 explains. To minimise the Scope 1 uncertainties, continuous updates of prices and composition of the fuel related purchase categories based on best available data on the governmental purchases is recommended. Information on the actual types of fuels purchased and the actual prices paid by the public institutions would be preferable as the data input. If possible, deriving the Scope 1 emissions based on purchased amounts of the fuels in physical, rather than monetary, units, would be even better, to avoid the calculation via price information, which inevitably introduces some uncertainty to the results.

The uncertainties related to the matching of GL accounts to Norwegian IO sectors as described in section 4.2 could also be decreased if it becomes possible to acquire more accurate data on the public purchases in each account. It is also recommended to verify that the accounts are used correctly by the public institutions, as the final carbon footprints calculated with the intensities are highly dependent on proper registration of expenses. A possibility is to conduct a separate project to investigate this.

Clearly consideration of liquid (transport) fuel use in the Norwegian context is of high importance, and in line with other policy goals to move to electrification of the vehicle fleet. Adding resolution to multipliers to capture the difference between electrified and non-electrified vehicles, as well as the type of transport activity (see discussion above regarding water transport) may be important to further accurately capture the decarbonisation efforts of public purchasing in this regard.

Future developments may include the use of the coupled model to analyse the carbon footprint of Norway, defined as the greenhouse gas emissions resulting from the total final demand in the country (i.e. by households, non-profit organisations serving households and government, plus capital formation and other changes in inventories). Similar analyses have been carried out in Denmark and Sweden using coupled models with the national IO tables and EXIOBASE, and could be used for comparison purposes.

5 Conclusion

To have updated and robust data on the greenhouse gas emissions associated with public procurements, climate intensities have been calculated for 155 purchase categories represented by GL accounts ("artskontoer") in DFØ's standard chart of accounts. The intensities have been calculated using a coupled environmentally extended multi-regional input-output (EE-MRIO) model. In the model Norwegian IO tables and emissions data are coupled with the global EE-MRIO database EXIOBASE to create climate intensities that include Scope 1, Scope 2 and (upstream) Scope 3 emissions. The coupled model ensures high quality results by the use of national data, while also providing full value chain coverage thanks to the extensiveness of EXIOBASE. The model provides results broken down into emissions happening in Norway and abroad for Scope 2 and 3, while all Scope 1 emissions are assumed to occur in the Norwegian economy. The results show that purchases in the categories *621: Gas* ("Gass"), *629: Other fuels* ("Annet brensel"), *625: Petrol, diesel* ("Bensin, diesel") and *700: Fuel* ("Drivstoff") are the most climate intensive, with total intensities of 415, 299, 239 and 239 t CO_2e/MNOK, respectively. The climate intensities can be used to calculate carbon footprints of public procurements and identify important emissions drivers among the procurements, but they are not suited for detailed analysiss of specific goods or services within the purchase categories. Regular updates of the intensities and the underlying data are recommended, and the attached MATLAB code and guidance can be used to implement the updates based on the Norwegian IO tables, emissions data and EXIOBASE.

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Appendices

Appendix A	Climate intensity table
Appendix B	Excel workbook with climate intensity table
Appendix C	Excel workbook with matching of DFØ categories with Norwegian IO sectors
Appendix D	Excel workbook with Scope 1 sources and calculations
Appendix E	ZIP file with MATLAB code including input and output
Appendix F	Guidance to MATLAB code

Appendix A: Climate intensity table

Table 6.1: Full list of climate intensities of public procurements in three-digit purchase categories (GL accounts, "artskontoer") in t CO_2e per MNOK. NO = Norway, RoW = Rest of World.

Climate intensities in Scopes [t CO_2e/MNOK]		Scope 1	Scope 2		Scope 3		Sum
#	Name of GL account ("artskonto")	Norway	Norway	RoW	Norway	RoW	
104	Programvarelisenser og egenutviklet programvare	-	-	-	3	11	15
107	Immaterielle eiendeler under utførelse	-	-	-	3	11	15
110	Bygninger	-	-	-	11	18	28
112	Bygningsmessige anlegg	-	-	-	4	10	14
113	Anlegg under utførelse	-	-	-	7	17	23
114	Jord- og skogbrukseiendommer	-	-	-	5	8	13
115	Tomter og andre grunnarealer	-	-	-	11	19	30
116	Boliger inkl tomter	-	-	-	11	18	29
117	Infrastruktureiendeler	-	-	-	5	18	23
118	Nasjonaleiendom og kulturminner	-	-	-	5	18	23
119	Andre anleggsmidler	-	-	-	4	32	36
120	Maskiner og anlegg	-	-	-	3	35	37
121	Maskiner og anlegg under utførelse	-	-	-	3	35	37
122	Skip, rigger, fly	-	-	-	3	49	52
123	Biler	-	-	-	1	32	33
124	Andre transportmidler	-	-	-	2	40	43
125	Inventar	-	-	-	2	33	34
126	Fast bygningsinventar med annen avskrivningstid enn bygningen	-	-	-	6	18	24
127	Verktøy og lignende	-	-	-	3	31	34
128	Datamaskiner (PCer, servere m.m.)	-	-	-	1	38	39
129	Andre driftsmidler	-	-	-	4	32	36
146	Innkjøpte varer (ferdigvarer) og driftsmateriell	-	-	-	14	39	53
147	Innkjøpte varer (ferdigvarer) og driftsmateriell, fortsettelse	-	-	-	14	39	53
400	Innkjøp av råvarer og halvfabrikater	-	-	-	20	45	65
403	Innkjøp av råvarer og halvfabrikater, fortsettelse	-	-	-	20	45	65
406	Frakt, toll og spedisjon	-	-	-	13	20	34
430	Forbruk av innkjøpte varer og tjenester	-	-	-	6	11	16
431	Forbruk av innkjøpte varer og tjenester, fortsettelse	-	-	-	6	11	16
432	Forbruk av innkjøpte varer og tjenester, fortsettelse	-	-	-	6	11	16
433	Forbruk av innkjøpte varer og tjenester, fortsettelse	-	-	-	6	11	16
436	Forbruk av innkjøpte varer og tjenester, fortsettelse	-	-	-	6	11	16
437	Forbruk av innkjøpte varer og tjenester, fortsettelse	-	-	-	6	11	16
450	Fremmedytelse og underentreprise	-	-	-	7	15	22
451	Fremmedytelse og underentreprise, fortsettelse	-	-	-	7	15	22
452	Fremmedytelse og underentreprise, fortsettelse	-	-	-	7	15	22
453	Fremmedytelse og underentreprise, fortsettelse	-	-	-	7	15	22
454	Fremmedytelse og underentreprise, fortsettelse	-	-	-	7	15	22

470	Forskning og utvikling		-	-	6	15	20
474	Programvarelisenser	-	-	-	3	11	15
476	Andre rettigheter	-	-	-	3	11	15
480	Bygninger	-	-	-	11	18	28
481	Beredskapanskaffelser	-	-	-	4	10	14
482	Bygningsmessige anlegg	-	-	-	4	10	14
484	Jord- og skogbrukseiendommer	-	-	-	5	8	13
485	Tomter og andre grunnarealer	-	-	-	11	19	30
486	Boliger inkl. tomter		-	-	11	18	29
487	Infrastruktureiendeler	-	-	-	5	18	23
488	Nasjonaleiendom og kulturminner	-	-	-	5	18	23
489	Andre anleggsmidler	-	-	-	4	32	36
490	Maskiner og anlegg	-	-	-	3	35	37
492	Skip, rigger, fly	-	-	-	3	49	52
493	Biler	-	-	-	1	32	33
494	Andre transportmidler	-	-	-	2	40	43
495	Inventar	-	-	-	2	33	34
496	Fast bygningsinventar med annen levetid enn bygningen	-	-	-	6	18	24
497	Verktøy og lignende	-	-	-	3	31	34
498	Datamaskiner (PCer, servere m.m.)	-	-	-	1	38	39
499	Andre driftsmidler	-	-	-	4	32	36
590	Gaver til ansatte	-	-	-	4	35	39
591	Kantinekostnad	-	-	-	3	16	19
592	Gruppelivsforsikring	-	-	-	2	5	7
593	Yrkesskadepremie	-	-	-	2	6	8
596	Velferdstiltak	-	-	-	4	16	20
599	Annen personalkostnad	-	-	-	4	13	17
610	Frakt, transport og forsikring ved vareforsendelse	-	-	-	33	25	58
611	Toll og spedisjon ved vareforsendelse	-	-	-	12	19	30
614	Frakt, transport m.m. ved utdeling av driftsmateriell	-	-	-	12	19	30
619	Annen frakt- og transportkostnad ved salg	-	-	-	114	41	155
620	Elektrisitet	-	14	0	6	20	40
621	Gass	375	14	0	6	20	415
622	Fyringsolje	2	-	-	20	44	65
624	Ved	15	-	-	0	15	31
625	Bensin, diesel	176	-	-	20	44	239
626	Vann	-	-	-	5	16	22
629	Annet brensel	235	-	-	20	44	299
630	Leie lokaler	-	-	-	8	15	23
631	Leie lokaler fra Statsbygg	-	-	-	8	15	23
632	Renovasjon, vann, avløp o.l.	-	-	-	44	25	69
633	Reservert	-	-	-	8	15	23
634	Lys, varme	-	14	0	6	20	40

636	Renhold, vakthold, vaktmestertjenester	-	-	-	5	14	20
639	Annen kostnad lokaler	-	-	-	7	14	21
640	Leie maskiner	-	-	-	5	18	23
641	Leie inventar	-	-	-	5	18	23
642	Leie av datasystemer (årlige lisenser m.m.)	-	-	-	5	18	23
643	Leie av datamaskiner og servere	-	-	-	5	18	23
644	Leie av andre kontormaskiner	-	-	-	5	18	23
645	Leie av biler	-	-	-	5	18	23
646	Leie av andre transportmidler	-	-	-	5	18	23
649	Annen leiekostnad	-	-	-	5	18	23
650	Maskiner	-	-	-	3	35	37
651	Verktøy og lignende	-	-	-	3	31	34
652	Programvare (anskaffelse)	-	-	-	3	11	15
654	Inventar	-	-	-	2	33	34
655	Datamaskiner (PCer, mobiltelefoner, nettbrett, servere m.m.)	-	-	-	1	38	39
656	Andre kontormaskiner	-	-	-	3	35	37
657	Arbeidsklær og verneutstyr	-	-	-	1	47	48
658	Annet driftsmateriale	-	-	-	15	47	62
659	Annet driftsmateriale, fortsettelse	-	-	-	15	47	62
660	Reparasjon og vedlikehold egne bygninger	-	-	-	13	19	31
661	Reparasjon og vedlikehold egne bygninger, fortsettelse	-	-	-	13	19	31
662	Reparasjon og vedlikehold egne bygninger, fortsettelse	-	-	-	13	19	31
663	Reparasjon og vedlikehold leide lokaler	-	-	-	13	19	31
664	Reparasjon og vedlikehold infrastruktureiendeler	-	-	-	4	13	18
665	Reparasjon og vedlikehold infrastruktureiendeler, fortsettelse	-	-	-	4	13	18
666	Reparasjon og vedlikehold maskiner og anlegg	-	-	-	5	28	32
667	Reparasjon og vedlikehold maskiner og anlegg, fortsettelse	-	-	-	5	28	32
668	Reparasjon og vedlikehold skip, rigger, fly	-	-	-	5	28	32
669	Reparasjon og vedlikehold annet	-	-	-	8	15	23
670	Konsulenttjenester innen økonomi, revisjon og juss	-	-	-	2	13	15
671	Konsulenttjenester til utvikling av programvare, IKT-løsninger mv.	-	-	-	2	11	13
672	Konsulenttjenester til organisasjonsutvikling, kommunikasjonsrådgivning mv.	-	-	-	2	13	15
673	Andre konsulenttjenester	-	-	-	5	12	17
674	Innleie av vikarer	-	-	-	3	8	11
675	Kjøp av tjenester til løpende driftsoppgaver, IKT	-	-	-	2	11	13
676	Kjøp av lønns- og regnskapstjenester	-	-	-	2	13	15
678	Kjøp av andre fremmede tjenester	-	-	-	8	14	21
679	Kjøp av andre fremmede tjenester, fortsettelse	-	-	-	8	14	21
680	Kontorrekvisita	-	-	-	2	29	31
682	Trykksak	-	-	-	6	17	23
683	Annonser, kunngjøringer	-	-	-	7	18	25
684	Aviser, tidsskrifter, bøker o.l.	-	-	-	7	17	25

685	Aviser, tidsskrifter, bøker o.l. i bibliotek	-	-	-	7	17	25
686	Møter	-	-	-	6	17	22
687	Kurs og seminarer for egne ansatte	-	-	-	5	13	18
688	Kurs og seminarer for eksterne deltakere	-	-	-	7	15	23
689	Annen kontorkostnad	-	-	-	7	11	18
690	Telefoni og datakommunikasjon, samband, internett	-	-	-	4	14	18
694	Porto	-	-	-	6	14	20
700	Drivstoff	176	-	-	20	44	239
702	Vedlikehold	-	-	-	6	16	22
704	Forsikring	-	-	-	2	5	7
709	Annen kostnad transportmidler	-	-	-	11	20	30
710	Bilgodtgjørelse	-	-	-	26	15	41
713	Reisekostnad	-	-	-	14	19	33
714	Reisekostnad, fortsettelse	-	-	-	14	19	33
715	Diettkostnad	-	-	-	11	23	34
716	Diettkostnad, fortsettelse	-	-	-	11	23	34
719	Annen kostnadsgodtgjørelse	-	-	-	3	16	19
730	Salgskostnad	-	-	-	5	12	16
732	Reklamekostnad	-	-	-	6	18	24
735	Representasjon	-	-	-	11	21	32
740	Kontingent	-	-	-	6	11	17
741	Gave	-	-	-	4	35	39
750	Forsikringspremie	-	-	-	2	6	8
755	Garantikostnad	-	-	-	2	6	8
756	Servicekostnad	-	-	-	2	6	8
760	Lisensavgift og royalties (ikke programvarelisenser, jf. 642)	-	-	-	5	14	19
761	Patentkostnad ved egen patent	-	-	-	5	14	19
762	Kostnad ved varemerke og lignende	-	-	-	5	14	19
763	Kontroll-, prøve- og stempelavgift	-	-	-	5	14	19
771	Styremøter	-	-	-	5	15	20
775	Eiendoms- og festeavgift	-	-	-	8	16	24
777	Bank- og kortgebyr	-	-	-	1	4	6
779	Annen kostnad	-	-	-	8	14	23

Appendix B: Excel workbook with climate intensity table

See separate file.

Appendix C: Excel workbook with matching of DFØ categories with Norwegian IO sectors

See separate file.

Please be aware that this file cannot directly be used as input to the MATLAB code – instead use the corresponding file in Appendix E.

Appendix D: Excel workbook with Scope 1 Calculations

See separate file.

Appendix E: ZIP file with MATLAB code including input and output

See separate file.

Appendix F: Guidance to the MATLAB code

See separate file.